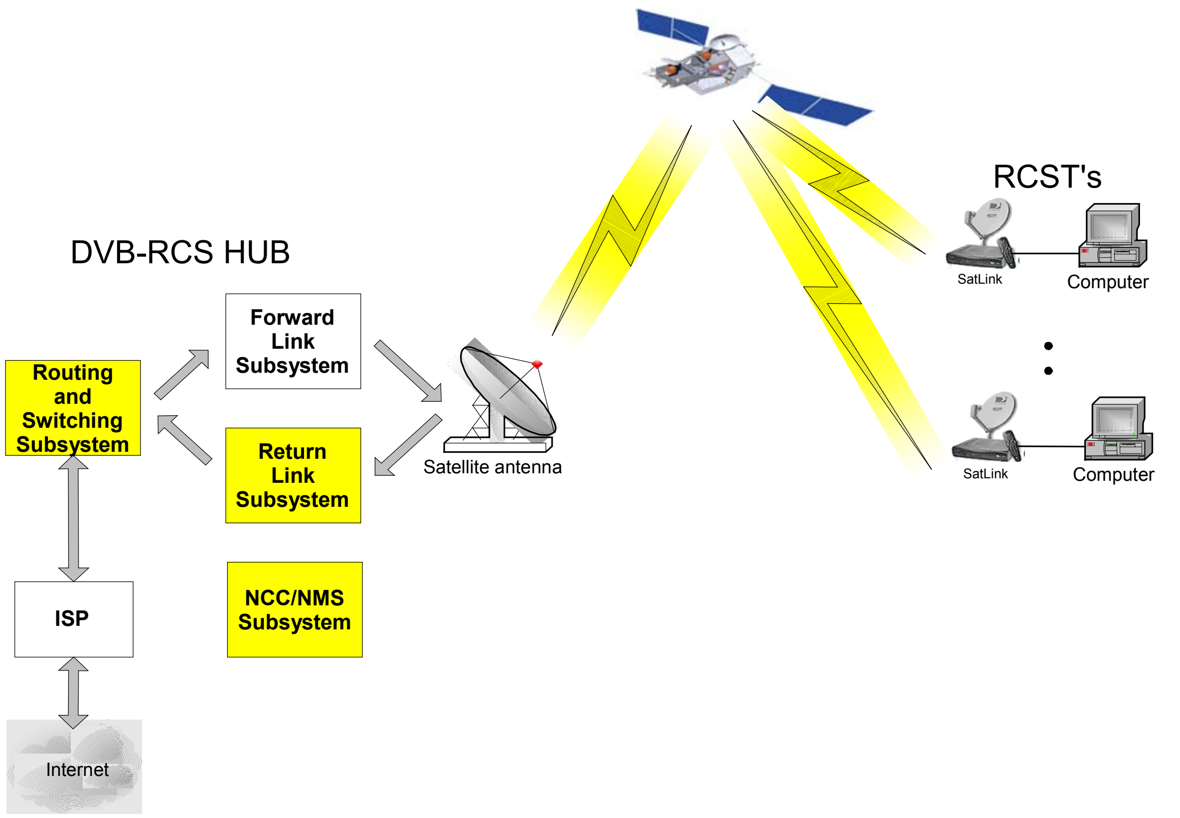
Digital Video Broadcasting, Return Channel via Satellite (DVB-RCS) Background Book



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Nera Broadband Satellite AS

Digital Video Broadcasting, Return Channel via Satellite (DVB-RCS) Background Book

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PREFACE

Technological innovation always creates demand for improved designs. Larger commercial aeroplanes, more fuel-efficient cars, increasingly automated production lines – the quest has always been for better performance.

This is particularly true in telecommunications, in which every advance has triggered demands for greater capacities for carrying information. Many transmission techniques, such as companding and multiplexing, originally were developed in the 1920s and 1930s to increase the capacities of analogue telephone trunk circuits. Likewise, the limitations of analogue trunks triggered research in digital techniques that resulted in the Bell T1 digital carrier first put in service in 1962. Thereafter, digital techniques gave birth to new radio communications services that could not have been possible with analogue technology because extremely high transmitter powers would have been required to make a continuously varying analogue signal intelligible above atmospheric noise at a receiver. Digital signals are more easily discerned amid noise and can be sent and received at far lower powers. Moreover, compared to the analogue signals that they now are replacing, digital signals require less radio frequency bandwidth for equivalent information transport and consequently increase the information-carrying capacity of the radio frequency spectrum. These principal advantages of digital signals have enabled the development of modern radio communications, such as mobile telephony, satellite networks and digital video broadcasting.

In turn, faster, higher-capacity communications have brought about interaction, a change as profound as that effected by increasingly higher communication speeds. Through the centuries and even as late as 1876, when French author Jules Verne had the daring *Michael Strogoff* carry the Czar's message to a remote outpost, communications principally were one-way. The electric telegraph, which spread round the world starting in the mid 19th century, speeded communication, but otherwise hardly changed the one-way pattern. The telephone, another 19th century invention, arguably provided the first interactive communications because it was based on a higher-capacity channel that could carry the human voice both ways, not just the one-way dots and dashes of the telegraph. The 20th century saw a similar scenario, first with radio, which early on provided wireless communication for ships at sea, then triggered broadcasting and, in the last two decades, put mobile telephones in the hands of peoples round the world. Television came next; it is now in the transition between one-way broadcasting and two-way interactive services, thanks to digital techniques. That's the topic of this book. Moreover, the focus is on high-capacity, digital radio channels via satellite, as opposed to similar channels linking transmitters and receivers totally within the Earth's atmosphere.

So this is a book compiled at the break point in the evolution of a technology of enormous promise. In compiling it, we are grateful to the R&D staff of Nera Broadband Satellite for their contributions and to the DVB Project Office for permission to use the wealth of information available on its website.

Billingstad, Norway
November 2002
Michael Brady and Michael Rogers

1. Broadband over Satellite

1.1 Challenges

1.1.1 Broadband access

The current trend in telecommunications is toward “broadband”, a term reflecting telecommunications history. In the days of analogue transmission, the principal way to increase the information capacity of a channel was to transmit it over a wider range of frequencies. A broadband system could carry more information because it used a greater portion of the frequency spectrum. Digital transmission techniques, computers and data processing changed the rules that had applied to analogue channels. Increasingly sophisticated digital processing techniques have expanded the information carrying capacity of channels. So “broadband” now means “high information carrying capacity”, even though the channel involved may occupy no broader a band of frequencies than an analogue transmission channel of lower capacity.

Most of the developments that enable today’s broadband technologies have benefited the core, or “backbone” facilities of networks, such as the trunks and exchanges of telephone networks. But the edge facilities that provide user access to the networks have been less well developed. The principal reason is tied to the economies of scale. A high-quality channel serving many users costs less per user than an individual channel of comparable quality serving a single user. Just as modern motorways often interconnect cities with their streets in disrepair, modern telecommunications networks consist of broadband trunks but only limited broadband access to them.

The Nera SatLink System overcomes this shortcoming by offering broadband access to broadband core networks, according to the international Digital Video Broadcasting – Return Channel via Satellite (DVB-RCS) standard.

1.1.2 The Last Mile

In telecommunications, the “Last Mile” is a popular name for the link between a central facility, such as a telephone exchange, and each of the subscribers it serves. The word “mile” is not specific: it means “any distance” – less than, equal to or greater than a mile (1.6 km). Likewise, the word “last” can mislead; from a subscriber’s viewpoint, it’s the “first mile” that constrains access to the network.

In telephone systems, the “Last Mile” link long has been two insulated copper wires wound together to form a “twisted pair” cable. The twisted pair was originally intended to carry analogue telephone signals at frequencies less than 4 kHz, which limits its usefulness in supporting broadband access. This drawback can be overcome in several ways that sort into five general approaches, as listed in Table 1.1

Table 1.1 Ways of providing broadband access

General approach	Typical method	Circuit carried by	Throughput	Advantages and Disadvantages
Retain or replace twisted pair; improve transmission technology	Digital Subscriber Line (DSL)	Twisted pair	up to 8 Mbit/s	Uses existing wires; separate line for each subscriber ensures consistent throughput; impractical in locations without backbone infrastructure.
Use another existing cable network	Community Access Television (CATV)	Coaxial cable and cable modem	up to 30 Mbit/s	Can be inexpensive in built-up areas; typically, cables are run in loops so throughput to a user goes down as number of users logged on goes up; impractical in areas with no cable service.
Build an new cable network	Fibre To The Curb (FTTC)	Fibreoptic cable	50 Mbit/s and higher	Inexpensive in high-population density areas that can afford installation; impractical for sparsely settled areas.
Use wireless links instead of cable connections	Local Microwave Multipoint Distribution System (MMDS)	Radio bands in the 12 – 50 GHz range	about 50 Mbit/s	Can be implemented quickly in areas with many short links; impractical if frequencies are unavailable or if links are few and long.
Use satellite links instead of terrestrial links	Links via ground earth stations and fixed or mobile terminals	Radio bands in the 28 – 50 GHz range	numerous channels, up to 1 Gbit/s each	Available throughout a satellite footprint; independent of ground infrastructure; in multicasting uses same amount of bandwidth to send to one user as to many; inexpensive for remote locations; impractical only when there is no direct line of sight to the satellite.

The Nera SatLink System exploits the inherent advantage of satellites in being better than terrestrial links in supporting numerous broadband applications.

1.1.3 Broadband TCP over satellite links

Internet protocol software functions well in terrestrial networks, including LANs and WANs, but not so well over satellite. This is because the Transmission Control Protocol (TCP), the principal protocol involved in all Web-enabled applications, was designed to work with the delays typically encountered in terrestrial networks. It copes less well with signals sent via satellite, because the delays are greater. A signal over a satellite travels a path some 70,000 to 90,000 km long, depending on the geographical locations of the transmitter and the receiver. The distance is about the same as twice around the Earth at the Equator. That's what causes the difficulty, as signals sent via terrestrial networks never travel more than a fraction as far. Radio waves, travelling at the speed of light, take 0.24 to 0.3 seconds to traverse the path via the satellite to the receiver. An acknowledgement from the receiver back to the transmitter must retrace the path. So the total delay, from the instant a packet is sent until the transmitter gets acknowledgement of its successful reception, is 0.5 to 0.6 seconds. TCP perceives this delay, or "latency", as an indication of poor link performance and reacts automatically to keep the window size for data packets small and to step up the number of requests for acknowledgement of successful transmission. The result is that performance is degraded in two ways. First, throughput is low, which slows file transfer. Second, the slow start of TCP is lethargic, which slows surfing. In a worst-case scenario, with many users active simultaneously, the performance of an individual Internet connection may be about the same as that of a 19.2 kbit/s modem of the early 1990s. For a complete description of challenge of TCP over satellite, see the Internet Engineering Task Force (IETF) overview [1]. The solution involves adjusting the protocol, which theoretically may be done in one of two ways:

1. Configure all end user entities – hosts, servers, Terminals, PCs and the like – for the longer latency of the satellite path.
2. Arrange the satellite gateway and the Terminals it serves to cope with the longer latency.

The first approach is clearly impractical, both because it would require modification of an enormous amount of equipment that may only occasionally or never communicate via satellite and because it would defeat the basic Internet design philosophy that protocols must be independent of transmission medium technology. Consequently, the second approach offers the only feasible way to speed up TCP over satellite. In short, whilst a gateway between terrestrial networks does not engage in processing at the transport level where TCP runs, a gateway between the Internet and a satellite network must actively process data at the transport level, as described in Section 1.3.

The processing of TCP in the transport layer may involve several strategies, including:

- Tuning: TCP is altered to make it more suitable for satellite links.

- Reducing the traffic: compression and caching can be used to minimise the data transmitted.
- Spoofing: a device at the Hub station of a satellite link pretends to be the receiver and returns ACKs.

The Nera SatLink System offers combined TCP optimisation strategies to provide high-speed Internet connections to Terminals.

1.1.4 VSAT

Almost all broadband satellite systems are based on the VSAT concept. VSAT, an acronym for Very Small Aperture Terminal, originally was a tradename for a satellite communications ground station developed and sold in the 1980s by Telecom General of the USA. It now is considered to be a generic word for all systems providing satellite communications to and from fixed user Terminals fitted with relatively small antennas. Worldwide, there are more than half a million VSAT Terminals installed in more than 120 countries, more than a hundred thousand of them in Europe, pointed at Eutelsat satellites. The international association for the VSAT sector, the Global VSAT Forum, has more than 100 member organisations in 34 countries [2]. VSAT systems may offer broadband services because they communicate via satellites at relatively high radio frequencies, where broader radio frequency bandwidths are available.

1.1.5 Convergence of Broadcasting and Telecommunications

Historically, broadcasting predates radio; the word was first used in 1829 to mean the widespread dissemination of information. By 1921, “broadcasting” had come to mean the sending of messages by wireless without receiving replies, principally as a means of communications to ships at sea but also as a means of sending material to the general public.

The word “telecommunications” came into being in 1932, when the International Telegraph Convention of 1865 and the International Radiotelegraph Convention of 1906 were combined to form the International Telecommunication Convention, and the name of the organisation responsible became the International Telecommunication Union (ITU). Accordingly, in general terms as well as those of the ITU, telecommunications means communication over long distances, usually by electrical means including telegraphy, telephony and broadcasting as well as their more modern offspring, including satellite communications and the Internet.

However, starting after the Second World War, engineers progressively distinguished broadcasting from telecommunications. In technical terms, broadcasting came to mean a “one-to-many” one-way service suited to the distribution of audio and video, and telecommunications came to mean a “one-to-one” two-way service, such as telegraphy, telephony and data transmission. That distinction became more pronounced as the Internet grew. People were said to receive broadcasts on TV sets, but engage in telecommunications at their PCs logged onto the Internet.

That said, broadcasting and telecommunications professionals now speak of convergence of their technologies [3], meaning the introduction of means of providing two-way communications in services that long have been one-way. In the future, TV sets will no longer be restricted to receive-only services, but also will support two-way interactive services that up to now have been available only via telephones or PCs connected to the Internet.

Two-way communication in a conventional broadcasting system entails the implementation of return channels, such as from TV sets back to a TV station. These return channels may be carried by wire connections, as are most Internet connections are today, by radio channels similar to those used in mobile telephone systems, or for systems broadcasting via satellites, back via those same satellites. This book is concerned with two-way communication via satellite: digital video broadcasting with return channels via satellite (DVB-RCS) [4, 5].

1.2 The standards landscape

As in all communications systems, standards ensure that the various parts of a satellite communications system work together to provide the service supported. For instance, adherence to standards ensures that a system provides the Internet characteristics that support applications for end users. Most commercial communications satellites in Geostationary Earth Orbit (GEO) act as relays. This is called "bent-pipe", which, by analogy to a water pipe, means that the satellite redirects a flow but does not take part in it. Consequently, standards apply as they do in all data communications networks and follow the hierarchy of the first three layers – Physical, Data link and Network – in the Open Systems Interconnection (OSI) model, corresponding to the first two layers – Network access and Internet – in the TCP/IP model.

Physical standards relate to the traditional characteristics of communications networks and apply regardless of the sort of traffic carried. In digital satellite communications, they apply at level 1 in the OSI and TCP/IP models and concern the radio-frequency equipment, antennas and intervening uplink and downlink that comprise a transmission path between two stations. They usually are specific to a particular satellite and are set forth by the satellite operator to ensure that radio-frequency parameters at the satellite stay within set bounds so that the transponders operate properly. They usually include:

- radio frequencies (RF) and bandwidths
- transmitted Effective Isotropic Radiated Power (EIRP)
- received signal level to noise ratio, E_b/N_o
- noise and spurious frequency levels
- antenna patterns including sidelobe levels
- uplink and downlink link budgets

In turn, these parameters dictate the design of station antennas and RF equipment. They remain the same, no matter which system or service uses a transponder. Therefore, different satellite communications systems may employ the same physical standards because they use the same type of satellite. However, physical standards usually change whenever transponders change, such as whenever services are switched from one satellite to another.

Data link and network standards reflect the blurring of the traditional boundary between communications and data processing. They apply at levels 2 and 3 in the OSI model (levels 1 and 2 in the TCP/IP model) and concern the ways in which digital signals are sent via a transmission path. In satellite communications, they are specific to a system and usually are set forth by the system operator to ensure that the stations of the system work together. They specify how the system's Digital Signal Processing (DSP) functions are to be conducted and usually include requirements on:

- encoding and decoding
- compression and expansion
- multiplexing and demultiplexing
- modulation and demodulation

In turn, these parameters dictate the design of all station functions up to the Intermediate-Frequency (IF) interface to the RF equipment. They differ considerably, depending on the system or service to which they apply. Therefore, different systems usually have different data link and network standards, even though they might use the same types of transponder on a satellite and hence adhere to the same physical standards. Like the data link and network standard for other data communications systems, those for satellite communications systems may be classified according to four attributes:

- **closed** with few or no published parameters
- **open** with all parameters published, including *de facto* industry standards
- **proprietary** for the exclusive use of a standards owner(s)
- **public** and available to all.

Nera designs, builds and delivers satellite communications stations and systems for the three feasible combinations of these four standards attributes:

- **open and proprietary**, as used in the Inmarsat global mobile satellite systems. Inmarsat operates both its satellites and its systems, some of which are subject to strict maritime communications requirements, and accordingly retains control of the flow of data communications over its satellite transponders. Nera Satcom is the market leader in Inmarsat gateways and Terminals, with market positions of 50% for gateways and above 40% for most Terminals.
- **closed and proprietary**, as used in many regional and continental VSAT systems. Closed, proprietary standards afford their system operators a monopoly for their services within their satellite footprints, but may tie an independent service provider to a single supplier of hardware and/or

software. Since the early 1980s, Nera has built VSAT stations and systems and has pioneered VSAT technologies including Demand Assigned Multiple Access (DAMA) and the 1 GHz IF interface.
- **open and public**, as is the DVB-RCS specification described in the following sections. The ready availability of DVB-RCS is expected to promote widespread production of applicable hardware and software and thereby bring down unit prices due to economies of scale. Nera Wireless Broadband Access AS provides terrestrial and satellite broadband communications solutions.

Nera SatLink designs use open, public standards to promote growth in affordable broadband over satellite.

1.2.1 DVB enables broadband

DVB is an abbreviation for Digital Video Broadcasting. It has three strengths indicated by its name:
- **Digital**: DVB is all-digital, and digital communications systems do not distinguish between the different types of information they convey. So DVB can deliver any information that can be digitised, whether it is high definition TV, multiple-channel standard definition TV (NTSC, PAL or SECAM) or broadband data and interactive services.
- **Video**: At the outset, DVB principally was concerned with television, which is a broadband service. Moreover, DVB is intended to work at the higher satellite communications frequencies described in Section 1.6.5, which further enhance its broadband capability. DVB is fundamentally broadband.
- **Broadcasting**: DVB is designed as a broadcasting service for many users. So, though based on VSAT concepts, the satcom version, DVB-S, with the Return Channel via Satellite (RCS) is scalable to networks far larger than those supported by conventional VSAT systems. For instance, VSAT systems serve from tens of users to no more than a few thousand users. But DVB-RCS systems are scalable. A simple, single-gateway DVB-RCS system might serve up to thousands of users, whilst a distributed gateway architecture DVB-RCS system might provide integrated services to several hundred thousand users.

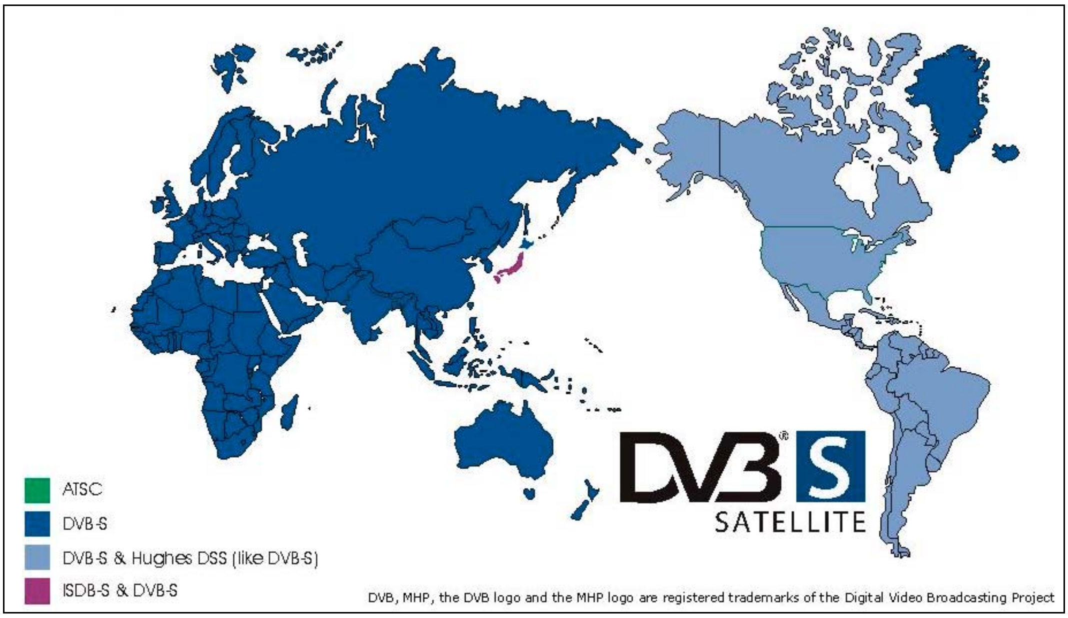
DVB-RCS is a marriage between VSAT and TV. It's the easy way to provide interactive broadband over satellite.

1.2.2 DVB specifications

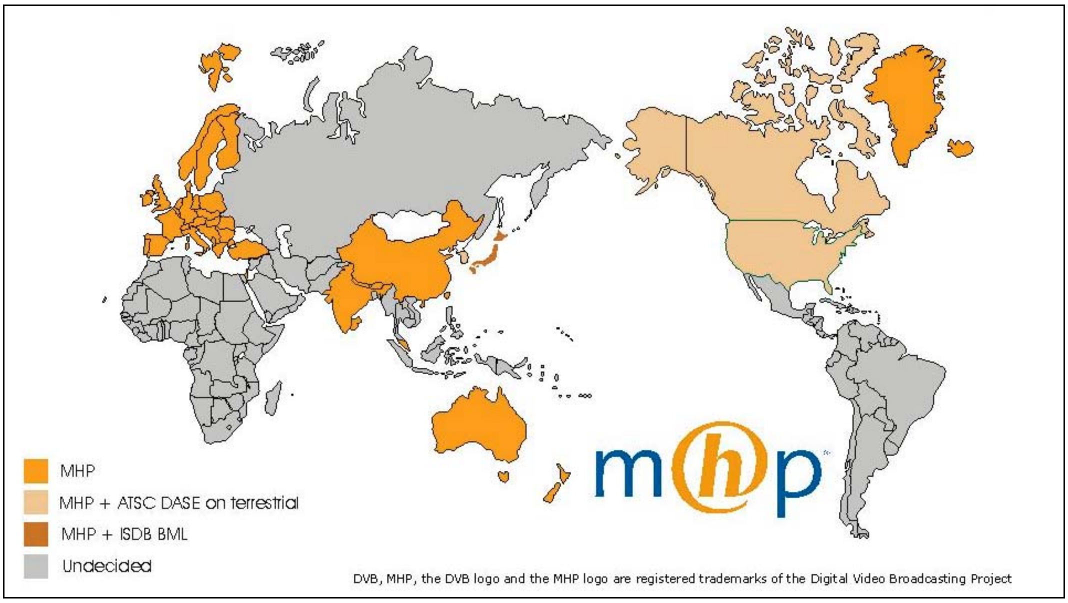
DVB specifications are developed by the DVB Project, initiated in 1993 in liaison with the European Broadcasting Union (EBU), the European Telecommunications Standards Institute (ETSI) and the European Committee for Electrotechnical Standardisation (CENELEC). The DVB Project is a consortium of some 300 member organisations, of which Nera is one. As opposed to traditional governmental agency standards activities round the world, the DVB Project is market-driven and consequently works on commercial terms, to tight deadlines and realistic requirements, always with an eye toward promoting its technologies through achieving economies of scale. Though based in Europe, the DVB Project is international, and its members are in 57 countries round the globe. DVB specifications concern:
- source coding of audio, data and video signals
- channel coding
- transmitting DVB signals over terrestrial and satellite communications paths
- scrambling and conditional access
- the general aspects of digital broadcasting
- software platforms in user Terminals
- user interfaces supporting access to DVB services
- the return channel, as from a user back to an information or program source to support interactive services

Publications on DVB are available from ETSI [6], the DVB Organisation and its Multimedia Home Platform (MHP) Project [7]. DVB experts [8,9] have written two reference texts. DVB specifications are released as:
- DVB specifications in the DVB Blue Book
- ETSI publications: ETSI Guide (EG), ETSI Standard (ES) or ETSI Technical Specification (TS)
- European Norms (EN) in the telecommunications series of the European Committee for Standardisation (CEN)

DVB specifications become standards when they are issued by organisations legally empowered to require adherence, such as ETSI with the ES series or CEN with the EN series. The world-wide application of DVB specifications is illustrated in Fig. 1.1.



(A) Digital Satellite TV standards.



(B) Interactive TV standards.

Fig. 1.1 Digital video broadcasting (A) and interactive (B) standards worldwide (maps courtesy of the DVB Project Office); DVB specifications are listed in Tables 1.2 and 1.3.

The DVB specifications are interrelated with other recognised specifications. DVB source coding of audio-visual information as well as multiplexing are based on the standards evolved by the Moving Picture Experts Group (MPEG), a joint effort of the International Organization for Standards (ISO) and the International Electrotechnical Commission (IEC). The principal advantage of MPEG compared to other audio and audio coding formats is that the sophisticated compression techniques used make MPEG files are far smaller for the same quality. For instance, the first standard, MPEG1, was introduced in 1991 and supports 52:1 compression, while the more recent MPEG2 supports compression of up to 200:1. For further details, visit the comprehensive MPEG website [10], which has links to related websites round the world. DVB uses the data link layer (OSI model layer 2) MPEG facility:

- MPEG2 188 Byte packets as “digital data containers” in an MPEG2 transport stream (MPEG2-TS)

- DVB Service Information surrounding and identifying the MPEG2-TS packets

DVB specifications apply to all forms of digital video broadcasting, as listed in Tables 1.2 and 1.3. Consequently, there are similarities between the specifications for differing modes of transmission. This promotes common designs, a clear advantage in today's complex signal distribution environment.

Table 1.2 DVB transmission specifications. The Nera SatLink System implements DVB-S.

Short name	Date	Blue Book	ETSI doc.	Title
DVB-C	03/98	A035	EN 300 429	Framing structure, channel coding and modulation for cable systems
DVB-DSNG	06/99	A049	EN 301 210	Framing structure, channel coding and modulation for Digital Satellite News Gathering (DSNG) and other contribution applications by satellite
	06/99	A050	EN 301 222	Co-ordination channels associated with Digital Satellite News Gathering (DSNG)
	06/99	A051	TR 101 221	User guideline for Digital Satellite News Gathering (DSNG) and other contribution applications by satellite
	03/99	A033	none	DSNG Commercial User Requirements
DVB-MC	02/97	A015	EN 300 749	Framing structure, channel coding and modulation for Microwave Multipoint Distribution (MMDS) systems below 10 GHz
DVB-MS	05/96	A013	EN 300 748	Multipoint Video Distribution Systems (MVDS) at 10 GHz and above
DVB-MT	06/99	A052	EN 301 701	Orthogonal Frequency Division Multiplexing (OFDM) modulation for microwave digital terrestrial television
DVB-S	02/99	A040	EN 300 421	Framing structure, channel coding and modulation for 11/12 GHz satellite services
	03/98	A036	TR 101 198	Implementation of BSPK modulation in DVB satellite transmission systems
	05/95	A033	none	User Requirements for Cable and Satellite delivery of DVB Services, including Comparison with Technical Specifications
DVB-SFN	04/97	none	TS 101 191	Mega-frame for Single Frequency Network (SFN) synchronisation
DVB-SMATV	06/99	A042	EN 300 473	Satellite Master Antenna Television (SMATV) distribution systems
DVB-T	06/99	A012	EN 300 744	Framing structure, channel coding and modulation for digital terrestrial television
	03/98	A037	TR 101 190	Implementation guidelines for DVB terrestrial services; Transmission aspects
	03/96	A004	none	User Requirements for Terrestrial Digital Broadcasting Services

Table 1.3 DVB interactive (return channel) specifications. The Nera SatLink System implements DVB-RCS.

Short name	Date	Blue Book	ETSI doc.	Title
DVB-NIP	02/97	A021	ETS 300 802	Network-independent protocols for DVB interactive services
	05/97	A026	TR 101 104	Guidelines for implementation and usage of the specification of network independent protocols for DVB interactive services
DVB-RCC	02/97	A023	ETS 300 800	Interaction channel for Cable TV distribution systems (CATV)
	03/98	A031	TR 101 196	Interaction channel for Cable TV distribution systems (CATV); Guidelines for the use of ETS 300 800
	06/99	A023	ES 200 800	Interaction Channel for Cable TV distribution systems (CATV)
DVB-RCCS	03/98	A034	TR 101 201	Interaction channel for Satellite Master Antenna TV (SMATV) distribution systems; Guidelines for versions based on satellite and coaxial sections
DVB-RCD	03/98	A030	EN 301 193	Interaction channel through the Digital Enhanced Cordless Telecommunications (DECT)
DVB-RCG	06/99	A043	EN 301 195	Interaction channel through the Global System for Mobile Communications (GSM)
DVB-RCL	06/99	A032	EN 301 199	Interaction channel for Local Multipoint Distribution System (LMDS) distribution systems
	early draft	none	TR 101 205	Guidelines for the implementation and usage of the DVB interaction channel for Local Multipoint Distribution System (LMDS) distribution systems
DVB-RCP	02/97	A022	ETS 300 801	Interaction channel through Public Switched Telecommunications Network (PSTN) / Integrated Services Digital Network (ISDN)
DVB-RCS	05/00	A054	EN 301 790	Interaction for Satellite Distribution Systems

DVB-S is the oldest and most widespread of the DVB specifications family, and services based on DVB-S are now implemented on six continents. The basic DVB-S techniques are proven by the test of time, as they have long been used in point-to-point, point-to-multipoint and mobile satellite data communications systems for “professional” users. One of the principal contributions of the DVB Project has been the development of integrated, inexpensive chip sets that perform the digital signal processing that adapts baseband signals for transmission over satellite.

Nera SatLink implements DVB-RCS to fully exploit the advantages of satellite communications.

1.3 The Internet Protocol (IP)

The data communications protocols of the Internet are depicted in the layered Transmission Control Protocol / Internet Protocol (TCP/IP) model. There is no widespread agreement on its correspondence with the seven-layered Open Systems Interconnection (OSI) model. The most common correspondence is as listed in Table 1.4 and illustrated in Fig. 1.2.

Table 1.4 TCP/IP model compared to OSI model.

TCP/IP protocol architecture model	OSI model equivalent
Application layer: supports user programs and their protocols, including File Transfer Protocol (FTP), Simple Mail Transfer Protocol (SMTP), Domain Name System (DMS), Routing Information Protocol (RIP), Simple Network Management Protocol (SNMP) and Telenet (terminal emulation program).	7 Application layer 6 Presentation layer 5 Session layer
TCP runs here to provide end-to-end connectivity, and User Datagram Protocol (UDP) runs here to provide connectionless service.	5 Session layer 4 Transport layer
IP runs here, to provide addressing.	3 Network layer
Network Interface layer: manages the exchange and routing of messages.	2 Data Link layer 1 Physical layer

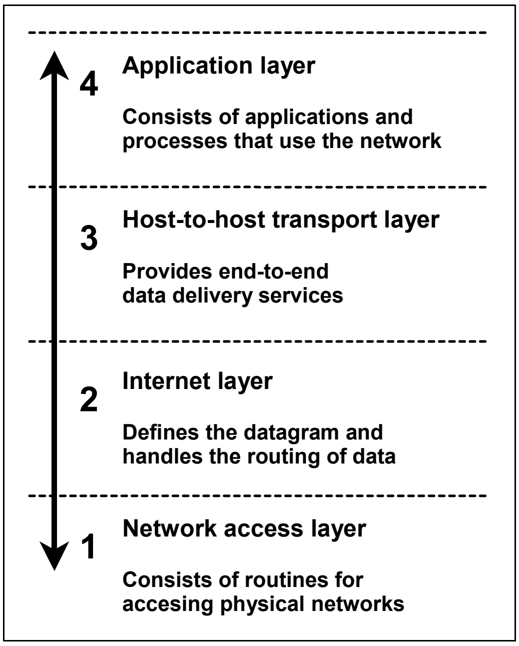


Fig. 1.2 Four-layer TCP/IP model.

Each of the four layers has its own independent data structures. Data sent to the network are passed down the stack whilst data received are passed up. In transmission, data from each layer are encapsulated in the underlying layer. Encapsulation involves adding control information in a field called a header, because it is placed ahead of the data to be sent. In reception, as data are passed up the stack, the process is reversed, and the headers are successively removed, as illustrated in Fig. 1.3.

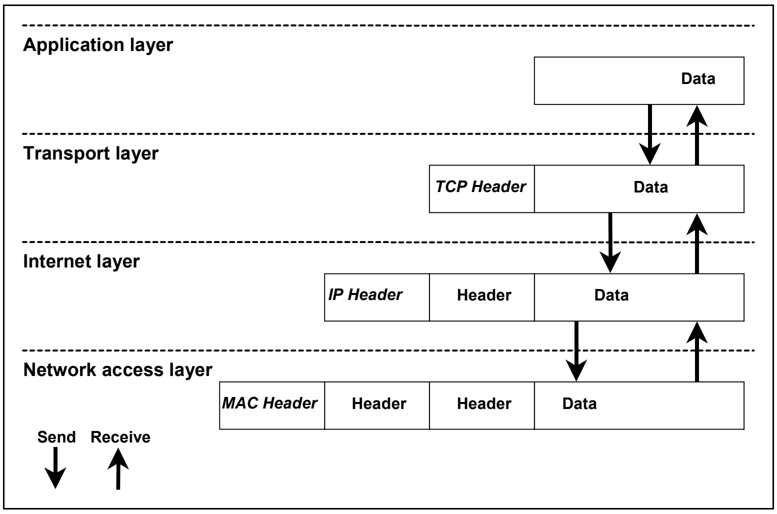


Fig. 1.3 Headers are added to data sent and removed from data received, as the data are passed between layers.

There are several terms for the data passed up and down between the layers. Most applications that use TCP call the data a "stream", whilst applications that use UDP call the data a "message". In TCP itself, data are said to be transported in "segments", whilst in UDP data are said to be transported in "packets". At the Internet layer, all data are regarded to be in "datagram" blocks. At the network access layer, "packet" is a common designation, as in "packet-switched network". But in radio communications systems, such as over satellite, "frames" is the most used term. The various terms are shown in Fig. 1.4.

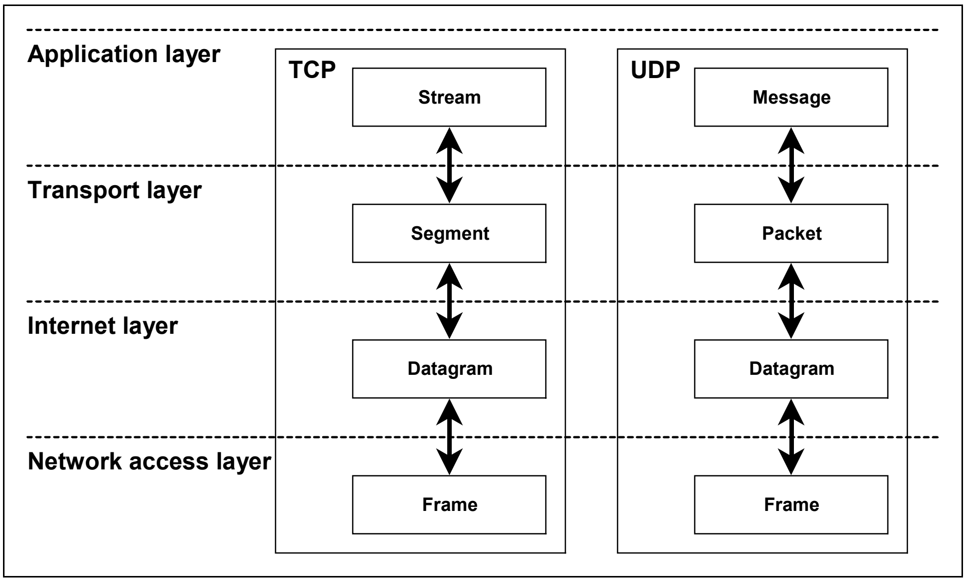


Fig. 1.4 Common terminology for data at various layers.

Data flow between networks via gateways, in which the frames are processed only up to the Internet layer, where routing tasks are performed. The basic network-to-network flow of data is shown in Fig. 1.5.

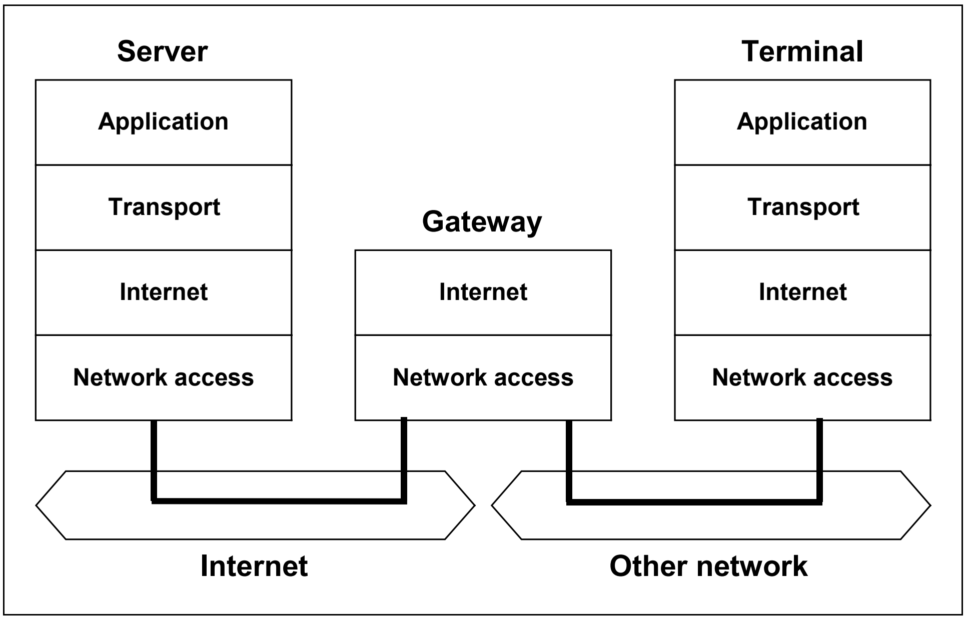


Fig. 1.5 Basic network-to-network flow of data between an Internet server and a user Terminal connected to another network.

If the "other network" shown in Fig. 1.5 is a Local Area Network (LAN) or another network similar to the Internet, the overall flow is like that in the Internet itself. In fact, the Internet is built up of many individual networks and gateways, so the "other network" might be another part of the Internet. However, if the "other network" is a satellite network, the poor performance of TCP over satellite links (see Section 1.1.3) may require that the gateway process data up to the Transport layer where TCP runs, as shown in Fig. 1.6.

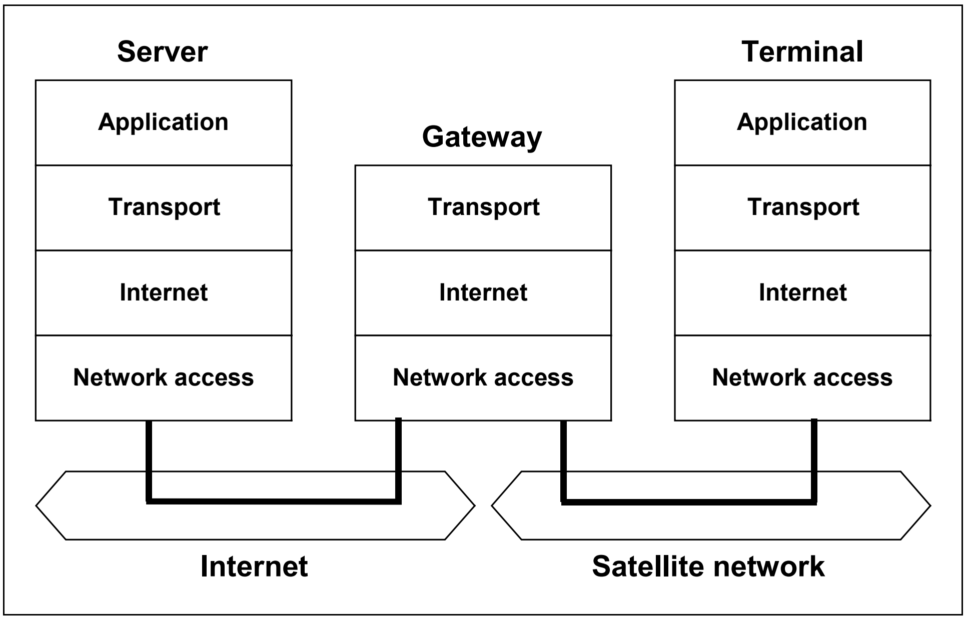


Fig. 1.6 A gateway providing TCP/IP over satellite processes data up to the Transport layer to provide Internet-quality connections to Terminals.

1.4 Access protocols

1.4.1 Necessity Dictates Sharing

In classical radio communications, a radio station monopolises its allocated radio-frequency bandwidth and transmission time. This is typical in broadcasting, such as when radio or TV stations transmit at assigned frequencies (with specified sideband widths) or channels during specified hours. Traditional two-way radio communication employs the same principles, as stations monopolise allocated resources when transmitting.

Communications satellites cannot be so wasteful, as satellite radio-frequency power is both limited and expensive. So a satellite's resources must be shared among the stations on earth using it. With the exception of dedicated continuous use, such as in broadcasting analogue TV programmes, satellite transponder capacity is shared by many users.

Therefore, almost all satellite communications systems involve controlling transmitters and receivers to permit Multiple Access (MA) to the limited satellite resources. As listed in Table 1.5, MA may be implemented in any one of the three domains of radio frequency transmission – time, frequency or space – as well as in the signal domain, in which each signal is given a code that makes it uniquely identifiable.

Table 1.5 Basic Multiple Access (MA).

Domain	**Conventional sharing, as between different systems**	**Satellite resource sharing**	
		Name	Method
Time	Local broadcasting stations transmit at different times of the day.	TDMA	Sequential: stations may use same radio frequency, but transmit only during time slots allocated by fixed or random assignment.
Frequency	Allocations of available frequency spectrum to different services.	FDMA	Spectrum: stations may transmit simultaneously, but at different radio frequencies allocated by fixed or random assignment.
Space	Right-hand circular (clockwise) and left-hand circular (anticlockwise) polarization used by communications satellites; some use both polarisations, and some receiving terminals are equipped to receive both.	SDMA	Electromagnetic waves in space: stations may transmit simultaneously at the same radio frequency, but with differing spatial parameters, such as signal polarizations (horizontal, vertical, right circular, left circular).
Code	Originally developed for military communications, to ensure security. Frequency hopping is most common: the transmitter changes its frequency at random, and the receiver, which "knows" the hopping code, follows the changes.	CDMA	Perception: all stations transmit simultaneously using the entire frequency band available. Accessing the satellite transponder is uncoordinated (the stations are completely independent of each other), and the signals are very resistant to interference. However, CDMA has two drawbacks for commercial applications: 1) It requires a larger power per signal than do other MA methods, 2) Receivers are complex and therefore expensive.

Claims of superiority have been made for all the multiple access systems listed in Table 1.5. For the theoretically perfect system, each can be shown to support the same number of user stations in the same bandwidth. However, in current practice, only the various varieties of TDMA and FDMA are viable in current commercial satellite communications systems. SDMA differs from TDMA and FDMA in that it is determined by the physical parameters of the antennas on the satellite and at the Terminals and gateways that communicate via the satellite. So, as a rule, SDMA is used to extend the bandwidth provided by a communications system rather than to provide access by multiple stations. CDMA is now used in several terrestrial mobile communications systems, such as the Japanese iMODE and in satellite systems for special applications, such as the Qualcomm Monitracks or the Euteltracks system. As coding techniques are increasingly refined, CDMA may be more widely used on satellite links, particularly for semi-continuous and burst communications at lower frequencies where where the uplink and downlink losses are lower and consequently can support the power requirements of CDMA.

Consequently, TDMA and FDMA are the basic multiple access methods used in today's broadband over satellite systems, as illustrated in Fig. 1.7. The sharing of a domain is often called "division," so TDMA becomes “Time Division Multiple Access” and FDMA becomes “Frequency Division Multiple Access.” Strictly speaking, “division” is correct only for an illustration of the technique. Time is continuous and cannot be divided, and frequency division describes the process involved in down-converting from one frequency to another, such as is done in upconverters and downconverters between Ku-band radio frequencies and the IF interface in stations. Nonetheless, “division” is in common usage and may therefore be considered equivalent to “domain” in the abbreviations of TDMA and FDMA.

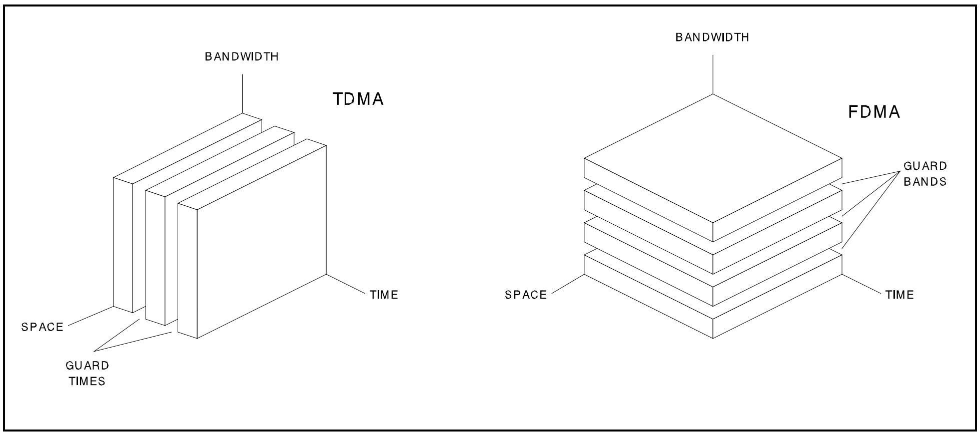


Fig. 1.7 Time domain and frequency domain multiple access. Guard times in TDMA and guard bands in FDMA prevent interference between adjacent signals. However, in system design, both guard times and guard bands are minimised, because they carry no information and consequently waste satellite resources.

1.4.2 Comparison of time and frequency sharing

The specific multiple access methods used in broadband over satellite are compared in Table 1.6.

Table 1.6 Specific Multiple Access (MA) methods.

Multiple Access (MA) method	Fundamental action	Implementation	Note(s)
TDMA	Time sharing.	Each user’s signal is divided into bursts. A multiple-access unit provides a time-gating function, which locates each burst in a preassigned time slot. When one user’s burst terminates, the next user’s time slot becomes available.	Regarded to be more efficient than pure FDMA and consequently used in combination with it in satellite systems designed according to the DVB-RCS specifications. The technique is called Multi-Frequency TDMA (MF-TDMA).
FDMA	Frequency sharing.	A multiple-access unit selects a carrier frequency for a user’s modulated signal. In Single Channel Per Carrier (SCPC) systems, each modulated signal has a separate carrier frequency.	SCPC version regarded to be more efficient than TDMA for continuous, higher traffic volumes from a large number of earth stations and consequently used in many mobile satellite communications systems.
RMA (Random Multiple Access)	Time sharing.	Like TDMA, except that any user transmits at any time, not at preassigned times; users contend with each other to share channel capacity.	Aloha (Hawaiian for “Hello” and “Goodbye”, as it was developed at University of Hawaii for Pacific Island communications). A variant, called slotted Aloha, uses preassigned time slots and consequently resembles TDMA with no definite slot assignments.

1.4.3 Demand Assigned Multiple Access (DAMA)

Demand Assigned Multiple Access (DAMA) is a name for a central allocation of network resources. In practice, it is an operation process that lies “above” MA processes, because it is an administrative, not a technical function.

In a DAMA system, typically, Terminals send requests to a control station, which responds by assigning specified time slots or frequencies. Accordingly, there is no risk of collisions between the signals of different Terminals and bandwidth is used efficiently. However, processing and responding to requests takes time. So the challenge in DAMA implementations is to minimise time delays and maximise the use of network resources. DAMA has limitations, particularly in transaction networks, in which a large Terminal population send short transaction messages to a Hub station. The probability of a request from a single Terminal usually is low. Consequently, slotted Aloha, as described in Table 1.6, is the only practical access method, as it results in a use of network resources of the order of 20%, which means that 80% of the allocated time slots allocated are wasted. In turn, this illustrates the dilemma involved in the trade-off between response time and network use. A configuration based on round robin (each Terminal has a specific time slot) often leads to unacceptable delay times.

1.4.4 Ethernet

Ethernet is the commonplace name of a Local Area Network (LAN) technically described by a family of Institute of Electrical and Electronics Engineers (IEEE) 802.3 specifications [11] that concern:

- Physical Layer (layer 1 of the OSI model) communications
- Data Link Layer (layer 2 of the OSI model) datagrams (no acknowledgement)
- 48 bit Medium Access Control (MAC) addresses
- Broadcasting with a connectionless protocol on a shared physical medium
- Variable frame lengths
- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

In an operating Ethernet, each connected entity senses the transmission medium (the Ethernet cable) to see if it is busy or free. If it is free, the entity starts transmitting a packet, while monitoring the medium to see if the transmission is successful. If another entity attempts to transmit at the same time, both entities experience transmission corruption and will stop transmitting for a random time (different for each entity) before trying again. Because all entities can monitor the transmitted signal and can stop transmitting as soon as a problem is detected, the practical use factor of the Ethernet is quite high; although at high network loads, the collision rate and consequent network latency increase.

1.5 Satellite systems and stations

1.5.1 Three make a system

All satellite communications involve at least three stations, two on the Earth and a repeater station on the satellite. So, as shown in Fig. 1.8, a satellite communications system consists of at least three parts:

- space segment: the satellite and the transmission paths through the atmosphere,
- ground segment: the stations that communicate via the satellite, and
- interfaces to the terrestrial (on the Earth and within its atmosphere) networks that the satellite system serves.

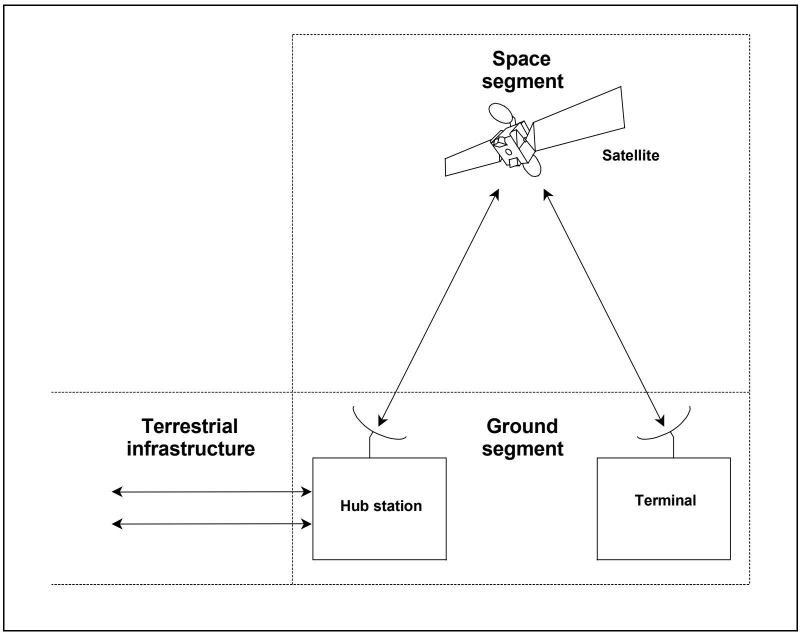


Fig. 1.8 Like all satcom systems, the basic broadband over satellite system has three parts.

Nera SatLink offers all components and sub-systems in the ground segment.

1.5.2 Satellite transponders

A transponder on board a communications satellite in geostationary orbit acts much as do transponders in terrestrial microwave relay stations: it receives a microwave signal on the uplink from Earth, changes its frequency, amplifies it and retransmits it on the downlink to Earth. Transponders usually have RF bandwidths of 33, 36 or 72 MHz, and almost always use travelling-wave tube (TWT) amplifiers. There are two basic types of transponders, transparent and regenerative.

The transparent transponder is the simpler of the two types. It converts the frequency of incoming signals and amplifies them, but does little else. It is called "transparent" because it amplifies all uplink signals, the desired carriers as well as the undesired noise. Hence it also is called a "bent pipe", by analogy to a pipe carrying water around a bend, to redirect it. Almost all communications satellites now in service have transparent, or "bent pipe" transponders. So in everyday telecoms usage, one speaks of "bent-pipe satellites".

The regenerative transponder has all the functions of the transparent transponder, but also employs on-board processing for demodulating, processing and remodulating the signals it carries. The onboard demodulation, processing and remodulation offers two advantages. First, the uplink noise is removed and not retransmitted on the downlink, which improves the overall quality of channels via the satellite. Second, it permits combining several uplink single Channel Per Carrier (SCPC) or TDMA channels into a single downlink Time Division Multiplex (TDM) channel. This avoids the need to feed many DVB signals to a central multiplexing facility on Earth. Instead, program material from several sources, such as individual TV stations or multiple small data service providers, is combined on board the satellite into a single broadcast, as illustrated in Fig. 1.9.

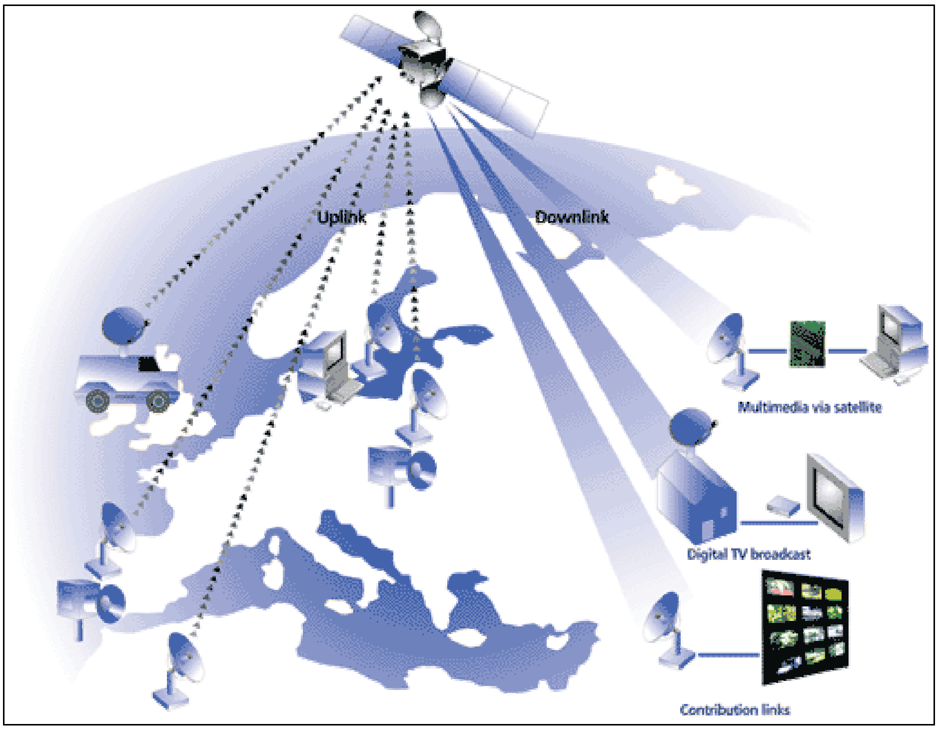


Fig. 1.9 Skyplex regenerative transponder system [drawing from Eutelsat website at http://www.eutelsat.org/].

The regenerative transponder system shown is the Eutelsat Skyplex, now implemented on a total of 12 transponders on the Hot Bird 4, 5 and 6 satellites. Each transponder supporting Skyplex can be operated either in the Skyplex regenerative mode or in the transparent mode. The Skyplex system is designed to operate with inexpensive uplink stations and to be compatible with Satellite News Gathering (SNG) uplink stations, and its downlink TDM is according to DVB specifications.

The drawback of regenerative transponders is that they are newer, less well proven and more complex than transparent transponders. Consequently, most of the transponders of the world's communications satellites are transparent. Nonetheless, the attractive features of regenerative systems such as Skyplex imply greater future use of the technology.

1.5.3 Stations

As shown in the block diagram of Fig. 1.10, all digital radio communications stations – be they for satellite communications systems or for terrestrial radio communications systems such as digital cellular telephones – comprise seven basic components.

The smaller the station, the more the seven basic blocks are packaged together. In a digital cellular telephone, for instance, all seven are in a single, hand-/pocket-held unit, with the peripheral telephone headset built in. In a Terminal, such as a Nera SatLink Terminal, they are separated into four units:

1. the Antenna.
2. the Indoor Unit (IDU) consisting of the interfaces, the DSP, the transceiver and the control equipment.
3. the Outdoor Unit (ODU) containing the RF circuitry.
4. the peripherals, such as a Personal Computer (PC).

In a typical Hub station, the seven are separate interconnected units, which, except for the antenna, are usually mounted in a rack. Regardless of its size or extent of packaging, the basic purpose of every station is, of course, to communicate with other stations, as illustrated in Fig. 1.11.

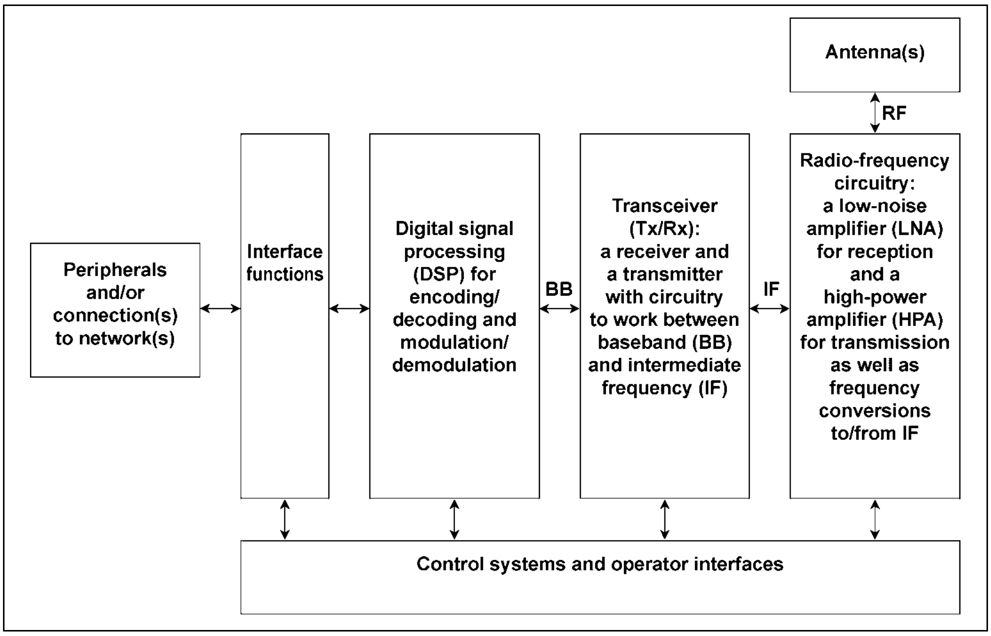


Fig. 1.10 All digital radio communications stations consist of seven basic "building blocks" that interwork between BaseBand (BB), Intermediate Frequency (IF) and Radio Frequency (RF).

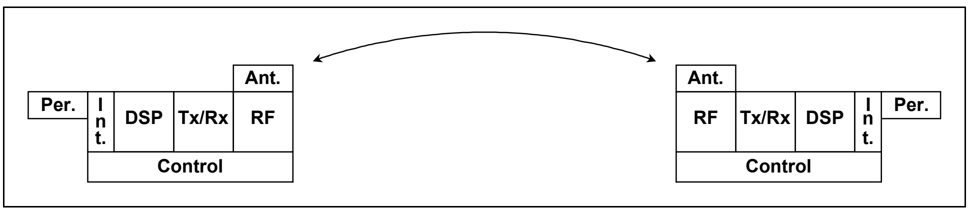


Fig. 1.11 Basic station communications.

The Nera SatLink approach emphasises commonality. Aside from their antennas, Nera SatLink and Nera terrestrial communications Hubs and Terminals share more than 80% of their respective design features. This simplifies station design and promotes reliability and ease of operation and maintenance.

1.5.4 Network topology

The way any two stations communicate with each other depends on the network in which they operate. In turn, the structure of the network influences station design. The stations, not the network, determine network configuration. The satellite normally does not determine network configuration. This is because in most cases, the satellite is a "dumb" relay that does not process or alter signals. As seen by the network, it is completely transparent.

As illustrated in Figs. 1.12 and 1.13, there are two basic network configurations:

- **Mesh:** Any two stations may communicate directly with each other without involving a third station.
- **Star:** All user stations communicate via base stations, or Hubs of the network.

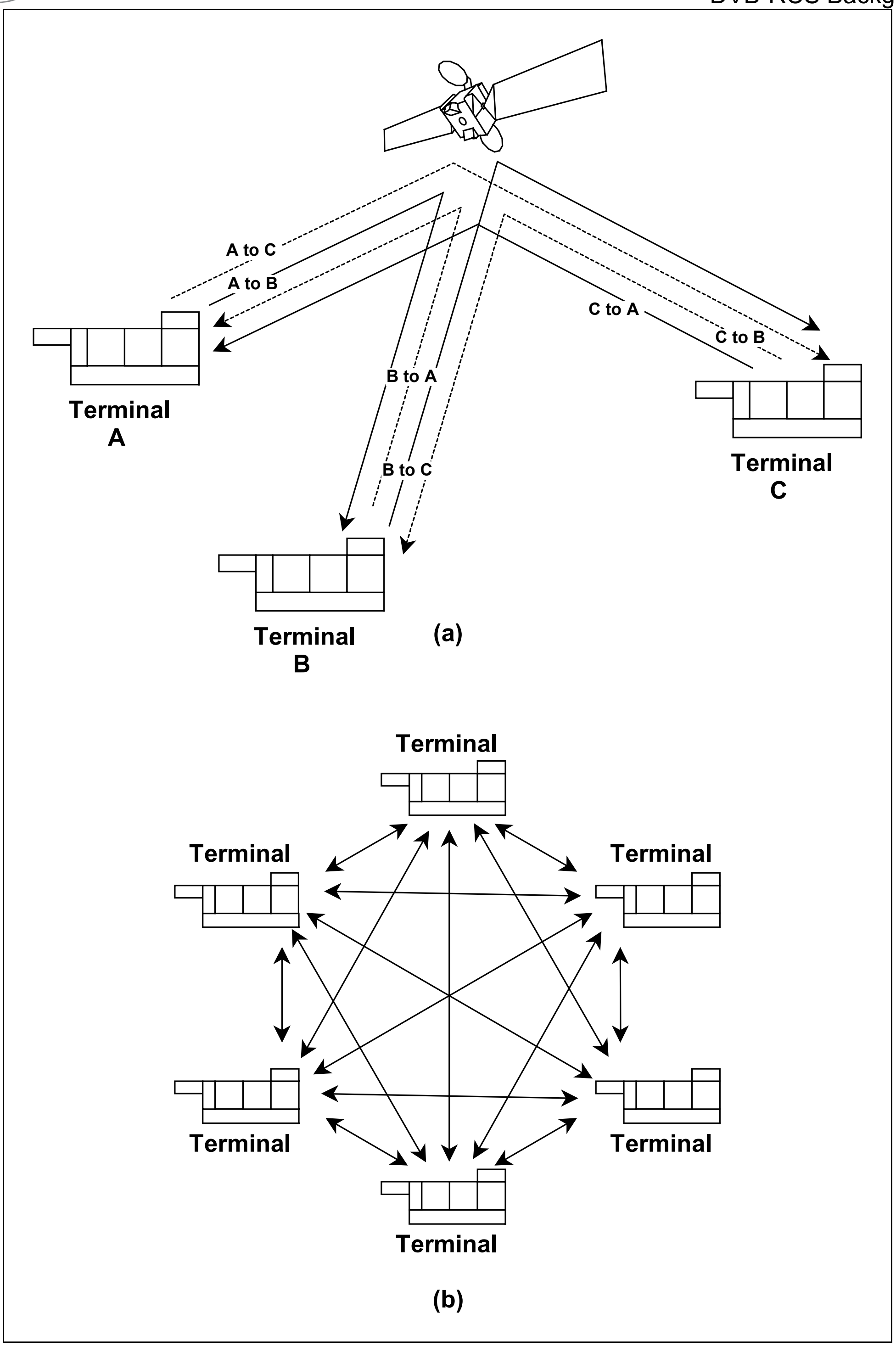


Fig. 1.12 Typical mesh network with three Terminals communicating via the satellite (a) and an overall mesh of communications between the Terminals of a six-station network (b).

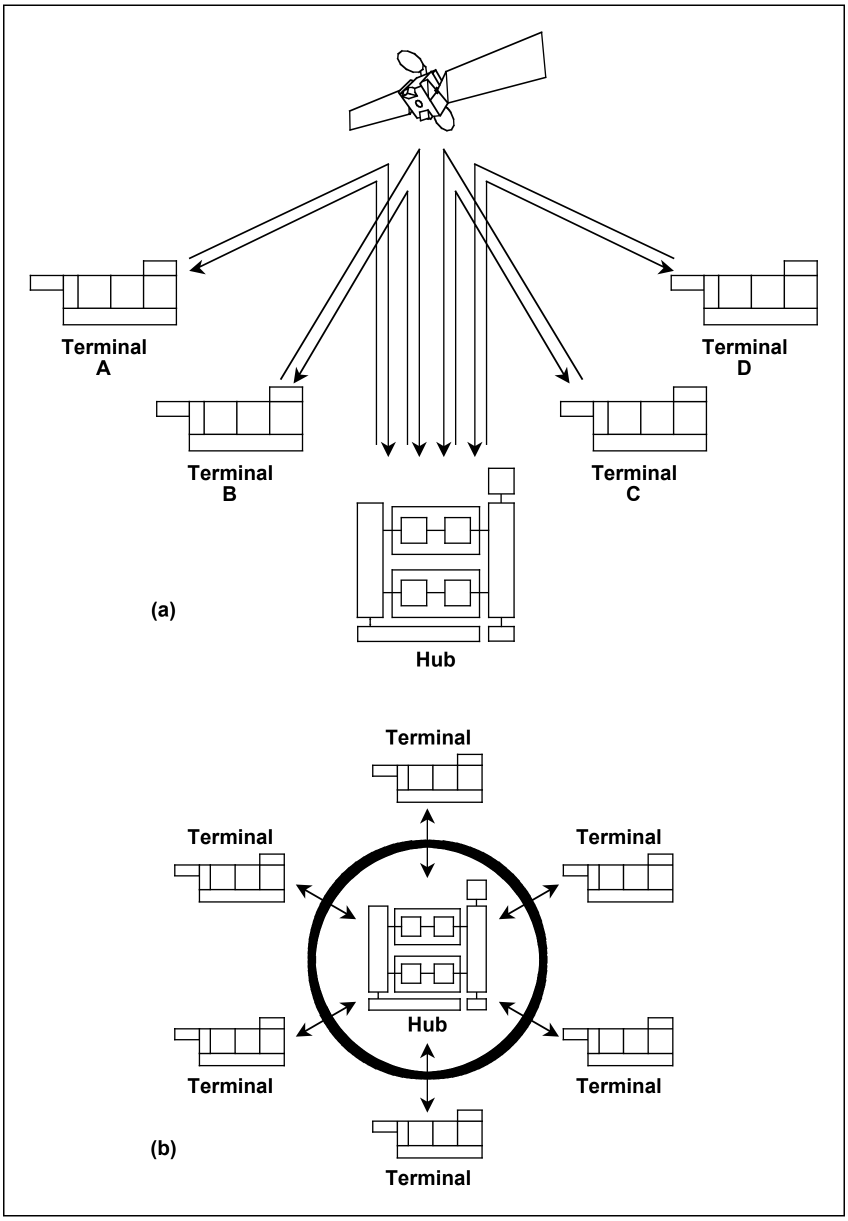


Fig. 1.13 Typical star network with four Terminals communicating via a central Hub station (a) and overall star of communication channels between the Terminals in a six-station network (b).

Mesh networks are simpler than star networks, because they require no Hub stations. Moreover, a channel set up between two Terminals (T-T) goes just once up to the satellite and down again, instead of the up-down-up-down sequence of a star network. Hence the latency is half that of T-T communications in a star network, which is an advantage in networks in which the Terminals send high volumes of data to each other. However, as there is no single large station with its large antenna in a network, so all Terminals need larger antennas than they would if operating in a star network. Moreover, as the number of stations increases, the communications traffic handling requirements at each station also increase, as all stations must always be aware of all traffic in order to place calls. So for a large number of stations, the mesh approach is costly. This makes mesh network Terminals more expensive than star network Terminals, particularly for larger numbers of Terminals.

On the other hand, star networks can support many small, inexpensive Terminals. Moreover, a single, large Hub station can be easily expanded or retrofitted with new services, so a star network can adapt more easily to changing patterns of user communications needs. Consequently, most practical networks are configured as stars, including most cellular telephone networks and all DVB-RCS communications networks.

1.5.5 Terminology: "Hub" and "Gateway"

The terms "Hub" and "Gateway" are both used to designate the major station in a satellite communications system that carries terrestrial network services to and from Terminals. In satellite communications, particularly VSAT, "Hub" means the central station of a star configured network, as shown in Fig. 1.13. In telecommunications systems in general, a "gateway" joins two networks and, in most cases, performs protocol conversion between them. Hence, a satellite Hub station that interfaces terrestrial networks is a "satellite gateway hub station". Almost all satellite Hub stations interface to terrestrial networks and consequently are gateways. However, the converse is not true, because not all telecommunications gateways are Hub stations.

The DVB-RCS system is configured as a star. So its central station is called a "Hub" in this publication. So, hereafter, **"hub" means "gateway hub station".**

1.5.6 Basic station configuration

Theoretically, a Hub station might be built by buying a number of Terminals and installing them in one place, as shown in Fig. 1.14.

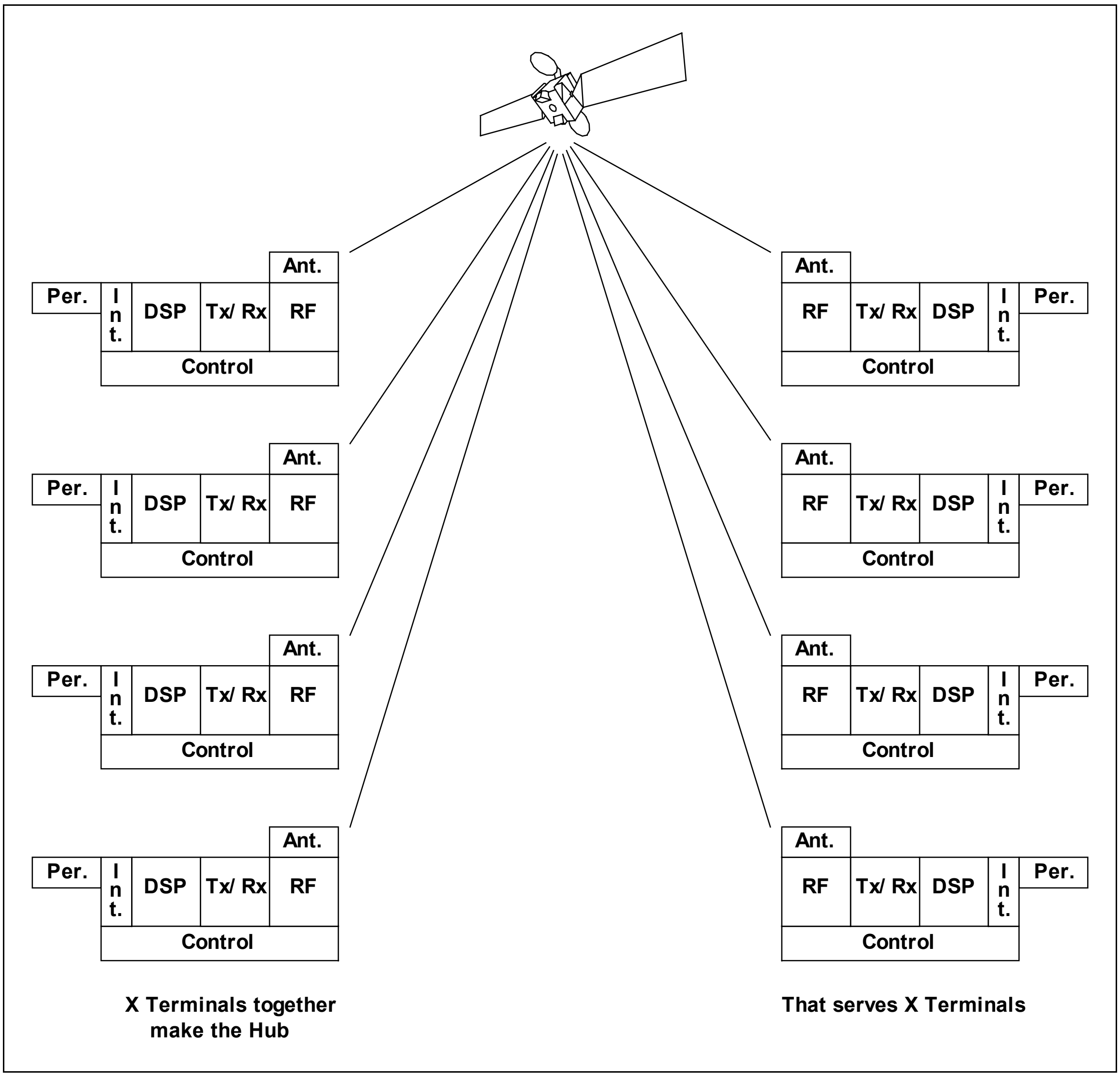


Fig. 1.14 Theoretically, a Hub station might be built using many Terminals.

The theoretical Hub station of Fig. 1.14 is cumbersome in practice. Even if each of its constituent Terminals were modified to accommodate the digital processing circuitry that caters to functions performed by a Hub but not the Terminals of a network, the composite station would be costly, principally because many functions are duplicated. Nonetheless, in theory it would work, because its structure is basically correct. Moreover, Single Channel Per Carrier (SCPC) stations (see Section 1.6) usually are built along similar lines and are fitted with multiple channel units (CUs) having DSP and Tx/Rx functions, but share common interface, control, RF and antenna functions.

As shown in Fig. 1.15, the basic practical Hub station for DVB-RCS applications has one transceiver per channel served. Its structure differs only by its sharing of interfaces, digital signal processing, RF equipment and antenna.

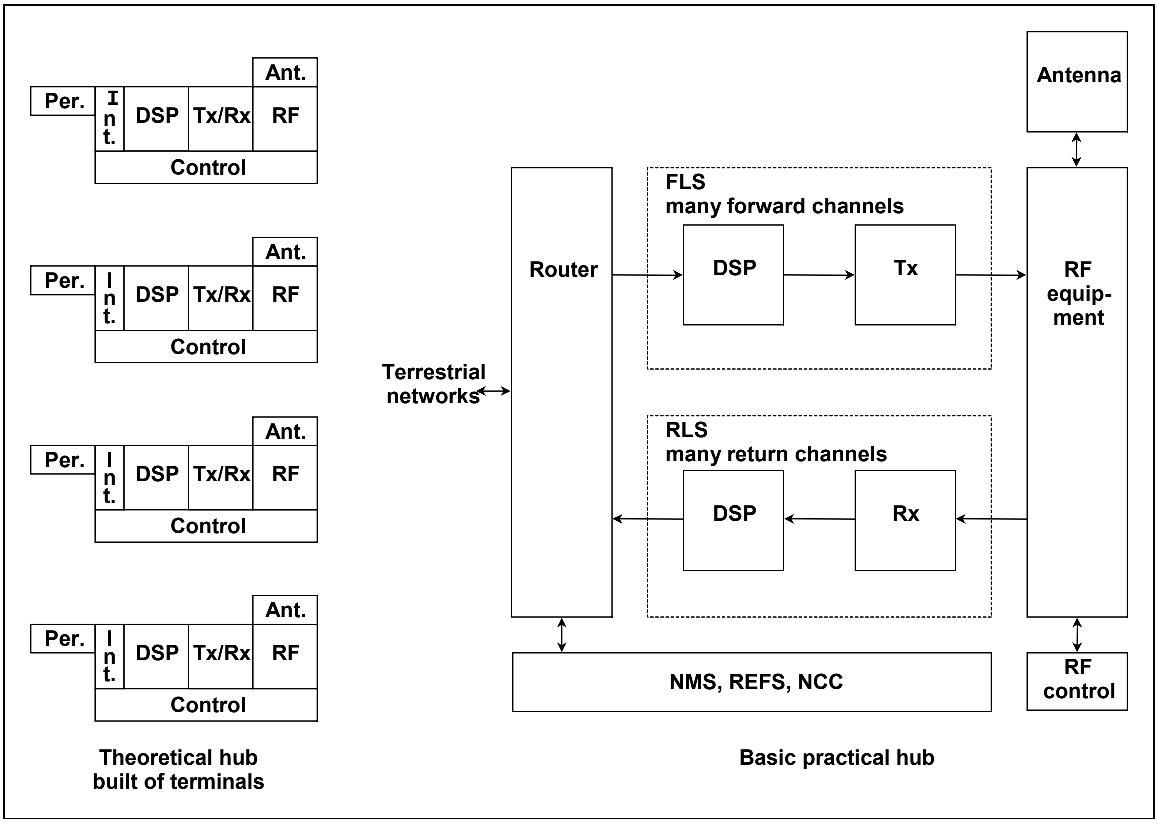


Fig. 1.15 The basic practical Hub station resembles the theoretical station built of many Terminals.

1.5.7 Coding

Coding is the process of encoding data at a transmitter and decoding it at a receiver to maximise the accuracy of the data presented to a user. In most data communications systems, coding involves adding extra bits, called "redundant bits" in a transmitted bitstream in a way that enables errors to be detected and corrected upon decoding at the receiver. There are two basic types of these codes.

- **Error detecting codes:** The simplest codes permit detection of a bit in error in a single codeword, but they cannot identify the bit exactly. So at the receiver, when errors are detected, an Automatic Repeat Request (ARQ) is sent to the transmitter.
- **Error correcting codes:** More complex codes permit correction without retransmission and consequently are known as "Forward Error Correction (FEC) codes". FEC is extensively used in satellite communications.

FEC codes are classified according to the "code rate", which is the ratio of the number of bits in a word or message in the original bitstream to the number of bits actually transmitted:

Code rate = (bits in original codeword)/(bits transmitted)

For instance, if one redundant bit is added for every three bits in the original bitstream, the code rate is 3/4. The performance of a code on a channel is expressed in terms of the relationship of the ratio of the energy per bit to the noise power (E_b/N_o) to the Bit Error Rate (BER) attained. The advantage gained is called the “coding gain”, which is the ratio in Decibels with and without coding, of the E_b/N_o ratios, as illustrated in Fig. 1.16.

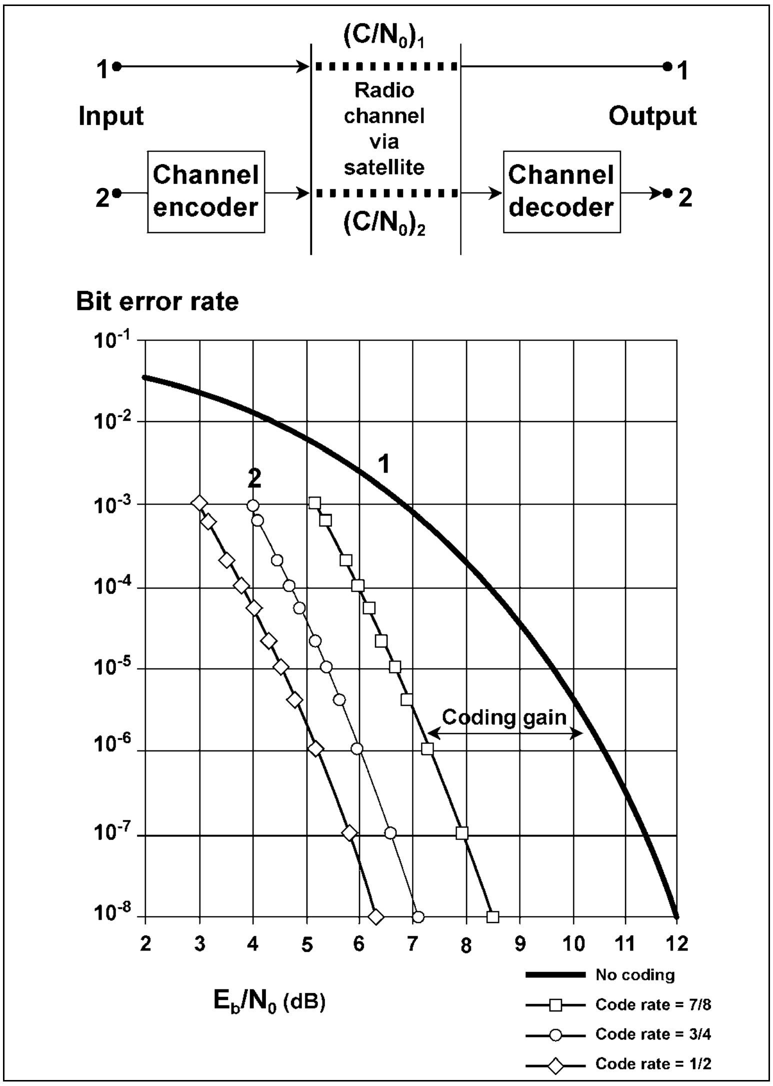


Fig. 1.16 Coding performance can be assessed by comparing the Bit Error Rate (BER) of coded links to that of an uncoded link. The curves shown are for convolutional coding and a typical Viterbi decoder at the receiver. Figure adapted from Fig. 5.35 in “VSAT Networks” [12]

Coding gain is one of the principal parameters that engineers may vary in the tradeoffs of system design. For instance, a greater coding gain may allow a lower transmitter power, a smaller antenna, a simplified modem, or all of these. The system designer may require an improved coding gain to provide a margin for error in calculating the uplink and downlink losses involved in the link budgets.

1.5.8 Modulation methods

Digital signals may be transmitted via radio links by modulating any feature of a radio-frequency carrier – amplitude, frequency or phase. If there were no noise, amplitude modulation might be the favoured method, because for a given amount of information transferred, it requires less bandwidth than do frequency or phase modulation techniques. However, noise exists in all practical communications systems and sets the fundamental constraint, because received signals must be distinguished from noise at the receiver. Therefore, frequency and phase modulation techniques, which offer greatest noise immunity, are almost universally used in satellite communications.

Frequency can be defined as the advance of phase with time. Therefore, for analogue modulating signals, the distinction between frequency and phase modulation is not well defined. However, for digital modulation techniques, the distinction is precise. There are only two states of the modulating signal (digital 1 and 0), modulation consists of "keying" between them. As illustrated in Fig. 1.17, Frequency Shift Keying (FSK) consists of producing two carrier frequencies f_1 and f_2 to represent the two states, whilst Phase Shift Keying (PSK) consists of altering carrier phase at transitions between the two states.

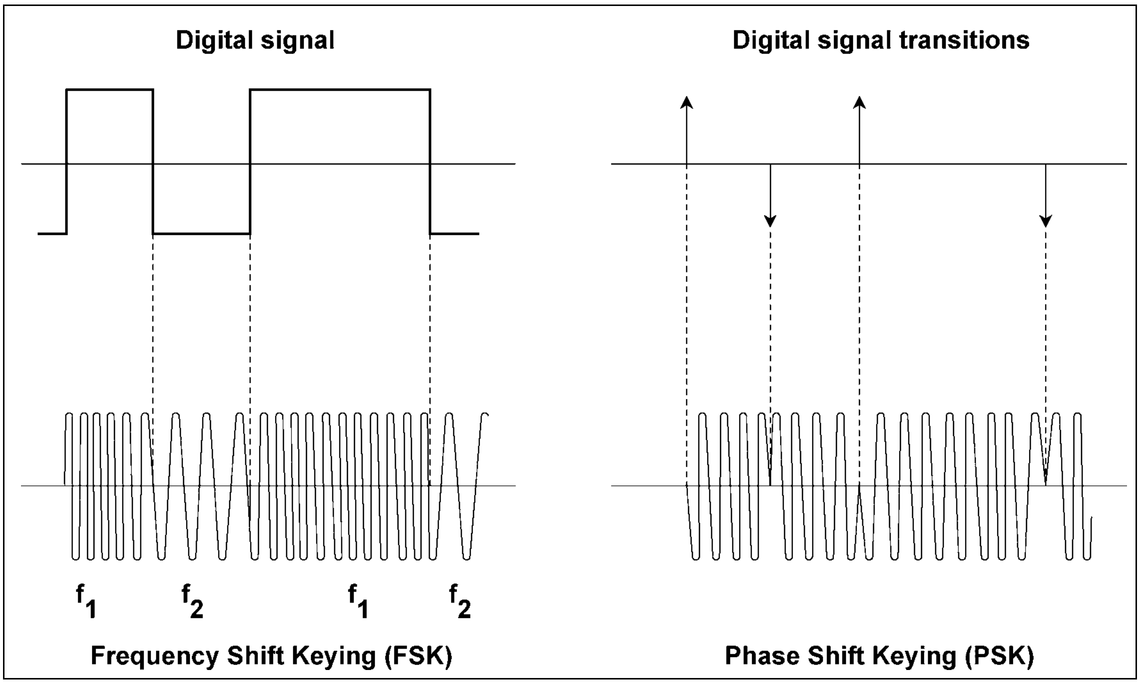


Fig. 1.17 Basic actions of frequency shift keying and phase shift keying.

In theory, FSK is more convenient, as the receiver can always distinguish between the two frequencies and consequently correctly identify the state of the received digit (0 or 1). Likewise, PSK has a drawback in that the receiver cannot identify the received digit unless it "knows" the nature of the most recent phase change. However, in practice FSK is more difficult to implement, not least because received frequencies are continuously altered by the ever-present Doppler shift due to satellite movement. Phase ambiguity can be resolved, particularly as all digital transmission systems employ clocks that either are synchronised between transmitter and receiver or are transmitted and then simulated by recovery of a timing signal at the receiver. Consequently, PSK now is the most commonly used modulation method in satellite communications.

In basic PSK, a binary data signal is mixed with a radio-frequency carrier signal and then filtered to produce an output signal in which 180° phase transitions mark the transitions between 0 and 1 or 1 and 0 in the data signal. This simplest form of PSK is called Binary Phase Shift Keying (BPSK) and is widely used in radio communications systems.

However, as described in the following section, the information carrying capacity of a BPSK modulated channel is limited to one bit per symbol. This constraint is overcome in Quadrature Phase Shift Keying (QPSK), in which the binary data are converted into two-bit symbols, which then phase modulate the carrier signal. In QPSK, four combination states containing two bits are possible in representing binary numbers made up of logical 0's and 1's. So the carrier signal is shifted between one of four states, +45°, +135°, -45° and -135°. QPSK is produced by dividing the binary data signal, bit by bit, into two binary data signals, one of which is shifted in quadrature (90° phase shift) with respect to the other. The two bit streams are then combined and are used to modulate a radio-frequency carrier signal. Each resultant symbol contains two bits, so a channel can carry twice as much information with QPSK as with BPSK.

The number of bits carried in a symbol is further increased in other modulation methods, such as 8PSK, which is like QPSK with twice as many states, and 16QAM, which has four times as many states as QPSK and uses Quadrature Amplitude Modulation (QAM), a combination of amplitude and phase modulation. Although these higher-order modulation methods can support higher bit rates, they have drawbacks, most notably in their lower power efficiency, which is crucial in channels transmitted via satellites, where power is limited. So as in most engineering designs, tradeoffs are involved. With current technology, these tradeoffs favour QPSK, as used in DVB-S and DVB-RCS.

However, the DVB specifications for QPSK employ an improvement to the basic technique by changing the bit patterns that actually are encoded in the transmitter and decoded in the receiver. The improvement is called Gray coded QPSK, because it uses the Gray coding, named after Stanford University professor Robert M. Gray who first proposed it in the early 1970s. The Gray code improves resistance to noise by minimising the number of bit errors produced by a symbol error. Its basic principle is that every transition from one value to the next in the binary sequence of numbers involves only one bit change, which simplifies the detection of errors.

1.5.9 Bit rate and symbol rate

The terms "bit rate" and "symbol rate" are both used in describing the parameters of satellite communications channels. They are not the same but are related to each other by the modulation method used, as described above.

A bit is the smallest quantity of information that can be transmitted on a digital channel. The bit rate, usually expressed in bits per second, is the capacity of the channel to carry information. The theoretical maximum error-free bit rate that a bandwidth-limited channel can carry is set by the Shannon bound according to the equation:

$$\mathbf{C = B \log_2[1 + P/N_o B]}$$

where C is the channel capacity in bits/s, B is the signal bandwidth, P is the received signal power, and N_o is the single-sided noise power spectral density.

In digital transmission, a symbol is an electrical state of specified duration, associated with a designated element transmitted. The symbol rate, usually expressed in symbols per second, is the capacity of a modulated signal to carry information. Consequently, the symbol rate often is said to be the "modulation rate". Traditionally, one symbol per second is equivalent to one Baud, the fundamental unit of telegraphic transmission speed. However, recently, the International Telecommunications Union (ITU) has suggested that the term "symbol rate" be used instead of Baud.

As shown in Fig. 1.18, in a typical digital satellite communications system, a user bit stream at a bit rate of I_b passes through a Forward Error Correction (FEC) device where redundant bits are added to produce the transmitted bit stream $I_{b'}$. In turn, the transmitted bit stream is modulated onto a carrier which then has a symbol rate R_s that depends on the modulation method used to code bits into symbols.

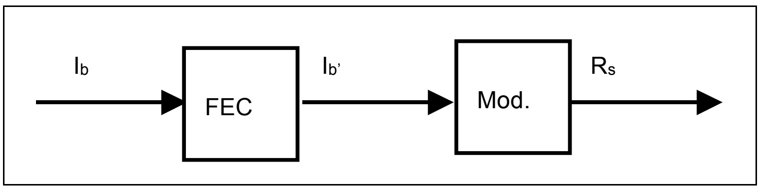


Fig. 1.18 Typical digital signal flow.

The output signal rate depends on the type of modulation and on the transmitted bit rate, according to the equation:

$$\mathbf{R_s = I_{b'}/K}$$

where K is the channel dimension given by $K = \log_2[SC]$

where SC is the number of points in the symbol constellation diagram of the modulation method employed. The relationships for the modulation methods most used in satellite communications are listed in Table 1.7

Table 1.7 Relationships for modulation methods most used in satellite communications.

Modulation method	**Number of points in signal constellation diagram**	**Channel dimension $K = \log_2[SC]$**	**Ratio of signal rate to bit rate $R_s = I_{b'}/K$**
BPSK	2	1	1
QPSK	4	2	1/2
8PSK	8	3	1/3
16QAM	16	4	1/4

For instance, for a typical FEC of 1/2 and QPSK modulation:

- the transmitted bit rate $I_{b'} = 2\, I_b$
- and the symbol rate = $0.5\, I_{b'} = I_b$

In this case, the symbol rate is equal to the initial bit stream rate. However, this is a simplification, because the frames in a satellite communications channel also carry bits that are added after FEC but before modulation, such as headers, unique words, Cyclic Redundancy Check (CRC) and pad bits.

1.6 Space segment

1.6.1 Satellite transponder access

A typical broadcasting satellite has twenty or more transponders. Typically, a transponder can transmit over an RF bandwidth of 33 MHz and deliver about 760 Mbit/s of data. An earth station transmitting via a transponder uses, or "accesses" its RF bandwidth in one of two ways.

If the transmitter sends a single carrier that occupies the entire bandwidth of the transponder, the access is said to be "single carrier per transponder". That single carrier can then be divided up using various access methods, such as TDMA, to provide communications via many channels. The result is the Multiple Channels Per Carrier (MCPC) method of access.

One or more transmitters may send RF carriers at differing radio frequencies via the same transponder; the access is then said to be "multiple-carriers per transponder". Each carrier serves a single channel, so the access is known as Single Channel Per Carrier (SCPC).

The two access methods are shown in Fig. 1.19. The DVB-S system is designed primarily for MCPC, in which all services are multiplexed into a single stream that uses the entire capacity of the transponder. Most VSAT systems use MCPC/TDMA or FDMA/SCPC.

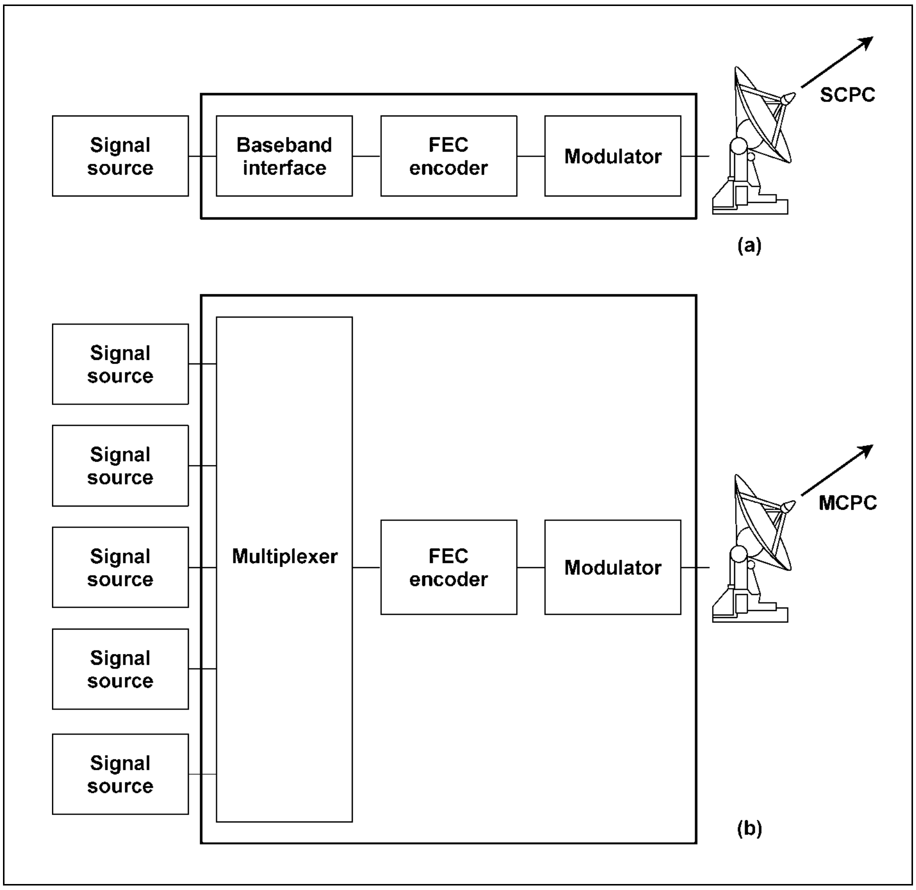


Fig. 1.19 MCPC and SCPC transponder access. DVB-S is designed primarily for MF-TDMA, which is a variety of MCPC.

In DVB-RCS, MCPC is implemented in two ways:

- Time Division Multiplex (TDM) from the gateway Hub station in the forward direction to Terminals, and

- Multi-Frequency Time Division Multiple Access (MF-TDMA), with a set of carrier frequencies, each of which is divided into time slots from Terminals, which permits many Terminals to transmit in the return direction to the Hub.

1.6.2 Transponders

A transponder on board a satellite acts as a radio relay to provide power over an RF band. Its principal parameters are the bandwidth over which it can operate and the power it can deliver. Resources on board a satellite are limited, so the capacity of a transponder may be said to be either bandwidth limited or power limited, as illustrated in Fig. 1.20.

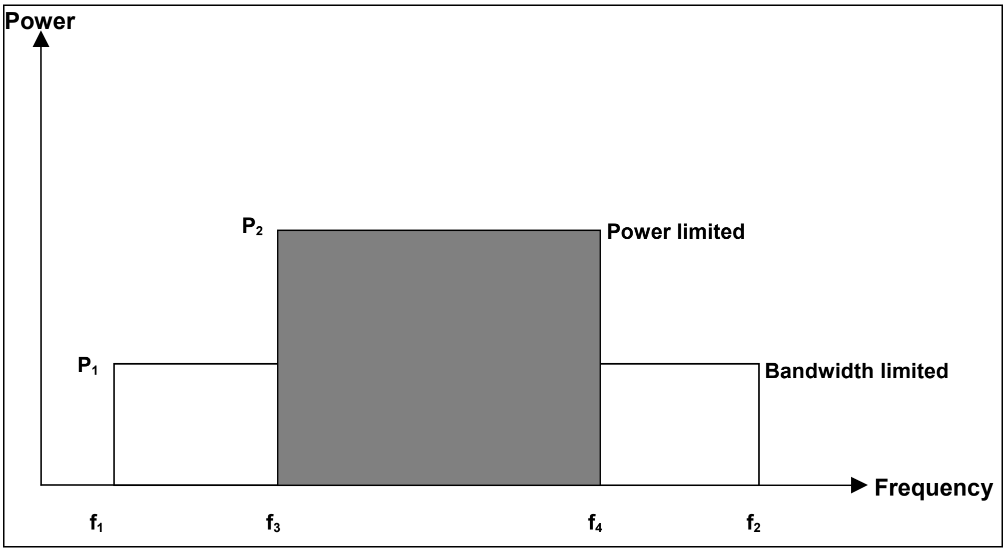


Fig. 1.20 A transponder is limited in bandwidth and power. If its maximum bandwidth, $f_2 - f_1$, is used, it is said to be bandwidth limited and can transmit at power P_1. If its maximum power, P_2, is used, it is said to be power limited and can transmit over a bandwidth $f_4 - f_3$.

The bandwidths of transponders which may be used to carry DVB-RCS channels are typically 33, 26 or 72 MHz. The parameters that determine the power delivered by a transponder are illustrated in Fig. 1.21.

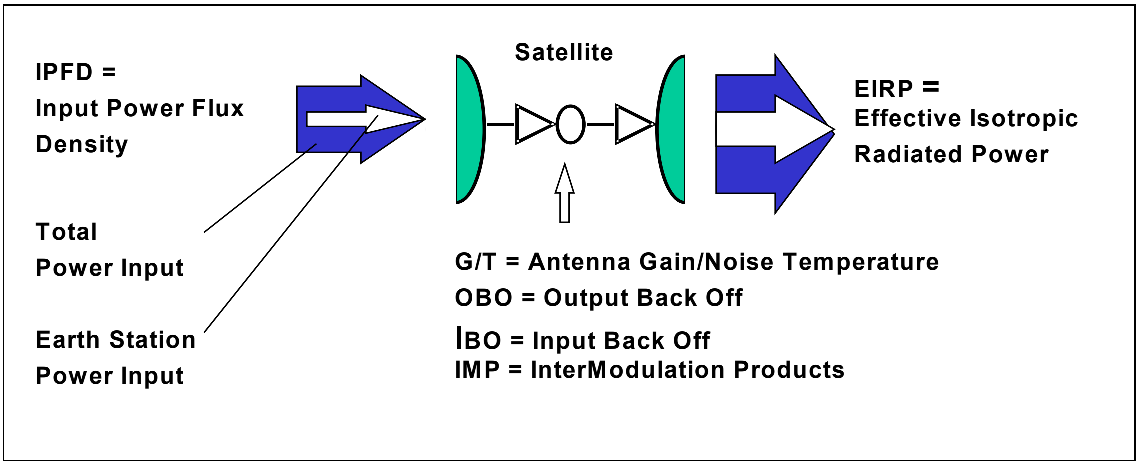


Fig. 1.21 Satellite transponder parameters.

1.6.3 Link budgets

Satellite network design aims to maximise all tradeoffs among parameters to enable two stations on Earth to communicate with each other via a satellite. The uplink path from a transmitter on Earth to the satellite must provide the required Input Power Flux Density (IPFD) at the input to the transponder. Likewise, the downlink path from the satellite down to Earth must use the transponder output power (EIRP) to provide a discernible signal at a receiver. The principal characteristics of these paths are determined by the physical characteristics of radio wave propagation through the atmosphere and through space, as shown in Fig. 1.22. Losses are incurred as the radio waves spread out over distance; additional noise is introduced from atmospheric sources; rain incurs further loss; interference from other radio signals deteriorates the desired signal, as shown in Fig. 1.23. For each path, these parameters are listed along with the transmitter and receiver characteristics in tabulation known as a link budget.

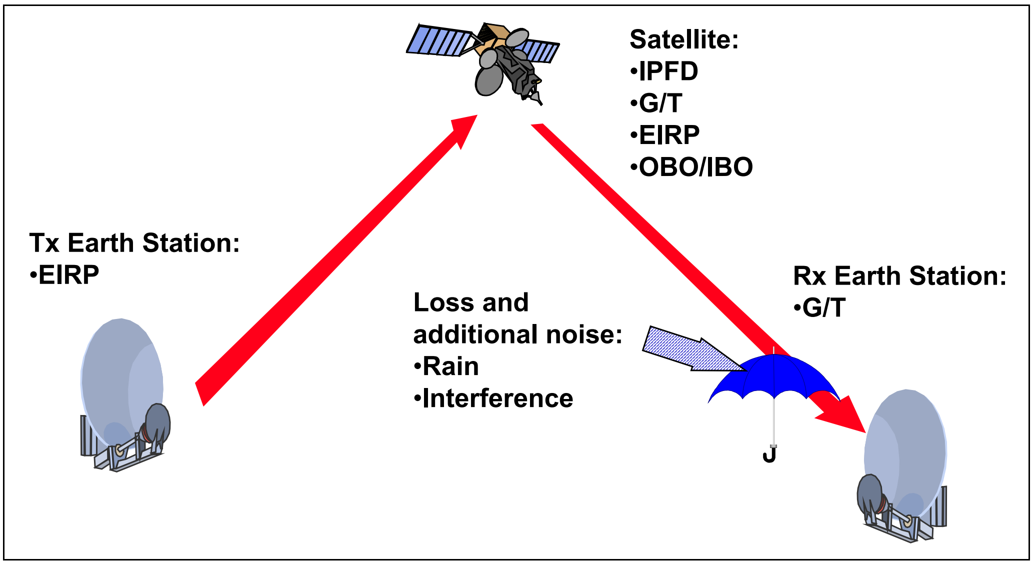


Fig. 1.22 Link budget parameters.

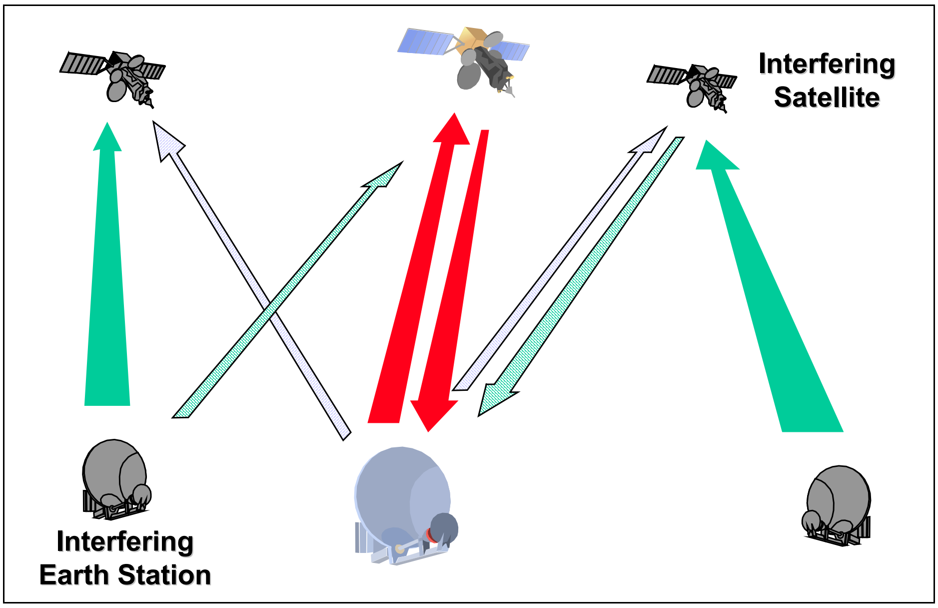


Fig. 1.23 Interference, from other Earth Stations upon the uplink and from the downlinks from other satellites, degrades communication and therefore must be taken into account in link budgets.

In a link budget, the Earth station transmitted power must be sufficient to cope with the:
- data rate
- loss on path plus noise plus interference
- rain rate (noise added)
- interfering signals received from adjacent satellites
- the size of the receiving antenna (the smaller the antenna, the greater the power needed).

The RF bandwidth required:
- is proportional to the data rate
- depends on the modulation used
- is limited in order to curtail interference with adjacent satellites

Antenna design aims to:

- attain the gain needed in the link budget
- curtail off-axis radiation to minimise interference between adjacent satellites, according to ETSI and/or Eutelsat specifications

The Bit Error Rate (BER) that can be attained on a link depends on the:

- physical parameters of the transmitter, receiver and intervening space
- rain attenuation, which varies considerably and depends on the operating radio frequency.

Typical curves of maximum BER as a function of EIRP including loss due to rain attenuation are shown in Fig. 1.24.

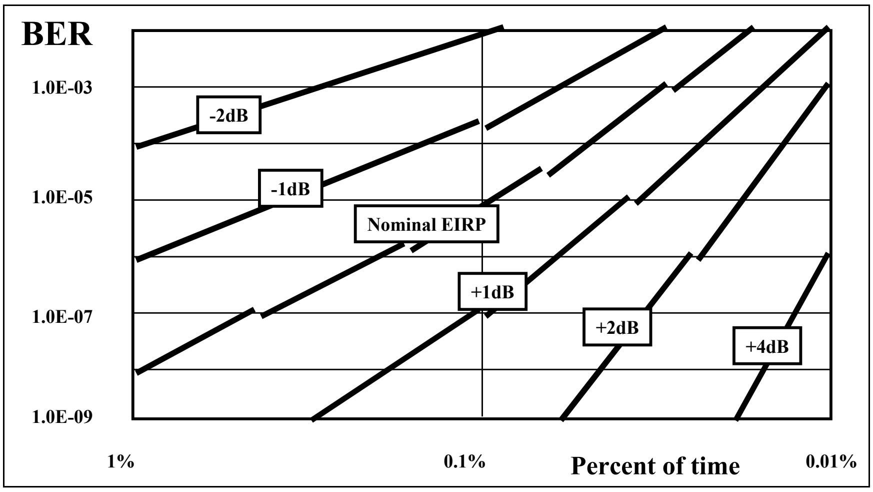
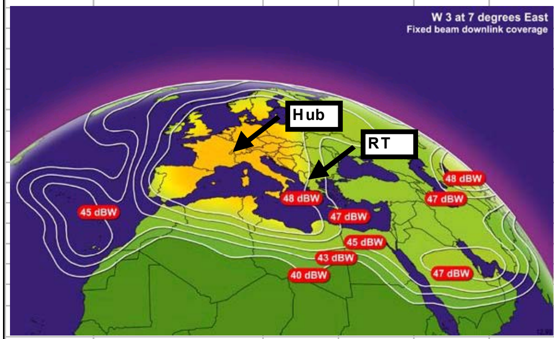


Fig. 1.24 Probability of maximum BER as a function of EIRP, including loss due to rain attenuation.

1.6.4 Typical link budget

A link budget is calculated for a specific satellite, Hub station and typical Receiver Terminal (RT). An example is shown in Fig. 1.25, calculated for the European Broadcasting Union (EBU) Data Distribution System from a Hub in eastern France, serving a typical RT located at a contour within the satellite footprint where it requires a transmitter power of 48 dBW EIRP to maintain communications of the specified quality, as listed in the budget.

Link budget example



Satellite	Eutelsat W3			
Satellite location:		7,0	deg. E	
Satellite Paramet	Hub	RT		
EIRP	50,0	48	dBW	
IPFD	-86,0	-85	dBW/m^2	
G/T	5,0	4	dB/K	
Transponder bandwidth		72	MHz	
Transponder Output Backo		3,7	dB	
Transponder Input Backoff		8	dB	
Earth Stations				
Hub Antenna	6,0	m		
RT Antenna	1,2	m		
Hub 5	deg. E	47	deg.N	
RT 30	deg. E	25	deg.N	
Hub elevation	35,9	deg		
RT elevation	38,1	deg		
Time delay	254	msec		
Frequency	Up	Down		
	14,30	11,00	GHz	

	Forward		Return	
Margin	Hub -> RT		RT->HUB	
Margin Implemented for rain and interference	11,00	dB	11,00	dB
Data Rate , Modulation				
User Data Rate	2 000	kbps	192	kbps
FEC	3/4		3/4	
Nominal Eb/No	5,5	dB	5,5	dB
Clear sky Eb/No	16,5	dB	16,5	dB
Results				
Earth Station RF power	4,4	Watt	1,4	Watt
Earth Station RF power	36,4	dBm	31,4	dBm
Earth Station EIRP	63,5	dBW	44,8	dBW
Satellite EIRP	39,0	dBW	19,3	dBW
Pwr. ltd. no. of carr. in transp.	3	#	313	#
Pwr. ltd. carrier spacing	21 304	kHz	230	kHz
Modulation bandwidth	1 800	kHz	173	kHz
Bandw. limited (B) Power limited (P)	P		P	

Fig. 1.25 Typical link budget, for EBU Data Distribution System. The cases shown are power limited in the transponder.

1.6.5 RF bandwidths at a user terminal

DVB-RCS systems may operate at radio frequencies in C-band, Ku-band and Ka-band, as listed in Table 1.8.

Table 1.8 Radio frequency allocations for Fixed Satellite Service (FSS) [13].

Band letter	Link direction	Frequency, GHz	Region(s)*
C-band	Downlink (space-to-Earth)	3.400 – 4.200	Worldwide
		4.500 – 4.800	Worldwide
	Uplink (Earth-to-space)	5.725 – 5.850	R1
		5.850 – 5.925	Worldwide
Ku-band	Downlink (space-to-Earth)	10.700 – 11.700	Worldwide
		11.700 – 12.200	R2
		12.500 – 12.750	R1 and R3
	Uplink (Earth-to-space)	12.500 – 12.750	R1
		12.700 – 12.750	R2
		12.750 – 13.250	Worldwide
		13.750 – 14.800	Worldwide
Ka-band	Downlink (space-to-Earth)	37.5-40.5	Worldwide
	Uplink (Earth-to-space)	24.75 – 25.25	R2 and R3
		27.0 – 27.5	R2 and R3
		27.5 – 31.0	Worldwide

* Three regions of the World: R1: Europe, Africa and CIS; R2: The Americas; R3: India, Asia, Australia, Pacific.

C-band is now used in some VSAT systems, particularly those operating in areas with heavy rainfall that degrades link budgets at higher frequencies. Ku-band is used in satellite TV broadcasting, including DVB-S, and in many VSAT systems. Kaband is the newest band to be used in DVB-S and DVB-RCS systems. The frequency bandwidths used at a Terminal in a typical DVB-RCS system are shown in Fig. 1.26.

- uplink: 14.0 – 14.5 GHz, or 13.75 – 14.25 GHz in some parts of the world
- downlink: 10.95 – 12.75 GHz, the entire TV band
- IF Tx: 950 – 1450 MHz
- IF Rx: 950 – 1450 MHz for VSAT only, extended to 950 – 2150 MHz for TV

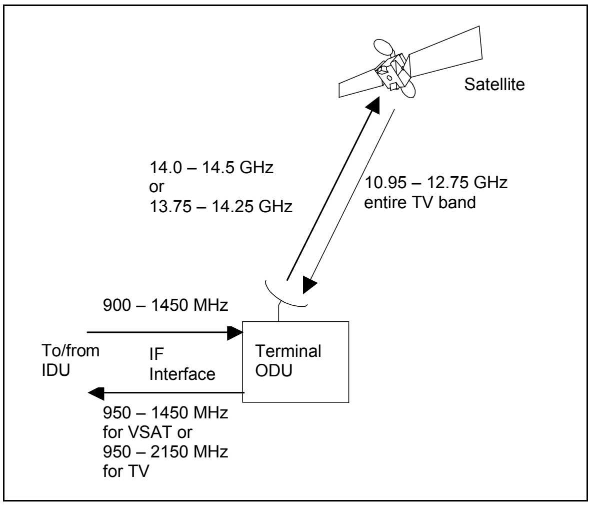


Fig. 1.26 Radio frequency bandwidths at a Terminal in a Ku-band system.

In a C-band system, a Terminal will have the same IF interface bandwidths for VSAT operations but no extended band for TV. Typically, the uplink operates at 5.95 – 6.45 GHz and the downlink at 3.7 – 4.2 GHz.

Ka-band systems also have the same IF interface bandwidths, but have varying uplink and downlink bandwidths. For DVB-RCS systems, a Ka-band system may actually use the Ku-band on the downlink, because many Ku-band TV broadcasting systems are in operation and a broad selection of receiving equipment is available. The Ka-band is used for the uplink, usually at 29.5 – 30.0 GHz.

1.6.6 Polarisation

A radio frequency wave propagating in space is regarded to consist of an electric field and a magnetic field, at a right angle to each other. The direction of the electrical field is defined as the polarisation of the wave. Typically, conventional AM broadcasting uses vertical polarisation whilst TV broadcasting in many, but not all, countries uses horizontal polarisation, which is why AM antennas are vertical and TV antennas are horizontal.

An antenna may also send in circular polarisation, in which the electric field of the transmitted signal appears to rotate as seen from the antenna. As illustrated in Fig. 1.27, there are two possible circular polarisations:

- Right-hand circular polarisation: the clockwise direction in which the electric field of the transmitted signal appears to rotate to the right as seen from the antenna, much as the right hand turns outwards in driving a conventional screw.
- Left-hand circular polarisation: the anticlockwise direction in which the electric field of the transmitted signal appears to rotate to the left as seen from the antenna, much like the left hand turns outwards in driving a left-hand-thread screw.

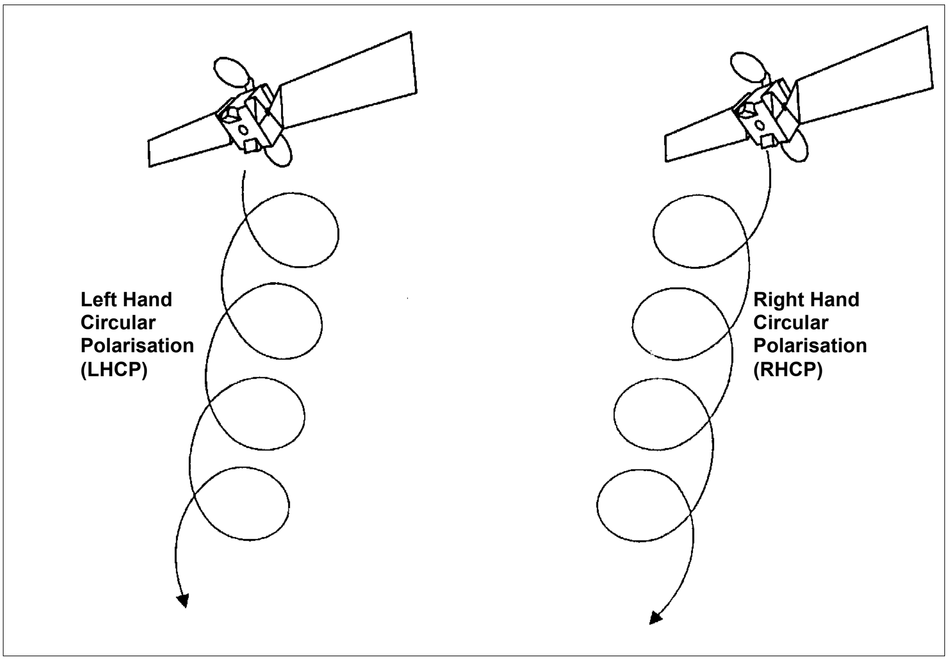


Fig. 1.27 Left-hand circular and right-hand circular polarisations.

A satellite antenna may be arranged to transmit or receive in any polarisation, and many antennas are arranged to use one polarisation for transmitting and the other polarisation for receiving. Likewise, some receiving antennas, such as those of satellite TV receivers, are arranged to two polarisations transmitted by a direct broadcasting satellite, in order to increase the number of channels broadcast.

In all cases, the two polarisations transmitted or received by an antenna are said to be “orthogonal”, because they are at right angles to each other. Accordingly, the device used to separate them is known as an Orthogonal Mode Transducer (OMT).

2. DVB-S System basics

2.1 Overview

The principal elements of a DVB Return Channel over Satellite (DVB-RCS) system are shown in Fig. 2.1.

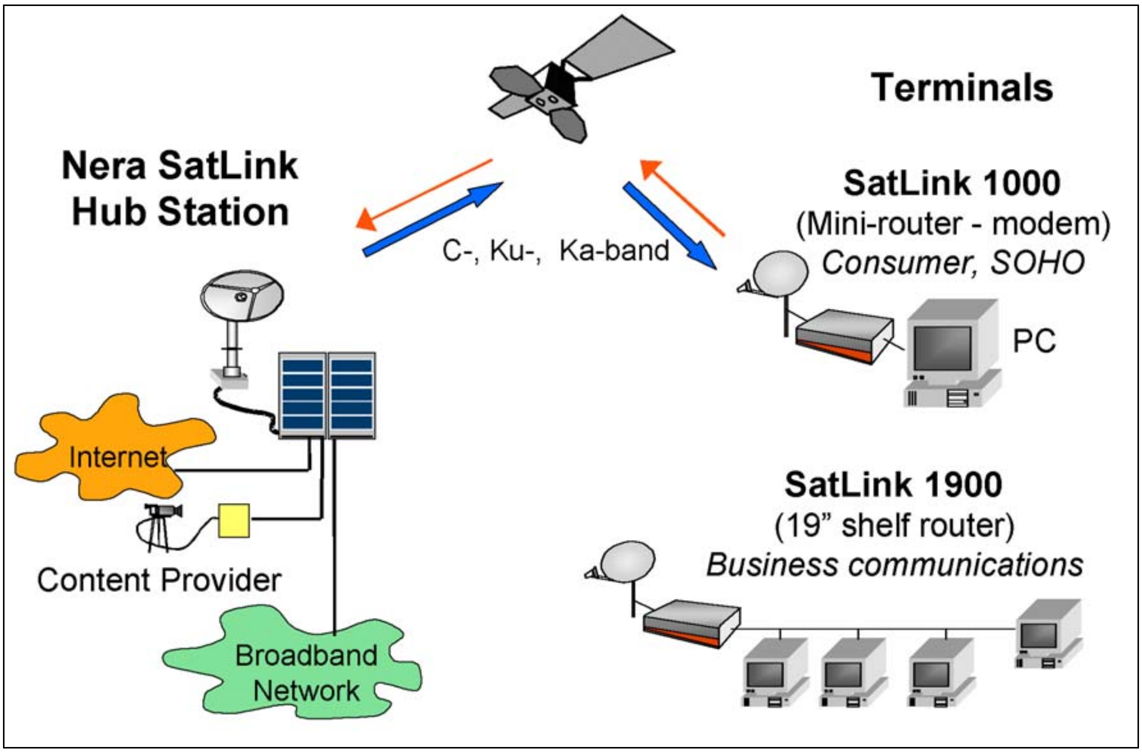


Fig. 2.1 SatLink DVB-RCS system block diagram.

The Nera SatLink system is a star network in which the Hub station controls the Terminals over the forward, or outbound link, and the Terminals share the return, or inbound link.

The Hub station continuously transmits the forward link in Time Division Multiplex (TDM). The Terminals transmit as needed, sharing the return channel resources using Multi-Frequency Time Division Multiple Access (MF-TDMA).

2.2 Communications

2.2.1 Two channel directions

As illustrated in Fig. 2.2, the DVB-RCS system supports communications on channels in two directions:

- Forward channel from the Hub station to many Terminals.
- Return channels, from the Terminals to the Hub station.

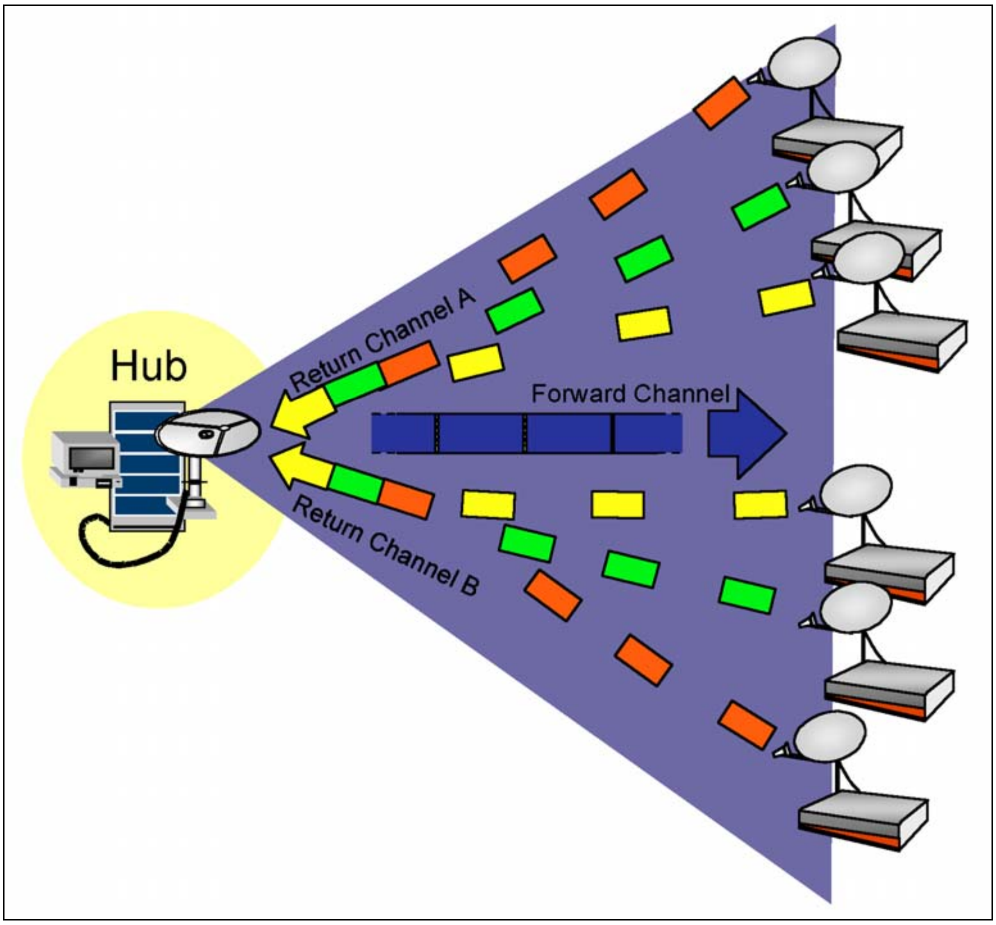


Fig. 2.2 Two-way communications via forward and return links.

2.2.2 Forward channel

The forward channel is said to provide “point-to-multipoint” service, because it is sent by a station at a single point to stations at many different points. It is identical to a DVB-S broadcast channel and has a single carrier, which may take up the entire bandwidth of a transponder (bandwidth-limited) or use the available transponder power (power limited). Communications to the Terminals share the channel by using different slots in the TDM carrier. The principal characteristics of the forward channel are:

- Gray-coded Quadrature Phase Shift Keying (QPSK) modulation
- Time Division Mulitplex (TDM)
- Bit-rate configurable from about 1 Mbit/s up to 50 Mbit/s
- Frame according to DVB-S specifications, including:
    - Framing fields
    - DVB-S Service Information (SI) tables, including a Burst Transmission Plan (BTP) broadcast to all Terminals. A Terminal uses the BTP to set up its Return Channel (RC) parameters
    - DVB-S Signalling Fields, including information to Terminals such as connection set-up and take-down, data flow-control, transmit power control and burst-timing synchronisation
    - Data fields that can carry MPEG-coded audio or video or IP packets encapsulated in 188-Byte MPEG2 containers
    - Network Clock Reference (NCR)

2.2.3 Return channel

The Terminals share the return channel capacity of one or more satellite transponders by transmitting in bursts, using MF-TDMA. In a system, this means that there is a set of return channel carrier frequencies, each of which is divided into time slots which can be assigned to Terminals, which permits many Terminals to transmit simultaneously to the Hub. The return channel can serve many purposes and consequently offers choices of some channel parameters. The principal return channel characteristics are:

- Gray-coded QPSK modulation
- MF-TDMA
- Choice of Reed-Solomon and Viterbi coding or Turbo coding for Forward Error Correction (FEC), as described in the following Section
- Choice of two burst formats in the physical layer:
  - MPEG2 Transport Stream (MPEG2-TS) data containers with 182 octets of information payload and 6 octets of signalling information.
  - Asynchronous Transfer Mode (ATM) data containers with 48 octets of information payload and 6 octets of signalling information.
- Depending on the choice of physical layer conveyance, a choice of two Medium Access Control (MAC) layer (OSI layer 3, TCP/IP layer 2) approaches:
  - MPEG2 mode MAC layer: DVB-RCS-defined burst signalling fields
  - ATM mode MAC layer: choice of return channel DVB-RCS-defined burst signalling fields or ATM cell-header signalling fields, which enable native ATM connections

The Terminals are agile to suit their purpose in multimedia communication. A Terminal can change frequency, bit-rate, FEC rate, burst length, or all of these parameters, from burst to burst. Slots in the return channel are dynamically allocated, as illustrated in Fig. 2.3.

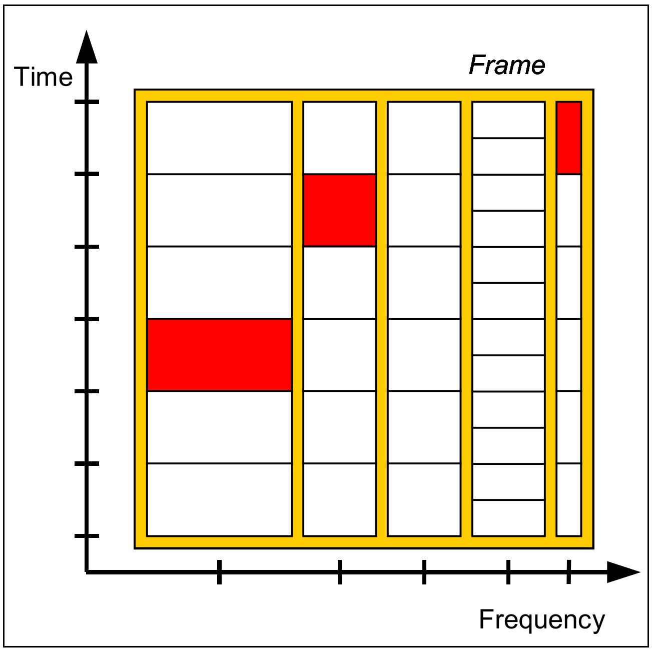


Fig. 2.3 Dynamic slot MF-TDMA.

The Hub is at one point on the surface of the Earth and the geostationary satellite is at one position. So the uplink and downlink transmission times between the Hub and the satellite are very nearly fixed. However, the Terminals are at different points, so the signal transit times between them and the satellite vary. On the forward channel, this variation is unimportant. Just as satellite TV sets successfully receive signals whenever they arrive, the Terminals receive downlink signals without regard to small differences in their times of arrival. However, on the uplink, in the return direction from the Terminals to the Hub, small differences in transit time can disrupt transmission. This is because the Terminals transmit in bursts that share a common return channel by being spaced from each other in time. For instance, as illustrated in Fig. 2.4, a burst from one Terminal might be late because it takes longer to reach the satellite than a burst sent by another Terminal. A burst that is earlier or later than it should be can collide with the bursts sent by the Terminals using the neighbouring TDMA slots.

The difference in transmission times to Terminals throughout the footprint of a satellite might be compensated for by using time slots that are considerably longer than the bursts transmitted by the Terminals, so both before and after a burst there is a guard time sufficiently long to prevent collisions with the bursts in neighbouring slots in the TDMA frame. The one-way delay time between a Hub and a

Terminal varies from 250 to 290 milliseconds, depending on the geographical location of the Terminal with respect to the Hub. So the time differential, ΔT, might be as large as 40 milliseconds. Consequently, the round-trip time differential might be as large as 80 milliseconds. Consequently, the total guard time associated with a slot would have to be at least 80 milliseconds. This is excessive, particularly as the guard time does not carry information and consequently wastes satellite resources. So most TDMA satellite systems minimise guard time by incorporating various means of timing adjustment to compensate for satellite path differences. DVB-RCS has two built-in methods of pre-compensating the burst transmission time of each Terminal:

- Each Terminal "knows" its local GPS co-ordinates and therefore can calculate its own burst transmission time.
- The Hub monitors the arrival times of bursts, and can send correction data to Terminals if need be.

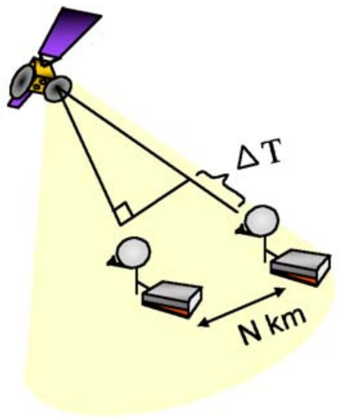


Fig. 2.4 Terminals are located at different places, so the uplink transmission times to and from them vary.

2.3 Frequency and time

In conventional broadcasting, stations need only ensure that the frequencies of their transmitted signals are sufficiently accurate to remain within their allocations. However, when signals are returned from terminals that may be located anywhere within a transmitter's coverage area, system frequencies and times must be accurate, particularly when the return signals from the terminals are multiplexed in time, as they are in the DVB-RCS system. The return signal from a terminal that transmits at the wrong time will interfere with the signals from other terminals, so all terminals must "agree" on a single, correct time in order for the return channel to function.

So, in the DVB-RCS system, a hub station has one or more receivers for the signals sent by Global Positioning System (GPS) satellites. GPS signals are accurate, because each satellite carries four atomic clocks, accurate to a nanosecond (one billionth of a second). The hub station has equipment to convert the accurate GPS signals into a 10 MHz frequency reference and one pulse per second and network time server time references.

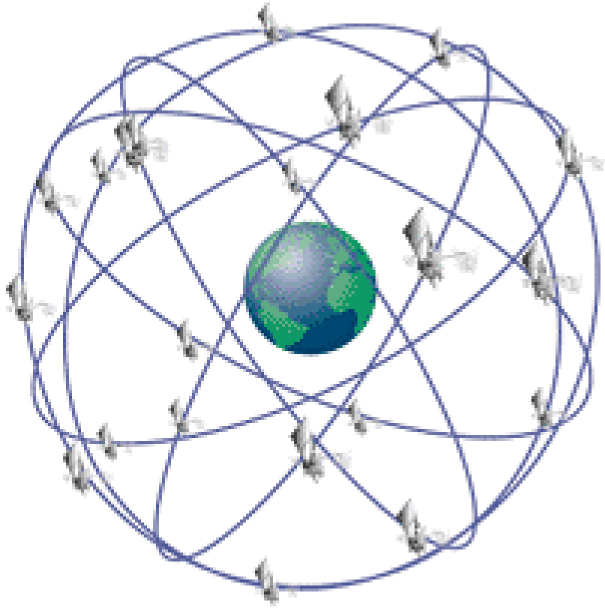


Fig. 2.5 Global Positioning System (GPS) satellite constellation, with 24 satellites in six orbital planes; each orbit is at an altitude of about 20,200 km above the surface of the Earth. Drawing from the GPS pages of the Federal Aviation Administration website at gps.faa.gov/index.htm

The details of GPS are beyond the scope of this Background Book. However, several websites provide excellent overviews:

- A comprehensive, clearly-illustrated *GPS Overview*, compiled by Peter H. Dana, at http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html
- EGNOS, the European Space Agency's GPS augmentation service, at www.esa.int/export/esaSA/navigation.html
- *GPS World Magazine*, a monthly magazine at http://www.gpsworld.com/
- The *Bureau International des Poids et Mesures (BIPM)* in France, which maintains Coordinated Universal Time (UTC), at http://www.bipm.fr/
- The United States Coast Guard (USCG), which is responsible for communicating with civilian GPS users worldwide,at www.navcen.uscg.mil
- The United States Interagency GPS Executive Board (IGEB), which sets GPS system policy, at www.igeb.gov/
- The United States Naval Observatory (USNO), which maintains the timing reference for GPS, tycho.usno.navy.mil/gps_datafiles.html
- The US Federal Aviation Administration, which is principally concerned with satellite navigation, at gps.faa.gov/index.htm

2.4 Return channel burst formats

2.4.1 Four types

There are four basic types of return channel bursts:

- Common Signalling Channel (CSC):
  - Handles Terminal logon
  - Slotted Aloha
  - Extended guard time
- Acquisition (ACQ):
  - For initial synchronisation
  - Extended guard time
- Synchronisation (SYNC):
  - For maintaining synchronisation
  - Conveys signalling to the Hub
  - Smallest bandwidth that can be allocated to a Terminal

- May be used in Slotted Aloha contention mode
- Traffic (TRF):
  - Carries payload user data
  - Either ATM or MPEG2; some Terminals support both

2.4.2 Common Signalling Channel (CSC) burst format

A Terminal uses the Common Signalling Channel (CSC) burst format to identify itself during logon. The format comprises:

- a variable size preamble for burst detection
- a field describing the Terminal capabilities, including:
  - Terminal return channel (RCST) Capability, 24 bits
  - Terminal (RCST) MAC address, 48 bits
  - Reserved for future use, 40 bits

The burst format is illustrated in Fig. 2.6.

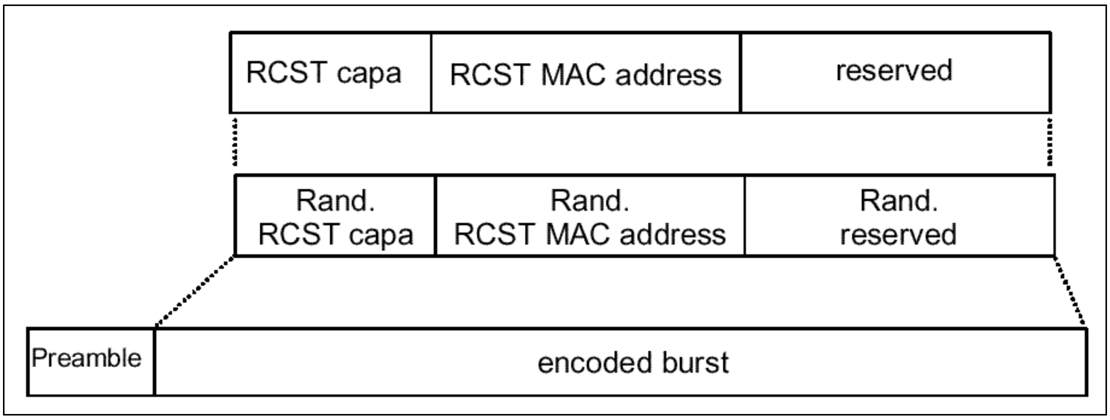


Fig. 2.6 Common Signalling Channel (CSC) burst format, from Fig. 9 in ETSI EN 301 790 [15].

2.4.3 Acquisition (ACQ) burst format

A Terminal can use the Acquisition (ACQ) burst format to achieve synchronisation before operationally accessing the network. As illustrated in Fig. 2.7, the format comprises a preamble and a frequency sequence, both sent to the Terminal from the Timeslot Comparison Table (TCT) held at the Hub.

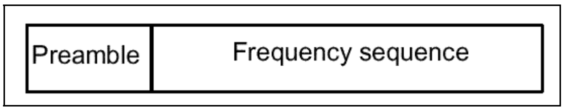


Fig. 2.7 Acquisition (ACQ) burst format, from Fig. 8 in ETSI EN 301 790 [15].

2.4.4 Synchronisation (SYNC) burst format

A Terminal uses the Synchronisation (SYNC) burst format to maintain synchronisation and to send control information. As illustrated in Fig. 2.8, the format comprises a preamble and an encoded Satellite Access Control (SAC) field, both sent to the Terminal from the Timeslot Comparison Table (TCT) held at the Hub.

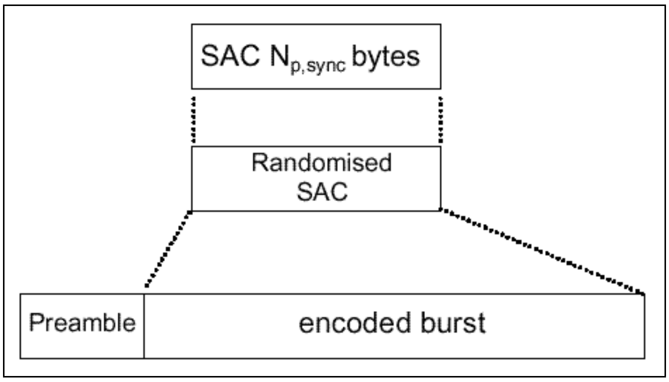


Fig. 2.8 Synchronisation (SYNC) burst format, from Fig. 7 in ETSI EN 301 790 [15].

2.4.5 Traffic (TRF) burst formats

1.1.1.1 Two formats

A Terminal uses the Traffic (TRF) burst format to transmit traffic to the Hub. The burst format acts as a digital wrapper for traffic data. One of two types of burst format may be used:

- MPEG2
- ATM

1.1.1.2 MPEG2 format

MPEG2 has been universally adopted by DVB in all its varieties for source coding of video, audio and associated data information and for transmitting various source data streams in digital wrappers, also called digital containers. DVB-RCS uses the MPEG2 digital wrappers, in which "protocol-independent" client traffic is enclosed within the payloads of a stream of 188-Byte* packets. As shown in Fig. 2.9, the MPEG2 digital wrapper offers a 182-Byte payload and has a 6-Byte header. In DVB-RCS, the payload may be:

- IP traffic
- MPEG2 source coded information, also known as "native MPEG2"
- other bitstreams that comply with TCP/UDP

For complete details, see the ISO/IEC coding standard for MPEG [14].

[*A Byte is a quantity of digital information made up of 8 bits. But in computer systems, particularly mainframes, Bytes may be smaller, 4 bits, or larger, 16 bits. So in telecommunications, the term for a sequence of 8 bits is the more precise "octet". However, in the DVB specifications, bite is universally understood to mean 8 bits. So in this publication, **Byte = octet = 8 bits**.]

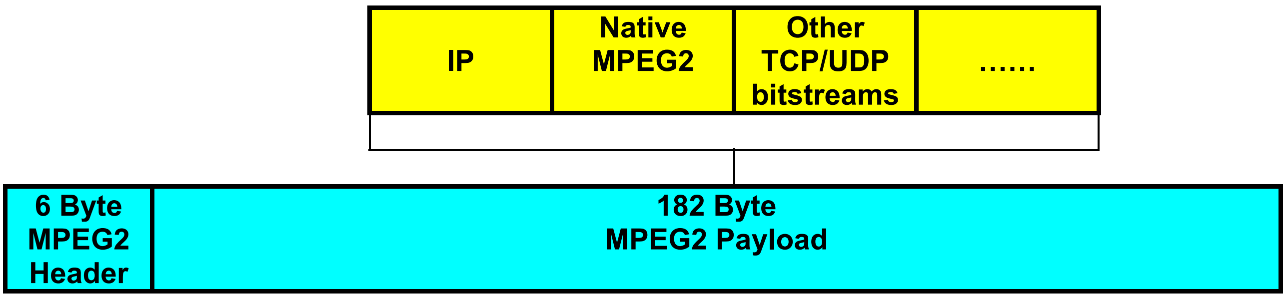


Fig. 2.9 Digital wrapping in which traffic having various protocols is enclosed in MPEG2 packets.

The MPEG2 burst format is shown in fig. 2.10.

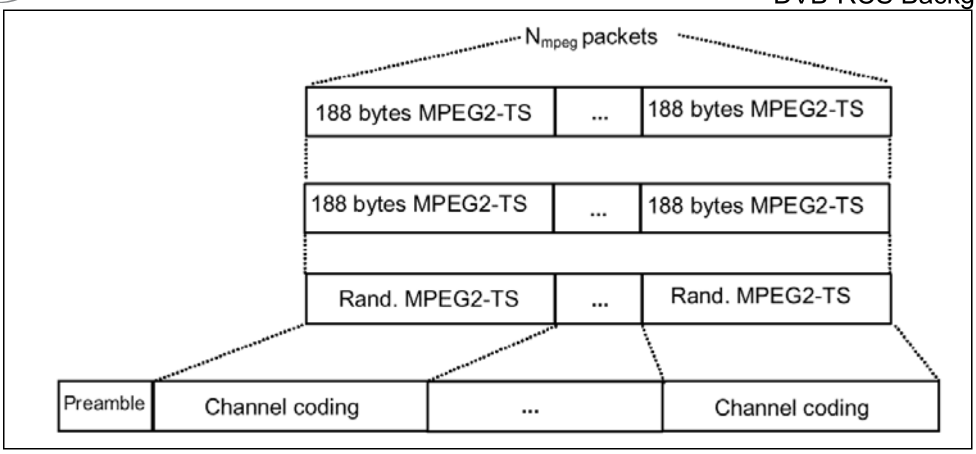


Fig. 2.10 Traffic (TRF) burst format using MPEG2 wrappers, from Fig. 6 in ETSI EN 301 790 [15].

1.1.1.3 ATM format

The ATM format is supported as an option on the return channel. As shown in Fig. 2.11, it comprises ATM cells, each 53 Bytes long, plus a prefix.

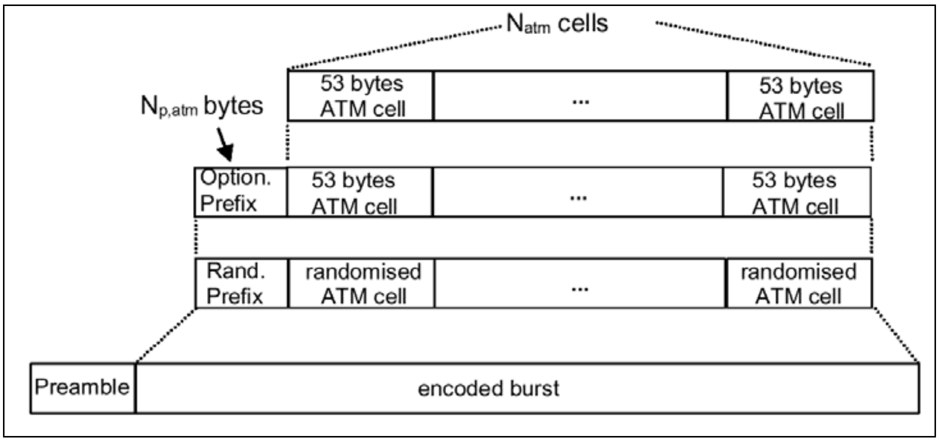


Fig. 2.11 Traffic (TRF) burst format using ATM wrappers, from Fig. 5 in ETSI EN 301 790 [15].

2.5 Signal processing

2.5.1 Generic processing

DVB-S services are routed over the same types of satellites as are the services of other systems and involve communications between stations having the same types of antennas and RF equipment as do stations of other systems. However, DVB-S is distinguished by the ways in which digital signal processing is conducted. As shown in Fig. 2.12, the basic DVB-S channel can be described in terms of its baseband processing and subsequent digital signal processing (DSP), with complementary functions in reception.

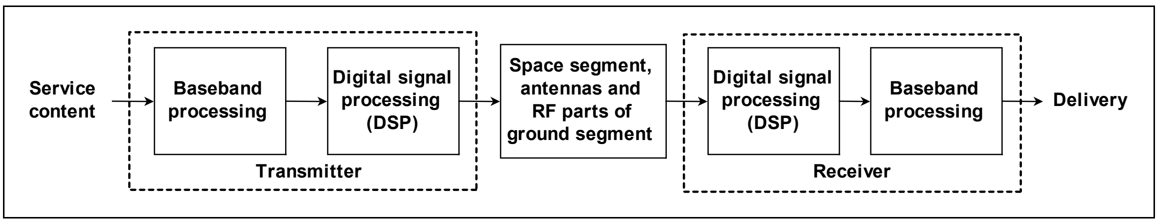


Fig. 2.12 Generic DVB-S communications channel.

In TCP/IP communications, for instance, the sequence of processing in transmission is:

1. The TCP/IP message arrives and is subjected to TCP optimisation.
2. The IP packets are divided into smaller pieces and put into data sections with 96-bit Digital Storage Medium – Command and Control (DSM-CC) headers.
3. The DSM-CC data sections are further divided in the baseband processor into 188-Byte MPEG2-TS packets, as shown in Fig. 2.6.
4. The MPEG2-TS packets then are subjected to channel coding in the DSP.

The baseband processing might be regarded to be part of DSP, but it is shown separately because it is a separate function that need not be an integral part of a station. In terms of the building blocks of the generic communications station of Section 1.5.6, the baseband processing may be regarded as an extended interface function.

2.5.2 Baseband processing of programme material

DVB source coding of video, audio and data information as well as multiplexing are based on the MPEG2 standards. The conceptual block diagram of an MPEG2 baseband processor is shown in Fig. 2.13.

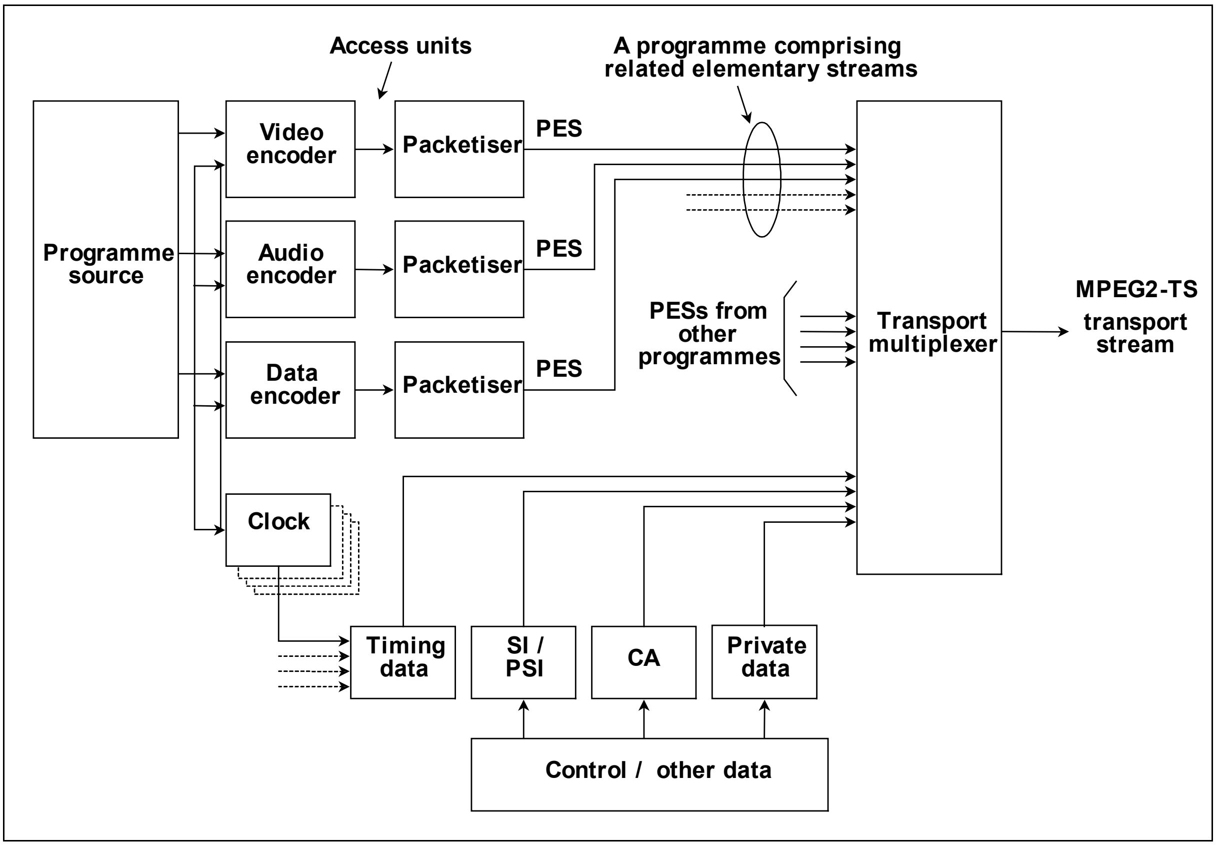


Fig.2.12 Baseband processing of programme material to an MPEG2 transport stream. Key: CA: Conditional Access, PES: Packetised Elementary Stream (long streams, for local use only), PSI: Programme- Specific Information, SI: Service Information, TS: Transport Stream.

Practical baseband processors need not include all the functions shown in Fig. 2.13.

2.5.3 Baseband processing of IP material

The baseband processing of IP material involves encapsulation into MPEG2 packets, as shown in Fig. 2.14.

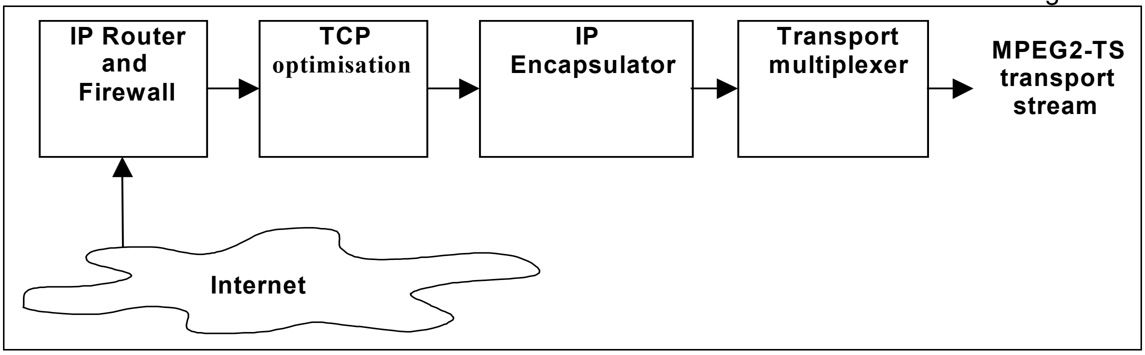


Fig. 2.14 Baseband processing of IP material to an MPEG2 transport stream.

The packets of a typical TCP/IP message arriving from the Internet:

1. pass through a firewall and is routed to the baseband processing, then
2. undergo TCP optimisation to suit it to the space segment, and then
3. are divided into smaller parts and inserted in data sections with 96-bit Digital Storage Medium – Command and Control (DSM-CC) headers.
4. The DSM-CC sections are then further divided into 188-Byte MPEG2 packets.
5. The MPEG2 packets are combined in the transport multiplexer into the MPEG2 transport stream.

2.5.4 Basic Digital Signal Processing (DSP)

The digital signal processing (DSP) performed in transmission and reception is also known as "satellite channel adaption" because it conducts the intermediary functions between the MPEG2-TS and the channel transmitted to or received from the satellite. In DVB-RCS, DSP is performed in two ways, differing in the manner in which Forward Error Correction (FEC) is performed:

- Concatenated coding, shown in Fig. 2.15
- Turbo coding

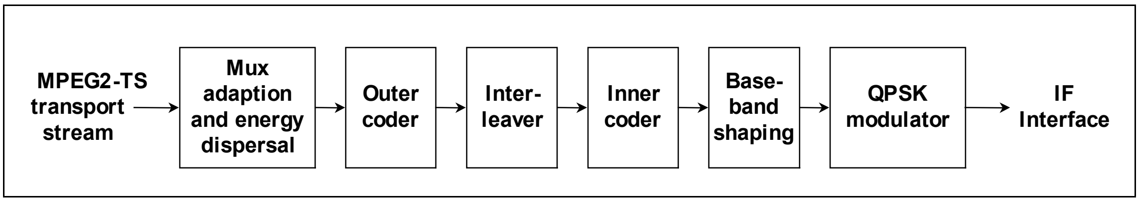


Fig. 2.15 Functional block diagram of digital signal processing using concatenated coding in a transmitter. The functions are reversed in a receiver.

- **Multiplex adaption and energy dispersion**: The transport stream is transformed into a regular structure and then randomised.
- **Outer coder**: The first of the concatenated (linked together) error-correcting coders. The outer coder uses Reed-Solomon block code, named for Irving S.Reed and Gustave Solomon, who first described the code in 1960. Since then, it has evolved to a family of well-proven codes that are widely used in radio communications. In the versions used in DVB-S, the Reed-Solomon code adds an overhead of about 8.5%. In reception, the outer code is algebraically decoded.
- **Interleaver**: An error-correcting function in which code symbols are reordered before transmission such that any two successive symbols are separated by a specified number of other symbols.
- **Inner coder**: The second of the concatenated error-correcting coders. The inner coder uses a convolutional code in which the parameters are varied to suit the service involved and result in an additional overhead of 14.3% to 100%. The selection of the inner code rate involves some trade-offs, as listed in Table 2.1. In reception, the inner code is Viterbi decoded.
- **Baseband shaping**: A square-root raised cosine filter with a roll-off factor of 0.35.
- **QPSK modulator**: The bitstream modulates a carrier using QPSK.

These six processing steps are accomplished in various hardware and software devices. The extent to which they are separately implemented depends principally on the volumes of data handled. For instance, many of the steps are handled in the CPU of a Terminal, but by separate software in a Hub.

Table 2.1 Trade-offs between link power requirement and capacity referenced to an inner code rate of 3/4.

Inner code rate	Available capacity	Power requirement (E_b/N_o)	Receiver antenna diameter
1/2	-33.3%	-1.0 dB	-11%
2/3	-11.1%	-0.5 dB	-6%
3/4	*reference*		
5/6	+11.1%	+0.5 dB	+6%
7/8	+16.7%	+0.9 dB	+11%

The concatenated coding using a Reed-Solomon outer coder and a convolutional inner coder has one drawback when applied to DVB-RCS. It uses a relatively large interleaver to process packets and therefore cannot cope with datastreams comprising packets from many sources. So it is poorly suited to the RCS situation in which many Terminals simultaneously send RCS messages to the gateway Hub station. This shortcoming is overcome by using Turbo coding, as shown in Fig. 2.16, a newer channel coding scheme developed in 1993 in France by Berrou, Galvieux and Thitmajshima.

The Multiplex adaption and energy dispersion, the baseband shaping and the QPSK modulator shown in Fig. 2.16 perform the same functions as the equivalent functions shown for concatenated coding in Fig. 2.15. However, Turbo coding is represented by a single block that contains simple convolutional coders separated by internal bit internal bit interleaving to produce block codes. The coding uses a Circular Recursive Systematic Convolutional (CRSC) code.

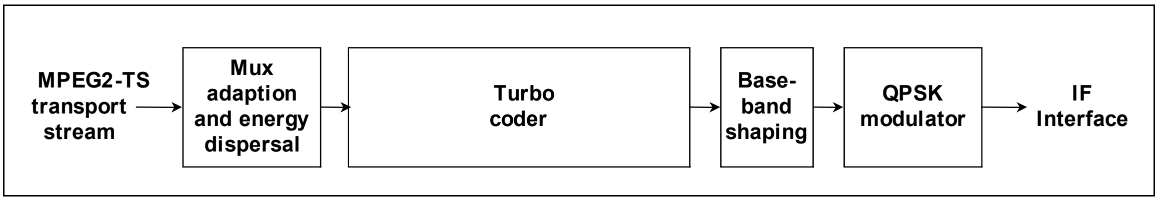


Fig. 2.16 Functional block diagram of digital signal processing using Turbo coding in a transmitter. The functions are reversed in a receiver.

In addition to being able to cope with numerous shorter packets sent on a TDMA carrier by different Terminals, Turbo coding also can dramatically reduce the bit error rate (BER) of the radio channel.

Consequently, Turbo coding is frequently used on the RCS channels from Terminals to the Hub, and according to the DVB-RCS specifications, Terminals should support both concatenated coding and Turbo coding.

2.6 Security

2.6.1 Overview

Security provides a way of ensuring that data on a network are protected against unauthorised use. Four levels of security may be applied in DVB-RCS communications:

1. DVB common scrambling in the forward link (could be required by the service provider)
2. Satellite interactive network individual user scrambling in the forward and return link
3. IP network security
4. Higher layer application security mechanisms

IPSec is a standards-based method of providing privacy, integrity and authenticity to information transferred across IP networks. IPSec is not one specific solution, but a framework of open draft standards released by the Internet Engineering Task Force (IETF).

Although a user or service provider might use its own security systems above the data link layer, a security system at the data link layer offers the advantage of security on the satellite section without recourse to additional measures. Because the satellite interactive network forward link is based on the

DVB/MPEG2-TS specification, the DVB common scrambling mechanism may be used as well, because it adds an additional protection to the entire control stream.

2.6.2 Internet Security

A DVB-RCS satellite router may support three main ways of using IPSec to secure a network.

- **Authentication**. An authentication header is added between the IP header and the layer 4 (TCP, UDP) header. This provides authentication and integrity of an IP datagram, including most of the IP header.
- **Encryption in transport mode.** The payload, including the layer 4 header, is encrypted. This provides confidentiality (or privacy) in addition to authentication and integrity. The original IP header is unchanged, which allows an attacker to perform traffic analysis based on who is communicating with whom.
- **Encryption in tunnel mode.** Both the payload and the IP header are encrypted, a new IP header identifying the IPSec proxies is added. This solution protects against traffic analysis, but special processing (for example, quality of service) in the intermediate network based on the information in the IP header is not possible.

IPSec used for authentication or encryption in transport mode is suitable for implementation in end systems. Encryption in tunnel mode is often used in network components such as routers.

A DVB-RCS Terminal may support the Internet Key Exchange (IKE), formerly known as the Internet Security Association Key Management Protocol or ISAKMP/Oakley, for security association management. IKE authenticates each peer in an IPSec transaction, negotiates security policy and handles the exchange of session keys. Both manual and automatic key exchange are supported.

2.6.3 DVB security

A DVB-RCS Terminal may also support link layer security defined by DVB-RCS specifications. Security is defined at a level higher than the individual Terminal, so a Terminal may handle several users with their own security rights. An authentication algorithm will either check for user name and password on the client device or a Smart Card within the Terminal. All data and control to and from each user are scrambled on an individual user basis. Each user has a control word for the return and forward links that permits the Terminal or the Hub to descramble data but bars others from descrambling.

Authentication is implemented by a request for a user name or password on the client device, such as a PC connected to a Terminal. The Terminal then need not support any special implementation. However, if the Terminal contains a proxy client, the proxy will be able to authenticate itself to the Hub. This means that an authentication server may be implemented at the Hub, which manages the authentication of each user.

Authentication could also be replaced by a Smart Card on the Terminal, also used for the link layer individual control word encryption.

DVB Common Scrambling may be employed on the forward link from the Hub to a Terminal. Individual scrambling then is implemented at the section level, but the Medium Access Control (MAC) address of the user may remain in the clear, because the Terminal uses the MAC address to filter messages. Individual layer 2 scrambling is implemented on the return link from a Terminal to the Hub.

The security mechanism consists of two separate subsystems:

- A set of MAC messages used for authentication and key-agreement between the Hub and a Terminal. These messages are used for key negotiation during a session set-up as well as for on-the-fly update of keys
- On-the-fly encryption and decryption of payload data streams passed between the NCC and a Terminal.

When a session is being set-up and before payload data are transferred, one of three request/response MAC message-pairs is used to generate a session key specific to the payload stream associated with the session. The session key is a shared secret between the Hub and the Terminal: even if every MAC message is intercepted, the cryptographic properties of the protocol ensure that an eavesdropper cannot determine the session key value.

This is achieved by using a public-key protocol, which requires no up-front shared secret, or a simpler protocol based on a long-term shared secret between the Hub and a Terminal. It is also used for authenticating the Terminal to the NCC at logon.

2.6.4 Public key infrastructure

The DVB-RCS satellite router uses certificate management ITU-T X.509.V3 [16] for device authentication. The solution supports hierarchical certificate structures and cross-certification necessary for a Public Key Infrastructure (PKI).

A public key exchange primitive is used to allow the Hub and Terminal to agree on a secret, although communicating in public, by use of a Diffie-Hellman key.

2.6.5 Cryptographic primitives

The key exchange protocols and data stream encryption are based on a set of known primitive cryptographic functions. The functions and their associated key sizes can be easily changed, in case crypt-analytic or brute-force attacks become a realistic threat.

In principle, nearly any encryption algorithm may be used together with IPSec/DVB security, but the DVB-RCS specifications stipulate particular algorithms. The specific set of functions and key sizes are negotiated between the Hub and a Terminal at sign-on time. The functions and key size supported may include:

For authentication:

- Hash-based Message Authentication Code (HMAC) with Message Digest version 5 (MD-5)
- HMAC with Secure Hash Algorithm version 1 (SHA-1)
- Diffie-Hellman /512 bit
- Null Authentication

For payload encryption (ESP – Encapsulating Security Payload):

- Triple Data Encryption Standard (DES) or DES in Cipher Block Chaining (CBC) mode / 40 and 56 bits
- Null encryption

3. Markets and applications

3.1 Technology provides

The DVB-RCS communications technology enables a wide variety of services. Unfortunately, in the broadband over satellite sector, there is no uniform way of classifying or describing services. The NBS classification is straightforward. All broadband over satellite services may be classified either by the provider of the service or by the basic category of service:

- **Provider:** The flip side of the ability of a satellite communications system to serve many users is that it takes many users to support a satellite communications system. Therefore, except for government agencies, larger businesses and other organisations with high telecommunications volumes, intermediate providers are involved in supplying solutions and services to end users. So Nera SatLink systems are sold mostly to providers, as described in Section 3.2 below.
- **Category:** All services sort into two principal categories, direct access and content distribution. Within each category, there are many applications, and some applications in one category may use of features from the other. Nonetheless, the prime offering of a service classifies it into one of the two categories. Internet services principally entail direct access, even though they occasionally may involve fetching files from web caches, which are repositories for content distribution.

3.2 Markets interact

Nera offers a broad range of solutions for all aspects of satellite and terrestrial radio communications and therefore is the ideal single source for solutions that merge satcom and Internet technologies to meet the needs of providers and larger organisations, including:

- Satellite-based Internet services networks that may mix satellite, terrestrial radio and fibreoptic systems to provide services to others.
- Internet Service Providers (ISPs) and other Providers that seek to expand their value-added services as well as to expand their coverage of their services to areas lacking the requisite terrestrial infrastructure.
- Government agencies, academic institutions and businesses that need Internet backbone connectivity and aim to extract greater value from their Internet activities.
- Content distributors and content aggregators that aim to exploit Internet media delivery technologies such as edge broadcasting, caching and streaming in order to serve more users and cut distribution costs.

3.3 Applications meet needs

3.3.1 In satellite-based Internet services networks

A Nera SatLink system can be stand alone or be combined with a Nera NetLink terrestrial system to interconnecting smaller networks or extend the services of nodes to outlying districts. As shown in Fig. 3.1, satellite communications are ideal for providing communications to locations previously under-served. A number of Nera SatLink Terminals can be implemented to support cellular telephone services and a Wide-Area Network (WAN) that provides Internet services.

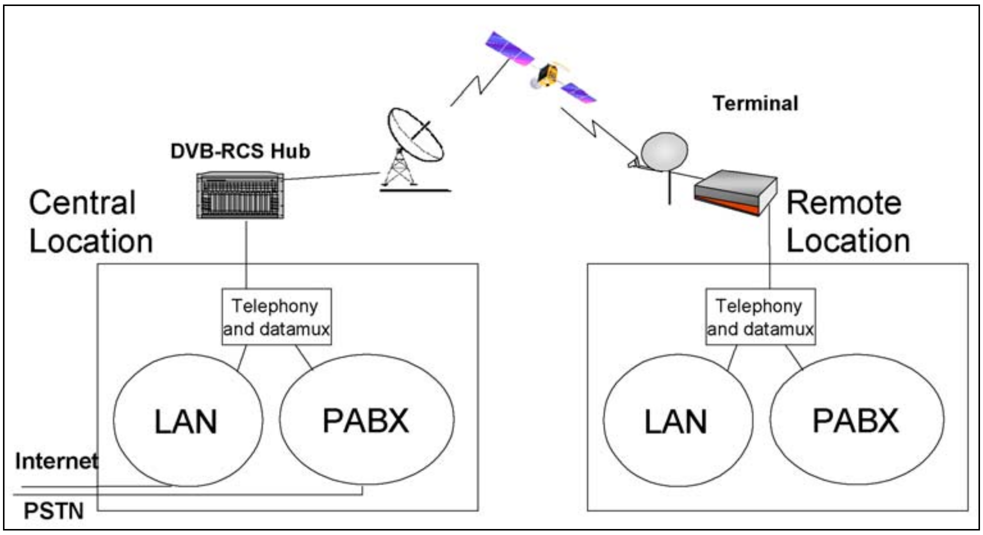


Fig. 3.1 Satellite links can bring telecommunications to locations previously under-served.

3.3.2 For Service Providers

Nera SatLink enable service providers to extend services in areas lacking conventional terrestrial infrastructure, including:

- Internet Service Providers (ISPs)
- Application Service Providers (ASPs)
- Universal Mobile Telecommunications System (UMTS) basestations
- Digital Subscriber Line (xDSL) nodes
- Point-to-Multipoint (PMP) radio basestations

A typical application, the extension of IP services, is shown in Fig. 3.2.

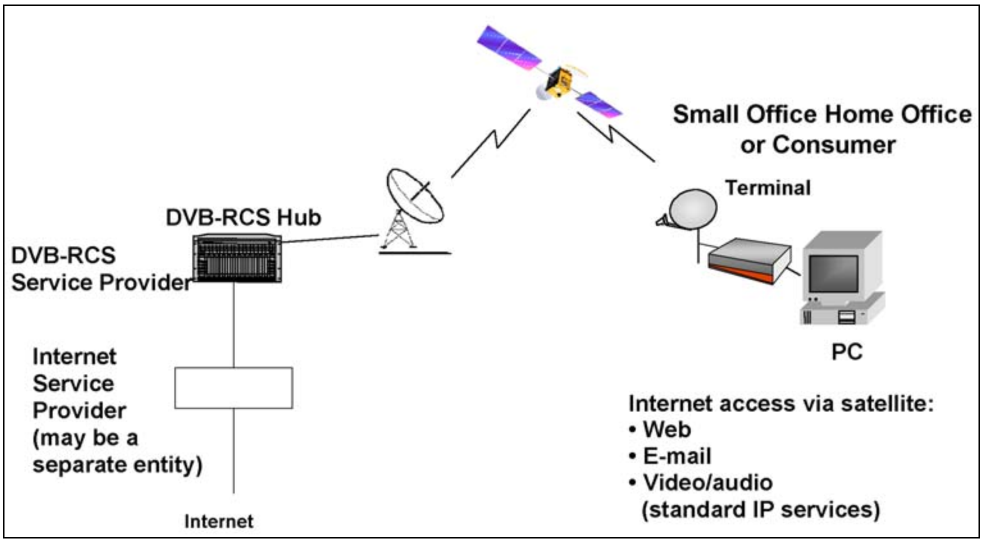


Fig. 3.2 Satellite links permit ISPs to extend their services.

3.3.3 For government, education and business

A Nera SatLink system supports innumerable applications, including:

- Banking and financial services
- Finance and stock market services
- CoLo: Colocation for web servers and web hosting to provide Internet feeds.
- VoIP: Voice over Internet Protocol providing carrier-grade telephony.
- VPNs: Virtual Private Networks
- Distance learning (video, text, voice)
- Tele-medicine
- Interactive TV broadcasting

A typical application, a VPN for a Betting Shop Network, is shown in Fig. 3.3.

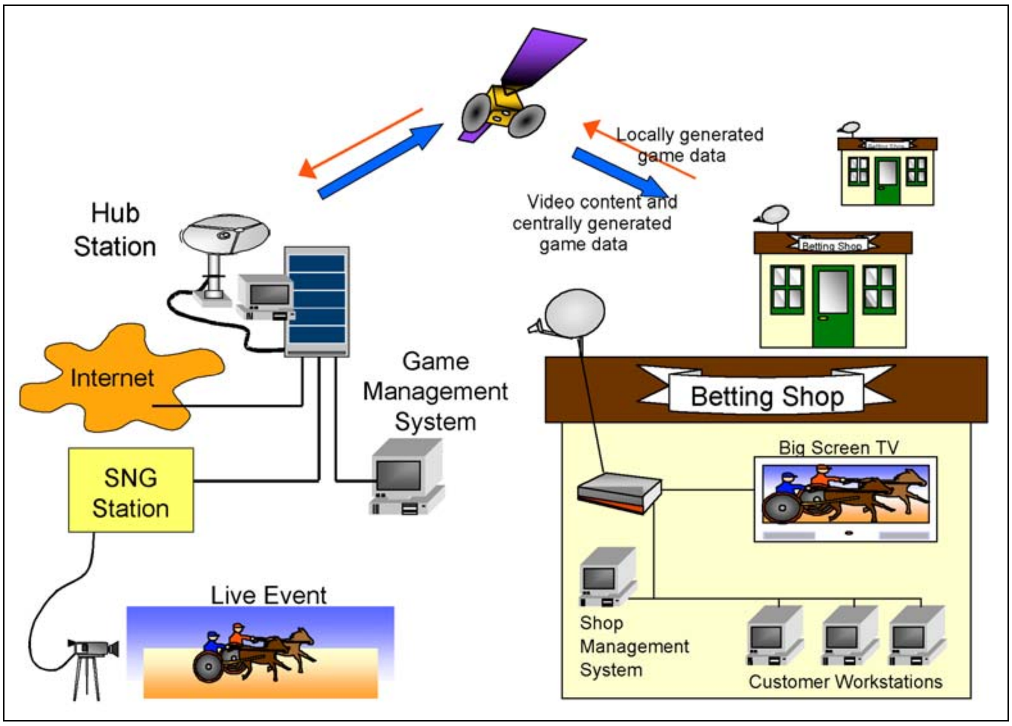


Fig. 3.3 A Betting Shop Network is typical of a VPN easily supported by satellite.

3.3.4 For content distributors

Nera SatLink

- Business broadcasting
- Religious broadcasting, particularly in thinly populated areas subject to censorship
- Edge broadcasting from caches near final users
- SMATV: Satellite Master Antenna TeleVision head-end facilities
- Distribution of broadcast-quality streaming media
- Distribution of digital movies to be shown in cinemas equipped with Digital Light Projectors (DLPs)

A typical application, the SMATV head-end facilities, is shown in Fig. 3.4. The SatLink IDUS share the same uplink. The hub co-ordinates the use of the return channel, and only one IDU is allowed to transmit at a time.

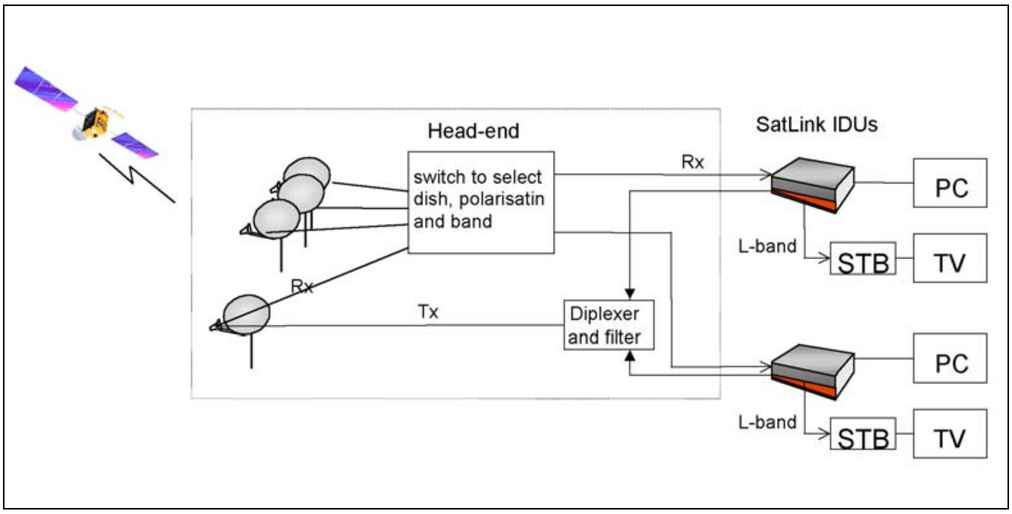


Fig. 3.4 SMATV head-end facilities are easily supported over satellite.

4. Glossary

4.1 [0-9]

1GL Abbreviation for first-generation language, an assembly language.

2GL Abbreviation for second-generation language, an assembly language.

24/7 Abbreviation of slang term 24 hours a day, 7 days a week, meaning ”always on”.

3GL Abbreviation for third-generation language, a programming language.

2SD Abbreviation for Two-Stage Dialling, a scheme in which the calling party first dials an access number, then the final destination number of the called party (typically upon request by a voice prompt).

4.2 [A-B]

AAA database The logical part of the Network Management database containing read-only authentication data, read-only authorisation data, and internal accounting records generated by the Satellite Gateway.

AAA functions The functions concerned with authentication, authorisation, and accounting. Authentication concerns establishing the identity of the terminal or person requesting access to the system. Authorisation concerns verification of the right of access to the services requested (by checked against the access/service rights as stored in the subscriber profile database). Accounting concerns collecting and storing accounting information for the purpose of subsequent billing and statistics.

Access Control The procedures that limit access to resources based on users’ identities and their associations in predefined groups.

Access time required to retrieve data from storage.

Accounting file A group of external accounting records bound by a file header as the first record and a file trailer as the last record.

Accounting management A method of establishing the charges for communication resource usage, based on the Satellite Gateway-provided collection and secure storage of such usage records, such as call data records (CDRs).

Accounting record A record that provides details on one specific connection (whether successful or not) and contains all data needed (such as connection time, data volume transferred) to fully bill the mobile user for service use.

Accounting record database The logical part of the **AAA database** containing the internal accounting records.

ACTA Abbreviation for the Administrative Council for Terminal Attachments, a telecommunications industry organisation in the USA, established in 1999 when the Federal Communications Commission (FCC) privatised significant portions of its rules governing telecommunications connectors, in particular 47 CFR Part 68. The ACTA now acts as a clearing-house for information on connectors used in telecommunications equipment; website at http://www.part68.org/

Alarm classes Three categories of alarms contingent upon the severity of the effect of a fault (or faults) upon traffic-carrying capacity within a given coverage area. A **critical alarm** state exists if half or more, of the nominal traffic-carrying capacity is affected. A **major alarm** state exists if less than half of the nominal traffic carrying capacity is affected. A **minor alarm** state exists if the traffic-carrying capacity is not affected. Examples: 1) There are two TIs, each handling a different coverage area. If one TI fails a critical alarm state exists since a complete coverage area is affected. 2) There are three TIs, all serving a common coverage area. If one TI fails, a major alarm state exists because less than half of the traffic-carrying capacity is affected.

Algorithm A mathematical process or set of rules, often expressed in algebraic form, and frequently used in computing. The word “algorithm” derives from al-Khowarazmi, the surname of the 9th century Arab mathematician Abu Ja'far Mohammed Ben Musa, whose works on Arabic numerals and algebra were among the first on those topics in Europe.

Allocation In radio systems, such as those over satellite, the designation of bands of radio frequencies as determined by **WARC** and set forth in the **Radio Regulations**.

Allotment in radio communications systems, the designation of portions of the spectrum for specific services; for satellite communications systems, such as those used in DVB-RCS, the specific orbital positions of satellites may also be involved.

Almanac In GPS, a lower precision subset of the ephemeris parameters that are used by GPS receivers to compute the elevation and azimuth angle of a satellite. Each of the 24 GPS satellites broadcasts the almanacs for all satellites in service.

Aloha A satellite access protocol that enables a station to transmit at will. Once it receives an acknowledgement of a connection established, it continues transmitting. Without acknowledgement, or if its signal collides with that of another station, the station transmits again.

Analogue Representation of a magnitude by a continuously varying value, such as a voltage or a current.

ANSI American National Standards Institute (USA). For newer technologies, as computers and data communications, ANSI and **ISO** standards have been developed in parallel: an example is the standard for the **ASCII** code, stipulated in ANSI standard X3.4-1986 and in ISO standard 646:1983; ANSI website at http://www.ansi.org/

Application Layer seventh layer of **OSI** Reference Model, exchanges messages.

Application software The software that typically is above the middle-ware software, such as commercial off-the-shelf (COTS) databases and operating system Software.

ASCII American Standard Code for Information Interchange, a standard 7-bit character encoding scheme widely used in computers and communications; the ASCII standard was first published by **ANSI** and subsequently by the **ISO**. The original 7-bit set of 128 characters was subsequently extended to an 8-bit set of 256 characters.

ATM Abbreviation for Asynchronous Transfer Mode, a type of packet switching essential in the trend toward broadband, as it handles continuously varying and irregular bandwidths.

Authentication Procedure in which people (or entities) can verify their identity to attain access.

Authorisation The granting of right to access services to a user or an entity.

Availability The ratio of the time the system is capable of carrying all services required without loss of traffic to the total time, expressed as a percentage.

Azimuth one of the two **look angles**; the "horizontal" angle at which the antenna at an earth station must point to "see" the satellite; measured eastward from geographic north to the projection of the satellite path on the local horizontal plane at the earth station. See **elevation**.

B channel digital channels carrying PCM voice or other services in a TDM signal, such as an ISDN 2.048 Mbit/s. The "B" does not designate the properties of the channel. In the early days of digital telephony, a need arose to distinguish it from analogue telephony. As analogue telephony was oldest and the word analogue begins with the letter "a," it seemed logical to call the second channel "B", which also could mean "Binary" or "Bits." The smaller signalling channel was seen as an increment. So the mathematical symbol for an increment, the Greek letter "delta," was used, and the signalling channel became the *Δ Channel*. This was before word processing became available, and English-typewriter keyboards of the time did not have Greek letters. So the Roman alphabet capital "D," the equivalent of the Greek capital " Δ," was used, and the signalling channel became the *D Channel*. Consequently, the 2.048 Mbit/s ISDN TDM is often called the "30 B + D" (the synchronising/framing channel is not available to end users).

Bands The radio-frequency spectrum, as defined by the International Telecommunications Union (ITU), is said to extend from 3 kHz (3,000 Hz) to 3,000 GHz (3,000,000,000 Hz). The spectrum is divided into nine bands that according to ITU Radio Regulations 1998, Volume 1, Article RRS2, "Nomenclature, Section I - Frequency and Wavelength Bands" are listed below. Also see **Radio bands**:

Band	Abbreviation	Name	Range	Metric subdivision name
4	VLF	Very Low Frequency	3 to 30 kHz	Myriametric waves
5	LF	Low Frequency	30 to 300 kHz	Kilometric waves
6	MF	Medium Frequency	300 to 3,000 kHz	Hectometric waves
7	HF	High Frequency	3 to 30 MHz	Decametric waves
8	VHF	Very High Frequency	30 to 300 MHz	Metric waves
9	UHF	Ultra High Frequency	300 to 3,000 MHz	Decimetric waves
10	SHF	Super High Frequency	3 to 30 GHz	Centimetric waves
11	EHF	Extra High Frequency	30 to 300 GHz	Millimetric waves
12	(none)	(no name assigned)	300 to 3,000 GHz	Decimillimetric waves

Band number N extends from 0.3 x 10^N Hz to 3 x 10^N Hz. The common prefix multiples are k = kilo (10^3), M = Mga (10^6) and G = Giga (10^9)

Band letters Unofficial, non-standard and consequently imprecise designations of radio frequency bands in the microwave spectrum, originally devised for military secrecy:

Band letter	Frequency band, GHz	Wavelength range, cm
P	0.225-0.390	133.3-76.9
L	0.390-1.550	76.9-19.3
S	1.55-5.20	19.3-5.77
C	4.20-6.20	7.14-4.84
X	5.20-10.90	5.77-2.75
K	10.90-36.00	2.75-0.834
Q	36.0-46.0	0.834-0.652
V	46.0-56.00.	0.652-0.536
W	56.0-100.0	0.536-0.300

In order of ascending frequency, the bands from L through V are often divided into subbands, designated by suffix subscript letters. For instance, the K band used in VSAT systems usually is divided into at least two subbands, designed Ku for frequencies in the range 10 – 14 GHz and Ka for frequencies in the range 24 – 36

Bandwidth The total range of frequencies in a signal, usually expressed in kiloHertz or Megahertz.

Baseband 1) In radio communications systems, the range of frequencies, starting at 0 Hz (DC) and extending up to an upper frequency as required to carry information in electronic form, such as a bitstream, before it is modulated onto a carrier in transmission or after it is demodulated from a carrier in reception. 2) In cable communications, such as those of a Local Area Network (LAN), a method whereby signals are transmitted without prior frequency conversion.

Baud a measure of transmission speed in digital communications, equal to the number of signalling elements, or symbols per second that are generated. A signalling element may consist of more than one bit, so a baud is not always equal to a bit per second.

Baudot a five-bit code used in the terrestrial telex network; often has an additional start bit and an additional stop bit; known as the International Telegraph Alphabet No. 2 (ITA2); named after J.M.E. Baudot (1845-1903), French inventor and data transmission pioneer.

BCH Bose-Chaudhuri-Hocquenghem code, binary, linear, error-correcting block code used in data transmission; easily encoded and decoded using shift registers.

Bent pipe By analogy to a pipe carrying water, the simplest, “transparent” satellite communications function in which a signal is related between a user terminal and a ground earth station with little or no **On-board processing** in the satellite and no relaying via an **inter-satellite link**.

BER Bit Error Rate, measure of noise-induced distortion in digital communications links.

Billing The actions that follow accounting and are involved in collecting payment for services. Usually, a gateway station has a facility for accounting, but billing is performed elsewhere, as it depends on both data collected as part of accounting and on commercial rules (such as tariffs, discounts, subscription types, currencies handling, payments schemes, inter-operator settlements, etc).

Binary numeration system with a radix of 2; employs two characters, 0 and 1; used in digital computers where the off and on states of switches or storage devices represent digits. See **Number systems**.

Binary code The basic code of computers and data communications in which there are only two values, mathematically a 0 and a 1. In processing and transmission, the values may be represented by the presence or absence of a pulse, a voltage or a current or by two different levels of a voltage or a current.

BIOS Basic Input/Output System, a program that controls the fundamental communications between a processor and its associated input/output peripherals. Also called a ROM BIOS.

bis twice, a second time; from the Latin *duis* [twice], used as a suffix in some protocol standards and designations, as ITU-T V22bis ["the second V22"].

Bit An abbreviation of Binary digit; the basic unit of data that a device can process or a communication system can carry; usually transmitted using **binary code**.

Bit synchronisation Process by which a digital receiver comes in step with a received bit sequence, in order to extract information from it. Because the process primarily results in synchronisation of the receiver clock, it is also called clock acquisition.

Bitstream A continuous, uninterrupted stream of bits transmitted via a communications channel.

Block A group of bits transmitted as a unit.

Boresight A term borrowed from gunnery to designate the true aim of an antenna. There are two types of boresight, the physical geometric principal axis of an antenna and the direction of the peak of its radio frequency (RF) pattern. The angular difference between the two is called squint.

BPSK Binary Phase Shift Keying, a modulation method used in digital communications systems.

Board Everyday word for Printed Circuit Board (PCB); usually a flat board of insulating material, such as fibreglass or plastic, on which electronic components are mounted.

Brick-wall filter An ideal low-pass filter with a completely rectangular characteristic; unrealisable in practice, unless modified by **roll-off**.

Broadband Originally a physical description of a relatively large portion of the radio frequency spectrum used for a communications purpose and therefore often expressed in terms of a bandwidth in kilohertz or megahertz. Subsequently, "broadband" came to be a synonym for high throughput in a channel of a digital communications system, because a higher bit rate could carry a greater, or "broader" amount of information; usually expressed in the maximum bit rate that a channel can support. In either case, "broad" is a relative term, because there is no concise definition of the width of a radio-frequency channel or the throughput of a digital data channel that qualifies it for the designation "broad".

Broadcast service radio communications via satellite aimed at a large group of end users with no individual addressing.

Buffer Temporary storage or memory; usually used in receiving, to allow a slower device, as a disk or a printer, to accept information at a higher rate.

Bug An error in hardware or software.

Bus a signal route to which several computers may be connected. Also called a **trunk** (mostly in the USA) and a **highway** (mostly in the UK).

Byte a quantity of information, usually (but not always) eight bits.

4.3 [C-D]

C/A Abbreviation for Coarse/Acquisition code, the code made available to civilian users of GPS.

Cache A high-speed memory logically located between a central processing unit (CPU) and the main memory of a computer or system. It holds data or instructions that the CPU may repeatedly use and consequently saves time by avoiding accessing the disk drives.

Call The general term in telecommunications for a channel set up between two stations or terminals for the purpose of communicating. In systems supporting both telephone and data communications, the word is ambiguous, so communications are usually said to comprise "voice conversations" or "data transactions".

Carrier A transmitted signal that can carry information, usually in the form of modulation.

Carrier frequency The frequency of the un-modulated signal of a radio transmitter.

CCSDS Abbreviation for the Consultative Committee for Space Data Systems, a liaison organisation formed in 1982 by the major space agencies of the world to provide a forum for common problems in the development and operation of space data systems. CCSDS now has ten member agencies, 23 observer agencies and 100 industrial associates and is active in developing recommendations, including recommendations for IP over satellite, many of which have been adopted by the International Organisation for Standardisation (ISO); website at http://www.ccsds.org/

Channel 1) a band of radio frequencies (*radio communications definition*); assignment is a *radio channel*, 2) a path for transmitting digital signals (*digital transmission definition*); assignment is a *data link*, 3) a temporary allocation of system resources to transmit a message (*digital transmission system use definition*); assignment is a *logical channel assignment*.

Checksum an error detection method in which the number of bits in a **block** of data are counted. The count is included with the block upon transmission. The receiver counts the number of bits in the block received. If the counts agree, the receiver assumes that the block was correctly received. Checksum is used both in **TCP** and in **UDP**.

Circuit switching A network in which a communication path between a sender and a receiver is maintained continuously for the duration of a transmission session. The name comes from traditionally telephony, in which circuits were switched through to connect subscriber telephones for the duration of a call. Circuit switching is the opposite of **packet switching**.

Client A communicating entity that is the initiator of a connection or service request. A client accesses a server. In the everyday situation of eating in a restaurant, a guest is a client and the chef is the server.

Clock acquisition See **bit synchronisation**.

Clock bias The difference between a GPS receiver's clock time and the correct universal time (UTC).

Closed network a private network available only to selected registered users, with access from the public network being barred to users not so registered.

Cloud Originally a descriptive term coined to describe the Bell Data Network (BDN) developed in the 1970s and its successors, the Advanced Communications System (ACS) and the AT&T Net 1000 system of the early 1980s, but now sometimes designates the portions of a data communications network that are obscured from user view and about which users need no knowledge in order to be able to use the network. For instance, in discussions of Internet Protocol (IP) communications via satellite, the space segment, including the uplink to and downlink from the satellite, is within "the cloud".

C/N Carrier-to-Noise Ratio, a measure of the intelligibility of a communications channel.

Codec Coder plus Decoder, a unit combining the functions of encoding and decoding.

Collision a conflict between two or more burst packets transmitted in the same time slot. All such packets are lost and must be re-transmitted.

Combiner device that combines two or more radio frequency (RF) signals to a common RF channel for further transmission.

Configuration management An approach to configuring the Satellite Gateway. This includes configuration of hardware services, routes, etc. The configuration is alterable by the Satellite Gateway operator, and the configuration of the Satellite Gateway is quasi-static as it is in effect until explicitly changed.

Configurable value A value that it is possible to change by accessing the Fault, Configuration, Accounting, Performance and Security (FCAPS) management database.

Connection service A transmission service in which a circuit is connected through at the beginning of a transmission session and is kept in place until it is disconnected after the session ends. The connection may be made via a **real circuit** or a **virtual circuit**. The service is also said to employ **circuit switching**.

Connectivity The ability to communicate. If a host or a terminal can have a communication relationship with another host or terminal then there is connectivity between the two communicating entities.

Conectionless service A transmission service in which communication takes place without a circuit being established before a transmission session.

Connectivity An expression of the ability of a network to support communication between dissimilar devices.

Control Segment A global network of GPS monitoring and control stations that ensures the accuracy of satellite clocks and satellite positions.

CoS profile The class of service provided to a subscriber under specified conditions. A subscriber may be assigned a default CoS profile or he may be assigned a custom CoS profile. The CoS profile is part of the subscriber profile.

CPU Central Processing Unit [microprocessor], the core of a computer that executes the instructions of a program.

CUI Abbreviation for Character User Interface, an on-screen display comprising an array of characters, each of which usually is an ASCII character, as in the display for the MS-DOS operating system. Compare with **GUI** and **WUI**.

Cyclic Redundancy Code (CRC) a way of checking for errors in transmitted data. Upon transmission, a polynomial of 16 or 32 bits is applied to a **block** of data and then added to the block. The receiver applies the same polynomial to the block and compares the result to that transmitted. If the results agree, the block is regarded to have been successfully received. If they disagree, the receiver may request retransmission. The ITU-T has standardised on a 16-bit CRC, which accordingly is called the "ITU-T CRC". The Ethernet local area network protocol uses a 32-bit CRC.

D channel digital channels carrying signalling in a TDM signal, such as an ISDN 2.048 Mbit/s. The designation "D" has no connection with any characteristics of the channel. See **B channel** for full definition.

Datagram A self-contained packet of information that is sent over a network that employs **packet switching**. The packet contains source and destination information along with the **payload** data and consequently is independent of other packets.

Data Message A 1500 bit message in the GPS signal that reports the satellite's location, clock corrections, and health.

Decimal numeration system with a radix of 10, the conventional number system; see **number systems** for comparison with other systems.

Diffie-Hellman key A method of changing encryption techniques whenever desired; named for W. Diffie and M. Hellman, in 1976 the authors of a paper in the IEEE Transactions on Information Theory that put forth the rules for the key.

Digital Usually refers to a digital computer, which performs operations on data in digital (number) form, using the binary system.

Direct Memory Access (DMA) Method in which a device reads from or writes to memory directly without intervention of a processor; often used by block input/output devices.

Doppler shift in satellite communications, the apparent change of received frequency due to the relative motion of a satellite and the motion of a mobile receiver; named after C.J. Doppler (1803-53), Austrian physicist.

Downlink radio link from the satellite down to receiving station on the surface of the Earth or within its atmosphere.

Drift 1) a long-term and usually steadily increasing change in a parameter, such as frequency, from its nominal value, 2) the tendency of a geosynchronous satellite in orbit to move towards one of the two satellite stable points, at 750E and 1050W.

DTE Data Terminal Equipment, ITU-T designation of a peripheral device at which a telecommunications path starts or terminates, such as a telephone or telefax.

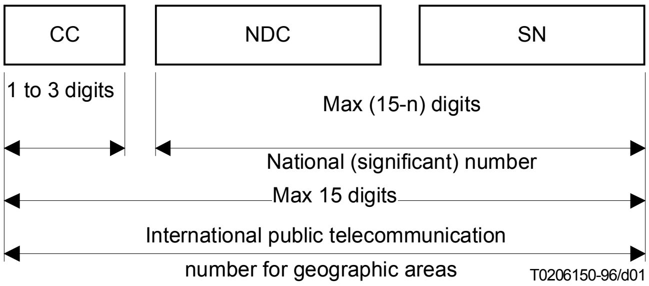
Duplex a communications method that affords simultaneous independent communications in both directions.

DVB abbreviation for Digital Video Broadcasting; originally meant television broadcasting using digital signals (as opposed to analogue signals), but now refers to broadcasting all kinds of data as well as sound, often accompanied by auxiliary information and including bi-directional communications. Standards and recommendations concerning DVB are published by the Joint Technical Committee (JTC) of the European Broadcasting Union, the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI) and may be downloaded free from the ETSI website at http://www.etsi.org/

DVB Project An commercial entity set up in 1993 to promote the development of uniform standards for digital video broadcasting, to avoid the anarchy of proprietary settop boxes that had developed in analogue satellite transmission. The DVB Project is not a standards body in itself, but is a forum for actors in the sector to agree upon specifications that then may be passed onto standards bodies, such as the **ISO** og **ETSI**. Website at http://www.dvb.org/

4.4 [E-F]

E.164 Number A telecommunications number according to the International Public Telecommunication Numbering Plan (ITU-T Recommendation E.164) and comprising up to 15 digits as shown below.



E.164 number structure, replicated from Fig. 1/E.164 of ITU-T Recommendation E.164 (05/97); CC = Country Code for geographic areas, NDC = National Destination Code (optional), SN = Subscriber Number and n = number of digits in the Country Code.

Earth segment in satellite communications, one of the two segments of the overall services, comprising the facilities involved in communicating via a satellite, except for the satellite itself. See **Space segment**.

Edge broadcasting technique of storing video and other program material at a **cache** near final users; a typical implementation may entail bypassing the Internet backbone by transmitting live video and audio via satellite to a cache from which it is broadcast to users. This is called caching of **streaming** media. Edge broadcasting is held to have two principal advantages over conventional TV broadcasting. First, content providers may use Web facilities to track and obtain information on customers. Second, viewers may have additional control, such as recording and play-back, as well as selection of camera view in a pay-per-view event.

EdgeCasting an InfoLibra tradename for **edge broadcasting**.

EIRP abbreviation for Effective Isotropically Radiated Power, the power of a hypothetical transmitter and isotropic antenna (one that radiates equally in all directions) that would achieve the same result as the transmitter and antenna to which the figure applies. Numerically equal to the product of the power supplied to an antenna and its gain in a specified direction.

Elevation one of the two **look angles**; the "vertical" angle at which the antenna at an earth station must point to "see" the satellite; measured upward from the local horizontal plane at the earth station to the direct path line to the satellite. See **azimuth**.

Elevation Mask In GPS, the angle below which a satellite is deemed not usable.

End-to-end connection a connection between both ends of a message circuit which is established for the duration of a call. The channel used may be *full duplex*, whereby it permits simultaneous transmission in both directions, or *half duplex*, whereby it permits transmission in either direction, but not both directions simultaneously.

End-to-end QoS The quality of service (**QoS**) provided at the end nodes across a potentially non-homogenous network.

Entropy A term borrowed from thermodynamics and introduced by Claude Shannon in 1948, entropy indicates the degree of disorder or uncertainty in a communications system. The information content of a message can be associated with its source, so entropy often is said to be "source entropy". Entropy also may be associated with the channel carrying a message, in which case it indicates the lower limit of the channel capacity (with its associated data required) required to carry information. If the source entropy of a system is less than its channel entropy, messages may be conveyed without error. But if the source entropy is greater than the channel entropy, error-free transmission is not possible. Numerically, source entropy is equal to the average rate of transfer of information of a message or of a language. A source that exploits 80% of its freedom of choice has an entropy of 0.8. The **redundancy** of the resultant message is 100% minus the entropy, or 20%. The English language, for instance, has a redundancy of 50%, which indicates that at best, half the elements of a message in English are freely chosen and half the elements are determined by the structure of the language. In its original use in thermodynamics, particularly the second law of thermodynamics, entropy is a measure of the randomness of the condition of a system in which heat is a parameter.

Error code A number generated by a computer that corresponds to a particular error fault; frequently used to alert an operator.

ESA Abbreviation for European Space Agency, the joint space agency of 15 European countries; tasks include launching satellites, website at http://www.esrin.esa.it/

Ethernet originally an experimental Local Area Network (LAN) operating at a rate of 3 MBit/s and using coaxial cable, effectively provides one implementation of the two lower layers of the ISO/OSI seven-layer reference model. Now operates at 10 MBit/s.

ETSI European Telecommunications Standards Institute, an organisation promulgating engineering standards for telecommunications equipment, secretariat at Valbonne, France; http://www.etsi.org/

Event message A message stored by an Simplified Network Management Protocol (SNMP) manager. The event message is derived by the SNMP manager upon reception of an SNMP trap or an SNMP notification.

Event object An **Management information base (MIB)** object used to represent and model an event to be handled by a simplified network management protocol (SNMP) agent.

F The type designation of the family of push-on 75Ω coaxial connectors that are widely used for the radio-frequency connections of consumer television and video equipment at frequencies up to 1 GHz. A precision FD series of 9.2 mm outer diameter screw-on 75Ω coaxial connectors are used in DVB equipment, such as Terminals, at frequencies up to 1.5 MHz; for details, see the ANSI/EIA-550-1989 standard.

Facsimile In telecommunications, the reproduction of an exact copy at a remote location by scanning and transmission. To date, there are four facsimile transmission standards.

Standard	**ITU-T Rec., year first standardised**	**Features**
Group 1	ITU-T T.2, 1968	Analogue transmission, transmits one page in about 6 minutes, now obsolete.
Group 2	ITU-T T.3, 1976	Analogue transmission, transmits one page in about 3 minutes, now obsolete, though a few terminals are still in use.
Group 3	ITU-T T.4, 1980	Analogue transmission, transmits one page in about 1 minute, now most prevalent, accounting for more than 90% of all fax terminals world-wide.
Group 4	ITU-T T.6, 1984	Digital transmission, transmits one page in about 6 seconds, intended for use with 64 kbit/s ISDN circuits.

Fault management The approach to fault detection, fault isolation and the correction of the abnormal operation of the Satellite Gateway. Fault management includes functions to:

1. Maintain and examine alarm/error logs.
2. Accept and act upon alarm/error detection notifications.
3. Trace and identify faults.
4. Carry out sequences of diagnostic testing
5. Correct faults

Fax A common abbreviation for **facsimile**.

Fax over Internet Protocol (FoIP) Technology that supports transmission of telefax messages via networks using the Internet Protocol.

Firewall Computer hardware and/or software that protects a computer or a network by blocking unwanted signals from the outside.

FIFO First In, First Out, a method of storing and retrieving data in tables, stacks or lists, in which entries are made at one end and removed from the other, so the oldest entry is retrieved first.

Figure of merit see *G/T*.

Final destination number The number of the VoIP subscriber or FoIP subscriber within the numbering plan of the GW. The final destination number is not part of the PSTN numbering plan.

Finite state machine (FSM) see **state machine**.

Firmware A program or set of software instructions that have been permanently burned into memory devices, such as a Read Only Memory (ROM) or an Erasable Programmable Read-Only Memory (EPROM).

Footprint The area on the surface of the Earth that is "seen" by a satellite and within which signals may be received and sent via it. Usually, a footprint is centred on the principal axis of the satellite antenna and shows concentric contours of decreasing received signal intensity at successively greater distances from the centre.

Forward direction In satellite communications, the direction from the principal gateway or hub station to a Terminal.

Forward error correction (FEC) an error correction system in which signals detected as being in error are automatically corrected at the receiver before being sent further for processing.

Forward direction the communications direction via the satellite from the principal **Gateway** to the **Terminals**.

Frame 1) a defined, repeated part of a **bitstream** consisting of a specified number of bits or Bytes or being of a specified duration in time, 2) one complete television or video display image.

Frame synchronisation Process by which a digital receiver unambiguously identifies received frames in order to demultiplex information, sub-band information and dummy bits, as well as to synchronise descrambling and FEC decoding.

Framing bits Synonym for **unique word (UW)**.

Frequency allotment designation of portions of frequency bands available for specific services and/or countries.

Frequency allocation radio frequencies, usually in a specified band designed by an upper and a lower frequency, designated for use by one or more of the 38 terrestrial and space radio communications services defined by the ITU.

Frequency bands See **Bands**.

4.5 [G-H]

Gateway The facility that provides entrance to and exit from a telecommunications network. For satellite systems, a gateway almost always interconnects to terrestrial telecommunications networks, such as the public switched telephone network (PSTN) or the Internet and provides mapping to all seven layers of the **OSI Model**.

Generator polynomial a polynomial, G, used in the **cyclic redundancy check (CRC)**; the message signal M is multiplied by G before transmission; upon reception the signal is divided by the same G; a residue indicates error(s).

Geoid The true physical shape of the earth, which cannot be described precisely, due to surface irregularities.

Geostationary satellite a **geosynchronous satellite** whose orbit lies in the plane of the earth's equator (zero inclination) and is prograde (the satellite moves in the same direction as the earth revolves, west to east).

Geosynchronous satellite A satellite whose period of revolution is equal to the period of rotation of the earth about its axis. A communications satellite must also be in a **prograde orbit**, moving in the same direction as the earth revolves.

GLONASS Abbreviation for GLObal NAvigation Satellite System, the Russian navigational satellite system, website at http://www.rssi.ru/SFCSIC/english.html

GMT Greenwich Mean Time, the mean solar time of the meridian at Greenwich, England; used until it was replaced by UMT in 1972 as a basis for standard time throughout the world; see **Time**.

GPS Abbreviation for the Global Positioning System comprising 24 NAVSTAR satellites, their ground control and monitoring stations and the users of the navigational and time services they provide.

Graphical User Interface (GUI) The on-screen display of a computer that communicates with the operator by using pictures in addition to words, symbols and numerals. The first GUIs, which were implemented at Xerox's Palo Alto Research Center (PARC) in California, inspired the personal computer graphical interface first implemented in 1984 on the Apple Macintosh and subsequently in the MicroSoft Windows operating systems.

Graphics controller a circuit that assists graphics drawing algorithms by performing logical functions on data written to the memory of a display device.

G/T a figure of merit expressing the efficiency of a receiver, pertains to the combination of an antenna and the receiver; G is the overall gain in decibels and T is the noise temperature, expressed in decibels relative to 10°Kelvin. Hence G/T is expressed in decibels, with the appended symbol dB/K to indicate the Kelvin scale of temperature.

GUI Abbreviation of Graphical User Interface, a general term for any on-screen information display based on graphics, as opposed to characters as for **CUI**. Well-known GUI include Microsoft Windows and the Apple Macintosh displays. GUI for Windows or Internet web viewing are also called **WUI**.

H.323 The ITU-T recommendation on packed-based multimedia communications system that covers the Voice over Internet Protocol (VoIP).

Hacker A computer programmer whose status has had several meanings. In the early years of computers in the 1950s, a hacker was a person who tinkered, or "hacked away" at a programmable system to make it work, so the word implied capability in programming. However, in the 1983 film *Wargames*, directed by John Badham, a young hacker breaks into the American military computer network and creates havoc in it. Thereafter, a hacker came to be a person who attempts to break into computer systems for fun and sport, often malicious.

Handover word A word in the GPS message that contains synchronisation information.

Hardware A modern electronics system is said to have two parts, hardware and software. The hardware comprises all physical devices and systems, including electronic circuits and components and electromechanical systems. The software comprises all programs, computer languages, procedures and electronic documentation of a system. In one popular definition, a piece of hardware is said to be something that you can drop on your foot, whilst software is said to be something you cannot see until it works.

Hardware platform A unit of hardware that runs some software and consequently is regarded as a support, or platform for it.

Header coded information at beginning of a **packet**, usually comprises control details.

Hex abbreviation for hexadecimal.

Hexadecimal numeration system with a radix of 16; see **number systems**.

Highway sometimes contracted to **hiway**, another term for **bus**.

High-level signalling See **Signalling level**.

Host term used in data communications for user facilities; from a data communications viewpoint, DVB-RCS hubs are hosts.

Housekeeping for a communications satellite in orbit, all its support systems and the power they consume; i.e., everything on board the satellite except for the communications equipment fulfilling its primary purpose.

Hot Bird Tradename of a family of five Eutel direct broadcasting satellites at 13°E orbital position; sometimes used to describe a direct broadcasting satellite located elsewhere.

HRU Abbreviation for Hardware Replacement Unit, the smallest unit in terms of fault detection, fault isolation and part replacement. An HRU may be a hardware unit or a collection of hardware units which are so interconnected that it makes sense to replace them as a whole.

Hub in a satellite network, the principal, large, fixed ground station that interconnects to fixed telecommunications systems, such as the PSTN and the Internet.

Hydrogen line A line in the spectrum of hydrogen at 1.42 GHz, or 21 cm wavelength, used by radio astronomers to study the amount of hydrogen in the universe and consequently not used in satellite communications.

4.6 [I-J]

IEC Abbreviation for the International Electrotechnical Commission, the leading global organisation that prepares and publishes international standards for all electrical, electronic and related technologies. These serve as a basis for national standardization; website at http://www.iec.ch/

IETF Abbreviation for the Internet Engineering Task Force, an international organisation that sets standards for Internet protocols in Request for Comment (RFC) publications made available on the IETF website at http://www.ietf.org/

Interleave to spread the components of signals in time and intersperse them with each other, so as to distribute errors which may occur.

Intermediate Frequency (IF) A frequency or band of frequencies to which a signal is shifted locally as an intermediate stage, often involving amplification, in transmission or reception.

Intermodulation products The result of interference between two or more signals that are transmitted simultaneously; depend on modulation method employed.

Internet A message-forwarding system connecting and comprising computer networks worldwide.

Internet Protocol transit (IP transit) A measure of the delivery of Internet traffic entailing connections between Internet firms and backbone providers. IP transit can be configured in step with changing prices and consequently has become a commodity in bandwidth trading.

Inter-satellite link (ISL) A bi-directional microwave link between satellites in orbit; may be between satellites in the same orbit – as between low-earth-orbit (LEO) satellites – or between satellites in differing orbits, as between geostationary and low-earth-orbits, in which case the link is called an inter-orbital link (IOL).

Intersymbol interference In a digital pulse train, the tendency of a physical pulse to interfere with pulses following it.

Intranet A network based on the same technologies and standards as the **Internet** but providing services to a single organisation or network.

Inventory In configuration management, the tally of devices connected to a network.

IP address pool A pool of allocate IP address. An IP address pool consists of a contiguous set of IP address that all are within one and only one IP sub-net.

IPv4 The common abbreviation of Internet Protocol version 4, the current version that was first standardised in 1981. The address field in IPv4 is 32 bits.

IPv6 The common abbreviation of Internet Protocol version 6, the forthcoming version intended to replace iPv4. IPv6 has a 128 bit address field and other new features, including enhanced security and real-time communications. It is described in IETF RFC 1752.

ISO The International Organisation for Standardisation; head office in Geneva, Switzerland, website at http://www.iso.ch/

ITU International Telecommunications Union, international organisation that oversees and compiles standards for telecommunications, headquarters in Geneva, Switzerland, website at http://www.itu.int/home/

JTAG Abbreviation for Joint Test Action Group, a working group formed in 1998 by manufacturers of Application-Specific Integrated Circuits (ASICs) in North America to develop means of automatic software-controlled testing of ASICs. The methods developed were first standardised by the Institute of Electrical and Electronics Engineers (IEEE) in 1990, in standard IEEE 1149.1, the latest version of which is IEEE 1149.1-2001.

4.7 [K-L]

Ka-Band Utilization Conference An annual international engineering and scientific conference dedicated to the dissemination of information on satellite communications at 20-30 GHz and higher frequencies; first held in 1995; Secretariat at IIC – Instituto Internazionale delle Communicazioni, I-16125 Genova, Italy, website at http://www.iicgenova.it/kaconf/2002/home2002.html

L1 and L2 Bands The two frequency bands transmitted by each GPS satellite. L1 centred at 1575.42 MHz, and L2 centred at 1227.60 MHz. Both L1 and L2 carry an encrypted signal for military users, and L1 also carries one unencrypted signal for civilian users.

Last mile The final link between a central telecommunications facility, such as a telephone exchange, and each of the end users it serves. The word “mile” just means “a distance” that can be less than one mile (1.6 km) or can be far longer. In telephone systems, the link traditionally has been a **twisted pair** of copper wires that originally were designed and installed to carry analogue telephone signals and therefore have limited bandwidth for other applications, such as digital communications. Accordingly, the last mile links often limit the provision of broadband services to end users. DVB-RCS overcomes this constraint and provides a last-mile broadband solution.

Latency Accumulated delay of a transmission circuit, usually expressed in milliseconds. Latency arises principally from three sources of delay: propagation delay, as of a signal via a satellite; transmission delay, the time required for a packet of digits to transverse a network; and processing delay, the time required by network devices to perform their tasks.

Leap Second Name of a second added to or subtracted from UTC on the last day of June and/or December every year, so that it remains co-ordinated with the rotation of the earth; see **Time**.

Look angles the co-ordinates to which an earth station must point to "see" the satellite. **Azimuth** and **elevation**, as used in satellite communications, are the most common specifications. However, other pairs exist, as the right ascension and declination used in radio astronomy.

Loschmidt number The number of molecules in one cubic centimetre of a gas at one bar pressure and 0° C temperature, approximately 2.687×10^{19}; first calculated by and named for Austrian chemist Joseph Loschmidt (1821-1895); used in theoretical calculations of radio-frequency signal attenuation in the atmosphere.

Low-level signalling See **Signalling level**.

Link budget a list of powers, gains, and carrier-to-noise/interference ratios along the entire transmission path between two stations.

Link layer, or "Data Link Layer," second layer of **OSI** Reference Model, exchanges frames.

Login A user validation procedure required to access a communications system.

Logout The termination of access initiated by a **login**.

4.8 [M-N]

Management computer A computer that runs typical management applications, such as network management, and possibly also the parts of the traffic handling software for resource management and protocol handling that do not have hard return requirements.

Manually blocked The state of a resource that an operator has barred from being used.

Medium-level signalling See **Signalling level**.

Menu A list of operations available to an operator/user; usually displayed on screen, but may be printed out.

Management Information Base (MIB) A database of network performance information accessed by a **Network Management Station**.

MHP Abbreviation for Multimedia Home Platform, an organisation created by the **DVB Project** to promote the development of standards for interactive multimedia in the home; website at http://www.mhp.org/

MIB object A node in a **Management Information Base (MIB)** tree. However, a MIB is not a database. It is a pattern for organising management data. It provides a map for accessing management data, but provides no details on the format of the data or whey they are physically stored. Consequently, a MIB should be regarded as a logical form.

Monitor Station In GPS, one of five ground stations that control and monitor the satellite clock and orbital parameters.

Multimedia The combined presentation of numerous types of data, such as text, audio and moving or still pictures. Multimedia communication involves the collective transmission and presentation of multimedia data in real time or otherwise, as by store-and-forward.

Multipath Errors Disturbances due to the interference of a signals that take differing paths between a transmitter and a receiver.

Multiplexing Process in which two or more signals are combined into one for transmission via a common medium.

NASA Abbreviation for National Aeronautics and Space Administration, the space agency of the USA whose tasks include launching satellites, website at http://www.nasa.gov/

National Measurement Institute (NMI) In each country, the national agency, usually governmental, that promulgates measurement standards and is the source of official time.

NAV DATA The 1500 bit navigation message broadcast by each satellite at fifty BPS (Bits Per Second) in both the L1 and L2 bands.

NAVSTAR The collective name of the GPS satellites, website at http://gps.losangeles.af.mil/

Network layer third layer of **OSI** Reference Model, exchanges packets.

Network management All functions related to management of a Satellite Gateway, including its external interfaces; divided into five main functional areas:

1. Fault management.
2. Configuration management.
3. Accounting management.
4. Performance management.
5. Security management.

Network management client computer The point affording access to parts of the network management functions, as implemented on the network management station, of the Satellite Gateway are accessible.

Network Management Station The server providing centralised network management functions.

NIST National Institute of Standards and Technology, the National Measurement Institute in the United States, instrumental in matters concerning GPS, website at http://www.boulder.nist.gov/

Number systems Methods of writing numbers that comprise sequences of characters, each a factor of a polynomial in the radix (number base) of the system. The four most common, all of which are used in satellite communications systems, are the common decimal system to radix ten, binary to radix two, octal to radix eight and hexadecimal to radix sixteen. The binary system is used in computers, as its two characters correspond to the off and on states of devices. Compared to the decimal system, the octal system requires about 10% more digits, the hexadecimal system is far more compact, while the binary system requires considerably more digits. The four systems are compared in the table below.

Number system	Radix	Characters	Example: expressing fifty-eight (polynomial written here in the decimal system)	Written
decimal	10	0-9	$5x10^1 + 8x10^0 =$	58
binary	2	0,1	$1x2^5 + 1x2^4 + 1x2^3 + 0x2^2 + 1x2^1 + 0x2^0 =$	111010
octal	8	0-7	$7x8^1 + 2x8^0 =$	72
hexadecimal	16	0-9 & A-F	$3x16^1 + 10x16^0 =$	3A

The octal and hexadecimal systems are frequency used in communicating with computers, as they may be easily converted to and from the binary system. Binary numbers are converted to octal numbers first by dividing them into groups of three digits starting at the right, and then expressing each group as a number. The conversion to hexadecimal is similar, with groups of four binary digits. In the above example:

The binary 111010 = (111)(010) which is read as (7)(2), or 72 in octal
Likewise (11)(1010) is read as (3)(10), or 3A in hexadecimal

4.9 [O-P]

On-board processing Functions in an orbiting satellite that process the signals it relays; may include regeneration such as change of access method, switching such as to another satellite and multiplexing such as of several user terminal signals.

Open network a public network, as the PSTN.

OSI Open Systems Interconnection, a Reference Model for network operations standardised by the ISO [ISO 7498 principal] and the ITU-T [X.200 principal]; involves a seven-layer network architecture that is used for defining network protocol standards that enable OSI compliant computers to communicate with each other. The layers are: Physical, Data Link, Network, Transport, Session, Presentation and Application.

Overhead That part of a **bitstream** or **packet** that carries information not useful to the end users, such as signalling, addressing and **CRC**.

P Code The protected or military code transmitted by GPS satellites in both the **L1 and L2 bands**.
Packet a group of binary digits that includes data and control elements.

Packet switching Message transmission in which the complete message is assembled into one or more packets that can be sent through the network, collected and then reassembled into the original message upon reaching the destination. The individual packets need not be sent by the same route. The communications channels are occupied only during the transmission of a packet. Packet switching is the opposite of **circuit switching.**

Palimpsest From the Greek, meaning ‘rubbed again’ and originally applied in medieval times to a parchment that had been used again by erasing its original writing; in radio communications now used to describe any means of communication in which messages are layered underneath each other, as by using differing types of modulation.

Parity check Checking of binary errors.

Path loss the total losses, expressed in decibels, on the uplink and downlink transmissions through space.

Payload That part of a **bitstream** or **packet** that carries information useful to the end users.

Peer process equivalent process at opposite end of a call; communication is always between peer processes in **OSI** Reference Model.

Performance management A way of evaluating the behaviour of resources in the Gateway and the effectiveness of the communication activities to be evaluated. Includes functions to:

1. Gather statistical information.
2. Maintain and examine logs of system state histories.
3. Determine system performance.
4. Alter system modes of operation for the purpose of conduction performance management activities.

Physical connection in data communications, the actual process of communication, as via a satellite communications circuit.

Polarisation the orientation in space of the electric field of a propagating radio wave.

Poll a protocol which allows a terrestrial user to initiate some action at a **Terminal**.

Polling a service whereby one or more Terminals are interrogated.

Peripheral component interconnect (PCI) A 32-bit local bus used inside a personal computer (PC) or a Macintosh computer.

Physical Layer first layer of **OSI** Reference Model, exchanges bits.

Ping The Internet Control Message Protocol (ICMP) used to ascertain if a network node can be reached and if it is responding.

Preamble Initial introductory information ahead of other information in a **frame**.

Prefixes, magnitude a word placed in front of the name of a unit to indicate division or multiplication by a power of 10. Prefixes derived from the Latin are used for sub-multiples, or divisions by 10, as centi- (one hundredth) and milli- (one thousandth) commonly encountered in length measurements, centimetre, millimetre. Prefixes derived from the Greek are used for multiples by powers of 10, as kilo- (one thousand), mega- (one million) and giga- (one billion). In the metric system of measurement, the prefixes are consistent. However, in satellite communications systems and other telecommunications systems operating at radio frequencies, there is an inconsistency, as the prefixes are also used in the computer portions of a system to indicate the closest power of the base 2 in the binary system. The difference is illustrated below.

Prefix	Name	Meaning in the decimal system, as for frequencies in Hz	Meaning in the binary system, as for capacities in Bytes
k	Kilo	10^3 = 1,000 Hz = 1 kHz	2^{10} = 1,024 bytes = 1 kbyte
M	Mega	10^6 = 1,000,000 Hz = 1 MHz	2^{20} = 1,048,576 bytes = 1 Mbyte
G	Giga	10^9 = 1,000,000,000 Hz = 1 GHz	2^{30} = 1,073,741,824 bytes = 1 Gbyte

Presentation Layer sixth layer of **OSI** Reference Model, exchanges messages.

Priority rank of importance; in sending a message, assigning Priority determines how rapidly a message is delivered.

Programmable value A value set in software that can be changed by updating the source code, building the software and downloading it onto a specific target platform.

Protocol 1) the rules for communications system operation which must be followed if communication is to be possible. 2) the complete interaction of all possible series of messages across an interface.

4.10 [Q-R]

QPSK Quadrature Phase Shift Keying, modulation method.

Quality of Service (QoS) A measure of the parameters of a network that influence perceived quality of communications, including the delay, jitter, bandwidth, and packet loss that packets sent by the application experience when being transferred by the network.

Radio Bands According to the **Radio Regulations**, systems such as those implemeting DVB-RCS, provide Fixed Satellite Services (FSS) that may operate at designated C-band and K-band frequencies, which depend in part on regional availability and on the regulatory allocation of the country in which the system operates.

Band letter	Link direction	Frequency, GHz	Region(s)*
C-Band	Downlink (space-to-Earth)	3.400 – 4.200	World-wide
		4.500 – 4.800	World-wide
	Uplink (Earth-to-space)	5.725 - 5.850	R1
		5.850 – 5.925	World-wide
Ku-Band	Downlink (space-to-Earth)	10.700 – 11.700	World-wide
		11.700 – 12.200	R2
		12.500 – 12.750	R1 and R3
	Uplink (Earth-to-space)	12.500 – 12.750	R1
		12.700 – 12.750	R2
		12.750 – 13.250	World-wide
		13.750 – 14.800	World-wide
Ka-Band	Downlink (space-to-Earth)	37.5-40.5	World-wide
	Uplink (Earth-to-space)	24.75 – 25.25	R2 and R3
		27.0 - 27.5	R2 and R3
		27.5 – 31.0	World-wide

* Three regions of the World: R1: Europe, Africa and CIS; R2: The Americas; R3: India, Asia, Australia, Pacific.

Radio Frequency (RF) A frequency or band of frequencies in the electromagnetic spectrum that lies between audible frequencies and the infrared spectrum. In radio communications systems, a transmitter or receiver customarily is divided into three major parts, respectively operating at **RF**, **IF** and **Baseband**.

Radio Regulations The internationally-accepted rules governing radio communications, as issued by the **ITU**. The most recent edition was published in 1998. Article S5, entitled “Frequency allocations”, sets forth the frequencies that may be used for satellite uplink and downlink communications.

Real circuit In telecommunications, a point-to-point circuit that consists of physical connections via cables or radio channels and usually is made available for the duration of a call.

Redundancy 1) In the implementation of systems, a general term for duplication of systems to ensure reliable communications, such as the provision of a backup subsystem to take over a function should the operating subsystem fail. 2) In communications theory, the part of a message that can be eliminated without loss of essential information. Generally speaking, redundancy is the excess capacity required over the **entropy**.

Reed-Solomon A code used in Forward Error Correction (FEC); named for its originators Irving S. Reed and Gustave Solomon, who devised it in 1960 at the MIT Lincoln Laboratory. Reed-Solomon codes are described by their parameters, n and k, written RS(n,k), where n is the total number of code symbols in an encoded block and k is the number of data symbols encoded. RS(n,k) codes are used in MPEG2 compression, as carried on DVB channels.

Region In radio communications, one of the three areas of the world as designated by the International Telecommunications Union (ITU): Region 1: Europe, Northern Asia and Africa; Region 2: North and South America and Greenland; Region 3: Southeast Asia, Australia and the Pacific. Frequency allocations for radio communications are not the same in all three Regions.

Reliable transmission The conveying of messages from a sender to a receiver using a **connection-service** so as to guarantee sequenced, error-free, flow controlled reception for the duration of the connection.

Remote management A way of managing the Satellite Gateway from a network management client that is geographically remote to the Satellite Gateway itself. A wide-area network (WAN) connection is used to support the remote management of the Satellite Gateway. The Internet Protocol (IP) is used as the basis network protocol for doing remote management.

Resolution The smallest discernible increment of any measurable magnitude.

Return direction In satellite communications, the communications direction from a Terminal to the principal gateway or hub station.

Rise time and Set time The times between which a GPS satellite is visible to a receiver. A satellite is said to rise when the elevation angle from the receiver to it exceeds the elevation mask and set when the elevation drops below the mask.

Risk Management Activities and plans aimed to avoid risk and minimise damage in the event of an unwanted event.

RJ The abbreviation for Registered Jack in the Universal Service Order Code system; see **USOC**. Though called 'jack', a RJ designation applies to both the jack and the plug of a connector pair. Physically, there are three types, as listed in the table of plugs below. However, the RJ designation is not of the physical connectors, but rather for the their wiring configurations, of which there are more than 50. Moreover, the customary mounting in telecommunications installations in buildings and the complexity of wiring are indicated by suffixes, so a complete RJ designation reads RJnnl, where nn is a two-digit number and l is one of five suffix letters: C for a surface- or flush-mounted jack, W for a wall-mounted jack, S for a single-line jack, M for a multi-line jack, or X for a complex multi-line or series-type jack. Most connector manufacturers now offer RJnn connectors fitted with contacts C, always in pairs starting from the centre of the connector, up to the maximum number of positions P in a connector, as listed in the table.

Principal RJnn family designation	Numbers of pin positions P and contacts fitted C	Plug width mm	Plug length mm
RJ11	4P2C 4P4C	6.65mm	12.32mm
RJ12 or RJ11 six-pin	6P4C 6P6C	9.65mm	12.32mm
RJ45	8P4C 8P6C 8P8C	11.68mm	21.52mm

Roll-off A gradual rounding off of the vertical "wall" of a **brick-wall filter** that permits the filter to be built.

4.11 [S-T]

Satellite In astronomy, a celestial body that orbits another celestial body, such as the Moon, which orbits the Earth. In satellite communications, an artificial (man-made) satellite that orbits a celestial body, such as the communications satellites that orbit the Earth. In everyday usage, the words "satellite" (meaning artificial satellite) and "**spacecraft**" are synonymous, "spacecraft" is the more general term.

Satellite Gateway The entire gateway that interfaces a DVB-RCS system to terrestrial networks.

SCPS Abbreviation for the Space Communications Protocol Specification (SCPS), the principal **CCSDS** recommendation for IP over satellite.

Security management The support of application of security policies by means of functions, including:
1. The creation, deletion and control of security services and mechanisms.
2. The distribution of security-relevant information.
3. The reporting of security-relevant events.

Security record The set of persistent data defining the security profiles for the Satellite Gateway (such as user names, passwords and firewall configurations.

Self testing The testing performed by a unit of hardware or software to to detect and isolate failures within itself. As a minimum the self testing should be able to decide if the piece of hardware is fully operational (no failures) or not.

Server An entity that provides a service to a client.

Session In data communications and computing, the interval during which logical, mutually-agreed correspondence between two application processes exists for the transfer of information.

Shanon bound The theoretical maximum rate at which error-free digits may be transmitted over a channel that is limited in bandwidth and subjected to noise.

Signalling level A relative term indicating the general category of a signalling message; historic in telephony, now used in other telecommunications systems. Low-level signalling is the most rudimentary and comprises all signals exchanged in call or session set-up, such as via the D Channel in ISDN telephony. High-level signalling provides user or network facilities and permits interaction; the Intelligent Network Application Part (INAP) of Signalling System number 7 (SS7) in connection with ISDN is an example. Other intermediate signalling messages are classified as medium-level signalling.

Slotted Aloha A satellite access technique based on **Aloha** but in which packets are transmitted in defined slots in a time frame.

Smart card A type of credit or identity card that contains a microprocessor that stores information.

Sniffing The rapid examination of a packet to determine its nature, such as of received packets, to distinguish TCP from UDP.

SNMP Abbreviation of Simple Network Management Protocol, the most frequently-used way in which network management applications can send queries using a management information base (**MIB**).

SNMP trap (SNMP version 1 definition) Another word for messages sent by an SNMP agent to an SNMP manager. An SNMP trap is essentially the same as an “SNMP notification”.

SNMP notification (SNMP version 2 definition) Another word for messages sent by an SNMP agent to an SNMP manager. An SNMP notification is essentially the same as an “SNMP trap”.

Software A modern electronics system is said to have two parts, hardware and software. The hardware comprises all physical devices and systems, including electronic circuits and components and electromechanical systems. The software comprises all programs, computer languages, procedures and electronic documentation of a system. In one popular definition, a piece of hardware is said to be something that you can drop on your foot, whilst software is said to be something you cannot see until it works.

Solar Time Time determined by the revolution of the earth around the sun.

Space segment In satellite communications, that part of the overall system that comprises the spacecraft and the launchers and other devices used to put it in orbit, as well as the radio uplinks to and downlinks from the spacecraft in orbit.

Spacecraft a man-made, self-contained vehicle intended for spaceflight; also known as a “space vehicle”. The basic spacecraft has a propulsion system, a power supply and a payload, which in satellite communications comprises the transponders and their associated antennas.

Spectrum A relative term meaning the range of radio frequencies used for communications and other purposes.

Speed of light One of the primary physical constants, the speed of electromagnetic radiation, including light and radio waves, in a vacuum: 2.99792458×10^8 m/s, in everyday usages, often rounded off to 3×10^8 m/s.

Splitter device that splits a composite radio frequency (RF) channel for further processing.

Spoofing A method of speeding packet data transmission in systems that may involve delays greater than the time-outs of the protocols involved. When data are delayed or may be delayed, either the transmitter or the receiver is “fooled” into “thinking” that data are being successfully transmitted. For instance, a **TCP Accelerator** employs spoofing by sending acknowledgements back to the transmitter of a TCP/IP message, so the transmitter will “think” that the data have been successfully received and therefore will continue transmitting.

Spot Beam An antenna beam of a satellite that is aimed at a specific limited-area spot on the surface of the earth, the extent of which is considerably less than the total area of the earth in view.

Spurious signals Unwanted transmitter output signals not due to harmonics, transmitter noise or intermodulation products.

Squint The angular difference between the physical geometric axis of a direct5ive antenna and the direction of the peak of its radio frequency pattern. With squint, the true aim, or radio-frequency boresight, of an antenna is not where it seems. Squint may result from unwanted flaws in antenna design or construction, but more often results from intentional designs that optimise feeds and other antenna features. For instance, many marine radar antennas have squint, as a result of feeding the slotted waveguide radiating structure from one end to attain a robust construction.

State machine A computational model (or a computer using it) which consists of a finite number of states and transitions between those states, with accompanying actions. A state machine is always in a specific state at every instant in time. Each state consists of all the values of the state machine's variables, including the program counter. Formally, the computational model is a quadruple: (S, M, I,T), where S is the set of states that the processes and channels can assume, M is the set of frames that can be transmitted over the channel, I is the set of initial stages of the processes and T is the set of transitions between states. Upon turn-on, a state machine starts in the initial state, and reaches other states through a sequence of transitions.

Streaming media In packet-switched networks, a software means at a user terminal whereby an audio and/or video file may start to "play" (be heard and/or seen) as it flows or "streams" toward the terminal, before the entire file is received.

Sub-satellite point The point on the surface of the Earth directly "beneath" a satellite and geometrically on a direct radial line from the centre of the Earth to the satellite at its orbital position.

Subscriber A user or other entity having access to telecommunications or computer services.

Subscriber name Synonym for **User Name**.

Subscriber profile A list of all parameters and settings of interest to a certain subscriber. The subscriber profile is part of the AAA database.

System integration testing The testing that takes place between two or more subsystems of the Satellite Gateway. System integration testing normally takes places after the integration testing of each individual subsystem, and before the full system testing (which is to involve all subsystems).

TCP/IP The abbreviation of Transmission Control Protocol / Internet Protocol, first developed in the 1970s by the US Department of Defense Advanced Research Project Agency (DARPA). It comprises a suite, or "stack" of four layers:

TCP/IP protocol suite	**OSI model equivalent**
Application layer: supports user programs and their related protocols, including file transfer protocol (FTP), simple mail transfer protocol (SMTP), domain name system (DMS), routing information protocol (RIP), simple network management protocol (SNMP) and Telenet (terminal emulation program).	7 Application layer 6 Presentation layer 5 Session layer
Transport layer: the Transmission Control Protocol (TCP) runs here to provide end-to-end connectivity, and user datagram protocol (UDP) runs here to provide connectionless service.	5 Session layer 4 Transport layer
Internet layer: the Internet Protocol (IP) runs here, to provide addressing.	3 Network layer
Network Interface layer: manages the exchange and routing of messages	2 Data Link layer 1 Physical layer

TCP Accelerator (TCPA) Method of speeding up the **throughput** of circuits employing **TCP/IP**, principally to compensate for excessive **latency**, as on satellite links.

TCP accelerator duplex constraint A limitation on any individual TCP connection in that all IP packets (for both half-connections of the TCP connection, that is – in both directions) belonging to this TCP connection must be routed via the same RTG unit in the GW.

Telefax A synonym for **facsimile**.

Telnet A terminal-to-remote host protocol that permits computers to interconnect via the Internet.

Terminal 1) Short for Data Terminal Equipment (DTE), the precise term defined by the ITU as designating a device comprising a data source, a data sink or both; hence in radio communications systems, a peripheral device connected to a user station which itself is designated as data circuit-terminating equipment (DCE) because it provides the functions required to establish, maintain and terminate a connection, as well as signal conversion and coding between a connected DTE and the communications channel. 2) In everyday usage in satellite communications systems, a user station, consisting of a DCE or of combined DCE and DTE equipment. To preclude confusion with the precise ITU designation, "Terminal" meaning "satellite communications user station" is almost always capitalised.

TIA Abbreviation for the Telecommunications Industry Association (TIA), the leading U.S. non-profit trade association serving the communications and information technology industries; activities include standards development; website at http://www.tiaonline.org/

Time As used in DVB-RCS, "time" means Coordinated Universal Time (UTC), the global time scale. UTC is derived from International Atomic Time (TAI), which is a time reference calculated at *Bureau Interrnational des Poids et Mesures (BIPM)* (http://www.bipm.org/) in France from data supplied by some 200 atomic clocks in 50 countries. The TAI second is kept as close as possible to the SI second, which since 1967 has been defined as the duration of 9,192,631,770 of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium 133 atom. TAI is uniform and stable and consequently does not keep step with the slightly irregular rotation of the Earth. UTC does in the long term. UTC is identical with TAI, except that on the first day of June and/or December, a leap second is added to ensure that when averaged over a year, the Sun crossing of the Greenwich meridian occurs at noon UTC to within 0.9 second. Leap seconds are added as advised by the International Earth Rotation Service (IERS) (http://www.iers.org/) and are currently updated on the BIPM website.

Throughput The capacity of a data communications channel, usually meaning the overall transmission rate in bits per second but sometimes referring to the useful user information rate equal to the overall rate minus the **overhead**; a high throughput channel is said to be **broadband** in the data communications sense.

Time Division Multiple Access (TDMA) A satellite multiple access method based on **Time Division Multiplex** techniques.

Timestamp A record of the date and time of an action, such as the entry of data.

Trace session One individual act of performing trace on a given "target", such as a SDL Design Tool (SDL) process via a dedicated "trace window" or the like.

Transponder A receiver-transmitter radio communications package on a satellite, comprising receive and transmit antennas, receivers, transmitters, filters and ancillary equipment, which together receive signals at one carrier frequency and retransmit them at another carrier frequency.

Transport layer fourth layer of **OSI** Reference Model, exchanges messages.

Twisted pair The most prevalent type of telecommunications cable used to connect user equipment; consists of two copper wires, each with colour-coded insulation, twisted together to form a pair. Larger cables are built up of many twisted pairs, encased in an outer sheath, usually of plastic. The length of the twists of the pairs in a multiple-pair cable is varied to reduce cross-talk interference between pairs carrying different signals. Unshielded twisted pair (UTP) cables are the most common throughout the world. Shielded twisted pair (STP) cables are intended for use in locations subjected to external electromagnetic interference (EMI). Building cabling standards according to the US ANSI/TIA/EIA 568-A (1995) or the international ISO/IEC 11801 Ed. 1.2 (2000) standards specify five categories of twisted pairs: Category 1 is the traditional analogue telephone twisted pair, whilst Categories 3, 4 and 5 are intended for newer installations of telecommunications equipment.

Category	Type	Maximum data throughput Mbit/s
1	UTP	1 Mbit/s
2	UTP	4 Mbit/s
3	UTP or STP	10 Mbit/s
4	UTP or STP	16 Mbit/s
5	UTP or STP	100 Mbit/s

4.12 [U-V]

UDP User Datagram Protocol, a protocol at the Transport layer of the **TCP/IP** protocol suite. UDP provides connectionless service in which individual data units, known as datagrams, are sent and received independently, each with complete address and control information. UDP is used when the amount of data to be sent via the satellite is small, as in telephone services to and from the PSTN.

Unique word (UW) A code word comprising a sequence of ones and zeros, used to establish frame synchronisation in formatted digital transmission channels. Upon reception, a UW is sent to a UW correlator where it is correlated with a stored pattern of itself. The spike output of the UW correlator then indicates the occurrence of a unique word, which references the time of occurrence of the burst and marks the symbol time reference for decoding information in the message part of the burst.

Uplink radio link from a station on the surface of the Earth up to the satellite.

Unreliable transmission The conveying of messages from a sender to one or more receivers using **connectionless-service**. An unreliable service is a *best effort* to deliver a packet data unit (PDU), meaning that messages may lost, duplicated or received out of order.

Unsupported VoIP calls are VoIP calls that do not go via the VoIP Gateway of the GW and which are not controlled by the VoIP Gatekeeper of the GW. The types:

1. Direct VoIP calls to/from the Internet from /to an H.323 terminal.
2. Direct VoIP calls to/from an H.323 terminal to another H.323 terminal.

The IP packets of unsupported VoIP calls are treated as IAS/data traffic by the GW. This means that unsupported VoIP calls do not benefit from the QoS features of the GW related to the handling of VoIP (such as MU user channels and priority handling in TI and SI). The IP packets of unsupported VoIP calls are billed as ordinary IAS/data traffic.

User ID A string of characters that uniquely identifies the user of a resource.

User Name The identity of a VoIP subscriber.

User Terminal A complete Terminal consisting of a Return Channel via Satellite Terminal (RCST) and its peripherals, such as one or more computers and/or an Ethernet.

USOC Abbreviation for Universal Service Order Code, or Universal Service Ordering Code, a three to five character alphanumeric code designating telecommunications products and service data elements, originally devised in the 1970s by the Bell System in the USA. After 1984, when the Bell System was broken up into smaller companies, the individual companies retained and extended their USOCs. The USOCs for telecommunications connectors have in part been incorporated in the Federal Communications Commission (FCC) rules, Part 68, Subpart F, Section 68.502, which were privatised in 1999; see **ACTA**.

USNO Abbreviation for the U.S. Naval Observatory, which keeps the atomic clock that is the official source of time for the United States and thereby important in GPS timing; website at http://tycho.usno.navy.mil/

UTC Abbreviation (in French) for Co-ordinated Universal Time; see **Time**.

Verification The action of ensuring the correct identity of the parties involved in a transaction.

Virtual circuit In **packet switching**, a connections that appears to its users to be a point-to-point circuit but actually may involve the transmission of packets over different paths in the network. A virtual circuit usually is made available for the duration of a transmission session.

Voice frame A frame comprising the voice samples encoded in an RTP/UDP/IP packet.

Voice over Internet Protocol (VoIP) Technology that supports transmission of voice conversations over a network using the Internet Protocol.

VME Acronym for VersaModule Eurocard, a computer bus standard originally developed in the late 1970s by Motorola in Germany and now an open standard according to IEC 60821 (Edition 2, December 1991). Many commercial off-the-shelf (COTS) products are available for VME, and it is the most common bus in large, open computers.

Voice minute A measure of the deliverable communications capacity of a network carrying voice circuits. Voice minutes are now regarded as a commodity to be bought and sold, so volume users and communications operators now engage in bandwidth trading in terms of voice minutes.

VoIP Gatekeeper An entity that controls a VoIP Gateway and that performs AAA functions for voice calls.

VoIP Gateway An entity that takes care of the transport of the voice traffic, including conversion of voice representation between the two networks that the gateway interconnects.

VSAT An acronym for Very Small Aperture Terminal; originally a tradename for a satellite earth station developed and sold in the 1980s by Telecom General of the USA. VSAT is now considered to be a generic word for all such systems. At the international level, the Global VSAT Forum, a non-profit association of companies active in the VSAT sector, promotes the relevant technologies and standards; website at http://www.gvf.org/

4.13 [W-X]

W3C Abbreviation for the World Wide Web Consortium, an international organisation that creates standards for the World Wide Web; website at http://www.w3.org/

WARC The World Administrative Radio Conference, a periodic **ITU** meeting that drafts international regulations governing the use of radio frequencies, including those used by satellite systems.

Warning An indication of a serious condition that is not classified as an alarm. A warning is typically less critical than an alarm, but should still be notified to the Satellite Gateway operator.

Wavelength Distance, usually in metres or centimetres, between successive peaks in a radio-frequency waveform propagating in space.

Windows NT™ The tradename of for Windows New Technology, a computer operating system developed by Microsoft.

WUI Abbreviation of 1) Windows User Interface, a **GUI** based on Microsoft Windows or 2) Web User Interface; a **GUI** used to view web pages. Compare with **CUI**.

4.14 [Y-Z]

Z Digit An additional discriminatory or language digit, used with ITU-T signalling systems numbers 4, 5, R1 or R2, and located after the country code for international calls and ahead of an entire number called in national calls, according to ITU-T Recommendation Q.107.

5. ABBREVIATIONS AND ACRONYMS

5.1 [0-9]

2G Second Generation (of a system)
2SD Two-Stage Dialling
3G Third Generation (of wireless systems)
3GPP Third Generation Project Partners
4CIF 4 times **CIF**
16CIF 16 times **CIF**

5.2 [A-B]

AAA Authentication, Authorisation and Accounting
AAADBLIB AAA DataBase LIBrary
AAAP AAA Proxy server
AAAS AAA Server
AAC Authentication and Accounting Client, Advanced Audio Coding
A/D Analogue to Digital
ABCS Advanced Business Communications via Satellite
ABR Available Bit Rate
ABT/DT ATM Block Tansfer/Delayed Transmission
ABT/IT ATM Block Transfer/Intermediate Transmission
AC Alternating Current
ACeS Asian Cellular Satellite
ACF Admission Confirmation, Association Control Function
ACI Adjacent Channel Interference
ACIA Asynchronous Communications Interface Adapter
ACK Acknowledgement
ACPOS Accurate Position
ACSE Access Control and Signalling Equipment
ACTS Advanced Communications Technologies and Services
ADPCM Adaptive Differential Pulse Code Modulation
ADSL Asymmetric Digital Subscriber Line
AFC Automatic Frequency Control
AGC Automatic Gain Control
AH Authentication Header
AIL Action Interim List
AIT Advanced Intelligent Tape (drive)
AIX Advanced Interactive eXecutive
ALT Altitude
AMP Amplifier
AMPS Advanced Mobile Phone System
AMR Adaptive Multi Rate, Anisotropic Magneto-Resistive
AMS(R)S Aviation Mobile Satellite (R) Service
ANSI American National Standards Institute
AOL America Online
APAC Asia Pacific
APC Asia-Pacific Telecommunity
APE Application Protocol Entity

API Application Programming Interface
APPOS Approximate Position
ARIB Association of Radio Industries and Business
ARJ Admission Reject
ARP Address Resolution Protocol (TCP/IP)
ARPA Advanced Research Projects Agency
ARPU Average revenue per user
ARQ Automatic Repeat Request
ASCII American Standard Code for Information Interchange
ASIC Application-Specific Integrated Circuit
ASCO Arab Satellite Communications Organisation
ASEAN Association of South East Asian Nations
ASN Abstract Syntax Notation
ASYNC Asynchronous data transfer
ATC ATM Transfer Capability
ATM Asynchronous Transfer Mode
ATU ASDL Transceiver Unit
ATU-C ATU Central office
ATU-R ATU Remote
AUI Attachment Unit Interface
AVP Attribute Value Pair

b bit
B Byte
BAS Bit rate Allocation Signal
DB DataBase
DBA Database Administrator
BBRAM Battery-Backup Random Access Memory
BCCC Billing and Customer Care Centre
BCD Binary Coded Decimal
BCF Bandwidth Change Confirmation
BCH Boise, Chaudhuri and Hocquengham
DDL Data Definition Language
DDS Downconverting, Decoding, Synchronisation
BEP Bit Error Probability
BER Bit Error Rate, Ballistic Encoding Rules, Basic Encoding Rules
BERT Bit Error Rate Test
BGP Border Gateway Protocol
B-HLI Broadband High Layer Information
BIOS Basic Input/Output Ststem
BIPM Bureau International des Poids et Measurements (Sevres, France)
BLT BLock Transfer
DML Data Manipulation Language
Bluetooth Codename for a PAN
BoD Bandwidth on Demand
BOOTP BOOTstrap Protocol
BPF Band Pass Filter
bps Bits per second
BPSK Binary Phase Shift Keying

BRA Basic Rate Access
BRJ Bandwidth Change Reject
BRQ Bandwidth Change Request
BS Base Station
BSC Binary Synchronous Communications
BSM Broadband Satellite Multimedia
BSS Base Station Subsystem
BST Boosted Session Transport
BTC Broadband Transfer Capability
BTO Built-Transfer-Operate

5.3 [C-D]

C/I carrier-to-interference power ratio
C&I Control and Indication
C/N Carrier to Noise Power ratio (of a communications channel)
CAF Compiled Application Form
CAGR Compound Annual Growth Rate
CAP Carrierless Amplitude and Phase Modulation (DSL), Competitive Access Provider
CAS Column Address Strobe
CAT Communications Authority of Thailand
CATV Community Access Television
CBR Constant Bit Rate
CBT Computer-Based Training, Core-Based Trees
CCI Co-Channel Interference, Constellations Communications, Inc.
CCIR French-language abbreviation for International Consultative Committee for Radiocommunications, renamed **ITU-R** in 1993.
CCITT French-language abbreviation for Consultative Committee for Telegraphy and Telephony, renamed **ITU-T** in 1993.
CCSDS Consultative Committee for Space Data Systems
CD Compact Disc
CDIS Call Detail Information Source, Control and information DIstribution System, Collection Data Input System, Call Data Interface System
CDMA Code Division Multiple Access
cdma2000 tradename for CDMA air interface standard aimed at third generation systems
cdmaOne tradename for first generation CDMA air interface standards
CDR Call Detail Record, Critical Design Review
CD-ROM Compact Disk Read-Only Memory
CDSA Common Data Security Architectue
CDV Cell Delay Variation
CEPT French-language abbreviation for European Conference for Post and Telecommunications
CER Cell Error Ratio
CFR Code of Federal Regulations (USA)
CHAP Challenge Handshake Authentication Protocol
CHRP Common Hardware Reference Platform
CID Conference Identifier
CIDR Classless Inter-Domain Routing
CIF Common Intermediate Format
CIS Confederation of Independent States (of former USSR)
CITEL Latin American Telecommunications Association
CLD Conference Identifier

CLID Calling Line IDentification
CLR Cell Loss Ratio
CLEC Competitive Local Exchange Carrier
CLI Command Line Interface, Calling Line Indicator
CMIP Common Management Information Protocol
CMOT CMIT over TCP
CMR Cell Misinsertion Rate
CN Core Network, Change Note
CNAME Canonical NAME resource
CNG Comfort Noise Generation
CODEC Coder/Decoder
Conn Connector
CoS Class of Service
COTS Commercial Off-The-Shelf
CPE Customer Premesis Equipment
CPFSK Continuous Phase Frequency Shift Keying
CPM Conference Preparatory Meeting (ITU)
cps characters per second
CPU Central Processing Unit
CR Call Record
CRABS Cellular Radio Access for Broadband Services
CRC Cyclic Redundancy Check, Communications Research Centre (Canada)
CRL Communications Research Laboratory (Japan)
CRLF Carriage Return and Line Feed
CS Circuit Switched, Codespace
CSMA/CD Carrier Sense Multiple Access Collision Detection
CSC Common Signalling Channel, CS Communications Co., Ltd.
CT Computer Telephony
CTD Cell Transfer Delay
CU Communications Unit
CUG Closed User Group
CUI Character User Interface
CUSA Channel Unit SNMP Agent

D/A Digital to Analogue
DA Demand Assignment
DAMA Demand Assigned Multiple Access
D-AMPS Digital Advanced Mobile Phone System
DARPA Defense Advance Research Projects Agency
DAS Database Access Server
DAT Digital Audio Tape
dB deciBel
dBi decibels relative to isotropic radiator
dBK deciBels relative to 1° Kelvin
dBm deciBels relative to 1 milliwatt
dBW deciBels relative to 1 Watt
DC Direct Current, Dedicated Control
DCA Defense Connumications Agency
DCC DLC Connection Control

DCE Data Circuit terminating Equipment
DCH Dedicated Channel
DD Design Description
DDNS Dynamic DNS
DECT Digital Enhanced Cordless Telecommunications
DEMOD Demodulator
DES Data Encryption Standard
DFS Dynamic Frequency Selection
DHCP Dynamic Host Configuration Protocol
DIMM Dual Inline Memory Module
DIP Debtor in Possession
DL Downlink
DLC Data Link Control
DLL Data Link Layer, Dynamic Link Library
DLT Digital Linear Tape
DMA Direct Memory Access
DMI Desktop Management Interface
DNIS Detailed Number Identification Service
DNS Domain Name Service (TCP/IP)
DoD Department of Defense (USA)
DOS Disk Operating System
DPC Digital Phone Co., Ltd.
dpi dots per inch
DRAM Dynamic Random Access Memory
DRNS Drift RNS
DRP DAMA Remote Processor board
DRQ Disengage ReQuest
DSA Digital Signal Architecture
DS-CDMA Direct Sequence CDMA
DSI Detailed Spectrum Investigation, Digital Speech Interpolation
DSL Digital Subscriber Line
DSLAM Digital Subscriber Line Access Multiplexer
DSN Delivery Status Notification
DSNG Digital Satellite News Gathering
DSP Digital Signal Processor
DSS Digital Signal Standard
DTE Data Terminal Equipment
DTH Direct To Home (satellite system)
DTMF Dual Tone Multi Frequency
DTX Discontinuous Transmission
DUN Database Update Notifier
DVB Digital Video Broadcasting
DVB-S Digital Video Broadcasting – Satellite (ETSI EN 300 421)
DVMRP Distance Vector Multicast Routing Protocol
DWDM Dense Wavelength Division Multiplexing (fibreoptic)

5.4 [E-F]

EC Error Control, European Commission
ECC Error Correction Code, Efficient Channel Coding (company)

ECEF Earth Centred, Fixed Earth
ECP Extended Capability Port, Abbreviation in French of Channel Propagation Emulator
ECS Encryption Control Signal, Event Correlation System
ECSS European Co-operation for Space Standardisation
ECTRA European Committee for Telecommunications Regulatory Affairs (CEPT)
EDGE Enhanced Data Rates for GSM Evolution
EDI Electronic Data Interchange
EEPROM Electrically Erasable Programmable Read-Only Memory
EFR Enhanced Full Rate
EHF Extra-High Frequency
EIA Electronic Industries Association (EIA, USA)
EII European Information Infrastructure, Electronic Image Industry
EIRP Effective Isotopically Radiated Power (of a transmitter)
EISA Enhanced Industry Standard Architecture
EMC Electromagnetic Compatability
EMEA Europe, Middle East and Africa
EMI Electromagnetic Interference
ENG Electronic News Gathering
EPOC Symbian operating system for mobile terminals
EPP Enhanced Parallel Port
EPROM Erasable Programmable Read Only Memory
ER Entity Relationship
ERC European Radiocommunications Committee (CEPT)
ERO European Radiocommunications Office (CEPT)
ES Earth Station
ESA European Space Agency
ESC Engineering Service Circuit, Escape (on keyboard)
ESCC Enhanced Serial Communication Controller
ESD Electro-Static Discharge/Damage
ESMTP Extended Simple Mail Transfer Protocol
ESP Encryption Security Protocol
ESTEC European Space Research and Technology Centre
ET Ephemeris Time
E-TACS Extended Total Access Communication System
ETNS European Telephony Numbering Space (CEPT)
ETO European Telecommunications Office (CEPT)
ETSI European Telecommunications Standards Institute
EU European Union
EUR Euro (currency)

FA Fixed Assignment, Foreign Agent
FACH Forward Access Channel
FAQ Frequently-Asked Questions
FAS Frame Alignment Signal
Fax Facsimile
FCAPS Fault, Configuration, Accounting, Performance and Security
FCC Federal Communications Commission (USA)
FDC Floppy Disk Controller
FDD Frequency Division Duplex

FDDI Fibre Distributed Data Interface
FDM Frequency Division Multiplex
FDMA Frequency Division Multiple Access
FDS Frame Definition Slot
FEC Forward Error Correction
FER Frame Erasure Ratio
FFT Fast Fourier Transform, Fast File Transfer
FG First Generation
FG-GNS First Generation Gateway Networking System
FG-IDU First Generation Indoor Unit
FG-IDU/External "Stand alone box" modem (USB or Ethernet based)
FG-IDU/PCI PCI based first generation modem
FG-MC First Generation Multicasting
FG-MDU First Generation Multi-Dwelling UNIT
FGNG First Generation Networking Gateway
FG-NMS First Generation Network Management System
FG-ODU First Generation Outdoor Unit
FG-PTS First Generation Pro Trunking Service
FGRO First Generation RollOut
FIFO First In First Out
FMS Fault Management System
FMSA Fault Monitoring SNMP Agent
FoIP Fax over IP
FPLMTS Future Public Land Mobile Telecommunications System
FRQ Frequency
FS Fixed Service
FSK Frequency Shift Keying
FSM Finite State Machine
FSS Fixed Satellite Services
FT Frequency Time
FTP File Transfer Protocol (TCP/IP), Foil Twisted Pair (cable)
FTTC Fibre To The Curb (fibreoptic)
FTTH Fibre To The Home (fibreoptic)
FWD forward

5.5 [G-H]

G Giga (one billion)
G3 Group 3 facsimile
G4 Group 4 facsimile
G/T Gain to Noise Temperature ratio (of a receiver)
GB Base Antenna Gain
GBps Gigabits per second
GB-SCPC Gateway Bypassed SCPC
GC General Control
GCC General Conference Control
GCF Gatekeeper Confirmation
GDOP Geometric Dilution of Precision
GEO Geosynchronous
GES Gateway Earth Station

GGSN Gateway GPRS Support Node
GHz GigaHertz (one billion Hertz)
GII Global Information Infrastructure
G-IP Gateway generated IP (messages)
GK Gatekeeper
GLONASS Global Navigation Satellite System
GM Generic Service Module
GMM Global Multimedia Mobility
GMPCS Global Mobile Personal Communications Services
GMR Giant Magneto-Resistance
GMRC General Milestones Review Committee
GMSC Gateway MSC
GM-SCPC Gateway Managed SCPC
GMSK Gaussian Minimum Phase Shift keying
GMSS Global Mobile Satellite Standard
GMT Greenwich Mean Time
GM-T2T Gateway Managed Terminal-to-Terminal
GoS grade of service
GPF General Protection Fault
GPIB General Purpose Interface Bus
GPRS General Packet Radio Service
GQoS Guaranteed **QoS**
GPS Global Positioning System
G-RAC Gateway generated RAC
GSA Global Mobile Suppliers Association
GSM Global System for Mobile Communications
GSO Geostationary Orbit
GTP **GPRS** Tunnelling Protocol
GUI Graphical User Interface
GW GateWay

HA Home Agent
HAL Hardware Abstraction Layer
HCF Host Command Facility
HDLC High Level Data-link Control
HCT Hardware Conformance Test
HDR Hard-Disk Recorder
HDSL High Bit-Rate Digital Subscriber Line
HDTV High Definition Television
HDVS High-Definition Video System
HEMS High-level Entity Management System
HEO High Earth Orbit, Highly Elliptical Orbit
HF High Frequency
HFC Hybrid Fibre/Coax
HH Hand-held
HINFO Host INFOrmation
HLR Home Location Register
HP Hewlett-Packard
HPA High Power Amplifier

HPF High Pass Filter
HRU Hardware Replacement Unit
HSCSD High Speed Circuit Switched Data
HTML Hypertext Mark Up Language
HTTP Hypertext Transfer Protocol
HW Hardware
Hz Hertz

5.6 [I-J]

i/f interface
I/O Input/Output
IAB Internet Activities Board
IACK Information Acknowledgement
IANA Internet Assigned Numbers Authority
IAS Internet Access Service
IBC ISA Bridge Controller, International Broadcasting Corporation Co., Ltd.
IBO Input Back-off
IBS Intelsat Business Services
IC Integrated Circuit
ICANN Internet Corporation for Assigned Names and Numbers
ICMP Internet Control Message Protocol (TCP/IP)
ICNIRP International Commission on Non-ionising Radiation Protection
ICO Intermediate Circular Orbit
ICP Integrated Communications Provider
ID Identification
IDC Insulation Displacement Connector
IDE Integrated Drive Electronics
IDR Intermediate Data Rate (Intelsat)
IDRP Inter-Domain Routing Protocol
IDU Indoor Unit
IE Information Element
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers (USA)
IEM Integrated Encoder/Modulator
IESS Intelsat Earth Station Standard
IETF Internet Engineering Task Force
IF Intermediate Frequency
IFD Image File Directory
IFFT Inverse Fast Fourier Transform
IFL Inter Facility Link
IFRB International Frequency Registration Board (Now Radio Regulations Board)
IGMP Internet Group Message Protocol (TCP/IP)
IGW Inter Gateway Link
IHU I Heard You
IKE Internet Key Exchange
ILEC Incumbent Local Exchange Carrier
IM Inter Modulation
IMAP Internet Message Access Protocol
IMMSAT IP over MultiMedia Satellite

i-mode proprietary packed-based service for mobile phones (Japan)
IMT2OOO International Mobile Telecommunications System 2000
IMUX Input Multiplexer
IN Intelligent Network
INAK Information Negative Acknowledgement
INAP Intelligent Network Application Part
INETS Input Networks
INX Iridium second-generation satellite system
IOB Input Output Board
ION Ionosphere
IP Internet Protocol
IPv4 Internet Protocol version 4
IPv6 Internet Protocol version 6
IP/ATM Internet Protocol Asynchronous Transfer Mode
IPC InterProcess Communication
IPCP Internet Protocol Control Protocol
IPDS Inmarsat Packet Data Service
IPR Internet Protocol Router, Intellectual Property Rights
IPSAT IP over SATellite, a Radyne-ComStream Tradename
IPSec Internet Protocol Security
IPX Internetwork Protocol Exchange
IRD Integrated Receiver Demodulator
IRPA International Radiation Protection Association
IRQ Information Request
IRR Information Request, Internal rate of return
IS Inter-Service
IS-95 CDMA standard
ISA Industry Standard Architecture (bus)
ISASIO ISA Super Input/Output Device
ISDN Integrated Services Digital Network
ISI Inter-Symbol Interference
I-Signal In-phase Signal
ISL Inter-Satellite Link
ISO International Organisation for Standardisation
ISP Internet Service Provider
ISPC Internet Service Providers Consortium (USA)
ISUP ISDN User Part
IT Information Technoliogy
ITU International Telecommunication Union
ITU-R Section of **ITU** dealing with radio communications, formerly **CCIR**
ITU-T Section of **ITU** dealing with telecommunications, formerly **CCITT**
IVR Interactive Voice Response

JATE Japan Approvals Institute for Telecommunications Equipment
JISC Japanese Industrial Standards Committee
JIT Just In Time
JSA Japanese Standards Association JTC Joint Technical Committee
JTAG Joint Test Action Group (IEEE 1149.1 standard)

5.7 [K-L]

K kelvin (temperature scale), degrees Kelvin
k Kilo (one thousand)
kb kilobit (one thousand bits)
kBps kilobits per second
kg kilogram (one thousand grams)
kHz kiloHertz (one thousand Hertz)
kHz kiloHertz (one thousand Hertz) kps kilobits per second

L2F Layer 2 Forwarding
L2TP Layer 2 Tunnelling Protocol
LAC L2TP Access Concentrator
LAN Local Area Network
LAP Link Access Protocol
LAPP Look Ahead Project Planning
LAT Latitude
L-Band Generally 1-2 GHz
LCD Liquid Crystal Display
LCN Logical Channel Number
LCP Link Control Protocol
LCR Least Cost Routing
LDAP Lightweight Directory Access Protocol
LED Light-Emitting Diode
LEO Low Earth Orbit
LES Land Earth Station
LF Low Frequency
LI Lawful Interception
LLC Lower-Layer Compatibility, Logical Link Control, Limited Liability Company
LLU Local Link Unbundling
LMDS Local Multipoint Distribution System
LNA Low Noise Amplifier
LNC Low Noise Converter
LNS L2TP Network Server
LO Local Oscillator
LON Longitude
LOS Line-Of-Sight
LQM Link Quality Measurement
LRJ Location Reject
LRQ Location Request
LSB Least Significant Bit

5.8 [M-N]

M Mega (one million)
m milli (one thousandth)
MAC Media Access Control
Mbit Megabits (one million bits)
MBLT Multiplexed BLock Transfer
Mbps Megabits per second
MC Multipoint Controller, Multi Carrier

MCA Micro Channel Architecture (bus)
MCG Modulation, Coding and Gain
MCHI Mobile Communications Holdings, Inc. (for development of Ellipso system)
MCOT Mass Communications Organization of Thailand
MCPC Multiple Channels Per Carrier
MCS Multipoint Communications System
MCU Multipoint Control Unit
MD Multi-Destinational
MD5 Message Digest algorithm number 5
MDF Main Distribution Frame
MDN Message Disposition Notification
MDU Multi-Dwelling Unit
MEO Medium Earth Orbit
mErlang milliErlang
MES Mobile Earth Station
MexE Mobile Station Application Execution Environment
MF Medium Frequency, Multiframe
MFM Modified Frequency Modulation
MF-TDMA Multiframe Time Division Multiple Access
MGCP Media Gateway Control Protocol
MHz MegaHertz (one million Hertz)
MIB Management Information Base
MIDI Musical Instrument Digital Interface
MIME Multipurpose Internet Mail Extension
ML Maximum Likelihood
MLPPP MultiLinkPoint-to-Point Protocol
mm millimetre
MMDS Multichannel Multipoint Distribution System
MMI Man-Machine Interface
MOD Modulator
Modem Modulator/Demodulator
MOSPF Multicast Extensions to OSPF
MOTC Ministry of Transport and Communications
MOU Memorandum Of Understanding
MoU Memorandum of Understanding
MP Multipoint Processor
MPA Multi Port Amplifier
MPC Multimedia Personal Computer
MPE Maximum Permissible Exposure
MPEG Moving Picture Expert Group
MPU MicroProcessing Unit
MRC Maximum Ratio Combining, Milestone Review Committee
MRP Market Representation Partner, Multicast Routing Protocol
MS Mobile Station
MSB Most Significant Bit
MSC Message Sequence Chart, Mobile Switching Centre
MSN Multiple Subscriber Number, MicroSoft Network
MSO Multiple Systems Operator
MSS Mobile Satellite System, Maximum Segment Size

MT Mobile Termination, Master Terminal
MTBF Mean Time Between Failures
MTM Multipoint-to-Multipoint, Mobile-to-Mobile
MTP Message Transfer Part (**SS7**)
MTU Maximum Transmission Unit, Multi-Tenant Unit
MU Multi-User (slot)
MUD Multi-User Dungeon
MUX Multiplexer
MX Mixer

NA Not Applicable
NACK Negative Acknowledgement
NAP Network Access Provider
NAPC Network Access Provider Centre
NAP-NT NAP Master Terminal
NAP-NCC NAP Network Control Centre
NAS Network Access Server, Non Access Stratum
NASA National Aeronautics and Space Administration (USA)
NASDA National Space Development Agency (Japan)
NASDAQ National Association of Securities Dealers Automated Quotation System (USA)
NAT Network Address Translation
NAV Navigation
NBAP Node B Application Protocol
NCC Network Control Centre
NCP Network Control Protocol
NCSA National Center for Supercomputing Applications (USA)
NEXT Near-End Crosstalk
NGSO Non Geostationary Orbit
NHRP Next Hop Routing Protocol
NI Network Interface
NIC Network Information Centre
NIR Non-ionising Radiation
NIS Network Information Service
NIST National Institute for Science and Technology (USA)
NM Network Management
NMDB Network Management Database
NMI National Measurement Institute
NMS Network Management System, Network Management Station
NMT Nordic Mobile Telephone
NNI Network Node Interface
NNM Network Node Manager
NNTP Network News Transport Protocol
NO Network Operator
NOC Network Operating Centre
NO-MT Network Operator Master Terminal
NO-NCC Network Operator Network Control Centre
NPL National Physical Laboratory (UK)
NPV Net present value
Ns nanosecond

NSAP Network Layer Service AccessPoint
NSP Network Service Provider
NT Network Termination
NTB Network Test Bed
NTP Network Time Protocol
NTSC National Television Standards Committee (USA)
Nt Notification
NTP Network Time Protocol
NTSC National Television Standards Committee (USA)
NTW Windows NT Workstation
NVOD NearVideo on Demand
NVRAM Non-Volatile Random Access Memory

5.9 [O-P]

OBEX Object Exchange
OBO Output Back-Off
OBP On-Board Processing
ODBC Open Data Base Connectivity
ODU Outdoor Unit
OEM Original Equipment Manufacturer
OET Office of Engineering and Technology (of the FCC)
OFDM Orthogonal Frequency Division Multiplexing
OID Object IDentifier
OMPAC Over-Molded Pad Array Carrier
OMT Ortho Mode Transducer
OMUX Output Multiplexer
OS Operating System
OSB One-stop Billing
OSI Open Systems Interconnection, Operations System Interface
OSPF Open Shortest Path First
OSS One-Stop Shopping, Operations Support System
OTP One-Time Programmable
OUI Organisationally Unique Identifier
OV Open View (usually implies “HP Open View”)

P2T TSTN-to-H.323 Terminal
P&C Point and Connect
PABX Private Automatic Branch Exchange
PAD Packet Assembler/Dissassembler
PAL Programmable Array Logic, Phase Alternate Line (TV standard)
PAN Personal Area Network
PAP Password Authentication Protocol
PAT Port Address Translation
PBN Packet Based Network
PBX Private Branch Exchange
PC Personal Computer
PCG Project Co-ordination Group
PCI Peripheral Component Interconnect
PCM Pulse Code Modulation

PCN Personal Communications Network
PCR PCI Configuration Register, Program Clock Reference
PCS Personal Communications Service (wireless)
PDA Personal Data Assistant
PDC Personal Digital Cellular
PDCH Packet Data Channel
PDR Preliminary Design Review
PDS Processor Direct Slot
PDU Packet Data Unit, Protocol Data Unit
PEN Private Enterprise Number
PEST Personal Earth Station
PFD Power Flux Density
PGP Pretty Good Privacy (encryption)
PHB PCI Host Bridge
PHS Personal Handiphone Service (Japan)
PHY Physical Layer
PIB PCI-to-ISA Bridge
PICS Platform for Internet Connection Session
PIM Protocol Independent Multicast, Processor Interface Module
PIM-DM PIM Dense Mode
PIM-SM PIM Sparse Mode
PIN Personal Identification Number
PKCS Public Key Cryptography Standards
PKI Public Key Infrastructure
PLL Phase-Locked Loop
PM Performance Monitoring
PMC PCI Mezzanine Card, Piloting, Monitoring and Control
PMR Private Mobile Radio
PN Pseudo-random Number
PNG Portable Network Graphics
Pnl Panel
POLSK Polarisation Shift Keying
POP Point Of Presence, Post Office Protocol
POS Point Of Service
POT Point Of Termination
POTS Plain Old Telephone Service
PPP Point-to-Point Protocol
PPS Precision Positioning Servicer
PPV Pay Per View
PRA Primary Rate Access
PRC Program Reference Clock
PRCLC PRC Latency Correction
PRI Primary Rate Interface
PRN Pseudo Random Number
PROM Programmable Read Only Memory
PS Packet Switched
PSDN Public Switched Data Network
PSK Phase Shift Keying
PSTN Public Switched Telecommunications Network

PTM Point-to-Multipoint
PTO Public Telephone Operator
PTP Point-to-Point
PTT Post, Telephone and Telegraph (outdated European ministry name)
PUID Pseudo-User IDentification

5.10 [Q-R]

Q-Band Generally 36-46 GHz
QA Quality Assurance
QAM Quadrature Amplitude Modulation
OBP On-Board Processor
QCIF Quarter CIF
QFP Quad Flat Package
QoS Quality of Service
QPM Queuing and Prioritising Module
QPSK Quadrature Phase Shift Keying
Q-Signal Quadrature Signal

RA Registration Authority
R&D Research & Development
RAB Radio Access Bearer
RAC Receive Access Channel
RACH Random Access Channel
RADB Routing Arbeiter DataBase
RADIUS Remote Authentication Dial-In User Service
RADLIB RADIUS LIBrary
RADSL Rate Adaptive Digital Subscriber Line
RAID Redundant Array of Independent/Inexpensive Disks
RAM Random Access Memory
RAN Radio Access Network
RANAP Radio Access Network Application Part
RARP Reverse Address Resolution Protocol
RAS Remote Access Server, Registration, Admission and Status, Row Address Strobe
RAST Receive and Send Terminal
RCF Registration Confirmation
RCS Return Channel System, Return Channel via Satellite
RCST Return Channel Satellite Terminal
RCVO Receive Only
RF Radio Frequency
RFC Request for Comment
RFI Radio Frequency Interference, Request For Information
RFP Request For Proposal
RGB Red, Green, Blue
RIP Routing Information Protocol (TCP/IP), Request in Progress
RISC Reduced Instruction Set Computer
RJ Registered Jack (prefix)
RLC Radio Link Control
RNC Radio Network Centre, Radio Network Controller
RNS Radio Network Subsystem

RNSAP Radio Network Subsystem Application Part
RNTI Radio Network Temporary Identity
ROM Read-Only Memory
RPC Remote Procedure Call
RQ Repeat request
RR Radio Regulations (**ITU-R**)
RRC Radio Resource Control, Root-Raised Cosine
RRM Radio Resource Management
RRQ Registration ReQuest
RS Reed-Solomon, Recommended Standard (EIA prefix, as in RS-232), Requirement Specification
RSAC Recreational Software Advisory Council
RSVP Resource Reservation Protocol
RT return, Remote Terminal
RTC Real-Time Clock, Request Transmit Capacity
RTCP Real-Time Control Protocol
RTG Real-Time Gateway, Routing
RTP Real-Time Protocol
RTSP Real-Time Streaming Protocol
RTT Radio Transmission Technology, Round Trip Time
R&TTE Radio equipment and Telecommunications Terminals
Rx Receive, Receiver

5.11 [S-T]

s second
SA Slotted Aloha, Selective Availability
SAC Service Access Control
SAM Stand-Alone Module
SAN Storage Area Network
SAP Service Access Point
SAR Specific Absorption Rate
SASP Satellite Access Service Provider
S-Band Generally 2-4 GHz
SBC Single-Board Computer
SBE Single Byte Extension
SBS Satellite Base Station
SC Selection Combining, Single Carrier
SCADA Supervisory Control and Data Acquisition
SCC Satellite Control Centre
SCH Schedule
SCM Selected Communications Mode, Service Control Manager
SCN Switched Circuit Network
SCPC Single Channel Per Carrier
SCPS Space Communications Protocol Specification
SCS Structured Cabling System
SCSA Signal Computing System Architecture
SCSI Small Computer Systems Interface
SCTE Society of Cable Telecommunications Engineers
SD Single Destination
SDDI Serial Digital Data Interface

SDH Synchronous Digital Hierarchy
SDI Serial Digital Interface
SDL Specification and Description Language
SDLC Synchronous Data Link Control
SDMI Secure Digital Music Initiative
SDP Session Description Protocol
SDSL Symmetrical Digital Subscriber Line
SDT SDL Design Tool
SDU Service Data Unit
SDV Switched Digital Video (fibreoptic)
sec second
SECBR Severely Errored Cell Block Ratio
SEP Spherical Error Probable
SET Stock Exchange of Thailand, Secure Electronic Transaction
SG Second-Generation
SGMP Simple Gateway Monitoring Protocol
SGSN Serving GPRS Support Node
SHF Super-High Frequency
SIM Serial Interface Module, Subscriber Identity Module
SIM card Subscriber Identification Module card
SIMM Single Inline Memory Module
SINUS Satellite Integration into Networks for UMTS Service
SIO Super I/O
SIP Session Initiation Protocol
SIT Satellite Interactive Terminals (ETSI EN 301 359)
SLA Service Level Agreement
SMA Super high frequency connector
SMC System Maintenance Client
SME Small and Medium Enterprises
SMI Structure of Management Information
SMP Symmetric MultiProcessing
SMS Satellite Multiservice System (Eutelsat), Short Message Service
SMT Surface Mount Technology
SMTP Simple Mail Transfer Protocol (TCP/IP)
SNG Satellite News Gathering
SNMP Simplified Network Management Protocol (TCP/IP)
SoC Statement of Compliance
SOHO Small Offices or Home Offices
SONET Synchronous Optical Network (fibreoptic cable)
SoW Scope of Work
SP Service Provider
S-PCN Satellite Personal Communication Network
S-PCS Satellite Personal Communications Service
SPI Synchronous Parallel Interface
SPOF Single Point Of Failure
SPS Standard Positioning Service
SPX Sequential Protocol Exchange
SR Selective Repeat
SRAM Static Random Access Memory

SRM Satellite Resource Management, Service Reference Module
SRNS Serving Radio Network System
SS Space Segment
SSBLT Source Synchronous BLock Transfer
SS#7 Signalling System Number 7
SS7 Signalling System no. 7
SSL Secure Socket Layer
SSPA Solid State Power Amplifier
SSRC Synchronisation Source Identifier
STI Singapore Telecom International
STP Shielded Twisted Pair
SU Signalling Unit, Single User (slot), Spacing Unit (of rack panel width, 5.08 mm), Single User
SUT Satellite User Terminals (ETSI EN 301 358)
S-UMTS Satellite UMTS
SV Space Vehicle
SVGA Super Video Graphics Array
SW Short Wave, Stop and Wait, Software
SW-C/TDMA Wide band Hybrid Code- and Time Division Multiple Access Scheme based Satellite standard
SW-CDMA Satellite Wideband Code Division Multiple Access
SYNC Frame Synchronisation (slot)

T2P H.323 Terminal-to-PSTN
T2T H.323 Terminal-to-H.323 Terminal
TAC Transmit Access Channel
TACS Total Access Communication System
TAF Terminal Adaptation Function
TAI International Atomic Time
TAMS Track and Manage System
TBC To Be Confirmed
TBD To Be Defined
TBTP Terminal Burst Time Plan
TC Time Code, Technical Committee
TCH Traffic Channel
TCM Trellis-Coded Modulation, Technical Clarification Meeting
TCP Transmission Control Protocol
TCPA TCP Accelerator
TDD Time Division Duplex
TDM Time Division Multiplex
TDMA Time Division Multiple Access
TE Terminal Equipment
TETRA Terrestrial Trunked Radio
TFTP Trivial File Transfer Protocol
TG Technical Group
TI Time Interval
TIA Telecommunications Industry Association (USA)
TIES Telecom Information Exchange Service
TIFF Tagged Image File Format
TIM Terminal Information Messsage

T-IP Terminal-generated IP (messages)
TLA Three-Letter Acronym
TLH Terminal Logon Handler
TLS Transport Layer Security
TO Telecommunications Operator
TOMAS Testbed of Mobile Applications for Satellite Communications
TOS Type Of Service
TOT Telephone Organization of Thailand
TP Time Protocol
TPC Turbo Product Code
TS Time Slot, Transport System
TSAP Transport Layer Service Access Point
TSG CN TSG Core Network
TSG RAN TSG Radio Access Network
TSG SA TSG Service & System Aspects
TSG T TSG Terminals
TSG Technical Specification Group
TTA Korean standards organisation
T-TAC Terminal generated TAC
TTC Telemetry, Tracing and Command
TTL Transistor Transistor Logic
TTP Trusted Third Party
T-UMTS Terrestrial UMTS
TV Television
TVRO Television Receive Only
TWT Travelling Wave Tube
Tx Transmit, Transmitter

5.12 [U-V]

U Rack Unit (of panel height, 44.45 mm)
UART Universal Asynchronous Receiver/Transmitter
U/C Up Converter
UCF Unregister Confirmation
UCID Universal Call Identification
U/M User/Message (slot)
UB User Bits
UDP User Datagram Protocol (TCP/IP)
UE User Equipment
UHF Ultra High Frequency
UK United Kingdom
UL Uplink
U/M User/Message
UMTS Universal Mobile Telecommunication System
UN United Nations
UNI User Network Interface
UNII Unlicensed National Information Infrastructure
UPS Uninterruptable Power Supply
URAN UMTS Radio Access Network
URI Uniform Resource Identifier

URJ Unregister Reject
URL Uniform Resource Location
URQ Unregister Request
US United States
USAT Ultra-Small Aperture Terminal
USD United States Dollars
USIM UMTS Subscriber Identity Module
USOC Universal Service Order Code
USRA UMTS Satellite Radio Air Interface
UT Universal Time
UTC Universal Time Co-ordinated (formerly GMT)
UTP Unshielded Twisted Pair
UTRA UMTS Terrestrial Radio Air Interface
UTRAN UMTS Terrestrial Radio Access Network
Uu UTRAN-user radio interface
UUCP Unix-to-Unix Communication Protocol
UUID Universal Unique Identifier
UV UltraViolet
UVGA Ultra Video Graphics Array
UWCC Universal Wireless Communications Consortium

V-Band Generally 46-56 GHz
VAD Voice Activity Detection
VANS Value-Added Network Services
VAT Value-Added Tax
VBNS Very high-speed Backbone Network Service
VBR Variable Bit Rate
VC Virtual Channel, Virtual Circuit
VCO Voltage Controlled Oscillator
VCXO Voltage Controlled crystal Oscillator
VDO Video On Demand
VDSL Very High Bit-Rate Digital Subscriber Line
VESA Video Electronic Standards Association (bus)
VGA Video Graøphics Array
VHE Virtual Home Environment
VHS Video Home System
VLF Very-Low Frequency
VLR Visitor Location Register
VLSM Variable-Length Subnet Masks
VM Virtual Machine
VME VersaModule Eurocard
VMS Voice Mail System
VoIP Voice over IP
VPA Voice Processing Application
VPN Virtual Private Network
VRAM Video Random Access Memory
VRML Virtual Reality Modelling Language
VSAT Very Small Aperture Terminal

5.13 [W-X]

W3C World Wide Web Consortium
WAN Wide Area Network
WAP Wireless Application Protocol
WARC World Administrative Radio Conference
WATS Wide Area Telecommunications Service
W-CDMA Wideband Code Division Multiple Access
WCR World Radio Communication Conference
WDM Wavelength Division Multiplexing
WDMA Wavelength Division Multiple Access
WHO World Health Organization
WID Wireless Information Device, Wireless Interface Device
WIMS Wireless Multimedia and Messaging Services
WIN Wireless Intelligent Network
WK Week number
W-LAN Wireless Local Area Network
WLL Wireless Local Loop
WML Wireless Mark-up Language
WOS Wireless Office Systems
WP Work Package
WRC World Radiocommunications Conference
WUI Windows User Interface, Web User Interface
WWW World-Wide Web (Internet)

xDSL Digital Subscriber Line of type “x”: A Asymetric, H High Bit Rate, RA Rate Adaptive, S Symmetric, V Very High Bit Rate
XMA Voice or Fax Mail Application
XMS Voice & fax mail server
XGA eXtended Graphics Array
XoIP Fax over IP
XIOPM Voice/fax over IP mail (server)
XML eXtensible Mark-up Language
XPD Cross Polarisation Discrimination
XPI Cross Polarisation Isolation
XSL eXtensible Style-sheet Language

5.14 [Y-Z]

Y2K Year Two Thousand
Y/N? Yes or No?
YTD Year To Date

z file name extension indicating packed (Unix)
ZAK Zero Administration Kit (Microsoft)
ZIF Zero Insertion Force
ZIP file name extension indicating packed (PKWare)
ZSL Zero Slot LAN

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