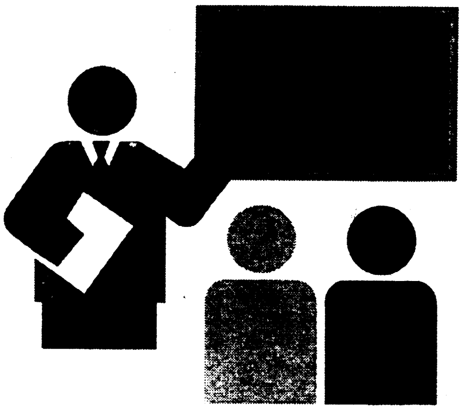
ORION ATLANTIC EUROPE, Inc.

VSAT Certification Training Course



Ground Operator Training Manual

Table of Contents Ground Operator Training Manual

Chapter 1
Orion Company Profile
Who we are

Table of Contents

1. Orion Company Profile

1.1. Who we are

Orion is an independently managed Satellite Company, which means that we are one of the few companies in the world which operate and control its own satellite. In contrast, for example, the INTELSAT and Eutelsat companies are owned by conglomerates of state owned PTTs. Because Orion does not have to go through a complex system of approvals in order to provide a Satellite circuit to a customer, we can respond to the market faster and with more flexibility than many of our competitors. With its successful stock offering in November 1996, Orion became a publicly owned company, trading on the NASDAQ stock exchange.

Orion Network Systems Inc.

Vision Statement

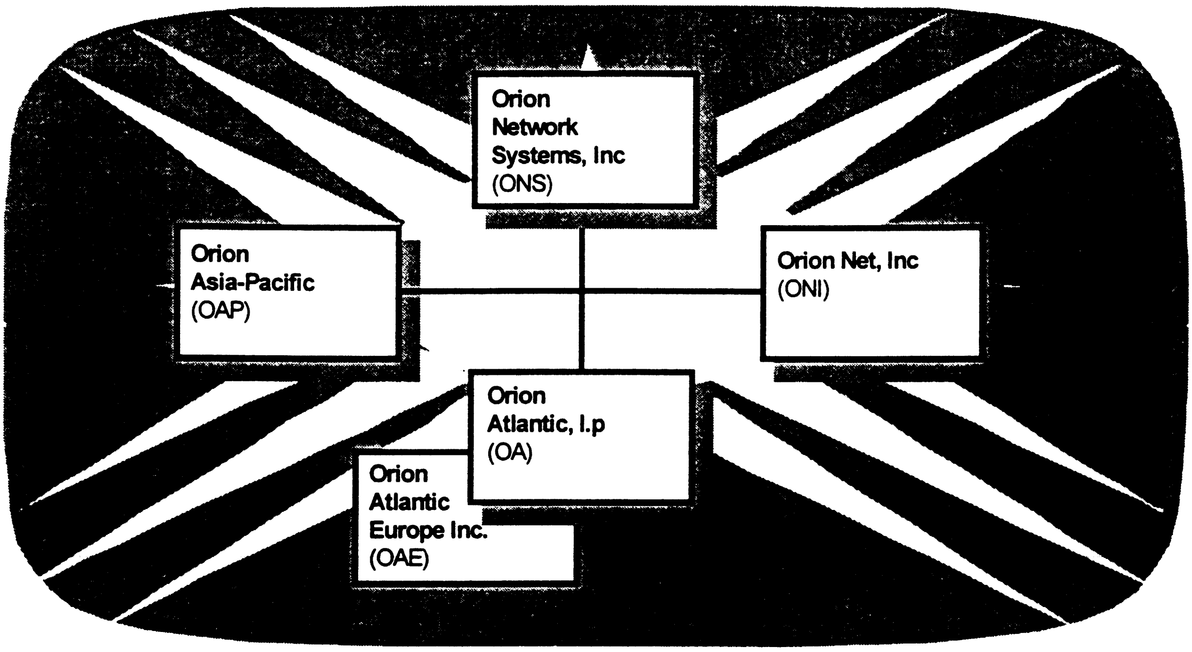
Be a leading global provider of innovative telecommunications services differentiated by reliability and responsiveness to Businesses, Content Providers, Broadcasters and Carriers.

1.2 Overview of Orion Companies

Below a schematic overview of the relationship between the main Orion companies is presented.

Orion Network Systems, Inc.	- Holding
OrionNet, Inc.	- Owner Ground Equipment
Orion Asia Pacific	- F3
Orion Atlantic l.p.	- Owner of F1 & F2
Orion Network Systems Europe Inc.	- Work Company

Orion Companies

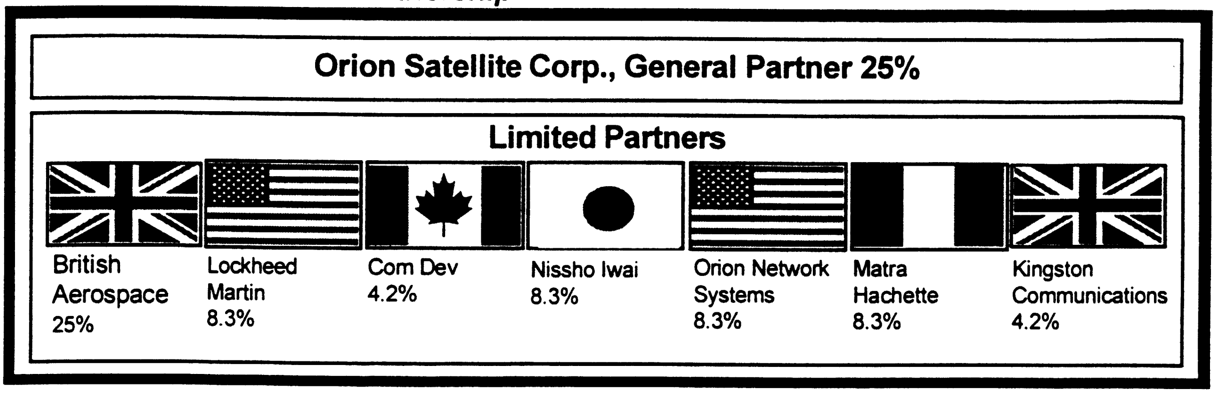


To serve the European market to the best of our capabilities, in February 1996, Orion Atlantic l.p., founded Orion Atlantic Europe Inc. From its office in Amsterdam, Orion Atlantic Europe serves as the European headquarters. It provides sales support, program management, project engineering, management, integration, logistics support, and training.

1.3.The Orion Atlantic Limited Partnership

To Build, Launch and Operate a Spacecraft like the Orion F1 you obviously need an in-depth knowledge in the field of Satellite Communications and Spacecraft Technology. On top of that you also need to bring a rather large amount of money to finance the project. This is why Orion searched and found companies willing to invest both knowledge and capital for the F1 project. The Orion Atlantic Limited Partnership was born.

Orion Atlantic Limited Partnership



On January 31, 1997 Orion Network Systems, Inc., annouced that it closed a public bond offering of U$ 710 million.Together with other available financings, the bond issue enables Orion to fulfill it's long term capital requirements for the establishment of a powerful three-satellite global communication system covering approximately 85% of the world's population.

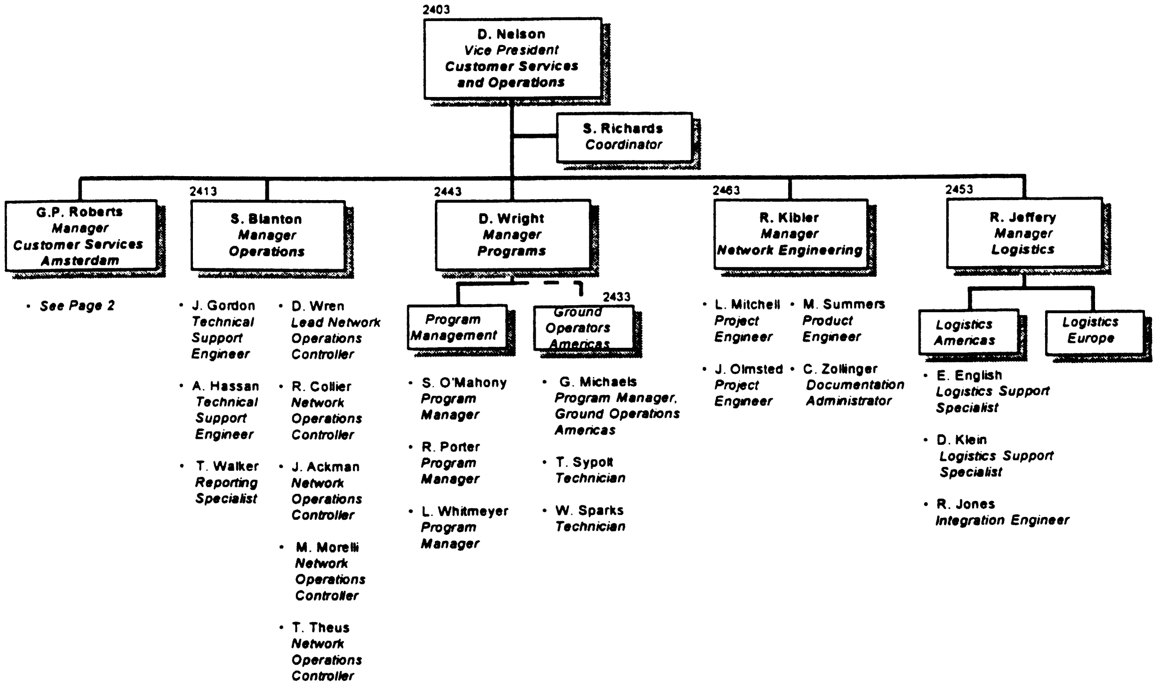
In conjunction with the financing, Orion simplified its corporate structure and increased both its equity and outstanding shares by acquiring all remaining limited partner interest in the Orion Atlantic partnership.

Although most of the former limited partners are still major investors, the exchange of stock announced the end of the limited partnership and made Orion Atlantic a 100%-owned Orion Networks Systems company.

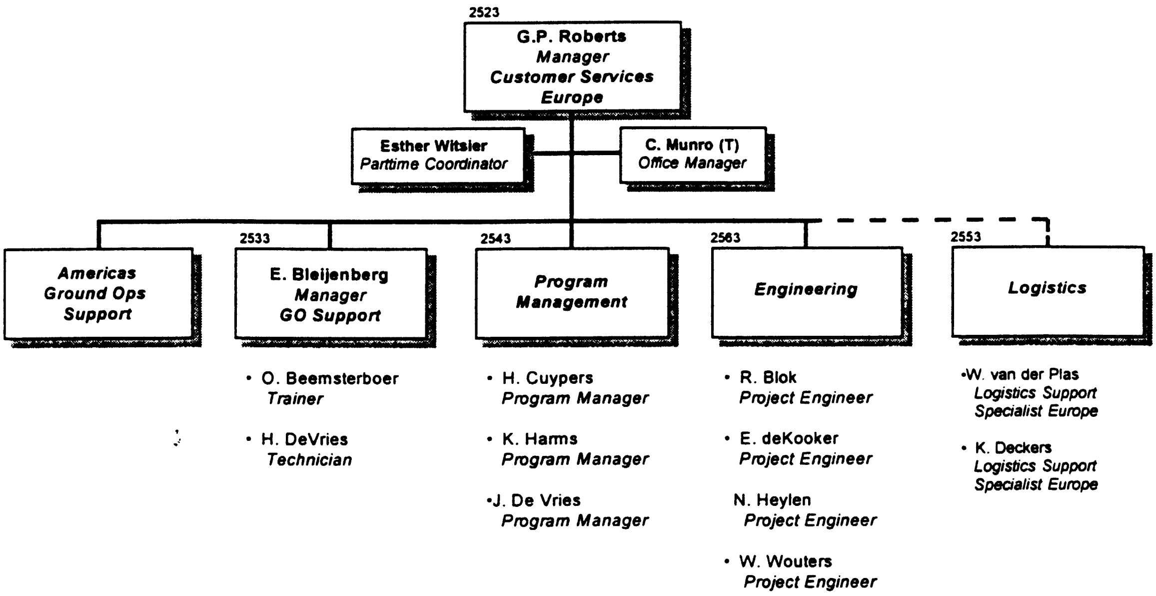
1.4. The Orion Atlantic Operational Organization

Orion structured it's operational organization into functional departments that allow matrix operations. What this organizational structure means, basically, is that departments have access to all necessary resources within their department but may also call upon other departments for their expertise. The following organograms (November '96) depict the structure of the operations organization.

1.4.1. Operations US



1.4.2. Operations Europe



A brief summary of the individual departments and their main tasks.

Program Management	**Project Engineering**	**Orion Operations Center**
• Reviews contract. • Contacts customer. • Initiates project design & integration. • Issues Service Order to ground operator (GO). • Plans and maintains schedule. • Delivers service.	• Designs network. • Produces documentation describing network design and configuration. • Supports GO during installation • Develops and tests products.	• Assigns frequency • Configures Up- and Down link configuration for the VSAT system. • Assists GO with line-up and cross-pol.

Ground Operations Support	**Logistics**	**Network Management & Control**
• Selects and contracts with GO and Administers the GO program. • Supports GOs. • Trains & Certifies GOs. • Controls the quality of GO work. • Dispatches Technicians.	• Arranges rack integration. • Arranges equipment shipping & delivery. • Arranges for equipment to clear customs. • Manages in-country VAT issues. • Manages spare part handling.	• Manages the Orion Network Management Center. • Issues trouble tickets. • Issues service calls to GOs.

1.4.3. Teleport Europe

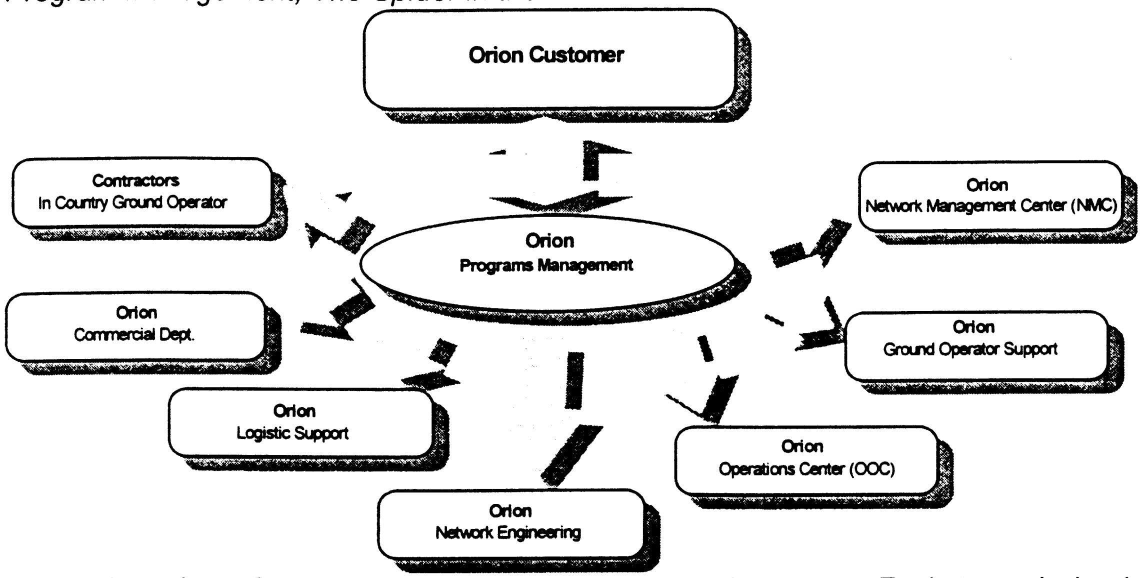
March 26 1997 marked another key milestone for Orion. On this date, orion closed the acquisition of Teleport Europe. With this addition, approximately 60 more people have joined Orion Network Systems. Teleport Europe has pursued a business strategy which was similar to Orion exept that they leased capacity rather than own satellites.

Teleport Europe is located in Hannover, Germany and has been operating since 1991. TE now provides services to customers in 32 countries and were the first to establish a point-to-point VSAT service from Germany to China. TE provides service on multiple satellites (Eutelsat, Intelsat, Kopernikus) which will provide Orion with greater flexibility, particularly prior to the launch of Orion 2.

1.4.4. The Vital Role of Program Management

The Program Management group fulfills a vital role within the Orion organization. The Program manager (PM) is the main point of contact for the customer, is the coordinator for all operational activities and is responsible for delivering the project in time. In order to achieve this demanding task the PM has free access to all resources within the operational organization.

Program Management, The Spider in the Web



For each project, Orion's management creates a project team. Each team is lead by a program manager. The team design and implement the project in close cooperation with the customer and the ground operator. During the implementation process, the assigned program manager is the main point of contact for all issues and has the overall responsibility for the project.

1.4.5. The Orion Operations Center (OOC)

The Orion Operations Center (OOC) is the watchdog over all communications being received and transmitted by Orion's premier satellite Orion 1. The OOC has the rigorous task of guaranteeing Orion's customers a communications environment that is readily available when needed, easily accessible for transmission lineup, and free from any service impairing interference. Today the OOC manages customer usage on 34 Orion transponders, 24 hours a day, 365 days a year. In addition to the continual monitoring of all full-time transmissions, the OOC controls over 100 new accesses per week. The new accesses could be new full time users, occasional users, and prospective users conducting tests in preparation for future service.

In order to maintain strict control over the transponders, Orion has published the Orion Access Procedures. These procedures outline the method for a customer to arrange for a service contract and receive frequency assignments. They also provide instructions for a customer to receive authorization to transmit to our satellite and the step by step process for verifying performance of their uplink equipment. Most importantly, the Orion Access Procedures grant the OOC the authority to deny access or terminate the transmission of any customer that is violating the terms of the agreement or is operating in a way that causes interference or threatens the health of the satellite.

Performance Verification Procedure

Most anomalous conditions occur on the satellite during the circuit initiation stage. To certify the suitability of a new or reconfigured uplink earth station prior to their operating on an Orion transponder, the OOC controller guides the uplink operators through the Performance Verification Procedure. The process prevents any harmful interference to Orion's and other satellite companies' space segments due to an out of tolerance condition of the earth station equipment.

In the near future the OOC will submit a Performange Verification Certification Number after each succesfull line-up. The certification number must then be included inthe station certification letter, a field installation report, and the GO invoice in order for billing to be complete.

The Staff

The staff of the OOC staff is available to provide 24-hour a day technical service to the customers and users of Orion transponders.In addition to controlling accesses and verifying uplink performance, the OOC Controllers assist the earth station operators in pointing their antenna to Orion 1 by identifying beacon frequencies and providing pointing look angles. They can prepare printed transponder spectrum plots and/or other identifying features for locating the Orion spacecraft for fax transmission to the uplink operator.

James DiFlaminies:	Operator
Thomas Gwynn:	Operator
David Maas:	Operator
Bill Merrill:	Operator
James Harry:	Operator
Brian Park:	Manager Brian started as Manager of the Orion Operations Center with Orion in May, 1995. Brian has over 18 years experience in satellite communications. He retired from GTE after 27 years and last served with GTE Spacenet as Manager of Satellite Services Operations before coming to Orion. Brian can be reached at + 301 258-3223.

1.4.6. The Orion Network Management Center

The Orion Atlantic Network Management Center (NMC) is tasked with providing reliable and responsive network management and systems maintenance services to Orion Atlantic customers worldwide, twenty-four hours per day.

The NMC consists of a North American center located in Rockville, Maryland and a European center located at Stevenage Teleport in the United Kingdom. Together, these two centers provide network management services 24 hours per day, 365 days per year. Both centers are normally staffed during overlapping business hours in western Europe and the U.S. eastern time zone. When only one center is operating, telephone systems automatically route calls. Both centers are staffed with qualified controllers and have full access to all network management tools. Either center is fully capable of managing all of Orion's networks at any given time.

North American NMC:
Telephone - 800-464-6603 or 301-258-3365 **Facsimile - 301-258-3389**

The North American NMC is normally staffed from 9:00 a.m. (1400 GMT) to 2:00 a.m. eastern time (0700 GMT) during normal business days, and 2:00 p.m. (1900 GMT) to 2:00 a.m. (0700 GMT) on weekends and holidays. When the North American NMC is not staffed, calls to the number listed above are automatically transferred to the European NMC.

European NMC:
Telephone - 011 44 1438 740 181 **Facsimile - 011 44 1438 780 067**

The European NMC is normally staffed from 2:00 a.m. (0700 GMT) to 4:30 p.m. eastern time (2030 GMT) during normal business days, and 2:00 a.m. (1900 GMT) to 2:00 p.m. (0700 GMT) on weekends and holidays. When the European NMC is not staffed, calls to the number listed above are automatically transferred to the North American NMC.

Technical support is available to field engineers and network controllers 24 hours per day. Currently the NMC is staffed with two technical support engineers. The NMC is able to resolve more then seventy percent of reported troubles without requiring a dispatch by using state-of-the-art network management tools.

The NMC:
- Responds to reported network problems, isolates faults and takes corrective action.
- Coordinates dispatches and restoration activities with ground operators and customers.
- Keeps customers informed of restoration activities.
- Measures network performance and equipment reliability.
- Prepares monthly service interruption reports and network availability reports for customers and for the Orion Accounting Department.
- Establishes operating procedures with new customers.
- Prepares special reports on system performance as required.
- Performs special network and system testing as required.
- Determines spares requirements.
- Manages spares usage.
- Supports development of new fault management and trouble tracking systems.
- Provides input, as required, to new product development.

1.4.7. The Ground Operations Support Group

During the second quarter of 1996 Orion Atlantic successfully completed the organization of the European operations division. During this process, Orion management identified the business need to support their European ground operators. A specialized group of people in the same time zone has been dedicated for the task of providing Ground Operators with a single point of contact for all related issues. Below is a summary of the main support functions.

Ground Operator Agreement Issues

Ground Operations Support (GOS) is appointed to Issue, mediate and negotiate all GO agreements. Updates, changes and requests concerning a new or existing GO agreement can be initiated using the GOS group, and questions concerning related matters (e.g. like test equipment - or personal selection questions) also are considered.

Regulatory, License and Homologation Issues

If required Ground Operations Support assists Ground Operators with regulatory and/or license issues by providing information on common international telecommunications regulations, or by providing an Orion representative during management level meetings. Ground Operations Support also provides all known means for achieving type approvals and VSAT certifications within a specific territory. However, at all times, Orion considers the Ground Operator as the expert entity with the main responsibility for the territory in question, and acts according to the suggestions of the ground operator.

Training, Technical Information and Technical Assistance

Ground Operations Support presents at least four VSAT certification training courses a year for the European territory. Two of these four are held at the European headquarters in Amsterdam, the other two are held within the facility of one of the Ground Operators. Participants in the courses receive an Orion VSAT certification upon successful completion of the certification training course. Furthermore, the Ground Operations Support group can be contacted for advice on technical issues or for technical documentation. A technical bulletin isbe issued on occasion; and, as required, regular updates to the GO Manuals are made. In case of a major outage or extremely persistent technical difficulties, Ground Operations Support assists the GO by sending an Orion field technician to the site.

Orion is committed to achieve superior customer satisfaction through a high level of customer service, on-going product development and quality control. This objective can be achieved only by keeping a optimum and long term relationship with our ground operator subcontractors. The Ground Operations Support group does everything in their power to maintain this relationship.

1.5. Orion Products and Services

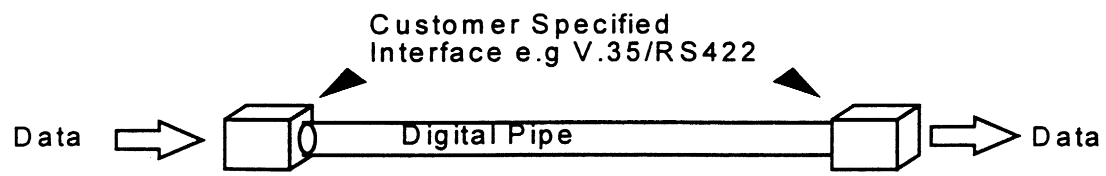
Orion Network Services offers five different products to it's customers. The Orion products are distinctive because they can be integrated in various ways to closely match the needs of the customer .

1.5.1. Satellite Services

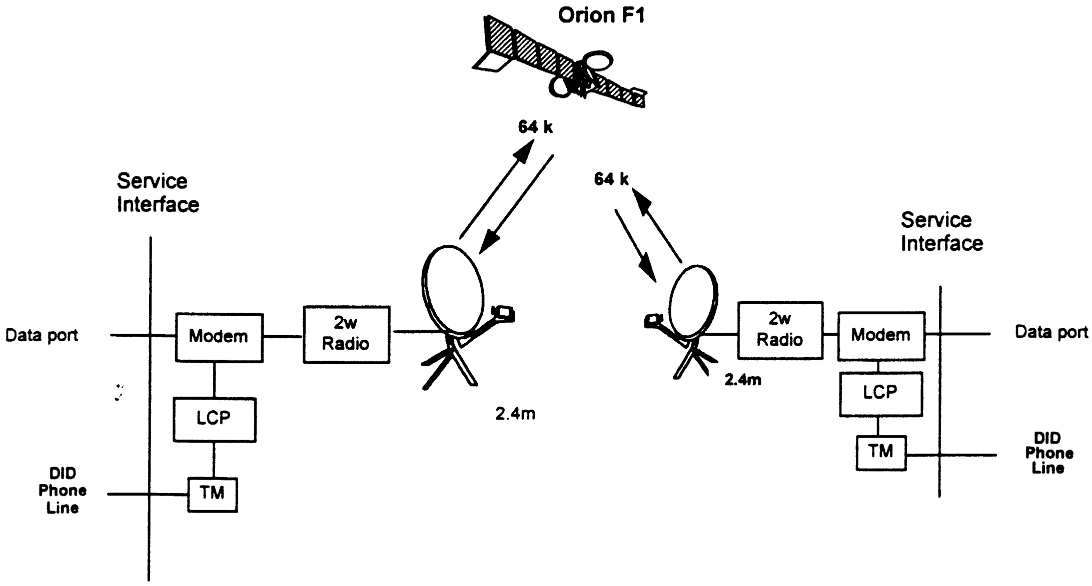
When a customer purchases Orion's Satellite Services product, he receives only satellite bandwidth capacity. Access to the spacecraft is facilitated by the customer, but must meet Orion's strict access requirements. Equipment and access specifications are set by the Orion Operations Center.

1.5.2. Digital Link

Digital Link is also known under the more common term "Clear Channel". Orion delivers the required bandwidth within a point to point network. The installation of the ground stations (VSATs) with M&C is included in the service, and the customer-specified interface is provided. The link is transparent to any network protocol and acts as a clear digital pipe.

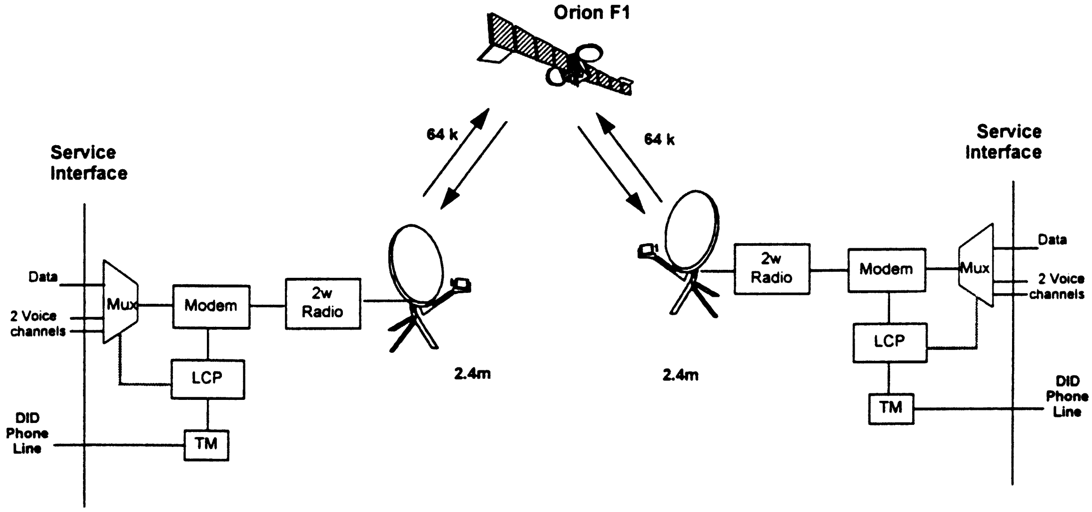


A Typical Digital Link Configuration



1.5.3. Digital Channelized Link
With the Digital Channelized Link Orion provides tailor-made solutions for the customers network application requirements. Data, LAN-WAN, and voice channels are defined within a point to point connection, and the required interfaces are provided. Allocation of available bandwidth is flexible. Voice channels can be set up to allow use for data on demand or to be used for voice only. This flexibility is made possible by using state of the art digital multiplexers. When channels are being shared, voice channels are compressed to 8 kbps and have priority over data.

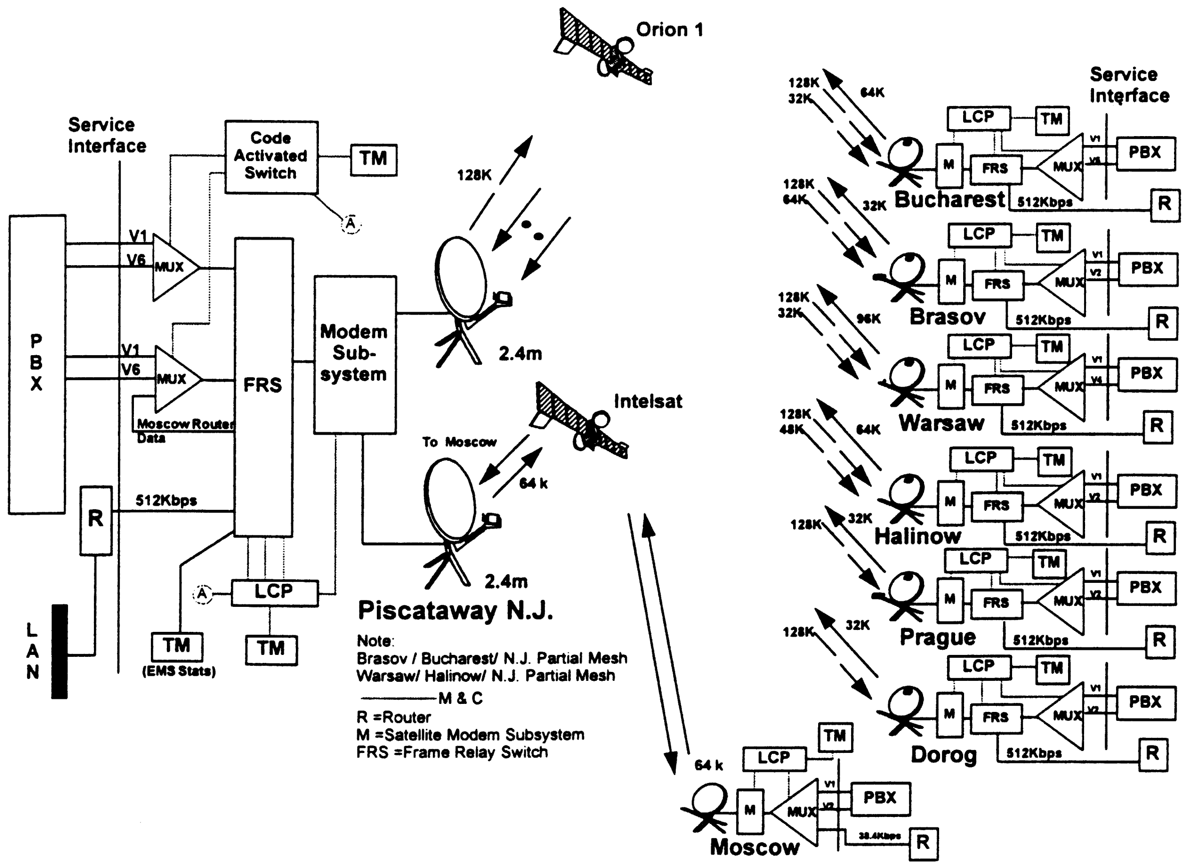
A Typical Channelized Link Configuration



1.5.4. Digital Meshed Network

The Digital Meshed Network utilizes frame relay switches to provide star connectivity. This service is of particular use for companies requiring private voice and data links between offices in different countries.

A Typical Meshed Network Configuration



1.5.6. WorldCast

WorldCast is a family of innovative Internet/ Intranet solutions.

ORION Network Systems Europe, Inc.

Chapter 2
Satellite Communications
A general overview

ORION Network Systems Europe, Inc.

Table of Contents

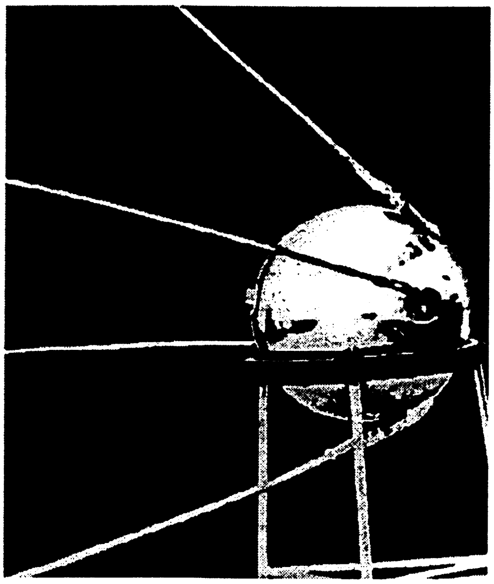
2.1 Introduction

Most satellites and their transponders are known for their video transmissions. However satellites also carry large amounts of non-video products that range from audio news services to high speed data systems. Many of these transmissions can be received with simple, readily obtainable equipment. Other types of satellite networks may require complex computer and microprocessors to obtain the proper signal and receive intelligent copy.

Typical satellite applications are:
- Video, voice and data transmissions
- Remote sensing -environmental and surveillance
- Broadcast - direct to home (DBS)
- PC data - direct to home
- Military applications
- Scientific research - space exploration

2.1.1. A Brief History

Satellite communications technology evolved from microwave, radar and rocketry technologies developed during the second World War. In the 1960's, successful experiments demonstrated the transmission of voice, data and video via satellite. In the late 70's and early 80's microwave components became cheaper and satellite technology found more and more attractive applications in private networks. This trend was accelerated by the use of higher frequency bands such as the Ku- and Ka-band. *(see section 2.3)*



Spoetnik-1 The first (Russian) Satellite

1945 A rthur C. Clarck conceived the idea of geosynchronous satellites located in space to effect long distance communication.
1957 First satellite (The Russian Sputnik 01) in space.
1961 First man in space
1962 First phone communication & TV broadcast via satellite (Echo 1)
1964 First geostationary (telecommunication) satellite: Syncom 3.
1974 First DBS satellite (ATS 6)
1994 Nov. 29th. Launch of Orion F1

2.1.2. Today and the near Future
Besides the booming and very popular DBS satellites (Direct Broadcast Satellites, intended for TV receive-only) such as the Luxembourg based SES with ASTRA and the American Galaxy (Hughes) which may have influenced many household and (political) systems; there are satellites with all kinds of other missions in space. Observation of the sun and the earth, navigation, and meteorology are just a few examples. The relaying of medium- and long-distance telephony is common sense over satellite. Today (1996), approximately 16% of all the Ku-band transponders worldwide available are DBS but this number is increasing dramatically, first in the US and Europe, followed by the Asia Pacific.

The trend for the late 1990's will be new LEO satellite constellations (see chapter 2.4.6..), primarily using the L-band, providing voice and data sevices to users (moving people, cars, ships and planes) with handheld, dual satellite / cellular receivers. Current mobile satellite applications include the Inmarsat and American Mobile Satellite Corp. (AMSC) networks. These networks allow users to make voice or data calls from a mobile or transportable earth station directly to the satellite, which provides a connection to the PSTN via fixed earth stations.

Most innovative satellite proposals, either for new services or new technologies, have taken more than seven years to get off the ground.

Parallel to the development of Ka-band satellite systems that will provide high data rate, interactive multimedia services to consumers with small antennas Ku-band will become available in more areas of the world, including Asia, South America and the Mideast. Developing areas are becoming more prominent markets for satellite communications. The Asia-Pacific already has the largest number of new satellites as well the most new satellites on order.

Late 1996, for the first time, satellites have communicated with each other without the invention of a ground station. The inaugural message was transmitted between Virginia and Hawaii via two Milstar military communication satellites. Motorola's satellite mobil phone system Iridium is based on this technology.

Earth stations are growing as well. The rapid growth in demand for DTH (direct to home) television, VSAT networks and other satellite-based communications has been driven by technological advances that have increased the power, capabilities and cost effectiveness of satellite communications, in space and on the ground.
By the end of 1994, there were some 5000 individual VSAT networks in operation worldwide. Now, eighteen months later, the number has grown to over 20,000 sites. VSAT has great promises and the expectations are that this market will expand to over 150,000 terminals by the year 2000. These networks provide data, voice and video communications to a wide range of enterprises.

Very important for the Orion organization the Very Small Aperture Terminals or VSATs.
A VSAT is an earth station characterized by an antenna less than three meters in diameter and capable of transmitting a limited volume of traffic
Generally, VSATs:

1. antenna transmit gain is lower than 49 dBi
2. transmit signal information rate is less than 2 Mbs

ORION Network Systems Europe, Inc.

Orion Atlantic, along with several other companies, has been at the forefront of developing and applying new technologies to create fully integrated private network services, for companies that realize the advantages of integrating voice, data, fax and video.

2.1.3. Satellites and the Internet

Satellite (VSAT-)systems already are used for providing high capacity links for Internet service and to access providers by supplying high capacity links to supplement or even replace lower capacity telephone lines. DirecPC in the US and Canada provides satellite based on line subscriptions and is supposed to move into Europe soon. Microsoft announced planes to use satellite links for downloading Internet in Japan. For now it is only possible to provide a subscriber with asymmetric (one-way) Internet access. The normal telephone line is used for "the way back", however the next-generation satellite systems propose fully symmetric, interactive services.

"The market for Internet access service in Central and Eastern Europe -- especially in the commercial sector -- is growing enormously, existing infrastructures cannot support such explosive demand, particularly with the broadband international links needed for access to the global information based economy". With Orion's cost-effective and flexible network solutions, Central and Eastern European ISPs can now offer an Internet service -- in a region with inadequate telecoms infrastrucutre -- that is equal to that provided by ISPs in Western Europe, the United States, and the Pacific Rim."

2.1.4. Regularity

DBS operators already face issues of content regulation, as they deliver programming that some countries or localities might challenge for various reasons. These issues might become more significant for VSAT (and related Internet services). Each separate state is allowed to make its own rules with its own local restrictions as for example on installing antennas (particularly in historic areas). For VSAT service licensing alone, chaos is already there and fees vary wildly among EU member states and other European countries. There are still (EU) countries which have not yet developed licensing structures for satellite services and their national operators hold a monopoly over such services. The criteria on which fees are based can be:

- Frequencies (Sweden)
- Power level (Austria)
- Data speed (Belgium)
- Bandwidth (The Netherlands)
- To open the processing file (France & Germany)

Fees can be very straightforward, as in the Scandinavian countries, or extremely detailed, as in Switzerland. Outside the EU, the chaos in some European countries can turn into a nightmare.

In one Mediterranean monopoly, an operator is required to pay a large fee and donate the earth stations to the local PTT. And then they must also pay for hypothetical "lost revenues" that the PTT will incur from the service provided by the earth station it would not have owned otherwise.

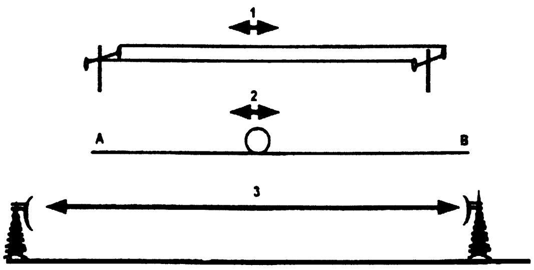
2.2 Satellite versus Terrestrial, the Pros and Cons.

Satellite systems make an excellent choice for communications between widely separated points on the earth. They require no user investment in terrestrial "infrastructure" except at the termination points. This reduced entry cost makes them particularly attractive for rural telephony applications in areas with no service at all, especially when the terrain is problematic and projected traffic volumes may not support a terrestrial network. In addition, they are also popular for data and voice Public Switched Telephone Network (PSTN) bypass in countries with poor terrestrial networks. Many banks in developing countries use satellite networks to ensure high reliability of data communications between their branches.

While cost is an important point for comparing satellite (VSAT) versus terrestrial systems, the question of whether they compete directly or indirectly depends always on the application involved. VSAT has no competition with regards to broadcasting while interactive systems compete on price and/or quality. Both price and quality depend on geography.

2.2.1. What is a Terrestrial Link

A terrestrial Telecom link is a link over :



1. Copper wire — max. data rate 28 kbps* (2 Mbps with ADSL)
2. Fiber — max. data rate 600Mbps* (2.4 Gbps with ATM)
3. Microwave — data rate >155 Mbps

*maximum datarate increase as data technology improves.

If the customer is almost your neighbor, a terrestrial link will probably fit better in the budget than one over satellite.

2.2.2. Quality

Once in orbit and operational the quality of service provided by satellites is exceptionally high and far more reliable than terrestrial links. A solid satellite transponder is available every minute of the year, except for very brief times during the two equinoxes. There are no concerns about dug up cables, power outages in the terrestrial network, or failures of intermediate repeaters. The use of concatenated (Reed-Solomon and Viterbi) encoding (see chapter 3.1.15.) produces satellite bit-error rates equal to or better than terrestrial networks.

If you want to offer, for example, a pan-European service, the satellite has an advantage. VSAT may even be the best alternative for access to eastern Europe, with its developing infrastructure and questionable quality of land lines to western Europe.

Quote from one of Orion's customers: "We were running a data center in Vienna for our subsidiaries. With terrestrial lines we had an uptime of 70%-90%. But now we are running at 99.99% uptime an that is a bit different!

2.2.3. Cross Border Communications

If you regularly exchange bulk information over a leased line between two different countries, A and B, you must buy half of the circuit from PTT A and the other half from PTT B. This solution could be very cost ineffective and less reliable than a link over satellite.

Certain types of satellite systems - especially VSATs - are moving into the cost benefit calculations of organizations wanting to bypass the fragmented (European) Telecom market.
For example a large volume of graphical data (= large bandwidth) is more easy to transport via VSAT than a common terrestrial lines. When using 'receive only terminals', an infinite number of sites under the footprint(s) can be connected with one source and it is no problem to transmit 25 Mbps of data in less than thirty second to all these sites.

2.2.4. Disadvantages.

The spectrum space and power are limited, so the cost per bit per hour can be higher than terrestrial solutions. Earth station prices are declining significantly, but are still more expensive than terrestrial terminal equipment. However these disadvantages are being intensively addressed in the industry. The increasing use of highly integrated digital circuitry is leading to less expensive terminals. And more dramatically, the increasing use of sophisticated multiple access techniques allows more users to share the same spectrum space, reducing the cost per minute of a circuit.
But what can be an advantage can also be a disadvantage. Communications via satellite is a technology which jumps over national boundaries and makes the natural monopoly argument for local infrastructures harder to maintain. Some national governments cannot accept this and start protecting themselves by difficult regulations and / or a extreme high license fee.

Another big disadvantage of satellite communications is the unfamiliarity with the technology.

An executive for a major operator once remarked: "A general problem we have as service providers is that companies view satellite services as something out of 'Star Wars'. Customers are afraid of the satellite falling out of the sky. They are afraid that they cannot communicate if it rains. They are basically nervous about a communications network 36,000 km in the sky".

Moreover, satellites carry their own risks and are extremely capital intensive.

'As is normal practice, Telstar 401 was being tracked and controlled by Skynet's TT&C facilities. But on January 11, 1997, all was not normal. Skynet reports that telemetry was perfectly fine until about 6:15 a.m. on Saturday when there was an abrupt cessation of telemetry an the satellite "disappeared." There were no maneuvers or intervention of the satellite being conducted at the time.......' On Friday, January 17, Telstar 401 (launched in December 1993) was finally "declared permanently out of service" by Skynet officials.

Some of these disadvantages are being intensively addressed in the industry. The increasing use of highly integrated digital circuitry is leading to less expensive terminals. And more dramatically, the increasing use of sophisticated multiple access techniques allows more users to share the same spectrum space, reducing the cost per minute of a circuit.

The Satellite Communication Advantage Résumé

- High Reliability
- Costs are independent of distance or number of locations
- Services can be provided directly to users facility
- Wide area of coverage is readily available
- Rapid access to undeveloped areas.
- Wideband capability is greater than immediate needs
- Compatible with new technologies
- Provides capabilities for new concepts and opportunities
- Customer may choose the network topology it prefers.
- Flexible network configurations as e.g. point to point
point to multipoint
meshed or star topology
broadcast

2.3 Space Segment Co-ordination

What is the best way to allocate satellite spectrum when there are too many buyers to go around? That is the question bedeviling the Federal Communications Commission (USA) and the ITU these days. It foresees soaring demand for scarce satellite spectrum and an inevitable quandary in deciding who should get what.

2.3.1. International Agreements

Frequencies available for satellite communications are allocated on an international basis by the ITU (International Telecom Union). The ITU headquarted in Geneva, Switzerland is an international organization within which governments and the private sector coordinate global telecom networks and services.Through the ITU nations cooperate in the use and management of Telecom resources and also adopt policies to minimize interference, to provide common standards and to promote the development of efficient technical facilities.

2.3.2. Frequency Plan

The frequency bands used for commercial applications are mainly the C-, Ku- and Ka- bands. These and other important and often used frequency ranges are listed in the table below.

Name	Receive Range
L-band	1 - 2 GHz
S-band	2 - 4 GHz
C-band	4 - 6 GHz
X-band	8 - 12 GHz
Ku-band	10.7-18 GHz
Ka-band	18 - 40 GHz

The geostationary orbit using C-band is almost fully populated. The Ku-band is rapidly filling. This is forcing communication satellite services to the higher frequencies. The Ka-band should start to fill in the next 10 years.

What is frequency

Frequency is expressed in Hertz (Hz), the name of a German physicist Heinrich Hertz, who lived a century ago. One Hz is one wave (or cycle) per second. Higher frequencies are measured in kHz (1 kiloHertz = 1000 Hz), higher frequencies in MHz (1MegaHertz = 1000 kHz) and even higher frequencies in GHz (1 GigaHertz = 1000 MHz). So a GHz is 1,000,000,000 Hz (one billion). Ku-Band satellite frequencies are expressed in GHz. The Orion satellite broadcast in the Ku

2.3.3. ITU Ku-band Satellite Frequency Assignments

(frequencies in GHz) *TU Frequency plan April 1990*

Region 1: Europe, Middle East and Africa (35^{o} E to 56^{o} W)		
	Transmit Range	Receive Range
Fixed Sat. Service (FSS)	14.00 -14.80	10.70 - 11.20
		11.20 - 11.45
		11.45 - 11.70
Direct Broadcast Service (DBS)	17.30 -18.10	11.70 - 12.50
Business Band Service (BBS)	14.00 - 14.80	12.50 - 12.75
Region 2: North, Central and South America (57^{o} W to 146^{o} W)		
	Transmit Range	Receive Range
Fixed Satellite Service (FSS)	14.00 - 14.50	11.70 - 12.20
Direct Broadcast Service (DBS)	17.30 - 17.80	12.20 - 12.70
Region 3: India, Asia and the Pacific (170^{o} W to 40^{o} E)		
	Transmit Range	Receive Range
Fixed and / or Broadcast Service		11.70 - 12.75

To avoid mutual interference's, the uplink and downlink frequencies are separated. The downlink frequency is usually lower than the uplink frequency as it suffers smaller propagation losses from the satellite to Earth, thus requiring less of the satellites limited power resource.

C-band is the first band used by commercial satellite systems.
A disadvantage is that its available bandwidth of 500 MHz is simultaneously used by satellite and terrestrial microwave users (serious interference problems)
C-band technology is well proven and signal transmission is not significantly affected by propagation effects such as rain and depolarization.

The **Ku-band** is not shared by terrestrial microwave systems. This significantly reduces the need for frequency coordination and terrestrial interference analyzes. The wavelength at Ku-band is about 2.5 cm (1 inch) compared to 7.5 cm (3 inches) at C band. As a result, a 1m dish at Ku-band has approximately the same gain as a 3m antenna at C-band. However Ku-band transmissions incur signal strength reduction, depolarization and distortion due to rain (At the Ku-band wavelength an average raindrop is a perfect 1/4 wave attenuator)

The **Ka-band** has an available bandwidth of 2500 MHz (broadcasting between 17.7-20.2 GHz) Higher powered satellites will use this band for trunking, customer premises and mobile applications.
Ka-band signals are more difficult to handle and they are much more susceptible to moisture in the atmosphere-whether it's clouds, snow or rain. Particularly in tropical regions this could be, like Ka-band a problem.

Higher frequencies have shorter wavelength than lower frequencies: This implies smaller microwave components and subsystems. Due to their small antenna sizes (compare to C-band), Ku-band (and Ka band) terminals can be compact, even portable and more easy to install in built-up metropolitan areas.

Although it has nothing to do with the goals of this manual the next article is one of those who makes satellite technology just that bit more interesting.

What exactly, is "Ka-band"? Nobody, as it turns out, is exactly certain. The term provides a handy shorthand but has little validity beyond that.

The term Ka-band dates back to World War II when U.S. and British radar developers attached random letter designations to various pieces of the electromagnetic spectrum. Such names were picked up by U.S. satellite engineers and have been used as shorthand to describe various spectrum ranges, much as broadcasters speak in terms of very high frequency, ultra high frequency and super high frequency ranges. Ka-band, like C-band or L-band, says Paul Roosa, senior staff engineer in the Spectrum Management Office of the U.S. Department of Commerce, "is a term of convenience that has no regulatory basis whatsoever."

Nor does "Ka-band" describe a precise area of spectrum. U.S. satellite operators agree that the term generally applies to the spectrum starting just under 18 gigahertz and ending at about 30 GHz. But even the allocation tables worked out by the Federal Communications Commission and National Telecommunications and Information Administration, the U.S. agencies responsible for assigning spectrum for private and governmental broadcasting, respectively, don't agree on every detail, due to an accumulation of errors over the years.

To further complicate things, satellite operators don't have access to the entire Ka-band. To them, "Ka-band" really means two sub-bands: 27.5 to 30 GHz for uplink signals and 17.7 to 20.2 GHz for downlink signals. The 7.3 GHz in-between? It has been set aside by the FCC and NTIA for a long list of activities including radio astronomy, radio location, space research, inter-satellite communications, radio navigation, amateur use and both terrestrial- and satellite-based mobile and fixed broadcasting.

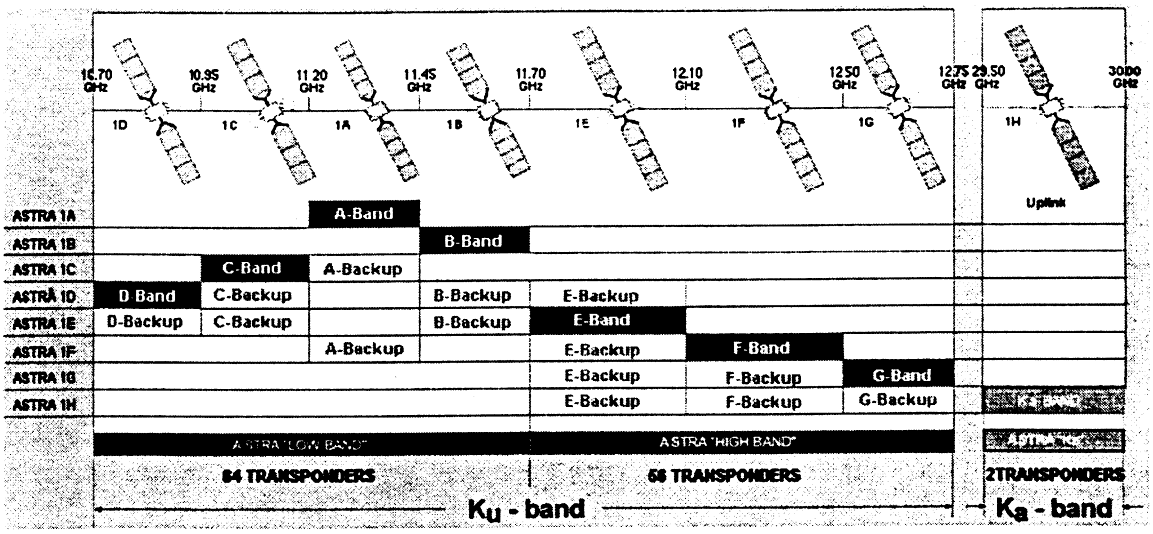
2.3.4. Satellite capacity

Satellite capacity can be enhanced by reusing frequencies. Four techniques are available to meet this goal:

- Space diversity via regional or spot beams. (see chapter 3.5)
- Polarization diversity (see chapter 3.8)
- The transformation from analogue signals into digital signals. For TV this can be e.g. DVB

  The next generation of TV broadcast standards will be based on digital data compression and digital transmission of the compressed signals. This allows both higher image quality and better bandwidth utilization. A set of formal standards which defines the European Digital Video Broadcast (DVB) system has been finished and published in the end of 1995. These DVB standards will be used to implement digital TV transmission in Europe and in many other countries.

- Co-location of satellites operating at different frequency bands.
  This means that two or more satellites orbiting at the same geostationary location, e.g. ASTRA 1A, B, C, D, E, F and G at 19.2° E. (sees picture below)



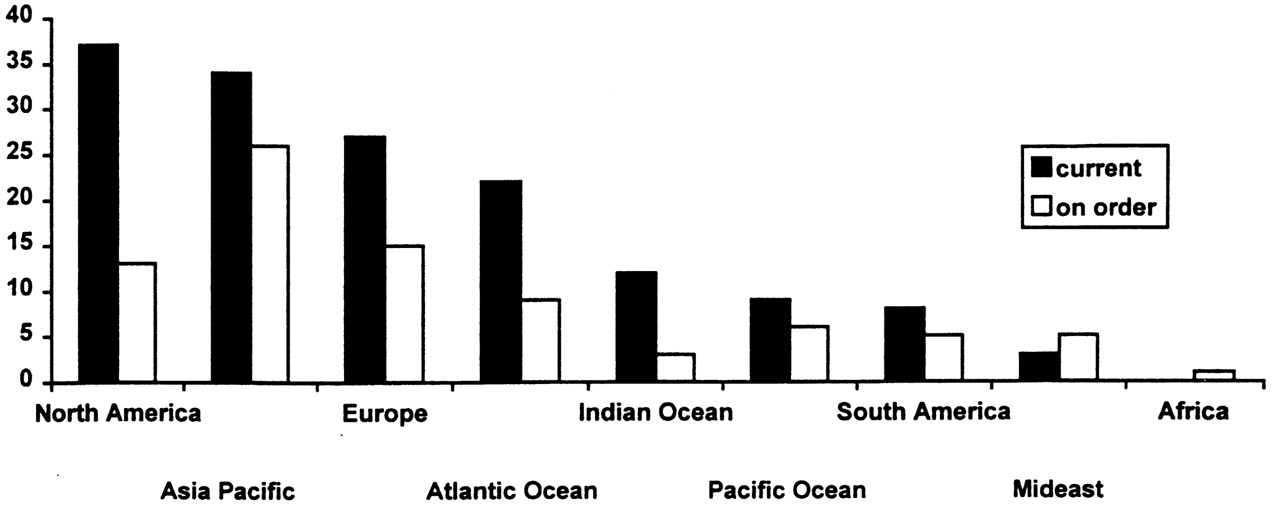
The place of a satellite, or a cluster of satellites on the Clarke Belt is referred to as position.
Satellite positions correspond with the latitude grid pattern we use for determining our position on earth. So satellites have unique, fixed positions, however, sometimes a group or cluster of satellites are positioned at the same orbital location. When seen from earth it looks as if these satellites are at the same point in the sky, so we say that these satellites are co-located. A very good example are the six ASTRA satellites which are co-located at 19.2°East. Also the Eutelsat II f1 and the Eutelsat II f6 (Hotbird 1) are co-located at 13° East. The main advantage of co-location is that these satellites can be received with only one satellite dish.

2.4 Orion and its Competitors

Orion is not the only provider of space segment on a satellite. All over the world and by many different companies (private, national etc.) satellites has been launched and/ or exploited. While US industry is concentrating on new Ka band systems, European operators are looking more a Ku band data downlinks using existing satellites

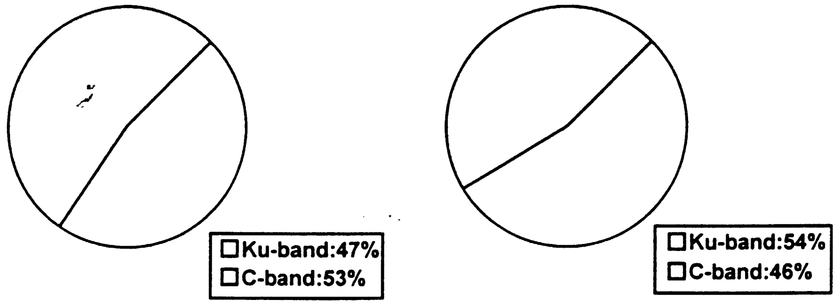
2.4.1. Geostationary Commercial Communication Satellites by Region*

The number of existing and planned commercial communication satellites that provide fixed satellite services, broadcast- and mobile satellite services are split up by region and shown in the graphic below.



* *excluding most Russian and all Chinese-built satellites*
** *many trans oceanic satellites provide regional and domestic coverage as well.*

In May 1996 a total of 152 GEO satellites from 45 satellite operators with 1640 C-band and 1435 Ku-band transponders were in orbit. Another 83 satellites *(worth $14.8 billion!)*, with a planned 980 C-band and 1128 Ku-band transponders, were on order and expected to be launched over the next three years (May '96)



The number of existing (left) and planned (right) C- and Ku-band transponders

Some Satellite Space Segment Operators are:

Private	National	Public	Defence/Govt.
Orion	Hispasat	INTELSAT	Skynet
SES-Astra	Italsat	Eutelsat	TDRS
PanAmSat	Copernicus	Asiasat	
Colombia	Sirius/ Thor		

In Europe and America Orion's major competitors are INTELSAT and Eutelsat.

2.4.2. Europe

The European satellite industry, one of the most mature in the world, continues to grow at a breathtaking rate. Its major players are:

Eutelsat

In 1979 the European Space Agency decided to build five ECS satellites whose management were given to the European organization EUropean TELecommunication SATellite, EUTELSAT. Eutelsat is the European equivalent of INTELSAT and was officially created in 1985. The initial mission was to complete telephone networks without acting contrary to INTELSAT laws.

The Satellites were aimed to respond to the post and telecommunications needs and to transmit EBU's TV channels. To avoid frequency interference problems in C-band, the satellites were designed to operate in the Ku-band only. The OTS program provided test transmissions with small earth stations using powerful onboard transponders.

Because of the great importance of Eutelsat for Europe and European VSAT links, some details of the main Eutelsat satellites are listed in the table below.

Eutelsat	ECS1	1F4	1F5	2F1	2F2	2F3	2F4
geost. orbit	inclined 1)	inclined 2)	inclined 3)	13°E	10°E	16°E	7°E
operational since	1983	1987	1989	1990	1991	1992	1992
beacon (GHz)	11.451091	11.44965	11.44895	11.451091	11.451820	11.452570	11.451091
				12.541667	12.541667	12.541667	12.541667

1) Inclined (orbit is offset from the equatorial plane) since Sep 1989. Two transponders still in service: 10 & 12 This satellite was not as efficient as other Eutelsat 1 series. It could only use transponders during an eclipse.
2) In inclined orbit since mid-May 1993. Transponders 1, 5, 7, 8, 9, 10, 11 and 12 have failed.
3) In inclined orbit since 1 Aug. 1994. Transponders 3, 4, 6 and 8 have failed.

Concentration of consumer broadcast programming for pan-European coverage on satellites co-located at 13° "Hot Bird" position continues apace. This slot also still contains the Aerospatiale-built Eutelsat 2 F1 satellite alongside the higher-power Hot Birds 1 and 2 from Matra Marconi Space. Three more Hot Birds are on order for this slot, and should all be in place by the end of 1998.

The Eutelsat 2F6-Hotbird 1 & Hotbird 2, both in the 13° slot, are less important for VSAT usage. Today Eutelsat makes 65% of its profit with TV channels.

When Eutelsat was created it had 17 member countries. Currently 48 countries are members of the Eutelsat organization.

Eutelsat contact:

Eutelsat
Tour Maine-Montparnasse, 33 avenue du Maine, 75755 Paris cedex 15, France
Tel: +33-1-..4538-4747
Fax: +33-1-..4538-3700
Fax on demand: +33-1-..4321-2338
Internet: http://www.eutelsat.com

SES/ASTRA

Founded in March 1985 Société Européenne des Satellites (SES) is the operator of the ASTRA Satellite System which broadcasts television and radio channels throughout Europe since early 1989. Its center is located at the Betzdorff castle in Luxembourg and is the first privately owned satellite operator in Europe. SES operates under a franchise agreement with the Grand-Duchy of Luxembourg which covers audiovisual services and possible new business applications. The State of Luxembourg holds a 20% stake in SES through two public financial institutions, with the rest of the share capital coming from private international and Luxembourg investors.

ASTRA is the most popular satellite system, reaching 94% of all satellite and cable households in Europe. Today (August 1997), SES operates six satellites ASTRA 1A-1F, all co-located on the orbital position of 19.2° East. Co-location ensures that the several hundred TV and radio programs carried on ASTRA both in digital and analogue can be received on small, single fixed dishes. By end 1998, SES plans to have 10 satellites in orbit, including two satellites at a second orbital position (28.2°).

The Company generates its revenue by leasing satellite transponders to television and radio broadcasters. However after saying for years that it would serve only the consumer broadcast markets, SES is now moving into other services. ASTRA 1H satellite will carry two Ka band transponders for bi-directional computer traffic aimed primarily at business users.

SES purchases its satellites from the leading international manufacturers (General Electric, Hughes Space Communications, Matra Marconi Space). SES is implementing a dual launch policy, using both the European Ariane and the Russian Proton launch vehicles to put its spacecrafts into orbit.

SES/ASTRA contact:

Société Européenne de Satellites
Château de Betzdorf, 6815 Betzdorf, Luxembourg
Tel: +352-710-7251
Fax: +352-710-725324
Internet: http://www.astra.lu

Hispasat
Covering Southern Europe, parts of North Africa and the Americas, the two Hispasat satellites at 30°W now have current or contracted transponder leases that account for 90% of available capacity. Most of the transponders, in a mix of bandwidths (36, 54 and 72 MHz) are not only used for TV distribution and contribution feeds but for VSAT networks as well. In addition to increasing domestic capacity, the third satellite (to be launched in 1999) will be used for further transatlantic program and data exchanges with Latin America.

Hispasat contact:

Hispasat S.A. Gobelas 41-45 Planta, 28023 Madrid -- SPAIN Tel: +34-1-372-9000 Fax: +34-1-307-6683

France Telecom
France Telecom, the national telco has four second-generation Telecom 2 satellites with C-, X-, and Ku band transponders in orbit: 2A at 8°W, 2B and 2D co-located at 5°W, and 2C at 3°E. The Telecom 2D, launched in advance, will be used for special event coverage, ad hoc traffic and full-time DBS regional digital needs. 2C carries mainly contribution feeds, business TV and VSAT traffic.

France Telecoms mission is telecommunication to over-sea territories, military communications and TV and data transmission.

France Telecom contact:

France Telecom 103 rue de Grenelle, 75007 Paris, France Tel: +33-1-4444-4522 Fax: +33-1-4555-9072

DFS-Kopernikus
DFS means Deutscher Fernmelde Satellit and is the German telecommunication program operated by DBP (Deutsche Bundes Post). The three Kopernikus satellites, built for Deutsche Telekom (DT) by the GESAT consortium led by Siemens, were launched in 1989 (DFS-1), 1990 (DFS-2, 28.5°E) and 1992 (DFS-3, 23.5°E) for services to Germany. DFS-1 ran out of control a few days in November 1995 but control was regained in early December however DFS-1 escaped again in mid-December 1995. The two other satellites are still operational and carry mainly telephone lines, VSAT and other business traffic. DFS-2 and DFS-3 have both Ku band and Ka band transponders.

DFS contact:

Deutsche Bundespost Telekom Godesberger Alle 87-91, 53175 Bonn, Germany Tel: +49-228-181-1211 Fax: +49-228-181-8872

Telenor and NSAB

Norway an Sweden each operate a collection of essentially national satellites; there is some collaboration between the two, but mostly competition. Telenor Satellite Services is a subsidiary of Telenor AS, the Norwegian state-owned telecoms corporation. The company is the largest user of Inmarsat capacity, and is active in the VSAT business, especially in Central Europe. TSS leases "almost all" the Ku band capacity on Intelsat 707 and bought in 1992 the MarcoPolo 2 satellite. MarcoPolo 2 was renamed Thor 1 and is replaced by Thor 2 by the end of 1997.
NSAB (Nordiska Satelitaktiebolaget), a joint venture between Swedish Space Corp, Teracom and Tele-Danmark owns the Tele-X satellite, Sirius 1 (ex MarcoPolo 1) and Sirius 2. All the satellites are co-located at 5.2°E and except of Sirius 2 mainly intended for TV broadcasting.

Telenor contact:

Telenor Satellite Services AS
PO Box 6914, St Olavs Plass, Oslo, N-0130, Norway
Tel: +47-22-777-950
Fax: +47-22-777-980

2.4.3 The Middle East

This whole area is highly dependent on satellites to delivers its TV and data networks. Despite this, there currently exist only two national, domestic satellite systems, and neither belongs to a state that is regarded as truly belonging to the Middle East as most people understand it. One is Turkey's two Turksats; the other is Israel's AMOS.

Amos (4°W), launched in May 1996, has a repointable beam aimed at Hungary, but the beam covers all the Central East European countries. VSAT is one of their revenue generators.

By the end of 1998, the Egyptian Nilesat should be launched and operational. For the rest , the Middle East is served by three main sources: INTELSAT, Eutelsat and Arabsat.

Arabsat

In 1976 22 Arabic countries founded the Arab Satellite Communications Organization (ASCO) and decided to build, launch and operate their own telecommunications geostationary satellites. Arabsat has been operating its satellites since 1985 and moved in 1996 on to its second generation. The two Arabsat 2s introduced Ku band to the Mid-East for the first time. The previous series relied mainly on C band. Arabsat 2A in mainly intended for TV broadcasting, 2B appears to be a telecom satellite.

Arabsat contact:

PO Box 1038,
11431 Riyadh, Saudi Arabia
Tel: +966-1-464-6666
Fax: +966-1-465-6983

2.4.4. Asia

Asiasat
The company's first satellite, AsiaSat 1, was placed in orbit by a Long March 3 rocket from Xichang, China on 7 April, 1990, pioneering China's entry into launching commercial satellites. AsiaSat's first lease contract was signed with the Ministry of Information of Myanmar in January 1990 before AsiaSat 1's launch. By December of the following year its capacity was fully leased. Prompted by the success of AsiaSat 1, a second satellite, AsiaSat 2, was launched on 28 November, 1995 by the Long March 2E, also from Xichang. The two satellites reach over two-thirds of the world's population covering more than 53 countries, providing high-quality telecommunications, television and radio broadcast services throughout Asia. AsiaSat has also started procurement on a follow-on satellite, AsiaSat 3, offering more capacities for more services in the region.

2.4.5. USA and Latin America

In tegenstelling to Europe, most satellite providers based in the US are not only servicing the Americas but other parts of the world as well

Orion Network Systems, Inc.
see chapter 1 of this manual

PanAmSat
On September 20, 1996: PanAmSat and Hughes Electronics announced plans to merge their respective fixed satellite services operations into a new publicly held company,.PanAmSat Corporation, a commercial provider of satellite-based communications services, was formed in May 1997 by the merger of the previous PanAmSat Corporation and the Galaxy Satellite Services division of Hughes Communications, Inc. PanAmSat's global network of 15 satellites and seven technical ground facilities enables the company to relay video programming and digital communications for hundreds of customers world wide. PanAmSat established first DTH television platforms in Latin America, South Africa and India. More than 80,000 VSAT antennas in nearly 40 countries are transmitting and/or receiving data, voice and video information via PanAmSat satellites.PanAmSat is preparing for the launch of three satellites in 1997 and four in 1998.

Galaxy Satellite Services
1983: The first Galaxy satellite is launched, creating the first cable television satellite for the United States. Galaxy I revolutionizes the U.S. television industry by delivering television channels to cable service provider around the country. 1990: The Galaxy business completes the purchase of the SBS fleet of satellites from IBM. These Ku-band satellites are combined with the current Galaxy satellites and the recently purchased Westar satellites from Western Union to create a vastly expanded satellite communications network in the United States. Galaxy Satellite Services is now part of PanAmSat Corporation, a new publicly held company created by the recent merger of PanAmSat Corporation and Hughes Communications, Inc. Galaxy International, Network Operations, Engineering and Technical Support have also joined the PanAmSat family.

Hughes

2.4.6. INTELSAT

In 1964, lead by the United States, the commercialization of satellite services began with the creation by 11 countries of the International Satellite Communications Organization; INTernational TELecommunication SATellite (INTELSAT). INTELSAT was founded with the purpose to design, develop, implement, operate and maintain the space segment of a global commercial communications system.

Since 1966, all the continents are covered by INTELSAT. Nowadays, numerous services are offered. INTELSAT users design their own earth stations, however, in order to keep the overall system at its design standards, each user must comply with INTELSAT requirements. INTELSAT is the largest satellite communications consortium, with 154 members. Currently there are more than 24 INTELSAT satellites in operation.

INTELSAT-1 or Early Bird (1965) was provided with 6000 solar cells and could handle 240 telephone channels.

INTELSAT has more satellites in operation than any other commercial organization, a fleet of over 24 high powered, technically advanced spacecraft in geostationary orbit: the INTELSAT V/V-A series; the INTELSAT VI series; and the INTELSAT VII/VII-A series. In addition, INTELSAT has a single all Ku-band satellite in service, known as INTELSAT K. The next generation of INTELSAT spacecraft, the INTELSAT VIII/VII-A series is under construction. The six satellites will be launched beginning in 1997. At the moment, INTELSAT's spacecrafts are deployed to four service regions, with overlapping coverage.These four service regions are:

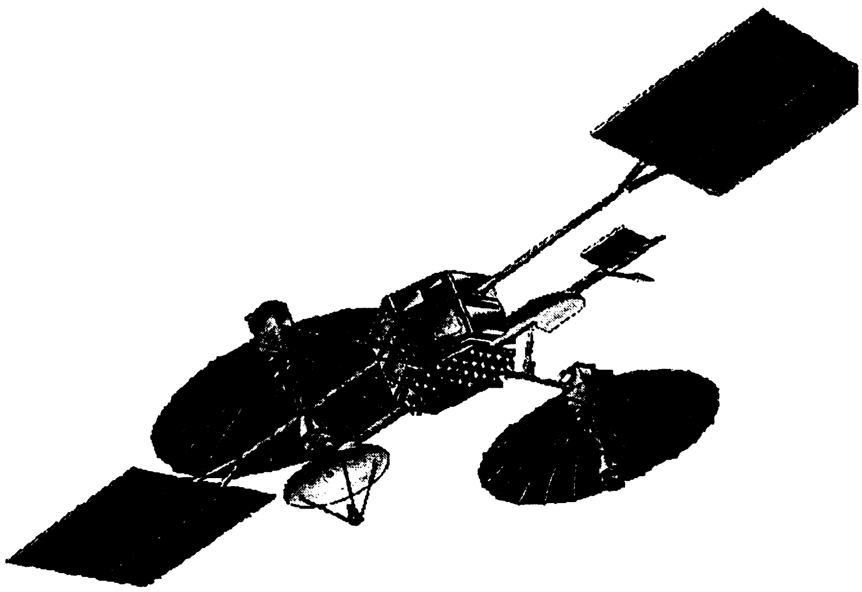
- The Atlantic Ocean Region (AOR), serving the Americas, the Caribbean, Europe, the Middle East, India and Africa. In the AOR, INTELSAT has satellites at orbital locations ranging from 307° E to 359° E.
- The Indian Ocean Region (IOR), serving Europe, Africa, Asia, the Middle East, India and Australia. In the IOR, INTELSAT has satellites at orbital locations ranging from 33° E to 66° E.
- The Asia Pacific Region (APR) serving Europe, Africa, Asia, the Middle East, India and Australia. In the APR, INTELSAT currently has two satellites, located at 72° E, and 157° E.
- The Pacific Ocean Region (POR) with coverage of Asia, Australia, the Pacific, and the Western part of North America. In the POR, INTELSAT has satellites at orbital locations ranging from 174° E to 183° E.

INTELSAT Contact:

INTELSAT 3400 International Drive NW, Box 63, Washington DC, 20008, USA Tel: +1-202-944-7500 Fax: +1-202-944-7890 Internet: http://www.intelsat.int:8080/

● ○ PAS-1 45° W
○ TDRS 4 (East) 41° W
● ○ Intelsat 502 40° W
● Orion 1 37.5° W
● ○ Intelsat 603 34.5° W
● Intelsat 506 31.5° W
● ○ Hispasat 1A/1B 30° W
● ○ Intelsat 601 27.5 W
● ○ Intelsat 605 24.5° W
● ○ Intelsat K/515 21.5° W
● TDF1/TDF2 18.8 W
● ○ Intelsat 515 18° W
● ○ Eskpress 02 14° W
● ○ Gorizont 26 11° W
● ○ Télécom 2A 8° W
● ○ Télécom 2B 5° W
● ○ Amos-1 4° W
● ○ Intelsat 707 1° W
● Thor 0.8 W
● TV Sat 0.6° W
● Télécom 1C 3 E
● Sirius/Tele-X 5 E
● Eutelsat II F4 7 E
● Eutelsat II F2 10° E
● Eutelsat II F1/Hot Bird 1 13° E
● Eutelsat II F3 16° E
● Astra 1A. 1B. 1C. 1D. 1E. 1F 19.2 E
● ○ Arabsat 1DR 20° E
● Eutelsat I F5 21.5° E
● DFS Kopernikus 3 23.5 °E
● Eutelsat I F4 25.4 E
● DFS Kopernikus 2 28.5 E
⦸ ● Arabsat 1C 31°E
● ○ Gorizont 17 34° E
○ Raduga 28 35°E
● ○ Gorizont 22 40°E
● Turksat 1B 42°E
○ Raduga 23 45°E
● ○ Intelsat 507 47°E
● Eutelsat I F1 48°E
○ Raduga C 49°E
● ○ Gorizont 27 53°E
● ○ Intelsat 510 57°E
● ○ Intelsat 604 60 E
● ○ Intelsat 602 63° E
● ○ Intelsat 505 64.9°E
⦸ ○ Raduga 32 C 65°E
○ Intelsat 704 66°E
● ○ PAS-4 68.5°E
○ Radugar 32 70°E
○ Gals 1/2 71°E
○ Insat 2A 74°E
● ○ Thaicom 1&2 78.5°E
○ Gorizont 24 80°E
○ ○ Insat 1D 82.9°E
⦸ ○ Raduga 30 85°E ⊘ ● ○ TDRS 3 85°E
○ Chinasat 1 87.5°E
○ Statsionar 6 90°E
○ Intelsat 501 91.5°E
○ Insat 2B 93.5°E
○ Statsionar 14 95 E
○ Asiasat 2 100.5°E
○ Statsionar 21 103°E
○ Asiasat 1 105.5°E
○ Palapa-B2R 108°E
● Yuri 3A/3N/3B 109 E
○ Dong Fung Hong 25 110°E
○ Palapa-B2P 113°E
○ Mungunghwa 116°E
○ Palapa B4 118°E
● ○ JC Sat 3 128°E
○ Palapa B1 129°E
● ○ Gorizont 29 130°E
● Sakura 3A 131°E
⊘ ● ○ N Star A 132°E
○ Sakura 3B 136°E
○ Apstar 1 138°E
● ○ Gorizont 18 140°E
● ○ Gorizont 30 142°E
● ○ Gorizont 21 145°E

● Ku-Band
○ C-Band
⦸ S-Band
⊘ X-Band



ORION Network Systems Europe, Inc

Chapter 3
The Basics of Satellite Technology

Table of Contents

3.1. What is a satellite?

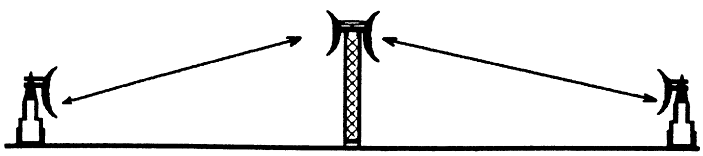
3.1.1. Introduction

Webster's Dictionary gives the following explanations for the word "satellite" (originally from Latin):

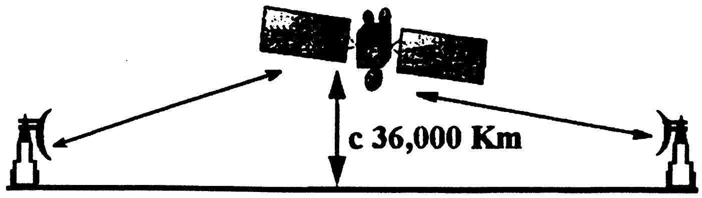
1. An often obsequious attendant or follower
2. Natural body that revolves around a planet
3. A country under the domination or influence of another
4. A device designed to orbit a celestial body, as the earth

For our specific situation, the communications satellite, the most simple description of a very complex system can be given by the next definition:

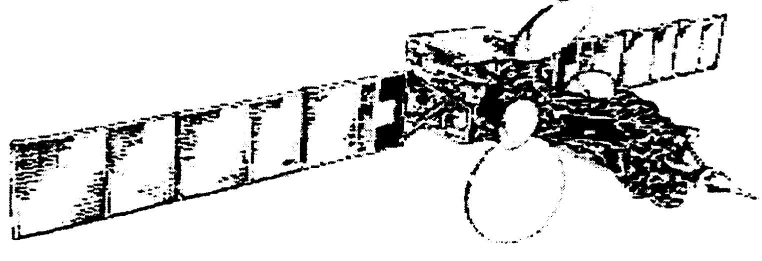
A communications satellite is a kind of spacecraft usually situated in geostationary orbit with on-board transponders which act like "simple" microwave repeaters. Situated in space, the satellite receives signals from transmitting earth stations and repeats, *i.e.,* re-transmits them in the downlink direction after amplification and frequency conversion.



Microwave link via relay site



Microwave link via satellite



Intelsat V

Orion Atlantic l.p., 2440 Research Boulevard Suite 400 Rockville, Maryland 20850 Tel: + 1 (301) 258-8101 Fax: + 1 (301) 258-8119
Orion Atlantic Europe Inc., Gyroscoopweg 2M. 1042AB, Amsterdam, The Netherlands. Tel: + 31 20 4487 110, Fax: + 31 20 4487 130

3.1.2. Major Satellite Components

Once a satellite has been placed in orbit, it is not practical to carry out direct, on-site maintenance and repair. In order to obtain the maximum operational lifetime from a satellite (about 10-15 years), one must pay great attention to its design and testing.

Most satellites contain two major sub-systems:

1. The service module (power supplies, regulators, attitude control, telecommand and telemetry functions)
2. The mission payload

The mission payload is the part of the satellite which carries out the mission requirements, *e.g.*, the communications transponders.

Spacecraft Structure

The structure must provide adequate protection to all on-board equipment. One of the major problems in satellite design is staying within the overall mass capability of the launch vehicle. Keeping the mass of the structure to a minimum is very important..

The Orion F1 mission payload has a mass of 375 kg, and its dimensions are 1.7 x 1.6 x 2.1 meters.

Energy Source and Storage

To carry out all its functions the satellite requires electrical energy. Early satellites carried primary batteries which had a very limited life and couldn't be recharged. On most current satellites energy is generated by the use of chemical fuel cells, nuclear sources and (more commonly today) silicon solar cells.

One of the main drawbacks with the solar cell energy sources is that energy is generated only when the cells are illuminated by the sun. When the Earth is between the satellite and the sun (eclipse) no energy can be generated. In order to allow the mission payload to operate under all conditions, including eclipse by the Earth, some form of energy storage must be included in the service module. Re-chargeable batteries are generally used to store the vitally needed energy.

Satellite solar panel and battery limitations mean that transponder output power is limited. The total power source for a communications satellite is typically in the range of 1.2 to 5 kW. This power has to be shared among all the transponders and the control circuitry.

Thermal Control

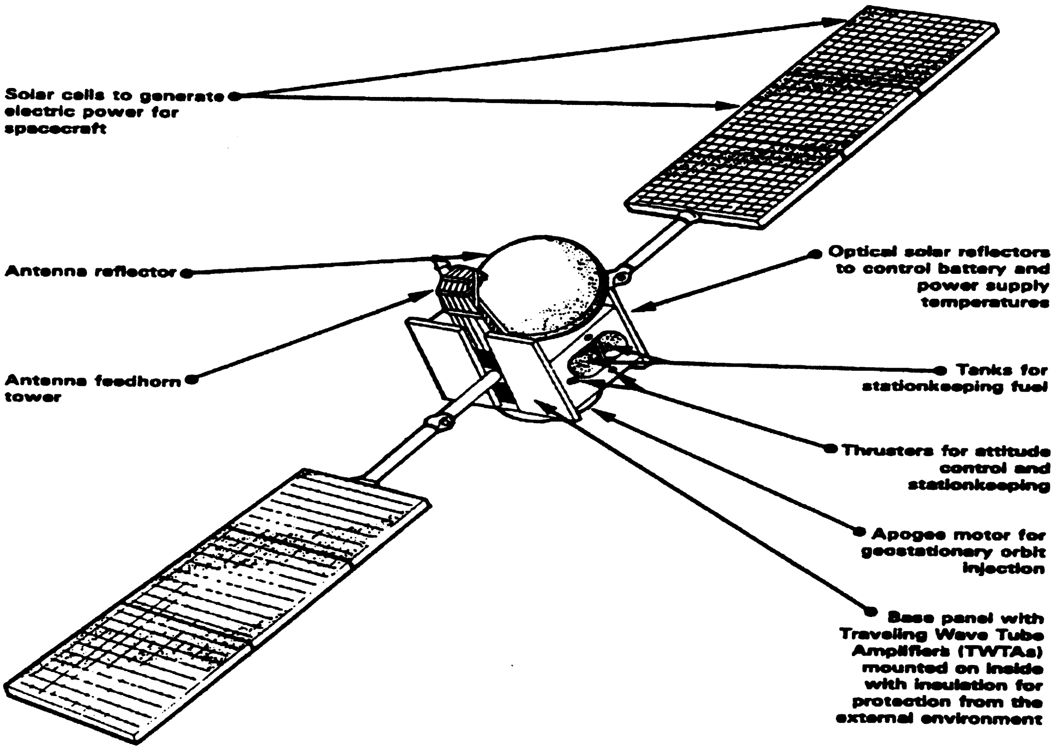
During each orbit the satellite is subjected to extremes of temperature by the presence or absence of the sun's illumination. Also heat is generated by the electrical components on board the satellite. In order to ensure correct operation, temperatures must be maintained within acceptable limits.

Attitude Control

To do their jobs, the satellite antennas must point always toward the earth. With the very low gain antennas that were used in the early days, stabilizing the orientation of one axis of the satellite with respect to the earth was sufficient. However, satellites using highly directional antennas require more sophisticated techniques.

Today Orion 1 and many other modern satellites use 3-axis stabilization in which the attitude of the satellite is precisely controlled with respect to the earth.

3-axis is a type of spacecraft stabilization in which the body maintains a fixed attitude relative to the orbital track and the earth's surface.



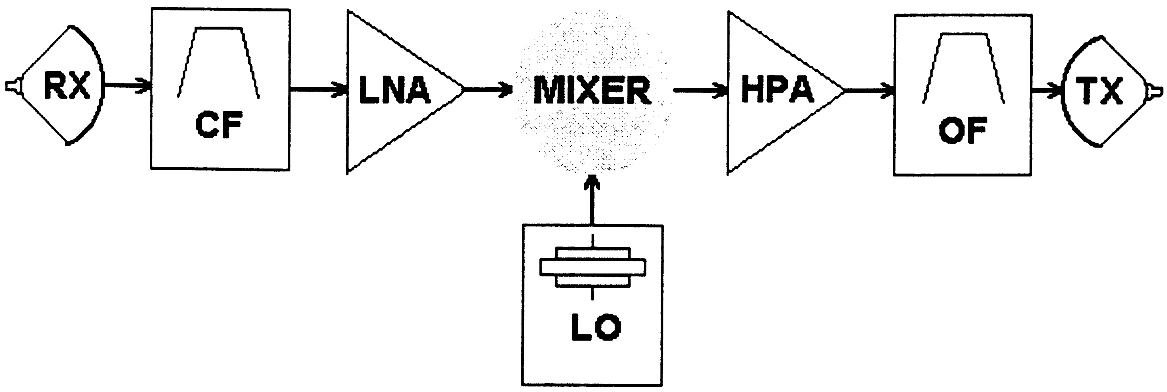
Tracking, Telemetry and Telecommand (TT&C)

In order to ensure that each part of the satellite is functioning as required, one must be able to monitor certain parameters within the satellite. Monitoring is achieved by means of a telemetry sub-system in which the appropriate data is transmitted to earth on the telemetry link.

A suitable ground system makes monitoring the performance of the satellite possible.

Transponders
Probably the most important part of a telecommunication satellite is the transponder. The word "transponder" is compounded from *trans*(mitter) and (res)*ponder.* This piece of electronic equipment inside the satellite acts like a microwave repeater, which receives, amplifies, and re-transmits the incoming signals.

The Orion 1 has 34 transponders, 6 with 36 MHz and 28 with 54 MHz bandwidth.



Schematic diagram of a satellite transponder.

RX: Receive antenna for the 14 GHz Earth uplink station
CF: Channel or Input Filter
LNA: Low Noise Amplifier
HPA: High Power Amplifier
OF: Output Filter
LO: Local Oscillator
Mixer: Device for transforming the uplink frequency into the downlink frequency
TX: TX antenna for the 12 GHz downlink

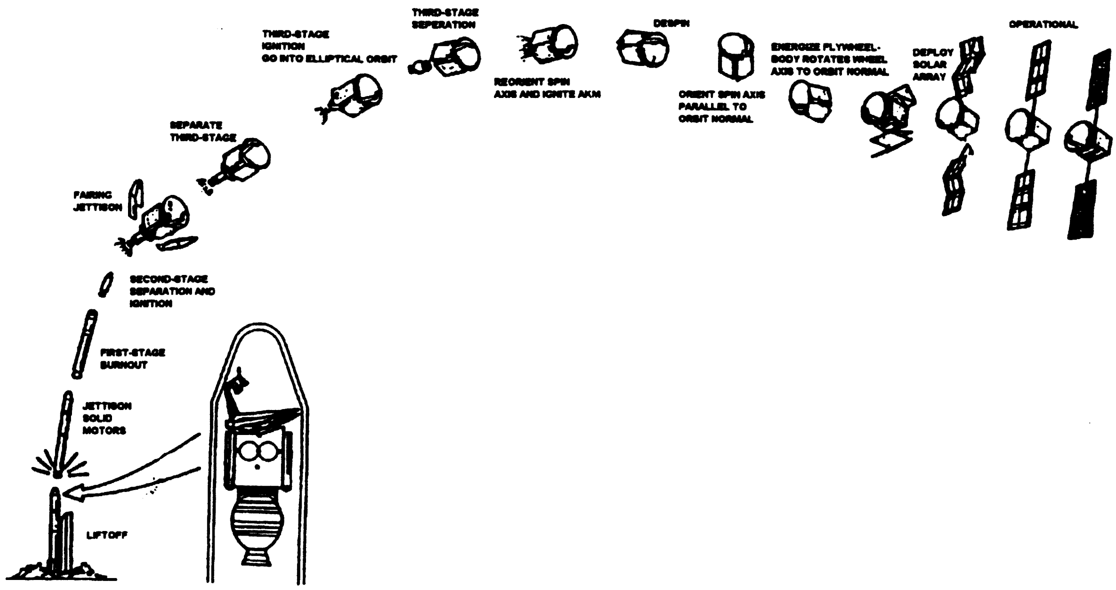
3.1.3. Satellite Launch Sequence

A Martin Marietta Astronautics Atlas IIA successfully launched the Orion 1 communications satellite into supersynchronous transfer orbit at Cape Canaveral air station, Florida, November 29, 1994, at 5:21 a.m. EST from Complex 36, Pad A. The Orion launch was the fifth successful Atlas launch of 1994.

The typical satellite launch from a launch vehicle is a very costly and complex operation. Generally 72 hours are needed from the time of launch vehicle ignition to the deployment of the solar arrays for the spacecraft to get on station or in its assigned orbital slot. Once the satellite is in position, it will provide service typically 10 to 15 years.

Ariane and Atlas space vehicles are often launched from below sea-level (French Guyana, Cape Canaveral). Why not launch them from 4 kilometers higher in the Bolivian mountains where the lower air pressure causes less friction and the influence of gravity is not so great? In addition to good political and national reasons, a more physical factor is important to consider when selecting a launch base. By launching a launch vehicle eastward from a spot near the equator the vehicle profits from the rotation of the Earth. The first 1660 km/h are free. Closer to the poles the Earth's rotation provides less profit to the flight. The Russians and the Chinese, who launch their missiles far up north, have to carry more fuel for a comparable flight. Bolivia might be a perfect elevation for a launch base, but for safety reasons a launch near the sea is preferable. Brazil is not interested in burning bits and pieces falling down on their cities. A floating launch base at sea and on the Equator might be perfect.

As of 1996, the United States and the Ukraine are carrying on a project to construct the Boeing Sea Launch platform in Stavanger, Norway. The platform will measure 430 feet in length and displace 31,000 tons.



Simplified display of a satellite launch

Launch providers work in a high risk business with high stakes. Each launch ends either in success or failure. There is no middle ground. The launch rate of commercial geostationary communications satellites is increasing by a factor of 80 to 100%, compared to the past decade. The average annual launch rate of around 15 GEO commercial satellites over the past 10 years could increase to 28-32 annually over the next five years, if the launch vehicle industry is able support this increase in demand.

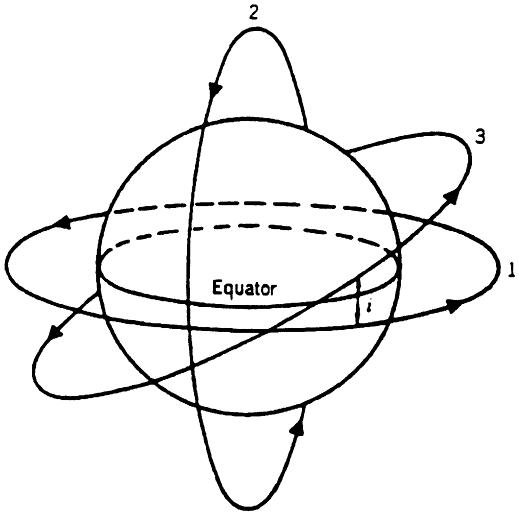
3.2. Circular Orbits, Elevation, and Azimuth

3.2.1. Orbits

The geostationary or Clarke belt is located 22.247 miles or 35800 km above the equator. At this altitude, a satellite has an orbital velocity equal to the Earth's rotational speed (one revolution per 24 hours), causing the satellite to appear stationary or motionless above the Earth. In this belt the satellite travels at the same speed as the earth rotation and is geosynchronous in the equatorial plane. Ground antennas can be aimed easily and stay pointed toward the right place.

A geostationary orbit is not the same as a geosynchronous orbit. A geosynchronous orbit is one orbit of the Earth in 23 hr., 56 min., and 4,.1 sec. A satellite that orbits the earth in this time period appears at the same position in the sky at a particular time each day, but does not appear stationary unless it is orbiting in the equatorial plane.

The possible types of circular orbits are shown in the figure below.



1. Equatorial orbit
2. Polar orbit
3. Inclined orbit
(i=angle of inclination)

Inclined orbits provide satellite visibility in the polar regions and provide higher elevation angles to user locations at high northern and southern latitudes. A disadvantage of inclined orbits, however, is that users are required to acquire and track the satellites.

Other types of, non geostationary, orbits are:

- MEO—Medium Earth Orbit—is about 11000 km in altitude with orbital periods on the order of 6 hours.
- LEO—Low Earth Orbit—is about 500-2000 km in altitude with orbital periods of 1.5 to 2.5 hours, and is designed to provide data services to users with hand held units.

The LEO and MEO orbits are most useful for mobile environments where the system operator provides a switching mechanism that frees the user from tracking individual satellites. The switching requirements are quite similar to those encountered in cellular systems, but both the user and cell site are moving when a satellite is involved.

The Iridium system will use LEO with maximum 66 satellites for its wireless communication. To avoid the need for a large number of ground stations, Iridium messages will be relayed from satellite to satellite until a satellite with a view of the appropriate ground station relays the message back to Earth.

The satellite position over the equator can drift because of the gravitational attraction of the moon and the sun. Because of this drift, the satellite orbit tends to become non-circular and inclined. Without correction, the inclination plane drifts a fraction of a degree every year. Over a 26 year time period, a an uncorrected satellite drifts 14,67° from initial 0° and drifts back again to 0° in the next 26 years. Also without correction, orbit inclination cause the satellite to trace a 'figure-eight' pattern over any 24-hour period. The dimension of this pattern increases with the inclination.

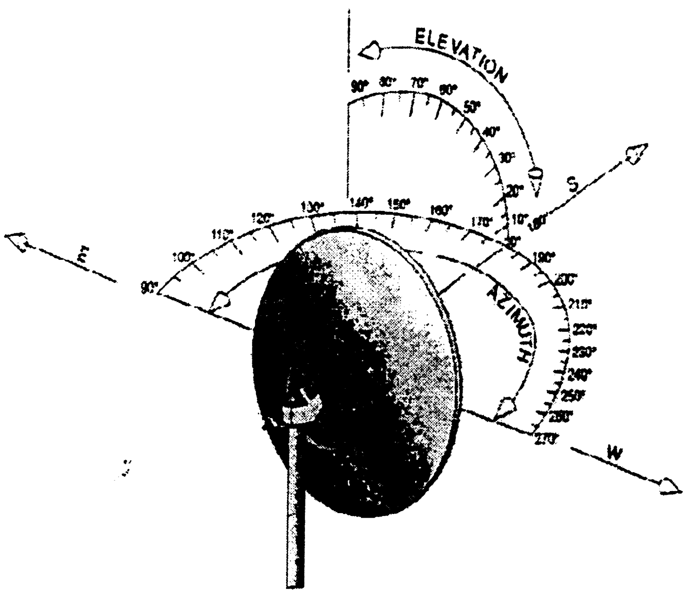
Because of the rapid growth in the number of satellites in Geostationary Earth Orbit (GEO),; might the GEO be overloaded in the near future, and might two satellites collide with one another? The circumference of the GEO is 250,000 km. As decided by international treaty, every satellite has a 'space cube' of 75 x 75 x 85 km (see also 3.3); The GEO has plenty of room available for at least 3300 satellites. At any rate, old and useless satellites don't stay in the GEO but are placed into the junk orbit.

3.2.2. Elevation-over-azimuth Pointing System

The Elevation-over-azimuth pointing system is an universal method of describing the direction of a point on earth as well as points in space.

Azimuth: Angle between antenna beam and meridian plane (measured in horizontal plane). The zero reference for measuring true azimuth is north. east is 90°, south is 180° and west 270°.

Elevation: The vertical angle measured from the horizon up to a targeted satellite. When the beam axis is parallel to the ground, the elevation is zero. A 90° elevation rotation points the beam to the zenith.



<u>Indispensable</u> in practicing the Elevation-over-azimuth pointing system is a compass and an inclinometer.

An Inclinometer is an instrument used to measure the angle of elevation to a satellite from the surface to the earth. (see chapter 6)

3.2.3. Azimuth and Elevation Angle Calculations

The azimuth and elevation angles to a particular *geostationary* satellite can be calculated in degrees from true north, using the satellite longitude (Ψ), the site longitude (Δ), the site latitude (Φ) and the equations given below.

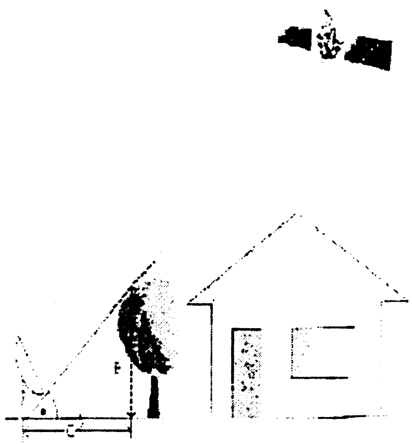
Azimuth angle $A = 180^{o} + \tan^{-1} [\tan(\Psi+\Delta) / \sin\Phi]$
Elevation angle $E = (\cos\Upsilon\cos\Phi - 0.15126 / \sqrt{[1 - (\cos\Upsilon\cos\Phi)^2]}$

Ψ: Satellite longitude in degrees east or west, whichever applies
EL: 180^{o} + satellite position
WL: 180^{o} - satellite position
Δ: Site longitude (in degrees east or west)+ 180^{o}
Φ: Site latitude
Υ: $\Upsilon = \Delta - \Psi$

For example: For Orion 1

Azimuth in Amsterdam is 229^{o} and elevation is 19^{o}.
Azimuth in Denver is 105^{o} and elevation is 9^{o}.
Values for other locations are listed in tables. Also consult the Orion "*Digital Satellite Services Calculator*" to compute azimuth and elevation angles.

To calculate the height of an obstruction (line B on the drawing below) *first* find a point from which the satellite can be seen above the obstruction.



Second, measure/calculate the elevation.

Third, measure the distance C. C = distance between antenna center post and imaginary line perpendicular from the highest point of the obstruction to the ground.

For each meter from the center post, the rise B can be calculated from the tangent of the elevation angle.

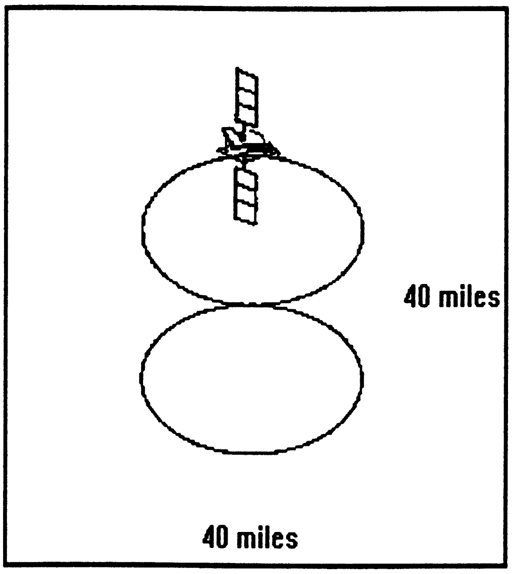
A few common samples are given below.

Elevation (degrees)	Rise B (cm) for each meter C
5	8.74
10	17.63
15	26.79
20	36.39

3.3. Doppler Shift and Satellite Transmission Delay

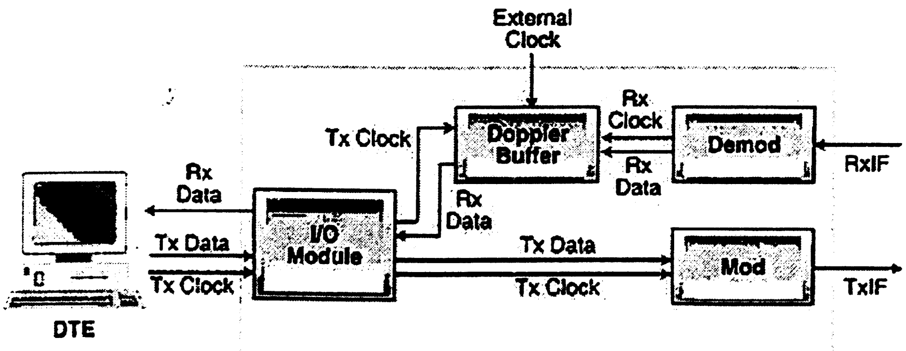
3.3.1. Doppler Shift

A very important factor to be taken into account when considering the suitability of frequency bands for use in a satellite service is the amount of Doppler shift that is imposed on the satellite emissions.



Although they are geostationary, most satellites drift slightly in their orbit with a 24-hour periodicity. Orbital forces from the Earth, sun and moon cause the satellite to move in an apparent figure eight with respect to the Earth. TT&C Operators "fly" the satellite to maintain it in station within a 40 mile square. This motion causes a Doppler shift in the satellite signals, resulting in data rate clocks at the receive site that are slightly different than clocks at the transmit site. Although identical in a 24-hour average, the data rate clock at a receive station will be slightly slower and slightly faster at different times of the day. Most data communication applications have no problem with this. These applications generally have independent transmit and receive clocks at each site and can tolerate the slight differences. Examples include most DTEs (Data Terminal Equipent) such as voice and data multiplexers that send an aggregate data rate over the satellite. Some applications, however, require that the receive clock and data from the satellite be exactly synchronized to another clock. These applications require the use of a Doppler buffer. An example is when the received satellite data stream is being multiplexed into a higher data rate aggregate stream at the earth station. Another example is when the received data is input to a synchronized terrestrial system. In both cases a Doppler buffer is needed because the received data from the satellite must be slaved to a specific clock.

Satellite modems located at the earth stations contain Doppler buffers to counter this effect and provide a constant clock to attached equipment which may be sensitive to these variations in frequency.



CM701 / DT7000

3.3.2. Satellite Transmission Delay

Although engineers have developed new technologies that alleviate satellite delay, some problems still exist. Data communications protocols (initially developed for LANs and terrestrial telephone lines) require many acknowledgments, and, as a result, suffer a decrease in data throughput due to satellite delay.

The *geostationary* satellite system *one-way* transmission delay [ms] is given in the table below.

	One-way transmission delay [ms]		
	Minimum	Maximum*	Mean
Between earth stations	240	280	260
Terrestrial extensions	10	50	30
Total	250	330	290

* Maximum delay is based on 5° elevation angle

IMPORTANT! Round-trip delay, is double what is shown above

Other delay considerations that should be accounted for may include:

- Front end multiplexers and/or switches
- Transmission equipment (error coding, overhead processing, scramblers, Doppler buffers)
- Host/server (application processing)

3.4. Decibel & EIRP Calculations

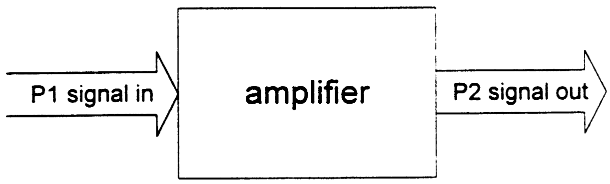
3.4.1. Decibels

The decibel [dB] is a means of expressing ratios logarithmically and is used to express the relative values of two signals. The logarithmic scale is used to compress large differences in numbers to a more manageable range. Because of pressures for standardization, the Bel (B) was defined by the following equation to relate *power* levels P1 and P2.

$G_B = \log_{10}(P2/P1)$

It was found that the Bel was too large, so the decibel was defined such that 10 decibels = 1 Bel

$G_{dB} = 10\log_{10}(P2/P1)$



A second equation for decibels shows the voltage or current gain in decibels.

$G_{dB} = 20\log_{10}(V2/V1)$

example: V_{in}=6 volt, V_{out} = 800 volt
The voltage amplification is 20log133.3=42.5 dB

One of the advantages of the logarithmic relationship is the manner in which it can be applied in cascade stages.

example:
One piece of cable has an attenuation of 3.6 dB; another piece has 2.4 dB. Connected to one another, they have a total attenuation of 3.6 + 2.4 = 6.0 dB.

Decibels are also expressed relative to a reference value such as watts (dBW), milliwatts (dBm), millivolts (dBmV) and micro volts (dBμV) to show the increase in power relative to one watt, one milliwatt, one millivolt and one microvolt, respectively. Decibels correspond to finite voltage or current levels—not to ratios.

A power level of 1mW into a 600 or 50Ω load resistance (read impedance) has become standard and is defined as 0 dBm (0 dBm into a 50Ω resistance corresponds to 0.225 V)

dBmV and dBμV are more in use in the world of CATV and video using loads of 75Ω, *e.g.*, 120 dBμV corresponds to 1 V or 11.2 dBm into a 75Ω resistance.

Example:
20logx=120 dBμV ⇒ logx= 6 ⇒ x=inv.log 6=1000000 ⇒ reference is 1μV ⇒ 1E6 * 1E-6= 1V. 1V into 75Ω is 0.0133 W=13.3mW ⇒ 10log13.3=x dBm ⇒ 1V=120 dBμV=11.2 dBm

3.4.2. dBm-mW Conversion Table (50Ω)

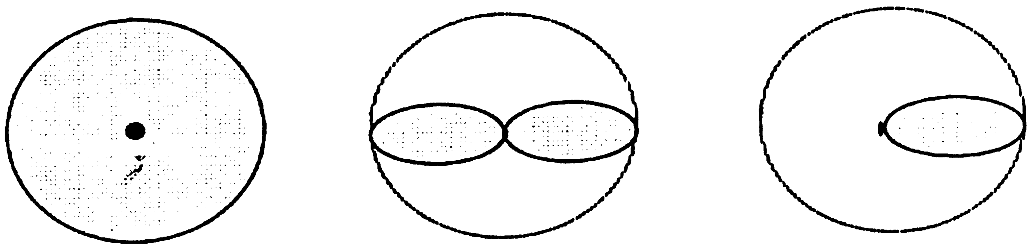
dBm	mW	dBm	mW	dBm	mW
-18	0.0158	-4	0.398	10	10.0
-17	0.0200	-3	0.501	11	12.6
-16	0.0251	-2	0.631	12	15.8
-15	0.0316	-1	0.794	13	20.0
-14	0.0398	-0	1.00	14	25.1
-13	0.0501	1	1.26	15	31.6
-12	0.0631	2	1.58	21	126
-11	0.0794	3	2.00	24	250
-10	0.100	4	2.51	27	500
-9	0.126	5	3.16	30	1W
-8	0.158	6	3.98	33	2W
-7	0.200	7	5.01	36	4W
-6	0.251	8	6.31	39	8W
-5	0.316	9	7.94	42	16W

3.4.3. EIRP

Effective Isotropic Radiated Power (EIRP) is the product of power supplied to the antenna and the antenna gain, in a given direction. EIRP is the greatest at the bore sight (center of the beam) and decreases at angles away from the bore sight.

$EIRP_{transp}$ = Transmit $power_{transp}$[dB] + $Gain_{ant}$[dB]
Higher satellite EIRPs permit the use of smaller receive antennas on the ground.

An isotropic antenna is omni directional and has no gain. If the transmit power P_{tx}= 60 dBW (=1MW) the EIRP will be 60dBW + 0 dBi = 60 dBW.
If an unidirectional antenna has 30 dB gain and Ptx = 30 dBW (=1 kW) the EIRP will be then 30 dBW + 30dBi = 60 dBW.



Radiation patterns of a isotropic antenna (left), bi-directional (middle) and unidirectional antenna (right)

The isotropic antenna is a hypothetical loss free antenna having equal radiation intensity in all directions. The make believe antenna is a convenient reference for expressing the directional properties of actual antennas.
EIRP can also refer to the signal strength transmitted from a VSAT towards the satellite, but is usually referred to as an earth station EIRP (E/S EIRP) or a VSAT EIRP.

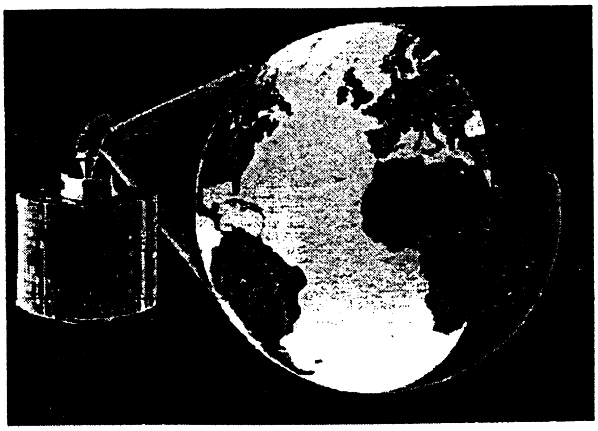
3.5. Footprint & Downlink Power Levels

Spacecraft used in conventional domestic systems are generally more powerful than those used for global applications. Downlink power is focused into smaller geographical areas to allow the use of smaller and cheaper earth stations.

Signals are broadcast to earth from satellites using two types of amplifiers:

- Traveling Wave Tube Amplifier(TWTA)
- Solid State Power Amplifier (SSPA)

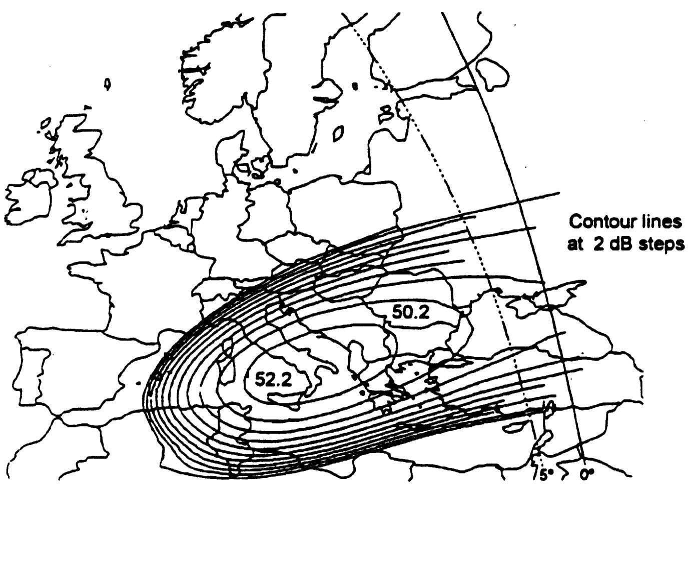
These amplifiers typically have power levels of 20 to 200 Watts per transponder on Ku-band satellites. Even though the power is relatively low, the signal level that is transmitted to earth is boosted many times by the gain of the downlink parabolic reflector *(see 3.11.5.)*



3.5.1 The Footprint

The footprint is the geographic area towards which a satellite downlink antenna directs its signal. The figure left shows the total area of the earth seen by the satellite at any instant; or conversely the area from which the satellite is visible from the surface of the earth. The measure of signal strength of this footprint is the EIRP. The highest signal levels are determined by the satellite reflector contours and feed array positions. Satellites which do not support maritime activities have most of their downlink power focused on population centers.

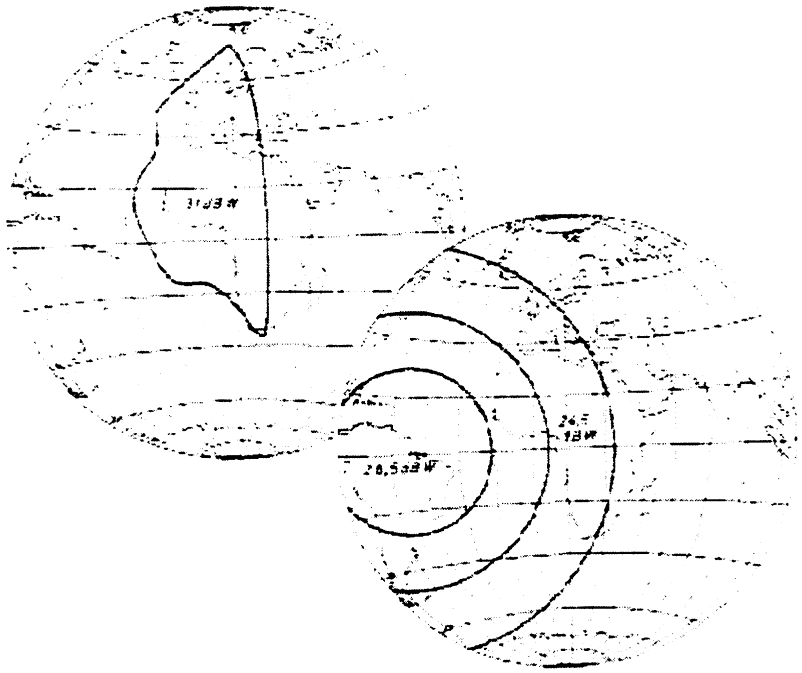
The way in which a satellite transmits its signal can be compared with the way a flashlight works. One satellite has various downlink dishes with which it can illuminate certain areas. These areas are called footprints. Most communications satellites have two or more footprint areas,



One of Orion's European spot beams. The numbers in the footprint represent the EIRP downlink levels in dBW

To cover the whole globe the following minimal numbers of satellites are required: 3 satellites in GEO, 12 in MEO and 24-66 in LEO. *(See also 3.2.1.*

The attenuation that a signal undergoes as it travels over the path between the earth station and the satellite is called path loss. Losses are due mainly to the spreading out of the signal on its long journey, and are dependent on the distance (GEO, MEO or LEO) and the signal frequency. At 12 GHz the path loss equals 205.11 dB when the receiving earth station is located on the equator directly below a GEO-satellite. In other locations the path loss is slightly more. Atmospheric absorption causes additional losses *(see 3.6.2.)*.



Example Hemispheric Beam (left) and Global Beam (right)

Some Frequently Used Types of Footprints and Their Names

- **Global Beam** is the footprint pattern used by communication satellites to cover nearly 40% of the Earth's surface.
- **Spot Beam** is a beam of circular or elliptical cross-section, covering a defined region of the Earth's surface. In relation to the Global Beam, the Spot Beam is small. Orion Spot Beam EIRPs vary between 46.7 and 52.7 dBW. *(see 4.1.3)*
- **Zone Beam** is a beam pattern, usually a shaped beam, intermediate between Hemispheric and Spot.
- **Hemispheric Beam** (see figure)
- **Broad Beam** is a beam which covers a large part of a continent. Orion Broad Beam EIRPs vary between 33.8 and 47.7 dBW *(see 4.1.3.)*

3.6. Elements Affecting Link Quality

3.6.1. Link Quality Criteria

All satellite links are designed to provide availability to meet a required level of performance. The performance criteria are usually the minimum (*or threshold*) Bit Error Rate (BER) and the availability, as a percentage, of time that the minimum BER must be met or exceeded.

The BER is the total number of erroneous bits divided by the total number of bits received. A performance guarantee of BER=1E-6 for 99.5% availability means that for the entire year except for 44 hours (of heavy rain, snow, sun outage, interference, etc) the link performs at BERs much better than the threshold. During the remaining 0.5% of the time, more errors are received than usual, resulting in more re-transmissions or a noisy signal.

Elements affecting the quality of the link can be generally divided into:

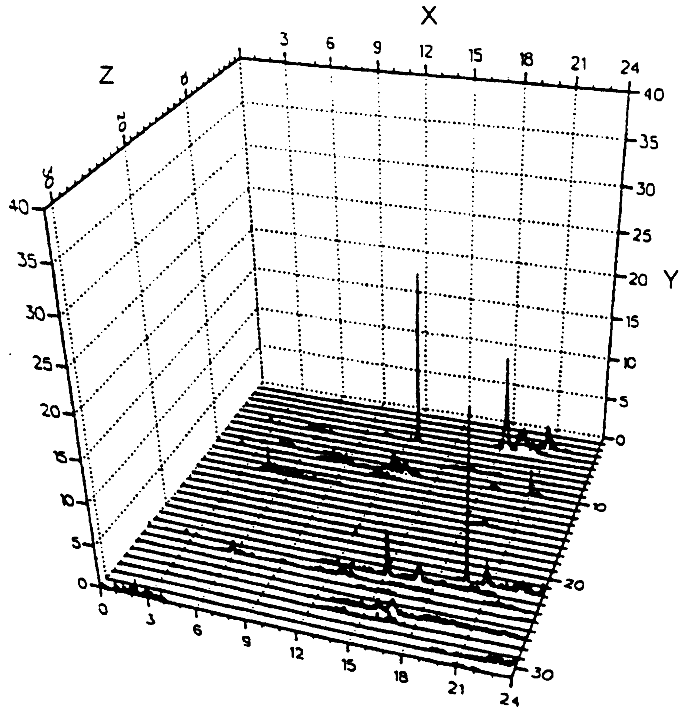
- atmospheric absorption and rain fade
- interference
- noise
- sun outages

3.6.2. Rain Fade

High frequency signals such as Ku band are susceptible to attenuation caused by absorption and the scattering effects of water in the atmosphere. The geometry of rain droplets is quite similar to a 1/4 wave attenuator at the Ku band wavelength, resulting in worsened link performance. Clouds attenuate according to their liquid water content and their proportions.

The total attenuation due to absorption by water depends not only upon the frequency (the higher the frequency, the higher the attenuation) but also upon the elevation angle (the smaller the angle, the higher the attenuation). This attenuation is overcome by increasing transmit power levels and/or lowering receive station noise temperatures in the initial design of the system. Models are used to predict the amount of rainfall and a percent availability is given to the system. Systems such as uplink power control are sometimes used to sense rain fade and increase transmit power levels accordingly. However, uplink power control systems are not usually used in VSAT systems due to the requirement of providing low cost systems.

Rain, sleet, thick clouds, fog, and snow will all reduce (fade) RF signal strength. Less signal received by the satellite means less power transmitted back to earth to receiving stations. Systems not using power control must take into account the signal reductions due to inclement weather, even when operating in clear weather conditions. Without Uplink Power Control (UPC), constant extra power, or "fade margin", must be leased to ensure that a strong enough signal reaches receiving sites during fade conditions. By using UPC to adjust signal power levels, you get higher network availability while minimizing satellite costs. In inclement weather conditions, UPC automatically adjusts the power level of transmitted signals to maintain a near constant receive signal at the satellite. There is no need for constant fade margin. Also, safeguards are built into the system to prevent operation at higher than permissible power levels. UPC is especially effective for Ku band frequencies, which are substantially more susceptible to rain fades than are C band. For Ku band systems requiring high service availability (99.95% - 99.99%) UPC can reduce the overall margin requirements from 9-20 dB without UPC to 3-12 dB with UPC. Every 3 dB decrease in margin required results in a two fold decrease in satellite costs.



Rain attenuation can be in extreme situations more than 15 dB. Satellite links include rain margins which are calculated to ensure a specified link availability *e.g.*, 99.5% per year. At Ku band frequencies, occasional service interruption due to weather are expected.

Rainfall versus attenuation (Y) during one month (example)

3.6.3. Interference on Transponders

As a result of increasing satellite use, the ability of the receiver to pick out weak wanted signals in the presence of strong (interfering) signals represents a very important performance criterion. Interference can be caused by the effects listed below.

- Cross polarization interference *(see 3.8.)*
- Adjacent channel interference
- Adjacent satellite interference
- Overloaded transponder

Adjacent channel interference is often caused by cross modulation and inter-modulation.

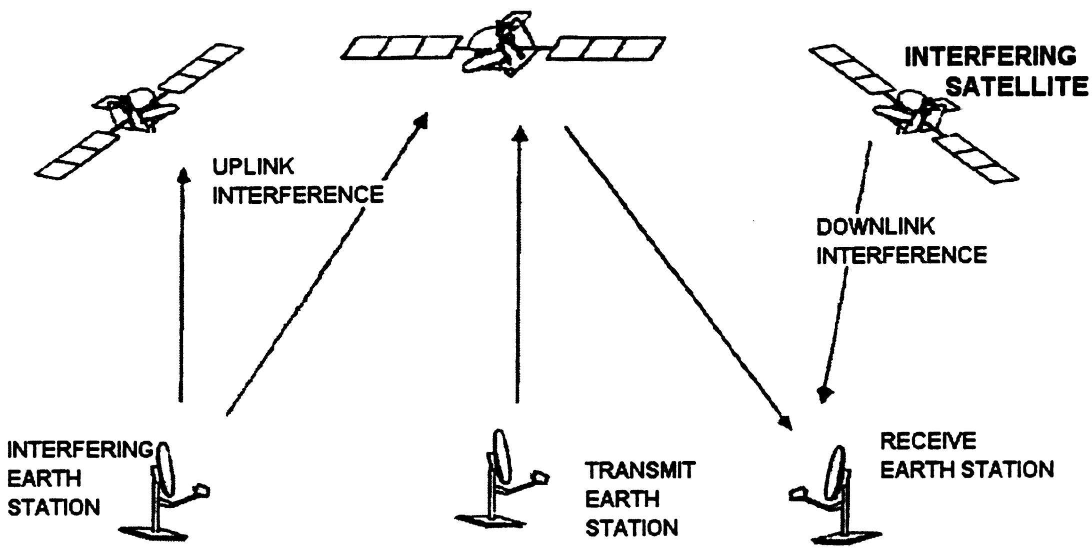
Inter-modulation occurs when two or more signals combine in a non-linear element (*e.g.*, amplifier) and produce a resultant interfering signal on the wanted signal.

Cross modulation occurs when an interfering signal modulates the signal of interest, or, in other words, when the modulation of one signal is affecting that of another. Poor intermediate frequency (IF) link cable shielding can cause local radio and television signals to be picked up and radiated toward the satellite. Cross modulation also can be caused by overloading an amplifier.

3.6.4. Adjacent Satellite Interference

Interference from an adjacent satellite occurs at the downlink site when the antenna is not properly assembled and/or not properly pointed. In this situation the antenna is able to pick up signals from an adjacent satellite at the same frequency as the frequency of interest.

A similar problem can occur at the satellite site if an earth station antenna is not well enough focused. In this case, the earth station antenna interferes with a satellite adjacent to the one toward which the transmission is intended. If, for example, the antenna is pointed so that the side lobe, rather than the main lobe points toward the intended antenna, the main lobe and the lobe on the other side of the peak, could interfere with adjacent satellites.
In some cases, side lobes may be interfering even though the main lobe is on target. In this case, a more selective antenna (a larger antenna with a narrower focus might be a good solution to avoid this kind interference). At any case, a carefully pointed antenna is crucial.



To avoid excess interference to adjacent satellites, a defined transmit co-polarised side lobe pattern is required for every earth station.

A satellite positioned close to Orion 1 (37.5°W) is the INTELSAT 603 on 34,5°W. This satellite has, for the US and Europe almost the same coverage area as Orion F1.

All the types of previously discussed interference are RF interference or interference on "microwave level". Other interference problems can occur on IF and LF levels.

3.6.5. IF and LF Interference

Many circuits, as well as detectors and even cables, are sensitive to IF and LF interference and could affect the BER in a negative way. Some of the most common creators of this serious problem are listed below.

- 50/60 Hz pick up with a sharp spectrum and constant amplitude can be caused by electrical wiring in the area. Interference from electrical wiring is easy to detect.
- Impulsive interference can be caused by lightning and nearby electrical equipment such as motors, elevators and air conditioners. This kind of interference is broad in spectrum and spiky in amplitude. Because of its irregularity, it is hard to detect.
- Radio and television stations can cause a serious problem near large cities.

Many of these sources can be controlled by careful shielding, filtering. and proper grounding. These topics will be discussed later in chapter 5.

LF—Low Frequency—is any frequency of the audio spectrum.

IF—Intermediate Frequency—is the frequency at which most of the signal processing takes place because the design is simplified and cheaper. For VSAT transmission or reception, IF is usually 70 MHz ± 20 MHz or 140 MHz ± 20 MHz. Mixer outputs are also called IF.

RF—Radio Frequency—is any frequency between an audio sound and the infrared light portion of the spectrum but usually considered to be 1 MHz to 1000 MHz.

3.6.6. Noise

Noise is an unwanted signal which interferes with the reception of the desired information and can affect the signal dramatically. Noise is present in all matter at temperatures above absolute zero. Noise from the environment becomes stronger as the temperature increases. Receiving antennas pick up more of this environmental noise as the signal bandwidth increases. In all cases, the lower the noise, the better the system performance.

Nature has given us two types of noise:

- Noise with a flat frequency spectrum, is called white noise. Fat frequency means that the same level of noise exists in each Hertz of frequency (up to some limit, of course).
- Pink noise has approximately a 1/f spectrum (equal power per decade of frequency).

Generally the sources of noise can be divided into:

1. External Noise
    - Atmospherics
    - Solar and cosmic noise
    - Thermal noise from the earth
    - Manmade impulse noise (*e.g.*, motorbikes, etc.)
2. Internal Noise
    - Resistive noise (caused by all the resistors used in the circuit)
    - Thermal effects in semi conductors
    - Other similar effects within the equipment itself

Little can be done in respect to external noise. On the other hand, considerable influence can be made to the problem of internal noise by designing carefully.

3.6.7. loss of Gain Due to Impedance Mismatch

Most RF and microwave systems are designed around a 50 Ω or 75 Ω impedance system. The input impedance of an antenna system, for example, directly affects the efficiency of energy transfer to or from the antenna. Radiation from transmission lines and cables can also modify the antenna's radiation pattern causing loss of energy and can lead to interference between co-located systems. The risk of interference and loss of energy are the reasons that each system should be matched as nearly perfectly as possible to its feed. When the correct terminating impedance, *i.e.*, an antenna, a waveguide, a coax cable, a connector, or any combination of the four, is connected to any feeder the voltage and current distribution along the line is uniform and no energy is lost.

An amplifier's impedance is designed to be as close as possible to 50 Ω; however, achieving exactly 50 Ω is not always possible when attempting to simultaneously achieve a good noise figure.

Voltage standing wave ratio (VSWR) is a measure of the efficiency of a signal interface, *e.g.*, the impedance match of the antenna to the LNA or, better yet, the actual impedance (Z) of a device with respect to the desired impedance (Z_0)

The VSWR is derived from the reflection coefficient $\Gamma = (Z - Z_0) / (Z + Z_0)$
$VSWR = (1 + |\Gamma|) / (1 - |\Gamma|)$

The next table shows VSWR and the comparing reflected signal loss

VSWR	% Loss	dB loss
1.0:1	0	0
1.1:1	0.2	0.01
1.2:1	0.9	0.03
1.3:1	1.6	0.07
1.5:1	4.0	0.18
2.0:1	11.0	0.50
38:1	90.0	10.0

If the system is not matched (*e.g.*, the cable has another impedance as the receiver) losses occur and the VSWR is not equal to 1:1.

With the right equipment VSWR is easy to check upon installation. The reflection coefficients are determined by comparing the incident power and the reflected power at both ports of the device. The ratio of the reflected power to the incident power is also known as the return loss.

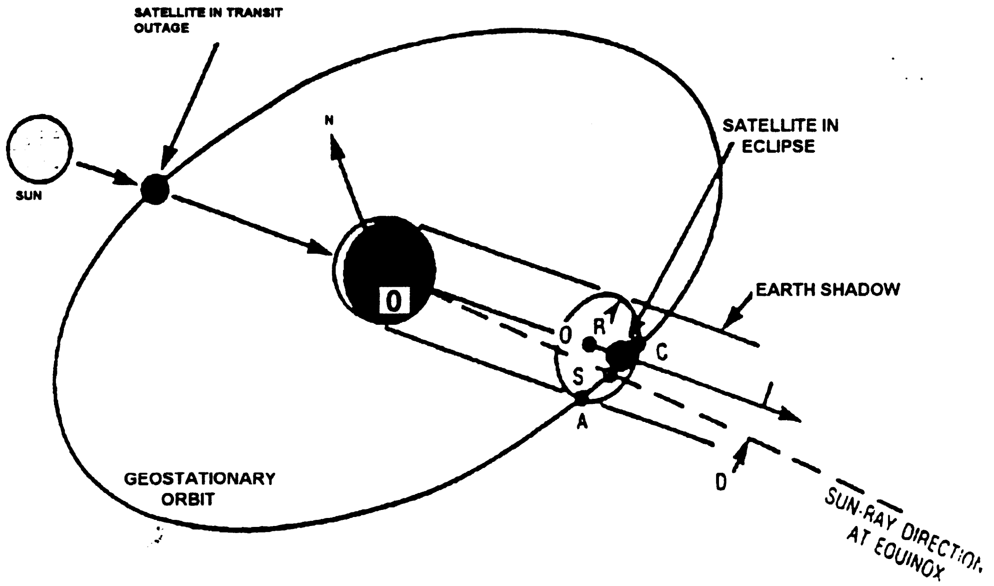
3.7. Sun Outages and Eclipse

Orion 1 is geostationary, and therefore has an orbit which lies in the equatorial plane. During the spring and fall equinoxes, the sun also passes through this plane. As seen from the ground, the sun seems to pass behind the satellites once per day. During the time when both the satellite and the sun are in the ground station's field of view, the RF energy from the sun can overpower the signal from the satellite. The loss or degradation of communications traffic from the satellite caused by the sun overpowering the signal from the satellite is referred to as *sun fade, sun transit or sun outage*. The duration of the sun outage depends on several things such as:

- Beam width of the field of view of the receiving ground antenna
- Apparent radius of the sun as seen from the Earth (about 0.25°)
- RF energy given off by the sun
- Transmitter power of the satellite
- Gain and S/N performance of the ground station receive equipment

Although the sun may degrade the signal for several minutes depending on the antenna size and available link margin, the effect of the sun fade could go unnoticed. The time of occurrence depends both on the geographic location of the earth station and the location of the satellite.

Sun outage at a fixed earth station occurs when the sun passes behind the geostationary satellite so that the earth station antenna is looking directly at the sun. The additional noise power of the sun raises the earth station system noise level causing the demodulator to operate below its threshold, rendering communication quality below acceptable limits.



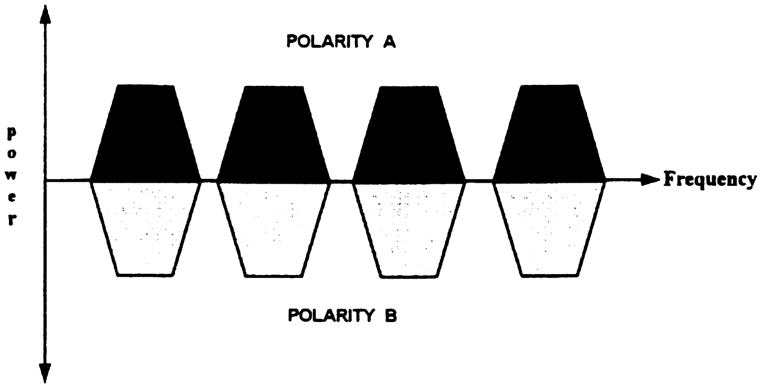
The exact point at which sun outage begins and ends is difficult to determine since it is a gradual transition. Also, due to the many differences in ground station equipment, some stations may experience a complete loss of signal while others may only experience a tolerable degradation of signal. The determination of antenna outage angles is made difficult without complete information about the ground station equipment.

Outage angle is defined as the separation angle (measured from the ground station antenna) between the satellite and sun at the time when sun outage or signal degradation begins or ends.
(Antenna Outage Angle = half the 3dB beamwidth + apparent radius of the sun)

Eclipse is the period when the satellite passes into the Earth's or the Moon's shadow, when satellite power must be drawn from on-board storage batteries.

3.8. Polarization Formats

All electromagnetic waves are polarized. Polarization is determined by the orientation of the electric and magnetic fields radiating from the transmitting antenna. If polarization is used two different signals can be transmitted in the same frequency range without interference, even if they overlap in frequency. In this way, twice the number of channels can be transmitted in a given bandwidth.

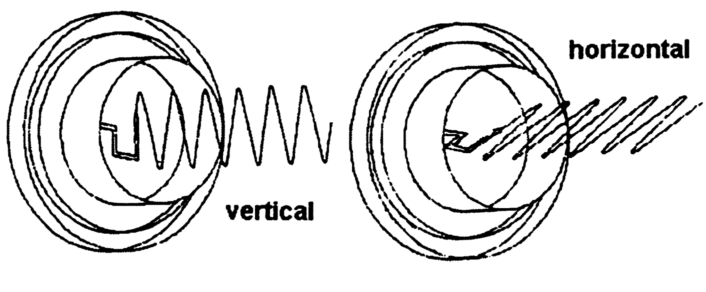


Satellite transponder spectrum

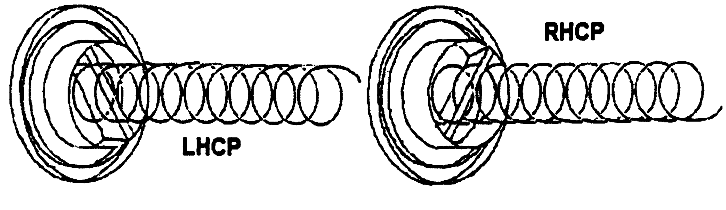
A power isolation of 35 dB between, *e.g.*, horizontal and vertical is quite common.

For example, conventional over-the-air television broadcasts are horizontally polarized; therefore, TV antennas must be oriented horizontally in order to receive the TV broadcast signals. If the TV antenna is rotated by 90 degrees to a vertical position, the signals cannot be received and the TV reception becomes poor. Satellite signals can be transmitted using one of four different polarization formats: linear horizontal, linear vertical, circular clockwise, and circular counterclockwise.

Linear, *horizontal or vertical*



Circular, *left hand (LHCP) or right hand (RHCP)*



Circular polarized waveforms vibrate in one plane and travel like a corkscrew through space with the electric field rotating clockwise. Horizontally (parallel to the ground) and vertically (perpendicular to the ground) polarized signals vibrate at 90° relative to each other.

A linearly polarized antenna receives 3 dB fewer decibels of power for a given circular polarized signal than would be received by a circular polarized antenna of the same size and the correct rotation sense.

The polarization angle depends on the location of the earth station. Because of depolarization, an offset of more than 20° (referring to the x or y axis) is common. Circular polarized signals don't have this problem.

Depolarization is the twisting of the polarization of a satellite signal as it passes through the atmosphere (ionic layer propagation)

An antenna may radiate unwanted energy in a polarization which is different from the polarization in which the antenna was intended to be used. This unwanted radiation is known as *cross-polarization*. The feedhorn must be set precisely to minimize cross-pol interference and receive signal loss.

Regardless of the polarization, all dishes reflect the incoming satellite signal to one focal point where the feedhorn is located. The feedhorn collects the energy and directs the microwaves via a waveguide to the "actual" antenna, usually a small probe precisely positioned within the waveguide. The position of this probe determines which sense of (linear) polarization is transmitted to the LNB.

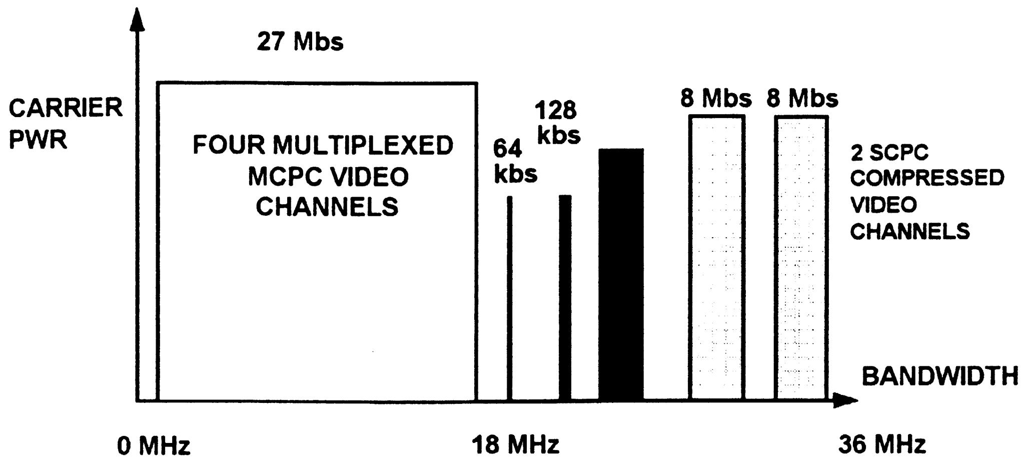
Care must be taken in the design and installation of earth station equipment to avoid transmitting or receiving on the wrong polarization.

In some installations, the feedhorn has the capability of receiving the vertical and horizontal transponder signals simultaneously, and routing them into separate LNAs for delivery to two or more receivers.

3.9. Bandwidth

Bandwidth actually means the amount of information that can be carried. A signal covering a wide band of frequencies can carry more information than can one covering a narrow band (compare this to a large-diameter pipe which can carry more water than a small one)

The figure below shows a 36 MHz bandwidth transponder. The example transponder is filled up with one MCPC (multi-channel per carrier) and five SCPC (single channel per carrier) channels. The example shows a transponder configuration quite commonly used on the Orion 1 satellite.



Transponders are also available with bandwidths of between 18 and 150 MHz.

3.9.1. Data Speed

The channel bandwidth not only depends of the type of modulation and encoding which is used but also on the data rate (the number of bits per second). Transmission speeds can be measured in bits per second (bps) or baud rate. Although often applied interchangeably, these terms do not mean exactly the same thing. The baud rate denotes the number of symbols per second in the transmission. For two-state (one-bit) symbols, bps and baud rate are identical. Above that, however, the bit rate is the baud rate multiplied by the number of bits per symbol.

The available bandwidth for carrying signals through local lines has not changed in 60 years. A 4-kHz bandwidth—corresponding to 4000 baud—and a 30 dB signal-to-noise ratio represent hard limits on transmission capacity. Symbol efficiency has brought Modem speeds from the 300 and 1200 bps that were ubiquitous only a few years ago to the 28.8 kbps speeds that are commonplace today. Note that a 28.8 kbps Modem still transmits at only 3824 baud.

64 kbps links are mainly used to connect computer networks to one another, 128 kbps and 2 Mbps are suitable for (low quality) video conferencing, multimedia and telemathics applications. Digital broadcast video needs 6 Mbps (MPEG2 compressed 30-95 Mbps analog video). High quality analog television signals require large bandwidths, on the order of 36 MHz (one whole transponder).

3.9.2. The Effect of Bandwidth on the System Noise Power

The noise power in any communication system is given by the following equation:

System noise power = $k * T_{sys} * B$

- T_{sys} is the system noise temperature mainly determined by antenna and LNB/LNC noise.
- k is Boltzman's constant.
- B is the used bandwidth.

If T_{sys} remains constant, the change in noise power is equal to the change of bandwidth. If the bandwidth were cut from 36 to 18 MHz as would be the case in half transponder formats, the noise power would be reduced by 50% or 3 dB. In the case of analog video, reducing the bandwidth results in decreasing the video quality. Sometimes reducing the bandwidth makes the difference between transmitting a watchable picture and a noisy one.

Increasing the number of states per symbol increases the bandwidth efficiency, calculated as bit rate divided by signal bandwidth (designated R/W) and measured in bps/Hz. Unfortunately, more bandwidth-efficient modulation schemes suffer from higher BERs. A higher signal-to-noise ratio is necessary to achieve acceptable error rates.

Digital TV pictures can be provided over a wide coverage area even with digital signals of low power, since the carrier to noise ratios required for satisfactory reception of digital signals (15 dB) are very much less than those for existing analog signals (40 dB). Using simple binary channel coding, the required basic transmission bandwidth of over 100 MHz compares with the quality of a 27 MHz channel bandwidth needed for FM DBS satellite transmission (and with the 8 MHz channel used for terrestrial analog PAL). By using new digital modulation systems, the necessary bandwidth can be reduced and C/N can be traded (see chapter 3.1.14) for bandwidth, rather like FM analog transmission, to enable high bit rates to be supported in smaller RF channel bandwidth. MPEG signal processing and bit rate data reduction techniques, developed by the Moving Picture Experts Group are playing a major part in these new developments.

3.10. Noise Temperatures or Noise Figure

The noise temperature (°K) or noise figure (dB) of an amplifier can be defined as the ratio of the output of the real amplifier to the output of a “perfect” (noiseless) amplifier of the same gain, with a resistor of value Rs connected across the amplifier's input terminals in each case. The natural resistive noise of Rs is the input signal.

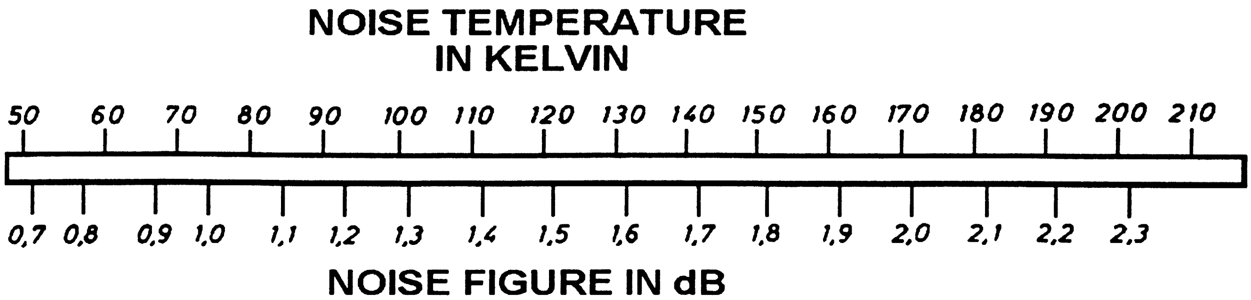
A perfect, but theoretical, amplifier (or LNA/B/C) has a noise temperature of 0°K, so that it would add no noise to the signal it is amplifying. Since all amplifiers add thermal noise, the signal or carrier to noise ratio at the amplifier's output is degraded. Practical LNA/B/Cs are rated by the noise they add to the signal. The lower the noise temperature, the less noise is added by the LNA/B/C.

The noise temperature (°K) or noise figure (dB) is a measure of the noise power produced by a communications system, subsystem, component, or “noise source.” It varies with frequency and source impedance but is always greater than 0 dB.

3.10.1. The Kelvin Scale versus Decibel

The Kelvin scale is used to measure temperatures above absolute zero, the theoretical point at which all molecular motion stops. This point is equal to 0°K

While most C band LNBs are rated by noise temperature, Ku band are generally categorized by noise figure (or noise factor). Common noise temperatures for C band LNBs are in the 25-30 degree (0.4 dB) range while Ku band LNBs below 0.8 dB (59°K) are rather sophisticated. Test data is supplied at +23°C unless specified otherwise.



Converting table noise temperature ⇔ noise figure

or in a formula:

Noise Figure = 10 $\log_{10}$ [T/290 + 1] [dB]

290 is the assumed ambient temperature.

3.11. The Antenna

The initial gain in a satellite system, by far the most important gain for receiving and transmitting, is provided by the antenna. Depending on the purpose and the wavelength, antennas are made in various forms and sizes.

Microwaves are nearly completely reflected by a solid metallic surface. When this surface is shaped into a parabola, almost all of the energy striking the parabola along its main axis is focused to a well-defined focal point.

3.11.1. Parabolic Antennas

The main advantages of a parabolic antenna are as follows.

- In principle they can be made to have as large a gain as is required.
- They can operate at any frequency.
- They require little set-up.

Disadvantages, however, are below.

- Parabolic antennas are difficult to point accurately, limiting the frequency at which a dish can be used.
- Large dishes are difficult to mount and may have a large wind load figure.

The basic principle of a parabolic antenna is that all the energy received by the dish is reflected to a single point at the focus of the dish or, in the case of transmitting, all the reflected output of the antenna feed is focused toward the satellite.

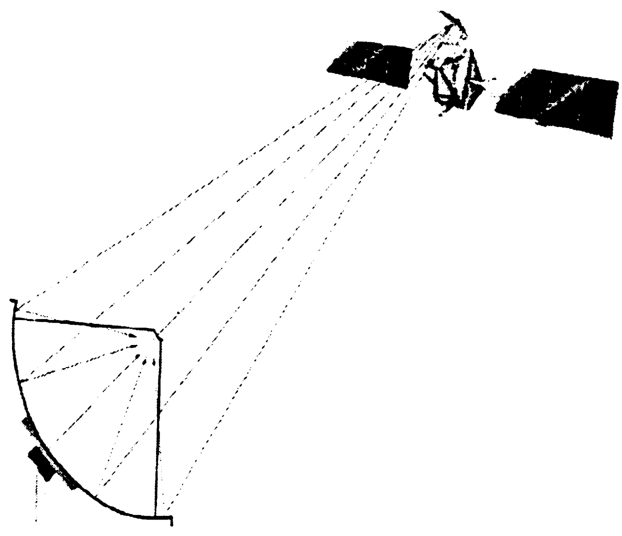
The primary specifications of an earth station antenna are given by:

- Type of antenna (shape, area, fixed or tracking, diameter, pointing range, etc.)
- Antenna gain
- Antenna noise temperature

3.11.2. Parabolic Antenna Types

There are two main types of parabolic antennas:

1. *Prime focus.* The prime focus antenna is round and has its feed/ LNA/B/C assembly at the focal point directly in front of the antenna. A prime focus antenna is easy to manufacture
2. *Offset antennas.* An offset antenna is oval and the feed/ LNA/B/C has an offset from the center of the reflector. Because of its oval form this type is more difficult to manufacture.

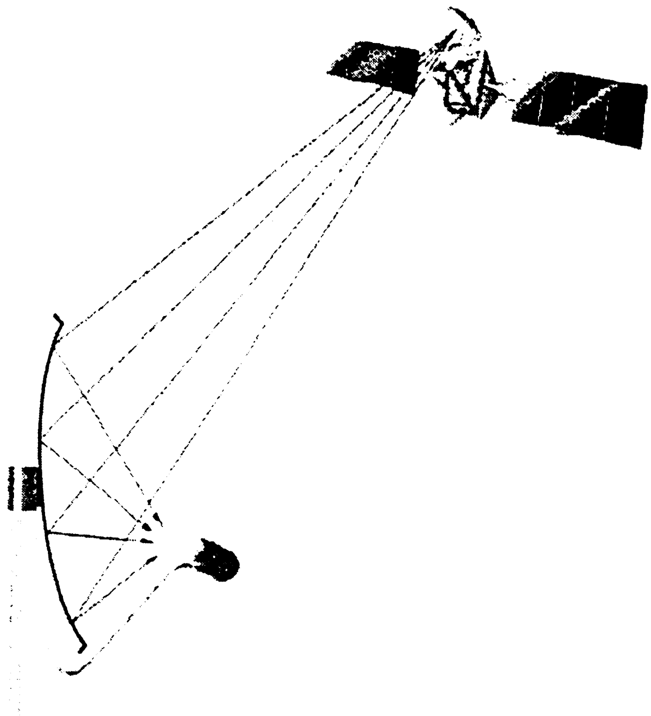


Prime focus antenna

Offset fed antenna have smaller diameters (30 cm-3 m) and the feed is located below the lower edge of the offset fed reflector. This configuration does not block the antenna aperture.

Elevation for an offset antenna is normally about 20° less than that of a prime focus antenna. The foreshortened elevation can be an advantage in more northerly latitudes where the antenna can be installed in an almost vertical position so that snow accumulation is minimised. Also, the antenna noise temperature is impacted favourably.

Small offset antennas have larger side lobes and a wider beamwidth than a prime focus antenna. Therefore, the antenna must be properly aligned on the main beam, rather than on a side lobe. Otherwise, signals radiate towards adjacent satellites and cause interference.



Offset antenna

Note that a dish or satellite reflector is generally incorrectly termed a satellite antenna. The true (receiving) antenna is actually the small probe inside the feedhorn that detects the reflected signal for relay to an LNA/B/C

3.11.3. Antenna Radiation Pattern

Radiation patterns of an antenna depend on the type of antenna, the frequency, the polarization, and the efficiency of the antenna. Antenna performance is modified by the effect of ground-reflected energy. The performance also depends very much on the antenna construction and its surroundings. As a result, each individual (site) antenna has its own radiation pattern.

In general radiation patterns can be plotted in two ways:

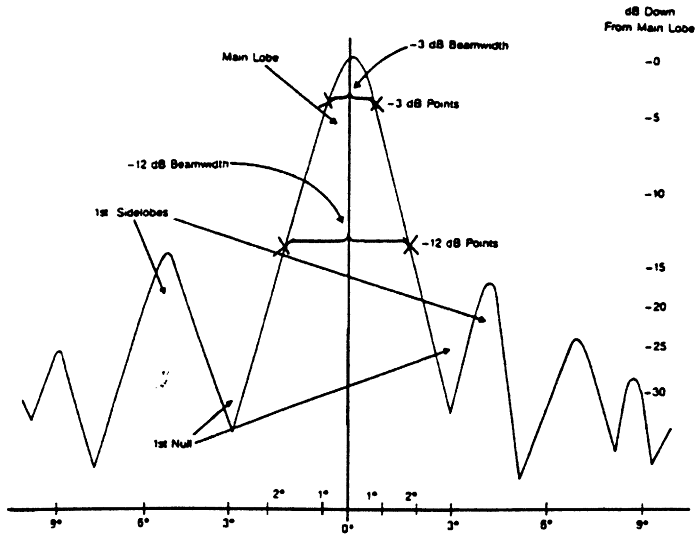
1. *Field pattern* for the electric or magnetic field produced by the antenna
2. *Power pattern* in which the pattern amplitudes are proportional to the power density radiated by the antenna

The radiation pattern for each parabolic dish is defined by its specified main lobe, or main beam. Depending on the antenna diameter, this beam is between 0.5 and 4 degrees wide. The pattern also has (undesired) side lobes which, in case of transmitting, radiate energy in a undesired direction or, in case of receiving, worsen the antenna noise temperature and thus the G/T. *(see also 3.13.)*

A Side lobe is (an undesired) parameter used to describe an antenna's ability todetect off axis signals. The larger the side lobes, the more noise and interference an antenna can detect.

The side lobe performance of an antenna is mainly defined by:

- Reflector illumination function (the most important)
- Blockage effects
- Feed spill over
- Edge diffraction of the reflector
- Edge illumination of the reflector



The most important parameters used in determining parabolic antenna performance are:

- the main lobe gain
- -3 dB points
- the first null
- side lobes
- cross-pol performance

typical parabolic antenna radiation pattern

In footprint areas with high EIRP levels good reception might be possible even when a side lobe is aligned on a satellite, at least until rain falls and signal attenuation increases. The radiation pattern should meet the minimum requirements set by the International Radio Consultative Committee (CCIR) and/or the national regularity agencies.

There is more illumination in the center area of the parabola and less near the edge.

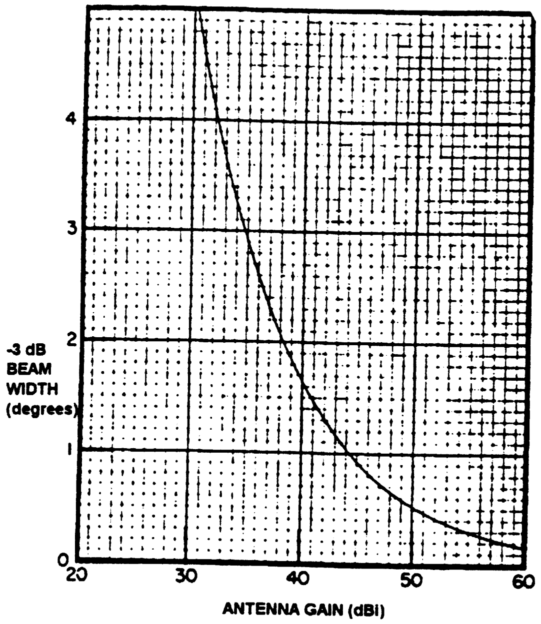
3.11.4. Antenna Beamwidth

An approximate but very useful formula for the 3 dB antenna beamwidth is:

Beamwidth = $70\lambda / D$

λ	= the wavelength of the incoming signal (cm)
D	= the antenna diameter (cm)

For example, a 2.4 meter antenna has, for a frequency of 12 GHz, a 3 dB bandwidth of 0.73° and a 1.8 meter antenna has a 3 dB bandwidth of 0.97°.



Beamwidth as function of gain

Narrowness of the beamwidth tends to be a limiting factor for the size of an antenna.

3.11.5. Antenna Gain

The gain of an antenna is always relative to an isotropic antenna (see 3.1.6), and therefore, expressed in dB(i). Each time the diameter of a dish *or* the used frequency is doubled, its gain is quadrupled (= 3 dB), other things being equal.

The gain (G) of a dish antenna depends on a few parameters:

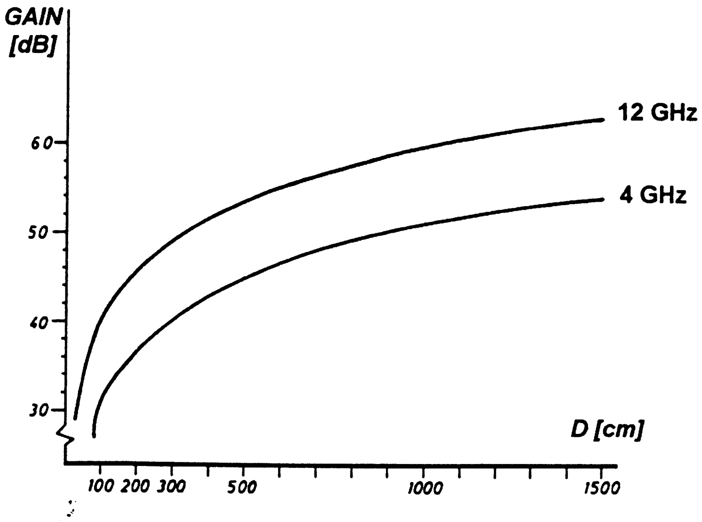
- match between the feedhorn and the parabolic surface
- size or diameter D [cm] of the aperture
- type of surface (accuracy) or efficiency E (%) (common E=55-65%)
- wavelength λ (cm)

or in a formula:

$$G=10\log\{E(\pi D/\lambda)^2\} \quad [dBi]$$

G	= antenna gain (dBi)
D	= antenna diameter (cm)
λ	= wavelength (cm)
E	= antenna efficiency (%)

For example, a 2.4 meter 12 GHz antenna with an efficiency of 55% has a gain of 47 dBi.



Average antenna gain versus aperture diameter

3.11.6. Loss of Gain with Surface Irregularities

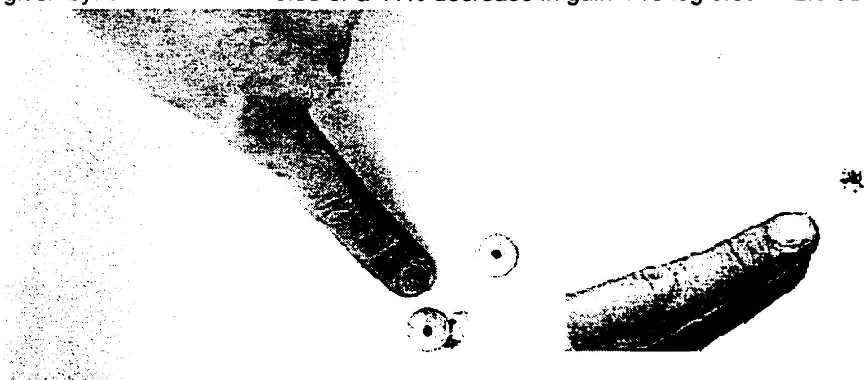
Damages or other surface irregularities may affect the antenna gain in a negative way because its focal point is longer be a well-defined, sharp point. The result of surface irregularities are loss of antenna gain and an increase in side lobe levels.

The decrease of gain relative to a perfect antenna having no surface irregularities is given by:

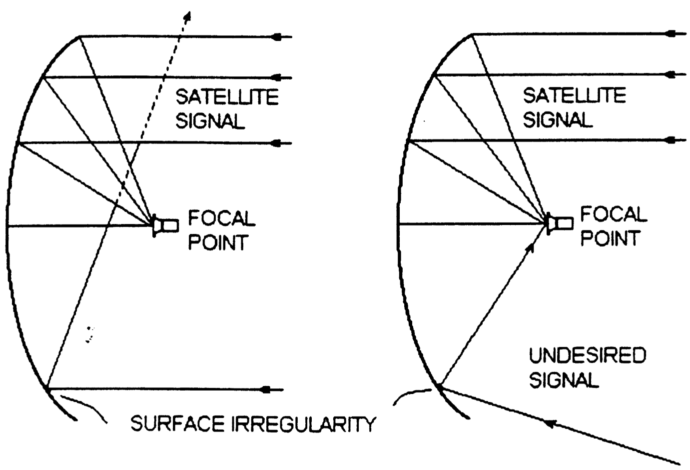
Loss of Gain = $e^{-8.80(RMS)/\lambda}$ [dB]

RMS is the surface error (cm)
λ is the wavelength of the incoming signal (cm)

For a Ku band antenna (λ = 2.5 cm) with a RMS tolerance of 0.15cm has decrease in gain relative to a perfect antenna given by: $e^{-8.80 \cdot 0.15/2.5} = 0.59$ or a 41% decrease in gain$\Rightarrow$10 log 0.59 = -2.3 dB



Two practical examples of surface irregularities, little damages of the aperture due to bad packing



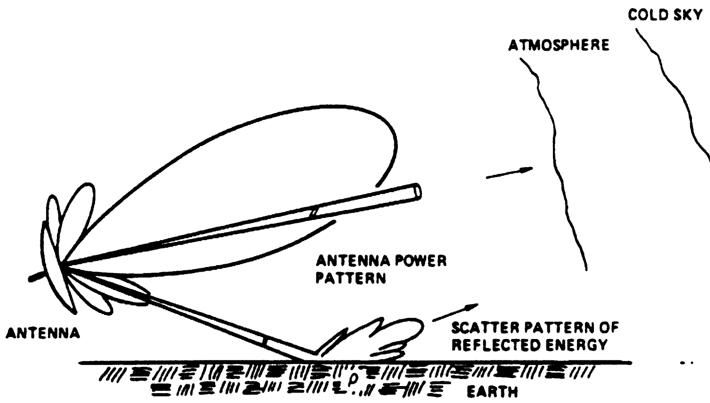
Surface irregularities affecting the radiation pattern

Normally a feedhorn movement of 2 cm up, down or to the side is reflected in a drastic drop in signal strength. If the same feedhorn can be moved over more than a few centimeters before the signal drops off noticeably, and if the signal level seems too low, then the reflective surface is probably inaccurate because it is pitted, badly rippled or sags in one area.

3.11.7. Antenna Noise

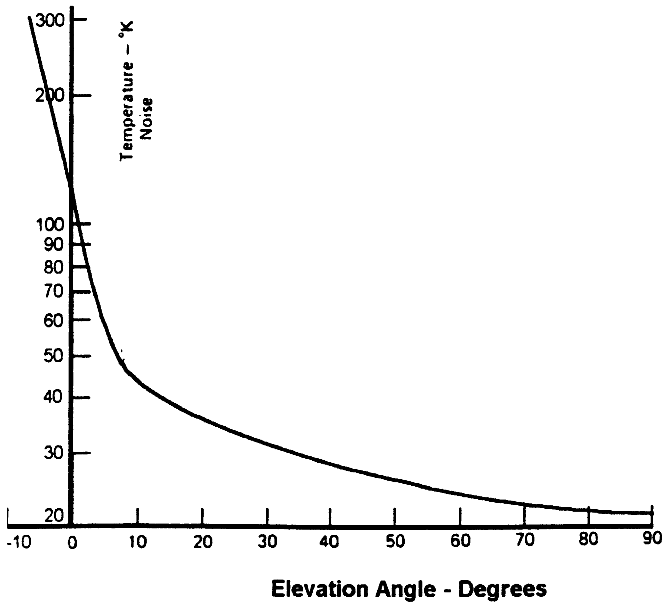
Antenna noise temperature is essentially a measure of how much noise the antenna system detects from the surrounding environment. A typical antenna noise temperature lies in the range, 50K to 100 K. However the overall noise temperature depends upon the direction in which the antenna is looking. At lower look angels (<7°), antennas begin to pick up noise caused by the ambient temperature of the earth. Since the warm ground emits radiation, noise temperature increases as an antenna is pointed at regions progressively further from the equator. Near the equator the sun is the main noise source. In addition less efficient antennas pick up more noise through relatively larger side and back lobes.

Sky noise temperature 'seen' by an antenna (see also 3.12.1)	
Sun	6000 K
Moon	20 K
Average star	1/2 k



Simplified illustration showing the concept of antenna temperature

Since the earth radiates noise, there is a look angle at which satellite signals can no longer be demodulated. As a result, the practical limit for viewing satellites is at an elevation of about 5 degrees above the horizon.



Larger antennas detect less noise because they have smaller side lobes and a more narrow main lobe. Also offset dishes benefit both by not collecting excessive snow loads and having their feeds angled farther away from the "noisy" ground.

The figure at left shows the relationship between look angle and noise

3.11.9 Manufacturing Materials

Typically, the antenna is manufactured of RF reflecting material in the geometric form of a parabola. There are four different categories.

- Fiberglass coated with RF reflecting material are easy to assemble but heavy.
- Spun or hydroformed aluminum/steel antennas have one of the most accurate parabolic surfaces.
- Stamped aluminum or steel antennas are also made.
- The screen mesh or perforated steel/aluminum type doesn't perform well at Ku band because the hole size is generally too large.

Offset antennas are typically produced by fiberglass and stamping.

Currently, antennas used for terrestrial communications, *i.e.*, point-to-point microwave, are of a one-piece construction, that is, they are formed as a single unit on a mold the same size as the finished reflector. Satellite earth station antennas, on the other hand, are of a segmented construction, the segments being high-pressure compression molded. Because earth station antennas can be shipped in segments, they offer significant savings for the customer in freight costs and are particularly easy to handle on site, reducing overall installation costs.

3.12. C/N and C+N/N

As with analogue transmission, the main criterion for digital communications is still the accuracy of the received information. The performance of a satellite link is considered in two parts:
1. The RF link, deals with the carrier signal strength with respect to the noise signal strength (C/N). The carrier to noise ratio depends on the characteristics of the radio terminals, the characteristics of the propagation medium, and the possible interference.
2. Modulation, multiplexing & multiple access, deals with channel performance and is dependent upon the techniques and hardware used.

The quality of a satellite link depends very much on:
- Received level
- Bandwidth
- Error Correction Technique
- Noise (from all possible sources, including interference)

3.12.1 C/N

The quality of the modulated signal is usually referred to by its carrier-to-noise (C/N) ratio and *after* demodulation by its S/N or Eb/No ratio. The important feature of any signal processing must be to maximize the S/N or Eb/No ratio to obtain a high-quality analogue signal or minimize the error rate in a digital signal.

C/N or S/N or Eb/No is used to state the quality of the (satellite) channel and represents how much carrier power is being provided with respect to the amount of noise power present at the receiving device input of the earth station.

C/N is calculated at many points in a communication system. Its value can determine problems and trade-offs between:
- Transmitpower
- Antenna gain
- System losses due to atmosphere and hardware
- Receiver capability

Typical signal to noise ratios include
⇒ 52 dB (4 Mhz) for “snow free” AM television
⇒ 12 dB (3 kHz) for intelligible voice communications
⇒ 7 dB (3 kHz) for 99.9 % data transmission

Several carrier to noise hardware configurations can be used to measure the ratio but most of these set-ups resemble that of a spectrum analyzer. Important is that the noise floor of the analyzer must be (at least 10 dB) lower than the noise contributed by the device under test.

3.12.2. C+N/N

C+N/N represents the carrier plus noise to noise ratio and is displayed on the screen of a spectrum analyzer used to measure satellite carrier signals.

The Noise (N) is the cumulative amount of noise contributed by every active and passive device in the path between the transmit earth station, modulator output and the receive earth station demodulator input. It includes noise added by the upconverter, SSPA, sky & ground, transponder and LNB in the bandwidth of the carrier.

The N in the numerator becomes insignificant at displayed C+N/N greater than 10 dB. In practice this means that C/N = C+N/N. If less than 10 dB, the N in the numerator must be calculated and the displayed value corrected accordingly. (see also 3.12.3.)

As noise power is a function of bandwidth, the spectrum analyzer resolution bandwidth filters should also be considered. Choose the bandwidths narrow enough to resolve the noise and exclude discrete signals, but not so narrow as to slow the process

3.12.3. Cross-reference tabel C/N ⇔ C+N/N

C/N given C+N/N		
C+N/N [dB]	C/N [dB]	Δ [dB]
3.0	-0.02	3.02
3.5	0.93	2.57
4.0	1.80	2.20
4.5	2.60	1.90
5.0	3.35	1.65
5.5	4.06	1.44
6.0	4.74	1.26
6.5	5.40	1.10
7.0	6.03	0.97
7.5	6.65	0.85
8.0	7.25	0.75
8.5	7.84	0.66
9.0	8.42	0.58
9.5	8.98	0.52
10.0	9.54	0.46
10.5	10.09	0.41
11.0	10.64	0.36
11.5	11.18	0.32
12.0	11.72	0.28
12.5	12.25	0.25
13.0	12.78	0.22
13.5	13.30	0.20
14.0	13.82	0.18
14.5	14.34	0.16
15.0	14.86	0.14
15.5	15.38	0.12
16.0	15.89	0.11
16.5	16.40	0.10
17.0	16.91	0.09
17.5	17.42	0.08
18.0	17.93	0.07
18.5	18.44	0.06
19.0	18.94	0.06
19.5	19.45	0.05
20.0	19.96	0.04

C+N/N given C/N		
C/N [dB]	C+N/N [dB]	Δ [dB]
3.00	4.76	1.76
3.50	5.10	1.60
4.00	5.46	1.46
4.50	5.82	1.32
5.00	6.19	1.19
5.50	6.58	1.08
6.00	6.97	0.97
6.50	7.38	0.88
7.00	7.79	0.79
7.50	8.21	0.71
8.00	8.64	0.64
8.50	9.07	0.57
9.00	9.51	0.51
9.50	9.96	0.46
10.00	10.41	0.41
10.50	10.87	0.37
11.00	11.33	0.33
11.50	11.80	0.30
12.00	12.27	0.27
12.50	12.74	0.24
13.00	13.21	0.21
13.50	13.69	0.19
14.00	14.17	0.17
14.50	14.65	0.15
15.00	15.14	0.14
15.50	15.62	0.12
16.00	16.11	0.11
16.50	16.60	0.10
17.00	17.09	0.09
17.50	17.58	0.08
18.00	18.07	0.07
18.50	18.56	0.06
19.00	19.05	0.05
19.50	19.55	0.05
20.00	20.04	0.04

N=10 x LOG10(10^(((C+N)/N)/10)-1)
(C+N)/N = 10 x LOG10(10^((C/N)/10+1)

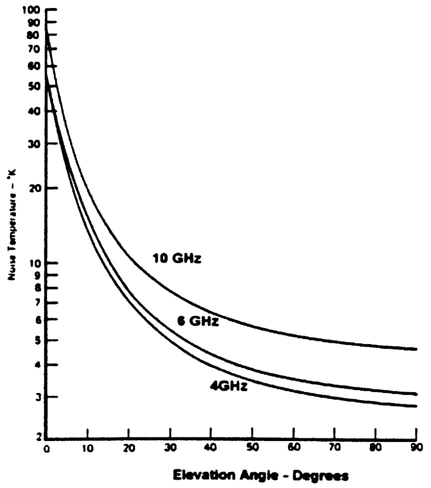
3.13. G/T, The Figure of Merit

The importance of this parameter lies in the choise that it presents to the system designer. A particular G/T ratio can be achieved with a large, very expensive, high-gain antenna, or a smaller antenna combined with a lower noise specification system. A higher G/T earth station will allow for a lower space segment utilization. So, there is a design trade-off between earth station G/T (related to a fixed equipment cost) and space segment (related to a monthly recurring cost).

3.13.1. What is G/T?

In a perfect communication system, the signal would be relayed with no interference or noise. In the real world the quality of a link is determined by the ratio of received signal to noise power [dB] which satisfies an established criterion.

The parameters which have a significant influence on the link quality are the following:



- Antenna performance
- Antenna elevation angle
  - * Thermal noise (see 3.6.6. and 3.11.7.)
  - * Sky noise *(figure left)*
- Feed and waveguide insertion loss
- LNA/B/C noise temperature
- Operating frequency
- VSWR (coupling losses) (≈ 0.5 dB)
- Pointing and polarization losses (≈ 0.5 dB)
- Gain variation vs. temperature
- Weather conditions

Relation between frequency, elevation angle and sky noise temperature.

The symbol G/T [dB/K] is called the figure of Merit and is most commonly used to relate the receiving performance of a satellite or earth station.
It represents the gain of the antenna compared to the noise temperature of all the receiving station components and is defined by:

$G/T = G_{ant} - Ts$ or $G/T = 10 \log [G_{abs} / Ts_{abs}]$ [dB/K]

G_{ant}: antenna gain in dB
G_{abs}: absolute antenna gain
Ts_{abs}: absolute overall system noise temperature
Ts: overall system noise temperature in dBK (see 3.12.2.)

example:
A 2.4 m. diameter antenna of 65% efficiency has a gain of approx 47 dBi (47.3 dBi @ 11.45 GHz) It may be pointed towards a signal source with a background noise temperature of 20 K. When used with an LNB that has a noise factor of 1.8 dB, or equivalent noise temperature of 150 K, the total noise temperature is 150 + 20=170 K = 10log170 =22.3 dB/K. The system G/T ratio is thus (47-22.3) = 24.7 dB/K

The G/T is one of the system parameters that is very much controlled by the antenna. The table below shows the relation between the antenna diameter and the *typical* G/T.

Earth Station Antenna Diameter (M)	Typical G/T (dB/K) Ts=170 K
0.85	16.1
1.2	18.7
1.8	22.3
2.4	24.8
3.5	28.1

relation between antenna diameter and G/T

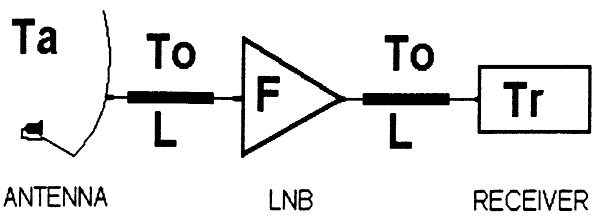
Idealy, G/T should always be measured in clear weather. Otherwise, the system noise temperature measurement will be higher than normal. Weather conditions that adversely effect the measurement, ranked from smallest to largest effect, are:

- type of clouds - cirrus clouds, stratus clouds, cumulous clouds
- snow
- (light) rain
- thunderstorms

3.13.2. Overall System Temperature

A satellite communications receiving system consists of active and passive devices. All these devices generate noise which combine to form the effective noise temperature of the cascade. This is usually carried out in terms of an equivalent overall system noise temperature Ts.

The overall system noise temperature Ts is a composite measure of receiver system performance and comprises link thermal noise, noise from the atmosphere and outer space, device noise etc.



Ta: antenna temperature - ≈ 25-100 K
L: loss (cable, etc.)
To: ambient temperature of the loss L
Tr: effective receiver temperature
F: noise figure / temperature of LNB
G: Antenna gain.

Simplified diagram of a receiving system

The lower the noise temperature of the LNA, the higher the G/T. The system noise temperature Ts is influenced largely by the noise temperatures of the components which precede the LNA and the LNA itself. The components which follow the LNA have a negligible contribution on the system noise temperature at the LNA input junction if the LNA gain is high.

3.13.3. How to meassure G/T

The G/T of an earth station is most accurately meassured using radio stars, but that is impractical for small antennas because the signal levels are too small to be easily measured. Consequently, a technique using the Orion satellite and a spectrum analyzer can be used. The test signal can be provided from two sources:

1. From the Orion beacon,or
2. From a calibrated test pilot provided by Orion .

Measurement of G/T of small antennas (less than 4.5 meters diameter) is easily and simply measured using the spectrum analyzer method described in the Procedure Manual, chapter 6. However great care must be taken to follow the instructions as small inaccuracies will result in large errors in the result.

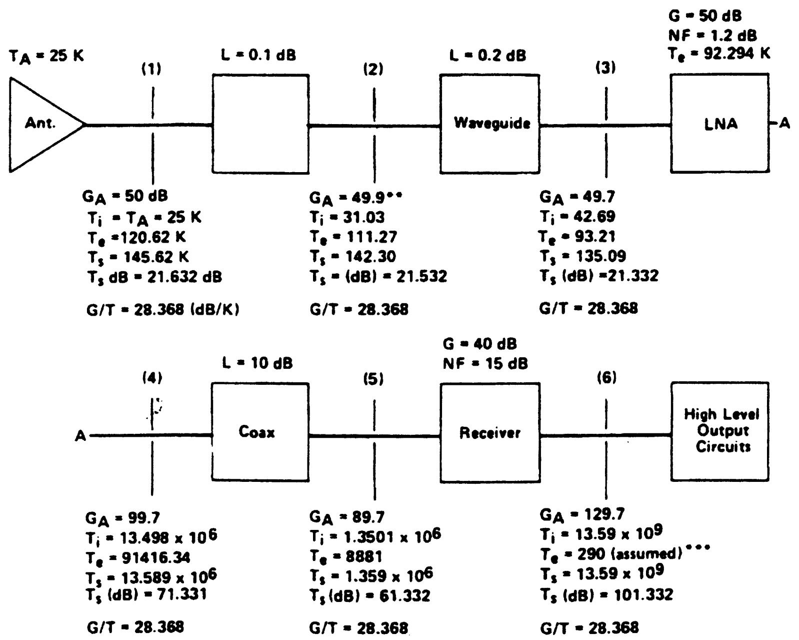
To compute the G/T the following parameters are required.

- Downlink carrier power (EIRP) [dBW],
- Pathloss [dB],
- Recorded C/N [dB] and spectrum analyzer noise power correction factor [dB]
- Noise bandwidth [dB/Hz]
- Boltzmann's constant is: 228.6 dBW/K/Hz

G/T=Pathloss - EIRP - Aspect correction - Boltzmann's constant + Noise bandwidth + recorded C/N

The downlink EIRP for the pilot of interest must be obtained from the Orion Operating Center. The path loss and the aspect correction depends on the pilot used and can be found in chapter 3.18.4.
C/N must be recorded and corrected according the procedure described the procedure manual.

An example of a complete receiving system in which both noise temperature and G/T calculations are illustrated is shown below. Note that the value of Ts is different at every junction.



Ti: internal noise temperature
Te: external temperature

Ts: Ti + Te
*** 20°C

3.14. Eb/No

Whereas the C/N ratio was a valuable indicator of analogue signal quality, in digital communication systems the primary performance specifications can be characterized by its bit error rate (BER) versus bit energy (Eb) to noise density ratio (No).

The BER is the total number of erroneous bits devided by the total number of bits received. A performance guarantee of BER=1E-6 for 99.5% availability means that for all year except 44 hours (of heavy rain, snow, sun outage, interference, etc) the link will perform at BERs much better than the threshold. During the remaining 0.5% of the time there are more errors received than usual, resulting in more re-transmissions or a 'noisy' signal.

BER versus Eb/No is a very convenient unit to use since its value is independent of data rate and occupied bandwidth

To understand the limitations of more bandwidth-efficient modulations, we need to define Eb/No and its use.

3.14.1. Eb/No, The Definition

Eb/No= C/N x W/R [dB]

Eb:	Bit energy [ ]
R:	Bit rate [bps]
No:	Noise spectral density [Watt/Hz]
C:	Average modulating carrier power [Watt]
W:	Signal bandwidth [Hz]
N:	NoW

Increasing the number of states per symbol increases the bandwidth efficiency, calculated as bit rate divided by signal bandwidth (designated R/W) and measured in bps/Hz. Unfortunately, more bandwidth-efficient modulation schemes suffer from higher BERs and higher signal-to-noise ratio is necessary to achieve acceptable error rates. A modulation scheme with a low (Eb/No) offers high power efficiency, since the signal-to-noise ratio required to carry the necessary information is lower than for a scheme that features high (Eb/No). Lower (Eb/No), however, also increases the probability of error.

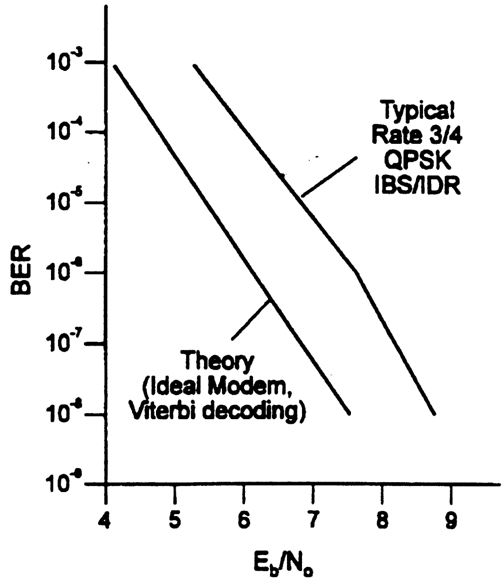
BPSK and QPSK have identical error curves, but as we increase the number of phase states beyond four (see 3.15.3.), the error rate increases for a given Eb/No. A lower Eb/No means we have less information about the state, because we have more uncertainty in the form of noise. This entropy effect causes the correct state detection probability to decline as the Eb/No declines.

Each modulation type requires a different Eb/No to produce a given bit-error rate.

This leads to the concept of power efficiency, in which the modulation types can be ranked by the Eb/No that results in a defined bit-error rate. The power-limited nature of satellite communications means that power efficiency is quite important.

3.14.2. Eb/No versus BER

The conclusion is that the bit error probability depends on the Eb/No required for a given bit error rate and also the type of modulation and encoding. As shown in de graphic below a small change in Eb/No ratio will cause a large change in BER



When the modem is connected back-to-back at IF, through an additve white Gaussian noise channel and in the presence of two adjacent carriers of the same transmission rate, the BER of the data channel measured on the terrestrial side of the FEC decoder as a function of the Eb/No at the demod input shall be **not more** than that shown in the table below.

Theory		R3/4 FEC	
Eb/No [dB]	BER	Eb/No [dB]	BER
4.2	1 in 10^3	5.3	1 in 10^3
4.7	1 in 10^4	6.2	1 in 10^4
5.3	1 in 10^5	7.0	1 in 10^5
6.1	1 in 10^6	7.6	1 in 10^6
6.7	1 in 10^7	8.3	1 in 10^7
7.2	1 in 10^8	8.8	1 in 10^8

System engineers designing or installing earth stations are interested in evaluation modem performance in terms of Eb/No vs. BER.

3.15. Calculating Absolute RX Level out of the Link Budget Variables

What is Link Budget

What a link budget actually involves is a relatively simple addition and subtraction of gains and losses within an RF link. When these gains and losses of various components are determined and summed, the result is an estimation of end-to-end system performance in the real world. To arrive at an accurate answer, factors such as the uplink power amplifier gain and noise factors, transmit antenna gain, slant angles and corresponding atmospheric loss over distance, satellite transponder noise levels and power gains, receive antenna and amplifier gains and noise factors, cable losses, adjacent satellite interference levels, and climatic attenuation factors must be taken into account.

The link budget will determine the earth station equipment necessary for a given satellite link. A careful link analysis provides the data necessary to specify what size antenna to use, SSPA or TWTA PA power requirements, link availability, bit error rate etc.

What do You need to compute the Link Budget.

The next information is absolutely necessary for a proper link budget calculation:

- The saturated EIRP and saturated flux density of the transponder.
- The satellite G/T figure appropriate to your planned uplink location.
- Satellite transponder bandwidth.
- Satellite transponder output backoff or attenuation.
- Satellite transponder input backoff or attenuation.

The above information can generally be obtained from the satellite operator, or from a good satellite database such as e.g. http://www.satnews.com on the internet. Other sources of this data include printed media, such as the Global Satellite Directory from Phillips Publishing.
You will also need the following information that you and your customer can supply:

- Latitude and longitude of the uplink and downlink earth stations.
- Planned data or information rate.
- Modulation type (BPSK or QPSK)
- Forward error correction rate (1/2 or 3/4)
- Spread Factor - if any (use only for spread spectrum systems)
- Uplink and Downlink frequencies.
- Uplink and Downlink antenna sizes.
- Uplink and Downlink antenna efficiency.
- Uplink and Downlink transmit and receive gains at frequency.
- Minimum digital signal strength (EB/No) for desired Bit Error Rate (BER) performance.

Fortunately in this age of computers and spreadsheet programs, the link budget does not have to be all that difficult to compute. Several companies now market quite sophisticated link budget calculation programs that contain large databases of information regarding satellite performance parameters, ground station antenna performance data, and other information vital to calculation. With one of these programs, all the user must do is fill in the blanks regarding earth station location, planned satellite(s) to use, required link availability, and – quick as a wink – the program generates a very good estimation of link performance.

In Ku band networks, it is a good rule of thumb to allow 7 or 8 dB of margin above threshold at the receive site with clear sky conditions.This will generally provide a link availability in excess of 99.5%. C band networks require much less margin, typically about 3 dB, for the same performance expectation, since there is less atmospheric attenuation with the C band.

Most satellite operators limit satellite received EIRP to a specific maximum level of 6dBW/4kHz, or about minus140 dBW per square meter on the ground. If spectral density exceeds these limits, you should use better LNB/C's or larger receive antennas to lower the power requirements. You can also spread the signal over greater bandwidth; either by changing FEC rates, changing modulation formats from QPSK to BPSK, or by using some form of additional signal spreading. With today's newer satellites operating at 4 times traditional satellite power levels, the established limits can become a problem with even balanced power / bandwidth carriers.

An in depth example of a link budget calculation is shown in the diagram on the next pages

ORION Network Systems Europe, Inc.

Carrier / Modem Information & Link Performance Requirements

Ckt Ref#:	2	Modem Make:	Fairchild SM2800
Network:	PTT		
		Step Size:	2.5 kHz
Information Rate:	64 kbps	Min. Allocatd BW:	25 kHz
Modulation Type:	QPSK	Symbol BW:	42.7 kHz
Code Rate:	3/4 Sequential	Noise BW:	51.2 kHz=1.20 SBW
Link Availability:	99.52%	Abs. Min. Alloc. BW:	59.7 kHz=1.40 SBW
		Actual Min. Alloc. BW:	60.0 kHz=1.41 SBW

RFT Information

	Uplink	Downlink	
Site Code:	Vienna	Reston	
Country:	Austria	USA	
Latitude:	48.2	38.9	N
Longitude:	-16.37	77.00	W
CCIR Rain Zone:	H	K	
Satellite G/T & Saturated EIRP:	7.5	50.8	dB/K & dBW
Azimuth:	241.4	127.3	degrees
Elevation:	14.7	29.3	degrees
Slant Range:	40155	38738	km
A (0.01%):	14.3	9.9	dB
Antenna Diameter:	2.4	2.4	m
HPA & LNA:		110	W & K
Waveguide Loss:		0.2	dB
Antenna Gain:	49.3	47.7	dBI
Antenna Efficiency:	0.65	0,65	
Antenna Noise Temp @20° elev:		32	dB/K

Satellite Information

Satellite:	Orion-F1
Transponder:	32
Longitude:	37.5W
Actual BW	54 MHz

	Uplink	Downlnk	
Beam Coverage:	E	NENA	
Beam Type:		SB	
Center Frequency:	14.341	12.041	GHz
Polarity:	V	V	
Total Operating point:	3.0	3.2	dB
G/T & EIRP Reference Contours:			dB/K & dBW
Xpdr Constant at Gain Setting of 0 dB:	-74.3		dBW/m^2K
Gain (Pad) Setting:	10.0		dB
Effective Xpdr Constant:	-84.3		dBW/m^2K

Space Segment Requirements

BW must be purchased in multiples of: 5 kHz from 54 MHz of useable transponder BW

Power:	0.0708% which is	34.7 dB COPBO	ref. to	3.2 dB	TOPO
Limited by BW:	0.1111% which is	60.0 kHz	ref. to	54 MHz	useable BW
Equivalent:	0.1111% which is	32.7 dB COPBO	ref. to	3.2 dB	TOPO
Power & BW:		60.0 kHz	ref. to	54 MHz	useable BW

Uplink Requirements

Power at HPA Flange:	-12.0 dBW	=0.06 W
Insertion Loss	0.5 dB	
Power at Antenna Flange:	-12.5 dBW	=0.06 W
Power Density at Ant. Flange:	-23.6 dBW/4kHz	
EIRP Density:	25.5 dBW/4 kHz	
EIRP per Carrier:	36.8 dBW	

Link Calculation

Probability of Rain Loss		Clear Sky	Rain on U/L 0.38 %	Rain on D/L 0.10 %	
Uplink					
Earth Station EIRP:	A	36.8			dBW
Path Spreading Loss:	B	163.1			dBm^2
Rain Loss:	C		2.9		dB
Power Flux Density:	D=A+B+C	-126.3	-129.2		dBW/m^2
Saturation Flux Density:	E	-91.8			dBW/m^2
Carrier Input Backoff:	F=E-D	34.5	37.4		dB
Area of Isoytropic Antenna:	G	-44.6			$dB\ m^2$
Satellite G/T:	H	7.5			dB/K
Boltzmann's Constant:	I	-228.6			
C/No:	J=F+G+H-I	65.2	62.4		dBHz
Noise Bandwidth:	K	47.1			dBHz
C/N	L=J-K	18.1	15.3		dB
Cross-Pol C/I:	M	25.7	22.9		dB
Adjacent Satellite C/I:	N	22.7	19.9		dB
Total C/I:	O	21.0	18.1		dB
Total C/(N+I):	P	16.3	13.4		dB
Downlink					
Saturated EIRP::	Q	50.8			dBW
Carrier Output BackoffL:	R	34.7	37.6		dB
Carrier EIRP::	S=Q-R	16.1	13.2		dBW
Path Spreading Loss:	T	162.8			dBm^2
Rain Loss	U			3.8	dB
Pointing Error Loss:	V	0.5			dB
Power Flux Density:	W=S-T-U-V	-147.2	-150	-151	dBW/m^2
Area of Isoytropic Antenna:	X	-43.1			$dB\ m^2$
Earth Station G/T:	Y	25.7		22.8	dB/K
Boltzmann's Constant:	I	228.6			
C/No:	Z=W+X+Y-I	64.1	61.2	57.4	dBHz
Noise Bandwidth:	K	47.1			dBHz
C/N	A'=Z-K	17.0	14.1	10.3	dB
Xpdr IM C/I:	B'	14.9	12.1		dB
Cross-Pol C/I:	C'	25.7	22.9		dB
Adjacent Satellite C/I:	D'	22.2	19.4		dB
Total C/I:	E'	13.9	11.0		dB
Total C/(N+I):	F'	12	9.3	8.7	dB

Link Calculation					
Total Link					
C/N:	I'	14.5	11.6	9.6	dB
C/I:	J'	13.1	10.3		dB
C/(N+I):	K'	10.7	7.9	8.0	dB
Noise Bandwidth:	K	47.1			dBHz
C/(No+Io):	L'	57.8	55.0	55.1	dBHz
Information Rate:	M'	48.1			dBHz
Ebi/(No+Io):	N'=L'-M'	9.8	6.9	7.0	dB
Rain Margin:	O'	2.9	0.0	0.1	dB
Implementation Margin:	P'	0.5			dB
Target Ebi/No:	Q'=N'-O'-P'	6.4			dB

An example of a rough analysis of the received C/N at an earth station (E/S) is shown below.

Downlink EIRP towards E/S-rx (from link calculation):	**+ 27.2 dBW**
Adjustment for actual level:	- 3 dB
Path loss towards E/S:	- 205.6 dB
Link Margin for rain, tracking etc.:	- 5.5 dB
RX Antenna gain (2.4 meter dish):	+ 47.5 dB
Loss (waveguide):	- 0.3 dB
Gain of the receiver unit (± 5 dB variation unit to unit):	+ 85 dB
Line Amplifier:	+ 20 dB
Worst case signal level at transceiver output:	**- 34.7 dBW = - 4.7 dBm**
IF cable loss e.g. 1000 ft at 1.3 dB/100 ft:	- 13 dB
Total divider loss (one 1:2):	- 3.7 dB
Connector losses:	- 1 dB
Worst case signal level into demodulator:	**- 22.4 dBm**

3.16. Modulation

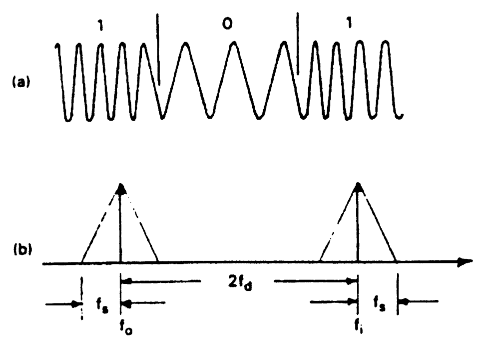
Modulation is the processby which intelligence, to include voice, data, and/or video, is added or encoded onto a carrier wave. Among other methods, this can be accomplished by frequency(FM), amplitude (AM) or phase (PM) modulation

Amplitude modulation (AM) encodes the information by changing the voltage, current, or power of the carrier signal. Frequency modulation (FM) encodes the information by changing the frequency of the carrier signal. Phase modulation (PM). encodes the information by changing the phase of the carrier signal.

There are hundreds types of modulation and many of them, to understand them well, require highly developed skills in electronics and mathematics. Pure AM is being used lless frequently, while FM types of modulation are still widely spread and PM types are becoming rather popular. For Orion VSAT systems, important are: FSK (because it is the base), BPSK and QPSK (the latter two are both derived from PSK)

3.16.1 FSK, Frequency Shift Keying

This method involves switching the RF carrier frequency between two discrete values, each representing logic 0 or logic 1.

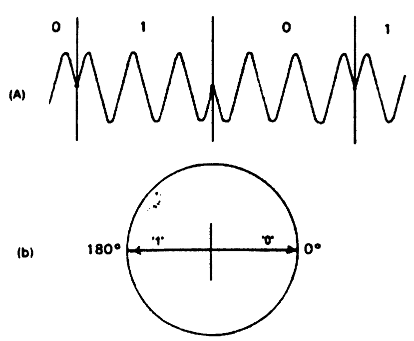


(a) Frequency shift keyed signal waveform
(b) The frequency spectrum

Minimum shift keying (**MSK**) is a special case of FSK in which the frequency shift is exactly twice the data bit rate and therefore represents the minimum possible spacing that allows the two states to be orthogonal to one another. MSK permits very narrow bandwidths for a given data rate. The 25 kbps data stream above would require only 30 kHz bandwidth. Therefore, GSM, PCS, and other cellular communications standards have adopted a type of MSK called Gaussian minimum shift keying (GMSK), where Gaussian baseband filtering smooths the frequency changes in the MSK signal.

3.16.2 PSK, Phase Shift Keying

This is essentially a single frequency method where the data stream causes the carrier phase to change.



(a) Phase shift keyed signal waveform
(b) The phasor diagram

BPSK

In binary phase-shift keying (BPSK or 2-PSK), for example, a carrier phase of 0° represents a bit value of zero, while a bit value of one produces a carrier phase of 180°. At one bit per symbol, this simple approach transmits data very accurately, but requires a lot of bandwidth. A data stream of 25 kbps, for example, would require a bandwidth of 225 kHz, clearly excessive for cellular phone and other practical applications.

More advanced modulation techniques convey multiple bits of information simultaneously by providing multiple states in each symbol of transmitted information.

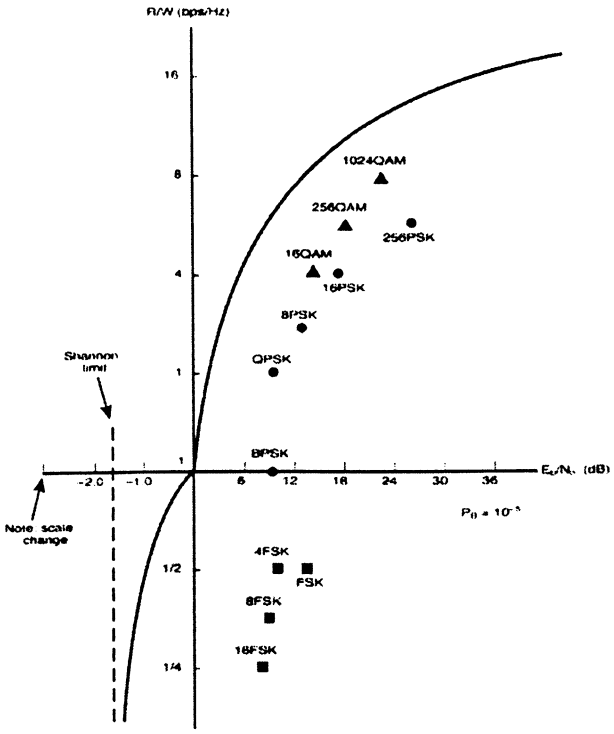
QPSK

QPSK is the most common modulation technique in satellite systems. Quadrature phase shift keying (QPSK or 4-PSK) conveys 2 bits per symbol. Some systems use 8-state PSK (8-PSK) More advanced variations permit a symbol to have more than two states, so it contains more than one bit. In quadrature (4-state) phase shift keying (QPSK), the carrier has four possible phase states 90° apart, representing binary combinations 00, 01, 10, and 11. Because the bit rate for this transmission is twice the symbol rate, the bandwidth necessary to convey a specific quantity of information is comparably smaller. The same 25 kbps data stream requires only 100 kHz - still too high, but better than for BPSK. Extending this principle, eight-state PSK (8PSK) offers 3 bits per symbol, 16-state PSK provides 4 bits, and so on.

The set of available transmission symbols in a particular modulation scheme is known as its alphabet. A graph of the alphabet on a complex plane is called a constellation. The alphabet for a quadrature phase shift keying (QPSK) approach, for example, might consist of the set of complex numbers A = {+1+j, +1-j, -1+j, -1-j}. The figure below shows the corresponding graph, as well as graphs for several other common schemes.

3.16.3. Other Common Types of (Digital) Modulation

Very popular in the world of "digital video" are Quadrature amplitude modulation (QAM) systems. QAM combines PSK and ASK to increase the number of states per symbol. Each state is defined as a specific amplitude and phase. This means that the generation and detection is more complex than a simple phase detection or amplitude detection device.



The highest schemes on the graph are the most bandwidth efficient. As an example, note that bandwidth efficiencies for 16-QAM and 16-PSK are identical, but QAM is more power-efficient and is therefore preferred. The curve itself represents the Shannon Limit - the absolute maximum amount of information that can be transmitted for a given bandwidth and S/N ratio.

Each time the number of states per symbol is increased, the bandwidth efficiency also increases. This bandwidth efficiency is measured in bits per second/Hz (bps/Hz). The modulation schemes shown in the figure all occupy the same bandwidth (after comparable filtering), but have varying efficiencies of 1 through 4 bps/Hz. Since more states produce a higher channel throughput, it would seem that increasing the states would provide a simple way of increasing channel capacity. Unfortunately, entropy prevents us from taking full advantage of the increased states.

By comparison of FSK to PSK, PSK has the advantage of the narrowest bandwidth and the capability of expansion to carry even more data without an increase in bandwidth.

Digital signals are often transmitted close to each other and to limit the amount of energy that falls outside the bandwidth allocated to each carrier, the transmitted signals will be filtered. The digital signal is also filtered at receiption to limit the amount of noise and to reject other signals transmitted outside the allocated bandwidth.

3.17 Encoding

3.17.1. Introduction

In satellite communications in general and in Orions satellite communications in particular, digital carriers in the great majority of cases employ either QPSK or BPSK, always associated with the use of some kind of FEC (Forward Error Correction).

FEC is a type of (convolutional) coding where the decoder obtains an estimate of the information sequence without the aid of a feedback channel. Convolutional coding combats errors by inserting error-correcting bits in the transmit information stream. These error correcting bits are injected into the stream via a shift registrer, which gives the coding process a "memory." The memory effect allows the decoder to correct many short duration error sequences by predicting the most likely value of the input information stream.
E.g. K=7 and 1/2 rate refer to the mechanics of convolutional coding. K is the constraint length and also the shift register length. A 1/2 rate channel would contain one input bit for every two bits transmitted.

The use of encoding and error control is highly desirable since satellite power is expensive and higher data rates, *without the increase of bandwidth*, are required. FEC also can be used to improve bit error performance on a marginal circuit or to lower Eb/No requirements without impacting error performance on other digital circuits.

Common schemes of encoding are 7/8, 3/4 and 1/2 rate Forward Error Correction. In this course we will only focus on the more popular modulation and FEC systems used in Orions satellite transmissions as there are:

- QPSK with Rate 1/2 or Rate 3/4 FEC
- BPSK with Rate 1/2 FEC

Using R1/2 FEC, an encoding bit is inserted for every information bit. Using R3/4 FEC, an encoding bit is inserted for every three information bits.
1/2 Rate encoding has *higher* bandwidth but allows a *lower* G/T than R3/4
3/4 Rate encoding has *lower* bandwidth but needs a *higher* G/T than R1/2

Modulation type	Datarate	FEC	Bandwidth
QPSK	64 kHz	R1/2	90 kHz
QPSK	64 kHz	R3/4	60 kHz
BPSK	64 kHz	R1/2	180 kHz
BPSK	64 kHz	R3/4	120 kHz

For SCPC applications Orion uses three different types of encoding:

- Sequential
- Viterbi
- Reed-Salomon

13.17.2. Sequential Encoding

A decoding technique for (convolutional) codes which invloves searching through the code tree representation. The search or computation time is random variable depending on noise statistics.

13.17.3. Viterbi Encoding

Is a maximum-likelihood technique used for short-constraint-length convolutional codes. Viterbi has less delay at a lower datarate than Sequential. Viterbi decoding works best with random input noise found in a satellite link. The output-error performance of a Viterbi decoder is bursty in nature and works well as the input to a Reed-Solomon decoder.

13.17.4 Reed-Solomon Encoding

Typically, Reed-Solomon coding is used in areas where sensitivity to transmission errors is particularly high. The Reed-Solomon option is particularly well suited to data communication applications with little or no packet acknowledgement or no packet retransmission. Also broadcast applications, digital video, and generally power-limited satellite links gain performance from the Reed-Solomon module. Power efficiency gains are highest when the sensitivity to errors occurs at BERs of 10-6 or lower. For instance, at 10-7 BER, using Reed-Solomon Coding can save 3 dB in Eb/No over Viterbi decoding alone - a savings of 50% in the amount of satellite power required for the link. This savings in power can be converted into a savings in bandwidth by using lower code rates in the underlying system. For example, using rate 3/4 Viterbi coding instead of rate 1/2 for the underlying code saves 33% in bandwidth at the expense of an extra 1 dB in Eb/No. (see 3.17.)

Reed Salomon Encoding decreases satellite power required for specific BERs by up to 20-50% (1 to 3 dB). It virtually eliminates all errors at nominal Eb/No levels. However for this better BER perfomance at a lower C/N (6 dB) is 10% more bandwidth required.

The Reed-Solomon Codec (Coder-Decoder) is a block oriented coding system that is applied on top of standard Viterbi coding. It corrects the bulk of the data errors that are not detected by the other coding systems and works best in a burst error enviroment

13.17.5. Video Encoding

Among the most prominent new technologies being adopted in the digital broadcasting world are video compression systems as MPEG2/DVB. These systems are being used to digitize and to compress analog transmissions. Without going in depth, a brief list of advantages over analog systems could include:

- The video quality remains the same thoughout the network. No snow, no artifacts, no degradation, as long as the C/N is above the threshold.
- Encryption and conditional access keys designed for truly anti-piracy protection.
- Full flexibility in terms of bit rates and number of channels per carrier.
- More channels per transponder.

13.17.6 Scrambling

If digital signals at the input of a phase modulator are not scrambled, long sequences of zeros may be present at the input of the modulator resulting in a non-modulated tone at the output. To ensure that a uniform spectral spreading is applied to the transmitted digital carrier at all times, a data scrambler should be provided. V.35, or a functional equivalent with similar spectrum spreading characteristics, shall be used.

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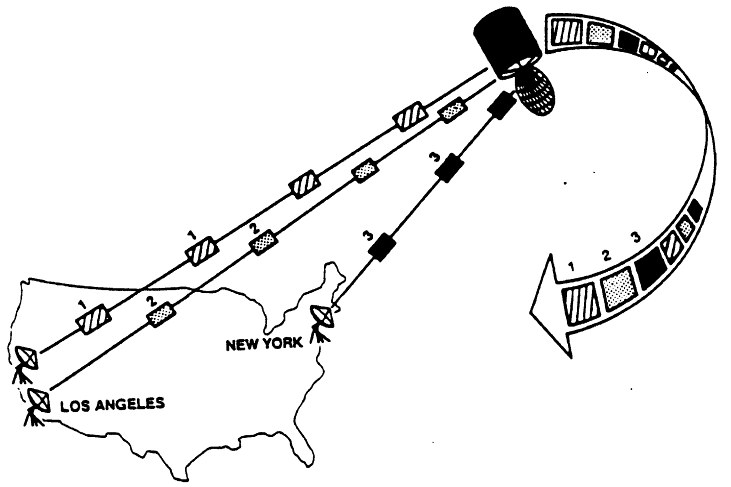
3.18. Multiple Access Techniques

3.18.1. Introduction

Other than broadcasting, most current satellite uses tend to be "stand-alone" circuits. They have tended to emphasize the point-to-point aspect of the links, independent of any circuit switching. Single Channel Per Carrier Frequency Division Multiple Access (SCPC FDMA) is the original and, currently, the standard method of putting multiple carriers on a satellite transponder. Each carrier is assigned a subset of the transponder bandwidth on a "permanent" basis. The advantages of this system are proven technology, a wide range of data rates, and inexpensive earth station hardware.

This technique has the disadvantage of supporting only full-time fixed point-to-point service. The major expense of most satellite users is the recurring cost of satellite bandwidth. This expense can be much greater than the equipment cost over the life of the system. Relatively few users need the circuit 24 hours a day, yet they generally have to pay full-time rates. Most of the growth in the full duplex (transmit/receive) segment of the satellite communications market will be a result of further application of multiple access techniques. For link transmission, there are currently four preferred multiple access techniques used in VSAT networks:

- Random Access Method (RAM): Allows an earth station to transmit whenever it is ready to send information without having to wait for a time slot or a command from the network control center. If the information is successfully received by the satellite, it is then repeated or retransmitted to the network Hub
- Frequency division multiple access (FDMA): Refers to the use of multiple carriers within the same transponder where each uplink has been assigned frequency slot and bandwidth. This is usually employed in conjunction with Frequency Modulation.
- Code Division Multiple Access (CDMA): Using spread spectrum technology and is specially developed for C-band applications. CDMA allows several users to share one satellite channel simultaneously. However, systems using spread spectrum technology are very bandwidth-inefficient.
- Time Division Multiple Access (TDMA): Devides the transmission and access time to a satellite channel into slots. A given remote channel is assigned a specific time slot in which it can transmit in order to access and utilize the satellite channel. The next time slot is assigned to a different remote terminal for its transaction (figure below)



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Because of the great importance of TDMA for the Orion Atlantic VISN product this course will be focused on TDMA only.

In a TDMA network, each station has a buffer that stores its data to be transmitted. With control from a designated master station (Hub), individual buffers of each transmitter (VSAT site) deliver intern stored data in bursts to the satellite. The satellite actually sees these data bits (bursts) as a virtually continuous transmission stream even though some stations are farther from the satellite than others. These differences have to be taken into account in calculating transmit and propagation timing adjustments (ranging). TDMA bandwidth is typically assigned on units of 2.048 Mbps

3.18.2. Advantage and Disadvantages of TDMA:

The advantages of Time division Multiple Access are:

- In heavy traffic conditions, the channel is accessed almost continuously. This results in a high system throughput
- TDMA reduces space segment charges substantially. For the target medium- density traffic routes, TDMA space segment costs are:
    - 50% less than FDM/FM
    - 56% less than SCPC
- TDMA can be used for the full range of international and domestic PSN applications, including:
    - Voice transmissions
    - Data transmissions
    - Digital television
    - Videoconferencing
    - Audio or printed material distribution
    - ISDN applications
    - Dedicated private digital networks (virtual private networks)

The most important disadvantage of TDMA is that in thin traffic conditions, delays may be longer than other access techniques. If one terminal needs to communicate, it must wait for its assigned timeslot.

More in depth information concerning TDMA Techniques in the Ground Operator VISN Manual (available mid 1997)

ORION Network Systems Europe, Inc.

Chapter 4
The Orion Satellites
Orion 1, 2 & 3

Table of Contents

4.1. Orion 1, The Digital Satellite

4.1.1. Introduction

The Orion 1 spacecraft was launched November 29, 1994 and was brought into geostationary orbit, 22,300 miles above the Atlanic Ocean at 37.5° West longitude by an Atlas Centaur launch vehicle. Its country of origin is the United States, and its mission is telecommunications.

The Centaur delivered Orion 1 into an unprecedented elliptical transfer orbit of 403 x 122762 km x 25.5°. The orbit was then raised to 25010 km x 122766 km x 3.0°. The apogee was then lowered until reaching GEO. The fuel-saving high apogee transfer technique had been used before, but never with such an extreme apogee.

Typical uses of Orion 1 include analog and digital voice, video, and data, as well as, the next-generation transportable low power digital satellite news gathering (SNG) terminals and full-connectivity VSAT networks.

The Orion Atlantic satellite system has been specifically optimized for small diameter earth stations (VSATs with a antennae smaller than 3 meters thah use low power amplifiers) and digital services. High quality broadcast video and data can be received using one meter diameter and smaller ground stations. Uplinks can relay either digital or analog transmissions of the same message. Converters that can translate between these two "languages" are available. However, the trend is to use digital, allowing higher amounts of information to be transmitted.

4.1.2. Orion 1, The Advantages

By comparison to other satellite systems, Orion 1 offers the following advantages:

- First transponder switching satellite
  - ⇒ Europe to Europe
  - ⇒ Europe to US
  - ⇒ US to Europe
  - ⇒ US to US
- Extremely large coverage areas under a single satellite
- High power output

4.1.3. Orion 1, Special Features

Orion 1 has many features that enhance performance flexibility and reliability. A few of these features are described below:

- On-board switching matrix: One of the significant features of the satellite design is its ability to reconfigure (by means of on-board switching capabilities) the 34 transponders into various geographic coverage areas to meet customer's changing communication requirements. The satellite system allows uplinks from either North America or Europe or, in some cases, uplinks from both regions combined within the same transponder. On the downlink available options allow connecting to any one of multiple North American or European beams or combining spot beams.
- Transponder gain setting: The transponder gain is controlled from the ground in 0.5 dBm steps over a 20 dB gain range. The variation in Orion 1 transponder gain is less than 2 dB peak-to-peak in any 24-hour period and less than 3 dB peak-to-peak over the life of Orion 1.

4.1.4. Orion 1, Technical Review

Technical spacecraft data:

- Prime contractor: Matra Marconi Space
- Platform: Eurostar 2000
- Mass at launch: 2350 kg
- Payload mass: 375 kg
- Dimension: 1.7 x 1.6 x 2.1 m
- Stabilization: 3 axis (East-West at +/-0.05 and North-South at +/-0.05)
- DC power EOL: 3200 W
- Payload power: 3100 W (in eclipse)
- Satellite location: 37.5° West longitude
- Design lifetime: 12 years

Orion 1 has 34 Kuband transponders, 6 transponders with 36 MHz and 28 transponders with 54 MHz bandwidth. To provide transponder redundancy, six additional spare amplifiers are available.

Transponder power:			15 W
Transponder frequencies:	Europe	uplink	14.00 - 14.50 GHz
		downlink	11.45 - 11.70 GHz
			12.50 - 12.75 GHz
	North Am.	uplink	14.00 - 14.50 GHz
	North Am.	downlink	11.70 - 12.20 GHz
EIRP spot beam:			50 dBW
EIRP zone beam:			45 dBW
Coverage Europe:			3 spots and 1 broad beam
Coverage America:			4 spots and 1 broad beam
Polarization:			Linear
Bandwidth:			36 MHz or 54 MHz
Satellite G/T:			7 to 10 dB/K
Saturation flux density			
The saturation flux density (SFD):			independently settable for each transponder over 20 dB range, in 0.5 dB steps.

Saturation flux density SFD (dBW/ m2)) is defined as:

- For 54 MHz channels: -(74.3 + G/T) to -(94.3 + G/T)
- For 36 MHz channels: -(75.3 + G/T) to -(95.3 + G/T) G/T:dB/K

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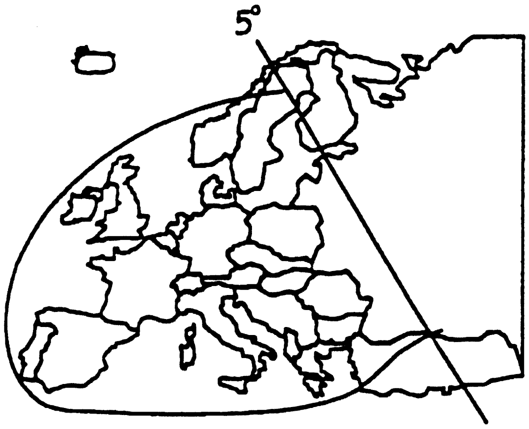
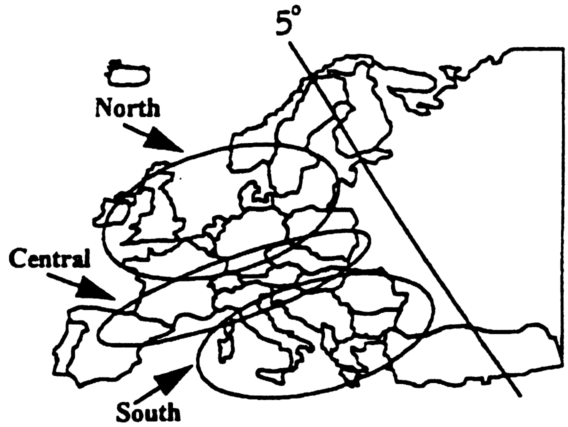
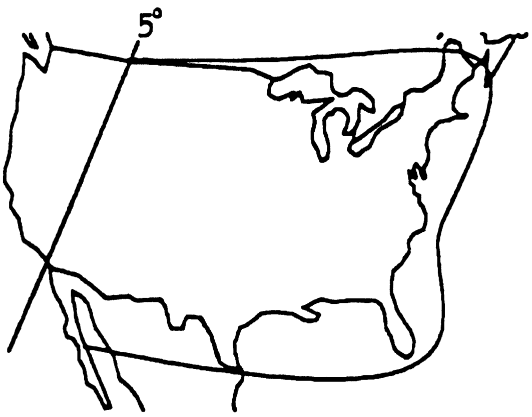
Orion 1 currently provides coverage to 34 European countries via a combination of European broad and spot beams.

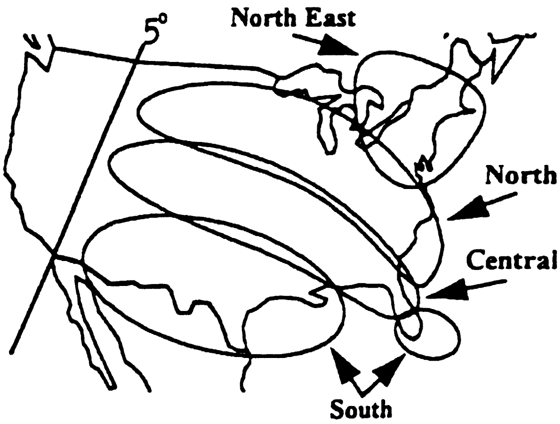
Specifications are shown in the coverage maps below.





The eastern two-thirds of the United States and portions of Canada and Mexico are also covered by Orion 1 North American broad and spot beams. The coverage is pictured below.





Anywhere within either of these footprints, Orion can establish for its customers fast, easy, barrier free, international, private network interconnectivity within sixty days.

Orion 1 has a multitude of beam switching and cross-strapping capabilities. For example, Orion 1 users can uplink from North America or Europe and downlink on various spotbeams in North America or Europe. For instance, users can downlink into the northeastern U.S. or northern U.S. spotbeams, or combine the two. It is even possible to combine all of the spotbeams in North America and europe, respectively

4.1.5. Beacon and Continuous Wave (CW) Pilot Carrier Technical Data

Orion 1 has two telemetry beacons that can be used to locate the satellite and to position the antenna.

Beacon 1:	11,450500 GHz
Beacon 2:	11,451000 GHz

Both beacons cover Europe and North America and have LHCP-polarization. The modulation is BPSK.

Orion has three linear polarized CW pilot carriers. The table below describes them.

Region	Frequency (GHz)	Pol.	Path loss (dB)
Europe HB	12,528000	V	206.4
USA	11,728000	H	205.6
Europe LB	11,656260	V	205.7
Frequency Stability: 10 ppm EIRP Stability: 0.5 dB (24 hours)			

4.1.6. The Orion 1 Antennas

The dual-reflector geometry of Orion 1's antenna subsystem provides dual linear orthogonal uplinks and downlinks in the following manner.

- Antennas are dual-gridded reflectors, with each dual assembly consisting of one custom shaped reflector (an associated single-feed horn assembly) and one parabolic reflector (an associated multiple-feed horn assembly).
- The custom shaped reflectors provide the broad beam downlinks; and the parabolic, multi-feed antennas provide the spot beam downlinks.
- Both horizontal and vertical uplink contours provide broad beam, continental coverage.
- Multi-feed spot beam downlinks are identified by NE (Northeast-North America only), N (North), C (Central) ,and S (South) beams.

4.1.7. Orion 1, Transponder Chart

Transponders are identified according to their downlink destination. Bandwidth and frequencies are shown in MHz. Uplinks to transponders are defined by frequencies, and can originate from either continent depending on the connectivity of the specific transponder.

Transponder Frequency Chart to Europe

European Broad Beam							
Downlink				Uplink			
Tr	Pol	BW	Fc	EurPol	NAPol	Fc	Notes
1	V	54	12528	H	V	14028	NTWK
2	V	54	12591	H	V	14091	NTWK
3	V	54	12654	H	V	14154	SW
4	V	54	12717	H	-	14217	REG
5	V	54	11483	H	V	14278	SW
6	V	54	11546	H	-	14341	REG
7	V	54	11609	H	V	14404	SW
8	V	54	11672	-	V	14467	XATL

European Spot Beam							
Downlink				Uplink			
Tr	Pol	BW	Fc	EurPol	NAPol	Fc	Notes
9	H	54	12528	V	H	14028	NTWK
10	H	54	12591	V	H	14091	NTWK
11	H	36	12645	V	H	14145	SW
12	H	36	12685	-	H	14185	XATL
13	H	36	12726	V	H	14226	SW
14	H	54	11483	V	H	14278	ANY
15	H	54	11546	-	H	14341	XATL
16	H	54	11609	-	H	14404	XATL
17	H	54	11672	-	H	14467	XATL

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Transponder Frequency Chart to North American Transponders

North American Broad Beam							
Downlink				Uplink			
Tr	Pol	BW	Fc	EurPol	NAPol	Fc	Notes
18	H	54	11728	H	V	14028	NTWK
19	H	54	11791	H	V	14091	NTWK
20	H	54	11854	H	V	14154	SW
21	H	54	11917	-	V	14217	REG
22	H	54	11978	H	V	14278	SW
23	H	54	12041	-	V	14341	REG
24	H	54	12104	H	V	14404	SW
25	H	54	12167	H	-	14467	XATL

North American Spot Beam							
Downlink				Uplink			
Tr	Pol	BW	Fc	EurPol	NAPol	Fc	Notes
26	V	54	11728	V	H	14028	NTWK
27	V	54	11791	V	H	14091	NTWK
28	V	36	11854	V	H	14145	SW
29	V	36	118855	V	-	141855	XATL
30	V	36	11926	V	H	14226	SW
31	V	54	11978	V	H	14278	ANY
32	V	54	12041	V	-	14341	XATL
33	V	54	12104	V	-	14404	XATL
34	V	54	12167	V	-	14467	XATL

Glossary to the Charts

Tr: Transponder number
Pol: Polarization
BW: Bandwidth
Fc: Transponder center frequency
XATL: Trans Atlantic
REG: Regional
SW: Switchable; either XATL or REG operation
NTWK: Networking, fixed combined uplinks from both continents.
ANY: Ntwk or SW operation
-- : Indicates no uplink available

4.1.8 The Orion Satellite Control Center (Rockville, Maryland)

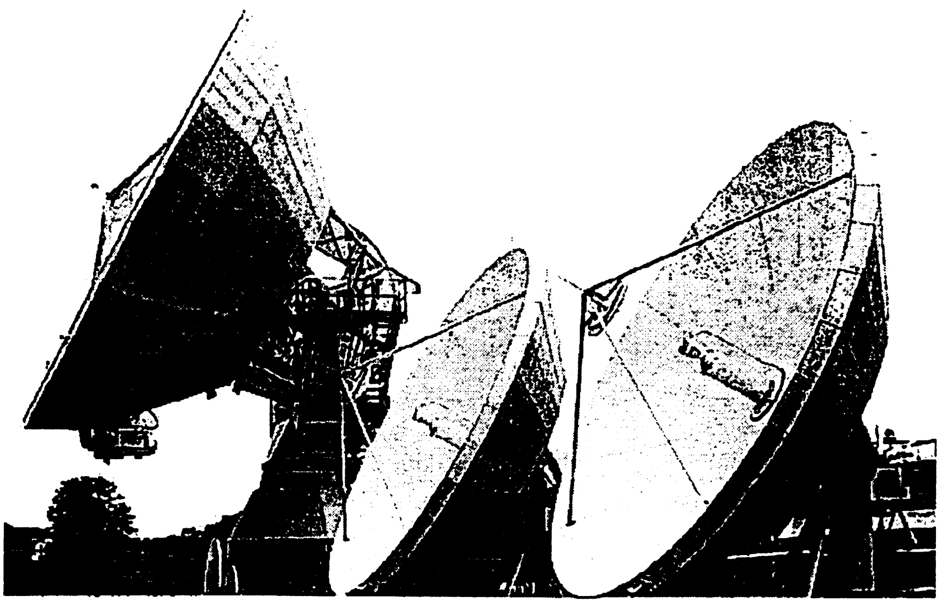
The Satellite Control Center is responsible for proper execution of commanding and monitoring of the satellite for activities such as Eclipse periods, Maneuver operations, Battery Reconditioning, Payload configurations, Satellite Ranging activities, Bolometer inhibitions, and Anomaly identification and recovery. The SCC also serves as a backup for these operations ,except ranging functions, through the use of a 2.4 meter rooftop Ku band antenna.

The Satellite Control Center provides a 24x7 coverage for the Orion-1 satellite. This involves maintaining Orion-1 's orbital position at its designated 37.5 degW location. The satellite and ground station telemetry data is sent across the LAN between the SCC and TT&C through redundant communication links. The network consists of 4 workstations at the SCC and 3 workstations at the TTC which are all capable of performing the necessary functions to control and monitor the Orion-1 satellite and the ground hardware at the Mt. Jackson facility.

There is a simulation network designed for training new personnel to become familiar with our operations through utilizing satellite and ground procedures to perform a wide range of configurations and anomaly scenarios.

Telemetry Tracking and Ranging Station. (Mt. Jackson, Virginia)
The Tracking station operates on a 24x7 schedule and is responsible for ensuring all the hardware and is maintained to meet the SCC operational needs, as well as providing a source for backup commanding and monitoring of the spacecraft if communications links between Rockville and Mt. Jackson are down. The station personnel are also responsible for C-band services and support to the Orion Operations Center.

The TT&C site currently has two 9 meter limited motion Ku band antennas which are used for the telemetr , command and ranging functions and one 15.2 meter full motion Ku band antenna.



Orions Earth Station at Mount Jackson (West Virginia, USA)

4.2. Orion 2

Orion 2 is being built by Matra Marconi Space. Its design includes 30 Ku band transponders; and it is intended to serve parts of North and South America, Europe, Russia, and The Mid-East (Transatlantic). A Lockheed Martin Atlas IIAS launch vehicle is scheduled to launch Orion 2 in the second quarter of 1999, and the satellite is expected to be operational in the third quarter of 1999.

4.3. Orion 3

4.3.1. Introduction

Orion Asia Pacific's satellite positioned at 139° East longitude above the Pacific Ocean is designed to cover more than 90% of the metropolitan business and population centers in the Asia Pacific region and tol provide two complementary services:

1. International private communications network services through the use of VSATs
2. Transmission capacity services for distribution of video programming, both digital and analog;: and digital transmission services to carriers for use in a variety of international public network services.

Orion 3 is being built by Hughes Space and Communications. Its design incudes 33 Ku band and 10 C band transponders; and it is intended to provide the Korean Peninsula with DTH (8 transponders), all of Asia with C band and major Asia Pacific markets with Ku band. A Delta III launch is scheduled for November 15, 1998 and Orion 3 is expected to begin operations in January 1999.

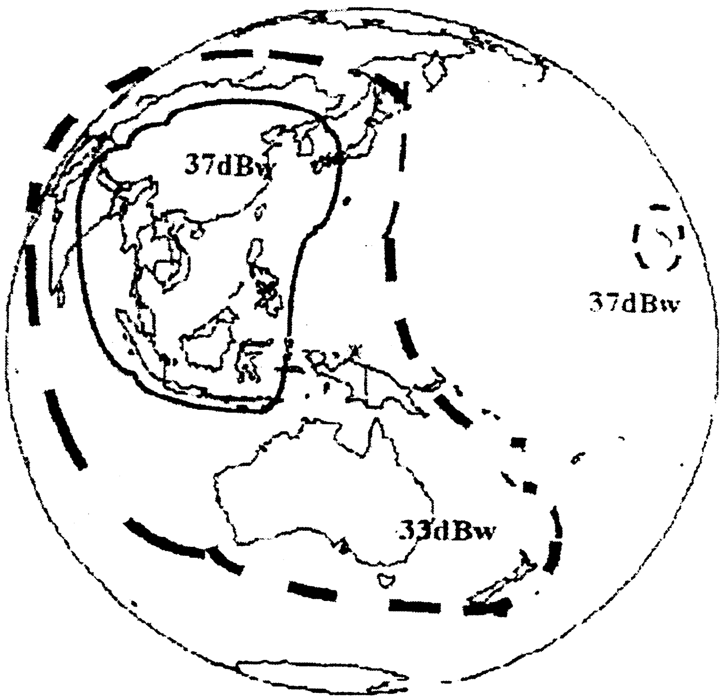
Hughes is providing hardware and software to the Orion satellite control center in Rockville, to the primary telemetry tracking and control station, and to the backup control station located near Seoul, South Korea.

4.3.2. Orion 3, Technical Review

Technical spacecraft data:			
• Prime contractor:	Hughes Space and Communications International, Inc.		
• Platform:	HS 601 HP		
• Mass at launch:	Dry mass: 1935 kg		
	Separation mass: 4159 kg		
• Stabilization:	3-axis		
• Payload power:	6900 W		
• Antenna reflector diameters:	C band:	1 @ 1.3m	
	Ku band:	1 @ 1.8m	
	Ku band:	2 @ 2m x 2.5m	
• Total available bandwidth:	C band	360 MHz	
	Ku band	1296 MHz	
	ext. Ku band	288 MHz	
• Satellite location:	139° East longitude		
• Design lifetime:	15 years		

4.3.3. C band data

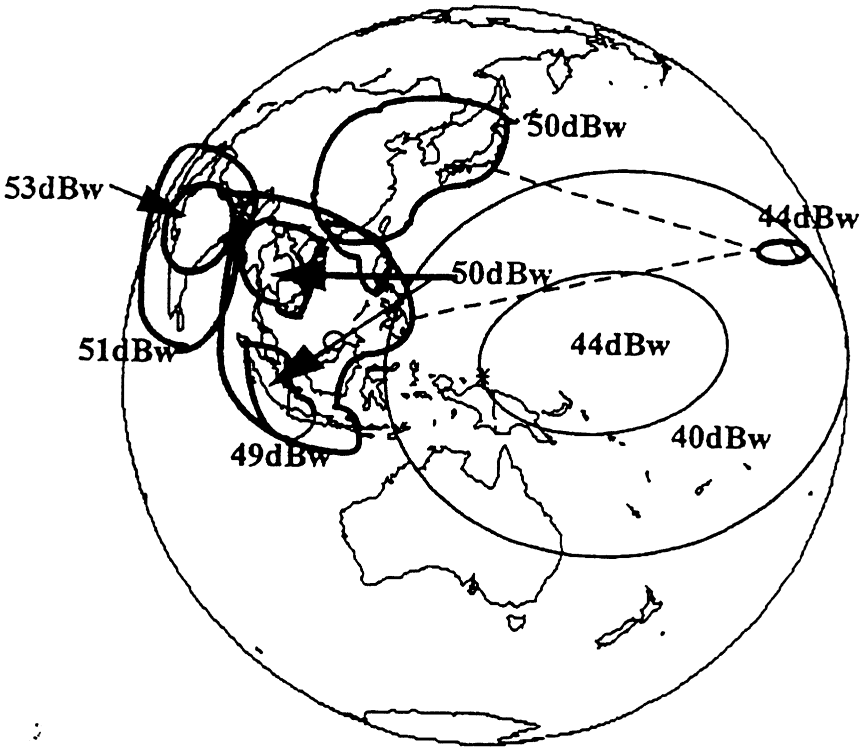
Number of transponders:		10
Channel bandwidth:		36 MHz
Transponder power:		55 W (TWTA)
Transponder frequencies:	uplink	6.425 - 6.625 GHz
	downlink	3.400 - 3.600 GHz
EIRP zone beam*:		33 - 37 dBW
spot beam Hawaii:		37 dBW
G/T		-1 to -10 dB/K
Polarization:		circular
*Coverage zone beam		Korea, China, India, Japan, Australia, Oceania and Southeast Asia.



Orion Asia Pacific C band Coverage

4.3.4. Ku band data

Number of transponders:			33 (8 used by DACOM)
Channel bandwidth:			27 MHz (2), 36 MHz (8), 54 MHz (23)
Transponder power:			80-140 W (TWTA)
Transponder frequencies:		uplink	14.00 - 14.25 GHz
		downlink	12.25 - 12.75 GHz
		(extended) uplink	13.75 - 14.00 GHz
		(extended) downlink	11.45 - 11.70 GHz
EIRP Zone beam	India:		50 - 52 dBW
	Southeast Asia:		49 - 50 dBW
	Japan, Korea		50 dBW
	Hawaii		44 dBW
G/T			-3 to 8 dB/K
Polarization:			linear



Orion Asia Pacific Ku band Coverage

When Orion has three satellites in operation, Orion becomes capable of providing global communications services to over 75% of the world's population with an emphasis on areas with relatively underdeveloped communications infrastructure. Orion also has additional orbital slots available for expansion in both the Atlantic and Pacific Ocean regions.

Chapter 5
VSAT Technology

Orion Network Systems. 2440 Research Boulevard Suite 400 Rockville, Maryland 20850 Tel: + 1 (301) 258-8101 Fax: + 1 (301) 258-8119
Orion Network Systems Europe,Inc. Polaris Avenue 53, 2132JH Hoofddorp, The Netherlands. Tel: + 31 235685779, Fax: + 31 235685748

Table of Contents

5. VSAT Technology

5.1 Introduction

5.1.1. What is VSAT?

Very important for the Orion Atlantic organization are the Very Small Aperture Terminals or VSATs.

A VSAT is an earth station characterized by reduced dimensions and capable of transmitting/ receiving a limited volume of traffic.
Generally, VSATs:

1. antenna transmit gain is less than 49 dBi
2. transmit signal information rate is less than 2 Mbs
3. G/T is less than 27 dB/K

There are two major functional subsystems internal to the VSAT station:

1. The data transmission system which provides transmission paths between the hub and the site.
2. The network management Monitor and Control system whose users are the network operators

VSAT earth station systems provide connectivity to the central Hub via satellite and are usually considered to be those designed to operate with antennas that are equivalent of 3 meters diameter or less. Data streams are fed directly to the earth station interface. Before the data is transmitted to the satellite, it undergoes several transformations within the baseband, IF- and RF stages.
A hub station provides the link to other network users, either via a second satellite link, the terrestrial PSTN or another suitable network.

A HUB is the master station through which all communications to, from and between micro terminals must flow. In the future satellites with on-board processing will allow hubs to be eliminated as MESH networks are able to connect all points in a network together. The Orion 1 satellite has high EIRP and low SFD, allowing for the creation of hub-less VSAT networks, where customer data and voice traffic travels directly from VSAT to VSAT.

5.1.2. The VSAT Technician

A VSAT System Technician must be capable of:

- Using a spectrum analyzer to measure absolute power and carrier to noise over noise ratios (C+N)/N
- Using a PC/ laptop to load and run software (e.g. radiosettings)
- Using compass, inclinometer and hand tools to repoint the antenna
- Mounting connectors to a cable in the correct way using the right tools
- Using a BER tester and a voltmeter
- Understanding Modems, Radio, Mux, UPS, RF, Networking, Prodelin antenna installation etc.
- Understanding the Orion Procedures
- Conversing in English with OOC and NMC and recording results of tests and measurements in English.

5.2 General VSAT Network Architecture

5.2.1. Earth Station Hardware

VSAT sites are divided into three basic sections as indicated by the figure shown on the next page.

- Outdoor unit
- Indoor unit
- Interfacilities link (IFL) cables

Outdoor Unit at a Glance

The outdoor unit is comprised of an antenna, feed system, transceiver and optional an anti-ice system. Orion standard VSAT antenna sizes are 1.8 m. and 2.4 m. These antennas are normally installed on a non-penetrating roof mount.

The transceiver is comprised of a low noise converter (LNC) and a driver unit. The LNC converts satellite downlink frequencies to 70 MHz or 140 MHz intermediate frequencies. Orion standard LNCs are 110^{o}K with 80 dB gain. The driver unit contains the power supply, upconverter, synthesized frequency sources for the LNC, monitor and control circuitry, and solid state (= semiconductor) power amplifier (SSPA). SSPAs convert 70 MHz IF to 14 GHz with 60 dB gain. Orion standard SSPAs are 2W, 4W, 8W, 16W and 25W. The orthomode transducer or OMT and waveguide (WG) separate and conduct the transmit and receive signals which always have an opposite polarization format to each other.

Both transmitter and receiver function on the dual conversion, double superhetrodyne principle. The Local Oscillator (LO) is normally a crystal controlled phase lock loop (PLL), with frequency synthesis to select the correct frequencies for up and downlink operation. The typical 1st IF are in the L-band (around 1 GHz), while the 2nd IF is commonly either 70 MHz or 140 MHz. To facilitate independent tuning of receive and transmit radio frequencies, the transceiver is dual synthesized.

Indoor Unit at a Glance

The Orion indoor unit is a rack which contains all necessary channel equipment, the monitor & control (M & C) unit, the PSTN modem, UPS unit and the multiplexer(s). The satellite modem includes the data encoder/decoder (codec) produces the IF-signal for the uplink, and demodulates the received IF signal.

The codec handles the forward error correction, and converts the source code, usually pure binary, into the channel code. Modulation is either BPSK or QPSK, the latter being preferred because it doubles the channel capacity without increasing the bandwidth.

The power splitters (combiner for TX and divider for RX) make IF-monitoring or the connection of an additional modems possible. An interface unit processes the baseband signals and matches the various input devices to the digital processing stages. As required a mux (multiplexer) is installed which converts/ distributes a given serial data channel into a number of voice and low speed data channels.

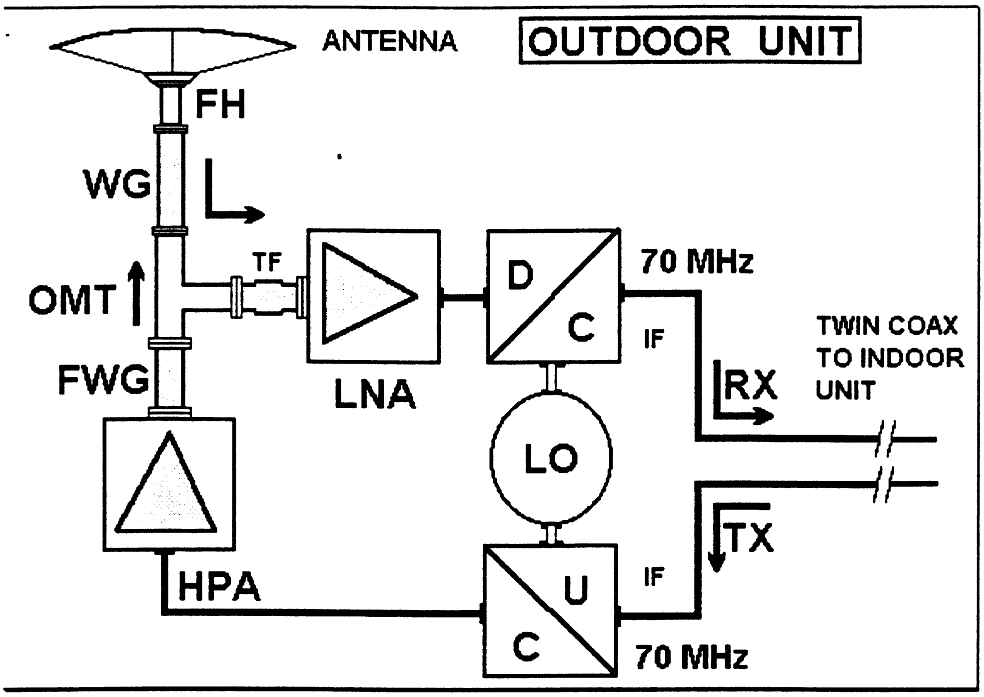
There is also a Monitor and Control unit within the indoor unit. This unit collects status information from the VSAT site and reports to the Network Management Center via a PSTN modem, either automatically or in response to a query.

IFL cables

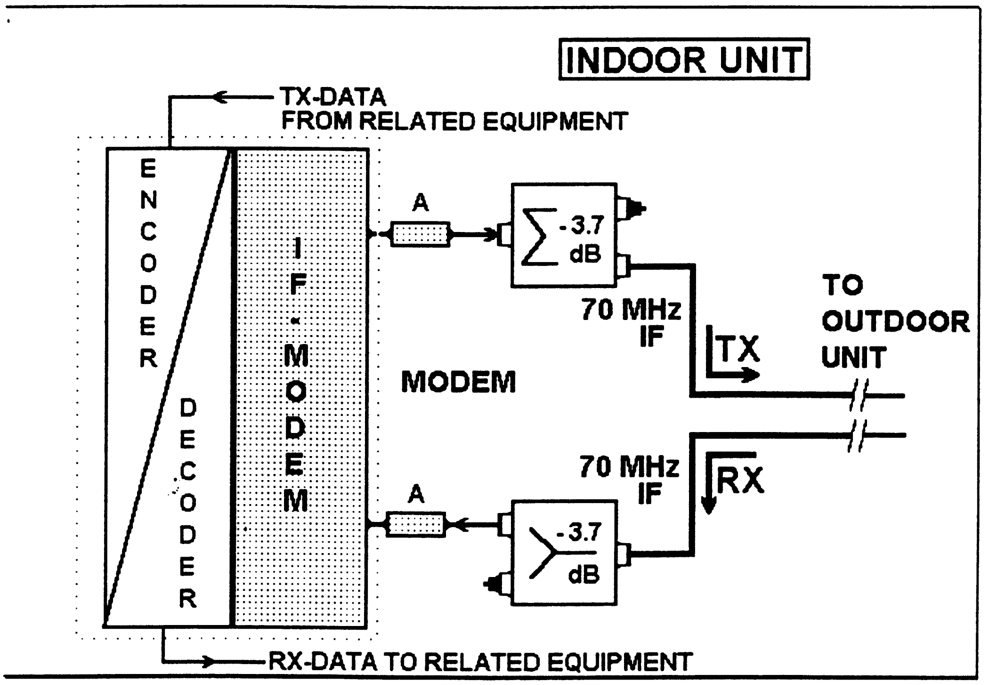
Transmit and receive 70 MHz intermediate frequency signals are carrier between the indoor and
outdoor units by dual-shielded twin coaxial cable. In addition, a twisted pair cable connects the transceiver monitor and control port to the M&C unit indoors.

For more detailed information and assembly procedures see chapter 8 of the Procedure Manual or the Orion Cable Manual.

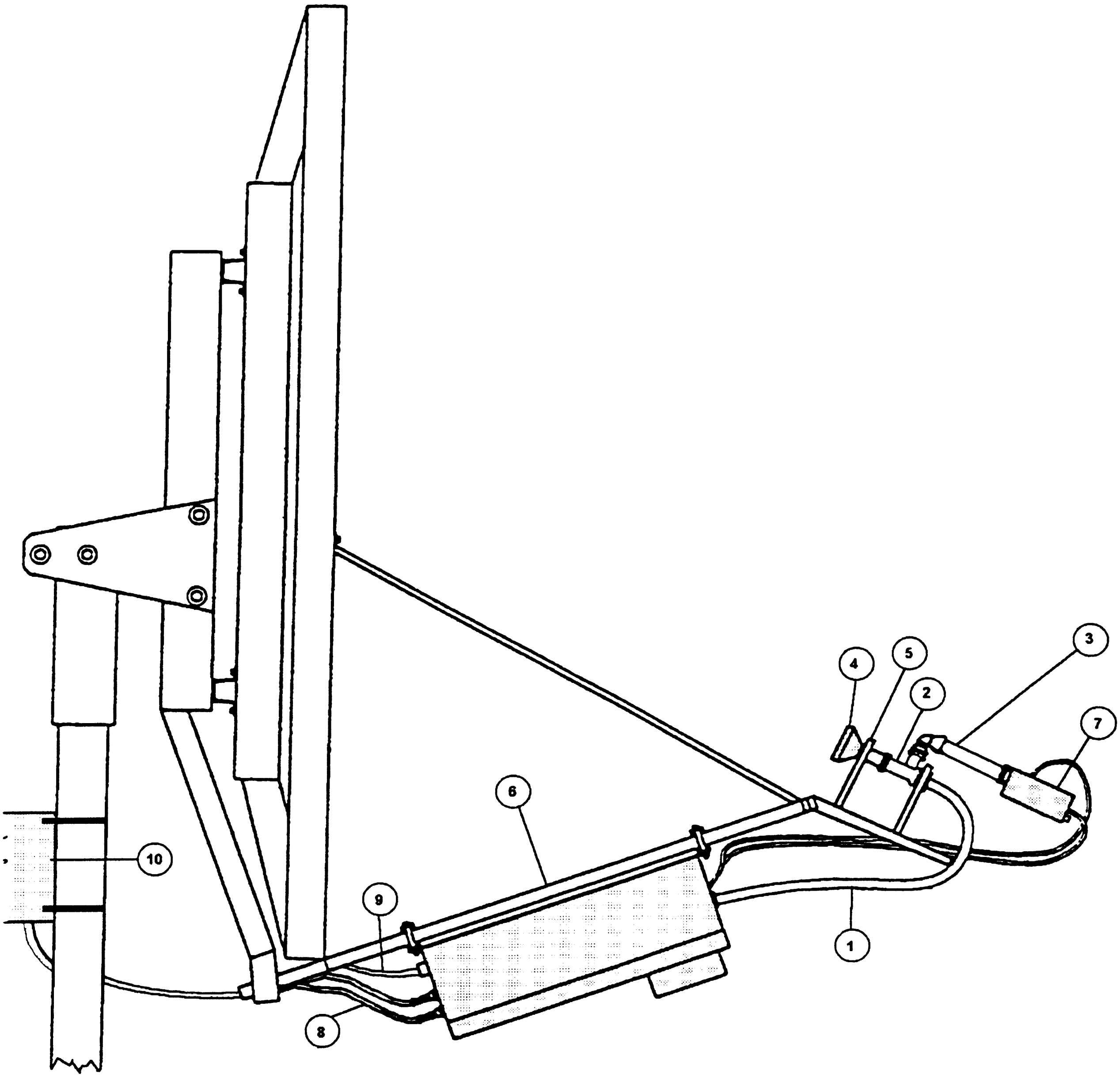
5.2.2. Typical VSAT scheme



(F)WG: (Flexible) Waveguide
FH: Feedhorn
OMT: Ortho Mode Transducer
LO: Local Oscillators
TF: Transmit reject Filter
DC: RX down converter
UC: TX up converter
LNA: Low Noise Amplifier
HPA: High Power Amplifier (Solid State)
A: Additional attenuation



5.3. The Outdoor Unit in Depth



basic VSAT outdoor configuration

1	Flexible Waveguide	10	Surge Line Powerbox
2	OrthoMode Transducer	11	90 Degrees Waveguide
3	Transmit Reject Filter		
4	Feedhorn		
5	Cradle		
6	Radio System		
7	LNC		
8	IF-cable		
9	M&C cable		

5.3.1. The Feedhorn

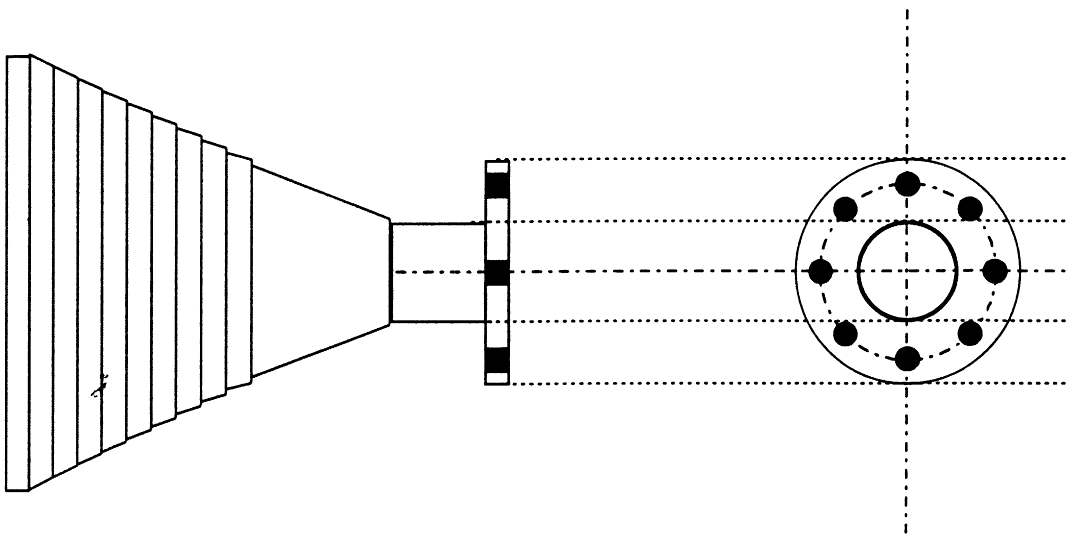
Proper installation and adjustment of the (correct) feedhorn is critical to system performance. This is particularly important if you are installing a feedhorn that receives Ku-band signals. In order to find the correct focal distance the feedhorn must be at the correct distance from the center of the dish, properly oriented, centered and perpendicular to the plane of the antenna.

Antenna Ku-band feedhorns must be placed within 0.25 inch = 0.64 cm of the specified location to meet expected G/T.

Proper setting of f/D on the feedhorn allows the feedhorn to take advantage of all of the signal being reflected off of the dish, without receiving interfering ground noise or terrestrial interference. The f/D ratio is the focal distance of the dish (f), divided by the diameter (D).

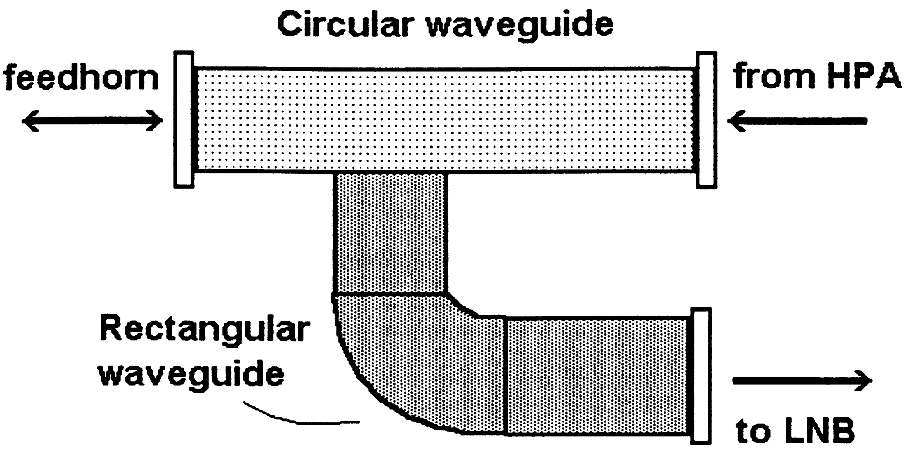
For a focalfeed (primefocus) antenna the feedhorn illumination angle is normally 120°.
For an offset antenna, correct illumination can only be obtained with a so called 90° feedhorn.
If a focalfeedhorn is used in an offset dish, the energy is all over the place and all the power which fails to hit the dish will be wasted. Together with the picking up of large amounts of ground noise this results in a low C/N.

Type of antenna	f/D	angle	L ("/mm)	D("/mm)
1 piece 1.8m Prodelin	0.6	51°	3.60 / 91.40	5.23 / 132.8
1 piece 2.4m Prodelin	0.6	51°	3.60 / 91.40	5.23 / 132.8
4 piece 2.4m Prodelin	0.8		4.29 / 108.9	5.76 / 146.3
4 piece 3.8m Prodelin	0.6	51°	3.60 / 91.40	5.23 / 132.8

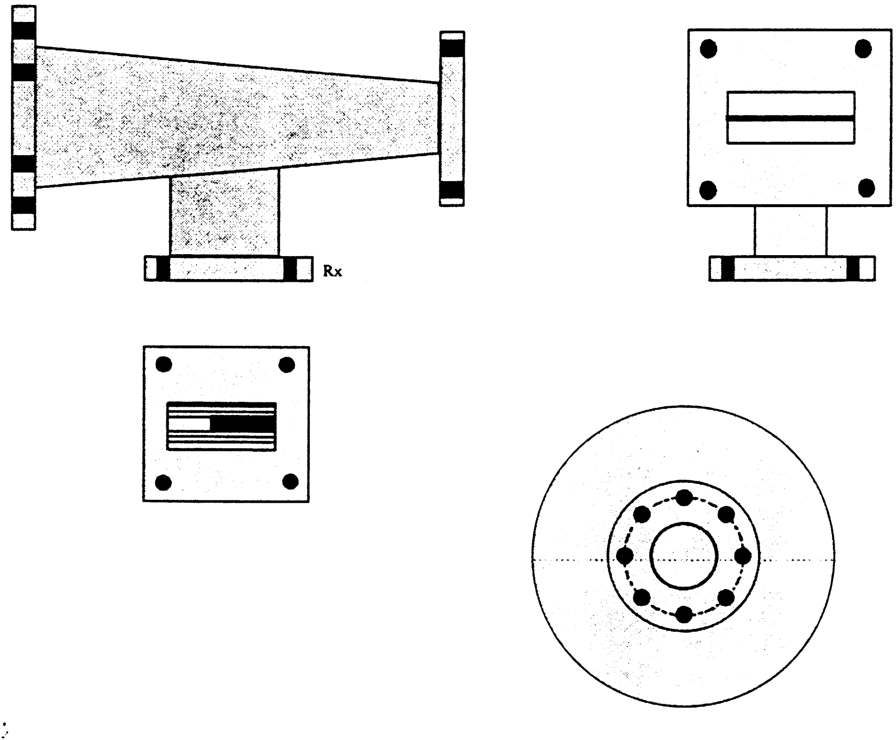


5.3.2. The OMT

To devide signals of both horizontal and vertical polarization the LNB and the HPA can be fed in parallel via an ortho mode transducer (OMT) in the manner indicated in the figure below. The OMT consists of a circular section of waveguide with a rectangular branch section.



The rectangular opening behaves as a low impedance to one component and a very high impedance to the other one



Feedhorn and OMT construction

5.3.3. 90 degrees waveguide

5.3.4. Transmit Reject Filter

The incoming RF downlink signal passes through a 14 GHz transmit reject filter before it enters the LNC. The transmit reject filter is necessary to avoid uplink signal at the input of the LNA. No filter at the input can give intermodulation products in the received signal or more worse permanent damage to the first input stage of the amplifier.

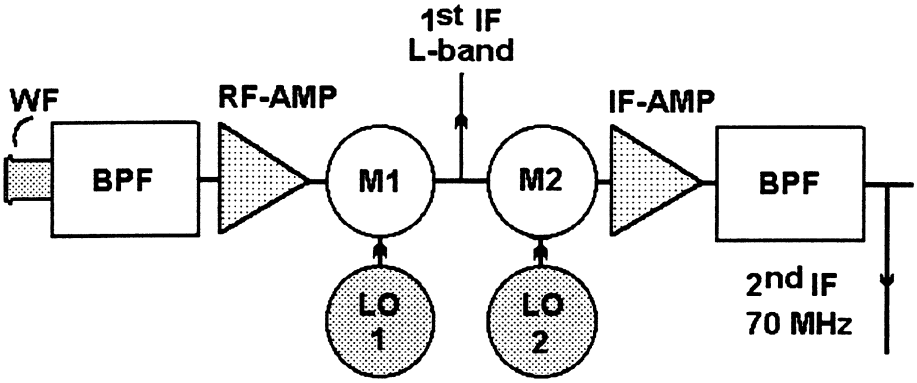
5.3.6. LNA / LNB / LNC

The LNA or Low Noise Amplifier is the heart of every satellite system. If the LNA is of poor quality even an antenna as large as six meters will not produce good signals. In order to function properly, the LNC must be correctly attached to a OMT/waveguide combination to the feedhorn and correctly positioned on the antenna boomarm.

The LNA is most often a part of the LNC (Low Noise Converter) which transforms Ku-band frequencies to L-band or the LNC which converts Ku-band to a more usable IF (70MHz) frequencies

The primary function of a LNC is to downconvert the received RF signal to an IF signal for use by the demodulator.

The LNA (RF-AMP in the figure below) amplifies the signal it receives from the waveguide while introducing a minimal noise level to the signal. Although the incoming signal has been focused by the antenna, the signal is still quite weak and must be boosted in power prior to the down conversion process.



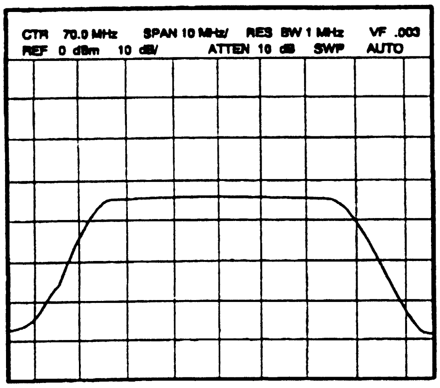
WF: Waveguide Flange
M: Mixer
LO: Local Oscillator
BPF: Band Pass Filter

Basic configuration of a LNC

LNA - Low Noise Amplifier. This is the preamplifier between the antenna and the earth station receiver. For maximum effectiveness, it must be located as near the antenna as possible, and is usually attached directly to the antenna receive port. The LNA is especially designed to contribute the least amount of thermal noise to the received signal. The gain is typical 50 - 65 dB. LNAs provide no down conversion.

LNB - Low-Noise Block (downconverter). A relatively inexpensive receiver which converts video signals on satellite downlinks to television input frequencies. No external mixing signals are required for down-conversion.

LNC - Low Noise Converter. A combination LNA and down converter which receives RF signals from satellites and converts them into intermediate frequencies used by demodulators. LNC require external mixing signals for down conversion.



Left: IF receive signal at the 2nd IF OUT connector on the LNC and shows the operating frequency range of 70 MHz ± 20 MHz. Observe that the noise floor is at -35 dBm on the spectrum analyzer. This is the level preset at the factory and this setting corresponds to a gain of 85 dB in the LNC.

Operating frequency range

The operating frequency range is the range of frequencies over which the LNC will meet or exceed the specification parameters. Like for the SSE radio frequency options are provided for INTELSAT LB & HB, PanAmSat, Eutelsat, Noram and Aussat. (see 4.3.8)

5.3.7. The (Flexible) Waveguide

The rectangular pipe structure attached to the OMT flange is the waveguide. A waveguide has the same function of a coaxial cable however at frequencies above about 1500 MHz, the losses in coaxial transmission lines become unacceptably high and therefore waveguides are commonly used. Although waveguides are physically larger, mechanically stiffer and more expensive than coax, these disadvantages are easily out-weighed by the low losses at microwave frequencies.

A waveguide acts like an high pass filter, because at some low frequency a critical wavelength occurs where the energy is simply reflected back and forth across the guide so that propagation ceases.
A waveguide must be of a specific size and shape to match the frequency band of interest. The loss per 30 feet for a non flexible waveguide is about 5.5 dB and the impedance for a waveguide (air filling) is 377Ω

We know two types of wave guides:

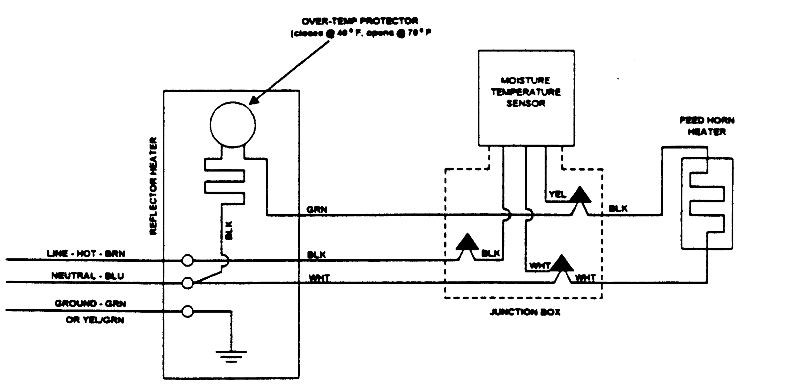
1. Circular waveguide, which is transparent to linear polarization, discriminate between left and right hand rotation This one is used to relay signals from the antenna into the feed or vise versa.
2. Rectangular waveguide, which is a polarized transmission line, discriminates between vertical and horizontal waves. This one is used to route signals to the LNB or HPA.

Flexible does not mean indestructible. Be aware when mounted to the radio and the OMT!

5.3.8. Surge Line Powerbox

5.3.9. De-Ice System

Ice buildup on the antenna reflector and feedhorn affects transmission and reception between the satellite and the earth station by decreasing signal strength. Antennas in localities where there is likely to be ice buidup require anti-icing equipment. Orion uses for its Prodelin antennas the ETSI Compliant Antenna De-ice System.



WIRING DIAGRAM FOR PRODELIN 230V ANTI-ICING
1.8 M & 2.4 M ETSI COMPLIANT ANTENNA

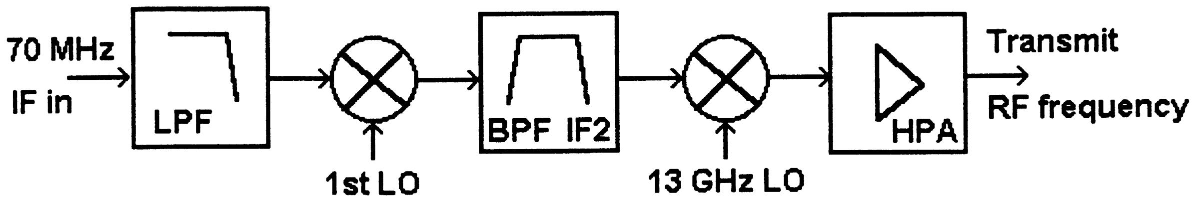
The Quad # 2 reflector heater assembly includes an over-temperature protector installed as part of the heater element circuit as shown in the diagram above. The protector opens at an outside temperature of 70^0 F and closes at 40^0 F.

With the de-ice turned on, the feedhorn heater may be producing heat when no heat is evident on the reflector panel. This can be caused by the protector being open due to the outside temperature.

5.3.10. The Radio System

Introduction
The four primary functions of the Radio *or* Radio Frequency Unit (RFU) *or* Transceiver (TRX) are:
1. To upconvert and amplify the modulator's IF output to an RF signal for transmission via an antenna.
2. To provide the local oscillators for upconversion and downconversion (by the LNC)
3. To downconcert and amplify the received signal from the antenna to present to the demodulator IF input.
4. To process and display alarm signals.

Basic Principal
Most of the radios used for VSAT are based on the same principal and designed for a two way satellite communications system that operates in the C- or Ku-band. Due to the importance of Ku-band for Orion only this frequency range will be highlighted.



LPF: Low Pass Filter
LO: Local Oscillator
BPF: Band Pass Filter
HPA: High Power Amp.

functional block diagram of the RFU

The RFU upconverts, in two steps, an IF signal from a modulator to an RF frequency in the Ku-band. After filtering the Solid State Power Amplifier (SSPA) provides signal amplification as a final step before transmission. Solid State means that semiconductors have been used instead of traveling wave tubes which could be another option.

Concerning the receiving path. The entire downconversion amplification process occurs in the LNC. The RFU provides the LNC with the necessary LO frequencies only. There is no further received signal manipulation inside the radio box. (see also block diagram SSE S1214)

In fact the IF signal could be of any frequency, however for VSAT use a IF of 70 MHz is most common. 140 MHz is an other standard but is used less often.

Various types of Radios used by Orion

CODE	MANUFACTURER	RX FREQ BAND NAME	RX FREQ BAND (GHz)	TX FREQ BAND (GHz)	I.F. BANDWIDTH
FL-2000	FAIRCHILD	INTELSAT LO	10.95 - 11.20	14.00 - 14.50	36 MHz
FH-2000	FAIRCHILD	INTELSAT HI	11.45 - 11.70	14.00 - 14.50	36 MHz
FN-2000	FAIRCHILD	NORAM	11.70 - 12.20	14.00 - 14.50	36 MHz
FA-2000	FAIRCHILD	AUSSAT	12.25 - 12.75	14.00 - 14.50	36 MHz
YL-AST	SKYDATA	INTELSAT LO	10.95 - 11.20	14.00 - 14.50	36 MHz
YH-ASI	SKYDATA	INTELSAT HI	11.45 - 11.70	14.00 - 14.50	36 MHz
YP-ASO	SKYDATA	PANAMSAT	11.45 - 11.95	14.00 - 14.50	36 MHz
YN-ASU	SKYDATA	NORAM	11.70 - 12.20	14.00 - 14.50	36 MHz
YA-ASE	SKYDATA	AUSSAT	12.25 - 12.75	14.00 - 14.50	36 MHz
(suffix) N	SKYDATA	e/w Delay Timer	n/a	n/a	n/a
(suffix) 220	SKYDATA	220 volt type	n/a	n/a	n/a
(suffix) 4w	SKYDATA	4 watts (std is 2w)	n/a	n/a	n/a
EL-1214M	SSE	INTELSAT LO	10.95 - 11.20	14.00 - 14.25	36 MHz
EH-1214M	SSE	INTELSAT HI	11.45 - 11.70	14.25 - 14.50	36 MHz
EP-1214M	SSE	PANAMSAT	11.45 - 11.95	14.00 - 14.50	36 MHz
EN-1214M	SSE	NORAM	11.70 - 12.20	14.00 - 14.50	36 MHz
EA-1214M	SSE	AUSSAT	12.25 - 12.75	14.00 - 14.50	36 MHz
EE-1214M	SSE	EUTELSAT	12.50-12.75	14.00 - 14.25	36 MHz

Orion prefers to use the SSE Technologies S1214 Radio. Occasionally SKYDATA or Fairchild radios are placed in the field. Technically most of the radios are based on the same principal and perform equal.

SSE Technologies contact:

SSE Technologies
47823 Westinghouse Drive
Fremont, California 94539-7437 USA
Phone: (+1-510) 657-7552
Fax: (+1-510) 490-8501

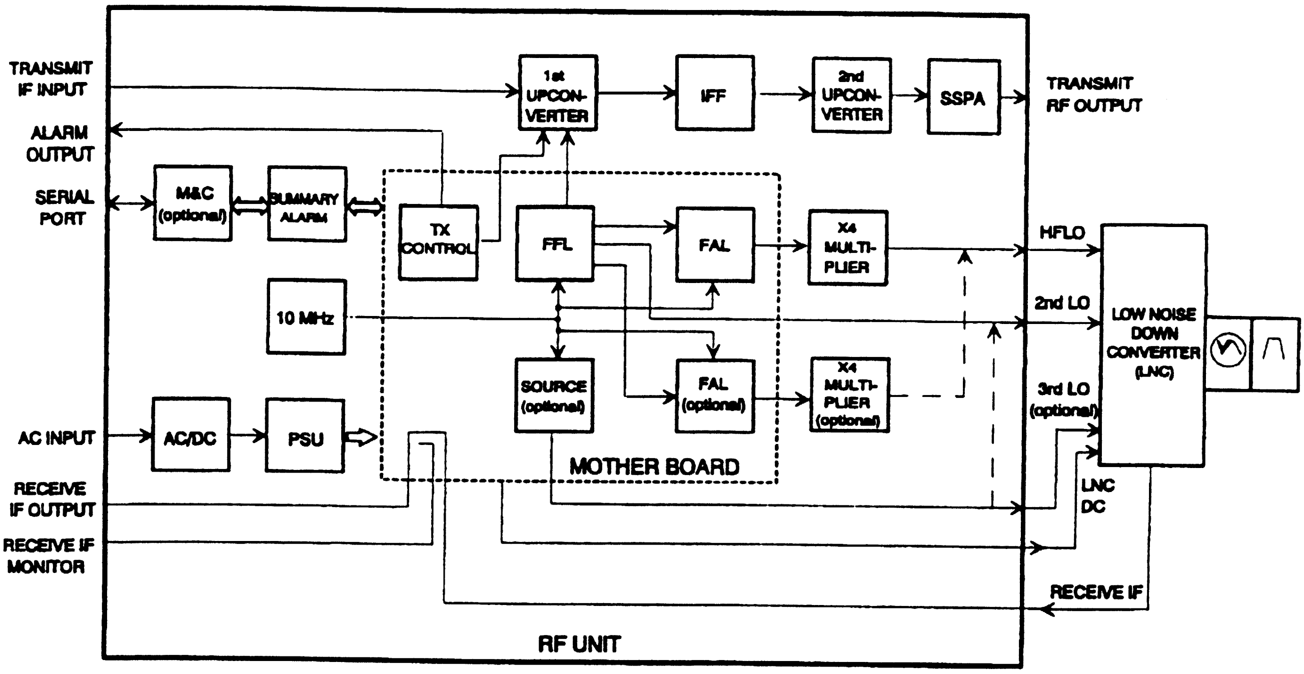
5.4. The SSE S1214

5.4.1. Introduction

The transceiver transmits between 14.0 - 14.5 GHz and makes it possible to receive between 10.95 and 12.75 GHz depending on the satellite format selected.
The radio is designed to interface with any 70 MHz or 140 MHz modem having a data capability of 9.6 kbs or higher and any size antenna and weights only 16 kg-20 kg

Orion Atlantic uses for the present only 70 MHz modems thus a 70 MHz IF

The block diagram in the figure below illustrates the transceiver's typical configuration.



Receiver part		Transmitter part	
IF Output Frequency	70.000 +/- 20Mhz	IF Input Frequency	70.000 +/- 20Mhz
RF to IF Bandwidth	40 Mhz	IF to RF Bandwidth	40 MHz
Gain min.	85 dB	**IF Input Level max !!**	**-30 dBm +/- 4 dB**
Max RF input level	-82 dBm	RF output level	see Radio Curve
Receiver Monitor level	20 dBbelow RX IF Output nom.		

More technical details about the SSE and SKYDATA Radio in chapter 3.2 of the Ground Operator Equipment Reference Manual.

5.4.2. SSE 1214 Part # Designator

The SSE RFU radio is available in five different types with five different output powers. They all come up with their own partnumber.

This designator is a 11 digit number, for example: 305-14 xxxxxx

type of radio

single (1) or dual (2) synthesized radio

indicate RF output [dBm]

Band	RX range[GHz]	TX range [GHz]	FFL	6th digit P # D
NORAM	11.70-12.20	14.00-14.50	4 port	305-14-**1**xxxxx
PANAMSAT	11,46-11.96	14.00-14.50	3 port	305-14-**A**xxxxx
EUTELSAT	12.50-12.75	14.00-14.25	3 port	305-14-**8**xxxxx
INTELSAT low	10.95-11.20	14.00-14.25	4 port	305-14-**7**xxxxx
INTELSAT high	11.45-11.70	14.25-14.50	4 port	305-14-**9**xxxxx

example:

A radio with the next designator 305-14-824133 is an Eutelsat, double synthesized radio with 33 dBm (= 2 Watt) output power. The table below shows a list of SSE radio types used by Orion.

Radio type/ power output [W]	Radio RF Output [dBm]	Gain[1)] [dB]
driver only[2)]	+ 8	31
2 Watt SSPA	+33	63
4 Watt SSPA	+36	66
8 Watt SSPA	+39	69
16 Watt SSPA	+42	72
20 Watt SSPA	+43	73
25 Watt SSPA	+44	74

[1)] Gain refers to the IF-input level

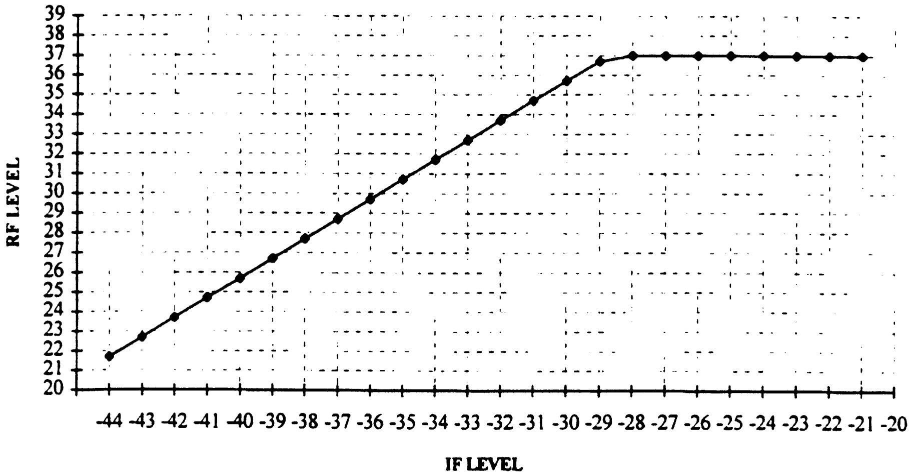
[2)]Transmitter disable on

Transmit gain for all the SSE radios is factory set and may not be readjusted. Adjusting the RF output can only be done by varying the IF input.

5.4.3 Radio Output power and Radio Curve

The output power of the radio depends on two parameters:

- The type of radio; 2 Watt, 4 Watt etc.
- IF driving level which is given for every individual type by the radio curve.



typical 4 Watt RF/IF radio curve. More curves are shown in chapter 7 / Test OA-2.2 of the procedure manual.

The type of radio is a given fact, the IF driving level is a modem adjustment which depends on the required bandwidth and cable losses. For a minimum of distortion (cross- / intermodulation due to overloading the amplifiers) it is absolute necessary that the IF input level (at the radio connector) does not exceed -30 dBm. Overdriving the radio gives not only a highly undesired spectrum but can cause permanent damage as well; however too little signal can limit the fade margin. The correct required radio driving level is in the Field Installation Manual (FIM)

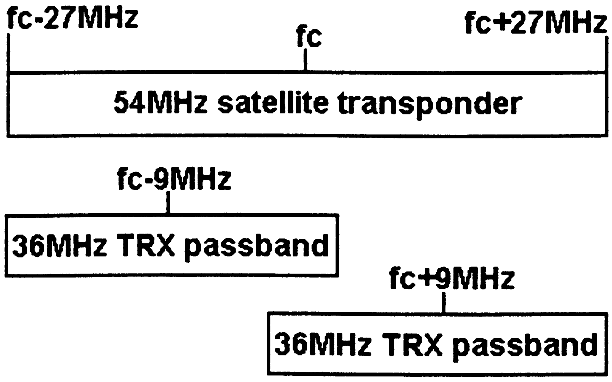
When connecting the modem to the radio be sure that there is enough additional attenuation in the transmit path available to avoid overloading of the radio. Since the VISN box has a fixed output power of 0 dBm, attenuators are absolutely necessary when the radio is used in VISN applications.

The radio only works properly within its dynamic range. This is the range over which the output power varies linearly with respect to the input power; the increasing slope in the radiocurve.
In the SSE radio specification (see also the Equipment Manual) is indicated the "output power at 1 dB compression"
This is a rather common spec. The 1 dB output compression point of an amplifier is simply defined as the output power level at which the gain drops 1 dB bellow the small signal.
As the output power increases to near its maximum, the transmitter will begin to saturate. The definition for the 1 dB compression point is the point at which the saturation effects are 1 dB from lineair

When transmitter disable is on does this *not* mean that the transmitter has been switched off !!
It is only lowered in power by 25 dB - 36 dB depending on the type of radio.
Before attempting any system change, make sure that the TX IF Input (J1) is disconnected at the RFU to prevent accidental transmission interference with adjacent satellites or transponders.

5.4.4. Setting the Radio Frequency

In most of the cases it is desirable that the transponder center frequency fc is transformed into the modem center frequency (70 MHz). Since a Modem has a bandwidth of ± 20 MHz and not ± 27 MHz it is not possible to transform the complete 54 MHz transponder. This is only possible using the following rules:



If carrier frequency < fc, then the TRX center frequency is fc-9 MHz

If carrier frequency > fc, then the TRX center frequency is fc+9 MHz

calculation example:

Transmit	
Required transmit RF frequency (in the FIM)	**14594.600 MHz**
Set radio TX center frequency:	14594.000 MHz
Difference:	0.600 MHz
Add difference to modem center frequency:	70.000 MHz
Set modem transmit frequency (in the FIM)	**70.600 MHz**
Receive	
Required receive RF frequency (in the FIM)	**11594.450 MHz**
Set radio RX center frequency	11594.000 MHz
Difference:	0.45 MHz
Add difference to modem center frequency:	70.000 MHz
Set modem receive frequency (in the FIM)	**70.45 MHz**

The required receive and transmit frequencies and the RFU center frequency are issued (in kHz) by the FIM. The RFU frequency or "center frequency" must be set with the radio synthesizer. The radio synthesizer provides selection of transmit and receive frequencies, in 1 MHz steps, over the 500 MHz band and can be set through DIP switches or by M&C.

When using the DIP switches refer to the frequency chart in the GO Equipment Reference manual.

When using the M&C, set all of the DIP switches to the "ON" position
Communication settings when a laptop is used:
Baud Rate: 1200 B
Data Bits: 7
Stop Bits: 1
Parity: even
Flow Control: Xon / Xoff

When using the M&C option with the SSE S-line radios, it is IMPERATIVE that the PTXON & TXON commands be entered into the radio. These commands have impact on the TX output performance. The PTXON command sets the TX power state to ENABLE at AC power up. If this command is not entered, when the AC power is cycled, the TX power will not be turned back on!!! IF DIP switches are used, this is not required. The TXON command enables the TX power, if this command is not entered, the TX power will not be enabled. IF DIP switches are used, this is not required. Also note that the ATTEN command is always available through the SSE M&C regardless of the installation of the IF Attenuator Option. If the attenuator option is installed on a SSE S-Line radio, the 8th digit of the part number will be "7". If the radio has the attenuator option, the M&C ATTEN value between 1 & 31 will have an impact on the TX output level.

5.4.5. SSE Ku-band S-line Radio Problems

Electronic equipment can turn your life into a real nightmare even a SSE Radio has this horrible habit. Although the list is probably not complete it may enlighten the situation when a failure comes up and the NMC requires you to go on site for solving the problem.

When the use of two different frequency bands is required (e.g. Eutelsat downlink and Panamsat uplink) you must set the radio with the dipswitches. In this case it is not possible to program the radio by using a labtop.

When you have programed the tranceiver with the dipswitches and the previous setting was done by a laptop and the TX=OFF and the PTXOFF option was set active the tranceiver will not work in its new configuration.
You only can program the radio with dipswitches if TX=ON and PTXON

There has been many failures on the 8 and 16 Watt radios. It has been determined that there are at l east two different failure modes:

- Moister & water causing electrical damage to either the fan windings and/or the circuit board with the active electronic components
- The DC power filter circuit in the radio that feeds 12 Volts to the fan.

The radio has a thermal protection circuit that will shut the SSPA off when the temperature becomes too high. When the temperature reaches a safe level as the unit cools off (with the SSPA shut down), the SSPA will then be turned back on. It is possible that the radio could toggle the SSPA on & off during this overheat & cool down cycle. Other complains may be a fluctuate or loss of radio power before the thermal protection circuit shuts the SSPA off totally.

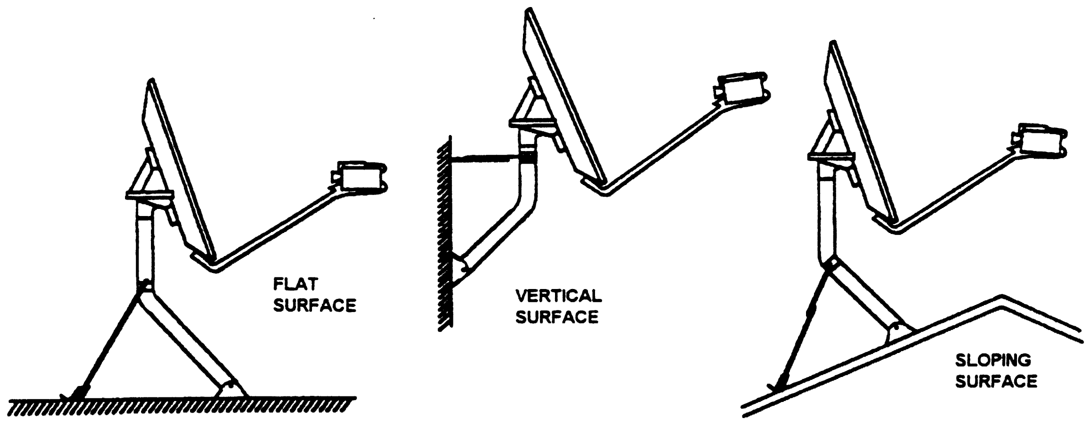
When the radio is found the cause of the problem, never open the radio but simply replace the radio by a similar type and sent the old one back according the Logistics Procedure described in the Ground Operator Procedure Manual.

5.5. Mounts

Various types of antenna mountings are available depending on the installation site. In general, either a roof, wall or ground mounting can be used. The selection varies by site and depends upon such factors as the look angle to the satellite, security requirements, physical characteristics of the site, etc. The configuration selected must provide adequate structural support and rigidity as specified in the Ground Operator Procedure Manual.

5.5.1. Types of Mounts

The roof-top installation enhances security by limiting access to the outdoor equipment to authorised personnel and provides the height to clear local obstructions for the signal path. The roof mount option can be either penetrating or non-penetrating in design. Another-less preferable- option is wall mounting.



Penetrating Roof Mount:
This type of mounting can be either welded or bolted to suitable structural members of the building. Another option is to attach the antenna to a suitable roof mounted pole which has been provided by the customer. This option is typically used when installations are associated with a newly constructed building.

Non-Penetrating Mount:
The non-penetrating mount (NPM) provides a method for an antenna to be mounted on the roof (or other flat surface) when penetration of the roof barrier is not feasible. This non-penetrating mount is easy to assemble, offers low uniform load distribution, minimum settlement into the roof barrier, and is compatible with many types of flat roof constructions. Generally, the NPMs are not physically attached to the building and use the weight of ballast (such as concrete blocks or block caps) and specially designed braces to hold the mast vertical and to avoid moving.

Wall Mounting:
Wall mounting the antenna offers limited access to the equipment while avoiding placement on the roof and is useful in a variety of situations. A wall mount is often a custom designed installation. Generally, wall mountings are only approved for use on solid concrete walls or concrete block walls that are filled with concrete. When mounting bolts pass through the walls, backup plates are required. Alternately, the mount may be attached to a vertical steel beam. For the antenna quick repoint feature to be usable, the mount must permit the antenna to move through the required range of azimuth without being limited by the antenna reflector striking the wall. One option is to attach the wall mount so that the reflector is above the roof line. The antenna must be mounted to allow for service access.

Orion perverse to use non-penetrating (roof) mounts as there are:
- Baird, model VL-10 with single, double (standard) or triple tray.
- Bard, model PXL-2 HD with single, double or triple tray. (for 3.8m Prodelin only)
- Rohn 2.4m Non Penetrating Mount

More detailed information and assembly instructions can be found in the Equipment Reference Manual (Chapter 1)

5.5.2. Antenna Mount Stability

The most common causes for antenna deflection and resulting beam pointing errors are:
- High winds or gusting wind conditions
- Settling of the antenna mounting
- Loosening of the assembly due to weather and wind conditions
- Flexing of the supporting structure
- Satellite movement.

In general, the amount of allowable deflection varies inversely with the size of the antenna reflector. For example, the 2.4m antenna has less allowable deflection compared to the 1.8m antenna as shown in the table below.

Size (m)	Deflections in Degrees
0.75	0.60
1.0	0.40
1.2	0.30
1.8	0.20
2.4	0.15

Sweep away loose rocks present on the roof structure before placing rubber mats over the installation surface. The amount of additional ballast is based on antenna size and weight, type and survival requirements as exposure to the wind, height and elevation angle and is absolutely necessary for non-penetrating mounts. An extra 600 kilos of ballast is quite common.

According to the EIA Standard RS-222C are the wind loading zones divided into three zones:
- Zone A: 85mph
- Zone B: 100 mph
- Zone C: 110 mph

The wind loading velocities projected for the three basic wind zones are measured at 33 feet (10.9m) above the ground and are for every state and country listed in tables.

Orion does not recommend a non-penetrating mount for the 3.8m antenna !! The total weight with ballast, mount and antenna is in the range of 10,000 lbs. (4500 kg) Many buildings cannot properly support this amount of weight and with the circuit margins that Orion allocates, if the mount is not extremely stable, the customer will suffer from outages due to mechanical instability which impacts the C/N & Eb/No. It is recommended that the 3.8m be either ground mounted or tied into the building structure.

5.5.3 Ballast for non-penetrating mounts

To obtain the ballast weight (concrete blocks) for a non-penetrating mount subtract the weight of the base, ballast trays and antenna (includes antenna, radio(s), LNC(s), cable harness(es) radio mounting kit etc.) from the weight given in the Ballast Calculation Report tables (see GO Equipment Manual, chapter 1). This gives the total weight of concrete block required to be placed on the ballast trays.

Required ballast weight = Total system supporting weight from Baird wind speed and building height chart - (VSAT antenna system + Baird non-pen mount)

Prodelin Antenna Weight

The prodelin antenna weight *is not the shipping weight*, but the overall assembled antenna weight including the OMT interface used for the SSE radio.

Type of Antenna	Weight	
1184 series, 1.8m 0.6 F/d	187 lbs	84 kg
1194 series, 1.8m 0.8 F/d	202 lbs	91 kg
1244 series, 2.4m 0.8 F/d	444 lbs	202 kg
1381 series, 3.8m 0.6 F/d	1525 lbs	691 kg

SSE S-line Ku band Radio and Mounting Kit Weight

This is not the shipping weight, but the overall minimum radio weight which includes RFU, LNC, Cable harness, Waveguide and Mounting kit. The overall minimum radio weight varies due to radio configuration

Type of Radio*)	Weight	
S-line 2 & 4 Watt ku band	45 lbs	20 kg
S-line 8 & 16 Watt ku band	50 lbs	23 kg

*) *Includes LNC, cable harness and mounting kit (boom mount)*

Baird Mount Weight

The overall Baird Mount Weight includes the mount base (center section), support pipe and ballast trays.

VS10 drop leg mount used for 1.8m antenna systems	Weight	
Single width ballast tray with 5 9/16" OD support pipe *)	281 lbs	126 kg
Dual width ballast tray with 5 9/16" OD support pipe	383 lbs	173 kg
Triple width ballast tray with 5 9/16" OD support pipe	484 lbs	218 kg

VS10 drop leg mount used for 2.4m antenna systems	Weight	
Single width ballast tray with 6 5/8" OD support pipe	359 lbs	162 kg
Dual width ballast tray with 6 5/8" OD support pipe *)	478 lbs	220 kg
Triple width ballast tray with 6 5/8" OD support pipe	596 lbs	268 kg

*) *Orion default standard*

5.6. The (Prodelin) Antenna

5.6.1. Introduction.

The Antenna is often referred as the dish and is also the most visible part of an VSAT earth station..Orion uses three types of Prodelin Antennas for its VSAT installation:

1. Prodelin one piece 1.8m series 1184 antenna system
2. Prodelin four piece. 2.4m series 1244 antenna system (occasionaly 1 piece 2.4m antenna)
3. Prodelin four piece 3.8m series 1381

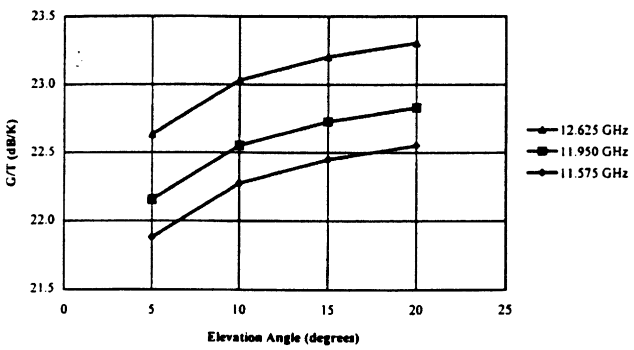
The main differences between the 1.8m, 2.4m and the 3.8m antenna can be found in antenna gain (which is determined to a great extent by its diameter) and antenna efficiency. The 2.4m antenna which is Orion default standard has a better G/T ratio than the 1.8m and is used in areas not covered by the Orion 1 spot beams. The 3.8m is mainly intended for C band use in South- and Central America. The 1.8m is constructed out of 1 piece, the 2.4m and 3.8m have a 4 piece reflector. All the Prodelin antennas are capable of operating on either C- or Ku band when outfitted with different feed components.

5.6.2. Prodelin 1.8m datasheet

Antenna Diameter	1.8 meters
Antenna Efficiency	63.00%
Elevation Offset	22.3°
LNA Noise Temp.*	110 K
Rx Loss*	0.2 dB
weight	91 kg

** necessary to determine G/T*

Frequeny	RX Ant Gain	20	15	10	5	Elevation Angle (degrees)
		38	42	49	66	Antenna Temp. (K)
[GHz]	[dBi]	dB/K				
11.450	44.7	22.5	22.4	22.2	21.8	
11.575	44.8	22.6	22.4	22.3	21.9	
11.700	44.9	22.6	22.5	22.4	22.0	
11.950	45.1	22.8	22.7	22.6	22.2	
12.200	45.2	23.0	22.9	22.7	22.3	
12.500	45.4	23.2	23.1	22.9	22.5	
12.626	45.5	23.3	23.2	23.0	22.6	
12.750	45.6	23.4	23.3	23.1	22.7	

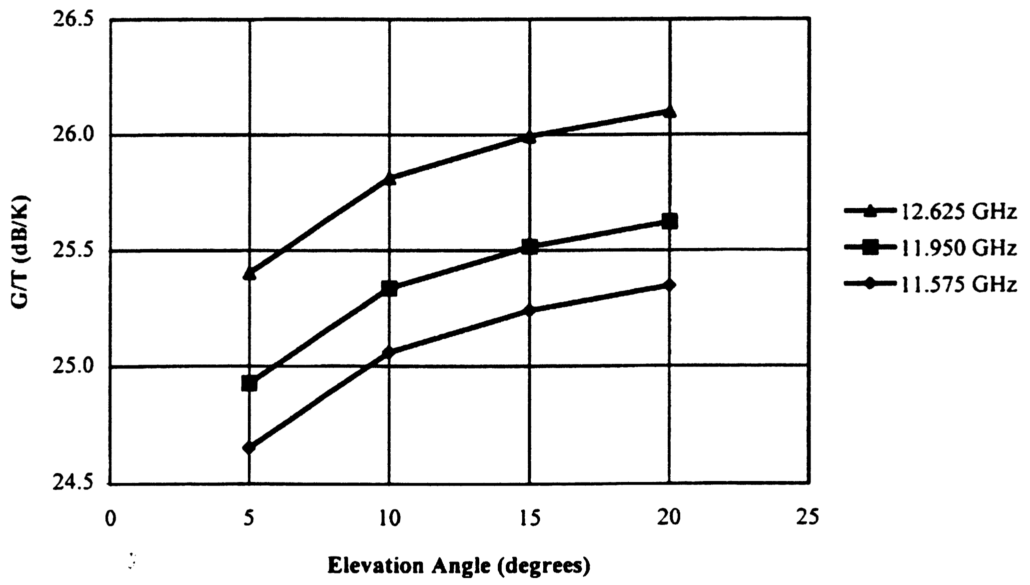


5.6.3. Prodelin 2.4m datasheet

Antenna Diameter	2.4 meters
Antenna Efficiency	65.00%
Midband Gain C band TX / RX	42 / 38 dBi
Midband Gain Ku band TX / RX	49 / 47 dBi
Elevation Offset	17.35°
LNA Noise Temp.*	110 K
Rx Loss*	0.2 dB
weight	200kg

** necessary to determine G/T*

Frequeny	RX Ant Gain	20	15	10	5	Elevation Angle (degrees)
		32	36	43	60	Antenna Temp. (K)
[GHz]	[dBi]	dB/K				
11.450	47.3	25.3	25.1	25.0	24.6	
11.575	47.4	25.3	25.2	25.1	24.6	
11.700	47.5	25.4	25.3	25.2	24.7	
11.950	47.7	25.6	25.5	25.3	24.9	
12.200	47.9	25.8	25.7	25.5	25.1	
12.500	48.1	26.0	25.9	25.7	25.3	
12.626	48.2	26.1	26.0	25.8	25.4	
12.750	48.2	26.2	26.1	25.9	25.5	



Prodelin now has INTELSAT type approval for the 1244, 4 piece, 2.4m antenna for both C & Ku band. The C band approval number is IA042A00. The Ku band approval number is IA041A00. The Ku approval is for a rating of E1 and Standard G.

5.6.3. Prodelin 3.8m datasheet

Antenna Diameter	3.8 meters
Antenna Efficiency	65.00%
Midband Gain C band TX / RX	42 / 51 dBi
Midband Gain Ku band TX / RX	46 / 53 dBi
Elevation Offset	22.62°
LNA Noise Temp.*	110 K
Rx Loss*	0.2 dB
weight	20kg

** necessary to determine G/T*

Frequeny	Polarization	10°	20°	30°	40°	Elevation Angle (degrees)
C band	Linear	31	25	21	21	Antenna Temp. (°K)
C band	Circular	27.7	21.9	19.8	18.7	
Ku band	Linear	29	21	20	19	

Note that you cannot assume that shipping and installing of this antenna is similar to the Prodelin 2.4m. Many single parts are in exess of 135 kg (300 lbd) and therefor this antenna requires either 2 men and a crane or 4 men to build it.

5.6.5. Super Hydrophobic Coating (SHC)

Prodelin coats its reflectors with Super Hydrophobic Coating. An SHC coated antenna will provide the user with additional operating margin under adverse weather conditions. It will provide an additional factor of safety that could keep your site on-line when weather conditions would indicate otherwise.

Super Hydrophobic Coating or SHC is a generic, descriptive name of a proprietary material used by Prodelin Corporation on selected antenna surfaces. The material is a solvent based formulation that repels water from whatever surface it is applied. The chemical and physical properties of the material are such that drops of water are actually separated from the antenna surface by a visible layer of air. By prohibiting actual contact with the surface, the water cannot adhere and falls away. Applied to an antenna surface, SHC gives a white, chalky appearance and texture that is nearly transparent.

What does SHC do on antenna surfaces?

SHC actually improves system performance under rain conditions by repelling water from the antenna surface. The phenomen on of & quot;rain fade & quot; is well documented and is a reality for Ku-band frequencies. The presence of SHC both on the antenna surface itself, as well as the feed horn, measurably improves system performance under moderate to heavy rain conditions. However SHC doesn't repel snow until it turns to a liquid.

How long does it last?

Longevity of SHC on the antenna surface is strictly a function of the environment. Air pollution attacks the hydrophobic surface causing it to deteriorate over time. From experience to date, two years is the typical surface life.

Kits for renewing the surface treatment are available from Prodelin at a nominal cost.

SHC is not hazardous or inherently toxic. Material Safety Data Sheets are available.

5.6.6. Prodelin 2.4m Installation Problems

Like most of the mechanical equipment even the Prodelin antenna comes up with some installation problems. To avoid mental depressions and the waste of time some tips and tricks to improve the quality of the installation. The list below which you also can use as checklist is suposed to be temporarely but valid for the time being. Updates to this list will come to you by the yellow Technical Bulletins.

- ☐ Do not mix up the major and minor axis plates
- ☐ Ensure that the placement and installation of the antenna quadrants is correct
- ☐ 4 piece antenna quadrants are not properly de-burred. Use a rasp or a knife
- ☐ Install the 65/66 thru-bolts properly. Follow the instructions as described in Technical Bulletin 5
- ☐ Under no circumstances should the 4 sets of hex socket screws on the corner of the backframe assembly be loosened or removed. (factory set)
- ☐ Install the GREEN washers properly
- ☐ Ensure that the correct boom arm part number and cradle height combination is used
- ☐ Ensure that the correct feedhorn is used
- ☐ De-ice + boomarm construction improper match - bolds don't fit. Enlarge the holes
- ☐ 4 piece antenna de-ice quadrants shrouds need to be trimmed around quadrant spacer hole. De-ice shroud does not have quadrant numbers affixed to corner.
- ☐ Cradle and feed support can be mounted in two ways, only one is the correct.
- ☐ Feed interface and feed support interchange improper matches. Use a rasp.

Since June 1997 Orion has started to ship a newer version of the Prodelin 1244-2.4m 4 piece antenna. This newer antenna is considered version # 2. There are some very significant differences from the version #1 antenna. Some parts are not interchangeable and some of the rules for this antenna are different.

The main differences between version #1 and version #2 are:

1. The antenna back frame is now a welded, 1 piece, unit for the 1244 version # 2, no adjustment hardware or screws whatsoever. This part has a new part number 0800-1925 vs. version # 1 system with part number 0800-1554.
2. The version # 2 antenna uses only 1 length antenna quadrant insert.This insert is considered the "short" insert with # 65 stamped on the head of the bolt. The older antenna, version # 1, used 2 different length quadrant inserts, # 65 & # 66. Please note that the antenna quadrant boxes include the quadrant inserts and therefore current inventory should not be intermixed with newer deliveries.
3. The version # 2 antenna uses a modified major axis template.The major axis template carries the same part number as the older part, however, there are 2 sets of holes stamped on the edge of the axis where is bolts to the antenna back frame. The newer version major axis is backward and forward compatible (fits both the 0800-1554 and 088-1925 backframe). The older version major axis with the single set of holes will not fit on the newer backframe (P/N 0800-1925).

Care must be taken not to intermix old version #1t inventory with newer deliveries.

High level part number for the new version # 2 Prodelin 1244 2.4m 4 piece antenna are as follows:

a. 0800-2003 Az/El positioner also know as the canister includes antenna panel assembly hardware unless repacked by Orion.
b. 0800-1925 New welded 1 piece antenna backframe. Require all #65 Quadrant inserts or quadrant part numbers 0800-1995, 0800-1996 or 0800-1918 and newer major axis template with 2 sets of mounting holes.
c. "Wooden coffin" includes feed arm, feed horn, feed stabilizer, major & minor axis templates and other hardware. This "wooden coffin" may also include antenna panel assembly hardware if repacked by Orion. Please note that there are "Early" versions of this 0800-1838 "wooden coffin" that have the major axis template with only 1 set of mounting holes, these systems will not work with the 0800-1925 1 piece, welded, antenna back frames.
d. Antenna quadrants for the version # 2 system should not be intermixed with version #1 antenna systems because of the different antenna quadrant insert lengths. For the new version # 2 system, the top 2 antenna quadrant part numbers need to be as follows:
   0800-1995 Quadrant # 1 with #65 quadrant spacer
   0800-1996 Quadrant # 4 with #65 quadrant spacer
   0800-1918 Quadrant # 4 with #65 quadrant spacer and ORION logo

5.6.7. Prodelin 3.8m Installation Problems

- ☐ This antenna has a total of 12 quadrant inserts of 6 different lengths. These quadrant inserts can be easily interchanged and could cause antenna gain and sidelobe performance problems.
- ☐ The 3.8m antenna has at least 4 different length feed support/ boom arms, 2 for C band and 2 for Ku band configurations.

Prodelin contact:

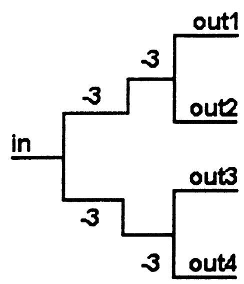
Prodelin Corporation 1700 NE Cable Drive P.O.Box 368 Conover, North Carolina 28613 USA Phone: (+1-704) 464-4141 Fax: (+1-704) 468-0860

5.7. The Indoor Unit in depth

To improve the MTBF (mean time between failure) keep the power always on.
Do not switch the electrical equipment off for the weekend !

5.7.1. Dividers / Combiners

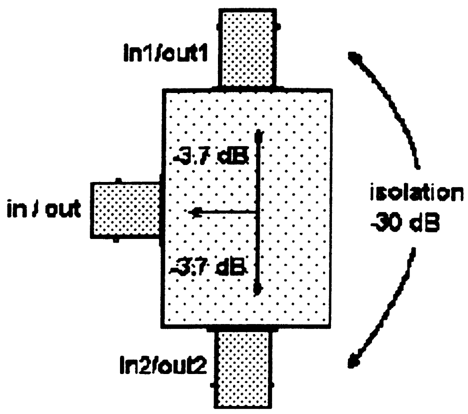
Dividers or combiners are actually the same piece of equipment and also called splitters. Basically they split the signal power into two equal parts. This means that the signal at the output is theoretical 3 dB lower than at the input. Practical loss depends on the used connectors, connected impedance (does it match with splitter in- and output impedance or not) and the frequency. A two-way splitter gives a loss of 3.4-3.7 dB. A three way splitter also excists as a basic component and has 4.8 dB insertion loss. Out of those two basics it is possible to create every desirable divider or combiner simply by adding them together. The table below shows often used splitters with their theoretical insertion loss.

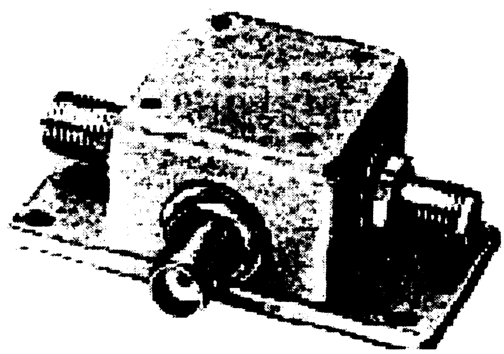


2-way	3.0 dB
3-way	4.8 dB
4-way	6.0 dB
6-way	7.8 dB
8-way	9.0 dB

Commercial splitters have an in- and output impedance of 50 Ω or 75 Ω and are flat from 5 MHz to 1 GHz or higher. Orion Atlantic uses Mini-Circuits 75 Ω types.
Unused out- or inputs always have to be terminated with the correct characteristic impedance.

Be aware, a splitter is directive and can not be connected in any way you like.



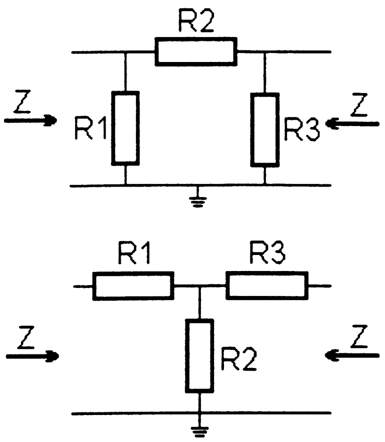


A standard two way combiner / divider. The loss between in ⇔ out is -3.7 dB (this is including the connector loss). The isolation between in1/out1 and in2/out2 is about -30 dB but depends on the correct impedance termination.

5.7.2. Fixed Attenuators

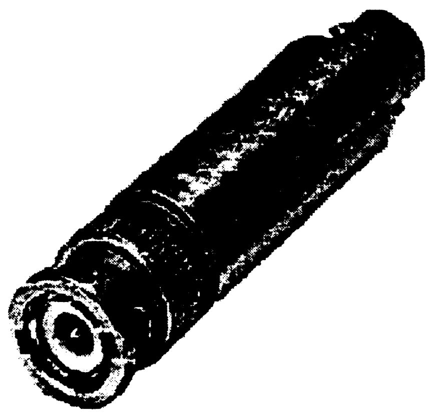
Attenuators are often found in the RF signal path of receivers (and transmitters). The use of broadband, rather than narrowband, input filters often result in considerable amount of unwanted RF energy reaching the first signal stage and mixer, giving rise to overload problems. One method of reducing this type of problem is to provide the option of adding some attenuation in the signal path. This can be effective in improving reception both when the desired signal is strong and is causing overload effects, or when a strong undesired signal is masking a weaker signal.

The used attenuator must be of the same impedance as the modem input and the cable. In effect, if the modem input filters are presented with the wrong drive impedance they will not achieve their design performance.



Two simple configurations are available for (unbalanced=one side is connected to the ground) attenuators. The Pi- and T network.

For the additional attenuation in the TX and RX path Orion Atlantic prefers to use the blue Mini Circuits Fixed Attenuators with BNC connectors. They have an input / output impedance of 75 Ω and are flat from DC to 500 MHz. The attenuator is available in the next values: 3, 6, 7,10,15 and 20 dB



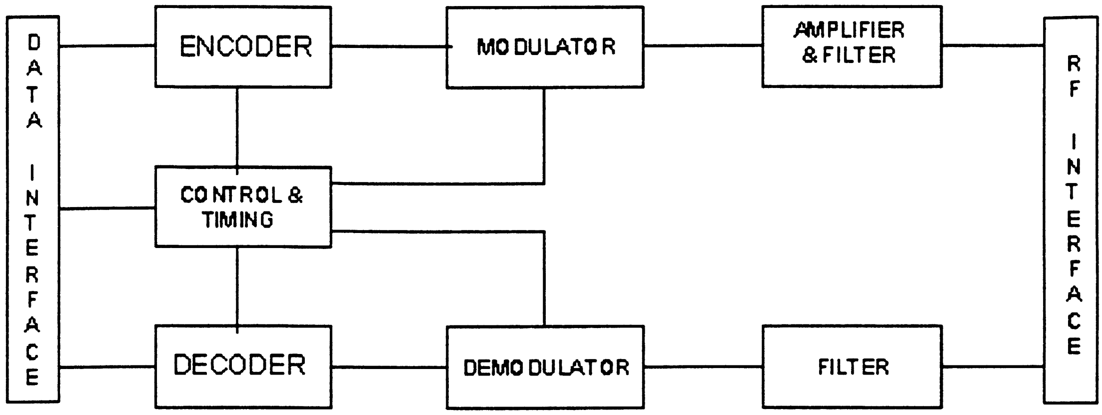
Mini Circuits Fixed Attenuator

5.8. Satellite Modems

5.8.1. Introduction

A method is needed to allow two (digital) devices to "talk" to each other through the dissimilar analog environment. The modem provides this interface. It alters either the amplitude, the frequency, or the phase to represent for example binary data as an analog signal. The word "modem" is a shortened term for *mod*ulation/*dem*odulation. Orion prefers to use its applications the Fairchild SM2800, SM2900 or the Comstream CM701. Satellite modems are factory configured for either 70±18 MHz IF or 140±36 MHz IF.

5.8.2. Simplified Description of Satellite Modem.



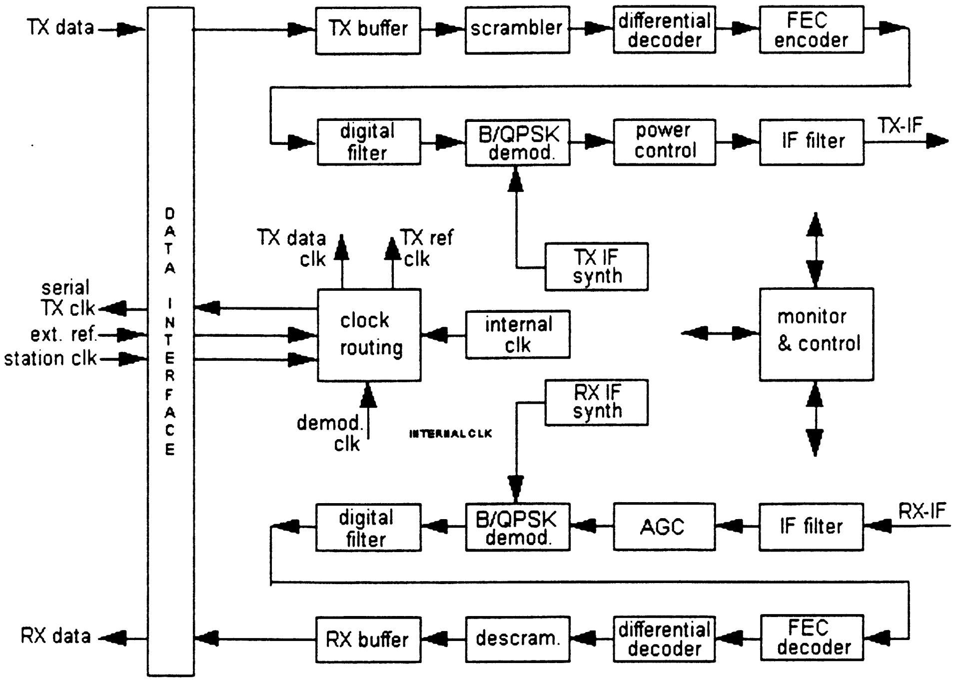
Transmit:
The send data from the DTE. (Data Terminal Equipment) is presented to the Data Interface. This data has an "Over Head" of data bits added in the Encoder for error correction and is then modulated onto a 70 MHz IF carrier. The modulated IF carrier is amplified to the correct level to drive the RF transceiver. The IF filter removes all unwanted out of band components.

Receive:
The receive 70 MHz IF signal is presented to the IF interface. This signal is filtered to remove unwanted components and adjacent carriers before being presented to the demodulator. The demodulator recovers the data stream which is passed onto the decoder for error correction. The recovered data is then presented to the data interface for onward transmission to the DTE.

Control and timing of all functions of the modem is provided a central Control; and Timing Unit.

5.8.3. Modular Description of a Satellite Modem.

The Basic Satellite Modem is made up of the following modules:



- **Data Interface:** Accepts the user information in a form specified by international standards. This interface conforms to all mechanical and electrical standards. The interface serves primarily as a data and clock routing switch converting the unique signal levels from external equipment to digital levels for processing in the modem.

- **Buffering:** Is provided in both transmit and receive paths. This buffering is designed to take up any timing errors in the system.The transmit buffer is used to synchronise the transmit data stream to the selected transmit clock source. The receive buffer is usually an elastic buffer that corrects any errors due to the Doppler shift associated with the satellite, it also synchronises the receive data to the selected receive clock source.

- **Scrambler/Descrambler:** is used in satellite modems to ensure that uniform spectral spreading is applied to the carrier at all times. Scrambling does not provide a means of data security.

- **Differential Encoder/Decoder:** Is an essentially part of the BPSK, QPSK system.This differential system is designed to provide a phase reference between the current and previous data symbol.

- **FEC Encoder/Decoder:** Is applied to the data stream before modulation and decoding is done after demodulation. Encoding adds a “overhead” to the data stream to enable error correction. The modems used by Orion normally use either Viterbi or Sequential coding. This encoding/decoding is selected with a defined overhead or FEC (Forward Error Correction) of either 1/2, 3/4 or 7/8. The higher quality modems can also be fitted with a Reed Solomon Encoder which adds further correction to the already encoded data stream.]

- **Digital Filter:** The spectrum of any PSK modulated signal contains a significant amount of out of band energy. This energy, if transmitted would result in adjacent channel interference or require a higher bandwidth allocation. To overcome this it is possible to remove all the unwanted energy in the side lobes by selective filtering whilst maintaining all the relevant information. This filtering is done using finite impulse response digital filters that emulate the Nyquist filter.

- **Modulation:** Satellite modems use either BPSK or QPSK modulation. The digital data stream is phase modulated onto a 70 MHz (+/- 18 MHz) carrier whose reference is obtained from a phase locked loop (PLL) synthesiser. In QPSK, two bits per symbol are transmitted, in BPSK, only one bit per symbol is transmitted, the bandwidth requirement of a QPSK carrier is therefore half the bandwidth requirements of a BPSK carrier.

- **IF Filters:** IF filters at the modulator output and the demodulator input are used to removes all unwanted out of band components.

- **Clock Routing (Clocking):** Satellite modems support synchronous data services, therefore the provision of stable synchronous clocks and data are paramount. All satellite modems have an internal reference oscillator that can be utilised as a reference clock. Provision is also made for the use of an external station clock, external DTE clock, or recovered demodulator clock. The clocking options of a satellite modem are numerous depending on application. The clock router is used to selects the desired clocking options to maintain system timing.

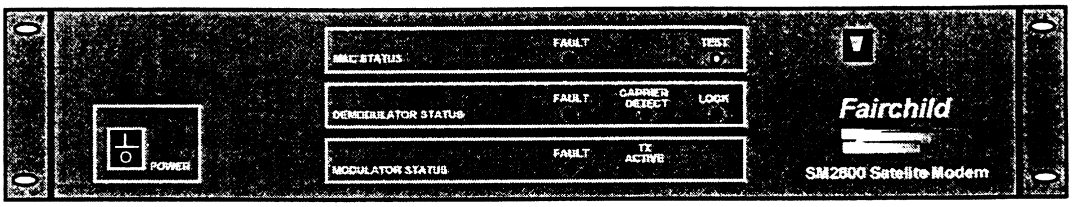
- **Monitor and Control:** A Monitor and Control function is provided that allows the user to set up all operational parameters. This M&C will also monitor the performance of the modem and raise any alarms that occur.

5.8. Fairchild SM2800 & SM2900

5.8.1. Introduction SM2800

This is the basic, satellite modem for data rates between 9.6 kbps and 512 kbps. The datarate depends upon the decoder (see table below). High Speed modulator cards and demodulator cards are now available for data rates between 512 and 2048 kbps. Depending on the data rate, BPSK or QPSK modulation is available. RS422 and V35 data interfaces are supported. Control of the modem is via an optional hand held terminal (ziggy) or Lap-Top PC running a ziggy emulation program.

Data rate range	1/2 rate (kbps)	3/4 rate (kbps)
BPSK	9.6 - 64	64 - 256
QPSK	32 - 512	48 - 512



5.8.2. Modular Architecture

The standard SM2800 is designed as a modular system and houses :

- M&C (topslot)
- RX (middleslot)
- TX (lowerslot)
- Universal input power supply

Exept from the power supply these modules are installed or changed by sliding them in and out of the chassis at the front panel. The SM2800 has an autoranging powersupply that accommodates input voltages from 90 to 250 VAC. The modulator and demodulator board contain no configuration jumpers which are field changeable.

5.8.3. The M&C Board

This is the top most board in the modem and provides the following:

- All Monitor and Control functions for the Modem.
- A Host Interface normally configured for RS485 operation.
- A Hand Held (ZIGGY) interface.
- A full set of Clock options for the Modem.
- Transmit and Receive Buffering.
- Red Fault LED. Illuminated for fault on M&C Board.
- Amber Test LED, Illuminated when modem is in Loop-Back or Pure Carrier Mode.

This board has four user configurable jumpers. For RS485 (Orion standard) operation the jumper on TP2 (RS232 option, factory preset condition) must be removed and placed on the two pins of TP3. If the modem is used as a stand alone unit or it is the last unit on the multidrop RS485 bus the jumpers on TP7 and TP8 must remain to provide a termination. If the modem is part of a multidrop bus, but not the last unit, the jumpers on TP7 and TP8 must be removed.

5.8.4. The Demodulator Board.

This is the centre board in the modem. The demodulator accepts 52 to 88 MHz IF input and performs BPSK/QPSK demodulation at a frequency determined by the frequency synthesiser. The demodulator output is applied to the decoder input where data is recovered. The demodulator board includes:

- AGC on IF front end.
- 52 to 88 MHz Frequency Synthesiser to provide the selectable tuning in 2.5 KHz steps.
- BPSK/QPSK Demodulator.
- Symbol Clock Recovery.
- Sequential or Viterbi FEC Decoder.
  V.35 (CCITT), Linkabit compatible, or V.35 (IESS 308) Descrambler.

5.8.5. The Modulator Board.

This is the bottom board in the modem. The modulator uses the data and clock output of the M&C board to produce a BPSK or QPSK modulated IF carrier after encoding. The modulator includes:

- 52 to 88 MHz Frequency Synthesiser to provide the transmitter selectable tuning in 2.5 KHz steps.
- FEC Encoder which accepts data and clock lines from the M&C board and provides an encoded output to the Modulator.
- V.35 (CCITT), Linkabit compatible, or V.35 (IESS 308) Scrambler.
- BPSK/QPSK Modulator.
- Power Level circuitry.
- Differential Encoder.
- Filtering to eliminate out-of -band components.
- Green Tx Active LED. Illuminated when Tx PWR enabled.
- Red Fault LED. Illuminated for fault on the modulator board.

Do not alter the setting of factory jumpers which are in place on the demodulator and modulator module.

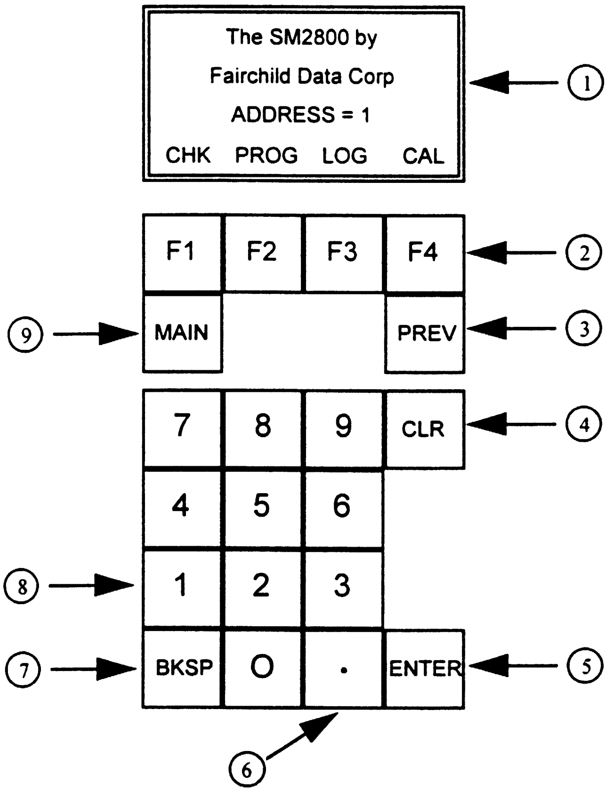
5.8.6. Configuration

Programming the SM2800 can be accomplished in a variety of ways:

- By handheld terminal ("Ziggy") which is optional.
- By software provided with the unit.

The software provided consists of two versions:

1. "HANDHELD", and is an exact emulation of the handheld terminal (minimum requirements are DOS 3.1 or later and one COMM port)
2. "SM2800", and is more flexable than "HANDHELD" (minimum requirements are MS Windows version 3.0 or later)



0 to 9	=	0 to 9
Fl to F4	=	Fl to F4
MAIN	=	m
PREV	=	p
CLR	=	Delete
BKSP	=	Backspace
ENTER	=	Enter
Quit	=	q

ZIGGY Display as viewed on Lap-Top PC.

Figure 4.

Handhold Terminal Description:

1. 4-Line Display for monitoring configuration and command.
2. Function Keys 1 through 4 which permit selection of items from the display located directly above each key. "F1 to F4" on the Lap-Top PC.
3. PREVIOUS key which allows existing from the current menu level and returns to the previous menu level. "P" on the Lap-Top PC.
4. CLEAR key allows the keypad entry to start over. "Delete on the Lap-Top PC.
5. ENTER key executes or implements the command upon completion of the command entry. Enter must be depressed to accept or execute a parameter. "Return/Enter" on the Lap-Top PC.
6. Decimal Point for numerical entry. "Decimal Point/Full Stop" on the Lap-Top PC.
7. BACKSPACE key clears the last entry and allows re-entry. "Backspace" on the Lap-Top PC.
8. Numeric keypad allows entry of numeric parameters such as frequency or power. "Numeric Keys" on Lap-Top PC.
9. MAIN menu which is the root menu of the menu tree. "M" on the Lap-Top PC

The structure of the Fairchild SM2800 menu tree is shown in figures 5.0 and 5.1. Depending on the Software version of the modem, some of the functions may not be available.

Site Specific Configuration Details.

The site specific configuration details are kept in the Orion Atlantic FIM (Field Installation manual). A typical configuration sheet is shown in figure 6. The format of this form may differ, depending on which Orion Engineer designed the installation.

5.8.4. Capability Summary SM2800

System Specifications	
Configurations	Full duplex, receive only, transmit only
Standard data rates:	From 9.6kbps to 512 kbps in 20 steps but depends upon decoder
Modulation types	BPSK and QPSK
Code rates and decoder types:	Decoder to be specified at time of order Viterbi rate 1/2, 3/4 Sequential rate 1/2, 3/4 Reed-Solomon option available
Data interface options:	RS442, V.35, field changeable, to be specified at time of order
Power:	90-250 V, 47-63 Hz (auto ranging) usage: 50 W (typical)
Programmability:	Via RS232, RS485 (remote),hand-held terminal
IF	
Impedance:	75 Ω
Programmable IF frequency:	52 to 88 Mhz, 2.5 kHz step size 104 to 176 MHz option available
Transmit power level:	-5 to -25 dBm in 0.5-dB steps
Receive level:	-35 dBm to -55 dBm
Mechanical	
Size:	19" Rack Mountable (2U)
Weight:	15 pounds

For more technical details according the Fairchild SM2800 is referred to the Ground Operator Equipment Manual chapter 5 or the Fairchild SM2800 Installation and Operation Manual.

5.8.5. Introduction SM2900

This is the professional modem from the Fairchild range. This modem supports data rates between 32 kbps and 3456 kbps. Depending on the data rate, BPSK or QPSK modulation is available. RS422, V35, E1, T1 data interfaces are supported. A drop and insert mux is also available for this modem. Control of the modem is via front panel push buttons and display.

5.8.6. Configuration

Programming the SM2900 can be accomplished in two ways:

- Local control is executed via a front panel LCD and keypad.
- An RS485 bus is supplied for the remote control which provides full monitoring and control capability.

5.8.7. Capability Summary SM2900

System Specifications	
Configurations	Full duplex, receive only, transmit only
Standard data rates:	Up to 2304 kbps (sequential) Up to 6312 kbps (1/2 Viterbi) Up to 8448 kbps (3/4 Viterbi)
Modulation types	QPSK
Code rates and decoder types:	Programmable Viterbi rate 1/2, 3/4 Sequential rate 1/2, 3/4, 7/8 Reed-Solomon option available
Data interface options:	RS422/RS449, V.35, G.703
Power:	90-265 V, 47-63 Hz (auto ranging) usage: 110 W (typical)
Programmability:	Via RS232, RS485 (remote)
IF	
Impedance:	75 Ω
Programmable IF frequency:	50 to 180 Mhz, 2.5 kHz step size 104 to 176 MHz option available
Transmit power level:	-5 to -25 dBm in 0.1-dB steps
Receive level:	-35 dBm to -55 dBm
Mechanical	
Size:	19" Rack Mountable (2U)
Weight:	15 pounds

For more technical details according the Fairchild SM2900 is referred to the Ground Operator Equipment Manual chapter 5 or the Fairchild SM2900 Installation and Operation Manual.

5.8.8 SM2800 and SM2900 Installation Problems

Problems come and problems go. The promblems listed below are temporarely and will fade out in time.

- There are SM2800 Modem known which in combination with Viterbi decoding an Eb/No of 1.9 dB show while the C+N/N ≥ 12 dB. Expected is that under this circumstance shouldn't be any problems with Eb/No. Fairchild has sent info regarding the Viterbi decoder with invalid Eb/No reporting. This problem occurs on both the SM2800 & SM2900 modems with the Viterbi decoder option. The problem is with bad firmware on the Viterbi decoder card. The firmware is located on the Viterbi decoder board in chip slot U2. The correct version firmware should be 4905-021 Rev. 1. Any other firmware part number or revision may cause invalid Eb/No data reporting at lower date rates. It appears that data rates at or above 512k may not be affected as much, however, it is a good idea to make sure all Fairchild Viterbi decoder cards have this latest firmware.

- SM2800 modems with version 1.03 firmware contain an anomaly which disables carrier tracking when timer value is set to zero. Later firmware versions prevent this.

- SM2900 in combination with the Reed-Solomon option: Alignment problem with the rear connector that mates the RS board with the M&C board. Looking at the M&C board with the LED's toward you the rear miniature connector right is known to become damaged in some cases with the installation of the RS board.

- Dribbling errors caused by the 33 MHz interface to the Reed-Solomon board. The one parameter that is crucial for RS to work is that the differential encoder and decoder must be set ON

- **Fairchild Sequential Decoder Problem - ECO not fully performed at factory**
  Part Numbers: 005445-021 Standard speed sequential decoder, Rev. F03 & F04
  005445-031 Hi speed sequential decoder, Rev. F03 & F04
  Symptoms:
  SM2800 - Intermittent operation, faults and loss of RX data. The demodulator card may have all LED's lit; Fault, Carrier Detect & Lock. The symptoms may appear and disappear when modem configuration is altered or modem is power cycled. The decoder may fail to lock onto RX carrier but may or may not lock in a self loop test.
  SM2900 - No know problems at this time with these "Bad Rev. F03 & F04 Sequential decoder cards" installed on the SM2900.
  Action to be taken: Power modem off and remove demodulator card. Locate the decoder daughter card on the left rear corner of the demodulator card when the status LED's are facing you. Determine if the decoder is a Sequential or Viterbi decoder card by viewing the part number. Sequential decoder part numbers are either 005445-021 or 005445-031. If the Rev is either F03 or F04, remove the decoder card from the demodulator card and inspect the underside of the decoder card for a jumper wire. The Rev. F03 & F04 Sequential decoders should have jumper wire, about 3 inches (76 mm) long, that connects a solder pad under U16 to a solder pad under U11 (16 MHz clock oscillator) If this wire is not present on the card, contact Orion and arrange for a good, replacement decoder card. DO NOT ATTEMPT TO ADD A JUMPER, AS THESE REV'S REQUIRE OTHER MODIFICATIONS.

- M&C card, part number 006600-011: U34 and/or U22 PLCC (Plastic Leaded Chip Carrier) chips (otherwise leadless chips) coming out or partially coming out of IC socket causing modem configuration to be lost, corrupted or incomplete. This is caused by the PLCC IC socket being too short and not holding the IC chip(s) firmly, allowing then to rock, come loose or fall our during shipping.
  Solution: Re-seat chip firmly and squarely with your thumb or index finger. If chip socket is still questionable, contact Orion NMC or Logistics for a possible replacement M&C board. We have found that if these chips are firmly seated and the modem is not shipped the problem will not usually reoccur. Fairchild has resolved this problem in newer M&C boards by using a different PLCC IC chip socket.

- Demod card, part number 006003-008, - 011, -061, -021, -071, -091. All these cards should have the DSP option.: U80, the DSP PLCC (Plastic Leaded Chip Carrier) chip (otherwise leadless chip) coming out or partially coming out of IC socket causing demod to perform poorly, loose lock, not regain lock, high BER. This is caused by the PLCC IC socket being too short and not holding the IC chip(s) firmly, allowing then to rock, come loose or fall our during shipping. Also look at the other 3 PLCC chips, U87, U 48 & U 51 and make sure they are properly seated.
  Solution: Re-seat chip firmly and squarely with your thumb or index finger. If chip socket is still questionable, contact Orion NMC or Logistics for a possible replacement M&C board. We have found that if these chips are firmly seated and the modem is not shipped the problem will not usually reoccur. Fairchild has resolved this problem in newer M&C boards by using a different PLCC IC chip socket.

- Sequential decoder card, part number 005445-021: We have seen some of these cards not perform correctly at data rates of 256 kbps, rate 3/4 only. The demod will not lock in an IF loop back or may have very high BER rate. This problem was just discovered and at this moment we are still gathering data. It appears that not all decoder cards are affected. This may be a component tolerance problem but at this time we do not have much supporting data. Fairchild is currently working this issue and more details will available soon. We expect the same problem to occur with the SM2900 and this decoder card in some instances, again only at 256 kbps, rate 3/4. Please advise if anyone else sees this same problem.

Fairchild contact:

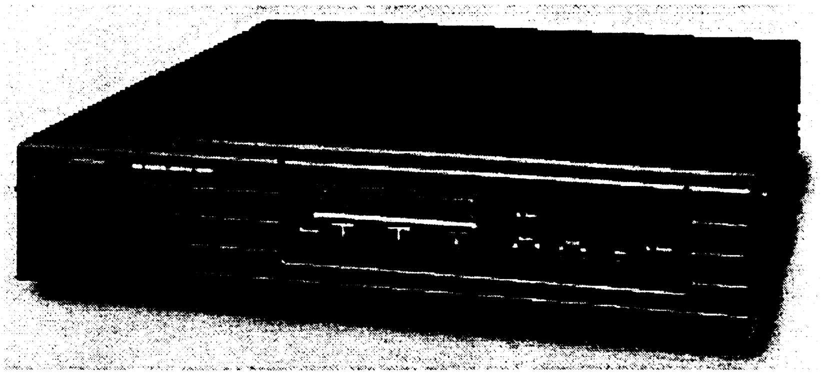
Fairchild Data Corporation 350 North Hayden Road Scottsdale, AZ 85257 USA Phone: (602) 949-1155 FAX: (602) 941-0023

5.9. ComStream CM701

5.9.1. Introduction

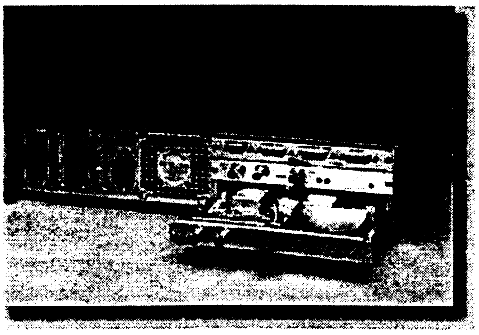
The ComStrean CM701 is a PSK digital modem using a modular architecture with variable rate modem specifications. The CM701 has a 100 Hz IF resolution, supports data rates with 1 bps resolution from under 9.6 kbps to 2.2 Mbps; BPSK and QPSK modulation uncoded or with code rates of 1/2, 3/4, 7/8; Viterbi and Sequential decoding algorithms and Reed-Solomon as an option.

ComStream CM701



5.9.2. Modular Architecture

The ComStream CM701 modem is designed as a modular system. The modulator, demodulator, data interfaces, and options are completely independent modules, or Field-Replaceable Units (FRUs), that work together as a system. These modules are installed or changed by simply sliding them in and out of the chassis at the rear panel. The modules plug into a backplane within the modem, much like the circuit cards in a PC. Each module contains its own microprocessor and nonvolatile memory, allowing it to store individual configuration and run comprehensive self-test operations. Receive-only and transmit-only applications are supported by removing modules that aren't needed. Also, modems in the field can be upgraded by sliding in another module.



Modulator option slot

The CM701 has an autoranging power supply that accommodates input voltages from 90 to 264 VAC. There are no internal jumpers, straps, or switches requiring customer setup prior to operation. All configuration selections are made from the control front panel or by using a remote terminal. Each CM701 has a built-in BERT and extensive system diagnostics to aid in network checkout and problem solving. The BERT reports BER, errors, number of bits, blocks, and block error rates with programmable data patterns. The modem and each module also contain extensive self-test capabilities to verify proper operation and calibration. A real-time clock time-stamps fault indicators to help track system problems.

Every CM701 contains a bit error rate tester.

5.9.3. Data Interfaces

The CM701 can have multiple interface (I/O) modules installed at one time. Using multiple I/O modules means transmit and receive data can be in different formats, or one modem can be moved from one application to another. The active interface is selected by front panel or remote control commands. Interface modules support the following interfaces:

- RS-449/422
- V.35
- G.703
- DS-1
- RS-232.

5.9.4. Options

Reed-Solomon Coding

The Reed-Solomon codec is an option module that fits into an available option slot. Because it encodes on top of standard Viterbi decoders, it can be added to CM701s in the field easily.

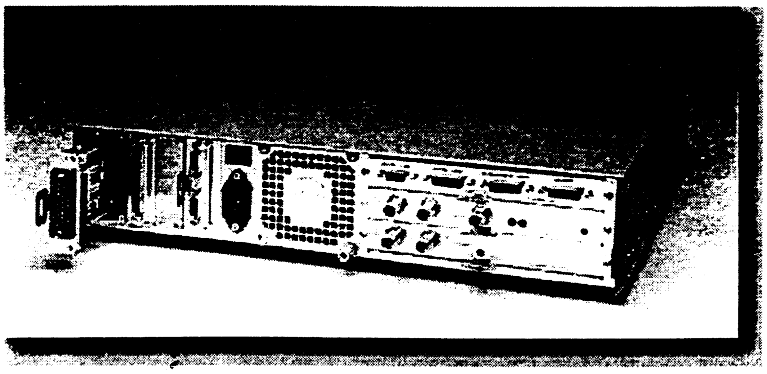
The Reed-Solomon option comes in two models, ComStream proprietary and INTELSAT compatible. The proprietary model is implemented on a 15.25cm x 25.5cm horizontal CM701/DT7000 option card.

Doppler Buffer

Doppler buffers smooth out the periodic frequency variation in the received data rate caused by satellite motion. This option module fits two primary applications:

1. With a DTE that requires exact synchronization between TX and RX clocks
2. When a high-stability clock is used to control the timing of all satellite modems at a single site.

Like the Reed-Solomon option the ComStream's Doppler Buffer Module is an option card and can be installed in the field by simply sliding it into one of the vertical option slots at the rear of the chassis in the CM701 modem *(see picture below)*.



Doppler buffer option card

The ComStreams Doppler Buffer Module buffers data received from the satellite on a first-in-first-out (FIFO) basis. Data is input to the buffer using the receive clock from the satellite signal. It can be output from the buffer using either an externally supplied clock, the transmit clock, or the internal clock. A self-test mode is
also built into the doppler buffer option. Issuing a single command puts the buffer into the test mode, then another command shows the results of the test

5.9.5. Capability Summary CM701

System Specifications	
Configurations	Full duplex, receive only, transmit only
Standard data rates:	From 4.8 kbps to 2.34 Mbps in 1-bps steps (Variable, quad, single, and 8 Mbps rate option)
Modulation types	BPSK and QPSK
Code rates and decoder types:	Programmable Viterbi rate 1/2, 3/4, 7/8, and 1 (uncoded) Sequential rate 1/2, 3/4, and 1 (uncoded) Reed-Solomon option available
Data interface options:	RS-449, V.35, G.703, RS-232, DS-1 standard (Multiple interface capability)
Power:	90-264 V, 47-63 Hz (auto ranging) usage: 50 W (typical)
Programmability:	Front panel and remote control
IF	
Impedance:	75 Ω
Programmable IF frequency:	52 to 88 MHz (software programmable) 104 to 176 MHz option available
Transmit power level:	-5 to -25 dBm in 0.1-dB steps
Receive level:	-10 dBm to -55 dBm
Mechanical	
Size:	19" Rack Mountable
Weight:	25 pounds

For more technical details according the ComStream CM701 is referred to the Ground Operator Equipment Manual chapter 5.

ComStream contact:

U.S.A./Canada/Latin America/Headquarters
Contact: Chick Reutter
10180 Barnes Canyon Road
San Diego, California 92121 USA
E-Mail: marreola@comstream.com
Phone: (619) 657-5416
FAX: (619) 657-5404

5.10 Comstream DT8000

5.10.1. Introduction

This Earth station is an indoor-outdoor satellite system that offers users a specialized variable rate option, a modem and Ku band transceiver. Combined, these elements receive voice or data signals. The outdoor unit can be ordered with various Ku band transceivers and comes with a low noise block down converter (L band). Programmable powerlevels and operating parameters allow the unit to support several satellite applications.

5.11. Power Supply Facility

The power supply facility on a VSAT site is supplied by the local authority in a single phase. On site an uninterruptible power supply (UPS) with a battery back-up system is capable of providing sufficient power during a commercial power failure and can usually keep a site on the air long enough to have commercial power restored or until the system can be switched over to generator power.

5.12. Grounding and Lightning Protection

About ground leads and shields is a lot of misunderstanding and can cause plenty of problems (e.g. biterrors) which are sometimes hard to trace. The main problem is that currents flowing through a ground line can generate a signal seen by another part of the circuit sharing the same ground.

> The RFU is provided with grounding lugs. As thick as possible stranded copper wire must be used to bond the RFU and LNC units together and to the earth ground, using the most direct and shortes routes

External ground connection points are provided on the RF Unit and quick repoint antenna canister. An appropriate ground wire of #10 gauge (AWG) or larger must be provided for connection to these ground studs at the outdoor equipment site. A suitable origination point for this ground is a connection to:

- Building ground
- Grounded structural steel building member
- Metallic cold water pipe, or if none of the above exists,
- a driven ground rod.

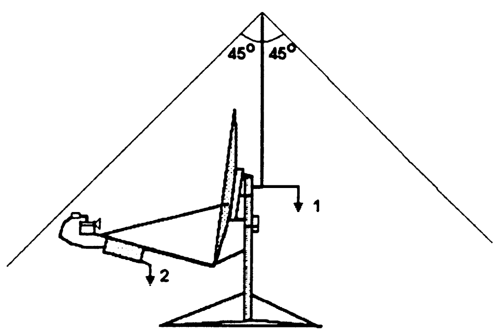
Prior to connection to the RF Unit ground lug, the DC resistance between the ground wire and electrical distribution box ground (equipment chassis ground) shall be:

- Connection to metallic cold water pipe: 25Ω or less
- Connection to grounded structural steel member 25Ω or less
- Connection to driven ground rod: Up to 25Ω is acceptable if lower resistance cannot be obtained.

> The building lightning protection is not equal to the building ground !

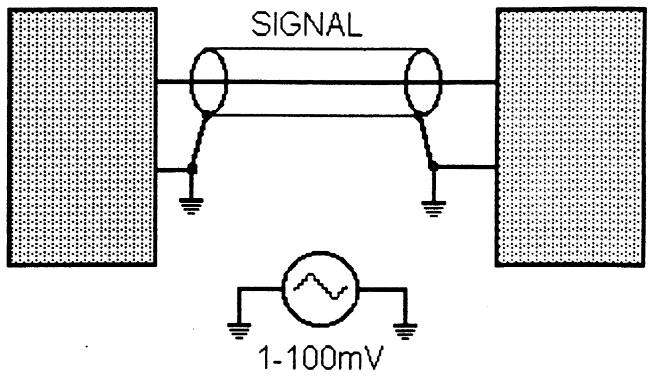
⇒ Building ground is a 15-20m copper pipe into the ground right under the building.

⇒ Lightning protection (and this is the responsibility of the building owner) is a very thick metal pipe on top of the antenna. The minimum height of this pipe is the height where the antenna is covered totally (see drawing on the right). After a lightning strike the equipment is gone anyway but it prevents you from fire.

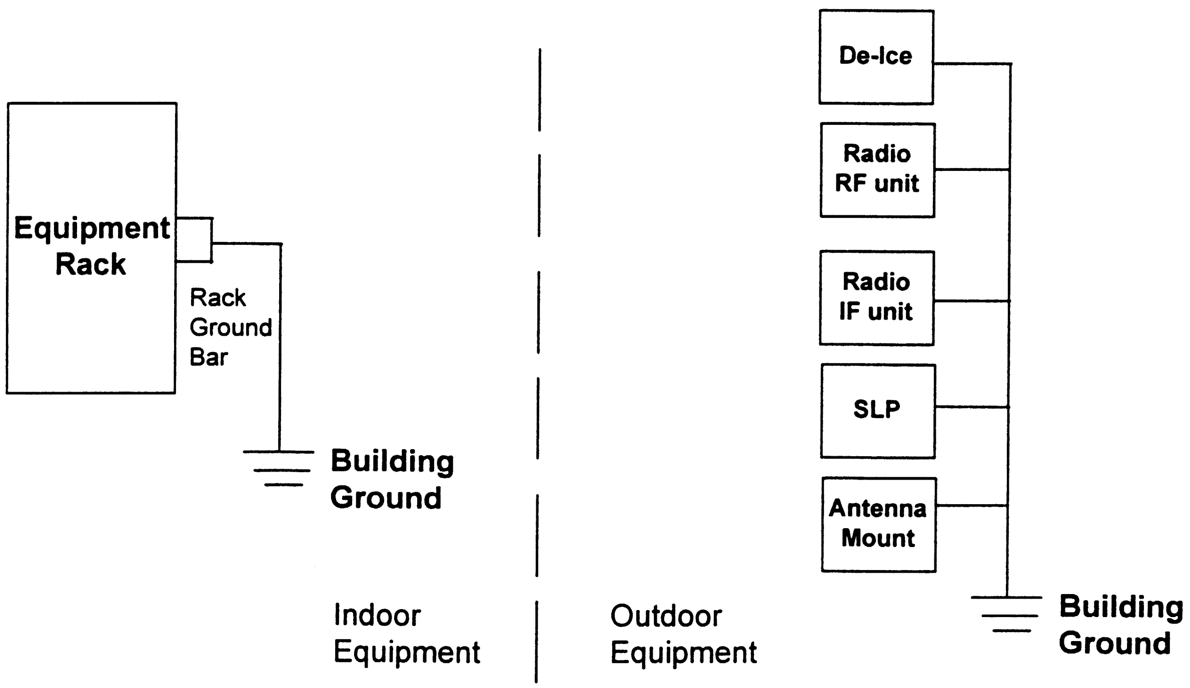


5.12.2. Grounding between Equipment

The voltage source shown between the two grounds represents the possible variations in local grounds you can find on different power-line outlets in the same room or worse, in different rooms or buildings. It consists of some 50Hz (USA 60 Hz) voltage, harmonics of the line frequency, some RF signals (the powerline makes a good antenna), and spikes. If your signals are large enough this won't be any problem if not then...



The indoor units utilize standard 3-prong, 220 VAC (120 VAC USA) convenience outlets for primary electrical power. These equipments obtain an electrical ground from the third wire (green) which originates at the electrical distribution box ground and is connected internally to the equipment chassis. It is essential that convenience outlets which are utilized be wired in conformance with the National Electrical Code and applicable local electrical regulations, in order to ensure proper electrical grounding of the indoor unit.



Note 1: Size ground connectors for less than 1 ohm difference between indoor and outdoor equipment (use #6 or larger wire). Use corrosion resistant hardware to mount outdoor ground wires.

Note 2 : All equipment chassis in rack should be grounded to grounding bar.

5.13. Safety

Safety is a primary issue and its considerations should take precedence in all situations. All Ground Operators must observe safety rules and procedures when performing installations or maintenance in and around the earth station. Some important safety tips are:

- Never work alone with power equipment. Approved insulating is absolutely necessary and ensure that insulating hooks and grounding rods are available closeby. Always be sure that that all the equipment and the supplying switch frame is turned off.
- (Regularly) check the grounding (and the balance of loading between phases).
- Be extremely carefully when working with batteries (wear goggles and gloves). Know where the eye-wash facilities are.
- Know were all fire fighting equipment is kept and know how to use it.
- Do not work on the antenna alone and be sure that the HPA is switched off.
- Do never work in front of a working HPA.
- Check radiation levels at the rear and side of antennas. Intenational safety regulations stipulate that exposure to levels of 4.0 mW/cm^2 should not exeed 6 minutes in duration at anyone time.

Once the fully two-way interactive satellite link is developed, some attention to radiation safety might be necessary. This issue does not arise for current DBS, since consumer antennas are receive-only. The issue may not be very important for future transmit-receive VSAT / consumer dishes if the power levels are very low, but at least some thought is already being directed to standards for interactive consumer dishes.

Safety is a primary issue and its considerations should take precedence in all situations.

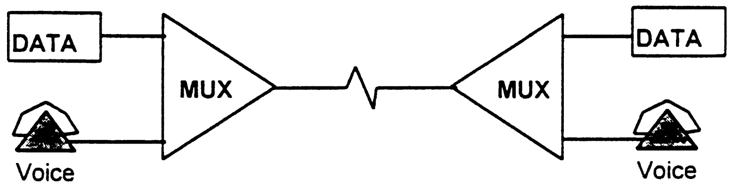
Chapter 5
VSAT Related Network Components

5.2. Multiplexers

Within Orion we use two different kind of Multiplexers, the Access Plus 100 and the ACT. In the following paragraph we would like to introduce you to the Multiplexer.

5.2.1. Why we use Multiplexers

A Multiplexer is a device that allows us to use a variety of interfaces with multiple variable speed channels over a single, higher speed carrier channel. In other words with a Multiplexer we can have several different inputs (Data or Voice) and one single output, as you can see in the drawing below.



On top of that, modern Multiplexers are capable of utilizing high data compression algorithms (like CELP and ACELP) for Voice Channels which bring down the used bandwidth significantly. Signaling between Multiplexers is propriety, which means that "the other side " always has to be a machine from the same manufacturer and type.

5.2.2. Data Interface Capabilities

Orion basically uses two different Multiplexers, the PCSI Access Plus and the ACT SDM-FP and SDM-JFP. From the two, the Access Plus is most used in our point to point links. The ACT can be found mainly in VISN installations.

The Physical interface on PCSI Network Port is a DB25 Male. The electrical specification can either be a RS422/449 or V.35. The jumper setting can be found on the Motherboard.
For the Data-ports we can choose from the following interfaces:

- RS232 (V.24)
- V.35
- RS422/449
- X.21

The PCSI Access Plus has 4 positions for Data expansion boards (IOP Cards). On one IOP-Card we find 4 Data-Ports. The physical interface is a DB25 Female. The electrical specifications are determined by a daughter board placed on the IOP Card making it a V.35 or RS422/499. For X.21 we need to use a RS422/499 daughter board and an active interface converter. The reason for an active converter is because on the X.21 pinout you only find one clock which is used for transmit and receive. With the delay caused by the satellite link the TX & RX clock are not in sync with each other which causes Clock Slips. The active converter has several buffers to avoid the Clock Slips.

On the ACT mux all Physical interfaces are DB25 Female, the electrical specification can in this case be RS232, RS422/449, X.21 and V.35. For RS422/449, X.21 and V.35, specific interface cards are required.

5.2.3. Voice Interface Capabilities

The PCSI Access Plus supports standard 30 channel, Channel Associated Signaling (CAS), voice links using a E1 card. For this, Digital Voice Cards have to be installed in the system. Furthermore the following analog signaling interfaces are supported:

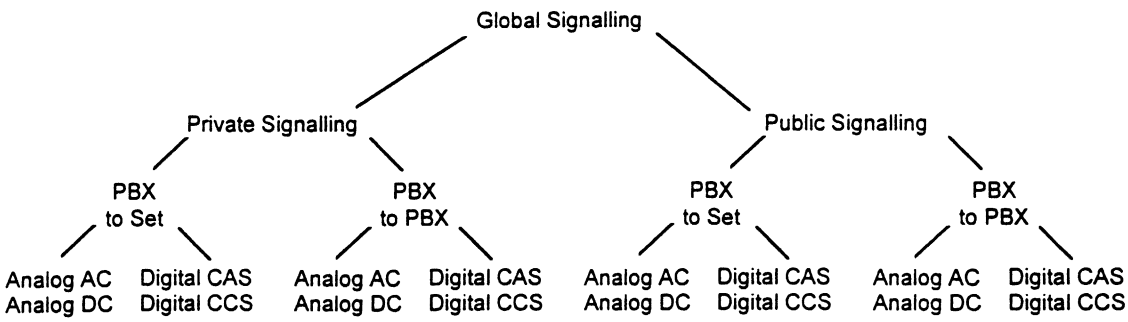
- 2 wire loopstart - ringstart
- 2 wire E&M type I to V
- 4 wire E&M type I to V
- 4 wire AC15-A and AC15-D (CEPT-L1)

The ACT systems support the same protocols however Orion has never used E1 links over a ACT Multiplexers.

5.2.4. Voice Signaling

There are several different kinds of Voice Signaling. In general they can be divided in Public Network (PSTN) and Private Network signaling. Furthermore these can be subdivided into signaling between PABX's and Set's and between two PABX's. And, as if this was not enough, there is also a division between Analog AC and - DC signaling, Digital Channel Associated Signaling (CAS) and Digital Common Channel Signaling.

The Telecom Voice Signaling Nightmare

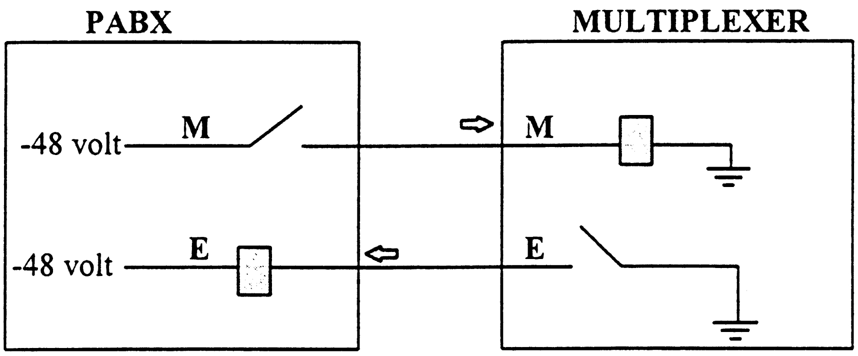


For Orion we concentrate on Private signaling types.
PABX to Set:
Uses 2 wires and a DC signaling type called "Loopstart - Ringstart." (Note: PCSI uses the term "Ground Start when they talk about PABX initiaded calls = Ringstart). Signaling and Speech Path are using the same 2 wires. Signaling is done by either closing a circuit and start the flow of a current (loop start), or by putting a "Ring current" on the line (ring start). Loopstart is always initiated by the Set, the ring start originates from the PABX.

PABX to PABX, AC15
AC15 signaling uses 4 wires and an AC signaling. Signaling and speech use the same 4 wires. Signaling is done by putting a 2280 Hz signaling frequency on the line. The presence or absence of the signaling frequency identifies a certain state of the circuit. After signaling has engaged the line, the signaling frequency is taken of the line and the speech path is opened. AC15 has four different types AC15-A to D. AC15-D is also know under the name CEPT-L1 which is the most used of the four.

PABX to PABX, E&M
E&M is one of the most used Private Trunk protocols in the business. It uses a 2 or 4 wires for DC signaling and utilizes 2 or 4 separate wires for the speech path. It is available in 5 different types which can be fully reversed making it one of the most flexible protocols simultaneously. However this also makes the E&M signaling a complex system to connect. Therefore a brief explanation is given below.

E&M type 1

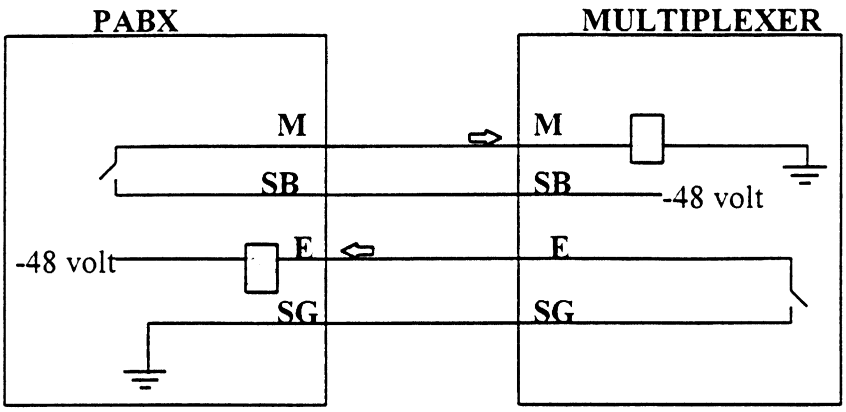


Detector unit

	M	*E*
On-hook	**GND**	**-48**
Off-hook	**-48**	**GND**

From the local PABX a call is initiated, M-lead closes, a current will be detected by the far end Multiplexer. The far end Multiplexer signals with grounding the E-lead, the far end PABX generates a dial tone. The digits are dialed, the phone rings. When the phone is picked up, the far end PABX reacts with supplying -48 volt to the M-lead, the local Multiplexer grounds the E-lead and the connection is available. It is important with this type off signaling that the PABX and the Multiplexer share a common ground. This can be done by connecting the SG from the PABX to the Multiplexer.

E&M type 2

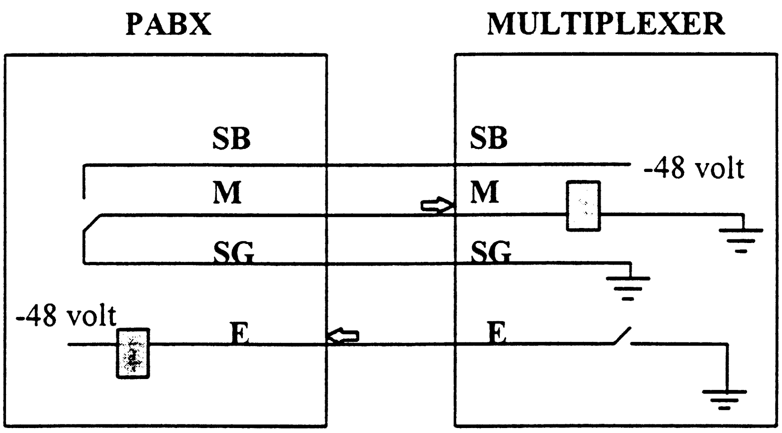


	M	*E*
On-hook	**GND**	**-48**
Off-hook	**-48**	**GND**

☐ Detector unit

From the local PABX a call is initiated, M-lead closes, a current will be detected by the far end Multiplexer. The far end Multiplexer signals with grounding the E-lead, the far end PABX generates a dial tone. The digits are dialed, the phone rings. When the phone is picked up, the far end PABX reacts with supplying -48 volt to the M-lead, the local Multiplexer grounds the E-lead and the connection is available.

E&M type 3

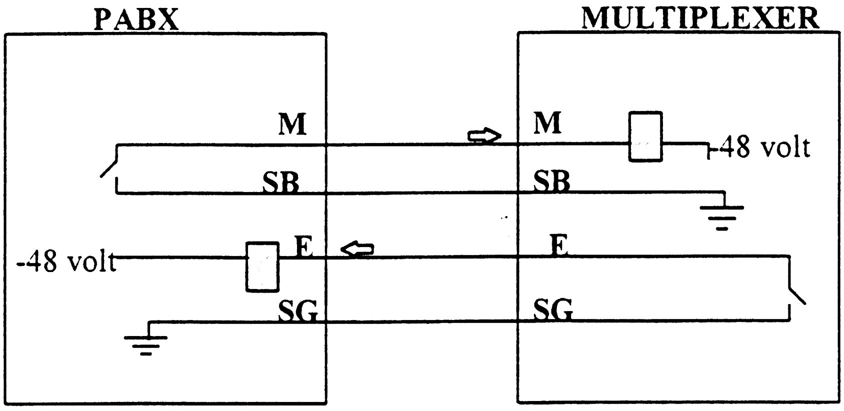


	M	*E*
On-hook	**GND**	**-48**
Off-hook	**-48**	**GND**

☐ Detector unit

From the local PABX a call is initiated, M-lead closes and puts a current on the line which is detected by the far end Multiplexer. The far end Multiplexer signals a ground to the far end PABX, dial tone is generated. The digits can be dialed, phone rings at the far end. When phone is picked up, far end PABX reacts with supplying a -48 volt current to the M-lead, the local Multiplexer grounds the E-lead. Connection available.

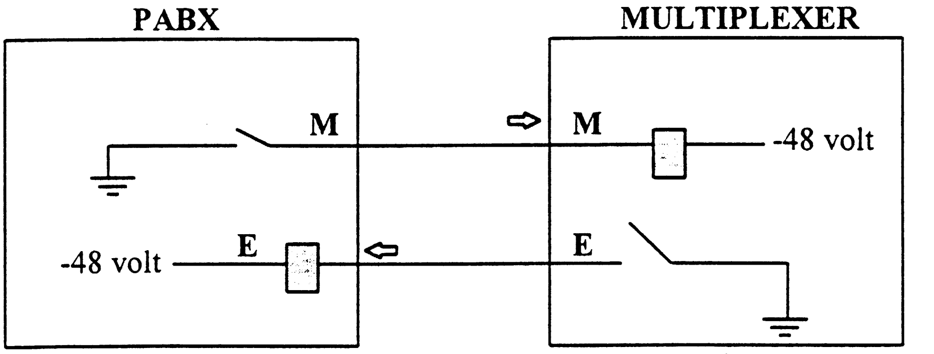
E&M type 4



	M	E
On-hook	-48	-48
Off-hook	GND	GND

From the local PABX the call is initiated, M-lead closes, M-lead goes to ground this will be detected by the far end Multiplexer. The far end Multiplexer grounds the E-lead, the far end PABX generates a dial-tone. Digits are dialed, phone rings. When phone is answered, far end PABX reacts with grounding M-lead, local Multiplexer grounds E-lead. Connections available.

E&M type 5



	M	E
On-hook	-48	-48
Off-hook	GND	GND

From the local PABX the call is initiated, M-lead closes, M-lead goes to ground this will be detected by the far end Multiplexer. The far end Multiplexer grounds the E-lead, the far end PABX generates a dial-tone. Digits are dialed, phone rings. When phone is answered, far end PABX reacts with grounding M-lead, local Multiplexer grounds E-lead. Connections available. It is important with this type off signaling that the PABX and the Multiplexer share a common ground.

SS5 Signaling
SS5 is a 4 wire transformer coupled interface. The signaling protocol is comparable to the AC15 standard and operates by detection of a 2400 hertz seizing signal and a 2600 hertz proceed to send signal. The SS5 standard is rarely used and until now has had no application in Orion Networks.

ISDN
At this moment ISDN is not supported on PCSI and ACT Multiplexers. However both companies have stated that a solution is under development. Orion can support ISDN connections but uses special interface converters for this purpose. These converters are always to be provided by the Customer.

5.2.5. Configuration
Generally speaking, configuration of the Multiplexers within an Orion Network will be done directly by the Orion Operations Center. However in specific cases Orion will ask the GO to perform a MUX configuration on site. In such a case it is required that the GO Technician contacts the Orion Program Manager or Project Engineer and follows the directives given by these people.

During such a “over the phone” configuration it is important to know the following specific PCSI and ACT terms/abbreviations for the possible connection types.

On the end with the Telephone the Multiplexer should be configured for FXS (PCSI), SLT (ACT) on the end with the PABX FXO (PCSI), OPX (ACT).

The phone is an extension from the PABX. Picking up the phone will provide a loop which will be detected by the PABX, you hear a dial-tone. At this moment you can dial an extension. FXO(OPX) to FXO(OPX) signaling will not work.

5.3 Network Management and Control.

The Network Management & Control Center "NMC" monitors the performance of the VSAT's equipped with a site manager. The ORION NMC's are located in Rockville, USA and Kingston, UK. These centers are 24 hours, 365 days a year operational.

Network Management & Control Center phone numbers.

Rockville : +1 - 301 - 258 - 3365
Kingston : + 44 - 1 - 438 - 740 -181

The Rockville NMC is the central number with call forwarding to the UK NM.
Whenever a trouble call is received by the NMC the will dial in to the site and determine if the problem is to solve remotely or by a field dispatch.
The NMC will assist the groundoperator during maintenance or service call to make the VSAT operational.

At this moment we use two types of site manager, the Logical Control Processor "LCP" and Logical Control Device LCD. This site manager devices call's the NMC in cause of failures at the remote sites.

5.3.1 LCP *III*

The Local Control Processor III is a small computing and interface device designed to facilitate the control and monitoring of VSAT stations. It is intended to be used as a component of a monitor and control system with a central computer directing and coordinating LCP's at the remote sites.

LCP is capable of interfacing with and monitoring a wide ranges of devices. The physical interfaces provide on the LCP include the following.

- 1 RS-485 serial port.
- 8 RS-232 serial ports.
- Up to 24 relay outputs
- Up to 24 contact closure inputs

The LCP monitors device by issuing the appropriate commands to the device's. The respond from these device will be stored and compared with the current information. If the information changes, then a changes of state "COS" is detected. When a COS occurs, the LCP uses a dial out connection to inform the NMC. This information may the be used by the NMC operator to take appropriate corrective actions.

5.3.2. LCD

The Logical Control Device "LCD" is built on a standard IBM PC compatible platform which runs specially developed M&C application software to be used in monitoring and controling VSAT equipment in ORION customer networks. The LCD's are controlled by, and report alarms, to PC work stations located at the ORION NMC's. Because this device is rather new there is no definitive information available on this moment.

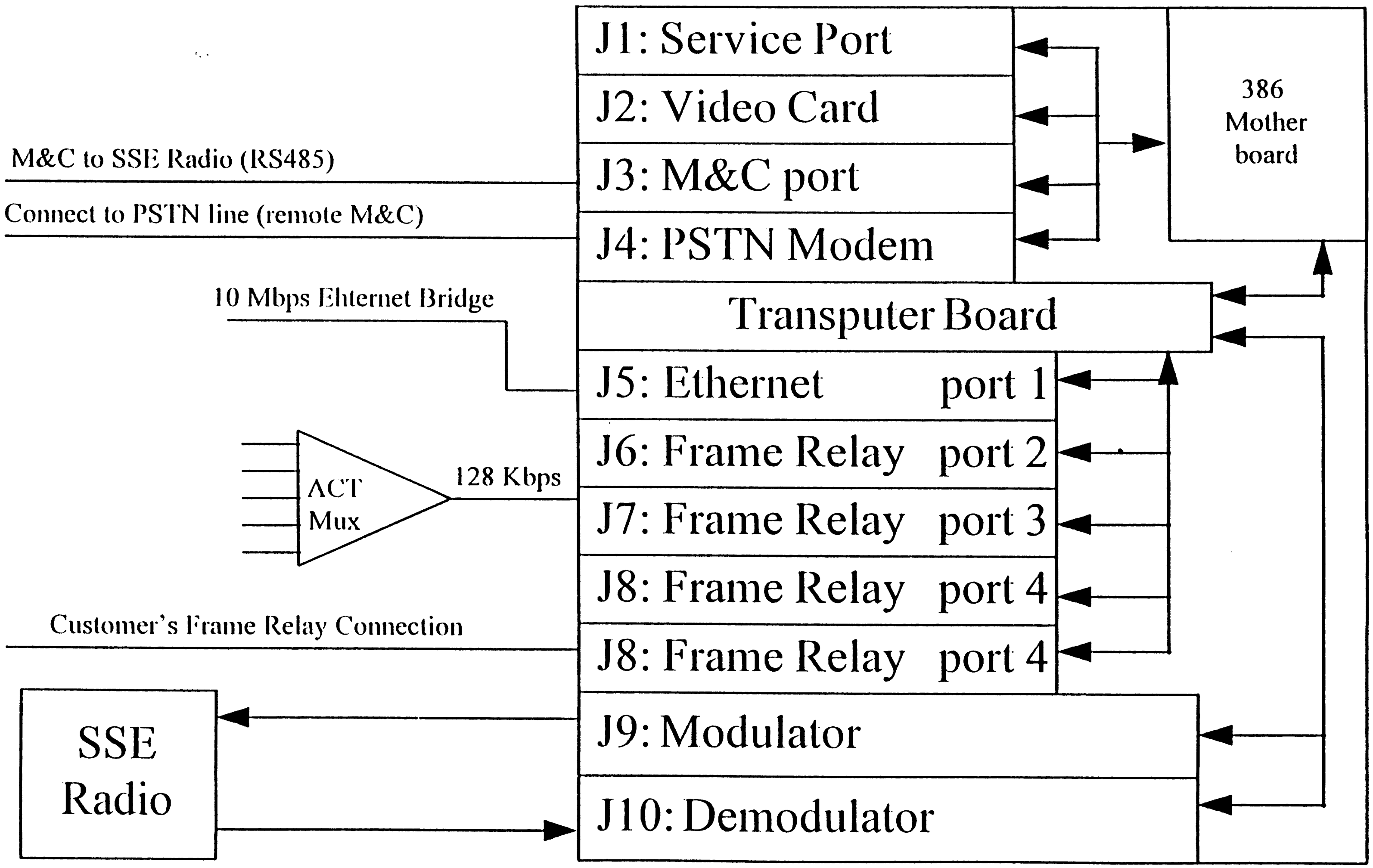
VISN Training Topics

- VISN Overview
- VISN TDMA (Time Division Multiple Access) Network
- VISN TDMA Protocol
  - TDMA Babwidth Allocation
  - VISN TDMA Frame Structure
- VISN Operating Parameters
  - Interfacing with VISN Terminal
  - VISN Parameter Files
  - VISN M&C
- Frame Relay Frame Format
- VISN Frame Relay Network

VISN OVERVIEW

- Two Frame Relay Ports
- MAC Layer Bridge with AUI Interface
- TDMA Modulator and Demodulator
- M&C Port with RS485 Interface
- PSTN Modem
- Service Port
- 386 SX PC Board
- Transputer Board (processor for the TDMA boards & Protocols)

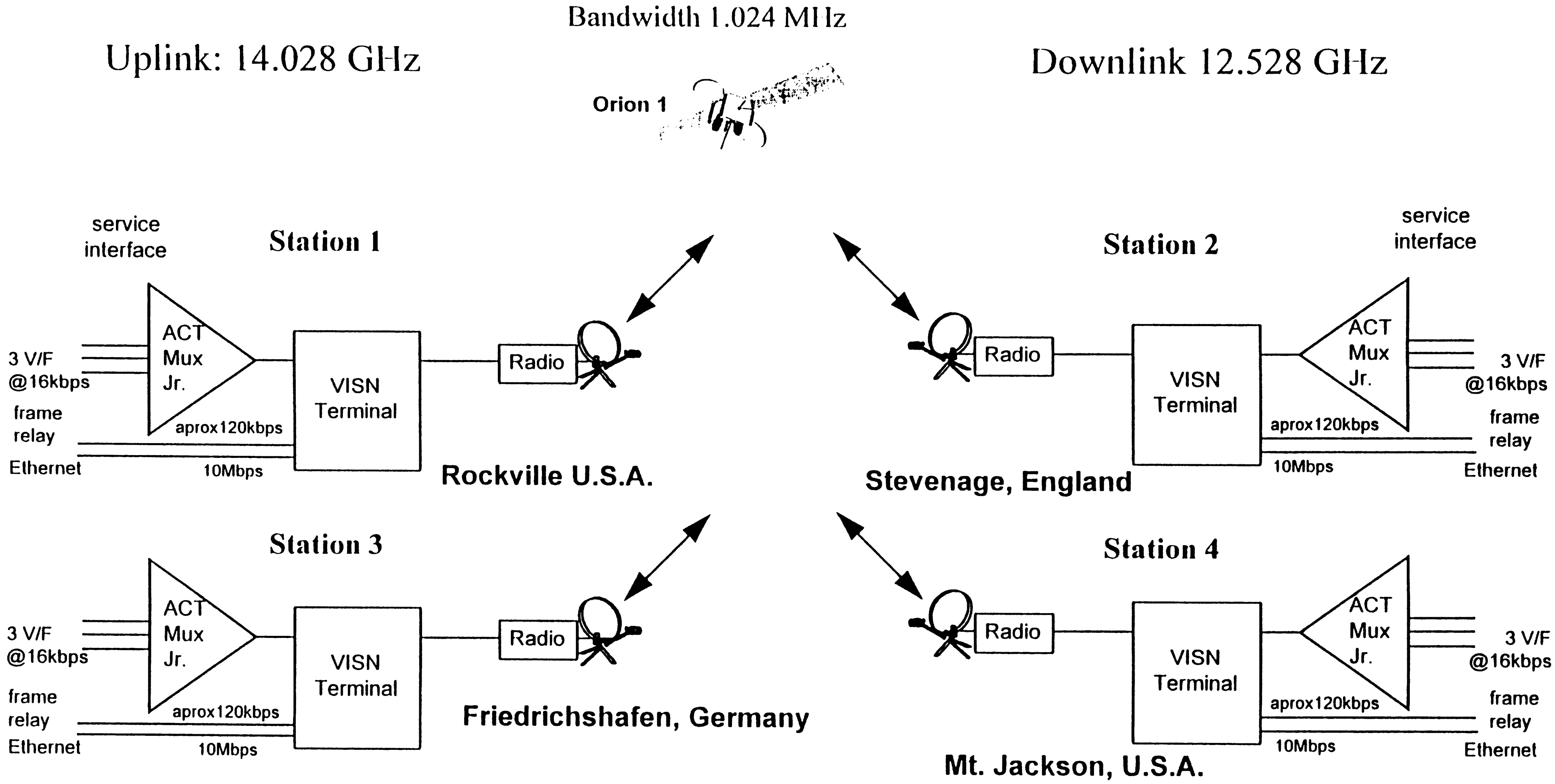
Hardware Block Diagram



Note: VISN Modulator output is at 0 dbm. level.
Most radio's have an maxium input level of -30 dbm. giving maxium transmit power out.

Orion Atlantic

VISN TDMA Network



Orion Atlantic

TDMA Burst Plan for a 4 Node Network

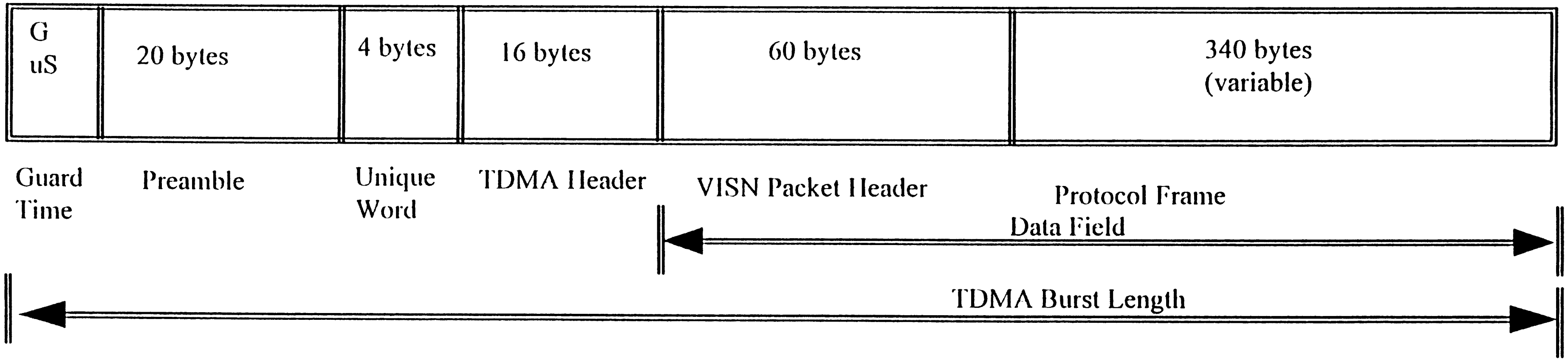
No Reservations: 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
all stations have 25 % of the bandwidth

Station 3 in Reservation: 1 3 2 3 4 3 1 3 2 3 4 3 1 3 2
station 3 has 50 % of the bandwidth and stations 1, 2, & 4 each have 16.7 % of the bandwidth

Station 2 & 3 in Reservation: 1 2 3 2 3 4 2 3 1 2 3 2 3
station 2 & 3 each has 37.5 % of the bandwidth and 1 & 4 have 12.5% of the bandwidth

Orion Atlantic

VISN TDMA Frame Structure



Note: This frame structure is for the current LANBRIDGE TDMA protocol

Interfacing with VISN Terminal

- Laptop PC via the service port
- Dialup via the PSTN modem
- Keyboard and Monitor
- SNMP (through the satellite link)

VISN Parameter Files

- Must be configured using one of the PC interfaces (laptop via the service port, PC via PSTN modem, or keyboard & monitor)

- STAPAR.PRM & STAPAR.TMP
  - VISN System Parameters
- NETPAR.PRM & NETPAR.TMP
  - VISN Network Parameters
- BRIDGE.SET
  - VISN MAC Layer Bridge Parameters

VISN M&C

- VISN M&C Interface is for controlling the outdoor unit (SSE Radio).
- Uses an RS485 interface.
- Accessed by the NMC or Terminal emulation software
- Transmit and receive LEDs located on M&C interface card

Frame Relay Frame Format

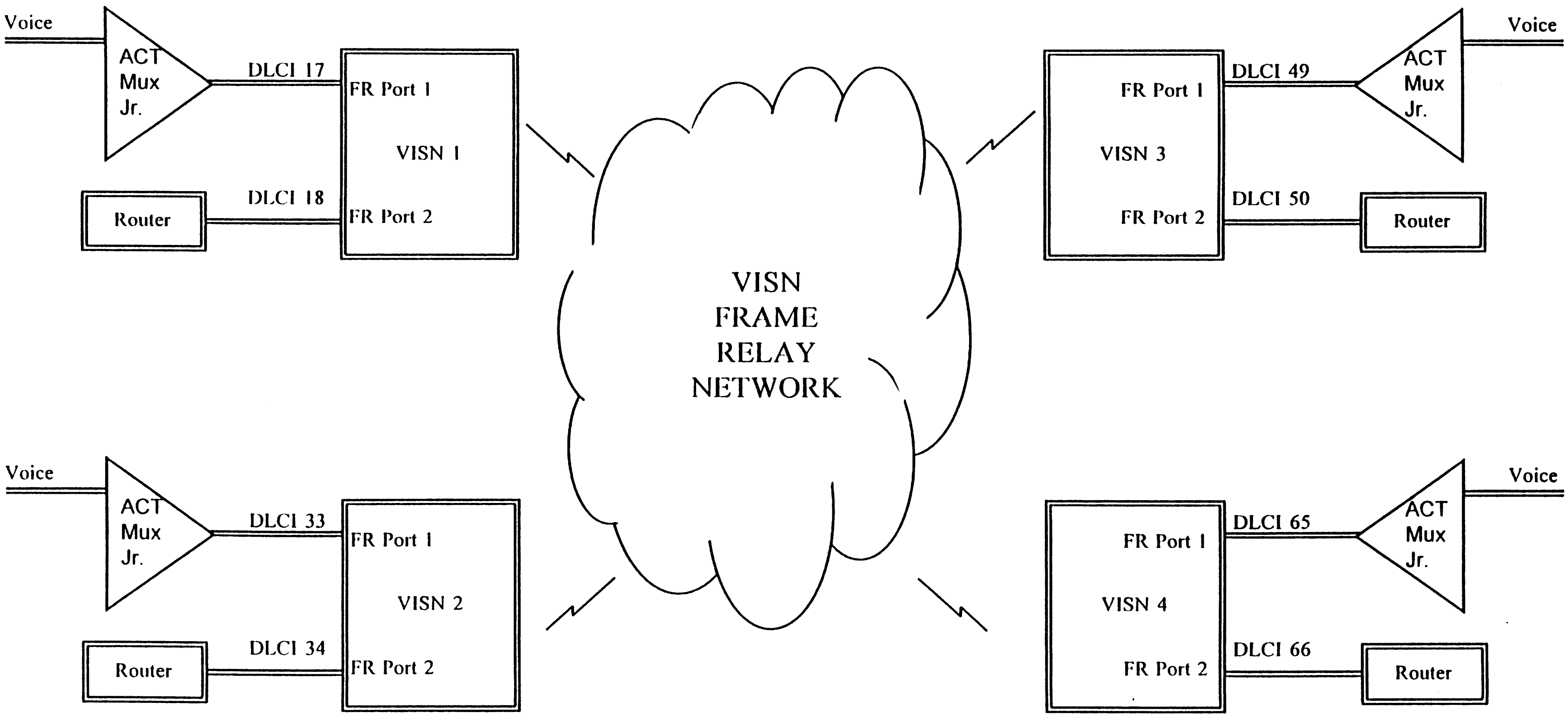
Flag 01111110	DLCI (High Order)	C/R 0/1	EA	DLCI (Low Order)	FECN	BECN	DE	INFORMATION FIELD	FCS

FLAG: Indicates Start of Frame
DLCI: Data Link Connection Identifier (address)
C/R: Command Reponse Field (used by higher level protocols)
FECN: Forward Explicit Congestion Notification
BECN: Backward Explicit Congestion Notification
DE: Discard Eligibility Indicator
EA: Address Field Extension

DLCI Calculated for a VISN Network:
Multiply VISN Station number by 16 and add frame relay port number:

Station 1:	Station2:	Station3:	Station4:
16 x 1 = 16	16 x 2 = 32	16 x 3 = 48	16 x 4 = 64
Port 1: 16 + 1 = DLCI 17	Port 1: 32 + 1 = DLCI 33	Port 1: 48 + 1 = DLCI 49	Port 1: 64 + 1 = DLCI 65
Port 2: 16 + 2 = DLCI 18	Port 2: 32 + 2 = DLCI 34	Port 2: 48 + 2 = DLCI 50	Port 2: 64 + 2 = DLCI 66

VISN Frame Relay Network



ORION ATLANTIC EUROPE, Inc.

Chapter 8
Maintenance

Table of Contents

8 Maintenance

8.1. Why Maintenance ?

*An unwritten law for engineers and technicians in VSAT and satellite broadcasting is, "**Ignore your antenna and pay the price**." The earth station antenna is an essential part of satellite communications, especially when sending and receiving live news or sports programming—signals that cannot be re-created. In addition to all the technical reasons for providing good maintenance Orion guarantees that is will provide the customer with 99.5% or better link availability. To meet the guarantee, and to keep the link functioning, the organization must have a regularly scheduled, thorough, antenna inspection and maintenance program.*

The lack of a well implemented preventive maintenance program could trigger a wave of problems. An electrical or physical failure could lead to a complete antenna failure, causing downtime or even loss of contract. It is known that 50-70 percent of all outages are caused by:

1. Equipment error
2. Human error
3. Lack of experience on equipment and test equipment
4. Improper or mal-function test equipment

This means that most failures can be avoided and outages can be substantially reduced by the implementation of a good maintenance policy. A proper inspection and maintenance program is a form of insurance.

Maintaining an earth station antenna is much less costly than to repairing one that has failed.

8.2. Maintenance Program

Although VSAT sites are varied and come in all sizes and complexities, they are functionally very similar. Functions at an earth station can be divided into those that are administrative and those that are technical. Administrative means that Orion advises every Ground Operator to keep a site log. A dated log (started from day one!) with photographs should be prepared when the antenna (and the other parts of the site) are installed. Entries into the log should be made during each inspection so a complete record of the entire antenna system and its condition is available. Maintenance logs should be stored with the equipment or within the equipment rack. Technical functions are typically into two, one being operations and other maintenance. Maintenance is the area which ensures that all equipment, machinery and circuitry continue to function as designed.

Generally, the maintenance procedure (see also the Procedure Manual chapter 10) takes from one hour to half a day, depending on the environmental conditions under which the antenna operates.

The Ground Operator is not allowed to bring the site down without contacting the NMC in advance! If you need to interrupt service for maintenance always contact the NMC first. They schedule the interruption, mostly when the antenna is not in use or for a short period during non-peak hours.

All the maintenance activities must not only be scheduled in advance with the customer but coordinated, in advance, with Orion Atlantic support organizations in the same way installation activities are scheduled. For installation activities, Orion Atlantic program management advises Orion Atlantic points of contact. For maintenance activities, the NMC personnel provide scheduling, restoration efforts, and answers to technical questions. In addition, they coordinate the activities with the customer and connect ground operators to the OOC for bringing carriers up and down, peaking antennas, leveling settings, etc.

The maintenance program should include maintenance to the following items.

- Inspect the total appearance of the equipment, including radio, LNC, feedhorn and de-ice.
- Inspect the antenna mount hardware.
- Inspect the ground connections.
- Inspect the power equipment and fcilities
- Inspect the IF equipment and terminal equipment (including modems, mux and LCD/LCP)
- Inspect the enclosures.
- Inspect the cables and connections.
- Inspect areas exposed to the weather to insure they are adequately waterproofed.
- Evaluate antenna's overall performance.

> Reliable and effective maintenance depends upon good test equipment which is regularly calibrated, in accordance with manufacturer's recommendations.

8.3. Check Appearance

Inspect all painted and galvanized surfaces of the antenna and its mounting structures at least once a year; however, never paint the coated Prodelin reflector! Note, the Prodelin reflector does not need much maintenance; however, if needed, Orion does stock SHC (super hydrophobic coating) re-coating kits. A visually pleasing installation helps avoid community opposition to its presence. Local requirements vary among countries *(see chapter 2),* but appearance is a factor.

If the main reflectors are made of painted steel, be sure to follow the manufacturer's instructions for preparation of the surface and for paint specifications. Remember, the wrong paint can affect your signal. Darker colors on the reflector's surface absorb sunlight; the resulting higher noise temperatures could cause signal distortion. Paint with to much lead can cause signal loss through attenuation or scattering. All reflectors used by Orion are molded fiberglass with imbedded mesh and have the SHC. Repainting, therefore, is not necessary.

Check Mount Hardware

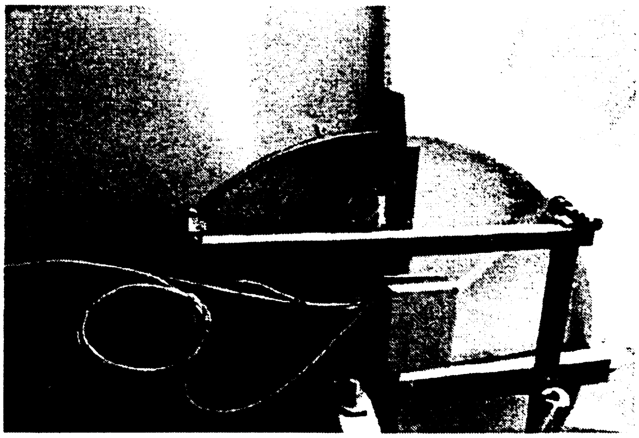
Not surprising, corrosion is the enemy of the nuts, bolts, rivets, and other fasteners used to assemble the antenna mount. Therefore, it is necessary to inspect the mount hardware, tighten loose bolts and replace missing or badly corroded parts. If loose bolts are found, and if they affect the antenna pointing, contact the Orion NMC and notify them that the antenna needs to be repointed.

> Repair any damage, even if it is minor!

Verify Ground Connections

The antenna, mount and RF unit should be grounded against possible lightning strikes. The grounding for both mechanical and non mechanical connections must be verified—a ground loop impedance test unit does very well. . After checking mechanical ground connections, replace rusted or corroded hardware to prevent a build-up of resistance.

Inspect Enclosures
Vermin (bees, spiders and spider webs, birds, etc.) can do unbelievable, and costly, damage if left unchecked. If equipment is housed in an antenna enclosure at the rear of the reflector, inspect the enclosure for water retention or infestation by insects or rodents. Repair and seal any suspicious openings.



a hornet's nest on the back of an antenna

Maintain Cables
Inspect and verify connector weather sealing and all cable ties. The interfacility link (IF) cables carry intermediate frequency and monitor and control signals between the roof and the equipment room. If, on inspection, you find or suspect any VSWR and/or insertion loss (IF-cable only), check to see whether any cables need to be replaced or repaired. (Are they still waterproof?) With a simple "home, garden, and kitchen" multimeter, the cables and the connectors check the conductivity and continuity of the cables. Also ensure that support and routing of the cables are consistent with the requirements described in the Ground Operator Procedure Manual. Stainless steel cable hangers or clamps are preferable to plastic cable ties for supporting the cables. If plastic ties are used, use only black nylon ultraviolet resistant ones. White or clear ties become brittle and break with prolonged exposure to sunlight.

Antenna Moves
Whenever the antenna has to be moved or the IFL-cable disconnected, the antenna must be taken out of service. Use this opportunity to inspect the antenna.

Monitor and Control (M&C)
Monitoring and Control is an activity of both corrective and preventive maintenance. Regular measuring and recording of key parameters will help note and identify potential problems and faults. Verify that the NMC can access the site and check for current alarm conditions on all equipment. Also verify that M&C to radio is connected and functional and that telephone access is available on the roof via the M&C line. At older sites, verify all connected equipment with the NMC and make sure site equipment is properly labeled. If the site does not have a site code label, install an appropriate label. on equipment or rack and fill out the site code information.

Radio, Equipment, and Rack Fan
Check to ensure the fan in the radio, if any, is operating properly. If not, repair as soon as possible because radios may fail within a few hours if not properly cooled. Check that all filters, if present, are clear and free from dust build up and inspect chassis air passages openings.
Pay special attention to all SSE systems to ensure that fans run continuously.

8.4. Checklist for Routine Antenna Inspection and Maintenance Program

For proper assembly, do not assume that the antenna is assembled correctly because it is in service! Review, first, any Orion Technical Bulletins that pertain to antenna assembly.

	INSPECT	MAINTAIN
Antenna Reflector	Hardware (Painted surfaces)	If galvanized, remove rust: replace or treat with zinc-rich paint. (Repaint where peeling, flaking or fading. Never paint a Prodelin antenna.)
Ballast & Roof	All	Install extra ballast if necessary and notify customer or building owner of possible roof damage or leakage.
Mount Hardware	All	Tighten, replace or reinstall hardware.
Ground Connection	Impedance Leads Resistance	Tighten or replace hardware. Remove sharp bends in leads. Verify proper resistance; add grounding if needed.
Reflector and Mount Openings	Water accumulation, infestation	Repair/seal openings as required.
Radio	Fan for proper operation	Repair as necessary.
Cables and Connectors	IF and M&C cables, connectors Cable conductivity and continuity Support hardware	Perform insertion loss tests. Replace cables if out of spec. Replace damaged connector hardware. Replace waterproof tape. Verify with multimeter Replace if missing, rusted or corroded.
Antenna	Azimuth, elevation, cross-pol feedhorn	Talk to the NMC. Check for moisture, dry out as necessary. Wipe surface with damp cloth to remove dirt and dust.
Indoor equipment	Cables and Connectors Fans	Clean, repair

8.5. Spare Parts & Inventory Control

You can only repair effectively if the required spares are readily available. Essential and critical spares should be kept by the Ground Operator so that repairs can be made immediately following a failure and that the VSAT site is brought back to a full redundancy working configuration. A proper and good storage and inventory control system is important in order quickly obtain spare parts when needed and to replenish stocks and keep these at an optimum level.

Act as described in chapter 9 (Logistics) of the Ground Operator Procedure Manual.

Generally, the maintenance procedure takes from one hour to half a day, depending on the environmental conditions under which the antenna operates (Picture: Rooftop Orion, Rockville USA)

ORION Network Systems Europe, Inc

Chapter 10
Glossary

A

ACTUATOR - Sometimes referred to as a motorized jackscrew. Power controlled motor that moves the dish in azimuth or elevation, and is usually controlled from indoor equipment.

ADC - Analogue to Digital Conversion. Process of sampling and coding an analogue quantity or signal to produce a digital representation.

AMPLITUDE MODULATION (AM) - The baseband signal is caused to vary the amplitude or height of the carrier wave to create the desired information content.

AMPLIFIER - A device used to boost the strength of an electronic signal.

ANALOG - A form of transmitting information characterized by continuously variable quantities, as opposed to digital transmission, which is characterized by discrete bits of information in numerical steps. An analog signal is responsive to changes in light, sound, heat and pressure.

ANALOG TO DIGITAL CONVERSION (ADC) - Process of converting analog signals to a digital representation. DAC represents the reverse translation.

ANIK - The Canadian domestic satellite system that transmits Canadian Broadcasting Corporation's (CSC) network feeds throughout the country. This system also carries long distance voice and data services throughout Canada as well as some transborder service to the U.S. and Mexico.

ANTENNA - A device for transmitting and receiving radio waves. Depending on their use and operating frequency, antennas can take the form of a single piece of wire, a di-pole a grid such as a yagi array, a horn, a helix, a sophisticated parabolic-shaped dish, or a phase array of active electronic elements of virtually any flat or convoluted surface.

APERTURE - Total reflective area of dish. A cross sectional area of the antenna which is exposed to the satellite signal.

APERTURE BLOCKAGE - Often caused by the LNB or LNB support rods casting a shadow across the reflective area of the dish.

APEX - Highest point. Usually referred in motorised dish set-up terms as the highest point angle which an antenna can be pointed.

APOGEE - Highest point (maximum altitude) of a geocentric orbit. The point in an elliptical satellite orbit which is farthest from the surface of the earth.
Geosynchronous satellites which maintain circular orbits around the earth are first launched into highly elliptical orbits with apogees of 22,237 miles. When the communication satellite reaches the appropriate apogee, a rocket motor is fired to place the satellite into its permanent circular orbit of 22,237 miles. (also see perigee).

APOGEE KICK MOTOR (AKM) - A small engine fired when the spacecraft reaches its apogee, to propel the satellite into a circular orbit.

ATTENUATION - The measure of signal loss in a transmission medium or component.
The loss in power of electromagnetic signals between transmission and reception points.

ATTITUDE CONTROL - The orientation of the satellite in relationship to the earth and the sun.

AUDIO SUBCARRIER - An audio signal transmitted within the bandwidth of a wider transponder signal. (The carrier between 5 MHz and 8 MHz containing audio (or voice) information inside of a analog video carrier).

AUTOMATIC FREQUENCY CONTROL (AFC) - A circuit which automatically controls the frequency of a signal.

AUTOMATIC GAIN CONTROL (AGC) - A circuit which automatically controls the gain of an amplifier so that the output signal level is virtually constant for varying input signal levels.

AZIMUTH - Angle between antenna beam and meridian plane (measured in horizontal plane). The angle of rotation (horizontal) that a ground based parabolic antenna must be rotated through to point to a specific satellite in a geosynchronous orbit. The azimuth angle for any particular satellite can be determined for any point on the surface of the earth giver the latitude and longitude of that point. It is defined with respect to due north as a matter of easy convenience.

AZ/EL MOUNT - Antenna mount that requires two separate adjustments to move from one satellite to another;

B

B-MAC - A method of transmitting and scrambling television signals. In such transmissions MAC (Multiplexed Analog Component) signals are time-multiplexed with a digital burst containing digitized sound, video synchronizing, authorization, and information.

BACKHAUL - A terrestrial communications channel linking an earth station to a local switching network or population center.

BACKOFF - The process of reducing the input power level of a travelling wave tube to obtain more linear operation.

BAND PASS FILTER - An active or passive circuit which allows signals within the desired frequency band to pass through but impedes signals outside this pass band from getting through.

BANDWIDTH - The range of frequencies occupied by a signal, or passed by a channel.
A measure of spectrum (frequency) use or capacity. For instance, a voice transmission by telephone requires a bandwidth of about 3000 cycles per second (3KHz). A TV channel occupies a bandwidth of 6 million cycles per second (6 MHz) in terrestrial Systems. In satellite based systemsa larger bandwidth of 17.5 to 72 MHz is used to spread or "dither" the television signal in order to prevent interference.

BANDWIDTH ALLOCATION - Refers to how much of the satellite's useable bandwidth has been leased to operate the VSAT system. The required allocation will depend on the peak level of traffic expected along with the maximum delay time that the system can tolerate

BASEBAND - The band of frequencies containing the information, prior to modulation (and subsequent to demodulation).
The basic direct output signal in an intermediate frequency based obtained directly from a television camera, satellite television receiver, or video tape recorder. Baseband signals can be viewed only on studio monitors. To display the baseband signal on a conventional television set a "modulator" is required to convert the baseband signal to one of the VHF or UHF television channels which the television set can be tuned to receive.

BAUD - Unit of data transmission rate, based on number of data bits per second.
Today most digital signals are characterized in bits per second.

BEACON - Low-power carrier transmitted by a satellite which supplies the controlling engineers on the ground with a means of monitoring telemetry data, tracking the satellite, or conducting propagation experiments. This tracking beacon is usually a horn or omni antenna.

BEAMWIDTH - The acceptance angle of the main lobe of an antenna, usually measured between half-power (3dB) points. The angle or conical shape of the beam the antenna projects. Large antennas have narrower beamwidths and can pinpoint satellites in space or dense traffic areas on the earth more precisely. Tighter beamwidths thus deliver higher levels of power and thus greater communications performance.

BER Bit Error Rate. A measure of the accuracy of digital transmission. The ratio of the number of errored bits received to the total number of bits received.

BIRD Slang for a communications satellite located in geosynchronous orbit.

BIT A binary digit. Smallest possible unit of digital transmission.

BIT ERROR RATE The fraction of a sequence of message bits that are in error. A bit error rate of 10-6 means that there is an average of one error per million bits.

BIT RATE Speed of digital transmission, measured in bits per second, or multiples (kilobits, megabits per second).

BLANKING An ordinary television signal consists of 30 separate still pictures or frames sent every second. They occur so rapidly, the human eye blurs them together to form an illusion of moving pictures. This is the basis for television and motion picture systems. The blanking interval is that portion of the television signal which occurs after one picture frame is sent and before the next one is transmitted. During this period of time special data signals can be sent which will not be picked up on an ordinary television receiver.

BLOCK DOWN CONVERTER A device used to convert the 3.7 to 4.2 KHz signal down to UHF or lower frequencies (1 GHz and lower).

BNC CONNECTOR Industry standard connector for intermediate frequency.

BORESIGHT The centre of an antenna beam, usually the direction of maximum gain.

BPSK Binary Phase-Shift Keying (Also see PSK).

BYTE A digital 'word', usually consisting of eight bits.

BUSINESS TELEVISION Corporate communications tool involving video transmissions of information via satellite. Commonuses of business television are for meetings, product introductions and training.

C

C-BAND This is the band between 4 and 8 Ghz with the 6 and 4 Ghz band being used for satellite communications. Specifically, the 3.7 to 4.2 Ghz band is used as the downl link frequencies in tadem with the 5.925 to 6.425 Ghz band that serves the uplink.

CAPACITY The maximum amount of traffic that a circuit or circuit group can handle.

CARRIER The basic radio, television, or telephony center of frequency transmit signal. The carrier in an analog signal and is modulated by manipulating its amplitude (making it louder or softer) or its frequency (shifting it up or down) in relation to the incoming signal. Satellite carriers operating in the analog mode are usually frequency modulated.

CARRIER FREQUENCY The main frequency on which a voice, data, or video signal is sent. Microwave and satellitecommunications transmitters operate in the band from 1 to 14 GHz (a GHz is one billion cycles per second).

CARRIER TO NOISE RATIO The carrier to noise ratio (C/N ratio) is the ratio between the pure signal level and the accompanying noise level in a given bandwidth, expressed in dB.; the higher the ratio **the** better the clarity of **the** final demodulated signal. In a video signal the higher the C/N, the better the received picture. This figure is directly related to G/T and S/N. and

CASSEGRAINE ANTENNA A parabolic dish using a secondary hyperbolic sub-reflector. Achieves higher efficiency than primary type because angle of wavefront entry to feedhom is less. (The antenna principle is a subreflector at the focal point which reflects energy to or from a feed located at the apex of the main reflector)

CCIR International Radio Consultive Commitee

CDMA Code division multiple access. Refers to a multiple-access scheme where stations use spread-spectrum modulations and orthogonal codes to avoid interfering with one another.

CENTRALLY FOCUSED ANTENNA Refers to a circular dish shape whereby the focal point is at the center.

CLAMP A video processing circuit that removes the energy dispersal signal component from the video waveform.

CHANNEL A frequency band in which a specific broadcast signal is transmitted. Channel frequencies are specified in the United States, for example, by the Federal Communications Commission. Analog television signals require a minimum of 6 MHz frequency band to carry all the necessary picture detail.

CIRCULAR POLARIZATION Unlike many domestic satellites which utilize vertical or horizontal polarization, the international Intelsat satellites transmit their signals in a rotating corkscrew-like pattern as they are down-linkedto earth. On some satellites, both right-hand rotating and left-hand rotating signals can be transmitted simultaneously on the same frequency; thereby doubling the capacity of the satellite to carry communications channels.

CLARKE BELT The circular orbit at 35800 km (22247 MIs) above the equator, where the satellites appear stationary to earth receivers. This orbit was first postulated by the science fiction writer Arthur C. Clarke in Wireless World magazine in 1945. Satellites placed in these orbits, although traveling around the earth at thousands of miles an hour, appear to be stationary when viewed from a point on the earth, since the earth is rotating upon its axis at the same angular rate that the satellite is traveling around the earth.

CODEC Coder/decoder system for digital transmission.

CO-LOCATED Two or more satellites orbiting at the same geostationary location, eg ASTRA 1A, B, C, D and E at 19.2' East. (different frequency bands are used.)

COLOR SUBCARRIER A subcarrier that is added to the main video signal to convey the color information. In NTSC systems, the color subcarrier is centered on a frequency of 3.579545 MHz, referenced to the main video carrier.

COMMON CARRIER Any organization which operates communications circuits used by other people. Common carriers include the telephone companies as well as the owners of the communications satellites, RCA, Comsat, Direct Net Telecommunications, AT&T and others. Common carriers are required to file fixed tariffs for specific services.

CO-POLAR(IZED) Of the same polarization.

COMPANDING A noise-reduction technique involving compression applied at the transmitter, with complementary expansion at the receiver.

COMPOSITE BASEBAND The raw demodulator output, prior to filtering and clamping and (usually) prior to de-emphasis. Contains all transmitter subcarriers. In some receivers this output is not intended for video use, and roll-off may be applied to the lowest baseband frequencies.

COMPOSITE SIGNAL Ambiguous term, variously used to refer to composite baseband or composite video.

COMPOSITE VIDEO Complete video signal including synchronising, luminance and color information, with Teletext where transmitted. Does not include audio or data subcarriers.

COMPRESSION A term used to denote reducing the amount of bandwidth needed to transmit video or audio, thus increasing the capacity of a satellite transponder.

CROSS MODULATION A form of signal distortion in which modulation from one or more RF carrier(s) is imposed on another carrier.

D

DAMA Demand-Assigned Multiple Access - A highly efficient means of instantaneously assigning telephony channels in a transponder according to immediate traffic demands.

DBS Direct broadcast satellite. Refers to service that uses satellites to broadcast multiple channels of television programming directly to home mounted small-dish antennas. DBS normally have smaller footprint areas and less number of transponders compared with medium power satellites.

dBi The dB power relative to an isotropic source.

dBW The ratio of the power to one Watt expressed in decibels.

DECIBEL (dB) The standard unit used to express the ratio of two power levels. It is used in communications to express either a gain or loss in power between the input and output devices. The number of dB = 10 x log10 of power ratio. So, 3 dB represents a factor of 2, 10 dB a factor of 10, 20 dB a factor of 100, etc.

DECLINATION ANGLE The angle between the polar axis and the dish axis so that it points to geostationary arc.

DECLINATION Angle between antenna beam and equatorial plane (measured in meridian plane). The offset angle of an antenna from its polar mount axis.

DECODER A television set-top device which enables the home subscriber to convert an electronically scrambled television picture into a viewable signal. This should not be confused with a digital coder/decoder known as a CODEC which is used in conjunction with digital transmissions.

DE-EMPHASIS Restoration of flat base-band frequency response after demodulation: the inverse or pre-emphasis.

DEPOLARIZATION The twisting of the polarization of a satellite signal as it passes through the atmosphere.

DELAY The time it takes for a signal to go from the sending station through the satellite to the receiving station. This transmission delay for a single hop satellite connection is very close on one-quarter of a second.

DEMODULATOR A satellite receiver circuit which extracts or "demodulates" the "wanted "signals from the received carrier.

DEPOLISER Device to convert circularly polarised signals to linear ones for selection by conventional pick-up probe in LNB.

DESPUN ANTENNA An antenna, mounted on a satellite with a spinning body, which is rotated in the opposite direction to the body rotation - so that the antenna beam points in a fixed direction

DEVIATION The level of modulation of an FM signal - the extent by which the base-band or subcarrier signal shifts the main carrier frequency.

DIGITAL Conversion of information into bits of data for transmission through wire, fiber optic cable, satellite, or over air techniques. Method allows simultaneous transmission of voice, data or video.

DIGITAL SPEECH INTERPOLATION DSI - A means of transmitting telephony. Two and One half to three times more efficiently based on the principle that people are talking only about 40% of the time.

DIRECTIVITY-The directivity of an antenna is the ability to concentrare the radiated energy in a preferred direction in the transmit mode, or to reject signals that are received off-axis to the normal or antenna boresight.

DISCRIMINATOR - Type of FM demodulator.

DISH ILLUMINATION - The area of a dish as 'seen' by the feedhorn.

DISPERSION - The effect of group delay of a wideband transmission channel changing with frequency, such that the different time delays are imparted to components of different frequencies. Most noticeable with pulse signals. Not to be confused with Energy Dispersal.

DOWNLINK The signal path from the satellite to the receiving dish on the earth.

DUAL SPIN Spacecraft design whereby the main body of the satellite is spun to provide altitude stabilization, and the antenna assembly is despun by means of a motor and bearing system in order to continually direct the antenna earthward. This dual-spin configuration thus serves to create a spin stabilized satellite.

E

EBU European Broadcasting Union.

EARTH STATION The term used to describe the combination or antenna, low-noise amplifier (LNA), down-converter, and receiver electronics. used to receive a signal transmitted by a satellite. Earth Station antennas vary in size from the.2 foot to 12 foot (65 centimeters to 3.7 meters) diameter size used for TV reception to as large as 100 feet (30 meters) in diameter sometimes used for international communications. The typical antenna used for INTELSAT communication is today 13 to 18 meters or 40 to 60 feet. Orion uses antennas between 2.4 to 15 meters.

ECHO CANCELLER An electronic circuit which attenuates or eliminates the echo effect on satellite telephony links. Echo cancellers are largely replacing obsolete echo suppressors.

ECHO EFFECT A time-delayed electronic reflection of a speaker's voice. This is largely eliminated by modern digital echo cancellers.

ECLIPSE Period when the satellite passes into the Earth's (or the Moon's) shadow, when power must be drawn from storage batteries.

ECLIPSE-PROTECTED Refers to a transponder that can remain powered during the period of an eclipse.

ECS European Communication Satellite

ED Energy Dispersal.

EDGE OF COVERAGE Limit of a satellite's defined service area. In many cases, the EOC is defined as being 3 dB down from the signal level at beam center. However, reception may still be possible beyond the -3dB point.

EIRP Equivalent Isotropically Radiated Power. This term describes the strength of the signal leaving the satellite antenna or the transmitting earth station antenna, and is used in determining the C/N and S/N. The transmit power value in units of dBW is expressed by the product of the transponder output power and the gain of the satellite transmit antenna.

ELEVATION The upward tilt to a satellite antenna measured in degrees required to aim the antenna at the communications satellite. When. aimed at the horizon, the elevation angle is zero. If it were tilted to a point directly overhead, the satellite antenna would have an elevation of 90 degrees.

ENCODER A device used to electronically alter a signal so that it can only be viewed on a receiver equipped with a special decoder.

ENERGY DISPERSAL A low-frequency wave-form added to the baseband signal before modulation, to reduce the FM signals peak power per unit bandwidth, and thus its interference potential.

ENHANCED LNB An LNB whose local oscillator is set at 9.75 GHz, and receiver bandpass enhanced to cover at least 1 GHz.

EOL End of Life (of a transponder or satellite).

EQUATORIAL ORBIT An orbit with a plane parallel to the earth's equator.

ERP (effective) Effective Radiated Power is the product of the RF power level multiplied by antenna gain relative to a half-wave dipole, in a given direction.

ESC Engineering Service Circuit - The 300-3,400 Hertz voice plus teletype (S+DX) channel used for earth station-to-earth station and earth station-to-operations center communications for the purpose of system maintenance, coordination and general system information dissemination. In analog (FDM/FM) systems there are two S+DX channels available for this purpose in the 4,000-12,000 Hertz portion of the baseband. In digital systems there are one or two channels available which areusually convened to a 32 or 64 Kbps digital signal and combined with the earth station traffic digital bit stream. Modern ESC equipment interfaces with any mix of analog and digital satellite carriers, as well as backhaul terrestrial links to the local switching center.

EXTENDED IF RECEIVER A receiver whose Ist IF tuning range is extended from 950 MHz to 2050 MHz.

F

F-CONNECTOR Industry standard connector used for attaching co-axial cables from used in cable television systems

f/D RATIO Ratio of length of dish depth at its centre point, and the diameter. Shallow dishes have higher f/D ratios.

FDMA Frequency division multiple access. Refers to the use of multiple carriers within the same transponder where each uplink has been assigned frequency slot and bandwidth. This is usually employed in conjunction with Frequency Modulation.

FEED This term has at least two key meanings within the field of satellite communications. It is used to describe the transmission of video programming from a distribution center. It is also used to describe the feed system of an antenna. The feed system may consist of a subreflector plus a feedhorn or a feedhorn only.

FEEDHORN A satellite antenna component that collects the signal reflected from the main surface reflector and channels this signal into the low-noise amplifier (LNA)

(FEED, FEEDHORN, FEED ANTENNA, FEED SYSTEM) The small, widebeam antenna that illuminates (gathers signal from) the main reflector in an antenna system (convention speaks of illumination, even in a receive only application, as if the antenna were transmitting).

FLAT PLATE ANTENNA Brought to public eye by the now defunct BSB who named it the Squarial. Operates by adding together the signal from an array of dipoles.

FM Frequency Modulation. The base-band signal is caused to vary the frequency of the carrier wave.

FM IMPROVEMENT Increase in S/N at the output of an FM demodulator relative to its input (at expense of bandwidth).

FM THRESHOLD That point at which the input signal power is just strong enough to enable the receiver demodulator circuitry successfully to detect and recover a good quality television picture from the incoming video carrier. Using threshold extension techniques, a typical satellite TV receiver will successfully provide good pictures with an incoming carrier noise ratio of 7db. Below the threshold a type of random noise called "sparkles" begins to appear in the video picture. In a digital transmission, however, signal is sudden and dramatically lost when performance drops under the threshold.

FOCAL LENGTH Distance from the center feed to the center of the dish.

FOCAL POINT The area toward which the primary reflector directs and concentrates the signal received.

FOOTPRINT Coverage area of a satellite beam:A map of the signal strength showing the EIRP contours of equal signal strengths as they cover the earth's surface. Different satellite transponders on the same satellite will often have different footprints of the signal strength. The accuracy of EIRP footprints or contour data can improve with the operational age of the satellite. The actual EIRP levels of the satellite, however, tends to decrease slowly as the spacecraft ages.
(a contour map showing EIRP, PFD, antenna size, or G/T contours within a satellites coverage zone)

FORWARD ERROR CORRECTION (FEC) Adds unique codes to the digital signal at the source so errors can be detected and corrected at the receiver.

FREQUENCY The number of times that an alternating current goes through its complete cycle in one second of time. One cycle per second is also referred to as one hertz; 1000 cycles per second, one kilohertz; 1,000,000 cycles per second, one megahertz: and 1,000,000,000 cycles per second, one gigahertz.

FREQUENCY COORDINATION A process to eliminate frequency interference between different satellite systems or between terrestrial microwave systems and satellites. In the U.S. this activity relies upon a computerized service utilizing an extensive database to analyze potential microwave interference problems that arise between organizations using the same microwave band. As the same C-band frequency spectrum is used by telephone networks and CATV companies when they are contemplating the installation of an earth station, they will often obtain a frequency coordination study to determine if any problems will exist.

G

GaAs Gallium Arsenide. High-mobility semiconductor material used in low-noise microwave devices.

GAIN A measure of amplification expressed in dB.

GEOSTATIONARY Refers to a geosynchronous satellite angle with zero inclination. so the satellite appears to hover over one spot on the earth's equator.

GEOSTATIONARY ORBIT The equatorial orbit used by TV satellites at a height of 35800 km (22247 miles) and speed matched to earth's velocity. A geosynchronous satellite in the equatorial plane.

GEOSYNCHRONOUS The Clarke circular orbit above the equator. For a planet the size and mass of the earth, this point is 22,237 miles above the surface.

GEOSYNCHRONOUS ORBIT An orbit of the earth in 23 hr 56 min 4.1 see. A satellite that orbits the earth in this period will appear at the same position in the sky at a particular time each day, but will not appear stationary if not orbiting in the equatorial plane.

GIGAHERTZ (GHZ) One billion cycles per second. Signals operating above 3 Gigahertz are known as microwaves above 30 GHz they are know as millimeter waves. As one moves above the millimeter waves signals begin to take on the characteristics of lightwaves.

GLOBAL BEAM An antenna down-link pattern used by, for example, the INTELSAT satellites, which effectively covers one-third of the globe. Global beams are aimed at the center of the Atlantic, Pacific and Indian Oceans by the respective Intelsat satellites, enabling all nations on each side of the ocean to receive the signal. Because they transmit to such a wide area, global beam transponders have significantly lower EIRP outputs at the surface of the Earth as compared to a US domestic satellite system which covers just the continental United States. Therefore, earth stations receiving global beam signals need antennas much larger in size (typically 10 meters and above (i.e.30 feet and up).

GREGORIAN DUAL-REFLECTOR ANTENNA Antenna system employing a paraboloidal main reflector and a concave ellipsoidal subreflector.

G/T A figure of merit of an antenna and low noise amplifier combination expressed in dB. "G" is the net gain of the system and "T" is the noise temperature of the system. The higher the number, the better the system.

GUARD CHANNEL Television channels are separated in the frequency spectrum by spacing them several megahertz apart. This unused space serves to prevent the adjacent television channels from interfering with each other.

ORION Network Systems Europe, Inc

H

HALF TRANSPONDER Method of broadcasting used to transmit two channels via the one transponder. Usually done by splitting a 72 MHz transponder into two 36 MHz ones - but the trade off is a reduced power output of at least half, ie 3 to 5 dB.

HDTV High definition television system using increased horizontal scanning rate for a sharper picture. Also associated with 16:9 screen ratio.

HEADEND Electronic control center - generally located at the antenna site of a CATV system - usually including antennas, preamplifiers, frequency converters, demodulators and other related equipment which amplify, filter and convert incoming broadcast TV signals to cable system channels.

HEMT High Electron Mobility Transistor; advanced donor techniques used in manufacturing that allows charge carrier movement at lower noise temperatures. A low noise LNB, typically less than 0.8 dB, might use an HEMT

HERTZ (HZ) The name given to the basic measure of radio frequency characteristics. An electromagnetic wave completes a full oscillation from its positive to its negative pole and back again in what is known as a cycle. A single Hertz is thus equal to one cycle per second.

HIGH POWER SATELLITE Satellite with transponder RF power in excess of about 100 W.

HUB The master station through which all communications to, from and between micro terminals must flow. in the future satellites with on-board processing will allow hubs to be eliminated as MESH networks are able to connect all points in a network together.

I

IBS INTELSAT Business Services.

INCLINATION The angle between the orbital plane of a satellite and the equatorial plane of the earth.

INCLINED ORBIT An orbit which is offset from the equatorial plane. Expressed in terms of degrees from the equatorial plane.

IRD Integrated receiver decoder. A satellite receiver with a built in decoder.

INMARSAT The International Maritime Satellite Organization operates a network of satellites for international transmissions for all types of international mobile services including maritime, aeronautical, and land mobile.

INTELSAT The International Telecommunications Satellite Organization operates a network of satellites for international transmissions.

INTERFERENCE Energy which tends to interfere with the reception of the desired signals, such as fading from airline flights, RF interference from adjacent channels, or ghosting from reflecting objects such as mountains and buildings.

ISOLATION The measure of separation (as dB or power ratio) between two potentially interfering signals, eg in different beams on different polarizations.

ISDN - Integrated Services Digital Network. A CCITT standard for integrated transmission of voice, video and data. Bandwidths include: Basic Rate Interface - BR (144 Kbps - 2 B & 1 D channel) and Primary Rate - PRI (1.544 and 2.048 Mbps).

ISOTROPIC ANTENNA A hypothetical omnidirectional point-source antenna that serves as an engineering reference for the measurement of antenna gain.

ITU International Telecommunication Union.

J

JPEG ISO Joint Picture Expert Group standard for the compression of still pictures

K

K-BAND The frequency spectrum 10.9 to 36 GHz. **KA-BAND** Used loosely for 31 / 18 GHz satellite systems. **Ku-BAND** is the range from 10.7 to 18 Ghz.

Kbps Kilobits per second (digital bit-rate). Refers to transmission speed of 1,024 bits per second.

KELVIN, K The temperature measurement scale used in the scientific community. Zero K represents absolute zero, and corresponds to minus 459 degrees Fahrenheit or minus 273 Celsius. Thermal noise characteristics of LNA could be measured in Kelvins.

KILOHERTZ (KHz) Refers to a unit of frequency equal to 1,000 Hertz.

KLYSTRON A type of high-power amplifier which uses a special beam tube.

KU-BAND Frequencies between 10.7 and 18 GHz used by satellite systems.

L

L-BAND - The frequency range from 0.5 to 1.5 GHz. Also used to refer to the 950 to 1450MHz used for mobile communications.

LEASED LINE - A dedicated circuit typically supplied by the telephone company.

LHCP (OR LCP) - Left-hand Circular Polarization.

LINK BUDGET - The calculation of power and noise levels between transmitter and receiver (uplink or downlink), taking into account of all gain and loss factors, to yield operating values of C/N, margin above threshold, and ultimate SNR or BER.

LINK MARGIN - The extent (in dB) by which normal working (or clear sky) CNR exceeds threshold CNR, or other value at which reception is deemed unusable.

LNB (OR LNCB) - Low-Noise Block (downconverter). A relatively inexpensive receiver which converts video signals on satellite downlinks to television input frequencies. No external mixing signals are required for down-conversion.

LNC - Low Noise Converter. A combination LNA and down converter which receives RF signals from satellites and converts them into intermediate frequencies used by demodulators. LNC require external mixing signals for down conversion.

LOW NOISE AMPLIFIER (LNA) - This is the preamplifier between the antenna and the earth station receiver. For maximum effectiveness, it must be located as near the antenna as possible, and is usually attached directly to the antenna receive port. The LNA is especially designed to contribute the least amount of thermal noise to the received signal. The gain is typical 50 - 65 dB. LNAs provide no down conversion.

LOW NOISE BLOCK DOWNCONVERTER (LNB) - A combination Low Noise Amplifier and downconverter built into one device attached to the feed.

LOOK ANGLES - The azimuth and elevation coordinates to which an earth station antenna must be pointed to receive signals from the satellite.

LOOPTHROUGH - Output , and input connections on a receiver that allows external equipment to be inserted in the signal path, or the receiver output to be connected to the transmitter input,

M

MATV Master Antenna Television - Private cable (Also see SMATV).

MAC (A, B, C, D2) Multiplexed analog component color video transmission system. Subtypes refer to the various methods used to transmit audio and data signals.

MARGIN The amount of signal in dB by which the satellite system exceeds the minimum levels required for operation.

MASTER ANTENNA TELEVISION (MATV) An antenna system that serves a concentration of television sets such as in apartment buildings, hotels or motels.

MAGNETIC POLARIZER Fixes to feedhorn. Used to bend polarized wave from say, vertical to horizontal. Works by principle of Faraday rotation, ie current through coiled wire.

Mbps Megabits per second (digital bit-rate)

MECHANICAL POLARISER Used to bend polarised wave from say, vertical to horizontal. Works by controlled mark to space voltage pulses from indoor unit. A small internal probe actually moves by 90'.

MEDIUM POWER SATELLITE Satellite with transponder power in the region of 30 W to 100 W.

MEGAHERTZ (MHz) Refers to a frequency equal to one million Hertz, or cycles per second.

MERIDIAN Plane passing through the Earth's axis and including one's location

MICROWAVE Line-of sight, point-to-point transmission of signals at high frequency. Many CATV systems receive some television signals from a distant antenna location with the antenna and the system connected by microwave relay. Microwaves are also used for data, voice, and indeed all types of information transmission. The growth of fiber optic networks have tended to curtail the growth and use of microwave relays.

MICROWAVE INTERFERENCE Interference which occurs when an earth station aimed at a distant satellite picks up a second, often stronger signal, from a local telephone terrestrial microwave relay transmitter. Microwave interference can also be produced by nearby radar transmitters as well as the sun itself. Relocating the antenna by only several feet will often completely eliminate the microwave interference.

MODULATION The process of manipulating the frequency or amplitude of a carrier in relation to an incoming video, voice or data signal.

MODULATOR A device which modulates a carrier. Modulators are found as components in broadcasting transmitters and in satellite transponders. Modulators are also used by CATV companies to place a baseband video television signal onto a desired VHF or UHF channel. Home video tape recorders also have built-in modulators which enable the recorded video information to be played back using a television receiver tuned to VHF channel 3 or 4.

MODULATION INDEX The ratio of peak deviation to highest modulating frequency in an FM system.

MPEG Moving Picture Experts Group. A signal processing system to compress data in digital TV transmissions.

MULTIPLEXING The combining of independent signals into one transmission channel.
(Techniques that allow a number of simultaneous transmissions over a single circuit)

N

NOISE Any unwanted and unmodulated energy that is always present to some extent within any signal

NOISE FIGURE Measure of the noise contribution in say, an LNB. Expressed in dB - the lower the figure the less noise contribution. Compares the device with a perfect device.

NOISE TEMPERATURE Noise measurement of a system, as the absolute temperature of a relative source delivering noise power. Expressed in (degrees) Kelvin.

NTSC - National Television Standards Committee
A video standard established by the United States (RCA/NBC} and adopted by numerous other countries. This is a 525-line video with 3.58-MHz chroma subcarrier and 60 cycles per second.

O

OFFSET-FED ANTENNA An antenna with a reflector that forms only part of a paraboloid of revolution, usually excluding the pole or apex, such that a front feed causes no aperture blockage.

OMT Orthogonal-Mode Transducer or ortho-coupler: waveguide component that separates or combines two orthogonallv polarized signals.

ORBITAL PERIOD The time that it takes a satellite to complete one circumnavigation of its orbit.

ORTHOGONAL Mutually at right angles (eg horizontal and vertical polarisation, right- and left-hand circular polarization).

P

PACKET SWITCHING Data transmission method that divides messages into standard-sized packets for greater efficiency of routing and transport through a network.

PAL Phase Altemation (by) Line. German-designed color TV encoding system.

PARABOLOID A parabola of revolution. Classical shape of antenna reflector.

PARABOLIC ANTENNA The most frequently found satellite TV antenna, it takes its name from the shape of the dish described mathematically as a parabola. The function of the parabolic shape is to focus the weak microwave signal hitting the surface of the dish into a single focal point in front of the dish. It is at this point that the feedhorn is usually located.

PERIGEE Lowest point (minimum altitude) of a geocentric orbit (Also see Apogee).

P.F.D. (OR PFD) Power-Flux Density (related to field strength).

PLL Phase-Locked Loop (type of demodulator) A type of electronic circuit used to demodulate (satellite) signals.

POLAR MOUNT Antenna mechanism permitting steering in hour angle (ie along the GEO arc) by rotation about a single axis. Also Equatorial Mount. A classical polar mount has its axis parallel to that of the earth. TVR0s use modified polar mount geometry, incorporating a declination offset.

POLARIZATION The property by which an electromagnetic wave exhibits a direction (or rotation sense) of vibration, giving the opportunity for frequency re-use by orthogonal polarisations.
A technique used by the satellite designer to increase the capacity of the satellite transmission channels by reusing the satellite transponder frequencies. In linear cross polarization schemes, half of the transponders beam their signals to earth in a vertically polarized mode; the other half horizontally polarize their down links. Although the two sets of frequencies overlap, they are 90 degree out of phase, and will not interfere with each other. To successfully receive and decode these signals on earth, the earth station must be outfitted with a properly polarized feedhorn to select the vertically or horizontally polarized signals as desired.

In some installations, the feedhorn has the capability of receiving the vertical and horizontal transponder signals simultaneously, and routing them into separate LNAs for delivery to two or more satellite television receivers. Unlike most domestic satellites, the Intelsat series use a technique known as left-hand and right-hand circular polarization.

POLARIZATION ROT(AT)OR A device that permits selection of one of two orthogonal polarisations, or of any polarisation angle. Not a polariser.

POLARIZER (ALSO DE-POLARIZER) A bi-refringent component in waveguide or antenna system, which converts between linear (plane) and circular polarizations. Not a polarization rotor.

POLAR MOUNT Antenna mechanism permitting steering in both elevation and azimuth through rotation about a single axis. While an astronomer's polar mount has its axis parallel to that of the earth, satellite earth stations utilize a modified polar mount geometry that incorporates a declination offset.

POLAR ORBIT An orbit with its plane aligned in parallel with the polar axis of the earth.

POLAROTOR A proprietary name for a type of polarisation rotor, a transition with a remotely rotatable probe.

PRE-EMPHASIS A method of improving SNR in an FM system, by increasing deviation at high (relative to low) baseband frequencies, according to a defined (BG or CCIR) function.

PRIME FOCUS The focal point of a paraboloid reflector. A feed system placed at that point.

PRO LOGIC Surround sound type effect developed by Dolby Laboratories to simulate cinema/theatre sound in the home.

PSK Phase-Shift Keying (type of digital modulation).

PTT - Post Telephone and Telegraph Administration
Refers to operating agencies directly or indirectly controlled by governments in charge oftelecommunications services in most countries of the world.

PULSE CODE MODULATION A time division modulation technique in which analog signals are sampled and quantized at periodic intervals into digital signals. The values observed are typically represented by a coded arrangement of 8 bits of which one may be for parity.

Q

QPSK Quadrature Phase-Shift Keying (Also see PSK).

R

RAIN OUTAGE Loss of signal (esp. at Ku-Band) due to absorption and thermal noise accompanying heavy rainfall (also see Attenuation).

RECEIVER (RX) An electronic device which enables a particular satellite signal to be separated from all others being received by an earth station, and converts the signal format into a format for video, voice or data.

RECEIVER SENSITIVITY Expressed in dBm this tells how much power the detector must receive to achieve a specific baseband performance, such as a specified bit error rate or signal to noise ratio.

RHCP (OR RCP) Right-Hand Circular Polarisation.

S

SATELLITE A sophisticated electronic communications relay station orbiting 22,237 miles above the equator moving in a fixed orbit at the same speed and direction of the earth (about 7,000 mph east to west).

SCALAR FEED The wide flare corrugated horn antenna feed, now standard in 4-GHz home TVRO. Hybrid modes contribute to pattem symmetry, high efficiency, and cross polarization discrimination.

SCART European 21 pin connector, now commonly used by European TVs, videos and satellite receivers. Some receivers have as many as four SCART sockets.

SCPC Single Channel Per Carrier. A satellite transmission system which places only one digital channel on a given carrier. SCPC carriers are seperated by frequency, beam, and/or polarization. Multiple Channel Per Carrier (MCPC) systems place more than one digital channel on a given carrier frequency. VISN is an example.

SCRAMBLER A device used to electronically alter a signal so that it can only be viewed or heard on a receiver equipped with a special decoder.

SECAM A color television. system developed by the French and used in the USSR. Secam operates with 625 lines per picture frame and 50 cycles per second, but is incompatible in operation with the European PAL system or the U.S. NTSC system.

SHAPED BEAM Beam of irregular cross-section produced by multiple feed or shaped reflector techniques.

SHAPED REFLECTOR Techniques for controlling beam pattern, aperture illumination, noise, and sidelobe power, and for increasing antenna efficiency by variation of antenna (and subreflector) shape from the true paraboloid, hyperboloid etc.

SIDELOBE Undesirable characteristic of dish to reflect or receive signal off axis of the main transmit or receive lobe.

SIGNAL TO NOISE RATIO (S/N) A method of indicating the strength of a signal compared with that of the noise accompanying it. Usually expressed in decibels.
A video S/N of 54 to 56 dB is considered to be an excellent S/N, that is, of broadcast quality. A video S/N of 48 to 52 dB is considered to be a good S/N at the headend for Cable TV.

SINGLE-CHANNEL-PER-CARRIER (SCPC) A method used to transmit a large number of signals over a single satellite transponder.

SKEW Fine tuning of polarizer to take account of differing plane of signal polarisation due to each satellites offset relative to the receive site. But more commonly used to compensate for amount of Faraday rotation of different channel frequencies in magnetic polarisers.

SKY NOISE Electromagnetic radiation from galactic sources and thermal agitation of atmospheric gases and particles.

SLANT RANGE Path length between satellite and earth station.

SLOT That longitudinal position in the geosynchronous orbit into which a communications satellite is "parked". Above the United States, communications satellites are typically positioned in slots which are based at two to three degree intervals.

SMATV Satellite Master Antenna TV. Single dish distribution system used in multiple dwellings.

SNOW A form of noise picked up by a television receiver caused by a weak signal. Snow is characterized by alternate dark and light dots appearing randomly on the picture tube. To eliminate snow, a more sensitive receive antenna must be used, or better amplification must be provided in the receiver (or both).

S/R Signal-to-Noise Ratio. A measure of how clean (noise-free) the recovered base-band signal is.

SOLAR OUTAGE or **SOLAR OUTAGES** occur when an antenna is looking at a satellite, and the sun passes behind or near the satellite and within the field of view of the antenna. This field of view is usually wider than the beamwidth. Solar outages can be exactly predicted as to the timing for each site. (Loss of signal caused by the sun passing through the receiving antenna's beam)

SPARKLIES Also known as impulse noise. Shows on picture as small black and white comet shape dots on screen. Commonly caused by dish too small which causes the C/N ratio to be lower than the FM detector threshold.

SPECTRUM The range of electromagnetic radio frequencies used in transmission of voice, data and television.

SPILLOVER Usable (but often unwanted) signal reaching locations beyond defined Edge of Coverage.

SPIN STABILIZATION A form of satellite stabilization and attitude control which is achieved through spinning the exterior of the spacecraft about its axis at a fixed rate.

ORION Network Systems Europe, Inc

SPLITTER A passive device (one with no active electronic components) which distributes a RF signal carried on a cable in two or more paths and sends it to a number of receivers simultaneously.

SPOT BEAM Beam of circular or elliptical cross-section, covering a defined region of the Earth's surface, small in relation to global beam.

SPREAD SPECTRUM The transmission of a signal using a much wider bandwidth and power than would normally be required. Spread spectrum also involves the use of narrower signals that are frequency hopped through various parts of the transponder. Both techniques produce low levels of interference Between the users. They also provide security in that the signals appear as though they were random noise to unauthorized earth stations. Both military and civil satellite applications have developed for spread spectrum transmissions.

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.

STATIONKEEPING Minor orbital adjustments that are conducted to maintain the satellite's orbital assignment within the allocated "box" within the geostationary arc.

SUBCARRIER An information-carrying wave, which in turn modulates the main carrier in a conunununications system. Subcarriers are used for colour information, TV audio, independent audio, and data transmission. Some satellite transponders carry as many as four special audio or data subcarrierswhose signals may or may not be related to the main programming

SYNCHRONIZATION (SYNC) The process of orienting the transmitter and receiver circuits in the proper manner in order that they can be synchronized . Home television sets are synchronized by an incoming sync signal with the television cameras in the studios 60 times per second. The horizontal and vertical hold controls on the television set are used to set the receiver circuits to the approximate sync frequencies of incoming television picture and the sync pulses in the signal then fine tune the circuits to the exact frequency and phase.

SUBSATELLITE POINT The place on earth surface directly beneath a geostationary satellite.

SYLDA Dual payload launch adaptor for Ariane.

T

T1 The transmission bit rate of 1.544 millions bits per second. This is also equivalent to the ISDN Primary Rate Interface for the U.S. The European T1 or E1 transmission rate is 2.048 million bits per second.

T3 Channel (DS-3) In North America, a digital channel which communicates at 45.304 Mbps.

TDMA Time division multiple access. Refers to a form of multiple access where a single carrier is the shared by many users. Signals from earth stations reaching the satellite consecutively are processed in time segments without overlapping.

THERMAL NOISE Electrical noise that arises from the agitation of electrons in a conductor due to heat.

THRESHOLD In an FM system, the value of C/N at which the linear relationship between CNR and demodulation signal SNR breaks down. (also see Sparklies).

THRESHOLD EXTENSION Techniques for reducing the CNR value at which threshold effects occur.

TI - Terrestrial Interference. Interference to satellite reception caused by ground based microwave transmitting stations.

TRANSMITTER An electronic device consisting of oscillator, modulator and other circuits which produce a radio or television electromagnetic wave signal for radiation into the atmosphere by an antenna.

TRANSPONDER Compounded from trans(mitter) and (res)ponder. Equipment inside a satellite responsible for transmitting a single channel. A combination receiver, frequency converter, and transmitter package and physically part of acommunications satellite. Transponders have a typical output of five to twenty watts, operate over a frequency band with a 36 to 72 megahertz bandwidth in the L, C, Ku, and sometimes Ka Bands or in effect typically in the microwave spectrum, except for mobile satellite communications. Communications satellites typically have between 12 and 24 onboard transponders although the INTELSAT VI at the extreme end has 50.

TRIPLE BAND LNB LNB capable of receiving all three bands of frequencies FSS, DBS, and Telecom about 10.7 GHz to 12.7 GHz. Usually worked in two range modes controlled by indoor unit.

TRUNCATION Loss of outermost side frequencies of an FM signal due to filtering. Shows as 'tearing' effect of noise on video transients, sharp vertical edges.

TRX Transmitter / Receiver or Transceiver

TVRO Television Receive-Only (terminal). terminals that use antenna reflectors and associated electronic equipment to receive and process television and audio communications via satellite. Typically small home systems.

TWEEKING The process of adjusting an electronic receiver circuit to optimize its performance.

TWT Travelling-Wave Tube.

TWTA Travelling-Wave Tube Amplifier.

U

UHF The spectrum 300 MHz through to 3 GHz. Terrestrial broadcast television occupies 470-890 MHz. The 620-790 MHz band is allocated for community DBS downlinks in developing countries and remote areas, and is used by the Soviet Union.

UPLINK The earth to satellite signal path.

USAT Small aperture terminals under 0.5 meters are sometimes referred to Ultra Small Aperture Terminals (USAT's)

V

VIDEOCRYPT Encryption system first used by Sky subscription channels that uses a smart card.

VOLTAGE SWITCHED LNB An LNB that has a built in polarisation selector - controlled from an indoor unit.

VSAT Very small aperture terminal. Refers to small earth stations, usually in the 1.2 to 2.4 meter range. Small aperture terminals under 0.5 meters are sometimes referred to Ultra Small Aperture Terminals (USAT's)

VSWR Voltage Standing Wave Ratio. A measure of impedance match in a cable, wave-guide, or antenna system.

W

WARC World Administrative Radio Conference. The International Telecommunications Union (ITU) meetings that determine standards for international radio communications (including satellite TV).

WAVEGUIDE A hollow conductor used for RF signal transmission. Linearly polarized waveguides are rectangular.

WEGENER Proprietary system for subcarrier stereo (for additional audio) transmission. Uses discrete low-level companded subcarriers.

WEIGHTING Correction of S/R measurements to take into account such factors as bandwidth and annoyance value.

X

X.25 A set of packet switching standards published by the CCITT. < P>

X/Y An antenna mount permitting independent steering about two orthogonal axes, not necessarily related to azimuth or elevation.

XPD Cross-polar discrimination (of an antenna).

Z

ZONE BEAM Beam pattern usually a shaped beam, intermediate between hemispheric and spot.

3-AXIS Type of spacecraft stabilization in which the body maintains a fixed attitude relative to the orbital track and the earths surface. The reference axes are roll, pitch and yaw, by nautical analogy.