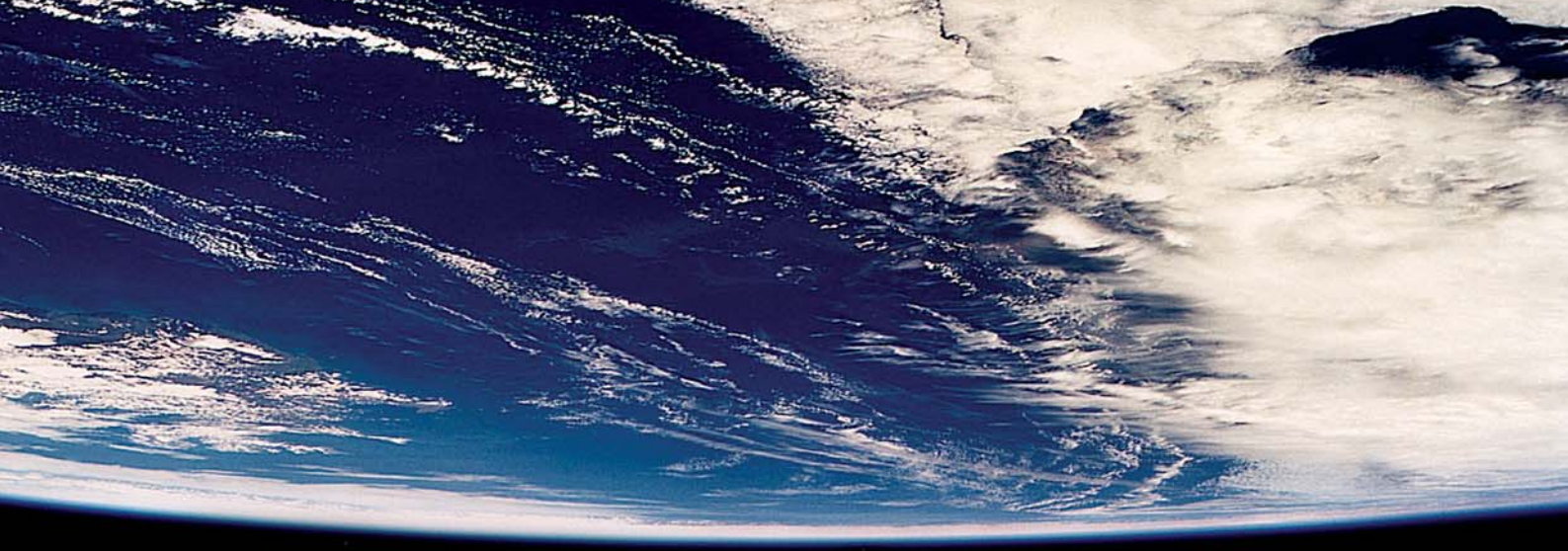


Improving access to further and higher education via satellites

A review of the opportunities afforded by recent developments in satellite technology in meeting educational needs



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This report was commissioned by JISC (the Joint Information Systems Committee) and supports its mission to provide world-class leadership in the innovative use of Information and Communications Technology (ICT) to support education and research. It is a part of a broader programme of work to review the potential offered by satellite technology to education and its ability to widen network access and enhance JISC service provision.

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The primary author of this report is **Mathy Vanbuel** who is the Managing Director of ATiT (www.atit.be). Mathy has many years experience in setting up and managing various types of projects using advanced technologies to support educational activities in the public and private sector. The author acknowledges the input and contributions from a great many people and organisations in compiling this report and case studies, particularly Helena Bijnens and Sally Reynolds.

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1. Executive Summary



The purpose of this report is to provide an overview of the opportunities afforded by recent developments in satellite technology in meeting educational needs. It has been commissioned by JISC and was written by Mathy Vanbuel of ATiT, Belgium.

1

Developments taking place in Satellite Communications Technology have significant implications for the educational community. Important innovations make low cost one- and two-way satellite services increasingly available. This technology builds on the history and experience of using satellite technology to support a range of broadcast and communications services. In broad terms, satellite communications technology can be applied for:

- Radio and television broadcasting
- Telephony
- Data, Broadband and Multimedia services
- Mobile Communications

Satellite communications service providers are expanding their business range from broadcast-type services based on high-powered and large-scale installations towards various 'direct to home' services. This evolution has been demonstrated by an increasing number of vendors offering cost-effective solutions for one- and two-way access to the Internet via satellite with small antennas. These services offer considerable advantages for end-users, particular for people in regions where other networks are not available:

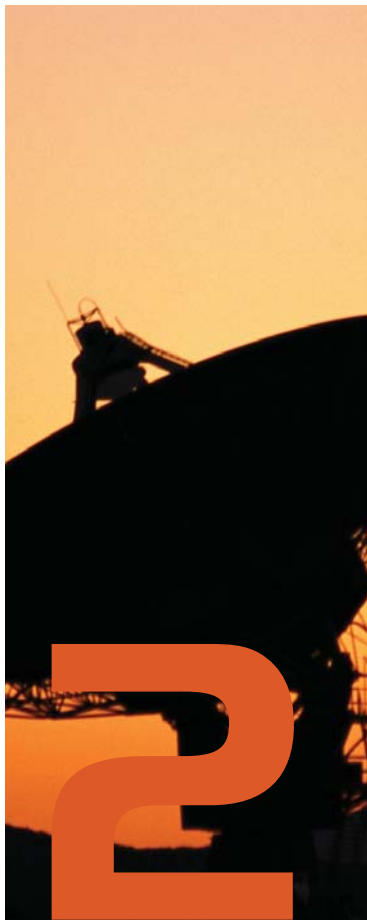
- Reception is possible with a small antenna (one already being used to receive TV could in many cases be sufficient)
- Connection is possible almost anywhere instantly within the footprint of the satellite, with no cabling work or delays depending on terrestrial infrastructure, thus effectively solving the typical 'last mile' problem
- Consumer equipment is relatively low cost
- Internet connectivity can be combined with traditional broadcasting technologies such as digital TV and radio, enabling content providers to select the most appropriate delivery means according to the type of content
- In addition, multimedia push services via satellite, such as data broadcasting or information streaming, are extremely efficient. In these cases, there is no need for a return link via modem, so there is no additional cost for connectivity to the Internet

Using satellite supported networks for educational purposes is already well established and many examples of projects and on-going initiatives exist in both the developing and developed world. It is useful to investigate these examples to understand the various issues that arise in using satellite-based services to support higher and furher education initiatives in the UK. Aspects of good practice that are worth mentioning are:

- Network design is crucial and should be based on a broad understanding of all network options including emerging services like small scale VSAT networks
- Network design should follow and support the sustainable and agreed pedagogical model. If the model is for a resources-based learning model with ready access to digital materials than the network required will be very different than for a virtual classroom type model which supports synchronous audio and video-based interaction.
- Vendors and service providers should be an integral part of the management and design team.



2. Introduction



Increased availability of online educational resources, widespread interest and an enthusiasm for Information and Communications Technologies (ICT) enhanced education, are driving the search for new ICT-based approaches. The use of ICT is dramatically changing the way in which formal and informal learning is taking place at every conceivable level of society.

A primary focus has always been enhancing infrastructure, including telecommunications infrastructure, hardware, software and networks. Without access to minimal infrastructure, transformation in the education sector through eLearning becomes almost impossible.

Regular and high-quality access to educational resources, centres of excellence, leading experts and lively peer groups is a pre-requisite for the development of eLearning programmes, regardless of where you live or study. Such access depends to a certain extent upon the available networks, their speed and reliability and how much it costs to run them.

One key technology that holds great promise is satellite communication. Important innovations are taking place throughout the satellite industry that are leading us more and more along the path towards low cost two-way satellite services bypassing the need for expensive cabling. Such services can offer near instantaneous high-quality access to digital information. However, much needs to be done and understood about these kinds of services before they can play a more significant role in education environments. Issues of availability, reach, network design, cost and authorisation, all have to be tackled and understood, both by potential service providers and potential users. It is important that the potential and implications of satellite communication are understood in the education world in order to influence the way in which services are made available and also to benefit early on from the exciting opportunities they offer.

This handbook provides the non-specialist reader with an overview of the opportunities offered by recent developments in satellite technology for education. It includes an overview of the main players and current and expected services. It also provides a general guide for those interested in setting up and using such systems in an educational context in terms of the way in which they can and should be deployed. The report makes extensive use of examples to bring to life the various types of educational applications of satellite technology in order to help the reader understand how the technologies can be put to use in education.

2.1. Outline

To allow for updates and additions, the report structure separates static from more volatile information. It is divided into 4 main sections:

Chapter 3: Basics of Satellite Communications aims to introduce satellite technology from a non-specialist point of view. The basic principles will be introduced along with a list of generic functions that satellite technology can perform, (broadcast, unicast, bi-directional, multi-casting, etc).

Chapter 4: Satellite Applications in Education will provide an overview of applications of satellite technology that are of particular interest to those concerned with education. It will also provide a basic list of the costing considerations that service providers need to take into account. This chapter also deals with specific topics of interest such as the distribution of multimedia via satellite networks, the use of satellite communications in CDNs (Content Delivery Networks) and the opportunities satellite communications can bring to provide access to remote or underserved areas.

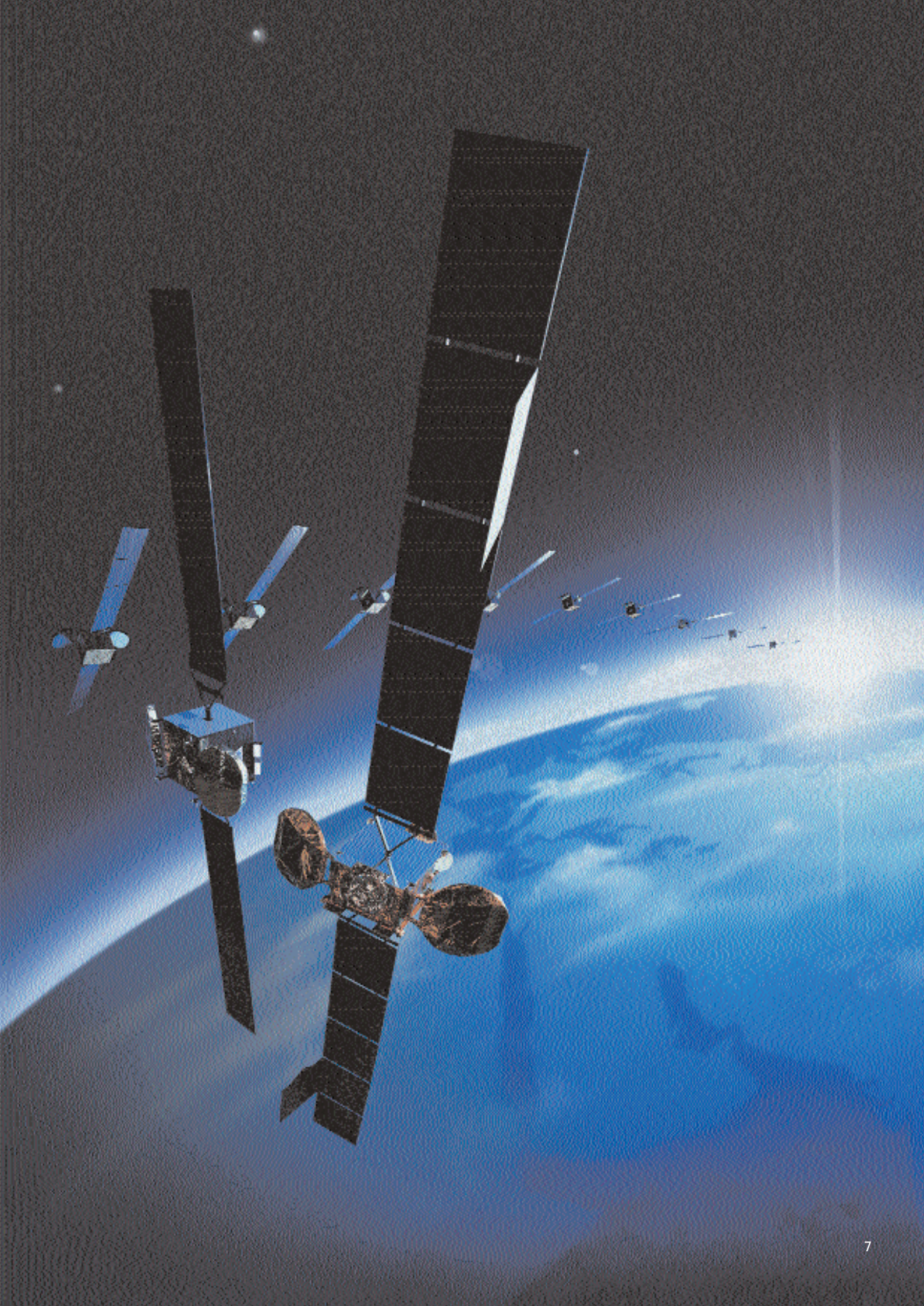
This handbook provides the non-specialist reader with an overview of the opportunities offered by recent developments in satellite technology for education.

Chapter 5: Access and Connection Technologies: this chapter focuses on the information and communication technologies (satellite based and others) that allow for end-users to communicate and exchange information.

Chapter 6: Satellites in Education (Case Studies) provides examples of applications from around the world.

Chapter 7: Satellite Operators: a list of current vendors and the services they offer in the UK provides information about vendors active in the UK.

In order to assist the reader, this report also contains a **Glossary** on page 94.



This chapter introduces satellite communication technology from a non-specialist point of view. The basic principles will be introduced along with a list of generic functions that satellite technology can perform (broadcast, unicast, bi-directional, multicasting). The chapter traces a broad history of satellite technology and discusses the developments currently taking place, covering broadcast type functions and additional applications and services.

3. Basics of Satellite Communications



It will further introduce general trends within the overall ICT sector that have an influence on the evolution of satellite technology. Although some issues and topics may not seem directly related to the use of satellites in an educational context, it is important to understand the fundamentals of the technology. This chapter is not the easiest part of the report and the reader may consider skipping to the following chapter which discusses the practical applications and return to this chapter at a later stage. Both chapters are self contained and can be read independently of the rest of the report.

3.1. Introduction

A satellite is an object that orbits or revolves around another object. For example, the Moon is a satellite of Earth, and Earth is a satellite of the Sun. In this document, we will examine human-made satellites that orbit Earth. They are highly specialized wireless receiver/transmitters that are launched by a rocket and placed in orbit around the Earth. There are hundreds of satellites currently in operation.

Satellite communication is one particular example of wireless communication systems. Similar and maybe more familiar examples of wireless systems are radio and television broadcasting and mobile and cordless telephones. Systems of this type rely on a network of ground-based transmitters and receivers. They are commonly referred to as 'terrestrial' systems as opposed to satellite systems.

Satellite communication systems differ from terrestrial systems in that the transmitter is not based on the ground but in the sky: the transmitter here consists of a ground-based part called the uplink, and the satellite-based part that 'reflects' the signals towards the receivers. This part is called the transponder.

3.2. Overview

3.2.1. Purpose

Satellites come in many shapes and sizes and have many uses. The first artificial satellite, called Sputnik, was launched by the Soviet Union in 1957 and was the size of a basketball. Its purpose was simply to transmit a Morse code signal repeatedly. In contrast, modern satellites can receive and transmit hundreds of signals at the same time, from simple digital data to complex television programmes. They are used for many purposes such as television broadcasting, amateur radio communications, Internet communications, weather forecasting and Global Positioning Systems (GPS).

3.2.1.1. Communications satellites

Communications satellites act as relay stations in space. One could imagine them as very long, invisible poles that relay high frequency radio waves. They are used to bounce messages from one part of the world to another. The messages can be telephone calls, TV pictures or Internet connections. Certain communications satellites are, for example, used for broadcasting: they send radio and TV signals to homes. Nowadays, there are more than 100 such satellites orbiting Earth, transmitting thousands of different TV (and radio) programmes all over the world.

3.2.1.2. Other applications: remote-sensing satellites

Military, government, weather, environment, scientific, positioning

Remote-sensing satellites study the surface of the Earth. From a relatively low height (480 km) up, these satellites use powerful cameras to scan the planet. The satellite then transmits valuable data on the global environment to researchers, governments, and businesses including those working in map making, farming, fishing, mining and many other industries. Instruments on remote-sensing satellites gather data about features such as the Earth's plant cover, chemical composition and surface water. Remote-sensing satellites are also used to study changes in the Earth's surface caused by human activity. Examples of this kind of observation include investigations into presence of ozone and greenhouse gasses in the atmosphere, the desertification in West Africa and deforestation in South America.

Weather satellites record weather patterns around the world. Almost all countries use the data coming from satellites like TIROS (Television Infrared Observational Satellite) ENVISAT to forecast weather, track storms and carry out scientific research. TIROS is part of a system of weather satellites operated by the National Oceanic and Atmospheric Administration (NOAA). There are two TIROS satellites circling Earth over the poles. They work with another set of satellites in geosynchronous orbit called Geostationary Operational Environmental Satellites (GOES), such as the Meteosat satellites. Using this group of satellites, meteorologists study weather and climate patterns around the world.

Many satellites in orbit conduct scientific experiments and observations. SOHO (SOlar and Heliospheric Observation) for instance is an international project managed by Europe and the United States. Its very sophisticated instruments can measure activity inside the Sun, look at its atmosphere or corona and study its surface. SOHO does not orbit Earth. In fact it orbits the Sun, about a million miles away from Earth. In that position neither the Moon nor the Earth can block its clear view of the Sun.

The military have developed the Global Positioning System (GPS), but now people are using these satellite services to determine their exact latitude, longitude and altitude wherever they are in the world. GPS satellites can be used for navigation almost everywhere on Earth: in an airplane, boat, or car, on foot, in a remote wilderness, or in a big city. GPS uses radio signals from at least three satellites in sight to calculate the position of the receiver.

Military and government institutions make extensive use of satellites for a mixture of communication, remote sensing, imaging, positioning and other services, as well as for

more secret applications such as spying or missile guidance. Extremely useful civilian technology spin-offs resulted from developments in this sector, although GPS originated as a military application. The domains of image processing and image recognition also benefited greatly from Military Research and Development.

3.2.2. System Elements

Although the purpose of this report is not to train future satellite engineers, there are certain parts of a satellite system that are worth knowing about and which can help the reader understand how satellites behave and how they can be used for different purposes. From this point onwards we will focus almost exclusively on communication satellites, particularly those parts and elements that are relevant to satellite *communications.*

The two most important elements of the communications system are the satellite itself and the Earth station.

3.2.2.1. The Earth station

Earth station is the common name for every installation located on the Earth's surface and intended for communication (transmission and/or reception) with one or more satellites. Earth stations include all devices and installations for satellite communications: handheld devices for mobile satellite telephony, briefcase satellite phones, satellite TV reception, as well as installations that are less familiar, eg VSAT stations and satellite broadcast TV stations. The term Earth station refers to the collection of equipment that is needed to perform communications via satellite: the antenna (often a dish) and the associated equipment (receiver/decoder, transmitter).

Antennas vary in size to match the particular service for which they are designed. For example, a 70 cm antenna may be sufficient for direct reception of satellite TV programmes in the home, but would not be suitable for, for example, transmitting television programmes.



Handheld satellite telephone, antenna for satellite TV reception, satellite transmitting Earth station

Images: Ericsson/Globalstar, SES-ASTRA (2)

The other part of the Earth station is the application device which, in the case of reception, translates radio signals into information that can be displayed on a TV screen or processed by a computer. In the case of transmission, this device will transform information into a signal that is suitable for transmission via the antenna, using modulation, amplification and other processing techniques. In the case of VSAT-type two-way systems, both send and receive functions can be carried out at the same time.

3.2.2.2. The parts in the sky

The two main parts in the sky common to all satellites are called the payload and the bus.

Payload: transponders, antennas

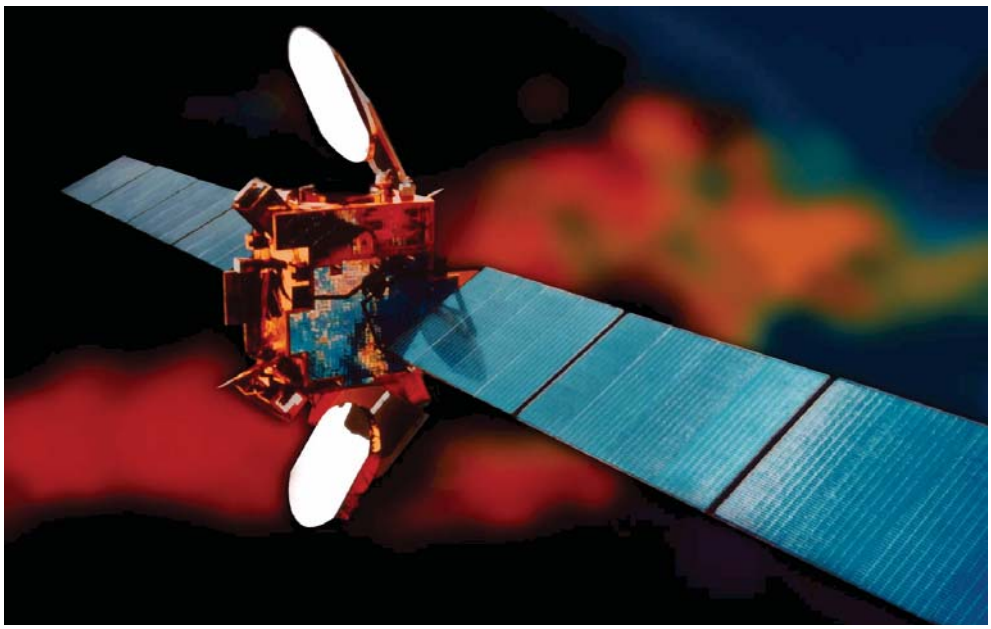
The payload represents all equipment a satellite needs to do its job. This can include antennas, cameras, radar and electronics. The payload is different for every satellite. For example, the payload for a weather satellite includes cameras to take pictures of cloud formations, while the payload for a communications satellite includes large antennas to transmit TV or telephone signals to Earth.

The transponder is the key component for satellite communications: it is the part of the payload that takes the signals received from the transmitting Earth station, filters and translates these signals and then redirects them to the transmitting antenna on board. Communications satellites carry a large number of transponders on board (normally from six to more than 24), enabling them to deliver multiple channels of communication at the same time. These channels are called carriers.

There are two main types of transponders. The 'bent pipe repeater' does not actually process the signal at all. The second type of transponder, the 'onboard processor', can introduce digital detection for the uplink signal and subsequent digital switching and modulation for the downlink. Onboard processing is a major step in the implementation of new technologies onto satellites. In the case of Iridium and many of the Internet access satellites, satellites act as mini switchboards in the sky.

Communications satellites carry, as part of their payload, antennas that receive the original signal from the transmitting Earth station and re-transmit this signal to the receive stations on Earth. The antennas that were used in the past to do this were omni-directional (transmitting signals in every direction) and not very effective. They were replaced by more efficient high-gain antennas (most often dish shaped) pointing quite precisely towards the areas they were servicing. To allow for flexibility in services or areas covered, later developments allowed the re-pointing of the so-called steerable antenna to cover a different area or to reshape or reformat the beam. Future developments will allow for a highly precise and efficient reshaping of the transmitted beam in order to cover very small areas (pencil beams). This will greatly facilitate the differentiation of services within large regions. The antennas on board the satellite are typically limited in size to around 2–3 m by the space that is available on the satellite structure.

Image Eutelsat



Communications satellite

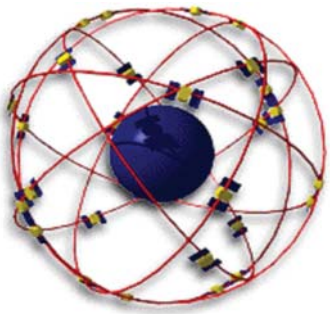
Bus: physical platform, remote control

The bus is the part of the satellite that carries the payload and all its equipment into space. It is the physical platform that holds all the satellite's parts together and that provides electrical power, navigation, control and propulsion to the spacecraft. The bus also contains equipment that allows the satellite to communicate with Earth, a kind of 'remote control'.

Orbits: GEO, MEO, LEO, elliptical, polar

The most common type of communications satellites, particularly the broadcast satellites like AfriStar, Intelsat, PanAmSat, Eutelsat and ASTRA, are in geosynchronous orbit (from geo = Earth + synchronous = moving at the same rate). That means that the satellite always stays over one spot on Earth. It does this by placing the satellite in a position 35,786 km out in space perpendicularly above the equator. The imaginary ring around the Earth where all geostationary satellites are stationed for their lifetime is called the Clarke belt. The consequence of this type of fixed location is that Earth stations (receive as well as transmit stations on the Earth surface) can almost be permanently fixed because they are constantly pointed to the same point in the sky where they 'see' the satellite.

A medium Earth orbit (MEO) satellite is one with an orbit from a few hundred miles to a few thousand miles above the Earth's surface. Satellites of this type are in a higher orbit than low Earth orbit (LEO) satellites, but lower than geostationary (GEO) satellites. The orbital periods (the time in between two successive passes over one particular place on Earth) of MEO satellites range from about 2 to 12 hours. Some MEO satellites orbit in near perfect circles, therefore they have constant altitude and travel at a constant speed. Others have a more elliptical shaped orbit, which results in different fly-over times according to the place on Earth from where they can be seen. A fleet of several MEO satellites with properly coordinated orbits can provide global coverage. There are several advantages of the use of MEO satellites: because they are closer to the Earth's surface than geostationary satellites, they require less power to transmit. The Earth stations (transmitters and receivers) by consequence can be much smaller and have a small rod-shaped antenna. It is possible to use mobile and even handheld terminals with such systems.



Low earth orbiting satellite system

A low Earth orbit (LEO) satellite system consists of a large number of satellites each in a circular orbit at a constant altitude between 320 and 800 km. Because they orbit so close to Earth, they must travel very fast so gravity does not pull them back into the atmosphere. Satellites in LEOs circle around the Earth at 27,359 km per hour. The orbits take the satellites over the geographic poles. Each revolution takes from less than 90 minutes up to a few hours. The fleet is arranged in such a way that from any point on the surface at any time at least one satellite is in line of sight. The system operates in a cellular network structure (almost like mobile phones). The main difference is that in a mobile telephone network the relay towers or aerials are fixed on the Earth while with satellites these aerials (called transponders or wireless receiver/transmitters) are moving in space. LEO systems may form the space segment of future mobile phone systems (such as S-UMTS) that will allow true mobile, global, broadband multimedia

connectivity. But although telecoms experts predicted a bright future for this technology in the beginning of this century, to date only a few systems have actually got off the ground.

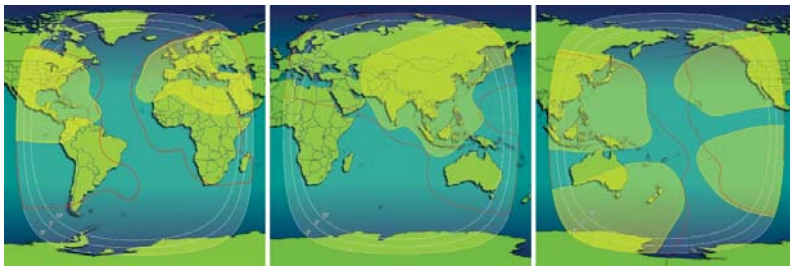
Footprints: global, regional, spot beams

The area on Earth that the satellite can 'see' (or reach with its antennas) is called the satellite 'footprint'. A satellite's footprint refers to the area over which the satellite operates: the intersection of a satellite antenna transmission pattern and the surface of the Earth.

Global coverage requires that the pattern of satellite antenna transmission covers the largest possible portion of the Earth that can be viewed from the satellite. For geostationary satellites, the beam width for global coverage is about 17.4 degrees.

No satellite can cover the whole surface of the Earth at one time: to achieve a global coverage, multiple transmission beams from at least 3 different satellites are combined.

Image: Intelsat



Combining footprints from Intelsat APR-1, 511 and 701 providing global coverage

The map above shows examples of how different satellites cover different areas. The combined Intelsat satellite footprints on this map cover the whole Earth. A person in Australia can use this satellite to communicate with anyone in Alaska. In combination with the regional beams from these satellites, communication can be established between many areas simultaneously.

Regional or zone coverage is the result of a partial illumination of the global coverage area. The area may have a simple shape such as a circle or ellipse or may be irregularly shaped (contoured) to cover certain areas most effectively, for example the shape of a continent or sub-continent. Typical regional beams measure around 5 degrees in width.

Image: Eutelsat



Regional coverage of the Eutelsat W1



Image: Eutelsat

Spot beam coverage towards South Africa from the Eutelsat W1

Spot beam coverage is an area that is much smaller than global coverage. The beam width is reduced to around 2 degrees. Spot beams have the advantage of high antenna gain, but are disadvantaged because they can only cover a smaller area. This drawback can be overcome by the combination of multiple spot beams.

Most geostationary telecommunication satellites cover large regions (continents or sub-continents). Sometimes satellites cover different areas at the same time from where they are positioned. For example: the Eutelsat W1 satellite, a typical broadcast satellite, positioned at 10 degrees East, provides a high-power coverage of Europe with a total of 20 channels. In addition, the satellite provides a high-power steerable narrow coverage carrying another eight channels directed towards southern Africa (see map above).

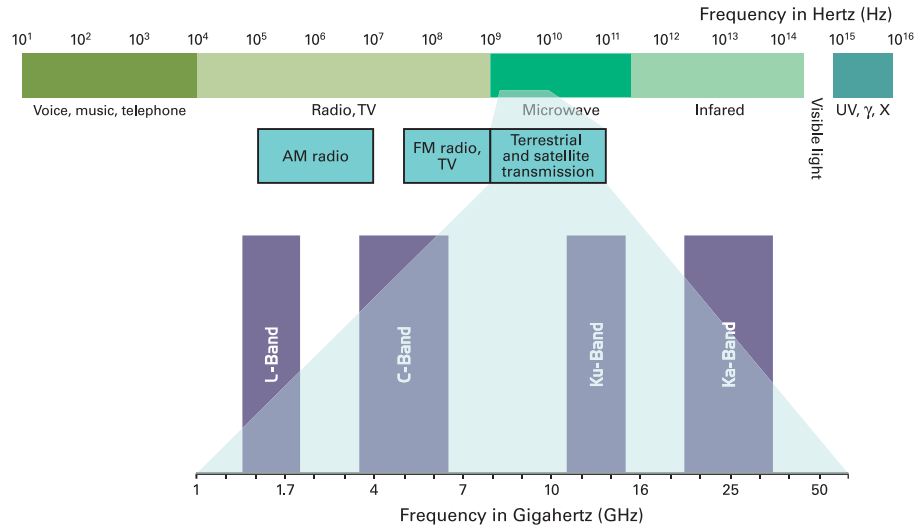
Being on the edge of the satellite footprint means the curvature of the Earth starts to disrupt transmission. It also means being further away from the satellite and therefore having to transmit or receive over larger distances through the atmosphere than would be required if transmitting/receiving from the centre of the footprint. Antenna size and power by consequence are invariably increased at the edge of the footprint. These values can be deducted from the footprint maps that are published by satellite service operators (see maps above). The numbers on the circles on the maps above indicate the signal strength received at that location expressed in dBW. From tables like the one below, users who wish to receive a transmission can read what size antenna they need. The size varies depending on the meteorological conditions of the location: places with regular heavy rainfall will need the larger dimension.

Antenna size and signal strength

Signal Strength	Minimum Size	Maximum Size
36 dBW	240 cm	360 cm
40 dBW	120 cm	150 cm
45 dBW	90 cm	99 cm
50 dBW	60 cm	65 cm
55 dBW	40 cm	50 cm

Frequency bands

Satellite communications, like any other means of communication (radio, TV, telephone, etc), use frequency bands that are part of the electromagnetic spectrum. The electromagnetic radiation spectrum starts with the longest waves (including those in the audible range) and extends through radio waves and the visible light, which is effectively a very small part of the spectrum, all the way to the extremely short wavelengths such as radioactive radiation. Within this broad range of frequencies, the International Telecommunications Union (the United Nations institution that regulates worldwide use of airwaves) has allocated parts of the spectrum that are suitable for and dedicated to transmission via satellite. Some of these bands are exclusively dedicated to satellite transmission; others are shared with terrestrial transmission services.



Satellite communications spectrum

The satellite transmission bands that are of interest to us are the C-, Ku- and Ka-bands.

C-band is the oldest allocation and operates in the frequency range around 6 GHz for transmission (uplink) and between 3.7 and 4.2 GHz for reception (downlink).

Ku-band is the most common transmission format in Europe for satellite TV and uses around 14 GHz for uplink and between 10.9 and 12.75 GHz for downlink.

Ka-band uses around 30 GHz up- and between 18 and 20 GHz downlink frequency. C-band and Ku-band are becoming congested by an increasing amount of users, so satellite service operators are more and more turning to the use of Ka-band.

The selection of the band is not something that individual service providers decide, but is rather chosen by large satellite operators based on different factors:

- Availability: C-band is still the most widely available worldwide. Ku-band is becoming more available recently in regions which were less covered in the past (South America, Asia, Africa)
- C-band is more prone to interference from other transmission services that share the same frequencies (adjacent satellites or terrestrial transmissions) than the higher bands
- While the C-band technology is cheaper in itself, it requires larger dishes (1 to 3 m) than Ku- and Ka-band (0.6 to 1.8 m) and therefore imposes relatively higher (installation) costs on the end-user
- Ku- and especially Ka-band make better use of satellite capacity
- Higher frequency bands (Ku- and especially Ka-) suffer significantly more from signal deterioration caused by rainfall: to ensure availability in bad weather conditions, the signal has to be much stronger. Note that 0.1% of unavailability means in fact that the service will be interrupted for almost 9 hours over a 1-year period. 1% unavailability represents 90 hours or almost 4 full days

3.2.3. Satellite control and lifetime

In principle, geostationary satellites occupy a fixed position in space and consequently the ground-based antennas do not need to be constantly redirected to follow the satellite's movements. The fact that the orientation of ground-based antennas is fixed is a major advantage of the geostationary satellite orbit used by satellite broadcasters. In practice however, the satellite wanders slightly around its nominal orbital position under the gravitational influence of bodies such as the Sun and the Moon, as well as other influences such as Sun radiation pressure and Earth asymmetry.

It is therefore necessary to take corrective actions in order to keep the satellite within acceptable margins from its ideal position. This is achieved by activating the so-called 'thrusters' that are mounted on the body of the satellite as part of its propulsion system.

As long as the satellite has enough fuel left to operate its thrusters, it can be kept in the correct position. As soon as the satellite is out of fuel, it will drift out of control and into space, which brings an end to its operational life. The satellite service operator can decide to save on fuel (and by consequence extend the lifetime expectancy of a satellite) by allowing the satellite to drift a little bit. Although this may bring down the costs for the communication via the satellite considerably, there is a consequence on the Earth station side. These stations have to be equipped for tracking (following the drift of) the satellite. The Earth stations that are used with LEO and GEO systems use omni-directional antennas that make precise pointing of the antenna unnecessary. However, for this application, the ability to 'see' the satellite (line of sight should not be obstructed by walls, roofs, excess foliage) is still required, which means that indoor use is excluded.

The communication functions of a satellite (antennas, processors) are powered by electricity provided through a combination of solar energy and batteries. These batteries automatically take over the power supply from the large wing-shaped solar cell panels at moments when the satellite finds itself in the shadow of the Earth.

LEOs and MEOs spin around the Earth at high speeds in order to resist the Earth's gravitational forces. They are designed to be cheaper and therefore are smaller and lighter than large GEOs. They take less fuel to correct their flight paths and in most cases have a shorter life expectancy than GEOs. LEO operators expect to renew their satellite fleet between 5 and 7 years. GEO operators estimate the lifetime of their satellites to be between 10 and 12 years.

3.3. Applications of Satellite Communications Technology

3.3.1. Introduction

Satellite communications systems differ from terrestrial systems in one obvious and important aspect – the transmitter is no longer located on the ground but rather in the sky. Because it's positioned in space, it is able to serve a very large geographical area. This has several advantages.

As few as three geostationary satellites can cover almost the whole of the Earth's surface, with the exclusion of the sparsely populated polar regions. To achieve the same coverage by terrestrial means would require a very large and expensive network of ground-based transmitters.

Services can be established quickly, since coverage is available for everyone from the day transmissions start. There is no need for a phased introduction as is the case with ground-based transmissions where antennas need to be added to meet the expansion of the serviced area. With satellite communications, even users in very remote locations enjoy the same level of service as any other user in the coverage area.

Satellites can overcome national boundaries, providing possibilities for truly international services.

Although terrestrial systems may be better suited generally to provide communications services, in many cases the need to be connected can only be met effectively and rapidly by the implementation of satellite services.

3.3.2. Radio and TV Broadcasting

The most familiar use of satellites is television broadcasting. TV satellites deliver hundreds of television channels every day throughout the world. These satellites are even used to supply television signals to terrestrial transmitters or cable-head end stations for further distribution to the home, or to exchange signals between television studios. The bandwidth required to transmit multiple programmes at the same time can easily be provided using satellites. In addition, developments in broadcast technology (digitalisation, multiplexing and compression) allow different types of transmissions to be sent sharing the same satellite signal. To address the largest possible number of viewers, the cost to the viewers must be small, requiring small receive antennas and cheap receivers.

Satellite service operators such as Intelsat, Eutelsat, ASTRA, PanAmSat, NileSat, AsiaSat and AfriStar carry the signals for satellite broadcasters such as BSkyB, CanalPLus, Multichoice, DirecTV and WorldSpace. These in turn bundle programmes from different public and private broadcasters in order to make them accessible for their viewers in an open ('free-to-air') or closed (restricted) way. Some satellite broadcasters bundle special offers into so-called 'bouquets of services' that are offered at additional cost.

The importance of satellite TV broadcasting is enormous: at the moment Eutelsat broadcasts over 900 TV channels and 560 radio stations to more than 84 million satellite and cable homes, the vast majority of them via the five HOT BIRD satellites at 13 degrees East. ASTRA, another European direct-to-home satellite system, transmits more than 1,000 television and radio channels in analogue and digital format to an audience of more than 89 million homes throughout Europe. It does this via 12 satellites at the orbital positions of 19.2 degrees, 24.2 degrees and 28.2 degrees East.

In order to make their offer more attractive to broadcasters, satellite service operators try to place their satellites aimed at the same regional market as far as possible in one single position. This is why we find the Eutelsat HotBird constellation at 13 degrees East or the ASTRA position at 19 degrees East, where in each case a number of satellites are clustered. In consequence, viewers need to point their antennas in one direction only in order to receive a large number of satellite programmes coming effectively from different satellites but looking as if they come from only one.

There are many different applications of satellite TV viewing, depending on the needs and objectives of the broadcaster or the viewers. Direct-to-Home or DTH – also called DBS or Direct Broadcast via Satellite – speaks for itself: the TV programmes are aimed at the consumer and transmitted in such a way that residential customers can buy and install the equipment to receive the programmes at the lowest possible expense. This requires a network of local resellers that offer the hardware (satellite receive

Image: Eutelsat



Satellite TV reception antenna



Image: Eutelsat

The Eutelsat HotBird position at 13 degrees East

equipment), installers (technicians that assist the customer in setting up the receive equipment) and service suppliers (who provide and administer subscriptions).

Programme suppliers can opt for free-to-air programming, where every viewer with a standard satellite receiver can receive and view the programme without restrictions. However, some programmes contain information that is not for public viewing. To protect these programmes so that only those who are the targeted audience will be able to view the contents, some type of conditional access can be applied. What happens is that programmes are encrypted and must then be unscrambled with a specific device (usually integrated in the receiver and therefore often called an Integrated Receiver Decoder or IRD) to view the contents.

The move from analogue to digital services

The number of analogue channels transmitted and the number of homes receiving analogue continues to decrease. However, analogue takes up a significant portion of the range of frequencies available. In addition, even in space, transmission capacity is limited. Where an analogue signal will occupy a full transponder consuming a bandwidth of 36 or even 72 MHz, digital broadcasting makes it possible to compress signals, vastly increasing the number of channels available by combining multiple programmes onto one single transponder.

Nowadays, most digital TV signals are compliant to the MPEG-2/DVB standard and can be received with standard consumer digital reception equipment that decodes the signal and separates the different types of content out of the data stream. With transmission bit rates between 34 and 38 Mbps, a digital signal can carry a combination of up to 12 television channels, along with numerous radio transmissions and data.

Consequently, it is digital television that is now driving the satellite TV market, aiming at large numbers of consumers equipped with small antennae of typically 50 to 80 cm in diameter in Western Europe and 1.2 to 1.5 m in diameter in other regions. Digital technology has spurred the development of interactivity and aided the convergence of the worlds of television, radio, personal computing and telephony.

It appeals to the end-user by providing better video and audio quality, improved programme and service choice and greater control over content delivery.

Pay TV is a service where the viewer is charged according to the programmes she/he

views, selected from the TV programme on offer. Video on Demand and Near Video on Demand enables individual viewers to decide at any given moment (in the case of real Video on Demand) or at a later time to be scheduled (in the case of Near Video on Demand) to view the programme of his/her own choice. IP-TV is a Video on Demand application using compression technologies that allow highly efficient distribution of video and audio using common multimedia formats such as MPEG-1, 2 and 4. Streaming technologies are based on the Internet Protocol, which allows delivery over all kinds of networks including the Internet.

The latest development in advanced television applications including delivery via satellite is the Personal Video Recorder (PVR). These devices are used both to digitally record and play back programmes: the programme provider sends the content the normal way (TV networks, cable, satellite). At the receive end the content is fed into the PVR. Compression such as MPEG-2 and MPEG-4 is used to decrease the bandwidth. The PVR unit is basically a computer that saves the incoming live TV signal from the cable or antenna onto its large internal hard drive. In this way, the viewer can play it back with a few seconds delay. The viewer is then watching off the computer hard drive, instead of straight from the antenna or cable connection. This allows the viewer to rewind, slow down, stop and pause at any point.

Broadcasters and content providers are able to improve their service offers. New satellite facilities that are being offered or under development are Pay TV services, (Near) Video on Demand, IP-TV delivery and Personal TV using devices such as the Personal Video Recorder (PVR) or the Multimedia Home Platform (MHP[1]), services that are called interactive TV or enhanced TV. While the concept of interactive TV (iTV) is not new (there have been numerous interactive TV pilot services and some limited applications have been rolled in parts of the world), the broadcast world seems to be waiting for final and concrete iTV standard protocols and definitions to give the public uptake the expected boost. Interactive or enhanced services such as electronic programme guides, on-screen games, quizzes, enhanced TV with retrievable background information on demand, recording, rewinding, even Internet services such as mail and web browsing, are all applications that are not only appealing new services for leisure TV but will also find applications within the education domain where the high degree of penetration of TV sets and transmit capacity combined with the low threshold of the television programmes for the end-user, may well become a strong argument for the use of interactive TV in educational communities.

1 The Multimedia Home Platform (MHP) is a software specification that will be implemented in set-top boxes, integrated digital TV receivers as well as multimedia PCs. The MHP will connect the broadcast medium with the Internet, television, computer and telecommunication and enables digital content providers to address all types of terminals ranging from low-end to high-end set-top boxes, integrated digital TV sets and multimedia PCs.

But even if the broadcasting world is rapidly going digital, analogue TV and radio are set to remain for several years yet. For some services, analogue is still the most attractive option due to the large installed audience base and the widespread availability of consumer equipment that is less expensive than digital equipment. Analogue is particularly popular for free-to-air broadcasting. Moreover, the capacity to transmit several audio sub-carriers on one analogue TV signal allows multilingual TV programmes. As for analogue radio broadcasting, up to eight mono channels or four stereo pairs can be transmitted as sub-carriers of an analogue television signal. However, due to the heavy use of analogue sub-carriers and the decreasing number of transponders used for analogue TV, analogue sub-carriers are becoming less and less available. Service providers considering new audio services should therefore consider digital. When you take into account the cost of transmission and the numerous innovative applications that are becoming available, such as the PVR, encryption and the ability to carry data for multicasting, the appeal of digital broadcasting is hard to resist.

Business radio and TV

Narrowcasting or business TV and radio is a term used for satellite broadcasters who use transmission time to reach a very specific audience. Technically speaking, there is no difference with broadcast satellite TV applications described in the previous section. Digital television has made it possible to distribute information within organisations and companies that are geographically dispersed, or to deliver distance education. Similarly, digital radio allows for the delivery of radio services to relatively small closed user groups.

MPEG-2/DVB technology is the dominant standard for digital television, but other computer-based media coding techniques (such as MPEG-1, Real Video, etc) are also used to embed video and/or audio into data streams, often integrated with other multimedia or Internet services. Transmission via satellite requires there to be digital receivers available at relatively low prices on the consumer market. The advantage is that more advanced or popular audio coding techniques (for example MP3) can also be used and that the same stream can be used for other applications, such as data distribution, outside broadcast hours.

Contribution ('backhaul' and SNG)

Satellite transmission technologies can be used to bring the signal that needs to be broadcast to the place where it can be processed and prepared for re-distribution, for example: to a broadcaster's main studio; to a number of cable-head end stations; to an Internet Service Provider where it can be injected into the Internet; or to a network of local Points-of-Presence for distribution in local networks. These links respond to the need for point-to-point and point-to-multipoint transmission and are often called a 'hop'. The signal can be digital or analogue and can include video, audio, data or multimedia.

When used by news companies this type of contribution link is called Satellite News Gathering (SNG). News and information are sent from a mobile station – a truck equipped with an antenna or a suitcase uplink – through the satellite to a central point, which is in most cases the home studio, equipped with an Earth station with a fixed antenna. The home studio can retransmit it live or record and re-edit it for later use.

3.3.3. Telephony

3.3.3.1. Thin route or trunk telephony

Telecom operators have been using satellite communications for many years to carry long-distance telephone communications, especially intercontinental, to complement or to bypass submarine cables. To the end-user this is transparent: the phone calls are routed automatically via the available capacity at any given moment. However, the 74,000 km round trip, even at the speed of satellite signals, takes 250 milliseconds causing a delay that makes telephone conversation rather unnatural, hence the preference for telephony over cable.

In regions where it is not so easy to install terrestrial telephone connections because of the low density of population or because of the nature of the terrain, satellite is still being used to connect the local switchboard to the telephone network. This technology is called thin route or trunk satellite telephone networking. Wireless (microwave, two-way radio, etc) and optical links, however, are replacing satellite increasingly in this area. With the advent of true mobile telephony (cellular systems such as GSM, the Global System for Mobile communication), and new end-user connection technologies such as Fixed Wireless Local Loop where there is no longer a need to wire up each subscriber, satellite thin route telephony is becoming less and less popular. In the future, satellite thin route telephony is expected to only hold a small share of trunk telephony in areas that are otherwise impossible to reach.

3.3.3.2. Mobile satellite telephony

Mobile telephony allows the user to make telephone calls and to transmit and receive data from wherever he/she is located. Digital cellular mobile telephony such as GSM has become a worldwide standard for mobile communications, but its services lack coverage over areas that are sparsely populated or uninhabited (mountains, jungle, sea), because it is not economically viable or practical for the network operators to build antennas there. Satellite telephony seems to be able to provide a possible solution to the problem of providing voice and data communications services to these other locations.

Inmarsat

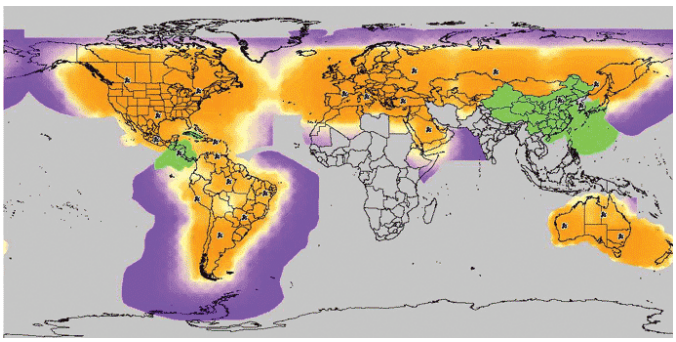
Inmarsat was the world's first global mobile satellite communications operator, founded in the late 1970s. It focuses on communications services to maritime, land-mobile, aeronautical and other users. Inmarsat now supports links for phone, fax and data communications at up to 64 Kbps to more than 210,000 ship, vehicle, aircraft and portable terminals.

The range of Inmarsat systems includes mobile terminals from handhelds to consoles, with easy set-up mechanisms that allow users wherever they are to connect via a global fleet of geostationary Inmarsat satellites to the terrestrial communications network and to carry out telephone conversations, data transfers, and increasingly multimedia applications and Internet access. Inmarsat is aimed at professionals who need a reliable communications system wherever they are: ship owners and managers, journalists and broadcasters, health and disaster-relief workers, land transport fleet operators, airlines, airline passengers and air traffic controllers, government workers, national emergency and civil defence agencies, and peacekeeping forces. The cost is rather high while the capacity is still rather limited: voice/fax/data systems achieve a maximum data rate of 64 Kbps at connection costs starting at almost US$ 3 per minute. Dedicated mobile IP systems can achieve a maximum download speed of up to 144 Kbps.

LEO-based telephony

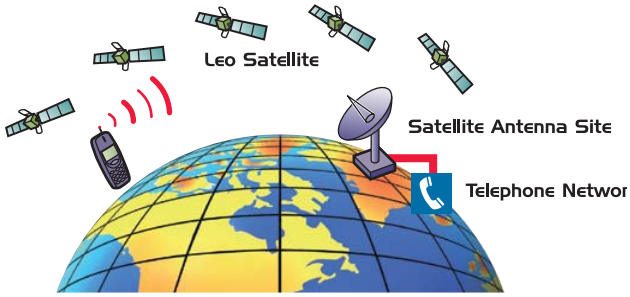
Another mobile satellite communications system is the Globalstar satellite telephone network. Globalstar, which was established in 1991 and began commercial service in late 1999, offers service from virtually anywhere across over 100 countries, as well as from most territorial waters and several mid-ocean regions. Globalstar deploys handheld telephone sets that switch between the terrestrial wireless telephone network (GSM) and a LEO-based satellite network in places where no terrestrial GSM network is available.

Image: Globalstar Europe



Globalstar telephony coverage map (April 2003)

Signals from a Globalstar phone or modem are received by one of the 48 LEO satellites and relayed to ground-based gateways, which then pass the call on to the terrestrial telephone network.



Globalstar LEO satellite telephone service

A similar LEO satellite communications system is Iridium. Both Iridium and Globalstar are based on constellations of satellites that can communicate with small handheld telephone sets as well as between themselves, effectively acting as switchboards in the

sky. The satellites orbit at approximately 800 km above Earth and provide worldwide mobile telephony and Internet access. Because of the short delay times (thanks to the low height and thus short distance between Earth station and satellite) it is theoretically possible to introduce videoconferencing and interactive multimedia to both fixed (with outdoor antenna) and mobile transceivers at a later stage. It is easy to understand how LEO services would be suited for urban or rural areas that are not connected to a broadband terrestrial infrastructure or that cannot be covered economically using traditional terrestrial infrastructures.

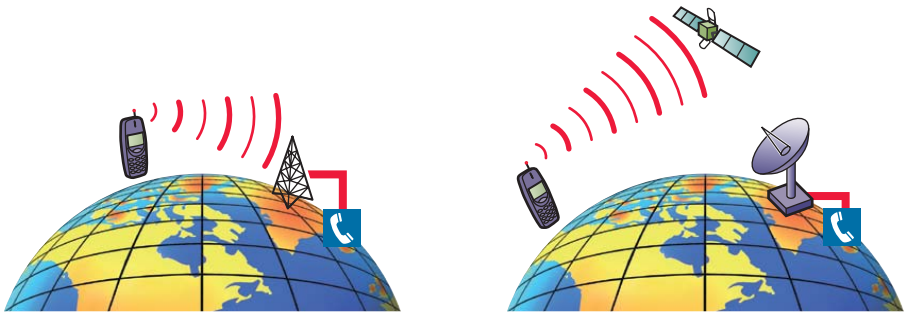
GEO-based telephony

An alternative approach to satellite telephony uses a geostationary satellite instead of the LEO. This results in longer delays (approximately half a second) but switching on board the satellite reduces this inconvenience as much as possible. The Thuraya mobile satellite system was launched in 1991, its satellite maintains a geo-synchronous orbit at 44 degrees East. Thuraya operates effectively in both satellite and GSM environments. Its satellite network capacity is about 13,750 telephone channels. When within reach of a GSM network, Thuraya's mobile phone acts as an ordinary GSM handset. Outside this GSM coverage it seamlessly switches to become a satellite telephone. The system can be used for voice, data, fax, SMS and location determination (GPS-like). Thuraya handsets and subscription services are distributed through service providers (mobile telecom companies) located in 106 countries in Europe, Africa, the Middle East, Asia and India. Through roaming agreements, customers can use their handsets in a number of other countries as well.

Image: Telit/Globalstar and Hughes/Thuraya



Satellite telephones



Thuraya GSM/satellite telephone service

Satellite based mobile telephony: conclusion

The deployment of these LEO-based services has not been as successful as had been hoped by the providers. While initially it took a long time before the first service became available, the competitors, in this case cellular mobile telephony, eg GSM, had already won a market share that was lost for the new technology. The receivers were initially too expensive (about US$ 2,000), the communications costs too high (from less than US$ 1 to more than US$ 5 per minute depending on the call destination and the payment programme, Thuraya being cheaper in general) and the service had a reputation of not being very reliable: the technology did not seem to be sufficiently mature and calls were frequently interrupted. The transmission speed was very low (maximally 9.8 Kbps which is comparable to GSM-based transmissions).

3.3.4. Data, broadband and multimedia services

When we consider that TV and radio, telephone and fax nowadays are all being digitised and packaged in datagrams (small data packets) to be transported on any type of network, it is easy to understand that any digital content can be distributed in much the same way. This is obviously the case with data over satellite communications networks.

Normally, data does not suffer from the small delay caused by the long transmission path via satellite. Telecoms and global telecommunications carriers have been using satellite data links to complement existing wire-based data networks for many years. Large, multinational companies or international organisations in particular have

exploited the ability to transfer data over satellite networks since the time when smaller and cheaper satellite terminals and more flexible satellite network services became available. Satellite services could support the different services they were interested in, such as data collection and broadcasting, image and video transfer, voice, two-way computer transactions and database inquiries.

The development of common datagram and data transport standards, and the digitisation of voice, image, video and multimedia in general, have led to a shift to Internet Protocol (IP)-based satellite communication systems that integrate seamlessly into the Internet world. It is useful at this point to make a distinction between three different types of applications.

3.3.4.1. IP over satellite for ISPs

Telecoms and connectivity providers have started using satellite communications to bypass the increasingly clogged terrestrial and submarine networks to complement their backbone connectivity or to supplement them where they are not yet available. This approach takes advantage of the fact that satellite is not a real point-to-point connection like cable, but a connection that allows the delivery to multiple points at the same time. This allows for simultaneous updating of multiple caching, proxy or mirroring servers.

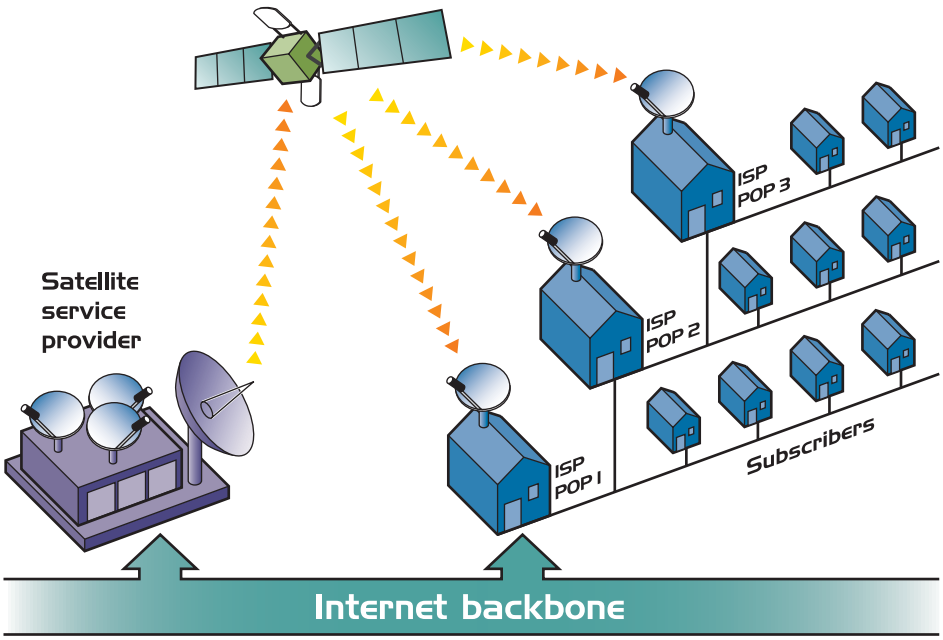


Image: Eutelsat

IP via satellite for ISPs

In much the same way, it is possible to push Internet content to and even over the edges of existing networks. When it is necessary to provide large amounts of content to places that are poorly connected to the Internet, it is now possible to push content to local PoPs (Point of Presence) edge servers. These can then in turn serve as ISPs to the local users or user communities.

Although cable may be the preferred way to connect areas with a concentrated demand for access (like cities or densely populated areas), satellite communications can still assist local ISPs especially when there is not yet a reliable wired connection to the Network Access Points or the Metropolitan Access Exchange points on the backbone. This is also practical when a large quantity of content needs to be transported between two particular points and high-capacity cable connections are not available.

3.3.4.2. Corporate or institutional VSAT networks

A particular application of data via satellite is VSAT (Very Small Aperture Terminal) networks. Organisations with many remote affiliates can create a private high-speed

satellite intranet, which links the main office reliably with all local sites. Within and amongst institutions there is an ever-growing need to communicate and to enhance the existing networks, both human and physical. These networks, comparable to the corporate or institutional networks of large multinational companies or international institutions, today need high speed, reliable and cost-effective communications. This is especially true when the locations are dispersed over remote regions and multiple countries, and barely connectable via a terrestrial network infrastructure. In this case, satellite communications are an effective way to provide private or secure data networks. VSAT can provide a complete network capable of connecting all sites and connecting to the Internet, wherever the facilities are located or wherever facilities will be located in the foreseeable future, including the homes of staff, members, students etc.

VSAT stands for Very Small Aperture Terminal and refers to combined send/receive terminals with a typical antenna diameter of 1 to 3.7 m linking the central hub to all remote offices and facilities and keeping them all in constant immediate contact. VSAT networks offer solutions for large networks with low or medium traffic. They provide very efficient point-to-multipoint communication, are easy to install and can be expanded at low extra cost. VSAT networks offer immediate accessibility and continuous high-quality transmissions. They are adapted for any kind of transmission, from data to voice, fax and video.

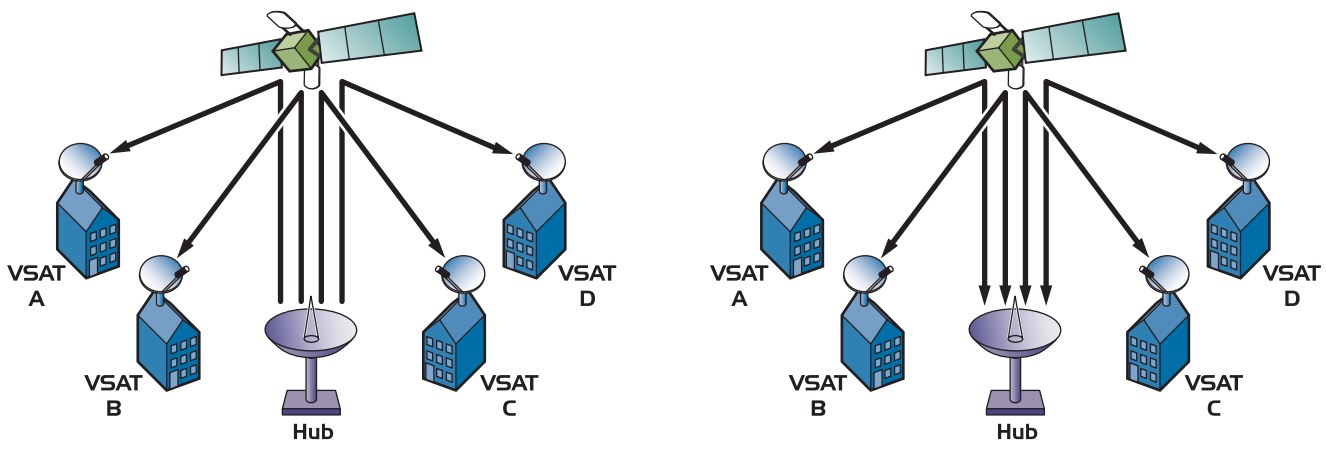
The great advantage of VSAT is its flexibility. It permits any kind and size of network based around a central hub and remote locations. This makes them particularly useful for corporate networks or, for example, communication between educational, government or health-care institutions. Through a VSAT network, a corporation can communicate freely and constantly with branch offices:

- Voice and fax transmissions
- Local Area Network interconnection
- Data broadcasting
- Videoconferencing
- In-house training

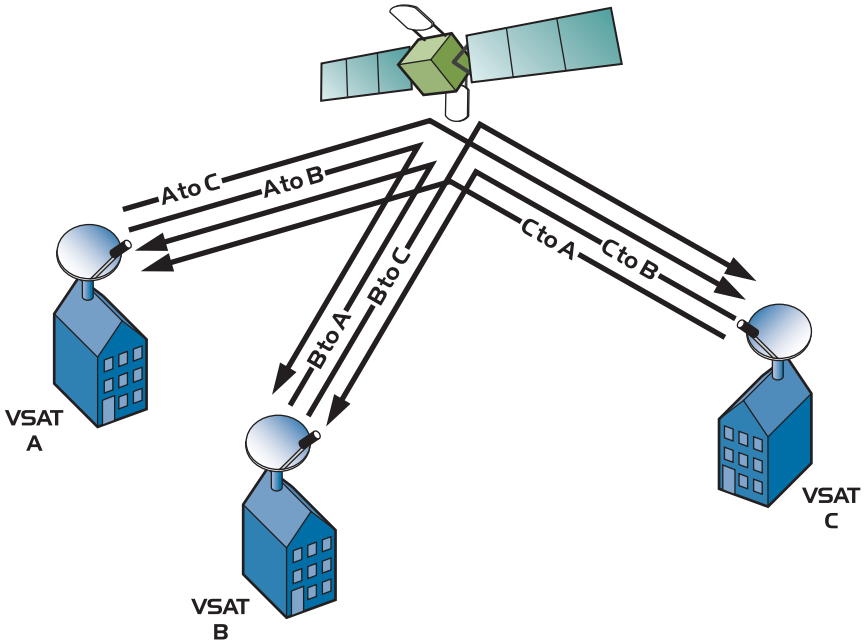
Various network topologies, protocols and interfaces are available to implement VSAT communications applications. It is possible to lease satellite capacity on a carrier-per-carrier basis for any type of VSAT network. VSAT operators offer turnkey solutions including installation, licensing and maintenance.

VSAT star-shaped networks

VSAT networks are generally 'star' networks. This means there is a central location that acts as a hub through which remote locations can transmit and receive data to and from each other. They can be one- or two-directional.



A mesh configuration enables remote terminals to contact each other without passing through the hub and is particularly appropriate for large corporations where local facilities need to be in contact with other regions.



VSAT mesh-shaped networks

New VSAT technologies and services are being offered to support these demands. Employing one- or two-way satellite communication, IP-compatible solutions enable private network operators to provide their network members with enhanced speed and reliability for institution-wide communication. Networks featuring PC-based user terminals equipped with data cards linked to a receive/transmit satellite dish ensure fast Internet access and fast, simultaneous data broadcast to all user terminals via satellite. Intranets, Extranets, Internet access and email messaging are becoming just as important as the traditional video, voice and data requirements of videoconferencing, business TV and data-file exchange. Different levels of VSAT services can deliver various options depending on the requirements of each network.

Capacity can be booked on a full-time basis with prior reservation for minimum utilisation of any 24–hour contiguous period per occasion or on an ad-hoc basis according to a pre–arranged plan of identical transmissions during specific periods, or for occasional use.

PAMA (Permanently Assigned Multiple Access) means having a permanently assigned frequency channel that provides dedicated bandwidth, through which the network can send data, voice or video. This may be required when larger amounts of data continuously need to be transmitted between each element of the network. This can be the case in mission-critical real-time processes such as process monitoring, distributed processes and data collection, but also in media streaming (as in TV and radio broadcasting).

DAMA (Demand Assignment Multiple Access) provides intermittent communication or managed VSAT services on a pay-per-usage basis. With DAMA, satellite capacity is instantaneously assigned and adapted according to immediate traffic needs. It is available when needed, and users only pay for what they use. DAMA can support changing or intermittent image-based or heavy data transfer needs and is best suited where multiple services are integrated into a single network, since it supports telephony, low- and high-speed data, video and multimedia applications. In order to be cost effective, DAMA requires the network to be designed quite precisely to meet the

organisation's needs for data distribution and communications. Peak and minimal usage levels need to be particularly estimated. DAMA is a highly efficient means of instantaneously assigning telephony and data channels in a transponder according to immediate traffic demands.

Advantages of VSAT networks include:

- Wide geographic coverage
- Independence from terrestrial communication infrastructure
- High availability
- Communication costs independent of transmission distance
- Flexible network configuration
- Rapid network deployment
- Centralised control and monitoring
- Any service can be provided from telephony through to ATM, Frame Relay, and of course, high speed broadband Internet

Disadvantages include:

- VSAT services are generally expensive
- VSAT services are not available for single site users, but only to multiple site networks
- The ODU (outdoor unit, antenna) may be prone to vandalism or adverse weather conditions (lightning, storm, etc)
- Requires professional installation, management, monitoring and maintenance
- In some countries VSATs are heavily regulated
- As with all satellite solutions, there is a latency (delay) in the signal, making telephone and videoconferencing services more difficult

3.3.4.3. End-user services for home or small office

Broadband access for end-users is usually considered a 'wired' solution: fibre optic backbones, cable modems on coax, xDSL and ISDN on twisted copper. ADSL can only be provided up to a distance of between 4 and 6 km from the local telephone exchanges, depending on various factors. The cost to upgrade the existing copper network is very high. This means that many households, particularly those in rural and remote areas, will probably never be able to receive ADSL. Similarly, the cost of laying bi-directional cables for interactive TV and Internet means that cable distribution is also unlikely to be available to those living in small towns or in the countryside.

Satellite broadband connectivity has never been considered seriously, as long as it did not allow for interactivity. However, nowadays satellites can provide interactivity via either the satellite return channel or by using a hybrid solution with narrow-band return path via a telephone line. With Internet via satellite, every user with the correct equipment and living within the satellite footprint can now have a broadband connection.

Satellite has the capability to reach everywhere, thus effectively removing local loop difficulties, especially in areas with poorly developed infrastructure. The subscriber requests (eg the click on a hyperlink in a web page) can still be routed through terrestrial telephone lines, but the downloaded data can now be routed via satellite directly to the Earth station of the end-user. The typical asymmetry of home and small business Internet use opens up the possibility of using a slow, small pipe in one direction and a fast, wide pipe in the other. The average user does not need in-bound high-bandwidth connectivity around the clock and needs even less out-bound high-bandwidth[2]. So the hybrid of high-speed satellite for in-bound matched to a low-cost, low-speed request path may well be the most cost-effective solution. Using phone lines and a satellite downlink path means that you don't pay for more technology than you need.

2 Most Internet-type traffic is asymmetric by nature: on average, the downlink (from ISP to end-user) is 20 times greater than the uplink (from end-user towards the Internet). It is worth noting however, that this is not true for certain particular end-users, web builders, content distributors etc, where the ratio is, of course, different.

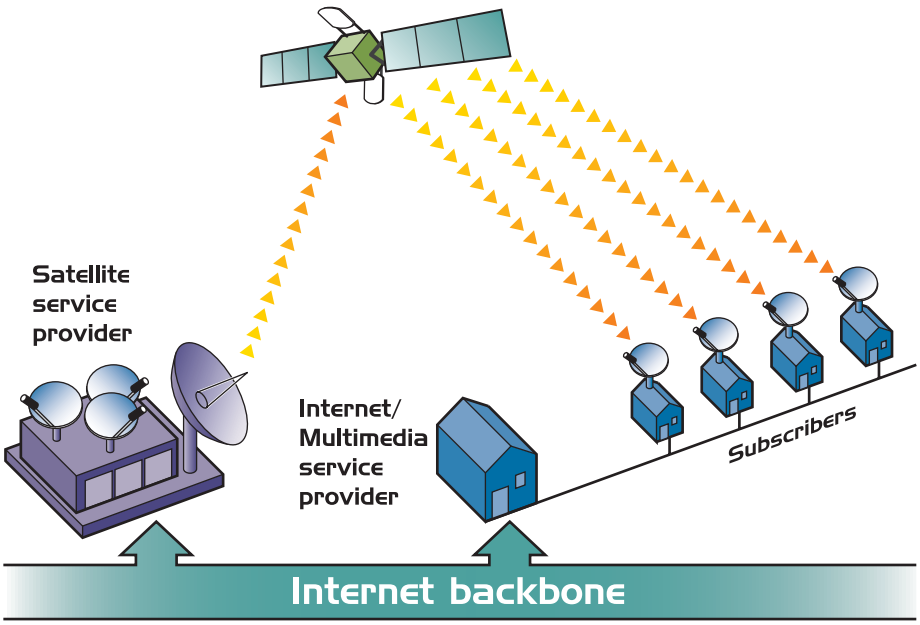


Image: Eutelsat

One-way satellite Internet connection

Recent developments have made it possible to send all requests and return data through the satellite, which is ideal for areas with a weak telephone infrastructure.

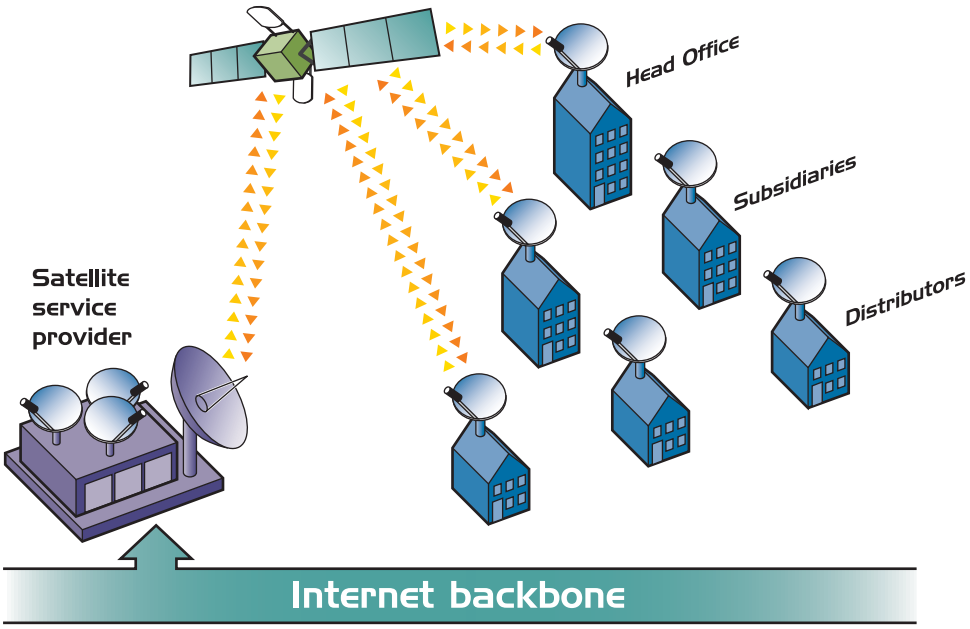


Image: Eutelsat

Two-way satellite Internet connection

Current configurations can deliver data at a rate of up to 40 Mbps, but in practice, this means that the hub communicates with the end-user terminals at speeds of up to 4 Mbps. The terminals have a return link to the hub depending on the set-up of the network via a telephone modem connection or via the satellite return system with speeds ranging from 16 Kbps to 512 Kbps. The hub is continually listening for data requests from the terminals so, to the user, the system appears to be 'always on'. It is understood that in order to use public Internet access through the satellite effectively, the hub needs to be well connected to the Internet backbone.

Not only does this system provide a broadband connection via the satellite downlink, but it also means that the inherent advantages of satellites in many applications can be exploited, especially the ability to multicast or broadcast the same data to millions of

users over a huge area. By applying intelligent caching techniques and news group feeds, traffic in the networks can be reduced and the relatively high bandwidth cost of the space link becomes insignificant especially when compared to the reach.

This allows not only for 'pull' services, such as high-speed web browsing, where a single user requests a specific item, but more importantly also for 'push' or multicast services, where a file or stream is transmitted to many users at the same time, for example, real-time information or streamed video. This type of push service is much harder to accomplish with traditional wire-based terrestrial Internet connection technologies because it consumes valuable bandwidth on all branches of the network.

With satellite transmission, the number of potential users that can receive and decode broadcast data can be restricted to one user, a group of users or all users. With a point-to-point data transfer, TCP/IP is used to send data addressed to one particular user. With point-to-multipoint file download or video stream, UDP or IP multicasting is used, and the satellite broadcasts data that can be decoded by a specific group of users.

Only authorised users can connect the base station through the Internet and operate in interactive mode (eg initiate an online web session). Conditional access is implemented at the DVB transport level by conventional means, using 'smart cards' or a similar technology. In addition, every user station has a unique station identification (hardware address) that is used at link level for individual addressing of stations. Service operators are able to set access authorisations on a user level so that transmissions may be restricted to a closed user group, for example, for security reasons, or to allow subscription-based services. The PC board can also be used for receiving video and audio broadcasting services already available and transmitted by digital broadcasters on the same satellite.

Satellite Internet connectivity offers possibilities that are becoming commonly accepted in many different end-user communities, in regions that are excluded from access until such time as wired or wireless broadband become available. Because it is impossible to predict when such services will become available, it may be better to opt for satellite telecommunications technology as it is immediately available. While financially it may seem to make sense to wait for the best solution that will become available in the future, in the short to medium term this could mean a high cost of lost (educational) opportunity.

Educational institutions can communicate across countries, regions and cultures, share libraries and databases of research information, or offer distance-learning services that are based on the TCP/IP protocols. Medical institutions can develop networks for telemedicine applications. Government entities can deliver citizen information services. Push services enable in all instances the multicasting of video and audio streams, database downloading and software update distribution. Access to Internet and multimedia becomes available to remote communities, effectively fighting exclusion.

To conclude, the advantages of two-way satellite Internet connectivity for end-users include:

- Reception is possible with a small antenna (one already in use to receive TV can, in many cases, be sufficient but may require adaptation)
- Connection is possible almost anywhere instantly within the footprint of the satellite, with no cabling work or delays dependent on terrestrial infrastructure, thus effectively solving the typical 'last mile' problem
- Consumer equipment is relatively low cost
- Internet connectivity can be combined with traditional broadcast technologies such as digital TV and radio, enabling content providers to select the most appropriate delivery means for particular content
- In addition, multimedia push services via satellite, such as data broadcasting or information streaming, are extremely efficient. In these cases, there is no need for a return link via modem, so there is no additional cost for connectivity to the Internet

Some of the main disadvantages include:

- Satellite Internet is generally more expensive than terrestrial access solutions, at least in regions where they are available
- The outdoor unit (antenna and cabling) are more prone to vandalism and weather conditions
- Bandwidth availibility is somewhat limited
- Requires professional support
- Not the ideal technology for videoconferencing

3.3.4.4. Mobile data communications

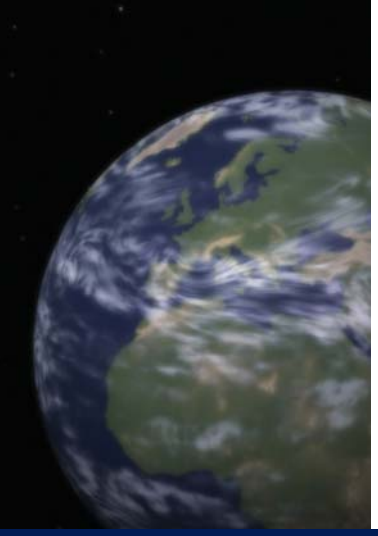
We talk about fixed or mobile services depending on the specific application. Fixed services are aimed at Earth stations that stay in the same place while operating. The antenna does not move during transmission and reception. Mobile services in contrast are aimed at users that need to receive or transmit while moving.

Euteltracs and some Inmarsat applications are examples of mobile satellite data communication services. Euteltracs equips cars, trucks, ships etc, with a small antenna, an on-board terminal with keyboard and LCD, plus software linking the on-board information system via the Euteltracs Network Management Centre based in France with the vehicle's home base. This set-up enables low data-rate services between the mobile vehicle's home base and the vehicle itself while on the move, which allows for:

- Vehicle or vessel localisation with an accuracy of 100 m
- Transmission of alarm and distress messages
- Message exchange between the mobile terminal and base
- Data collection and transmission from the vehicle or vessel
- Access to external databases for example, for weather or traffic conditions

This type of system is extremely rugged but allows only for very limited amounts of data to be transferred. It is therefore not an evident choice for multimedia applications.





4. Satellite Applications in Education

4

'If content is King, then connection is God'

4.1. Education Content: Contribute, Distribute and Retrieve

4.1.1. An introduction to different types of content

'If content is King, then connection is God' is a statement that is often heard in discussions around content distribution, no matter if it is about educational, business or commercial content. One cannot live without the other. Creating content is of no use if the creator cannot convey the message one way or another to his/her target audience. The type of technology that is right for the message, depends on many different aspects of the content and of the audience. In this chapter we will look first at the different types of content. It is important to have a clear picture of this before deciding further on the technological solution for the communication.

First of all, we should agree on the fact that content needs to exist in some material form. This can be in audio: the human voice, a conversation, a discussion, music, a speech, a lecture, a play… all are originally auditive information only, but all can be recorded and/or transmitted. Content can also exist in written form: a handwritten note, a letter, a newspaper, a magazine, a book, a course, course notes, a written assessment etc. Content is sometimes packaged in visual information: a drawing (eg, a drawing on the blackboard), a sketch, a map, a graph, an image, a photograph; even in moving images: a demonstration, a show, a film, a video, a computer animation, often accompanied with suitable audio information: for example, the soundtrack that goes with the film, a voice over on a videotape, or sounds accompanying the animation.

The above information can exist in its original form (the sound of your voice 'as you speak') or in a captured form (a tape recording of the same voice). The format of capture can be analogue (eg, the traditional audiocassette recorder is an analogue recording technology) or digital (eg, the audio CD). In both cases the content is no longer exactly the original, but a representation of the original. A collection of content representations (eg, a library, a collection of cassettes or CDs, but also an archive of messages that were exchanged between a number of people) can also be considered some typical form of content. Some of these can be considered libraries or resources, some are almost like databases, others start to look like Knowledge Bases. These resources are sometimes static (the content does not change once the resource is created, eg, a library with all the works of Shakespeare). In other cases the content is dynamic and the resource can be changed interactively by all their users at all times, for example, the contents of a Newsgroup on the Internet.

A less obvious type of content is data itself, although they have to be structured in some kind of a database to be usable and useful of course: for example, a contacts database or an information management system. Web sites are also examples of this: in essence they are archives with files, hierarchically connected and linked with each other. The files within such an archive themselves can contain all types of contents as described above: sound, images, text, and more.

Another form of content is a procedure or a programme: this can be in the form of a software but it can also be less tangible, for example, in the form of a procedural

description: for example, the description of how to perform certain dance movements or a cooking recipe easily fall in this category although one could argue that they need to be materialised in one or the other way: in text, in an aural explanation, with drawings or pictures etc. A more conventional example of this content is a computer program of course: this can be a copy of application software, for example, a text-processing or a spreadsheet application; it can also be some training programme, a simulation, a virtual reality application or a computer game where interaction between man and machine is required.

The most evolved form of content is a combination of all elements, where different types are combined in such a way that they make an effective and balanced mix. Blending is the term that is being used nowadays to describe this. It is often used in education to describe the combination of a technology-based delivery mode (eg, videotaped materials) with classroom teaching and learning but the definition can be used also to more elaborate mixed concepts: learning environments with classroom lessons, videoconferences with CD-ROMs etc.

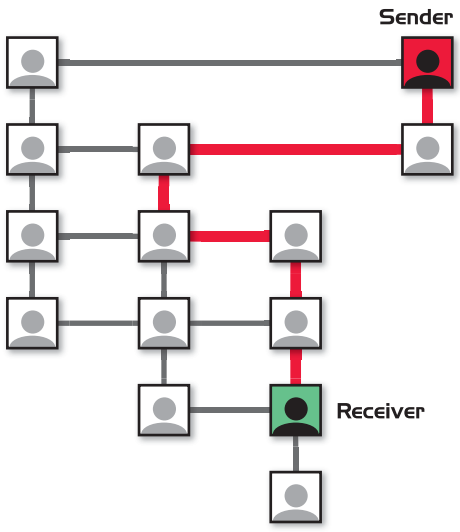
Web sites can be considered the ultimate way of converging different types of content. A web site is a collection of web files on a particular subject includes a beginning file called a home page. These web files can consist of various types of media: text, audio, images (still, moving, animated, virtual) and interactive elements: software applications and games, virtual reality applications, simulations etc.

4.1.2. How users want to access content: unicast, multicast, broadcast

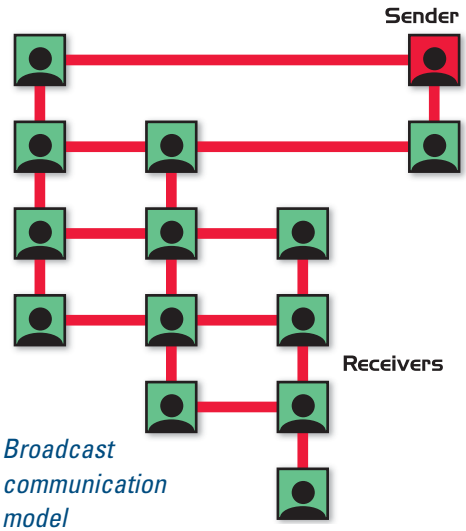
Depending on the nature of the content and the interest of the user in a particular content, there are different modes in which content is being delivered. Let's look at the various bits of information and communication that we receive or consume on an average day.

A handwritten, personal letter that arrives by ordinary mail ('snail mail' as it is being called nowadays) is unique: there is only one single copy, it delivers a personal message and travels from the sender to the receiver along a unique path. Newspapers on the other hand are less unique: maybe in your street there are a number of people that have subscribed to the same newspaper: they will receive the same newspaper at the same time, but each will have his/her own copy. In total there are maybe tens of thousands of newspaper copies that left the printing press at the same time on their way to their subscribers. Another kind of information is the door-to-door publicity: when campaigners want to hit the biggest mark, they organise a door-to-door distribution campaign for their leaflets: there is no subscription needed, everyone with a letter box will receive the content.

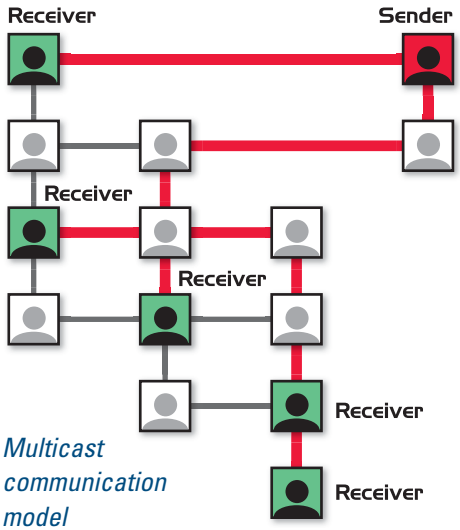
These are three types of delivery modes: the first, a personal communication mode, is called **unicast**: the communication is strictly individual. It applies to personal letters, to making a phone call, to email, to sending an SMS, but also to certain information retrievals from a web site: for example, when one performs a specific search in Google, Google will return with a customised and individual response. Nowadays, unicast communication is still the most important communication mode. Consider the following generalisation: while newspapers take up 90% of the volume and weight of mail, they only account for 10% of the revenues of the Post, letters and other personal mail are net subsidisers of newspaper delivery. In Finland, revenues from SMS messaging have surpassed in 2002 the revenues that commercial TV stations make from advertisement. Email is still the killer application on the Internet, more than the web, and its share of the Internet traffic is still growing. Unicast is a way of communicating rather than of distributing information: normally sender and receiver know each other and acknowledge receipt of the message.



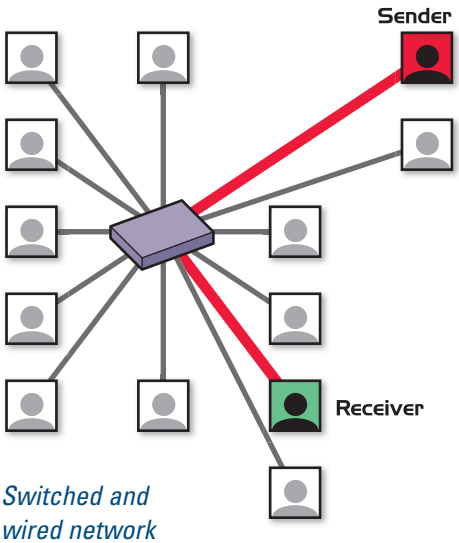
Unicast communication model



Broadcast communication model



Multicast communication model



Switched and wired network

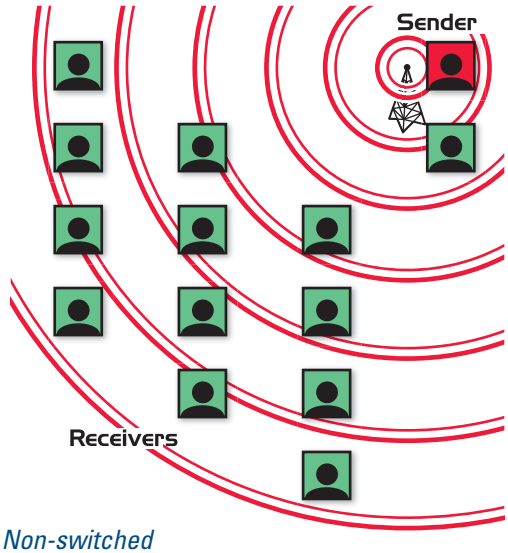
Broadcast mode is when the message goes to all potential users that are within reach of the network or the signal. Broadcast here means that the signal is cast (sent out) in all directions at the same time. A radio or television broadcast for example, is a programme that is transmitted over the airwaves for public reception by anyone with a receiver tuned in. When used in relation to email it means distribution of a message to all members, rather than specific members, of a group such as a department or enterprise. Broadcast mode is a typical way of sharing information with as many as possible: normally a broadcaster is more interested in getting his/her message out to as many as possible, without knowing the individual receivers personally, rather than to communicate back and forth with each of them.

Multicast is communication between a single sender and a specific group of receivers, where the sender transmits a specific content set to a specific target group. A typical and traditional example of multicasting is the newspaper that is delivered by mail. The same content travels almost all over the area and past every door, but is only delivered to the subscribers. Pay TV, where people subscribe to certain programmes on TV, is another good example: the signals are transmitted all over the area, but only people that are allowed to decrypt the content will effectively see the content. In Internet terms, multicasting is used to send content to certain well-defined IP addresses, or to a specific range of addresses.

Normally, switched and wired networks are ideally suited for enabling unicast communication: for example, the wireline telephone network allows for a unique channel of communication between two parties. Because of the switching capacities of the network, it is possible to use the network highly efficiently: many parties can have simultaneous distinct exchanges while the overall capacity of the network is only restricted to its own switching capacity and the number of participants. Adding a new participant to an existing wired and switched network however, requires establishing an additional physical connection between this new end-user and the switching point[3].

Wireless and radio networks are basically much better suited for broadcasting activities such as radio and TV. Intrinsically they are less suited to enable a large number of discrete two-way communications because of a number of limitations: the fact that the transmission medium is shared (the radio spectrum or available bandwidth in the ether), plus the fact that access to the transmission medium is almost completely under the control of the transmitting party (without the coordination that takes place in a switched network environment) makes it necessary to carefully regulate and agree on the use of the available radio spectrum. Transmission of a radio or TV programme to many is easier via this wireless and unswitched environment because the signals transmitted basically reach all the participants that are under the coverage of the transmission footprint. Adding new participants (typically called 'receivers') to such a network requires only installation of end-user equipment (or 'receiver') at the new participants' premises.

The fact that a network is wireless does not necessarily mean that it does not allow for switched (or unicast) communications. The wireless telephone network (GSM or mobile phone network) is a good example of wireless switched. Another example is Internet via satellite. Both are typical unicast applications. To establish a one-to-one connection they work on the basis of a request for time-limited use of part of the available wireless spectrum. Concurrent uses of the available total bandwidth are possible as far as its capacity reaches. This issue is expressed in the contention rate, which indicates the maximum number of participants that can be sharing the service at one given moment. While it is the norm of the network provider to have some level of contention (for wireless and satellite networks, the contention rate varies between 1:20 and 1:50[4]), it is best to obtain the lowest contention rate possible, in order to get the best service and to reduce the potential for a customer to experience congestion (communication interrupts) or reduced download speeds. The network service provider has to ensure that when the number of users of the network increases, also the number of available channels (the total amount of available bandwidth) increases at a similar pace. Otherwise the contention rate will drop and users may start to complain of bad connection service. This is what happens when the number of users of mobile phones increases far faster than the network capacity: the consequence is that many connection attempts fail because of a network overload. Similarly in satellite-based Internet access, users compete with each other for the available bandwidth: the satellite service provider has to keep up with the bandwidth demands of the user population and increase the total capacity accordingly.



Non-switched wireless networks

4.1.3. Interaction

The concept of communication comprises a certain form of interaction. Interaction in terms of information and communication technologies has three dimensions: the first dimension is topology (the actors between which the interaction takes place), secondly there is a time dimension, and then lastly there is an aspect of symmetry.

Topology

Interaction can happen between a human being and a machine: for example, between someone sitting at a computer and the application on that computer. Computer-based training programmes are of that type. Interaction of that type can range from simple actions (switching on and off the TV set can be considered the lowest level of interaction) to complicated and multi-layered activities: for example, the kind of activities that take place on web-based learning environments. Simulations and CD-ROM-based learning applications fall also within this category.

Interaction also happens between human beings: discussions, dialogues, telephone calls, letters etc, all are examples of interactions. Some happen between two parties: a telephone conversation normally takes place between two people. A lecture in a classroom is an interaction between one (the teacher) and many (the students). An electronic news group or a bulletin board is an example of many to many people interacting with each other.

When selecting an information and communication technology to support one or the other interaction topology, there are a number of obvious choices that can be made: for a private communication between two people, telephone is an obvious choice when

3 Wired networks are not necessarily always switched networks. A Cable TV Distribution network, for example, is not switched and is typically a broadcast medium: it is used to distribute an identical bouquet of content from a central source to *all* cable-connected subscribers *at the same time*, very much indeed like terrestrial (Hertzian) television reaches all viewers that are within reach of a transmitting antenna.

To make the distinction between different communication networks even more complicated, you should note that Cable TV distribution networks are increasingly converted into two-way interactive networks that also allow for typical unicast applications: in countries with a high penetration of Cable TV distribution, it is becoming increasingly possible to use telephone and Internet access services via the Cable network.

4 Note also that wired network service providers (Dial In or ADSL) deploy their services on the basis of a similar contention rate, comparable to the rates given here, otherwise their service offer would become too expensive.

these two people cannot meet physically. When one person wants to address many people at the same time who are dispersed over a large geographic area, broadcasting via radio or TV may be an appropriate means. Whenever there is a large number of people involved, groupware systems or news groups and billboards can be a solution.

Time

Another aspect of interaction is the element of synchronicity: in some cases it is necessary to communicate directly and without any delay between the exchanges: telephone conversations are the obvious example, videoconferencing too. Radio and TV broadcasts are synchronous too: if the receiving parties in the target audience are not watching, listening or recording while the programme is being transmitted, then their opportunity to receive is lost. Email is a typical asynchronous person to person communication system: the message is made available until the addressee has time to collect or read the message. In that sense, email compares again to the letter that is posted and sent via email or courier. Email may go as fast as the speed of light, but email does not require the receiver to be present at the other side of the communication chain at the moment the message is sent. Therefore it is called asynchronous.

Teaching in front of a classroom is synchronous: it only happens when teacher and students are effectively present at the same time.

Symmetry/asymmetry

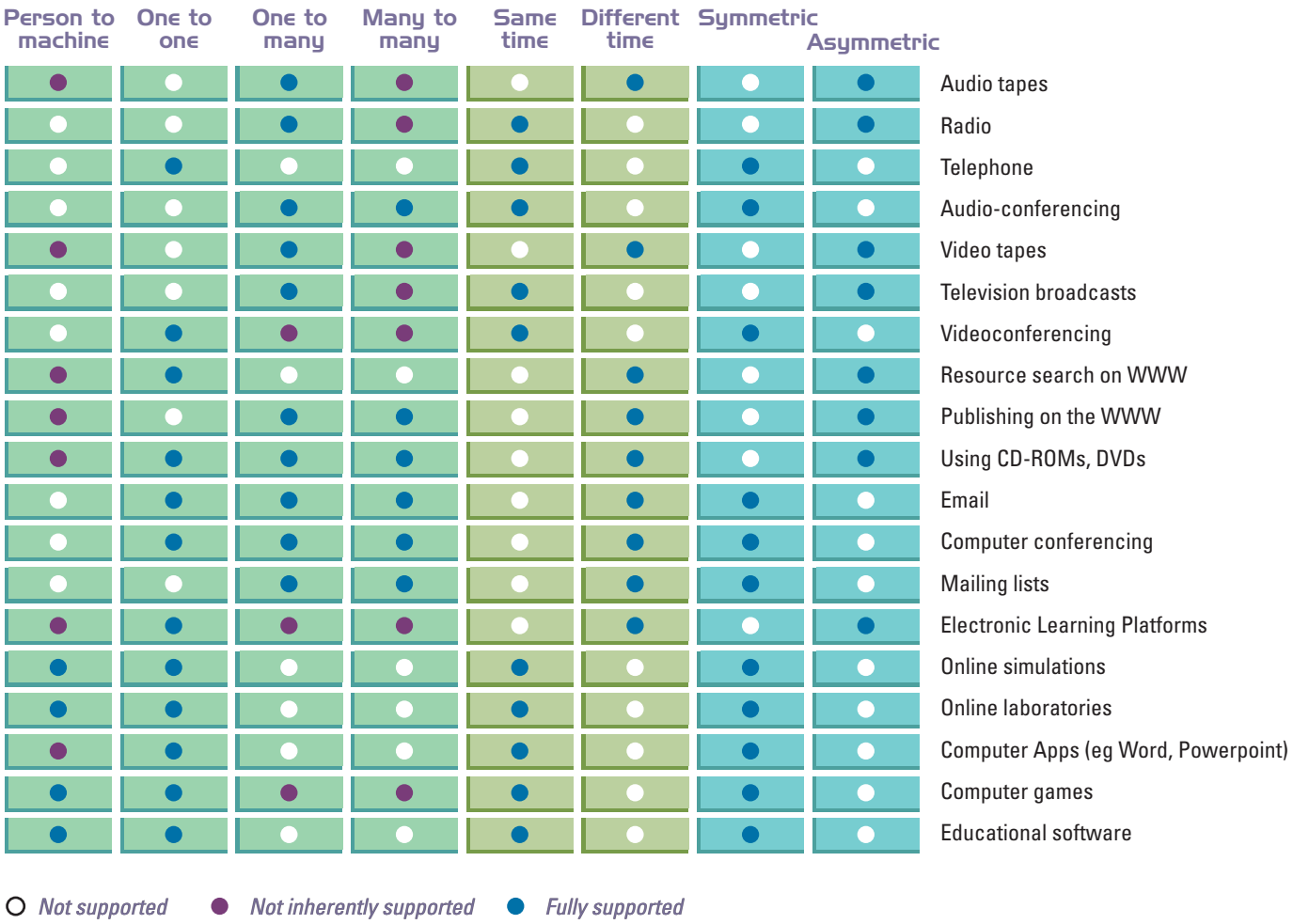
A third quality aspect of communication is the symmetry of the exchange or transfer of information. A normal conversation between two people can easily be understood to be symmetric: both parties have an equal say. In a classroom on the other hand, with one teacher lecturing to a hundred students, it is obvious that the communication is not so equal: the information flow from professor to students will normally be many times larger than vice versa. The same principle applies to technology-enhanced communication. Depending on the symmetry of the communication flow, it will be necessary to opt for the appropriate communications service: when the parties are equal contributors, videoconferencing may be the preferred solution. Email normally also is symmetric in the sense that all subscribers have equal possibilities to contribute. Radio and TV are asymmetric: the content flowing from the transmitting party towards the receivers is much larger and of much higher quality than the communication that listeners or viewers will be able to return.

Communication and information exchanges by means of the World Wide Web display a similar character. Browsing the web is clearly an asymmetric activity: the browser sends very small amounts of data to the server when he/she clicks on a hyperlink to request a page view. The webserver on the other hand returns a lot of data (the requested page view with all the page elements such as text, images, sounds, interactivity etc) towards the end-user. Browsing the web can effectively be called asymmetric communication. The webmaster and his/her web development team who are responsible for the content offered by the webserver on the other hand are more contributing towards the webserver than retrieving: their communication path may well be rather symmetric or even inversed asymmetric (more contribution than retrieval).

4.1.4. Matching a pedagogical model with an educational information and communication technology selection

The learning and teaching methodology may mean that one or the other information and communications technology has to be selected. The table opposite gives an indication of how each of the most common used technologies specifically addresses the communication quality issues of topology, synchronicity and symmetry.

In this chapter we have not referred to satellite communications technology at all. This will be done in the next part. We believe however, that it is important to understand the basics of (educational) content delivery issues before one can apply specific technological solutions to them. In the next part we will attempt to clarify the potential



relationship between the content, educational technology selection and satellite telecommunications.

Although it is not easy to categorise, it is useful to describe the various ways in which satellite communications can be configured and used in an educational context. In this section, we will provide some broad categories, describe the distinguishing features of each category and, where appropriate, the various sub-sections that occur within each category.

It is important to begin with a number of reservations to avoid misleading the reader. First, the technological environment is changing fast and therefore certain distinctions that applied in the past are no longer relevant and emerging services often span two or more of the categories described. Secondly, even where technological change is not a factor, there is a lot of 'carry-over' from one category to another and we have tried to point this out when it occurs. Thirdly, many terms like 'Interactive Television', 'Videoconferencing' and 'Multicasting' are being used differently, and there is little common understanding of terminology in this field. These distinctions are often region specific, for example, the term 'Videoconferencing' is used differently in Europe than in the USA. Different uses of the same terminology often occur depending upon sector or industry. For example, the broadcasting industry uses terminology differently from the computing industry.



4.2. Broadcasting

Most people are familiar with the use of broadcast radio and TV to support education, as this has been a common means to provide educational service to potential learners for many years. Probably the first educational TV programme was *Sunrise Semester*, broadcast from Chicago in the USA in 1959. Continuing until the early Sixties, *Sunrise Semester* featured a single broadcaster, a teacher, standing in front of a class with a camera shooting over the heads of the students. The initiative ceased because it was not economically sustainable.

Traditional educational television is one-way, sent by the broadcaster to the end-user at a fixed time and according to a set and pre-ordained schedule, as in the case of School TV and Open University programming carried by the BBC.

Categorised by its ability to address large potential groups of users, it is common for broadcasters to use satellite technology to transmit their signal, particularly in regions of the world where terrestrial broadcast services are unsuitable. The satellite technology used in such instances is usually a large-scale professional service involving large transmitting Earth stations and significant technical resources for production and play out of programmes. Reception equipment comprises a small dish with a satellite receiver. Many specialised broadcast channels offering, for example, sports, financial information and targeted programmes, are broadcast in this way with the set-top box acting as a filter ensuring that all licence and other fees are paid before the end-user gains access to the channel(s).

Satellite supports good-quality audio and moving video images thanks to its high bandwidth transmission capability. Production costs are relatively high and there is no possibility for interaction. Increasingly however, educational broadcasters are looking to embed this medium in a learning environment supported by other means. It is common nowadays to find associated web sites, help-desks and other support services for people accessing educational resources in this way. Well-known educational broadcast services in the world, like the China Central Radio and TV University, are transforming this type of service into a more interactive model (see next part on 'Interactive Television').

Numerous examples of this type of application exist including EMMA, BBC Education, Swedish Educational Broadcasting and InTeleCom in the USA. Some are associated directly with public service broadcasting organisations. Others operate more as educational programme producers that are selling programmes to broadcast television stations.

4.3. Interactive Television

The term 'Interactive Television' is one of the most confusing terms. It can refer in fact to any form of interaction with a television or broadcast service. This ranges from tele-polling, choosing camera angles in sports events, to using shopping channels, to video-on-demand. Many interactive television services use satellite technology to support at least part of the communications chain. Typically an interactive television service will involve various types of media, each supporting different functions. Let us look at a number of different samples to explain the range of applications possible in an educational context.

4.3.1. Video-on-demand

This kind of interactive television service usually involves a broadcasting station setting up a service whereby viewers can choose to have programmes sent to them on demand from a video server. This can be on an 'instantaneous' or 'near-instantaneous' basis: depending on the service, the programme is either instantly available to the end-user, or available later. The broadcast of the requested programme can be done via satellite. The ordering or request system is usually facilitated via a terrestrial

telecommunications network or even via the Internet. These kinds of services are increasingly on offer from cable operators and there are some examples of educational services using this service. The service offered by Les Amphis de france is a good example and is described in chapter 6. This type of service in an educational context demands considerable technological and organisational resources but is very useful when considered as a way in which educational institutions can manage access to large resources of video-based material. It is essentially pre-recorded and little opportunity for any 'live' interaction exists. Material can be maintained in a central service and then accessed when required by the institution or individual wishing to make use of the material.

4.3.2. One-way broadcast with asymmetric return

This model of interactive television services is increasingly common. What happens is that viewers watching a broadcast programme interact with those in the studio or support network via telephone, Internet chat or email messages or via a videoconferencing link. In this, the broadcast is in the form of listener feedback or questions to the studio panel. The system is essentially 'live' and can be configured in a number of ways. It supports synchronous communications although elements can be asynchronous, for example, using email for question and answer sessions after the 'live' event. Broadcast via satellite is often the way in which the signal from the studio is sent to the viewer, the return link is usually via terrestrial means. The quality of the signal from the studio to the viewers is pretty much always of higher quality than the incoming one (from the viewer to the studio).

In the educational context such networks can be set up either as 'closed' networks, whereby those taking part are known to the educational provider, or 'open' where this is not the case and anyone with the means to receive the broadcast signal can interact with the studio and ancillary services. Interaction can take the form again of questions and discussion, polling and feedback, even group work in remote sites with feedback provided to the central studio via remote group leaders is possible.

This kind of broadcast using satellite one-way and various different sorts of return channels is commonly used by commercial training channels like the Computer Channel or by large corporations including Ford and Daimler Chrysler for training staff. It is also used by those providing specialised medical educational services like Rockpointe Broadcasting in the USA or Plymouth University in the UK. There are a number of examples of this application in the educational domain, in our list of sample projects; these include the African Virtual University and Consorzio Nettuno.

4.4. Data Broadcasting and Multicasting

Data broadcasting and multicasting networks are often supported via satellite systems. These are essentially one-way communication networks offering data to the end-user, such as video files, web site contents, analytical and statistical information, applications (software updates) or any other form of information that can be digitally stored. The end-user stores the transmitted data on either a PC or on some sort of set-top box. These set-top boxes are developing into Personal Video Recorder (PVR) or Multimedia Home Platform (MHP) systems, supporting standardised data broadcasting and multicasting. The systems increasingly use the Internet TCP/IP protocol in the management of the data transmitted. The way the network is configured may include satellite download for one channel of the network, ie to the end-user using the satellite capacity to handle the bandwidth requirements, which may be high if there is a lot of video in the material being downloaded. The way the network is configured can allow for specific addressing, ie multicasting to specific recipients so the service provider knows exactly who is receiving the data and when it is sent out, or it can simply be broadcast to a wide variety of recipients. This kind of network is used frequently by educational providers as it allows for secure and managed distribution of data resources and a couple of examples of this type of application have been included in Chapter 6, including Espresso and the Austrian AVD project.

4.5. Internet Access

Many Internet Service Providers use satellite services to support one or both channels of their service to connect their subscribers to the Internet backbone. This is particularly true of developing regions where the terrestrial telecommunications infrastructure is poor. The type of infrastructure is normally based on relatively large-size antennas and significant resources for hosting, providing gateways, proxy servers, security etc.

When considering how this use of satellite fits into an overall educational perspective, it is interesting to recall that the Internet really took off as an academic network. Very often, it is educational institutions and universities in particular taking the first steps in providing an Internet service and Point-of-Presence (PoP) in regions or communities where such services were not previously available. As university campuses extend their reach and educational providers of one kind or another seek to reach new learners the question of creating new PoPs arises. Satellite is often the only way such services can be extended and there are important implications here regarding licensing on a national basis and on how the provision of such PoPs can be made sustainable. It is important to follow market trends in this rather fragmented ISP environment to make sure that educational providers have access to good quality and reasonably priced Internet connections either though a commercial service or by operating their own service. Satellite technology can be used to network ISPs should the need arise for outreach to underserved areas or to set up a content delivery network.

4.6. One and Two-way Connectivity

New satellite technology and more specifically Internet via Satellite can provide high speed IP connectivity via satellite with all the advantages of commercial digital television: wide uptake, high quality of service, scalability and data transmission capabilities.

Until very recently the vital return connection, the interactive connection or back-channel, happened via terrestrial lines, mainly through a dial-up modem connection via telephone line. This is a logical configuration given that most Internet applications are typically asymmetric – the traffic from client to server is usually much smaller than vice versa. This is usually in the order of 5 to 10% upload versus download, except for content creation and contribution. However, the return channel can also be supported via satellite as explained in the previous chapter.

The availability of these services via satellite for the end-user is an important development that has terrific potential for educational authorities wishing to serve remote learners or learner communities. Information about the likely players in this field is contained in Chapter 7 of this report. Typically such services operating in the Ku-band or mixed Ku-/Ka-band offer asynchronous network configurations of typically 56–128 Kbps outgoing (from the end terminal) and 200 Kbps to 8 Mbps incoming. Service operators typically target so-called SoHo end-users (Small Office/Home Office), but they are equally of value for educational users. They tend to operate with relatively low-cost, simple to install end-user equipment, which is hosted on either a separate box or as software installed on a PC. Dish sizes from the service providers currently active in the market range from 90 cm to 150 cm. Unlike the satellite services utilised by ISPs, these networks are aimed at the single end-user or as a gateway to a small and local area network (LAN). Licensing and network configuration are important issues to consider when considering these types of satellite-supported services in the educational context. How the network is configured depends upon the practical use that the organisation offering the service wishes to make of the service, and so there are a number of sub-categories of potential educational use here. In broad terms we categorise them as the following.

Virtual Classroom scenario: in this case, the individual end-user station is part of an educational network whereby other learners, teachers and resource people and materials are remote from the end-user. The system is used for a variety of applications

that are a surrogate for normal 'classroom-type' activities. These can include quasi-synchronous communications (usually online chat), asynchronous communications using a closed bulletin board type system and a common store of resources usually housed on a remote server, which are available to the user on demand or as part of a multicast set-up where digital materials are sent to the end-user's storage device via satellite and accessed when necessary.

Resources-based learning scenario: in this case the teacher and immediate learning peers are in the same location and use the satellite service to access resources when required. These resources can be accessed either with an open Internet-type connection or to a closed Intranet hosted remotely at the location of the satellite up-link server. This is a similar network set-up as described in the table on page 65.

Examples of projects using this type of service in Chapter 6 are SchoolSat and the JISC 2-way Satellite Access Trial.

4.7. VSAT Networks

VSAT communications can be used to set up virtual private satellite networks of one kind or another and are very often used in the commercial world to provide entire communications networks to outlying companies and institutions. Using relatively small-size dishes (by comparison with broadcast-type applications) such institutions use these kinds of services to support telephony, data communications and videoconferencing between a closed user set. VSAT networks are very common for example, in the banking world where commercial banks use them to provide a secure and comprehensive communications network. The exact configuration of such a network will depend upon the resources invested by the network operators, the bandwidth capacity required and often the location of the end-users. They can be used in both synchronous and asynchronous configurations. Many organisations favour an entirely closed system for both security and management purposes, given that the overall control of the system is completely in the hands of the owners and can be managed and controlled centrally. Such networks require high up-front investment and compliance with national and regional licensing authorities.

In the educational context, VSAT networks have significant advantages and allow the organisation flexibility in controlling the educational environment – within the technical constraints of the chosen network of course – to create learning scenarios with the precise media mix required. A good example of this kind of network is the Global Development Learning Network (GDLN) set-up by the World Bank and described further in Chapter 6. Interestingly, this network was built on the existing VSAT communications network used by the World Bank for all its communications requirements. Now an independent network, it seeks to collaborate with other institutions with common aims, interested in sharing the resources of the GDLN.

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4.8. Meeting Educational Needs by means of Satellite Networks

Before discussing the application of satellite technology in education further, it is useful to take a look at how generic educational activities can or might be supported by satellite services and where such services are most suitable. The following table provides an overview of this topic.

	Satellite services:					
Educational Activity:	Broadcast	Interactive television	Data broadcast	Internet access	One- & two-way Interactivity	VSAT network
Accessing digital library resources				●	●	●
Receiving resource materials	●		●	●	●	●
Communicating with teachers or tutors		●		●	●	●
Communicating with peer learners		●		●	●	●
Sending assignments				●	●	●
Group-work		●		●	●	●
Doing exams				●	●	●

Overview of satellite-supported education applications

4.9. Costs and Service Considerations

This section will provide a basic list of the costing considerations that service providers need to consider. These include hardware at both the send and receive sites, software and server considerations, bandwidth costs, licensing, maintenance and service. It will also cover aspects such as training, operation and personnel support and maintenance. The section starts with three examples of cost models, related to three of the most familiar satellite applications for education and training. In the next part we will elaborate on the different issues that surround the costing structure. Prices are calculated on the basis of averages and can only indicate a range of order. Most of the prices are susceptible to change especially in regions with a lot of competition. It has to be said that prices do not only differ from country to country (in some countries huge mark ups are applied with no apparent method of accounting), but also that fortunately prices tend to drop, sometimes slowly but steadily.

4.9.1. Cost models

4.9.1.1. Satellite TV broadcast

The cost structure for satellite TV broadcasting is the simplest. We assume that the content is pre-recorded in an acceptable format and quality. The costs of production are not taken into consideration as they are not directly related to the transmission format:

it can be assumed that they would be the same if the content were to be distributed on VHS tapes or via broadcast TV.

The costs can be divided into costs occurred at the originating side and costs at the receiving side of the chain. Costs can be quantified easily because they are directly related to the duration of a programme. We present below the cost for a one-hour programme, on a purely occasional basis. Tariffs will change according to the choice of satellite, the frequency of use, the number of transmissions, the time during the day of the transmission, the flexibility of the broadcast and several other parameters.

At the originating side:

	1 Hr analogue C band	1 Hr analogue Ku band	1 Hr digital MPEG-2 C/Ku band (2 Mbps)
Play out	50.00	50.00	50.00
Uplink transmission station	650.00	650.00	750.00
Transmission	1,450.00	1,200.00	200.00
Total	**2,150.00**	**1,900.00**	**1,000.00**

Costs in US$ per hour

Satellite TV broadcast costs

Transmission in digital format is cheaper because it occupies only a small part of the bandwidth and therefore it can be combined easily with other content materials.

At the end-user side (cost per site):

	1 Hr analogue C band	1 Hr analogue Ku band	1 Hr digital MPEG-2 C/Ku band (2 Mbps)
Satellite receive hardware (antenna)	1,200.00	250.00	200.00
Satellite receive hardware (receiver)	300.00	300.00	400.00
Installation	500.00	500.00	500.00
Transmission	0.00	0.00	0.00
Total	**2,000.00**	**1,050.00**	**1,100.00**

All prices indicated in US$

Satellite TV receive cost

The cost at the end-user side is per installation, not on an hourly basis. The depreciation time for this type of hardware, given the status of transmission standards, can be estimated to be at least 5 years. The number of receive site installations is unlimited in number, it is only limited geographically by the footprint of the chosen satellite and transponder. Because the cost at the originating side does not alter with the number of receive sites, it is easy to see that the cost per user per hour decreases by the quantity of clients.

One hour broadcast in digital video to one single receiver will cost US$ 1,100 per user per hour. For 1,000 hours of broadcast (that is one hour per day over 3 years time) transmitted to 10,000 viewers the cost will be about US$ 0.1 per hour per user.

Note: the above example is for non-supported content materials. If – as is mostly the case in educational TV programming – additional support (support materials, tutoring, helpdesk, etc) needs to be put in place, the cost to do so will be affected by the numbers of applicants.

4.9.1.2. VSAT community network

As in the previous example, we will provide an example of cost calculation without directly referring to the cost of the content creation, the pedagogical model, the standard or format of content exchange or the specific type of communications. A VSAT network, furthermore, can be tailored around specific requirements: architecture (star or mesh), bandwidth and power are just a few of the parameters that come into play. In the example below we describe the cost for a star network with broadband capacity (2 Mbps) available 24 hours a day all year long. This system allows for a mixture of videoconferencing with data and multimedia distribution and Internet connectivity. The specific costs for these applications are not included in the example below.

A VSAT network is a centrally organised and controlled networking system. Costs cannot be discriminated so easily between originating (central education provider) and individual clients' costs. Because scale of deployment plays an important role, it is more appropriate to calculate the total cost of operation for the whole network.

VSAT network deployment cost

	Total	Per VSAT per month
1 year / 30 VSAT stations	841,600.00	2,337.78
5 year / 30 VSAT stations	4,168,000.00	2,315.56
5 year / 300 VSAT stations	27,160,000.00	1,508.89
5 year / 3,000 VSAT stations	209,660,000.00	1,165.78

Costs in US$

The table above takes into account the following satellite communications-related cost factors:

VSAT Earth Station	**HUB Station**	**Satellite**
Equipment	Lease cost or ownership	Bandwidth
Installation	Applications platform	**Licence**
Spare parts	Connection to backbone	One-time fee (network)
Maintenance	Operation and Maintenance	Annual fee (Earth station)

In VSAT networks, dimensioning starts to play an important role: the number of clients will indicate whether it is cheaper to share a central hub or to invest in an own hub, the available bandwidth and the connectivity to the backbone will also depend upon the dimensions of the network.

The above cost gives an indication for a full-time high-bandwidth secure private communications network. While the investment cost may be frighteningly high at first sight, it is important to look at the operational costs (total cost over usage period per terminal) and it becomes clear that VSAT is a solution for broadband communications that can effectively compete with terrestrial solutions, even in countries where good quality terrestrial connections are available.

4.9.1.3. Broadband Internet via two-way satellite

Small two-way satellite Internet systems using Ku- and Ka-band are becoming more and more popular. They can be considered VSAT systems but they differ from the previous example in the sense that the network is set up by satellite providers who service a less homogeneous community of users. The service usually offered is limited to some form of high-bandwidth Internet access (in various bandwidth levels according to the customers requirements), sometimes extended with customised applications that are implemented to serve a particular part of the audience by multicasting, special

type of applications etc. In theory there is no need for the education provider to worry about the investment and running costs at the hub or server level of the system: it is enough to invest in client stations and connection fees. The service itself (connection of the hub server to the Internet backbone, satellite bandwidth sufficient to service all clients, maintenance and operation of the service) are not cost issues to the content provider. Specific centralised costs for the course or content provider are related to contribution costs (bringing or "porting" the content from the designer or producer to an access point within high bandwidth reach of the hub server, or preferably even on the hub server location itself), or the investment in specific server side applications or tools, if they are not supported by the service provider.

In this case, economies of scale do not affect either the end user or the education provider. They are taken absorbed in the commercial plan of the service provider. However, it may be worthwhile discussing the deployment plan for a network with the service providers involved, especially when it is very large and demanding, when certain levels of Quality of Service are required or when expansion is foreseen. It may turn out that migration from a public or semi-public service towards a VSAT community solution using the same technology is a more efficient solution.

Costs can be estimated easily:

	Unit price	Unit	Total
Hardware	2000.00	–	2000.00
Installation	500.00	–	500.00
License	120.00	per year	120.00
Communications costs	200.00	per month	2400.00
Total (per unit per month / depreciation over 5 years)			**251.70**

Costs in US$

Two Way Satellite Internet Cost

Compared to the VSAT network, costs are very low. Compared to terrestrial broadband network costs are competitive, certainly when taking into account the availability of the connection virtually everywhere almost instantly.

The big difference with the VSAT network solution is the fact that the network capacity is shared with a virtually unknown number of concurrent users, which may affect the network performance. The speed of download depends upon the number of users logged on and consuming bandwidth simultaneously, i.e. the contention rate. The same is true for Cable connectivity and to a lesser extent for ADSL, where different connections need to share the same bandwidth.

Another disadvantage compared to VSAT, is the limitation of application implementation that content providers most likely will incur: this will hinder for example the use of synchronous bandwidth demanding applications like videoconferencing.

4.9.2. Service costs

With the term "service costs", we refer to all costs that add up to the total cost of the delivery of a service (be it an occasional offer or an ongoing service). We have distinguished so far a number of cost elements that are directly related to the delivery and thus end up on the final bill of the content provider and/or the end user.

Furthermore, in this part we will go briefly into the trends that are or will affect price evolution of these cost elements. This will involve some assumptions and crystal ball gazing, because as we know from the last 10 years, economic factors tend to change

within periods of 6 months due to the rapid development of new technologies, the stormy nature of the Internet and the changing economics in which the largest players, especially the telecom companies, find themselves.

4.9.2.1. Cost Elements

This section seeks to identify the different cost categories that come into play when talking about ICT-based education and training. The highly important management issues that are related to the change that ICT-based education can bring into institutions are not examined here, because they can be considered external to the choice of the technology and delivery mechanism. It should be kept in mind that management plays a key role in the process and that even when certain technical choices impose themselves, it may be that managerial criteria change the options.

It is not our intention to cover all issues of ICT-based education and training in great detail. What we would like to do is indicate how the choice for a particular learning and teaching methodology and all its implications can influence the cost of network technology or capacity. We do not make a judgement on which methodology is best suited or most effective, this depends completely on the individual situation of each provider. Although some methodologies seem to be more appealing then others at first sight, their attractiveness should not mislead the user from the ultimate goal: enhancing education by means of technology support. Stepping into the pitfall of 'technology support for technology sake' should be avoided at all cost.

Pedagogical Model

New information and telecommunication technologies such as the Internet, multimedia, videoconferencing, simulation etc. allow for innovative or extended experiences for teachers as well as learners. Content providers, institutions, teachers and trainers find new means of getting their contents out to new and larger audiences. Learners on the other hand, have the possibility to gain access to educational resources much less dependent on place and time.

The ways in which this happens are varied: there are tele-courses via broadcast TV and radio, videoconferences between multiple locations, courseware is distributed on CD-ROM or DVD instead of in printed format, courses are delivered via email or FTP, courses are distributed in such a form that a complete electronic or virtual learning environment is created, vast electronic libraries as well as research databases are being made available, virtual laboratories enable learners and researchers to expand their experiments. It should be noted that most often, a complete course or content package consists of parts of each model, combining traditional modes such as face-to-face teaching, lectures, personal tutoring and print-based materials, with technology-supported modes that bring into the media mix elements that can be provided best in an innovative way.

To illustrate the vast choice of options that the content provider has, we would like to provide some examples that indicate how the mode can influence the choice of a particular technology: this list is not exhaustive and does not necessarily relate to the choice of satellite technology only. Our intention is to indicate how intricate the interplay is between all the different elements.

Telepresence classroom

The education mode that closest resembles the traditional classroom, as we know it, is the telepresence classroom in which the teacher teaches remotely to his/her learners by means of camera, microphone and supporting materials. The teacher can see, hear, and interact in real time with his/her students. Students can be miles away, even dispersed over a (limited) number of sites. Videoconferencing, and to a lesser extent audio-conferencing, is one of the most appealing applications of ICT in the domain of education and training, but not necessarily the most successfully implemented. Videoconferencing, gives the impression that a quick and easy transition can be made from classroom teaching and training models towards ICT-based education: setting up

a camera and a microphone in the back of the classroom, adding the hardware to transmit the images and sound of the teacher plus the equipment to receive these images and sound at the remote sites, already seem to fulfil a number of requirements to reach remote learners. However, it is often forgotten that videoconferencing significantly adds to the traditional classroom requirements (seats, opening hours, accommodations, etc) a number of technical requirements (AV equipment, telecommunications provisions, technical support, etc). It requires from administrators, teachers and learners a certain level of adaptation: classroom organisation; style of teaching, lecturing and tutoring; format and style of supporting lesson materials; interaction with the learners; all need to change to a certain extent to make videoconferencing a successful application.



ISDN is most probably the best network choice for the time being because it allows for a standardised global interconnection, it is widely available in the developed world, and it has a quality of service level that assures that performance is correctly predictable. Satellite technology and especially VSAT can support videoconferencing effectively especially in those areas and locations that do not have a reliable terrestrial telephone network. The newer type of VSAT systems not only allow for videoconferencing between the different VSAT stations of similar type, but also allow for seamless integration into an ISDN environment, thus allowing connectivity amongst systems in almost all parts of the world.

Depending on the quality requirements, one can choose different levels of compression. Satellite latency contributes to the difficulties of using videoconferencing: not only is there a delay caused by the treatment of the originating audio and video signal (compression and encoding) plus the subsequent processing of the same signal at the receive side for display, but in addition to this delay comes the satellite latency due to its remoteness from Earth, another 0.25 sec. In total, delays can add up quickly to several seconds when the encoding and compression take a long time. It is our experience that with a minimal amount of awareness training, most users will accept a total delay of maximum 1.2 sec. From 0.5 sec delay a 'walkie-talkie' effect starts to emerge. More than 1.2 sec makes normal interaction almost impossible.

In many cases it may not even be necessary to carry out interactive sessions live: it may be just as easy to distribute the audiovisual content in another way (via broadcast TV or radio) and when the time factor doesn't play such a large role, even on tapes, on CD, or DVD. It may be possible to set up an interactive system between learners and teachers and tutors separately from the content distribution mechanism: learners can view and consult the content and ask their question, post their assessments via telephone, email, fax etc.

When the requirements of the AV media quality and the time constraints are not very high, the Internet may be chosen as the way to deliver the content. For videoconferencing, the public Internet is simply not mature until additional protocols such as RSVP and Mbone are implemented and the overall bandwidth availability has increased. Although videoconferencing applications are being used on the Internet nowadays, we clearly see an uptake of home and recreational use rather than mission-critical business or education applications.

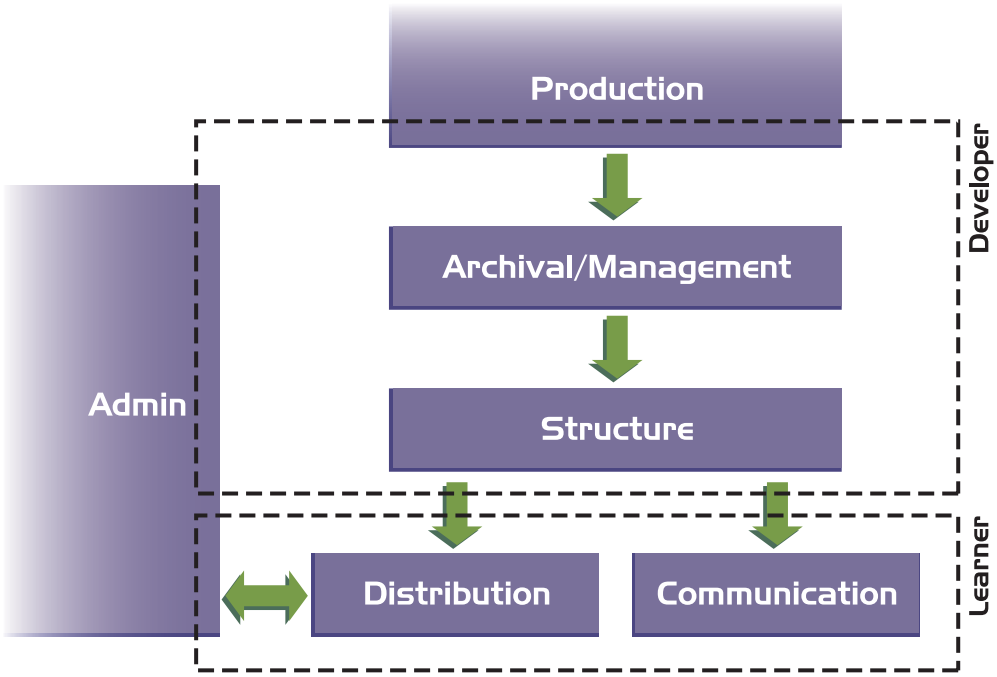
When putting in place a private or corporate network solution on which sufficient bandwidth is available to every client (be it over satellite or other links) it is worth considering the use of IP-based videoconferencing protocols. This protocol adopts the transfer technology that is also used on the public Internet but applied in a private controlled network, with much less restrictions and better controllability.

Virtual Learning Environments

With the advent of the Internet as the network of networks from the mid 90s onwards and its acceptance as the standard worldwide for communications between universities, research institutions, administrations, commercial organisations and individual end-users, education providers started to recognise the possibilities of this

new medium to not only reach new audiences but also to enhance existing education. This led to the creation of a new model of ICT-based education and training: the electronic or Virtual Learning Environment, integrated digital environments where the teaching and learning activity is organised and in large parts takes place. In other words, these applications are used for delivery of learning content and facilitation of the learning process. They can be used to connect learners and training departments electronically whether at the same location or dispersed over a wider area. Many electronic learning platforms have grown out of communication and collaboration tools with an important additional set of features and functionalities that make them more suitable for training purposes. Almost all platforms currently available are based on client/server architecture. In many cases, the client, located on the user side, is simply a web browser that is used to access HTML pages on the server. Although it is still possible to create and adopt learning environments that are completely stand alone (Computer Based Training and CD-Rom educational software) the vast majority of learning environments take advantage of enabling connections to teachers, tutors, peer learners, administrations, additional resources such as electronic libraries, simulations, the public Internet etc.

To understand what learning environments can do it is useful to consider the functionalities assigned to them.



Layered model of the electronic learning platform

Image: EuroPACE

Each of the functions described in the diagram above fulfil a more or less complicated task that has an effect on the other aspects of the environment: production of the learning materials for instance can include the making of elaborate multimedia materials, the building of assessment tools for the learner, the provision of communication mechanisms, libraries etc.

There are many different learning environments commercially available on the market-ranging from simple applications that concentrate on just one functionality, to complicated 'Swiss Army knife' type environments that can perform every possible function the user can think of.

A key aspect of the networked learning environment is its use of some way of connecting the different parties involved: creators, teachers, tutors, learners and administrators. As a consequence, the success of the environment is highly dependent on the selection of the appropriate communications network. Most are making use again of the IP protocol for packaging and transport and allow the user to access the

environment using a standard browser. All IP-supported applications can therefore be made part of the environment: conferencing, email, chat, simulation, interactivity, multimedia, etc. The inclusion of some or more of these applications may have quite drastic implications on the requirements for distribution to the end-user, especially when the end-user is remote.

There are two possible ways of approaching this problem. The minimal way is to restrict the functions that one implements in the environment to the accepted minimal level of network capacity for the least served end-user. However, especially in badly served regions, this may result in the elimination of a number of important desirable applications. The maximal way is to build the platform completely according to the pedagogical and technical requirements of the content provider and to impose the inherent network requirements to the end-users. By providing a specific networking solution to support the environment, the content provider has the advantage of complete control over the total environment. This can be achieved best by the implementation of a VSAT type corporate or institution network that spans regions and countries and allows for centralised management and control. The new type of cheap VSAT solutions that are based on DVB allows not only for a certain degree of bandwidth control between hub server and client server but adds to that the multicasting functionality that allows for just-in-time distribution of all kinds of materials including streaming media, software updates, applications etc.

Content

Content can take many shapes as already indicated in the previous part: educational content comes in the form of direct communication (lecturing, tutoring, conversation, discussion) between many actors involved (authors, teachers, tutors, learners, researchers, peers) and supported in many different ways (multimedia, laboratories, exercises, assessments).

In this section we would like to demonstrate how content choice and treatment can influence the selection of telecommunications support.

Linear multimedia content

The production quality of the teaching and learning support materials is a decisive factor contributing to the overall cost of an ICT-based education system. Some types of content require high-quality production standards (eg medical subjects mostly require high resolution and colour images, be it video, graphics or print materials), resulting in a relatively high production cost at the side from where the materials originate, and requiring equally high-quality transmission systems.

We do not intend to go into detail about the requirements for a certain level of production standard, but we would like to point out that the use of TV and TV-like distribution as the medium means that viewers have a certain level of expectation regarding the overall quality: the reference frame of educational TV programmes and videos is not very different from what the viewer is used to seeing on the TV screen and therefore he/she will not so easily tolerate poor quality material.

To give an impression of what bandwidth means in the case of TV and video: a VHS tape of 240 min colour video with an English and a French language channel represents an uncompressed storage of 23.4 Gb on a cassette costing less than US$ 4, weighing less than 300 g, fitting into almost any pocket, playing on an estimated 980 million VHS players installed worldwide[5]. MPEG-2 digital compression will allow you to store the same video in higher quality on 2 DVD disks, occupying about half the storage space expressed in bytes. Materials cost about the same. DVD players however are only now becoming a standard multimedia device. Shipping to a large number of users will increase the total cost quickly to unacceptable levels: depending on the urgency and the distance of shipment, the cost per item will be from 1 to a few hundred US$.

Broadcasting video content via a terrestrial or satellite TV channel will enable large quantities of users to receive the materials in high quality instantly and with very little

5 The worldwide TV household penetration of VCRs is more than 50%. Remarks by Charles Van Horn, President of the International Recording Media Association (IRMA), at REPLItech North America, 20 February, 2001, Los Angeles.

cost per item, with satellite having the advantage of reaching audiences way beyond national borders. These distribution technologies however, require access to the originating broadcast site: the satellite uplink or the terrestrial transmission centres. The cost is relatively high but when spread over a vast number of potential receivers this cost becomes almost irrelevant. On average this type of cost is in the order of about US$ 2,000 per hour for analogue TV or less than half of that price for digital TV. Adding additional viewers to the receive target group does not affect the cost of the distribution as opposed to distribution by mail. The main distribution cost is entirely imposed on the content provider (who in turn, of course, can opt for schedules such as Pay TV or subscription fees to recover his/her costs). The cost to the end-user is limited to investment in receive equipment and recording and display equipment (depending on the location the receiving antenna may cost from a few hundred to a few thousand US$, the receiver is again a few hundred US$).

The example above illustrates the costing principle for traditional video distribution, which should not be underestimated in terms of outreach, acceptability and impact.

IP over Everything, Everything over IP

In the mid 90s, the ability of the Internet Protocol (IP) to run across virtually any network transmission media and communicate between virtually any system platforms, led to IP's phenomenal success and to its ubiquitous presence on all communication means. The enormous growth of the Internet led to the convergence of the worlds of telecommunications (telephone), broadcast (TV) and multimedia (PC). The ability now exists to author and publish ones own content almost completely digitally (on the desktop) and to compress and package the content in such a way that it can be transported over the Internet. Such a system has a strong appeal to all types of content providers, commercial as well as institutional or educational.

A wide variety of new applications now make use of IP as the packaging protocol, to allow transport over any network, and many applications seem set to become available including telephony or voice over IP. However, this entire overload has made the Internet a victim of its own success.

Increasing the bandwidth – the data carrying capacity of the network – is not sufficient to accommodate the increasing demand. Internet traffic has not only grown dramatically, but it has also changed in character. New applications have new service requirements and, as a result, the Internet needs to change as well.

It all comes down to bandwidth. In an ideal world, all users, content providers as well as end-users, would have unlimited bandwidth at their disposal, wherever they are. Unfortunately, that is not the case and it does not look like it will happen soon. The available capacity now is insufficient (hence the disappointing performance of many broadband delivery systems). Telecommunication and connectivity providers are struggling to keep up with the pace of the demand while being forced by the end-user to decrease the price continuously. To give an idea, it is estimated that in Europe the bandwidth demand increases by almost 10% every month, while the price to the end-user for Cable, ADSL or Leased Line Internet access has dropped more than 50% over the last 3 years.

Continental interconnectivity bandwidth growth

Region	Mbps (2000)	Mbps (2001)	% (Growth)
Africa	649	1,231	90%
Asia	22,965	52,659	129%
Europe	232,316	487,400	110%
Latin America	2,785	16,132	479%
North America	112,222	274,158	144%

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This increase of demand is fuelled not only by the continuously increasing number of users but also by the bandwidth demand that applications are putting on all networks. This is true in all sectors of telecommunications: from mobile telephone to satellite communications. More and more users want to be able to do more while paying the same or preferably even less. Many of the new Internet applications are multimedia and require significant bandwidth. Others have strict timing requirements, or function on a one-to-many or many-to-many (multicast) basis. These require network services beyond the simple 'best-effort' service that IP delivers. In effect, they require that the now 'dumb' IP networks gain some 'intelligence' or that the user chooses an alternative networking solution.

It is most important to select the right type of communications mode that supports the application under consideration most efficiently and cost effectively. Some simple examples:

- There is no point in trying to do videoconferencing over cellular phone networks because of the low bandwidth (9.6 Kbps), and even given future versions of mobile wireless telephony it may not be the appropriate medium.
- ISDN is much better suited for videoconferencing because it is a standard that is accepted and that allows for reliable connections with sufficient transmission quality to allow for low-quality images and sound to be transferred live.
- For high-quality images however, ISDN videoconferencing falls short. When the images need to be sent and received live (synchronously) a distribution medium with high guaranteed bandwidth may be required. This could be satellite when multiple sites in geographically dispersed regions are targeted, or this could be a point to point connection (via microwave link, terrestrial landline, or satellite) when only one receiver is targeted.

When, on the other hand, the images do not have to be displayed live, it is again possible to use a lower capacity and asynchronous network for the transfer.

Network costs

Not only the amount of bandwidth (more bandwidth costs more) but also the chosen frequency band will have an effect on the overall cost: when the system requires the use of C-band satellite communications, it is understood that the cost for installation of Earth terminals will be higher. The choice of satellite position (and its inherent coverage and power) will also influence the cost of the Earth station (eg, size of antenna). Therefore it is necessary to calculate carefully the consequence of selecting the right satellite: paying higher costs for the lease of a more powerful or better located satellite, may pay back in savings made on the ground when installing smaller and cheaper Earth stations.

Operational costs

Choosing a pedagogical model, the technology to support it and a communications medium, always brings a number of related costs that should not be underestimated. Computers in the classroom require for example, maintenance, upgrades, security provisions, initial training, additional peripherals etc. and are more expensive than TV receivers to install and operate. TV receivers have a much longer depreciation time than computers. A videoconferencing room is more than just the videoconferencing terminal: the room itself always requires adaptations that have an important cost consequence as well. It is not unusual to estimate the cost of a technology-supported classroom installation and adaptation to be equal to the hardware technology costs.

Contribution

By contribution we mean the way by which the original content is brought to the place within reach of the end-user: the transmission point. Course providers and content creators need a priority access to the repository where the materials are kept and from where they are distributed. In the case where the content is distributed via IP-based

transport, the producers need to have sufficient bandwidth to upload to the servers. In the case of a videoconferencing type application, the originating site may need adaptations in order to enhance the effectiveness of the teaching and tutoring. It is therefore necessary to take into account the specific requirements of the course contributors because they may affect the choice and architecture of the network.

Time

There are many time issues related to technology-supported applications for education. The application may require synchronous (instant) feedback (by telephone), or asynchronous feedback (by email), or no feedback at all. This influences the choice of network application. The use of a satellite service that relies on a geostationary satellite implies a certain latency in the communications path, caused by the distance between Earth stations and the satellite. This delay can be crucial in some applications (such as remote process control), cumbersome (in telephone conversations or videoconferencing) or unimportant (eg, in web browsing or in emailing).



More bandwidth over the Internet is becoming available at a rapidly growing rate. The Internet is still not always the medium of choice. As long as there are no procedures in place that allow for the occupation of a particular segment of the bandwidth for certain purposes, the medium is not the most suitable for the transfer of synchronous content in the shape of audio conferences, videoconferences or live broadcast programmes of sufficient quality. The protocols to allow for these applications are under development but it will take more time before sufficient bandwidth plus the required bandwidth allocation mechanisms are in place.

For mission critical content, that is content that needs to be supplied at a given moment with a guaranteed level of quality and success, the Internet is just not the best choice. The alternative is some kind of private network. Such a network can be provided via terrestrial telecommunication means such as leased line, ISDN, ADSL or other flavours of broadband distribution. Unfortunately, the roll out of terrestrial networks is highly dependent on costly infrastructure works that build incrementally on existing structures. The rather slow roll out of ADSL in the UK and in other technologically advanced countries such as Finland is a clear demonstration of this problem. Satellite communications and especially the different versions of VSAT and broadband via satellite may overcome the long wait and may deliver the user an almost instantly available solution to connect according to his/her requirements.

Satellite network time requirements vary widely. Fortunately the technology adapts well to a range of different requirements: connections that are always on; on at set time intervals; irregular and unpredictable; night-time connections; and more. While connection time may be much cheaper at night, it may not suit the application. However, for data distribution that is not time-sensitive it may be a cost-effective option.

Location

So far we have been demonstrating that satellite communication is ideal to overcome distances. ICT-based education gives the user the impression that time and place are becoming irrelevant. However, careful consideration of the geographical requirements of a network application can avoid high costs or inefficiency. For example, the German Mediadesign Akademie (www.mediadesignakademie.de) in collaboration with a German employment office, uses satellite broadcast to deliver ongoing training courses to over 500 small offices and home offices all over Germany. The teacher/trainer lectures on camera for the largest part of the broadcast, and interacts during the lecture with his/her learners via email and chat. Because the images of the lecture have to be of sufficient quality, because some of the support materials have to be prepared carefully (slides, graphics etc) and because the interaction returning from the remote students requires a certain amount of infrastructure and support, a minimal level of resources is required. These cannot be found in every location of the teaching staff, so a central ‘studio/classroom’ based in Munich is being used, requiring the

teachers to travel from all corners of the country to that location to deliver their teaching contribution.

The design of a distance education network can indeed involve the use of a central location from where the teaching contents are distributed. It may be that for reasons of investment only one classroom is sufficiently well equipped with all the tools and equipment to support the teacher/tutor in his/her work. This can be because the architecture of the network is such that the output of the central location is better than the output of the individual remote sites (eg, because of the use of an asymmetric network such as broadcast TV or radio). In that case, the operational cost of bringing teachers to the central location can be considerable and should be evaluated against the investment cost of installing additional remote contribution sites, or using completely symmetric networks where all sites are equal.

Similarly, when providing web-based learning materials, it may be important to select the physical location of the content server in such a way that all end-users are served with sufficient quality. It may be worthwhile considering the porting of the content to a new server location that is better suited to service the whole user community. This may be a location that is closer to the backbone of the Internet. Economic factors here are rather the availability of the server to all users on the network rather than to the content provider itself. For example, if the content provider has only limited bandwidth to the Internet, it may be better to use this bandwidth to transfer the content even over longer periods, towards a central server that has sufficient access bandwidth in order to serve many clients at the same time. Furthermore, it may be necessary to investigate the need for a Content Delivery Network, that pushes the content to distributed servers that are within an easier reach to the end-user.

Whenever a networked application such as distance education or telemedicine is planned, a geographical plan should be part of the total project, because of the close relationship between costs of investment, network architecture, communications and operation.

Quality

Satellite communication can be tailored exactly to the needs of the users. Bandwidth and coverage are the most important factors of interest. Different levels of service can provide scalable levels of quality of service: fixed and privately allocated amounts of bandwidth or flexible bandwidth allocation whether always-on or available upon request. In addition, because there are no intermediate parties in the communications chain, monitoring, control and management can be done effectively and easily. Compare, however, the costs for VSAT networks with the cost estimate for a two-way satellite Internet connection solution, and it becomes clear very quickly how quality of service (such as guaranteed bandwidth) affects the overall cost.

Quantity

For traditional communications technologies such as TV and radio broadcast, numbers are extremely important: the larger the audience, the more cost effective the broadcast can be considered. This argument is true in public broadcasting where the government pays the cost for all to receive free. It is also the case for commercial broadcasting: viewers pay for a subscription or to receive certain programmes, or advertisement pays for the broadcast so that the audience can watch free of charge.

Quantity has a different significance for educators. It means economies of scale when they can produce once and reuse many times (eg, with good quality multimedia materials) or when they can distribute content (and teach) to many at the same time (eg, via broadcast TV or via the Internet). Communications technologies make it easier to reach more users. Technologies in themselves however, do not always improve the quality of communication.

Here is a simple example to illustrate this: videoconferencing interaction works very well between two sites when there are limited numbers of participants at each side.

When the number of participants at each site increases, it becomes impossible to interact effectively with each of them, very much like in a 500-seater university lecture hall where little or no interaction happens between the lecturer and the student at the back row. When more than two sites need to be connected via videoconferencing, costs increase while interactive effectiveness decreases.

In a similar way one should not underestimate the cost of support and tutoring required with web-based learning environments. These can be set up relatively easily and then made accessible to many. Support, tutoring, assessment and follow-up however, increase with the numbers of users. While the basic principle is sound (improving access to learning materials and education) the practical elaboration may require scalability consideration.

Availability

When the satellite system is properly designed at all sides (uplink dimension and redundancy; downlink specification; transponder availability), satellite is able to guarantee an almost unparalleled availability. An important factor is the balance between required availability (expressed in % per year) and installation margins. Availability of 99.5% and more is easily achieved. The weakest link in the chain here is the end-user Earth station which may suffer from adverse meteorological conditions (storms), accidents, lack of maintenance or interference. The availability of satellite communication parallels easily the availability of terrestrial Internet connectivity.

Energy

Power and access to telecommunications are considered readily available commodities in regions like Europe and North America. This is not the case in many other regions. While satellite can bring access to telecommunications surpassing territorial and geographical barriers, energy will still be needed on the ground to receive, process and apply the contents.

Satellite and terrestrial TV are equally accepted and important, but they require power for receiver and TV monitor. Satellite broadband and Internet are no different: their power consumption has become low but is still important enough to cause problems at some locations (for small VSAT-type installations including multimedia PC an average 500 W is needed).

Security

Because satellite communications avoid borders and physical infrastructures such as nodes and exchanges, it is a highly secure system. The only part of the transmission chain that is exposed and is in some way vulnerable is the outdoor antenna. The rest of the communication provision is not dependent on any intermediating elements that can delay, curtail or hinder the communications. The management and control system that is inherent to satellite communications, also allows the network provider to contain or restrict the communications, to set up a completely 'walled garden' or private network infrastructure that keeps the user community safe and secure. All levels of security and privacy can be managed easily and centrally, allowing for content filtering, conditional access, even pay-per-use and accounting.

Hardware installation and maintenance

The use of advanced technologies has a certain element of risk in it because of the lack of experienced support people in the field. In many cases where satellite communications are used for the first time, more initial support is required. Networks based on terrestrial communications on the other hand, are built more incrementally and allow both service-provider and end-user support services to become fully acquainted with all service and support issues.

The selection of a particular communications service (eg broadcast TV vs VSAT vs Internet via satellite) brings a different support requirement. Support for the course and content provider in the case of broadcast TV is almost always extensively organised as

an inherent part of the professional TV broadcast and satellite transmission services. The support service at the end-user side is also commonly dealt with in the commercial sector by professional satellite installers and resellers. Worldwide-distributed brands of consumer equipment using common standards make interchangeability and support easy even for the end-user themselves. Because there are no security issues around the use of receive-only satellite installations, installers and technicians do not require high levels of training, and consequently there is no shortage of this expertise and service to the end-user is cheap.

VSAT, at the other end of the scale, requires a lot more specialised support that is network specific. Service engineers and installers are not as widely available as for satellite TV and in some cases they may not even be based in your locality but cover a wider region. Although the technology is very reliable and tested, support and maintenance will be needed and may be more expensive than in the previous example.

Internet via satellite again, is relatively new to either group of support staff. It will probably require the set-up of a new and quite extensive support structure (including remote assistance, help-desk etc). Because this system is aimed at end-users, support structures close to the end-users (local and regional sales and support services) are required. Customers have learnt to expect and appreciate a certain level of support from ICT providers, and they will not compromise for a new service such as Internet via satellite.

Both these last examples require more than ordinary installation skills, because transmission implies security and safety risks on the ground as well as for the transmission path itself. Finding trained staff is more difficult than for the first example.

Depending on the scale and the typical requirements of each application, it may be that the course provider sets up his/her own support network, possibly linked to remote departments, facilities or affiliates. This may represent a considerable cost factor.

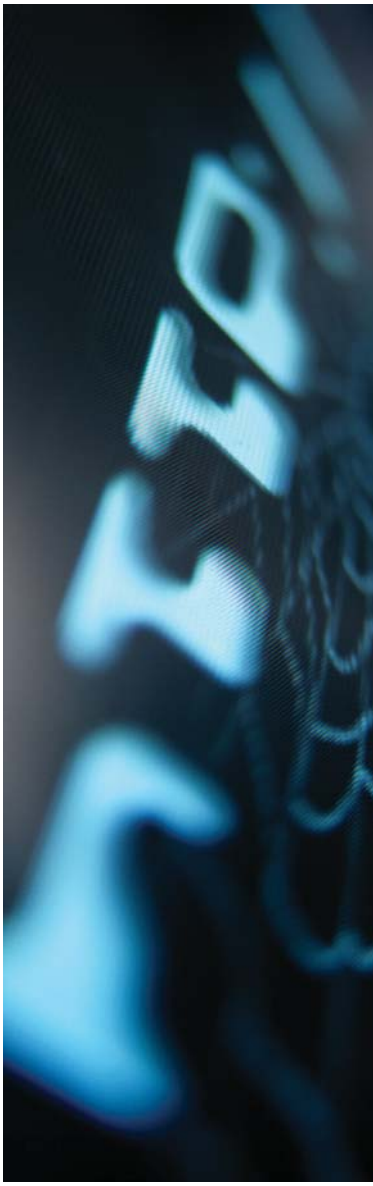
Support

An efficient service relies on quality support mechanisms. End-users need to be able to call for help with different aspects of the educational service. The first level of help is directly related to the content or the methodology of the provision and is ideally organised by the course provider and involves the person responsible for that particular course. This is the default support level for the end-user. Calls at this level can be dispatched to the appropriate destination: to the course content specialists, to the tutor or teacher, to the administration or elsewhere. In the case of technology support calls, the call needs to be transferred to the appropriate technical help service: this can be either a local or network specific support service, or the technical support service that is related to the satellite service provider. For example, let us take the case of a student participating in a web-based course delivered via two-way satellite Internet where the terminal is located at a remote campus of a university. If the student encounters a problem with his/her connection to the web site with course materials, he/she first calls the course providers' support service. This service checks if the problems are related to the content, if not the service will pass on the call to a technical support service that is located as close as possible to the end-user and that will diagnose first of all the technical problem. If the problem is related to the satellite network, the local support service will pass on the call to the satellite service provider.

Training

Depending on the selection of the technology and the pedagogical model, the parties involved may require a certain amount of training. It should be clear that very little training is required for the specific satellite part of the chain.

Regardless of the transmission path (terrestrial or satellite), most applications of technology-supported education require some training or at least some raising of awareness. Teaching and learning by means of a web-based learning environment requires some basic skills that are not related to the telecommunications technology



but rather to the methodology. It is much the same for producing quality video for distribution on tape or via terrestrial and satellite transmission. Videoconferencing requires some training in order to be effective, and in which there may be some specific reference to the network technology used: every network technology under consideration here will affect the performance in some way, whether it is ISDN, Internet or satellite.

Using satellite communication technology may necessitate specific training for those working at the side of the originating Earth station or the hub server where it may be necessary to make the satellite service provider's staff aware of specific educational issues. At the end-user side there may be a requirement for training in specific hardware-related topics such as the set-up of the Earth station (antenna pointing or software updates). Training can be provided to either the end-user him/herself (eg pointing of a satellite receive dish), or to local or regional support people when the technology requires a higher level of competency or specialised tools that cannot be made available to all end-users.

Sustainability

When considering the total cost of a technology application, all too often only the initial investment cost is taken into account. However, when setting up an ongoing service solution, operational costs including support, network communications costs, replacement scalability and upgrade costs are all important factors. Satellite communications services are perceived as being expensive. Satellite communications however, in general score very well with regard to operational costs: VSAT networks, for example, have a lifetime of more than 5 years before the network requires extensive upgrades or changes. This is because the network is independent of intermediate nodes, and switches and technologies can easily be implemented network wide.

For IP services over satellite, where the competition comes from terrestrial broadband networks such as fibre, a shorter lifetime expectancy is reasonable: with the evolution of fibre technology and the increasing installation of new backbone links to, as well as within, large areas (for example the construction of the Metropolitan Area Networks), satellite connectivity for backbone connectivity to the ISP will become less attractive within a few years. ISPs therefore take only medium- to short-term leases (up to 2 years) for this type of satellite service.

Internet connectivity for the end-user (using small one-way or two-way VSATs) may also have a medium-term life expectancy (3 to 5 years), at least in the areas where, because of the economic and demographic situation, deployment of terrestrial solutions is viable. In remote areas where access technologies will not become available within the short to medium term, satellite Internet may be a solution for at least 10 years. The problem with this type of technology however, is that many operators and service suppliers are relatively unfamiliar with supplying services to the end-user, and the sustainability of this has to be proven. The good news for the end-user is that costs keep coming down, both for hardware and for communications costs.

Revenue

We rarely think in terms of revenue when referring to education solutions. It is probably more appropriate to speak about potential cost savings. This can be achieved by combining the usage of technology solutions.

On the one hand, it is good practice to use the same network and technologies that are already in use (by the course provider itself or by a related institution or course provider). By joining a group or institution that is already using some service, a large part of the initial set-up costs (including piloting and trial costs) can be saved by sharing experiences and enlarging the existing network. Some of the services described in Chapter 5 are certainly open to this type of proposition.

On the other hand it is increasingly common for educational providers to make their technology solution available to others: for example by opening Internet access

facilities to other community or even commercial services. A school or a remote campus can, for example, share the infrastructure with a medical service, or make the access available to businesses and individuals outside campus hours. Although this approach requires careful planning and maybe some additional investment (security, accountancy), it may be worthwhile.

4.9.2.2. Pricing trends

Costs in the ICT world have come down dramatically over the last 10 years. Personal computers are costing less than 15 years ago and can come down much further. Competition in the telecommunications sector has brought the price of a telephone call down. The cost of Internet access has gone down significantly in the decade that it has become widely available to the public.

While this trend towards lower costs will probably continue, end-users are recognising more and more that there is no such thing as a 'free lunch'. The decline of DotComs has clearly demonstrated that electronic services need to adopt sustainable business models. Although free Internet access was very appealing to users, many providers have gone out of business. For professional or mission-critical applications a price has to be paid for a certain level of quality and service.

The same applies to satellite communications. While objectively speaking the costs have come down, a threshold seems to have been reached. Prices in the satellite communications industry have reached a level that can be compared to terrestrial services such as ADSL or leased lines. Service suppliers in any of these technologies will watch each other's price settings in order to stay competitive. When new technologies or players enter the market, they will again set their prices according to the service levels and quality guarantees they are able to deliver.

4.9.3. Regulatory issues

Satellite communications make use of a part of the radio spectrum, which is a valuable resource, shared by many different types of applications and users. In order to avoid conflicts, abuse and interference between users, but also to watch over public safety and health issues, some form of regulation is required. This regulation is handled by national or regional institutions that apply international recommendations, agreed in organisations such as the International Telecommunications Union (ITU). Some freedom does exist however within ITU recommendations, for each regulatory body to adopt the procedures according to local requirements. For the sake of simplicity we will in this section address VSATs in the generic meaning of the word: 'Very Small Aperture Terminal', any fixed satellite terminal that is used to provide interactive or receive-only communications.

Licensing problems

While satellite communications offer immediate cost-effective solutions, some countries' policies, rather than facilitating satellite communications, hinder or prevent their deployment. In many countries regulation procedures are outdated, expensive or cumbersome[6].

6 For a full overview of licensing in Europe see: http://telecom.esa.int/uso/training/licensing/

In some countries, the national public telephone operator is the only entity that may install and service, or even own, operate and maintain VSATs. In other countries a local commercial presence is required by administrations as a precondition for licensing.

Licensing fees also remain too high in many countries. Furthermore, some regulatory bodies apply additional taxes, annual operator fees, high customs tariffs restricting importation of VSAT equipment, and tariffs be paid to the incumbent Telecom Operator – even if they do not participate in the service chain. The accumulation of too many fees tends to be prohibitive for many VSAT applications.

Furthermore, many countries still apply unnecessary burdensome licence application processes resulting in unnecessary delays issuing regulatory licences. Sometimes, existing Earth-station regulations are geared to the broadcast industry and do not

contemplate current uses such as data, Internet, and private voice networks. Some countries enforce zoning restrictions that prevent the installation of rooftop VSATs.

Some administrations require type approvals for antennas, even though the antenna type is already being used for the particular satellite system being requested.

While there are more than 500,000 VSATs operating in most of the world's countries, many of them are precluded from international applications. This is an unfortunate waste of resources, because VSATs are ideally suited not only to provide domestic connectivity, but also to offer trans-border communications for wide-area networks. On the national level, VSAT rules are often neither transparent nor accessible to the general public. Further, these rules are often difficult to interpret. On the regional level, service providers are required to seek out a multiplicity of application forms – as well as contact details for the officials responsible for processing them – among the jurisdictions where they provide services.



In general, it has become apparent that the more regulations, fees and other requirements that are imposed on providers of VSAT systems and services, the fewer communications options will be provided in the individual country.

Licensing perspectives

The Global VSAT Forum (GVF), which acts as a representative body for the VSAT industries, has developed regulatory recommendations and guidelines as a tool for regulators and policy makers, who are interested in modifying regulation to facilitate the use of VSAT-based services. Regulators around the world are already taking these factors into account and are implementing new policies that facilitate the use of VSAT systems and services. For example, the regulator in the UK has adopted a one-stop-shop procedure that guarantees short turn-around times for applications.

In order to advance furthermore the uptake of satellite communications, the GVF encourages the elimination of licensing and monopolies to wipe out sub-standard services offered at above-market prices.

4.9.4. Conclusion

It should be clear from this chapter that a network solution for education, be it via a satellite communications network or via any other distribution means, has many different cost elements. Very often, decision-makers find themselves blinded by the cost of distribution. It is essential, however, that the contribution of these costs should not be overestimated. The first and foremost cost is always the cost of creation, collection and adaptation of the content and the cost of tuition and support. It is commonly observed that the cost of production of the content is at least five times the cost of distributing the content. The latter cost is only marginally affected by the medium itself.

The value of the distribution medium should be evaluated correctly by looking at the direct costs (and every education provider will agree that these are costs that are to be avoided as much as possible) as well as looking at the opportunities the technology brings to the education system. The possibility to widen the audience, to reuse materials, to better use staff resources and to improve the teaching and learning experience are factors that cannot easily be expressed in financial terms.



This chapter focuses on the ICTs (satellite based and others) that allow for end-users to communicate and exchange information. We intend to discuss only those technologies that connect end-users to the public access networks (the so-called 'Last Mile' or the connection technology that connects to the home) and amongst themselves (Local Area Networks – LANs and Wireless Local Area Networks – WLANs). The technologies that make up the public networks themselves (the backbone infrastructure) and the ISP to ISP infrastructure are not covered.

5. Access and Connection Technologies

It is most important to make a distinction between access technologies that allow for communication with the public network and the technologies that are used to communicate within a closed (private) group or environment. To make a simple comparison: the public network is like the public traffic and transportation system: this consists of public roads (from minor dirt tracks to multiple-lane motorways), plus public transport (buses, trains) and boats and planes. To travel in the wider world one selects the appropriate means of transportation: travelling to your neighbour is possibly done by walking, travelling to another country possibly by plane. In a similar way it is possible to connect to the public network by various means, depending on each end-users' typical situation, his/her requirements and the possibilities offered by services to and from the location.

In our roads analogy, the private network is limited to the local premises. Depending on the size and complexity of the estate, there is a choice of different technologies to connect the different parties within the estate and to connect if necessary to a gateway to the outside world (the public network). Compare this gateway to your own driveway between the garage and the public road: without an appropriate driveway it would not be possible to get from the private to the public space.

5.1. Access to Public Networks

5.1.1. PSTN, the Public Switched Telephone Network

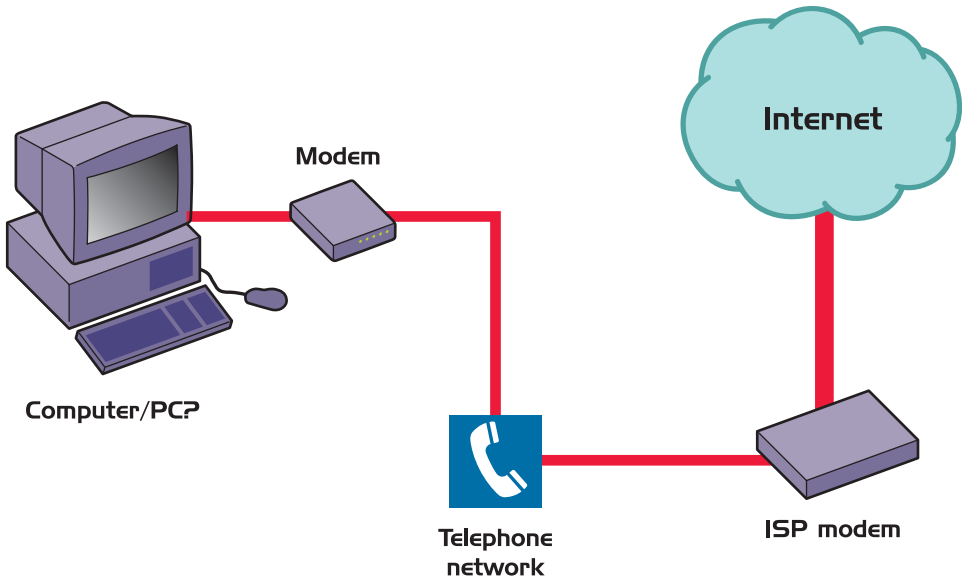
This is the most common access technology, also known as dial-up access. It requires a telephone connection, a modem, some kind of terminal or appliance that allows for interaction or communication with the hosting network (eg, a computer) and an account or agreement with the network owner or access provider that allows for dial-up access (eg, in the case of Internet access: the Internet Service Provider or ISP). The user establishes a connection by calling via its modem and the modem located at the network to access the services offered by the network. The public Internet is the most common example of such an application, but there are other applications such as billboards, or Compuserve and AOL initially.

The quality of analogue telephone connections is somewhat limited: because they were conceived in the first place to carry voice transmissions, they are not so fit for data communications as well. Consequently the speed of transmission of data over such connection is low (maximum 56 Kbps[7]). Such slow speed is less suited for media-rich applications (eg audio and video distribution, flash animations, multimedia web pages). This type of connection is adequate mainly for email with limited size attachments.

Poor-quality telephone networks also regularly result in loss of connection or degradation of speed. The cost for the user is relatively high because connections costs are almost always charged by the minute. And because the connection makes use of an existing telephone connection, voice calls over the same line are not possible during the connection.

7 An electronic version of the Bible and the Koran on the web is about 2.34 MB. Downloading such a file over this type of dial-up connection would take at best 5 minutes 42 seconds.

The advantage of using the telephone network is the fact that when the connection is established between your computer and the ISP, the bandwidth is uncontended: because of the switched nature of the network, that connection channel cannot be shared amongst multiple users, you, and only you, are the sole user.



5.1.2. ISDN, Integrated Services Digital Network

Integrated Services Digital Network (ISDN) is fundamentally a development of the analogue PSTN telephone network. ISDN allows for better services but requires an upgrade of the network, for example, by installing ISDN switching equipment at crucial points in the network. The end-user needs to install ISDN enabled terminating equipment: that means an ISDN telephone set, a different type of fax machine, ISDN modems etc. In return the user gets more and better services: his/her telephone line capacity is doubled (two channels over one single line make it possible to carry out two phone calls or one phone call and another connection at the same time and with better quality). ISDN allows also for higher connection speeds: 64 Kbps per channel, 128 Kbps per line maximum[8]. The main advantage is the increased speed of the connection and the short connection set-up time (about 2 sec) for the connection. This allows for a more satisfactory connection experience compared with the set-up time of an analogue PSTN connection which can sometimes last about a minute. The stability of the connection quality and the fact that multiple ISDN lines can be combined (bundled) to result in even higher capacity, allows for applications such as videoconferencing. Still, the connection is not an always-on connection: connection costs are normally charged by the minute[9]. And although ISDN is regularly being called broadband, in our opinion its speed and connection comfort cannot be compared with a real always-on broadband connection.

The major disadvantage of ISDN is its availability: although it has been taken up well especially in urban areas, ISDN has generally not been available everywhere. ISDN is often installed for videoconferencing purposes and to a lesser extent for ISDN-based Internet access.

5.1.3. Mobile and wireless telephony

Mobile telephony has over 500 million users worldwide and is available in almost 200 countries, of which more than 60% use the GSM standard[10]. The Global System for Mobile communication or GSM is a digital mobile telephone system that operates at either the 900, 1800 or 1900 MHz frequency band. Since many GSM network operators have roaming agreements with foreign operators, users can often continue to use their

8 The download of an electronic version of the Bible and the Koran from the web (size of 2.34 MB) would take at best (connecting over both ISDN channels at a maximum of 128 Kbps) 2 minutes 30 seconds.

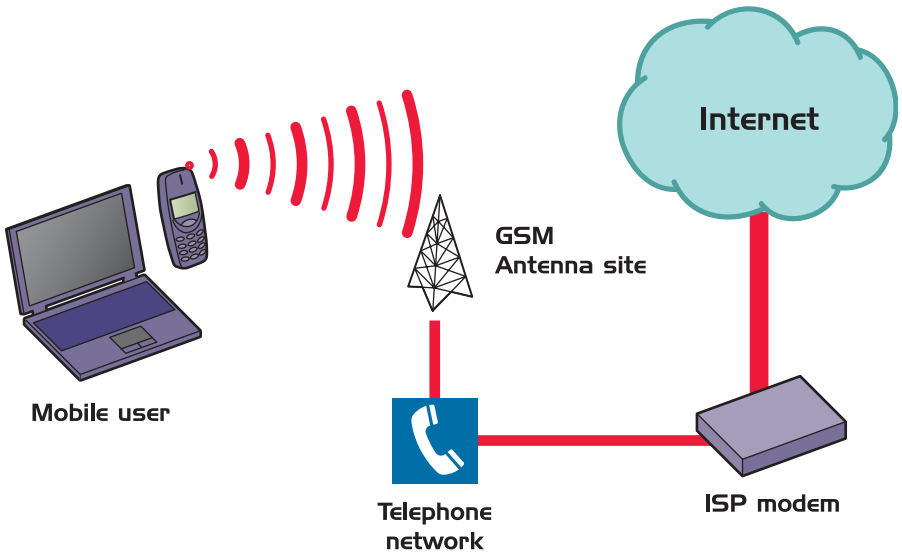
9 There are exceptions to the call duration charges: in some countries (USA, Singapore and others), call connection charges are billed, duration charges are not, for certain calls.

10 GSM uses a technology called time division multiple access (TDMA) and is the most widely used of the three digital wireless telephone technologies. Alongside the digital technologies, a few analogue mobile networks still exist, but these are disappearing slowly.

mobile phones when they travel to other countries. Wired telephone networks require extensive and expensive work on the infrastructure to cover large areas, especially in sparsely populated (rural) areas and in areas where the terrain is inhospitable. Wireless antennas on the other hand can be relatively quickly, easily and safely installed, and they instantly cover a wide area. Depending on the specific set-up of the network (frequency, power) and the local environmental situation (relief, foliage), one mobile-phone antenna can cover up to a 25 km diameter area. To connect isolated or remote GSM antenna sites to the telephone network, microwave technology or other wireless technologies (radio links, optical relay or even VSAT) are being used.

Mobile telephony operates very much in the same way as wired telephony in the sense that it establishes switched connections. Again the transmission speed is rather low (GSM typically not higher than 9.8 Kbps)[11]. Because it was conceived for voice communication it is not an ideal way to connect to the Internet or to carry multimedia services, although it can be done.

Because of the exponential uptake of mobile phones, nowadays many mobile phone operators seem to have problems coping with the growth of their customer base and the resulting increasing demand upon the network capacity.



In its present state mobile telephony is not ideally suited for Internet access. Wireless mobile telecommunication is however evolving rapidly towards new mobile telephony and mobile data technologies that allow for voice and data communications of higher quality, allowing also for Internet access and multimedia[12]. These include technologies under development such as High-Speed Circuit-Switched Data (HCSD), General Packet Radio System (GPRS), Enhanced Data GSM Environment (EDGE) and Universal Mobile Telecommunications Service (UMTS). These innovative technologies will allow for data transfers comparable to ISDN (around 128 Kbps) in the case of HCSD, EDGE and GPRS, and up to ADSL-like capacity (from 384 Kbps to 2 Mbps) (see further in this chapter). The new technologies also allow for always-on connection, again as is becoming the norm for broadband Internet access.

5.1.4. Satellite telecommunications

The solutions that satellite can offer, range from telephony in places where there is no other telephone network availability using portable handsets, to high-quality private data networks that can carry voice, video, data, Internet etc. (For extensive details about the various solutions that satellite telecommunications can provide, see Chapter 3). Depending on the network technology and the application, satellite provides connection speeds from a few hundred bps[13] (for example with L-band data transmission systems) to 80 Mbps[14] and more, for example for TV broadcasts. Satellite

11 The web download of electronic versions of the Bible and the Khoran would take at best 32 minutes 30 seconds via GSM.

12 iMODE, WAP, SMS, MMS and other current innovative adaptations or additions to the existing mobile phone network give a foretaste of things to come. iMODE is a Japanese GSM technology that allows for games, downloads, limited information services etc. WAP or the Wireless Access Protocol allows the mobile phone itself to be used as a device for access to web content. Short Message Services (SMS) allow for short texts to be sent between two mobile phones. Media Messaging Services (MMS) is the latest addition to the GSM technology of this generation: it allows for transmitting pictures between two mobile phones.

13 At this speed it would take 36 hours to download the digital Bible and Koran file.

14 At this speed it would take less than a second to download the whole Bible and Koran.

technology offers a great deal of flexibility (it can be applied almost anywhere with minimal costs related to infrastructure and with minimal delay in deployment) but it is not very efficient in its use of the available radio spectrum. Therefore almost all satellite telecommunications are heavily regulated[15] and although this is not necessarily a uniquely negative fact, it is often seen as a barrier. Satellite-based services are also considered expensive. Costing a satellite application is complicated because of a large number of parameters: the cost of hardware and the communication costs vary widely depending on the solution required.

Satellite telecommunications are most effective for broadcast or multicast type applications: the larger the target audience, the cheaper the application per use, without putting an unacceptable load on the network, unlike with switched terrestrial networks. TV and radio broadcasts as well as also other types of content delivery (eg pushing software applications, files, web pages, news content etc) from a central server to a large number of client locations, especially when these are very dispersed and difficult to access, are the most efficient uses of the technology.

The use of satellite for two-way communications (small two-way satellite systems for Internet access, VSAT systems) can provide a rapid solution for access again in places with insufficient terrestrial network capacity. Because of its cost, this type of solution is most viable for larger end-users (eg colleges, outreach centres, communities and libraries, or for aggregated access solutions, shared between multiple user groups). In this way it is being applied by end-user organisations (in the case of small two-way satellite Internet access solutions) as well as by telecommunication providers to provide end-users as well as the public with connectivity.

The RABBIT[16] initiative in the UK, is aimed at small businesses in areas that cannot receive ADSL or Cable Modem solutions, but who are prepared to try out the alternatives now available. They provide information about a number of satellite service providers that offer a range of Internet access solutions, often as subsidiaries of larger international consortia.

5.1.5. Leased lines

The traditional alternative to the public switched telephone network, is the so-called leased line, which is a telephone line that has been leased for private use, sometimes also called a dedicated line. Typically, leased lines are rented from the local (public or private) telephone company to connect sites with a certain quality of service: that means availability (eg the line stays connected 24 hours a day allowing for always-on connectivity) and guaranteed speed of transmission (leased lines are normally available in circuit segments of 64 Kbps and can be upgraded to 2 Mbps and more). The alternative is to buy and maintain one's own private line or, increasingly, to use the public switched lines with secure protocols such as Virtual Private Networks over Internet.

Leased lines are a commonly available technology which can be deployed virtually on every existing wired telephone line. Their cost, however, is prohibitive for other than critical businesses like banks, medical institutions, security services and government agencies.

5.1.6. Digital Subscriber Line – DSL

Digital Subscriber Line is a technology for transmitting digital information at a high bandwidth on existing phone lines that remain available for ordinary telephone voice conversations. DSL is mainly aimed at provision of Internet access services for home and business users. Unlike the regular dial-up phone service, DSL provides continuously available (always-on) connection. DSL comes in many flavours: ADSL, SDSL, VDSL etc. Asymmetric Digital Subscriber Line or ADSL is asymmetric in that it uses most of the channel to transmit from the service provider towards the user and only a small part to receive information from the user. SDSL, VDSL and the other DSL types provide even better quality services.

15 Regulations especially in the radio communications services are necessary to make sure that users of the bandwidth provided can do so safely and securely and that there is no unwanted interference from un-authorised users. However, it can be argued that many regulations are only in place to keep competitive or complementary service providers out of the market and to protect the incumbent operators, by imposing overly complicated and expensive procedures. Controlled and impartial regulation can contribute to a healthy telecommunications climate that is of an advantage to the whole country and society in general.

16 See: www.rabbit-broadband.org.uk

Telecom operators can adapt their existing copper wire-based telephone network infrastructure but this at a considerable cost: to deploy DSL services the whole network needs to be equipped with new hardware at the local and the central exchanges. Even then, DSL only serves as a last-mile solution: to connect from the local exchange to the end-user. Because of the specific technology used, DSL is limited in distance and it stretches up to a few kilometres only (3 to 11 km maximum), depending on the type of DSL as well as on the quality of the existing copper-wire infrastructure. The transmission speed ranges typically from 256 Kbps to 4 Mbps. With ADSL, the upload speed (traffic from the end-user towards the Internet) is usually slower than the download. Typically we see speeds of 256 to 512 Kbps for uploads. For downloading, providers offer from 512 Kbps to 6 Mbps. The typical switched telephone network infrastructure that lies at the heart of the DSL technology allows for very high contention rates, hence the quality of the connection is seen to be very high. DSL has been the most successful broadband technology in regions with a good telephone network. In Europe, for example, DSL accounts for 69% of all broadband connections, while in the UK DSL currently (beginning 2004) represents about half the number of broadband connections with 1,180,000 subscribers.

5.1.7. Two-way cable

Interactive cable or two-way cable makes use of the existing infrastructure of the TV distribution cable. That network in itself is not interactive, it was originally only intended for distribution (broadcasting) of TV and radio programmes, and therefore to become interactive and fit to provide other services such as telephone and Internet it must be converted into a two-way network. This needs to be done again at a whole network level: at the central nodes, at various points throughout the network (local exchanges, repeaters, etc) as well as at the end-user premises by adding cable modems. These modems allow for the connection of telephone sets and fax machines, but also for the connection of one or more PCs to the Internet, and to bring interactive services to the TV (games, TV shopping etc).

As with ADSL, the investment in the network adaptation is considerable, and although the cable used for cable TV distribution has inherently a greater potential than the copper wire used in telephony[17], it was originally, by its typical network architecture (broadcast rather than switched), less suited for Internet and voice connectivity. Because all users within a certain connection cell on the cable share the available bandwidth (contention) they are in practice offered bandwidths around 1.5 Mbps although, in reality of course, the cable is capable of much wider bandwidth.

The number of cable TV networks in the UK is limited, and many of them are only local or community based and used mainly for redistribution of broadcast materials (as CATV or Community Access TV).

5.1.8. Microwave, radio and wireless

Microwave and radio-based systems are deployed to provide access networks in two basic network architectures. The first is a point-to-point arrangement where one station connected to the core network provides connection to another single station. The second arrangement, point to multipoint, includes a base station connected to the core network that serves a number of remote subscribers within a coverage area.

5.1.8.1. Wireless point-to-point connections

In regions where the wired telecommunications infrastructure is not optimal, radio could form a valuable alternative for telecommunications. Besides of the way radio is used for broadcasting (as in public, regional or community radio and TV programmes), radio has also been used as a two-way communication device when the division of the available radio spectrum allowed access to service operators other than broadcasters, resulting in various new radio applications such as amateur short-wave radio transmissions, as well as walkie-talkies and two-way radio applications for Internet access.



17 The coaxial cable on which cable TV services are offered have a bandwidth of several hundred Mbps with less distance limitations than the copper wire used in telephony. The telephone wires are also limited to a much lower capacity (at best 10 Mbps).

Telecom operators use microwave links based on radio transmission technology. The microwave uses a frequency higher than 1 gigahertz (billions of cycles per second), corresponding to very short wavelengths (comparable with satellite transmissions).

Microwave signals travel in straight lines and are affected very little by the atmosphere but they work only within line of sight: two connecting antennas need to 'see' each other and some attenuation occurs when microwave radio frequencies pass through trees and non-concrete buildings. Radio-frequency energy at longer wavelengths (such as the one used for radio and TV broadcasting) is much less affected by walls etc, allowing radio reception within buildings for example.

Microwave is used by telecom operators for wireless transmission of signals having large bandwidth, for example to connect regional exchanges in cities that are otherwise hard to connect. In this way trunk telephone traffic is enabled between larger towns.

Optical cable (fibre) still allows for much higher capacity of traffic but is often more expensive to install, its deployment is difficult because installing it involves building permits along the whole trajectory, coping with adverse geographical conditions etc.[18]

18 For example, in Germany the average cost for laying cables is around US$ 15 per m. In Ireland, the average metre of cable installation costs 10 times as much due to the less favourable geographical conditions.

Microwave and radio solutions are rarely used for end-user connection solutions except for larger customers (eg banks, hospitals, universities and corporate clients) and in that case they complement satellite VSAT-type solutions by providing short- and middle-distance coverage. The decisive factor is the availability of a radio or microwave provider, as well as the total cost of the deployment of the land-based radio relay stations that are required. Radio-based solutions such as microwave certainly have great potential in rural areas because they are highly effective in flexibly extending an under-developed telecommunications network.



5.1.8.2. Wireless point-to-multipoint connections

There are a wide number of access solutions that fit within this description, depending on the specific requirements of the end-user as well as on the availability of specific technology providers in the area.

Some solutions can almost be called hobby solutions in the sense that they can be constructed by non-professionals and are made up of off-the-shelf parts and tools. However, they may need some careful research and testing. Lower frequency bands have the characteristic of permitting radio transmission without direct line-of-sight. This makes them particularly useful for communication to sites that are distributed in small villages and towns. Higher bands (10 GHz and higher) on the other hand offer the advantage of larger bandwidth and thus more capacity. These bands require a clear line-of-sight radio path and need to account for rainfall attenuation.

The 2.4 GHz band

This band is used extensively for indoor or outdoor WLANs and also for outdoor Fixed Access links. For telecommunication purposes it is exempt of licensing in most countries. The band is shared between users on a mutual interference basis, but various spread spectrum modulation schemes have been defined to permit co-existence, including Bluetooth and wireless Ethernet (also called mistakenly WiFi) or IEEE802.11b. Similarly, part of the 5 GHz band (IEEE802.11g) is used without licensing for Local Area Networking.

These are short-range nomadic systems where users can move within the range of the transmission without losing connectivity. Others can deliver high-speed IP data (including voice service) over ranges of 5 km or more in urban areas by using special antenna and amplification designs. Provision of service guarantees by operators in this band is difficult due to interference from many competitive systems, the security issues (it is not very difficult to hack into this type of network) and the narrow spectrum available. This limits the potential uptake for business-critical services. The main advantages are that they are unlicensed, cheap and easy to set up. The issue remains that at the central location some access to the public network with sufficient capacity needs to be provided. This can be a satellite gateway.

5.2. Competitive Technologies: Present and Future

In recent years there has been an almost euphoric attitude about the potential for growth within the satellite communications industry. The recent failures of companies to become profitable from the new Internet services via satellite, however, have given rise to a belief that developments in the multimedia broadband area will stall. ISPs and connectivity providers are taking only medium-term leases on satellites (maximum 2 years) because they expect fibre capacity to become sufficiently available thanks to the greater offer as well as transmission technologies that will enable more transmission over the same physical cable. There already seems to be an over-capacity of dark fibre (fibre that is not yet used for transmission) on some of the major traffic routes. It is only until such time as fibre effectively connects all global regions will satellite data trunking have a window of opportunity. From that moment, it looks like satellite capacity will shift massively towards an ever increasing TV and radio broadcasting market.

Two-way Internet access, although being deployed by an increasing number of companies (BT OpenWorld, TiscaliSat, Aramiska, Starband, Web-Sat) is not expected, at least in Europe and North America, to become a real threat to cable or ADSL broadband access. It may always remain a niche product although this could still represent an average of 10% of access in developed countries, and a lot more in developing countries.

The innovative high-speed broadband LEO satellite-based initiatives such as Teledesic and SkyBridge, which looked very promising especially as a way to provide services to sparsely populated areas that are underserved, seem to have been put on the back-burner since pioneers like Iridium, ICO and Globalstar failed to make a business case.

While terrestrial wireless telephone solutions, such as GSM or cellular telephone, enjoy almost universal coverage, it remains to be seen if the same will be true for the emerging and future versions of mobile telephony: GPRS, EDGE, UMTS, etc.

Fixed Wireless Local Loop, another broadband connectivity technology, uses terrestrial radio transmission networks to connect remote locations. Although it may well have some use in sparsely populated areas in developed countries, FWLL has come up against cost and licensing problems. FWLL has to rely on a vast (and thus expensive) terrestrial network of existing connections to be successfully deployed.

5.2.1. Fibre vs satellite

Roughly speaking there are about 6,200 transponders available on commercial communications satellites in operation. In the unlikely case that they would all be used for data transmission, we could estimate that there is a total capacity of about 450 Gbps available via satellite. Compare this to a single undersea cable system which carries more than this amount of data, thanks to revolutionary advances in fibre optic technology. This means that the capacity of a single undersea cable system already exceeds the combined throughput of all the world's commercial communications satellites. However, no worldwide voice or data network is complete without satellites and almost half of the world's countries remain dependent on satellites for international connectivity. Satellites and fibre play complementary roles in international networks. Fibre offers network builders practically unlimited bandwidth, but limited geographic reach, while satellites can provide limited bandwidth, but essentially limitless reach.

And although fibre optic capacity has grown exponentially, satellite operators have continued to prosper (apart from the debacles of some Low Earth Orbit systems like Iridium).

The largest satellite system operators, including PanAmSat and New Skies, have relied on broadcast applications to build solid businesses. These operators have also provided, to a lesser but increasing extent, point-to-point services such as voice telephony and IP backbone connectivity. IP backbone connectivity, which mainly links ISPs in developing countries to the Internet, is currently the fastest-growing service

segment for satellite operators. IP traffic on the New Skies system, for example, rose from 7% of revenues in 1999 to nearly 25% in 2000.

A key question facing satellite operators is how long this positive market trend will continue. The build out of terrestrial and undersea cables is proceeding at a fast pace. As terrestrial networks continue to grow, opportunities for satellite operators to provide point-to-point services will decrease. Market analysts therefore discourage IP over satellite, and therefore ISP investment, on anything longer than 2-year terms.

Transponders owned by the major satellite operators

Operator Name	C- and Ku-Band Transponders
Intelsat	2,105
SES-Global	1,094
PanAmSat	883
Eutelsat	498
New Skies	257
JSAT	184
Telesat Canada	165

5.2.2. Exploitation of new space in the ether

Room for expansion in the cramped C-band and Ku-band is increasingly limited due to the many services that are relying on these proven technologies. Satellite service providers are therefore researching the use of new frequency bands, starting with the Ka-band (between 20 and 30 GHz). Although at first sight this frequency band lends itself better to the new multimedia services that are being put in place, the deployment of Ka-band applications is suffering from delays, due to many technical problems. Although it was common some years ago to predict satellite multimedia services to be delivered at a fraction of the cost for the existing Ku- and C-band services, this price setting has been revised in the light of the R&D costs incurred so far and the cost for deployment of a reliable service.

5.2.3. Software-Defined Radio (SDR)

Software-Defined Radio refers to wireless communication in which the transmitter modulation is generated or defined by a computer, and the receiver uses a computer to recover the communication signal. To select the desired modulation type, dedicated software controls the transmitter and receiver.

The most significant advantage of SDR is its versatility. Wireless systems employ protocols that vary from one service to another. Even in the same type of service, for example mobile telephony, the protocol often differs from country to country. A single SDR set with an all-inclusive software repertoire can be used in any mode, anywhere in the world. Changing the service type, the mode, and/or the modulation protocol involves simply activating the required computer program. The ultimate objective of software-defined radio is to provide a single radio transceiver capable of playing the roles of wireless telephone, cell phone, wireless fax, wireless email system, pager, wireless videoconferencing unit, wireless web browser, Global Positioning System (GPS) unit etc. from any location on the surface of the Earth. Up to now, SDR has been more science fiction than reality. Its development can be expected only in 10 to 15 years.

In this chapter examples from different parts of the world illustrate the use of satellite-supported services in educational contexts. Contact information is provided for further information on each example or initiative where it is available. We have also indicated when this information was last updated. However, as with all such information the material included in this chapter is subject to change and so we recommend that if you are interested in a particular example, you contact the project directly.

6. Satellites in Education (Case Studies)



In a previous chapter we referred to various applications of satellite technology in education and described various broad categories in which such use could be considered. To recap, these categories are as follows:

Category	Type	Short description
1	Broadcast	Common use of satellite technology where complete educational programmes are broadcast to large numbers of potential learners – commonly used by large-scale public service broadcasters like the BBC and ABC.
2	Interactive television	Often a mixed media service where satellite is used for one-way delivery of educational material and other interactive systems used for the return link from the learner, also includes services like Video-on-Demand.
3	Data broadcast	Essentially one-way communication networks offering to the end-user data such as video files, web site contents, analytical and statistical information, applications (software updates) or any other form of information that can be digitally stored.
4	Internet access	Common use of satellite technology where complete educational programmes are broadcast to large numbers of potential learners – commonly used by large-scale public service broadcasters like the BBC and ABC.
5	One- and two-way satellite Internet access	This is where satellite technology is used by providers to offer one- or two-way high speed IP connectivity via satellite to individual end-users
6	VSAT network	Virtual private satellite networks of one kind or another often used in the commercial world to provide entire communications networks to outlying companies and institutions.

In this chapter and our description of each example, we will use this system of categorisation.

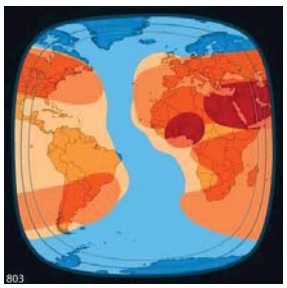
African Virtual University

Case study

CATEGORY 2

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Footprint of NSS for AVU

Type of Application

This is an example combining one-way broadcasting with a synchronous and asynchronous return channel via either telephone or online chat (Interactive Television or Category 2 in our categorisation).

Coverage

The AVU service footprint via New Skies Satellites (NSS) does not cover all of Africa equally well: see the areas indicated in the following diagram.

Short Description

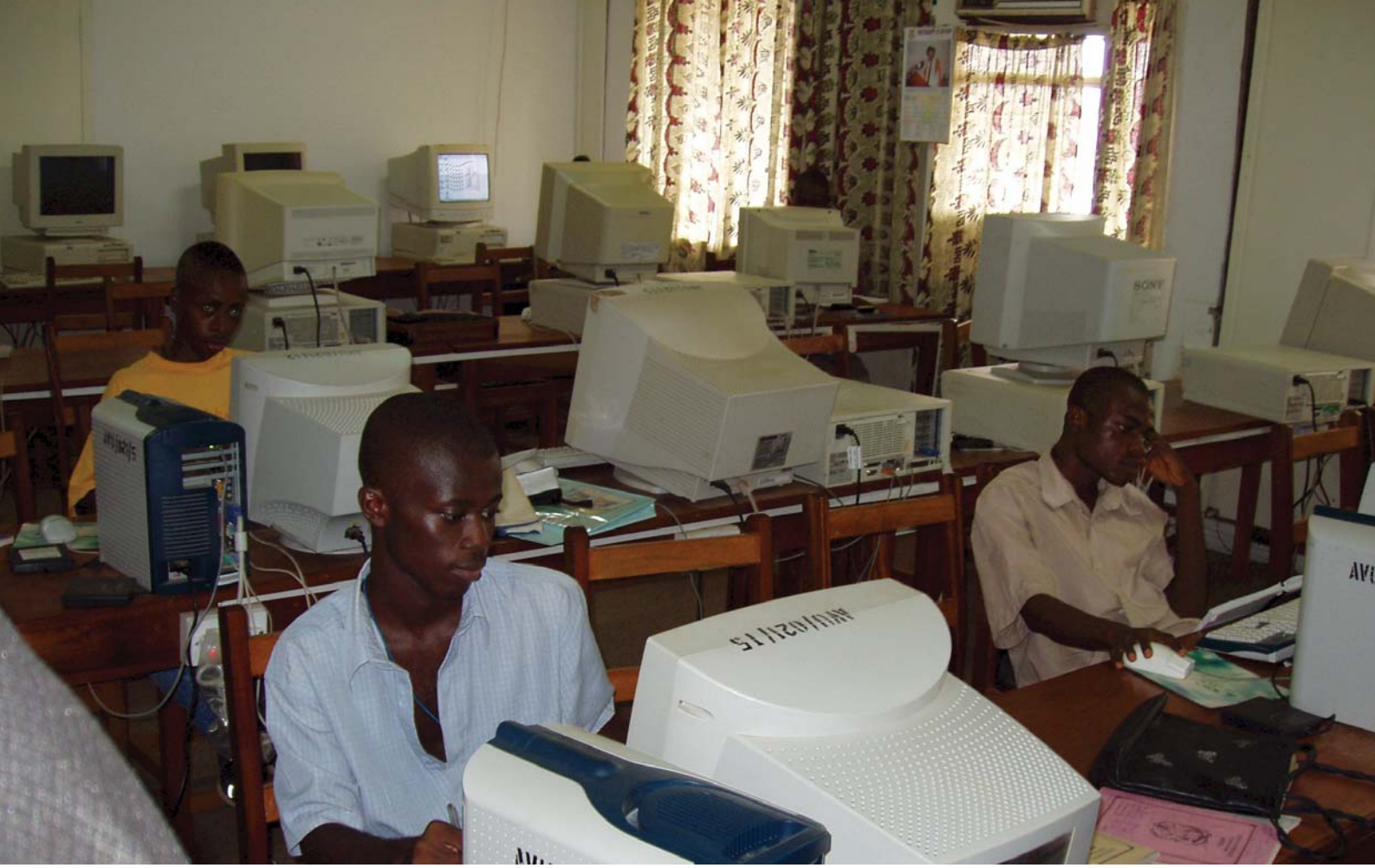
The AVU has a core commitment to enable greater access to higher education for African students using modern Information and Communications Technologies (ICT). The strategy involves a more focused and African-based operation committed to overcoming the constraints that limit access to quality tertiary distance learning opportunities in Africa.

The AVU began its pilot operations in 1997. By 2003, 31 AVU Learning Centres (LCs) have been established in 17 sub-Saharan countries in Africa. During this pilot phase AVU delivered some 3,000 hours of instructional programmes, registered over 23,000 students in semester-long courses, provided 1,000 personal computers to learning centres, and provided a range of other services to its members. In addition to courses, AVU offers a digital library with 2,000 full-text journals and a catalogue of subject-related web links, as well as a web site, which functions as a portal and currently receives over 1 million hits on average per month, with over 45,000 active email accounts and other web-based services.

The AVU infrastructure currently consists of a broadcast network with the uplink at Netsat express hub New York, USA and multiple receive-only sites (AVU learning centres) spread across Sub-Saharan Africa. This network utilises digital video and audio broadcast over the NSS 7 in C-band.

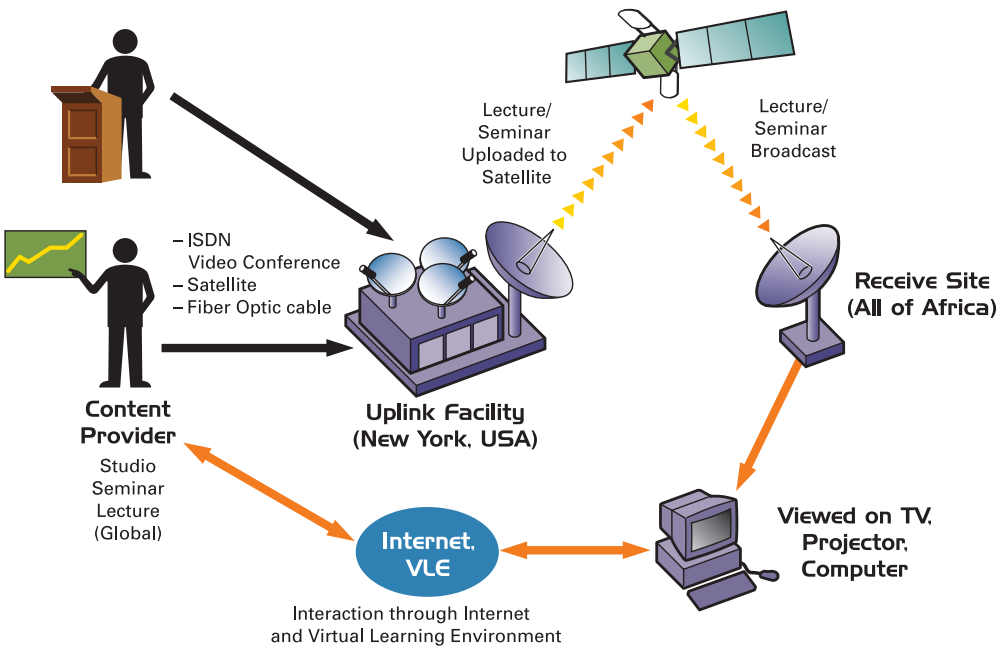
A flexible, mixed-mode delivery approach has been adopted, in recognition of the learner environment in which AVU operates. This approach uses a careful combination of synchronous video broadcasting, online materials, pre-packaged learning materials on CD-ROMs and DVD as well as synchronous chat sessions.

Interaction between the learner and the lecturer is primarily by email, and by online chats during synchronous lecture sessions. Students also have access to online chat sessions and discussion forums with their teaching assistant throughout their programmes. All tuition emanates from the learning centres. Students are expected to register at the learning centre before attending specifically scheduled synchronous sessions.



AVU LCs are supervised by trained facilitators. These are individuals who are familiar with the subject matter being taught and are mature enough to assist students during synchronous and asynchronous sessions. The facilitators are always in close consultation with the lecturer and teaching-assistant teams.

AVU classroom in Cape Coast, Ghana



AVU delivery platform

While the first two phases of the development of the AVU are successfully accomplished, the third phase of the AVU consists of developing a full two-way audio and video communication network. The AVU will achieve this through the deployment of VSAT systems with integrated videoconferencing, video-streaming, Video-on-Demand and VOIP (voice over IP) technologies.

Les Amphis de france 5

Case study

CATEGORY 2

Contact details

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Type of Application

This is an example of educational programmes video broadcast via the satellites Telecom 2C from France, HotBird 5 (analogue) and HotBird 5 (digital – TPS) from Eutelsat Telecom, the ASTRA 1 H (CANALSATELLITE) from ASTRA (Category 2).

Coverage

An estimated 14 to 20 million people watch france 5 every week, mainly in France but also in the rest of Europe and North Africa.

Short Description

Les Amphis de france 5, a French educational TV programme and web site, has been operating as a service since February 1996. It allows schools, training centres and individuals to access audiovisual products and documents via a dedicated web site or via television. The aim of Les Amphis de france 5 is to distribute knowledge and to provide pedagogical support, mainly to students and teachers in higher education. The programmes are also of interest to the general public, covering themes such as work, economy, sciences, art, history, literature and media.

Visitors to the web site will find a catalogue of 500 titles and the broadcast schedule. At the same time the web site allows access to the accompanying documents such as texts, exercises and corrections.

The TV channel france 5 is part of the France Television Group, alongside France 2 and France 3. The programme 'Les Amphis de france 5' is broadcast according to the following schedule:

- Monday mornings from 5.40 am: programmes that have been suggested by the public. For this purpose, viewers can choose from the 500 titles in the catalogue. The most requested programmes are then broadcast. This could be called a near 'video-on-demand' service.
- From Tuesday to Friday, every morning at 5.40 am: video lectures by academics from all over France. Each day covers a different subject area (science, humanities, mathematics, languages).
- On Saturdays and Sundays, every morning at 6 am: a selection of discussions and conferences.

Les Amphis de france 5 is also broadcast online via streaming as part of 'Canal U', the web TV service of French higher education establishments. Canal U consists of 10 different channels offering about 1,500 hours of educational videos. The channel 'Les Amphis de france 5' offers 130 programmes, enriched with synchronised illustrations and accompanying documents.

The programmes of Les Amphis de france 5 are available on 3 types of communication network:

- Terrestrial network: this consists of more than 1,000 broadcasters on the UHF band and exploited by Telediffusion de France. This network covers more than 87% of the French population
- Cable network
- Satellite network: the programmes of france 5 are also distributed by satellite for an international audience. This consists of the following satellites:
  - Telecom 2C from France Telecom
  - HotBird 5 (analogue) and HotBird 5 (digital – TPS) from Eutelsat
  - ASTRA 1 H (CANALSATELLITE) from ASTRA

The AVD project, Austria

Case study

CATEGORY 3

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Type of Application

This is an example of video broadcasting via satellite using the SkyMultimedia system (Category 3). SkyMultimedia is an interactive satellite-based system which enables the transmission of IP-based content between server and client (eg desktops). It uses the satellite for down-stream (from the central office to the clients) and any medium (dial-up modem, ISDN, satellite, leased line, GSM) for up-stream (from the clients to the central office). Because of the use of DVB/MPEG2 standard, the signal can be received from any current DVB-home-receiver (integrated receiver/decoder). The information is only available for authorised receivers.

Coverage

The satellite used is called Eurobird. The AVD project involves 89 schools, which are connected via satellite and provided with broadband access to the Internet.

Description

The AVD project ran during the school year 2002–2003 in Austrian schools and was co-ordinated by Education Highway in cooperation with the Federal Ministry of Education, Science and Culture and Telekom Austria.

The aim of the project was the creation of a satellite-based broadcasting system for media-on-demand solutions and interactive telelearning in schools. Upper secondary professional schools (economical and technical) and grammar schools and main general secondary schools from all over Austria could apply to participate. All participating schools received equipment, which was used for the following activities.

Download of videos via satellite (on demand): videos with supporting teaching material (working sheets, educational hints, subject analysis, content etc) could be downloaded

overnight via satellite and could be used the next day in school. The videos were searchable for picture sequences, single words or time codes without rewinding or forwarding. The teacher could choose and demonstrate the video or single clips of it in school. Each clip had a key frame (single pictures in chronological order of the content) and a short description of the prepared theme to give a quick review of the videos. Through simple navigation tools (eg a text transcript of the spoken word or key frames) it was possible to access and playback at any stage in the video. Additional material to each video was also provided, examples included short descriptions of the video content, theoretical backgrounds, learning aims, didactical hints/tips and resources on the web. Pupils also had access to all the video material provided. They could use the additional material, key frames, speaker text and the video clips for own projects.

Streaming of Interactive Telelearning: in special equipped broadcasting studios (locations in Linz) live lectures have been held and streamed via satellite to the schools. A special software tool was used, DistLearn, which allows for interactivity during the lecture. DistLearn integrates three components: audio and video display, a messaging tool (chat), a web browser and VNC (for slides, html sites or Word documents or any other screen the teacher would like to display). All courses have been recorded and archived so that all project schools have the opportunity to see the course 'offline' anytime and anywhere.

Boston College Mobile Satellite Van

Case study

CATEGORY 5

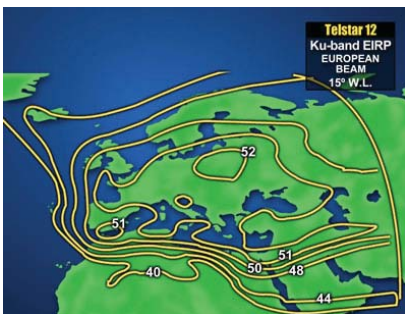
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Type of Application

Two-way Internet access via mobile satellite unit with wireless access for the local network (Category 5).

Coverage



Telstar 12 footprint

Short Description

Boston College, together with Satweb, Tachyon and ABK Ltd, developed a wireless network with satellite Internet access to deliver mobile training. The first Boston College mobile unit has been in operation since November 2001, a second van went into operation in February 2002.

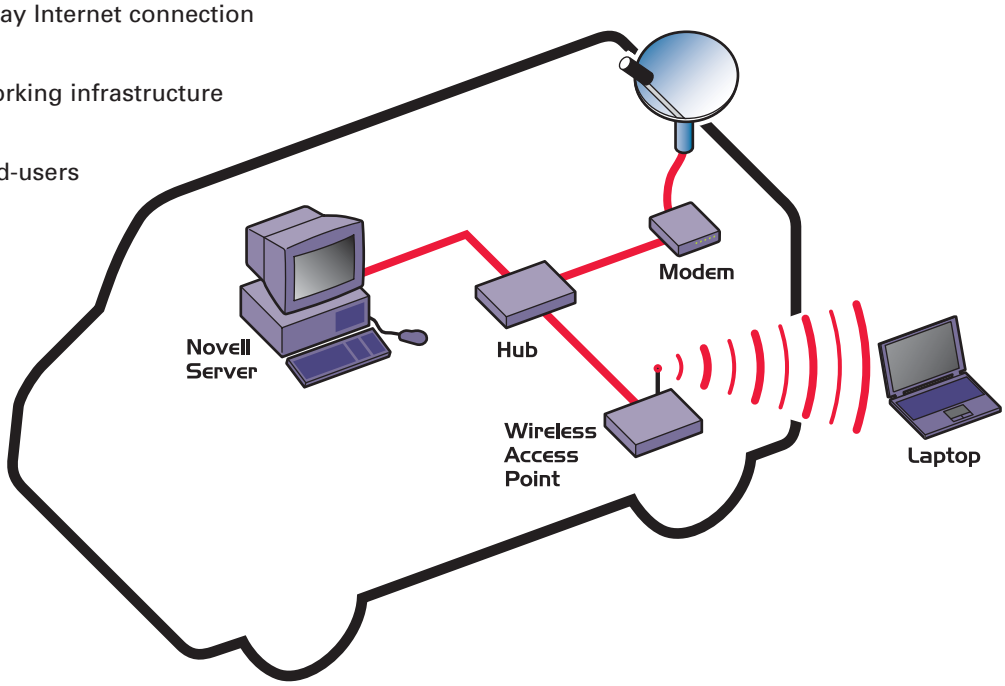
The underlying aim of the project is to bring online ICT training to rural and deprived areas of south and east Lincolnshire using grants and support from the DfES' Capital Modernisation Fund and the Lottery's National Opportunities Fund.

The Internet and online training is provided via satellite connected to a wireless network using a bridging unit to extend the range. The van can be parked outside the chosen venue and there are no trailing wires between the van and the venue. In this way the number of learners accommodated is limited only by the size of the venue, the number of laptops carried and the number of learners the staff can support. The wireless equipment can potentially support up to 250 users.

The unit provides laptop computers that are set up in each venue. These are totally portable and space saving to pack in and out of the vehicle. The van carries up to 20 portables initially with space for more if required. It was thought that class-sizes of over 20 would have additional staffing implications.

It is believed that the prototype Boston College Mobile Unit One was the first truly mobile satellite van in the country. It was built into a Mercedes Sprinter short wheel-base van, and is made up of the following components:

- Satellite two-way Internet connection
- Novell server
- Wireless networking infrastructure
- Generator
- Laptops for end-users



During the past year the units have visited well over 30 different communities in the College's catchment area and set up regular training sessions in over 20 different venues. The majority of these are in small rural villages and market towns. Two venues are located in deprived wards of a slightly more urban nature where the project works alongside other community development organisations.

Take up of the facilities offered has been very good. Over 500 individual learners have engaged with the mobile training units in the past year. The vast majority have enrolled on level one ICT qualification courses and achieved their learning aims. Over 60% of the people engaged, had previously little or no experience of using computers or the Internet. Boston College believes, therefore, that these innovative mobile units have genuinely reached new learners.

Centrelink Education Network

Case study

CATEGORY 2

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Type of Application

Live and interactive educational television. This is an example of one-way broadcast of television programmes with a return support channel via terrestrial lines (Category 2).

Coverage

Centrelink uses the Optus B3 satellite for broadcasting of all their programmes.

Centrelink has nearly 400 customer service locations throughout Australia, many in remote and rural locations. Centrelink currently has 371 sites equipped and connected to the satellite network. All customer service staff have access to a training room with this equipment installed either in their own office or in a site nearby. There are 2,017 keypads connected to this system. The network covers 7,692,024 sq km.

Short Description

The Centrelink Education Network has, as its main delivery platform, a state-of-the-art interactive distance-education facility, fully integrating video, voice and data to deliver live, real-time training and education to 24,000 staff members of 20 different government agencies across Australia. It is a two-way voice and one-way video system, ie a one-way broadcast with a return support channel via terrestrial lines. The student response keypad uses a telephone line to enable the facilitator and participant to talk to each other. Interactivity occurs in a number of ways. For example, a student can respond to pre-determined questions or he/she may ask the presenter for clarification on issues raised during the lesson.

Centrelink offers a blended solution to their education programmes, most of which are accredited to match nationally recognised qualifications. Prior to participating in the satellite-enabled learning, students may undertake an online Learning Needs Analysis to determine their skill gaps or learning needs. They then download workbooks and other materials from the Intranet for pre-reading, or they may watch a CD-ROM from their desktops. After a learning session, they may have face-to-face group discussions to relate their learning to the workplace.

For the satellite broadcasts, programmes of about 45 minutes duration are produced from the Centrelink Canberra studios and travel by satellite to Centrelink offices across the country. Employees log-on to the learning session via a student response key-pad, using an Australian Government Service number. This allows the system to recognise each employee and their work location and provides accurate management information on the amount and type of training each employee undertakes.

Support is provided in a number of ways. All learning programmes broadcast over the network are accompanied by a workbook that is available electronically and this often provides extra information for participants. All programmes are based on adult learning principles and an instructional design that uses the best mix of information delivery and interactivity. The network uses internal expertise such as subject matter experts who appear on camera from the Canberra studios or remotely through the voice recognition system.

Pre-recorded videos and DVDs are used to enhance the programmes and these can be played after the programme to review information. An email facility is also available to learners if they want more information after the programme. All emails received are responded to within a short time-frame.

In the actual work location, support can be provided by an office subject expert or trainer or team leader.

All Centrelink Education Network programmes are live and interactive. For each new lesson there are a number of broadcasts depending on the size of the target audience. For large initiatives this can be as many as 50. While video copies of all programmes are kept, staff are encouraged to use the video tapes only for 'refresher' purposes and not as the main source of learning, as evidence suggests that adults learn best by interaction. A 'video on demand' system is available where students can request a copy of the programme to view or review after the live programme.

Chinese Education TV

Case study

CATEGORY 2

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Type of Application

One-way video broadcast via satellite with return via various media (Category 2).

Coverage

SinaSat-1 From Sino Satellite Communications Company Limited covers all of China.

Short Description

China Central Radio and TV University (CCRTVU) is a dedicated distance education institution, which offers multimedia university courses through radio, TV, print, audio-visual materials and computer software. It is located in Beijing under the direct supervision of the State Education Commission (SEDC). The CCRTVU, together with 28 Provincial TV Universities (PRTVU), was set up in 1979.

At present, this distance education system is made up of the CCRTVU, 44 PTVUs, more than 690 branch schools at prefecture and city level, 1,600 study centres at county level and 13,000 teaching classes. The system is run and operated at different levels, both central and local, based on overall planning with the CCRTVU as its centre.

The CCRTVU comprises:

- The China TV Teacher College
- The central Radio & TV Specialized Secondary School
- The China Liaoyuan Radio & TV School, which offers practical courses
- The Distance Education Research and Information Institute
- The library
- The Press
- The Publishing House for Audio-Visual Materials
- China TVU Education Management departments
- Administrative offices

At the beginning, CCRTVU's courses were transmitted for 33 teaching hours per week nationwide via the microwave network of the CCTV.

On 1 July 1986, China Educational TV (CETV) was founded and began to transmit CCRTVU's courses via satellite. It has now three channels available to transmit programmes, mainly the CCRTVU's own courses.

At the moment, the total number of programmes transmitted via both CCTV and CETV per year amounts to about 9,000 teaching hours. Meanwhile, local TV and radio stations also transmit some of the CCRTVU's courses as well as local TVU's courses.

The CCRTVU system has become an important component in China's higher education system. It makes great contributions not only in extending the scale of higher education by training a large number of qualified professional personnel for economic construction and social development, but also in adjusting the disciplines for higher education and improving the imbalance in the geographical distribution of higher education in China.

Consorzio Nettuno, Italy

Case study

CATEGORY 2

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Type of Application

This is essentially an Interactive television type of application (Category 2).

Coverage

The Eutelsat HotBird 2 footprint provides full coverage of Europe and covers North Africa and Asia, including the entire Middle East.

Short Description

NETTUNO uses two satellite television channels and Internet to broadcast its courses and to carry out didactic activities. Reception is available as far as Moscow and Dubai. Participating universities in Italy are: the Politecnico of Bari, and the Universities of Ancona, l'Aquila, Bologna, Camerino, Cassino, Ferrara, Firenze, Genova, Lecce, Messina, Milano, Milano 'La Bicocca', Modena, Napoli II Università, Padova, Palermo, Parma, Perugia, Pisa, Roma 'La Sapienza', Salerno, San Marino, Siena, Teramo, Torino, Trento, Trieste, IUAV Venezia and Viterbo 'La Tuscia'. Other participants include the Open University in the UK and National Centres for Distance Learning of Tirana, made up of the eight universities of the Republic of Albania. Foreigners can earn a degree via NETTUNO on condition that they are subscribed to one of these universities.

The NETTUNO network was set up in 1992 by the Ministry for University, Scientific and Technological Research, and delivers first level University degree courses at a distance to a network of participating institutions which include 34 Italian State Universities, the Open University in the UK, technological companies and bodies such as TELECOM Italia, RAI, IRI and the Confindustria.

The teaching model used is a mixed one that combines the advantages offered by the traditional teaching system and by guided learning, with those offered by a distance-teaching model that makes use of new technologies. The model of distance teaching proposed by NETTUNO considers the distance arrangement that includes activities out of which the student studies alone and activities that use new technologies and activities that make the student interact with other people, either in person or at a distance. Professors that carry out studies in the different disciplines are the same ones that teach both traditional face-to-face courses and home-study courses.

Satellite television and the Internet are fundamental among the technologies used by NETTUNO. All Distance University Degrees are broadcast on two satellite channels RAI NETTUNO SAT1 and RAI NETTUNO SAT2. The NETTUNO network produces 280 courses which provide a total of 14,000 hours of university video lessons. Besides the video lessons, there are didactic books, workbooks, multimedia software and products, and didactic Internet web sites linked to the video lesson that are used for the distance learning courses. Students can interact amongst themselves and with the professors through chat, forum, email and videoconferences.

Students enrolled in NETTUNO distance university courses may access didactic and institutional support activities through the following structures:

The National Centre based in Rome, which manages the didactic coordination between supplying universities, coordinates the video lessons and multimedia didactic materials production, takes care of the arrangement of databases and telematics connections between different sites, plans and checks transmission on the two satellite channels, realises and checks the Didactic Portal on the Internet, and carries out research programmes.

The Supplying Universities take care of the students' enrolments, their curriculum and issue university degrees.

The Technological Poles are the didactic structures inside the universities and they supply students with the following services: practice exercises, lab activities, tutor assistance, video lessons and course didactic materials archive (software, exercises and written materials), exams, Internet access and videoconference tools.

The Auditing Centres and Enterprises Technological Poles are the structures outside the associated universities in enterprises, private or public bodies and structures and carry out, in close cooperation with the Supplying University Technological Poles, student didactic assistance functions.

The 'work at home' station consists of a video recorder, a television with a satellite dish and a decoder, a computer, a printer, a modem/fax, telephone and an Internet connection. Students can follow, from their homes or from wherever they want, university courses on television and carry out practice exercises, they can even interact with other students, tutors and teachers in real time by telephone and Internet or by fax and email.

The University Technological Centres set-up in the associated universities consist of multimedia didactic classrooms and laboratories equipped for video recording. Video lessons are recorded in these classrooms for transmission.

CRO.CU.S (CROss-CUltural Satellite services for immigrant communities in Europe)

Case study

CATEGORY 3

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Type of Application

This service used the IPerSAT communication platform, which is based on the Digital Video Broadcasting (DVB) standard deployed worldwide for digital television. It allows the user to receive television programmes and Internet high-speed services with the same small antenna (Category 3). Communication between users and the Service Centre was performed in a asymmetric way: the users received the multimedia data via satellite at high rate, and transmitted via modem their data at the rate allowed by their terrestrial Internet connection (PSTN or ISDN).

Coverage

Sessions were transmitted via the Eutelsat 13 degrees E Hot Bird fleet, which reaches every country of West and East Europe plus those countries that belong to the Mediterranean Sea basin, so including all those areas greatly affected by the immigration phenomenon.

Short Description

The Crocus (CROss-CUltural Satellite services for immigrant communities in Europe) project, supported by the European Space Agency, ran from November 2000 till June 2002. Its purpose was to disseminate multimedia and interactive didactic units for first and second language learning and intercultural education via satellite to schools, cultural centres, libraries, training agencies and associations of immigrants.

This use of technology guaranteed the necessary flexibility to follow complex curricula in an optimum fashion, ensuring continuity in teaching, training and social care for immigrant or refugee families' children, both at Italian and European level.

The CRO.CU.S system included:

- A pupil section for distance teaching to pupils from ethnic minority groups. The satellite-distributed lessons were integrated with text books, CD-ROMs, videotapes, and web-distributed learning units. The system offered distance tutoring and distance learning during lessons which were broadcast live
- A tele-kiosk section that offered multilingual services to school administrations and families from ethnic minorities. The service facilitated communication between school and families regarding administrative procedures and immigration legislation
- A teacher section for in-service training of teachers and other school staff in the field of intercultural teaching, multilingualism and the integration of foreign pupils in the school community

The main components of the CRO.CU.S communication system, implemented by Telespazio to run the CRO.CU.S services, were:

- The Telespazio Service Centre: this housed the system equipment and the distance learning platform called NetStre@m

- The up-link station: located at FUCINO (AV) Space Centre
- The Space Segment: to roll out the CRO.CU.S pilots, a 512 Kbps Ku-band on the Eutelsat 13° E Hot Bird fleet was used
- A teacher station: this remote station allowed the COSPE Centre in Florence to manage the live services and to schedule the contents distribution
- A satellite network: including the CRO.CU.S Pilot Schools and the Project Partners

The users, who were students, teachers or families could enjoy the CRO.CU.S information and learning services in real time or when convenient.

The CRO.CU.S services were configured and delivered in an 'interactive' or 'push' modality according to their typology or the need to interact. Learning programmes were received via satellite on a weekly basis and the CRO.CU.S portal could be accessed anytime by the Internet terrestrial connection.

The experimental phase of the CRO.CU.S project, completed in June 2002, involved over 400 pupils from ethnic minorities, 30 schools and cultural centres in various regions of Italy from the south to the north, and three Albanian schools. The schools included primary, middle and high schools, the centres included libraries, documentation centres and immigrant associations.

With the start of the new school year 2002–2003, a new phase began, with the promotion of the system so that it could function independently from a financial point of view. During the school year 2002–2003, the services were offered but only via terrestrial Internet connections and not via satellite anymore. This was because the number of subscribed schools was not yet high enough to make it an economically viable option. In the future, when more schools are subscribed to the CRO.CU.S services, satellite technology will be reconsidered.

Cyber Seminars, Japan

Case study

CATEGORY 1

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Type of Application

Broadcasting using the DVB standard in the C-band (Category 1).

Coverage

PAS-8, PAS-9 and PAS-10 from PanAmSat were used. They each have the following coverage:

- PAS-8: Asia, Oceania
- PAS-9: North and South America
- PAS-10: Asia, Europe, Africa

Short Description

The National Institute of Multimedia Education (NIME), Japanese Ministry of Education, which has been involved in various projects with overseas institutions, has embarked on an experimental collaborative project with the Waseda University, NHK International and Rikei Co. Ltd. In January 2002, NIME and Waseda University telecast four lectures developed by the university's Centre for International Education (CIE) for use by overseas institutions.

The lecturers are representatives of large Japanese companies and focus on the operations of Japanese companies and internationalisation of the Japanese corporate sector. The lectures were in English and designed for students, faculty and others interested in Japan and its corporations in an era of globalisation. The presentations were essentially designed and delivered for the classroom and then adapted for telecast purposes.

One programme series composed of four lectures was telecast three times a day (one lecture per day) from 28 January to 31 January 2002.

The Series title was 'The International Roles of Japanese Business' and it consisted of the following lectures:

- The Remaking of Japan (Dr Robert Feldman, Managing Director, Morgan Stanley Dean Witter)
- The Globalization of Japan's Electronics Industry (I) (Mr Kenji Tamiya, Senior Adviser, Sony Co.)
- The Globalization of Japan's Electronics Industry (II) (Mr Norio Gomi, Senior Adviser, Matsushita Electric Industrial Co.)
- The Japanese Financial Market in the Global Age (Dr Leslie F. Hoy, Manager, Orix Co.)

Each lecture ran for approximately 70 minutes and was broadcast via the satellites used for NHK World TV, namely the PAS-8, PAS-9 and PAS-10 from PanAmSat.

The cyber seminars are not being repeated anymore since the summer of 2003, because of a local management difficulty.

Espresso

Case study

CATEGORY 3

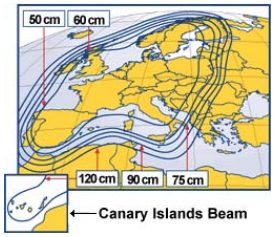


Image: SES-Astra

ASTRA footprint

Contact details

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Type of Application

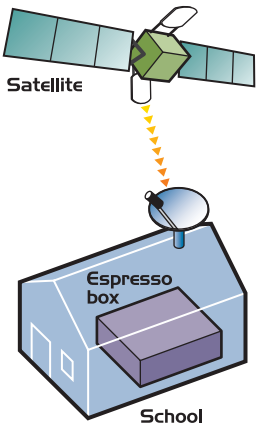
Espresso is a typical example of data broadcasting and so conforms to our description of a Category 3 application.

Coverage

Coverage: see footprint map of ASTRA for potential coverage. In reality, the 47 Local Education Authorities in the UK are participating.

Short Description

Espresso is an example of one-way video broadcast where computer files are downloaded by satellite. This allows Espresso to send full-screen video, which is the hallmark of the service. Data is delivered direct to the school's Espresso Box via ASTRA-NET. Schools receive the broadcast via their own satellite dish. Each broadcast is downloaded via a specially installed card in a school's PC, either to the school's network of computers (Local Area Network, LAN) through a server (proxy cache) or to an isolated PC's hard drive. Broadcasts are mostly carried out during off-peak hours at up to 6 Mbps. Espresso is a private network, unregistered users cannot access it, nor does it allow users access to the public Internet. This means that the network is extremely secure.

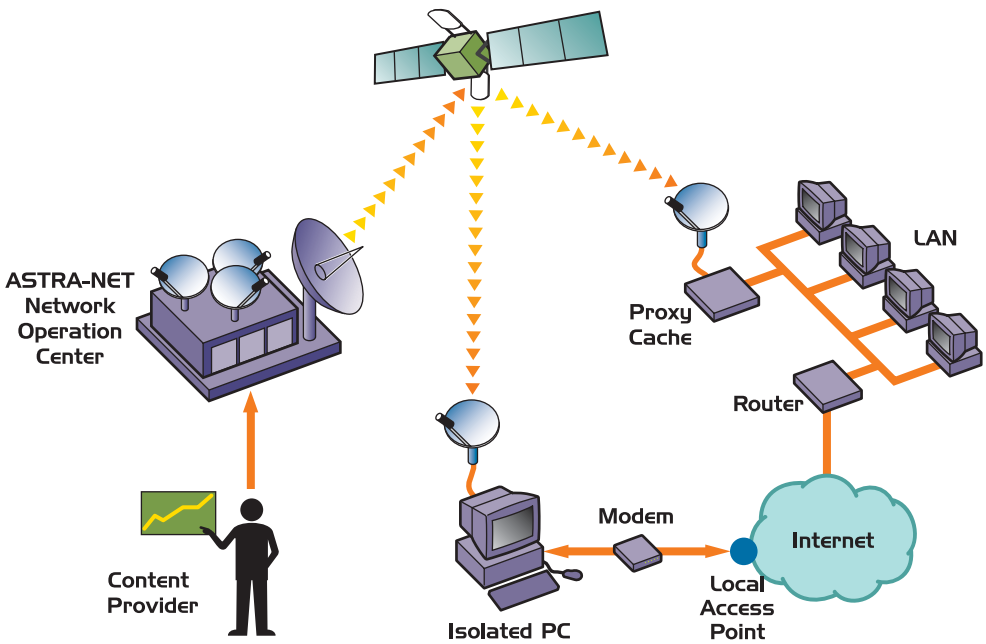


The final step in the delivery chain is that each school records that it has received its broadcasts via the Internet. This is done via a router if the school uses a server, or via a modem if the service is delivered to a stand-alone PC.

The Espresso service is delivered on a weekly basis. It updates and changes each week and offers multimedia resources for both teachers and pupils. It contains mainly video and a special selection of web sites intended to stimulate and reinforce learning and is intended as a way to bring events from the real world into the classroom, focusing on their relevance to the curriculum. More specifically, Espresso has 3 services:

- *Your Espresso* is a way to bring to life local history or a local project. Local resources, specially filmed video and carefully researched web sites are integrated to produce a multimedia resource bank that will stimulate learning
- *Espresso Teacher Training* addresses the need for teachers to have the confidence and competence necessary to make effective use of ICT in subject teaching. Video-rich training materials cover the ICT skills needed to use Espresso in the classroom, raising the standards of both teachers and pupils
- *Espresso for Schools*: the content of this service is updated weekly and consists of curriculum-focused materials built around TV, WWW, news reports and interactive activities. The service also contains a homework facility available to pupils from home. Subscriptions can be made for primary-school content and teaching resources or for secondary-school content and teaching resources.

Up until January 2000 Espresso was part-funded by the ARTES-3 Multimedia Programme of the European Space Agency. It is now a commercial service.



GDLN – World Bank

Case study

CATEGORY 6

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Type of Application

GDLN is an example of a VSAT network being used in an educational context (Category 6).

Coverage

The GDLN network uses a mix of satellites covering Africa, the Americas, Eastern Europe and Asia.

The satellite coverage for GDLN

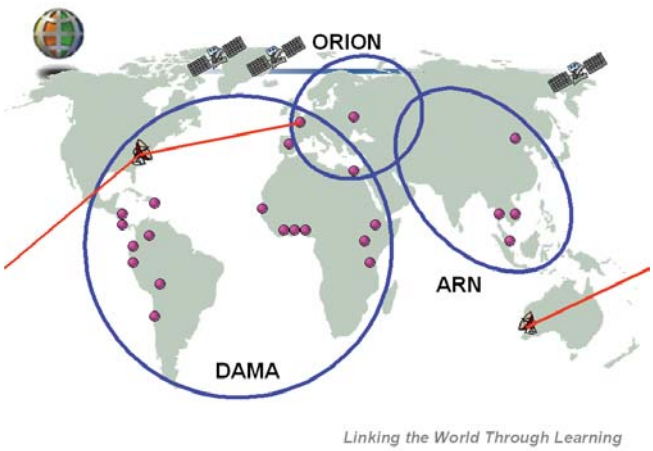


Image: GDLN

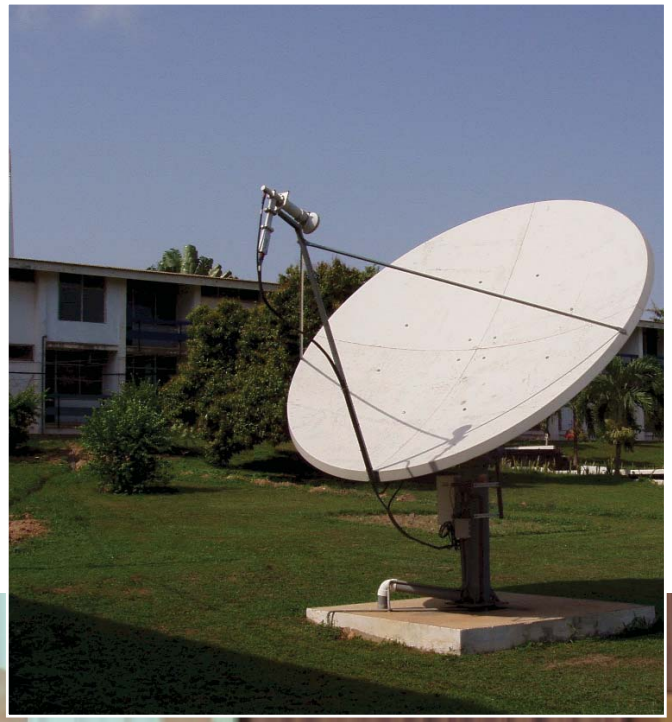
Short Description

The Global Development Learning Network (GDLN) established by the World Bank is a partnership of public, private and non-governmental organisations providing a fully interactive, multi-channel network with a mandate to serve the developing world. GDLN partner organisations work together to take advantage of the most modern of technology, for building local capacity, sharing learning and knowledge, and building a global community dedicated to reducing poverty. The mission of GDLN is 'to harness modern technology – including interactive video, the Internet, and satellite communications – in a cost-effective way, so that people who know are brought together with those who need to know, to learn with and from each other about the full range of development issues'. Network connectivity is achieved through a Very Small Aperture Terminal (VSAT) satellite transmission system for voice, video and data. A total of three satellites provide coverage to Africa and the Americas, Eastern Europe and Asia. GDLN uses Intelsat over the Atlantic to cover Africa and Latin America, using a technology called DAMA (Demand Assigned Multiple Access). Over Europe and parts of Central Asia they use Orion and over South Asia and East Asia they use an IOR satellite from an uplink in Perth. GDLN connects with Perth by fibre from Washington. In this way, the whole system is one satellite hop. The whole network is currently being converted to IP.

The GDLN network involves a growing consortium of facilities with high-quality interactive video conferencing and Internet capacity which is currently linking more than 50 countries in Europe, Africa, Asia, Latin America and North America. GDLN grew out of the successful pilot programme 'World Bank Learning Network', which has been under development since 1997 and relied on the Bank's high-capacity communications system.

Course topics include: Political Economy of the Environment for Journalists, Economic Growth and Poverty Reduction, Procurement, Urban and City Management, Analytical and Policy Issues in Macroeconomic Management, Controlling Corruption: an Integrated Strategy, Capital Flows Volatility and Financial Crises, Health Sector Reform and Sustainable Financing, Gender Health and Poverty, Social Safety Nets and Rural Development.

For a full schedule of courses broadcast on GDLN and further information about taking part, visit the GDLN web site.



GDLN centre in Accra, Ghana

JISC & UKERNA 2-way Satellite Access Trial

Case study

CATEGORY 5

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www.ja.net/development/network_access/satellite/trial.html



Higher and further education sites participating in the JISC Trial

Type of Application

Two-way satellite Internet access (Category 5).

Coverage

This pilot project will run from November 2002 until the end of April 2004. It involves 17 higher or further education sites in the UK, all located in areas described as being rural and/or remote. These areas are unable to receive ADSL or Cable Modem broadband services, and included locations in the Highlands and Islands of Scotland, Cornwall and Wales.

Short Description

The aim of this trial is to investigate how far satellite telecommunication technology can contribute towards solving connectivity and access problems in remote and currently underserved areas. Seventeen off-campus learning centres, off-campus sites and individuals (staff) were equipped with small VSAT-based systems and services to assess the feasibility of broadband satellite as a technology for Internet access.

Two satellite service providers, representing three major satellite telecommunications technology providers, and making use of four different systems have taken part in this trial. The user group is divided into two application areas, one focusing on connecting off-campus learning centres, small user-groups and individual users (1 to 4 PCs per site), the other focuses on providing Internet connectivity for larger sites (~10 PCs per site).

Two of the satellite platforms are being extensively trialled[1]:

- **SatLynx BBI** – Broadband Interactive Service (a DVB-RCS, Digital Video Broadcasting Return Channel via Satellite compliant system) – for two-way LAN connectivity supporting up to ten PCs
- **SatLynx Gilat 180 and 360e** (a Digital Video Broadcasting via Satellite compliant system) supporting standalone PCs and small workgroups of up to four PCs

The aim of the trial is to evaluate to what extent two-way satellite can effectively provide last-mile broadband connectivity to those JANET Connected Organisations in the UK who would like to connect off-campus learning centres, student residencies and individual learners to JANET via the Internet and who – at this stage or in the foreseeable future – are not able to gain access to broadband services such as ADSL or Cable.

The results of the trial evaluation show an increasingly satisfied user base, certainly after initial network problems have been ironed out. This has resulted in a take up of over 50% of the commercial VSAT offer within the pilot user group. Although the usage is relatively small (traffic rarely exceeds 1 GB per month per client station), users acknowledge the fact that in their location, they do not expect an alternative access method within the foreseeable future. Moreover, this technology is providing them with an opportunity to adopt innovative eLearning and teleworking methods, that were simply not possible with the previously available access provision.

On the basis of the final evaluation, JISC will consider whether it will offer or recommend a satellite-based service to its user community.

1 A third system, the HNS system, was also installed in one institution.





Outdoor and indoor satellite station in Scottish Highlands and Islands

Sat&Clic

Case study

CATEGORY 1,3 & 5

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Type of Application

The satellite communications infrastructure included a transmission platform and a hub located near Paris, which up-lined the educational bouquet of digital TV and Internet IP data multiplexed in DVB/MPEG-2 standard. The signal was transmitted in broadcast mode by one high-power TPS transponder of the HotBird 3 satellite of Eutelsat to the SAT&CLIC terminals. The TV signal was decoded by set-up-box equipment. A satellite board installed in a standard PC decoded IP data. The PC could be used as a gateway to be linked to any type of local network (Categories 1, 3 and 5).

Coverage

Coverage of the HotBird 3.

Short Description

At the beginning of 1999, the Satel-IT programme was launched by the French Education, Research and Technology Ministry. In this framework the SAT&CLIC project, running from December 1999 until June 2001, submitted by LAGARDERE Group and TPS (Television Par Satellite), had been selected to demonstrate how the space systems could help in providing interactive multimedia services for educational applications including Internet access, cooperative work, Internet conferencing and interactive digital TV.

The SAT&CLIC project involved more than 200 educational establishments in France, including primary and secondary schools, universities, teachers training centres (IUFM) and resources centres (CNDP). The network was not expanded after June 2001 due to a lack of support from the new government.

During the project's lifetime, the LAGARDERE Group, through its media (Hachette Multimédia, educational publishers) and technology partner companies from EADS Group (ASTRIUM, EADS Telecom), had developed a global SAT&CLIC offer which included a wide spectrum of educational services and multimedia products. Internet and broadband communications technologies were used for delivery of these services and products.

Satellite technology had been chosen because it offers the following advantages: an immediate availability on a large area especially for rural areas, the same service delivered for every user in this area, and a low-cost terminal when using current DVB standard for digital TV technology. Moreover, satellite was found efficient in this educational context because it allowed multicasting data while operating in an asymmetric interactive transmission mode, which is well adapted to Internet applications such as browsing the web.

The SAT&CLIC bouquet of services included a set of IP broadcast and multicast services. They supported delivery of educational online applications and multimedia contents, developed by Hachette Multimedia, LAGARDERE group publishers (Hachette, Didier) and several associated partners. In addition, Digital TVs selected for educational purposes were provided by TPS.

SAT&CLIC provided a set of IP services, including:

- Hi-Net service providing Internet access with satellite downlink. Optimisation of satellite link performance was based on the use of proxies and caches
- Hi-Want service enabled users to request for remote loading of Internet web servers into local caches
- Hi-Cast service supported secured data multicasting for distribution of any type of data to networked communities; applications were developed to support co-operative work between groups of teachers (Intranet), and database replication
- Hi-Channel service for data-streaming through dedicated satellite channel; applications were developed for broadcasting videoconference, live or recorded

Other IP services deal with FTP server mirroring, distribution of news feed (newsgroups) and multicast of Mbone programmes.

To take benefit from satellite transmission, and more generally from broadband telecommunication infrastructures, Hachette Multimedia provided dedicated educational applications, in collaboration with media companies of LAGARDERE Group, and many other public or private associated partners.

DIDACTUA was one of these online applications. DIDACTUA was a new multimedia service that gave access to:

- Educational services and contents associated to news events
- Educational libraries

Contents, structured by 'modules', were linked to radio news, videos, TV resources, articles from newspapers, web sites and other specific resources produced by publishers.

SchoolSat, Ireland

Case study

CATEGORY 5

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Type of Application

SchoolSat is an example of two-way Internet via satellite and is based on the Digital Video Broadcasting (DVB) standard, which is deployed Europe-wide (and is becoming accepted as a worldwide standard) for digital television (Category 5).

Coverage

The SchoolSat service is based on Web-Sat (www.web-sat.com) equipment and operates over Eutelsat W3. It is being trialled in Ireland with a small number of representative schools in a remote region in the north-west part of the country. There are nine secondary or vocational schools taking part in Donegal County, as well as the Donegal Education Centre.

Short Description

SchoolSat is an initiative which began in 2001 and aims to improve Irish schools' access to the Internet by using an innovative two-way 'Internet via satellite' network. It is a direct response to the relatively poor level of connectivity to the Internet experienced by primary and secondary schools, despite the Irish government's stated

intention to provide every Irish classroom with a broadband connection to the Internet. The expected outcome of the project was the establishment of a business and deployment plan for a fully operational and sustainable service for the Irish compulsory school sector based on a strategic mix of unicast and multicast services. In order to come to this business and deployment plan, a pre-operational satellite-based service has been set up and evaluated with ten sites.

SchoolSat ran from December 2001 to February 2003 and was partially funded by the European Space Agency through the ARTES 3 Programme. The partnership consisted of prime contractor ATiT (Audiovisual Technologies, Informatics and Telecommunications, Belgium), NCTE (National Centre for Technology in Education, Ireland) and Web-Sat (Ireland). From February 2003 till June 2003 the project was extended thanks to further funding from the Department for Education and Science in Ireland. At the time of writing, discussions have just been concluded to extend this service for a further academic year, 2003–2004.

The satellite system that is used by all the sites involved allows the user to receive Internet services with a relatively small antenna (less than 1 m diameter) and a PC equipped with a satellite modem anywhere within the footprint of the Eutelsat W3 satellite. This PC can be used as a gateway to connect multiple PCs to the Internet.

The system is supplied and serviced by Web-Sat in Dublin, a wholly Irish-owned company. It gives schools a fast connection to the Internet with up to 4 Mb download to the school and 64 Kbits return.

The teachers and pupils in the schools taking part are using this improved access to research the World Wide Web for various school subjects and for carrying out projects on many different topics. For many of the schools, this is the first time that they have been able to really use the Internet for educational purposes and it is really making a difference as to how the Internet is perceived in secondary schools. Digital content from a variety of sources, including data and video, is brought together into a managed content repository, www.schoolsat.net, where it is themed and channelled. A final report is publicly available about the operation and outcome of SchoolSat from: www.atit.be/dwnld/schoolsat_final_report2.pdf

St Helens e-Learning Bus

Case study

CATEGORY 5

Contact details

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Type of Application

Two-way satellite Internet access through VSAT technology from Hughes Network Systems (Category 5).

Coverage

The satellite used is the Eutelsat W1. The bus can be used by all inhabitants of the town of St Helens (near Liverpool, UK) and the surrounding villages.



Short Description

As one of seven IT Learning Centres in Granada Television's 'IT's Never Too Late' campaign, the St Helens e-Learning Bus was launched on 10 November 2002, as the result of a unique partnership between St Helens Rugby League Football Club, St Helens College and Granada Television. The funding was provided by the UK Online initiative and the New Opportunities Fund.

The 'IT's Never Too Late' campaign is specifically aimed at the young unemployed, long-term unemployed, ethnic minorities, people lacking in basic skills, lone parents and the disabled, and gives them a chance to get back into learning when they may be reluctant to attend more formal venues. The campaign is founded on local partnerships and is using sport as the lure.

The purpose of the bus is to tackle the digital divide. St Helens is an industrial town and has large areas of people with low self-esteem who think that going to college is something of which they would not be capable. The bus will go out into their community and give them the confidence to sit at a computer, use email, surf the Internet, and use basic packages like Microsoft Office and learn how to stay in touch with friends and family.

Many of the courses are delivered through learndirect and can be accessed online. There are also other learning and promotional activities associated with the college and its principal sponsors. Dedicated courses that are delivered include IT, Skills for Life, and Business and Management. Some of the courses are chargeable (but not expensive) and some are free. On board the bus there is continuous support from two facilitator/tutors.

There are 12 workstations on the bus which are linked to the Internet. Computer games and other hi-tech equipment are also available. The transmission bandwidth is relatively limited (about the same as an ISDN line) and the download is approximately the same as a terrestrial broadband connection. The service is provided by Hughes Network Systems. The bus travels around St Helens (19 km from Liverpool) stopping at set location at set times. The Internet connection is established by a satellite dish that is permanently fixed to the roof. It automatically unfolds, seeks the satellite and locks onto it. The system tracks its location via GPS and has a built-in compass to help it find the signal. The operator performs the operation from inside the bus using the MS2000 ISA server.

Current status

The initiative is becoming more and more popular and will continue as long as there is demand.

Telesecundaria, Mexico

Case study

CATEGORY 1

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http://edusat.ilce.edu.mx

Type of Application

Telesecundaria broadcast educational programmes or educational television via satellite (Category 1).

Coverage

The satellite used is the Satélite Solidaridad II, a government-owned satellite managed by the Ministry of Communications and Transportation.

Satélite Solidaridad II covers all of Mexico, the south of the United States, Central America and part of South America.

Short Description

Telesecundaria was launched in 1968 as a means of extending lower secondary school learning with television support to remote and small communities at a lower cost to that of to conventional secondary schools. It is the oldest project of its kind in Latin America.

In recent years, Telesecundaria has been renovated and extended to primary school and technical teaching as well, through the System of Educational Television Via Satellite (EDUSAT). Three institutions collaborate to produce the televised programmes: the Telesecundaria Unit (Unidad de Telesecundaria, UT), the Educational Television Unit (Unidad de Television Educativa, UTE) and the Latin American Institute for Educational Communications (Instituto Latinoamericano de la Comunicacion Educativa, ILCE). Staff of the Telesecundaria Unit includes teachers, communications experts and specialists in the production of educational materials. The Educational Television Unit produces the televised components of Telesecundaria. The Latin American Institute for Educational Communications is responsible for a broad range of distance education programming, and publishes a bimonthly magazine that lists programming for all six channels of educational and cultural television that form Red EDUSAT (EDUcation via SATellite). Five channels are used for other educational and cultural purposes, with one channel being used to provide training for Telesecundaria teachers.

The Telesecundaria programmes are broadcast on Canal 11 according to the following scheme: from Monday to Friday courses from 8.00 am until 14.00 pm, the programme is relayed between 14.00 pm and 20.00 pm. The programming scheme can be viewed on the EDUSAT web site, accompanied by a short description of each course.

Some 33,500 reception centres, with decoders and television sets, have been set up throughout Mexico. Each Telesecundaria school has at least three television sets, a decoder to decompress EDUSAT's digital signal, and a 1.9 m minimum metre external satellite dish. Larger schools are likely to have more TVs, and schools with more than five TVs require a second decoder. On average, the Telesecundaria schools have three teachers – one for each grade – and 22 students per grade. Students attend school 200 days a year, 30 hours a week. Each course takes approximately 15 minutes, afterwards students study the relevant material in a specially-designed textbook, followed by teacher-led discussions to help students fully understand the content of the course.

Teletuks

Case study

CATEGORY 2

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Type of Application

Teletuks is essentially an Interactive Television service (Category 2).

Coverage

PAS 7 (Ku-band) from PanAmSat. The university signal is multiplexed with 58 other commercial channels and grouped in one of three bouquets of channels. The scrambling of the signal is done with the IRDETO algorithm technology. At present, the signal is only spot beamed to southern Africa.

Short Description

The University of Pretoria has a history of investing in sophisticated educational technological applications. The Department of Telematic Learning and Education Innovation has used satellite transmissions, electronic networks, the Internet, and its virtual campus, to supplement traditional under- and postgraduate teaching for the past 7 years. Such education innovations not only support flexible, life-long learning, but also make it possible to provide high-quality education to learners, many in remote areas, who cannot be accommodated in traditional face-to-face teaching scenarios. The niche markets which the interactive transmissions serve are students enrolled for courses in the fields of education, nursing, African languages and some modules in other faculties.

Image Teletuks



Teletuks classroom with TV

Teletuks is a community-based project and broadcasts are currently beamed via digital satellite to 72 schools in the four inland provinces, namely Gauteng, Northern, North West and Mpumalanga. These schools are primarily located in rural areas although some townships' schools have also been equipped using sponsorship money. The transmissions can be viewed at any of the more than 72 viewing venues across the country or by anyone who has access to DSTV at home. Synchronous or asynchronous interactivity is possible as students can give feedback by phone, fax or email. The formal university programmes also include print-based materials.

As a community service, Teletuks also televises school lessons to senior secondary learners in an endeavour to help address some of the educational needs of the country and to help prepare potential students for the demands of tertiary study.

It is a free service aiming to supplement what educators do at schools by giving extra tuition in the 'killer subjects' like Mathematics, Physical Science, Biology, English, Geography and Accounting. Career Guidance and Primary Health Care slots are integrated as well, dealing with issues like AIDS awareness and even ways of becoming involved in playing professional rugby! The intention of the programme is not to replace educators at schools, but to assist learners preparing for their final school-leaving exam in the more difficult aspects of the particular subject. The lessons are generic and aim to review, rather than to introduce new content. Logistics, however, prevent printed support material being offered. The programme is currently aimed at senior learners aged 16/18 (Grades 11 & 12) who can watch 50-minute lessons in two

subjects, four afternoons a week of the academic year. The lesson schedule is prepared a term in advance and sent to schools where the designated facilitator is expected to notify learners and make further arrangements regarding accessibility and operation of equipment. Apart from the weekly lessons, a winter and spring School are also scheduled during July and October school holidays. A total of 30 hours per subject is screened annually.

The providers of Teletuks argue that as a mass medium, television is more accessible to the average learner than computer technology. Within rural areas, learners are also more likely to make a personal investment in satellite technology – which could be shared by the community – rather than buy a PC that has a dedicated application.

University of Derby Extension

Case study

CATEGORY 2

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Type of Application

Interactive television: uplink is via satellite, return link via terrestrial lines/satellite (Category 2).

Coverage

Transmission via Eutelsat towards users in Israel.

Short Description

Derby University with its partner Inter College in Israel and Gilat Communications (now renamed Mentergy) has set up 'telepresence' teaching for the university's extension programme which has over 5,000 full-time students. A complex of five studios transmits lessons to 26 classrooms on five sites (university extension centres) in Haifa, Tel Aviv and Jerusalem – where they each have a 2.4 m dish – using MPEG-1 Compression on IP protocols. Five studios and five centres is just a numerical coincidence. Each centre might be receiving up to five different lessons in five different classrooms at once but usually a studio is connected to between two and six classrooms (up to 200 students or more) – with about 500 Kbps video out and return sound/data, and 100 Kbps return video picture only (3 Mbps in total). Return signal is via landlines to the headquarters of Mentergy near Tel Aviv, which provides the switching arrangement that is remotely triggered by the teacher so he/she can view any class they wish from those logged on to the lesson. The selected video signal is transmitted by one of Mentergy's dishes back to the Derby 3.7 m dish. Sound and data from all the logged-on classes are on a separate channel from video, so the teacher might be talking to a student in one class, but watching another, while data from all his/her classes is on screen. Every student has a telephone handset that can be activated by the teacher for answers to questions etc and used by the students to log in, raise their 'hand' and answer multiple-choice questions. This instructional management system, ie the scheduling software and return video switching, are considered innovative features. In the first ten weeks of operation, over 7,000 classroom hours were received in Israel, amounting to more than 150,000 hours of student learning. The centre currently transmits up to 14 hours a day, 5 days a week.

7. Satellite Operators



7

PanAmSat

PanAmSat is a 23-satellite GEO system that provides broadcast and telecommunications services to customers worldwide. Their main services include the distribution of cable and broadcast television channels, private communications networks for businesses and international Internet access. Additional services include ship-to-shore communications, videoconferencing, paging, satellite newsgathering and special event and sports broadcasting. PanAmSat's customers include broadcasters like the BBC, Disney, China Central Television, news organisations like Reuters, Internet Service Providers in more than 30 countries and telecommunications providers in the USA, Latin America, Europe, Asia and Africa. Hughes Electronics are major shareholders of PanAmSat.

www.panamsat.com

Intelsat

Intelsat has currently a fleet of 24 satellites, which will be expanded soon to 32. It provides Internet access to 150 ISP's as well as television broadcast (including SNG, special events, studio-to-studio, direct-to-home). Intelsat also offers high-quality digital voice, data and multimedia communications for corporate networks.

In April 1998, Intelsat established New Skies Satellites (see below) as a wholly owned subsidiary.

www.intelsat.com

Inmarsat

Inmarsat supports links for phone, fax and data communications at up to 64 Kbps to more than 210,000 ship, vehicle, aircraft and portable terminals.

Inmarsat Ltd is a subsidiary of the Inmarsat Ventures plc holding company. It operates a constellation of geostationary satellites designed to extend phone, fax and data communications all over the world. The constellation comprises five third-generation satellites backed up by four earlier spacecraft. Today's Inmarsat system is used by independent service providers to offer a range of voice and multimedia communications. Users include ship owners and managers, journalists and broadcasters, health and disaster-relief workers, land transport fleet operators, airlines, airline passengers and air traffic controllers, government workers, national emergency and civil defence agencies, and peacekeeping forces.

The Inmarsat business strategy is to pursue a range of new opportunities at the convergence of information technology, telecoms and mobility while continuing to serve traditional maritime, aeronautical, land-mobile and remote-area markets.

Inmarsat's primary satellite constellation consists of four Inmarsat-3 satellites in geostationary orbit. Between them, the main ('global') beams of the satellites provide overlapping coverage of the whole surface of the Earth apart from the poles. The Inmarsat-3 satellites are backed up by a fifth Inmarsat-3 and four previous-generation Inmarsat-2s, also in geostationary orbit.

Inmarsat is now building its new Inmarsat I-4 satellite system, which from 2005 will support the Inmarsat Broadband Global Area Network (B-GAN) – mobile data communications at up to 432 Kbps for Internet access, mobile multimedia and many other advanced applications.

www.inmarsat.com

Eutelsat

Eutelsat's satellite infrastructure supports TV and radio broadcasts, the delivery of Internet backbone, push and cache services in Europe, and capacity for corporate networks, satellite newsgathering, telephony, mobile voice, data and positioning services. From its core market of Europe and the Mediterranean Basin, Eutelsat has expanded its market presence into the Middle East, Africa, southwest Asia, North and South America. Eutelsat's in-orbit resource include 20 satellites positioned in geostationary orbit between 5 degrees W to 76 degrees E and providing coverage from the Americas to the Indian-subcontinent. Eutelsat also commercialises capacity on three satellites operated by other companies (Loral Skynet, Telecom Italia and Russian Satellite Communications Company).

www.eutelsat.com

SES-Global

Société Européenne des Satellites S.A. (SES) is the operator of ASTRA, Europe's leading direct-to-home satellite system. ASTRA transmits in analogue and digital format to more than 1,000 television and radio channels as well as multimedia and Internet services to an audience of more than 89 million homes throughout Europe.

SES is a pioneer of satellite broadband services through SES Multimedia, a wholly owned subsidiary. SES Multimedia operates the ASTRA-NET platform, enabling service and content providers to transmit data directly, via satellite, to personal computers in businesses and homes across Europe.

The ASTRA fleet consists of 13 satellites which are located at the orbital position of 5.2 degrees, 19.2 degrees, 23.5 degrees, 24.2 degrees and 28.2 degrees E. ASTRA currently covers only Europe including Eastern Europe. In order to provide global connectivity to their customers and users, SES are expanding ASTRA's geographic reach. More powerful satellites, such as ASTRA 1KR, to be launched in the second half of 2005, will increase ASTRA's coverage area in the European core market.

SES is also a major shareholder in:

- AsiaSat, the leading satellite system in the Asian/Pacific region (34.10% since January 1999). The combined footprints of ASTRA and AsiaSat provide access to 74% of the world's population in Europe, Asia and Australia
- Nordic Satellite AB (NSAB), operator of the Scandinavian SIRIUS satellite system (50% since October 2000)
- Star One (formerly Embratel Satellite Division), owner and operator of Brasilsat, the largest satellite fleet over Latin America (19.99%, also since October 2000)

Through its strategic investments in AsiaSat, NSAB and Star One, SES will be able to interconnect the European ASTRA and SIRIUS satellites with the Asian/Pacific AsiaSats and the American AMERICOM satellites to offer satellite broadband services spanning four continents.

SES-ASTRA together with Alcatel and GILAT have founded the Germany-based SatLynx company in which they concentrate their efforts in the two-way satellite Internet connectivity and the broadband activities.

www.ses-astra.com

www.ses-global.com

www.satlynx.com



Hughes Electronics

Hughes Electronics Corporation is a world-leading provider of digital television entertainment, broadband services, satellite-based private business networks, and global video and data broadcasting. Hughes owns 81% of PanAmSat. One of its main units is Hughes Network Systems, a supplier of satellite-based private business networks. It is also a producer of set-top receivers for DIRECTV and provides the DirecPC satellite-based Internet access service. Hughes Network Systems provides a wide array of cost-effective global broadband, satellite and wireless communications products for home and business. Through its innovative ground and satellite-based communications networks, HNS tries to set the standard for the next generation of high-speed communications including video, data, voice, multimedia and Internet services.

www.hughes.com

New Skies

New Skies Satellites N.V. (New Skies) is a wholly independent satellite operator with five satellites in key orbital locations around the globe. New Skies operates NSS-6, NSS-7 and NSS-806 in the Atlantic Ocean region, NSS-703 in the Indian Ocean and NSS-5 in the Pacific Ocean region. These satellites provide complete global coverage at C-band, and high-powered Ku-band spot beams over most of the world's principal population centres. New Skies Satellites N.V.'s global fleet of C- and Ku-band satellites are suited for Internet, multimedia and corporate data transmission, and point-to-multipoint distribution of video to cable-head ends around the world.

www.newskies.com

Intersputnik

Intersputnik is an intergovernmental organisation, formed in 1971 to provide satellite telecommunications for the Soviet Union and other socialist countries around the world. Recently, Intersputnik has adopted a more open, commercial policy and many more countries have joined.

In mid 1997, Intersputnik formed a joint venture, Lockheed Martin Intersputnik, with Lockheed Martin which launched its first satellite in 1999.

Intersputnik's space segment is based on six satellites deployed in the geostationary arc extending from 14 degrees W to 142.5 degrees E. The satellite fleet consists of Express and Gorizont series spacecraft as well as the new generation LMI-1 and Express A satellites.

Over 70 trunk Earth stations, four monitoring stations and a ground control centre operate in the Intersputnik system.

Intersputnik provides satellite capacity for establishing international, domestic and regional communications services including PSTN, VSAT networks, television/radio broadcasting and high-speed Internet access.

Currently Intersputnik is planning a major expansion using up to 100 small geostationary satellites.

www.intersputnik.com

Europe*Star

Europe*Star is a joint venture between Alcatel Spacecom (51%) and Loral Space and Communications (49%).

Europe*Star leases wholesale transponder capacity for Internet and other broadband data applications, and for television and radio services. As a satellite owner-operator in the purest sense, Europe*Star's services are exclusively based around the provision and management of transponder capacity on the growing fleet of geosynchronous satellites.

Satellites already in service or planned include:

- Europe*Star 1 came into service in January 2001 at Europe*Star's 45° East orbital slot, the first satellite in a US$450 million programme that includes two satellites and ground segment. The satellite provides high-power coverage within and between Europe, southern Africa, the Middle East, the Indian subcontinent and South East Asia
- Europe*Star B was brought into service towards the end of 2000 at the 47.5 degrees E orbital slot. It provides cost-competitive point-to-point connectivity within Europe, with its primary market being Internet backbone access for Central and Eastern Europe

Applications include DTH TV and programme contribution, Internet backbone, and interactive services using small two-way VSATs

www.europestar.com

7.2. Internet via Satellite Service Providers in UK

It is impossible to keep an up-to-date list of providers of retail services because of the dynamics of the business. Therefore we recommend the reader to make use of services such as RABBIT-Broadband, the Scottish Business Broadband Incentive and the Welsh Development Agency SME Satellite Broadband Subsidy Scheme.

These initiatives are aimed mainly at small businesses, also in areas that cannot receive ADSL or Cable Modem solutions, who are prepared to try out the alternatives now available. Therefore they also provide information about satellite service providers that offer a range of Internet access solutions, often as subsidiaries of larger international consortia. These initiatives provide through their web sites up-to-date information about satellite service providers which is equally useful for educational institutions who are looking for satellite-based solutions. These details include:

- Company and product name and contact details
- Service and functionality offered
- Equipment and bandwidth costs if available

www.rabbit-broadband.co.uk

www.scottish-enterprise.com/sedotcom_home/services-to-business/broadband.htm

www.cymruarlein.wales.gov.uk/broadband.htm

8. Glossary



ADSL – Asymmetric Digital Subscriber Line is a technology for transmitting digital information at a high bandwidth on existing phone lines to homes and businesses. Unlike regular dial-up phone service, ADSL provides continously-available, 'always-on' connection. ADSL is asymmetric in that it uses most of the channel to transmit downstream to the user and only a small part to receive information from the user. ADSL simultaneously accommodates analogue (voice) information on the same line. (source: www.whatis.com)

Analogue – Information represented by a measurable physical quantity with continuous values, as opposed to information in digital form.

Beam – This is essentially the signal or group of signals that is sent from the satellite to the surface of the Earth. This surface, defined by the beam, is the satellite 'footprint', ie the area on Earth where the beam can be captured and used. No one satellite can transmit a beam to the entire Earth, though theoretically three equally spaced satellites in a network could cover the entire Earth.

Broadcasting – A means of one-way, point-to-multipoint transmission where the end receiver is not known to the broadcaster, ie it is an 'open' system. Broadcasting is typical for radio and television transmission where the audience is only defined by virtue of having the correct receive equipment.

Caching – Using a buffer within your own computer's fast memory to hold recently accessed data. It is designed to speed up access to the same data later.

Cellular network – Mobile radio system most often used nowadays for telephony, which has rapidly supplemented landline telecommunications as a means of two-way personal communications. Cellular networks works on the principle and use the physics of two-way radio communications and is named after the unit 'cell' into which an area is divided. As a mobile radio telephone moves through this pattern of cells, its user's calls, made as on an ordinary telephone, are switched from one cell to the next by a computerised system.

Compression – Reduce the number of bits required for data storage or transmission with special software. Decompression reverses the result of compression.

Contention – Contention is the case when multiple users vie for the right to use a communication channel within a multiplexed connection. The contention rate is in that case the number of users that in the worst case have to share the connection. If a connection has a bandwidth potential of 1000 Kbps with a contention rate of 20:1 it is possible that in the worst case users will fall back to a connection speed of 1000/20 = 50 Kbps.

Dark Fibre – Dark fibre is optical fibre infrastructure (cabling and repeaters) that is currently in place but is not being used.

Data broadcasting – Data can be broadcast or transmitted to users over various wireless and cable mediums. The most typical are radio broadcasts (VHF, UHF, satellite) and cable broadcasts (such as simple cable television).

dBW – Decibel Watts gives an indication of transmit power: the higher the value, the higher the signal strength.

Digital – Information represented as discrete numeric values, eg in binary format (zeros or ones), as opposed to information in continuous or analogue form. Binary digits (bits) are typically grouped into 'words' of various lengths – 8-bit words are called bytes.

DVB – DVB stands for Digital Video Broadcasting, the European standard for digital TV. This standard provides a very high-speed, robust transmission chain capable of handling the many megabytes per second needed for hundreds of MPEG-2 digital TV channels.

Encryption – Encryption is the process of altering a video and/or audio signal from its original condition to prevent unauthorised reception. This is done electronically at a place in the supply chain between the contribution point (eg the originating studio) and the uplink towards the satellite. Decryption is the process of returning the video and/or audio to its original condition. Decryption is mostly done at the side of the end-user.

Fixed Wireless Local Loop – Local connections that link customer equipment to the switching system in the central office using wireless connectivity – mostly used for broadband data purposes.

Geostationary orbit or Clarke Belt – Named after its founder Arthur C. Clarke, the Clarke Belt is an orbit used by satellites at a height of 35,800 km, in which satellites make an orbit in 24 hours, yet remain in a fixed position relative to the Earth's surface.

LNB – The Low Noise Block is an essential part of a satellite receiver which receives the signal and amplifies it for use. It is always located with the satellite antenna.

Mirroring servers – Network server maintaining an identical copy of its files in (a) another network server, or (b) a redundant drive in the same server. Note: Mirroring can be used as a rudimentary backup system for the original files, but is more often used to spread out the access load for popular sites, eg web sites, by offering users several different locations from which identical files can be accessed.

Mono – One or single channel as opposed to stereo or dual channel.

MPEG – MPEG is the 'Moving Picture Experts Group', working under the joint direction of the International Standards Organisation (ISO) and the International Electro-Technical Commission (IEC). This group works on standards for digital video compression and file formats. The purpose is to standardise compressed moving pictures and audio. The most notable current MPEG standards are MPEG-1, MPEG-2 and MPEG-4.

Multicasting – Transmitting information to a well-defined and controlled group of users on your network.

Multiplexer – Combines several different signals (eg video, audio, data) onto a single communication channel for transmission. De-multiplexing separates each signal at the receiving end.

Narrow-band – A low-bandwidth (low capacity) communications path. Narrow-band networks are designed for voice transmission (typically analogue voice), but which have been adapted to accommodate the transmission of low-speed data.

Orbit – The path taken by a satellite. A satellite is usually kept in its orbit through a combination of natural forces, mainly the force of gravity, and on-board resources.

PoP (Point of Presence) – The specific physical place where you make connection to the Internet.

Proxy – A proxy server can serve several purposes; it can hold the most commonly and recently used content from the World Wide Web for users (versus having to go all the way to the server on which it was originally stored) thus providing quicker access. Also it can filter web content (so it can be used by schools and libraries) and it can convert web pages to match the capabilities of the receiving software and/or hardware.

Rain attenuation – Loss of signal at Ku- or Ka-band frequencies due to absorption and increased sky-noise temperature caused by heavy rainfall. Attenuation is the decrease in the amplitude of a signal. In video communications this usually refers to the loss of power of electromagnetic signals between a transmitter and the receiver during the process of transmission. Thus the received signal is weaker or degraded when compared to the original transmission.

Revolution – The cycle that normally takes a satellite around Earth.

SoHo Small Office – Home Office – term to describe professional office solutions of the smallest scale: offices for people that work from home like teleworkers, home-based professionals like GPs, lawyers, but also small enterprises (shops, workshops etc).

SOHO also exists as a satellite-related term but in this context refers to the scientific SOlar and Heliospheric Observation Satellite.

Stereo – Two or more independent channels of information. Separate microphones are used in recording and separate speakers are used in reproduction.

Sub-carrier – A second signal sent alongside a main signal to carry additional information. In satellite television transmission, the video picture is transmitted over the main carrier. The corresponding audio is sent via an FM sub-carrier. Some satellite transponders carry as many as four special audio or data sub-carriers whose signals may or may not be related to the main programming.

Thrusters – Small axial jets used by the satellite to maintain its orbit. These are often fuelled by drazine or bi-propellant. In time, ion-engines will probably replace such thrusters.

Two-way – Operating method in which transmission is possible in both directions of a telecommunication channel.

Unicasting – Data is delivered to only one user within a network as opposed to multicasting. Each packet in a unicast contains a user ID number. The user's ID must match the ID in the header of the unicast packet, only then can data be received.

VSAT – Meaning literally 'Very Small Aperture Terminal', the term refers to any fixed satellite terminal that is used to provide interactive or receive-only communications. VSATs are used for a wide variety of telecommunications applications, including corporate networks, rural telecoms, distance learning, telemedicine, disaster recovery, ship-board communications, transportable 'fly-away' systems and much more.

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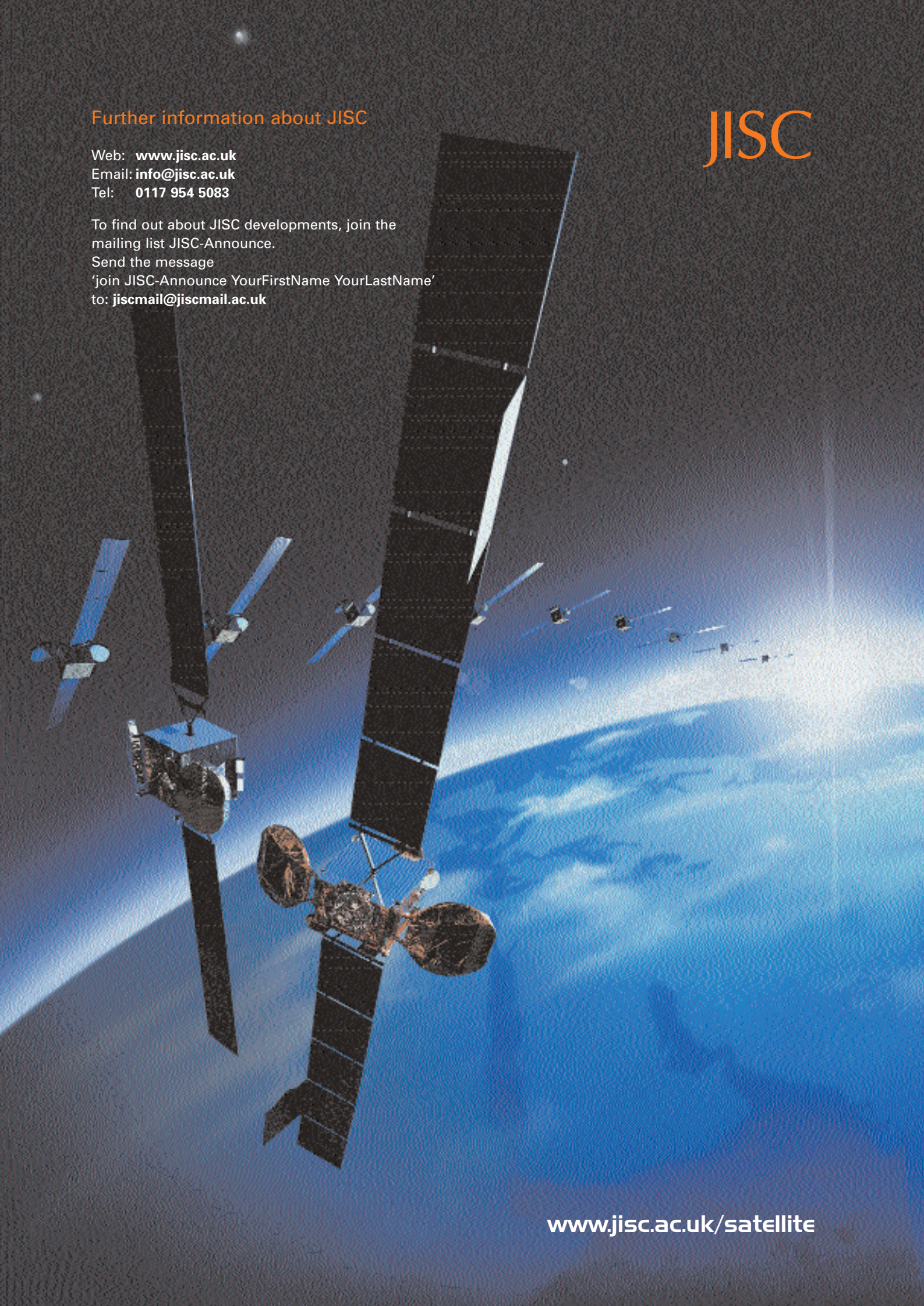
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