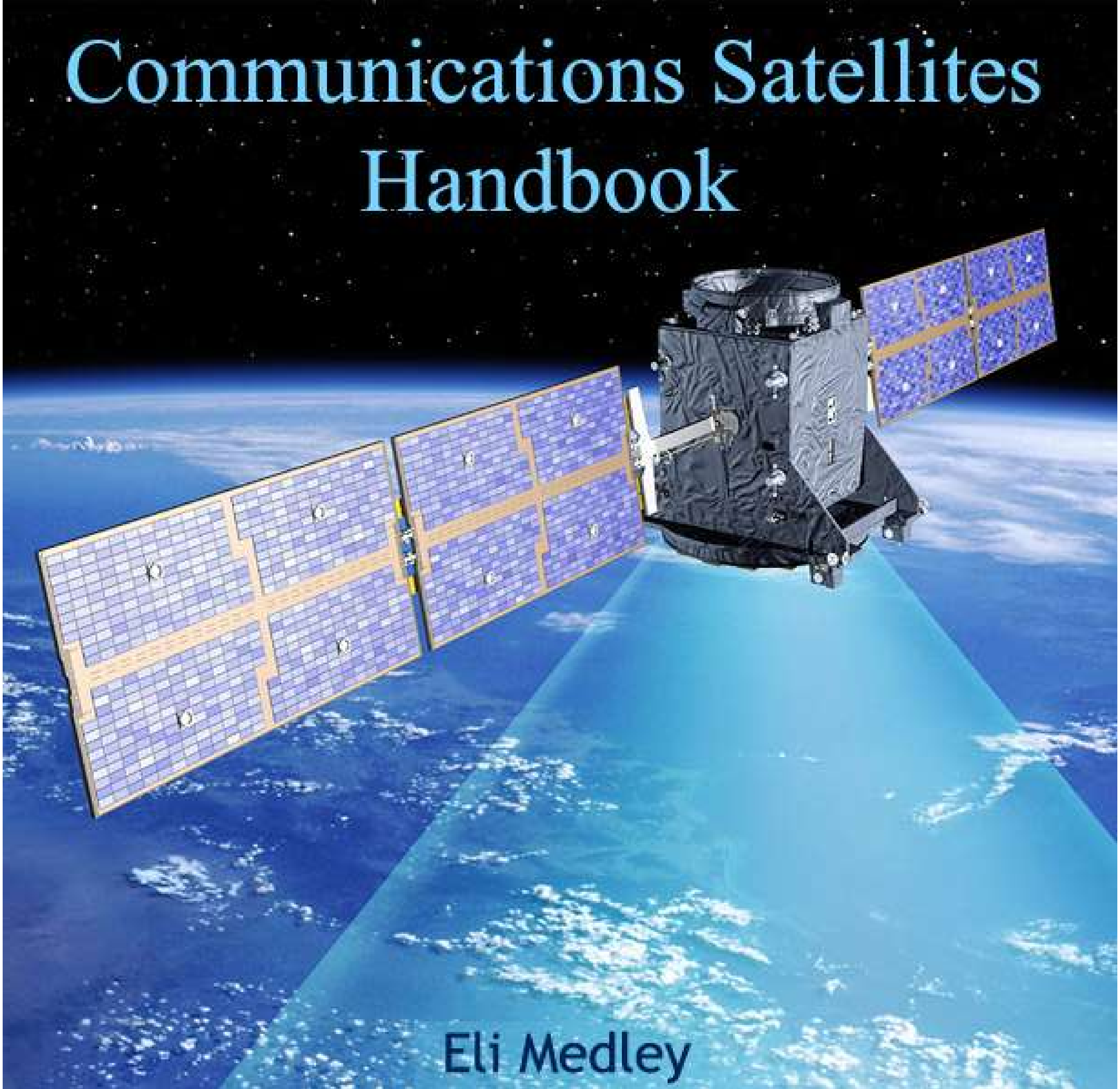
Communications Satellites Handbook



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Chapter- 1

Communications Satellite

U.S. military WGSS communications satellite

A **communications satellite** (sometimes abbreviated to **COMSAT**) is an artificial satellite stationed in space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits, Molniya orbits, other elliptical orbits and low (polar and non-polar) Earth orbits.

For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology complementary to that of communication cables. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting, for which application of other technologies, such as cable, is impractical or impossible.

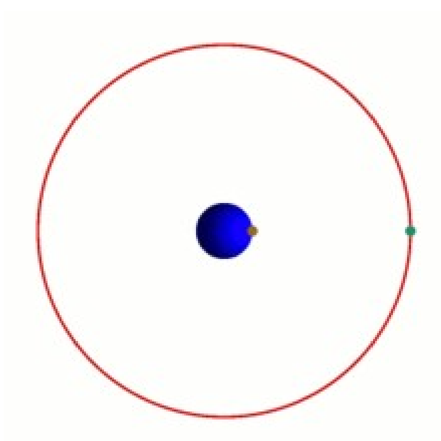
History

The first artificial satellite was the Soviet Sputnik 1, launched on October 4, 1957, and equipped with an on-board radio-transmitter that worked on two frequencies, 20.005 and 40.002 MHz. With the launch of Alouette 1 in 1962 Canada became the third country to put a man-made satellite into space. Because Canada did not have any domestic launch capabilities of its own, (and still does not), Alouette 1, which was entirely built and funded by Canada, was launched by the American National Aeronautics and Space Administration (NASA) from Vandenberg AFB in California. The first American satellite to relay communications was Project SCORE in 1958, which used a tape recorder to store and forward voice messages. It was used to send a Christmas greeting to the world from U.S. President Dwight D. Eisenhower. NASA launched an Echo satellite in 1960; the 100-foot (30 m) aluminized PET film balloon served as a passive reflector for radio communications. Courier 1B, built by Philco, also launched in 1960, was the world's first active repeater satellite.

Telstar was the first active, direct relay communications satellite. Belonging to AT&T as part of a multi-national agreement between AT&T, Bell Telephone Laboratories, NASA, the British General Post Office, and the French National PTT (Post Office) to develop satellite communications, it was launched by NASA from Cape Canaveral on July 10, 1962, the first privately sponsored space launch. Telstar was placed in an elliptical orbit (completed once every 2 hours and 37 minutes), rotating at a 45° angle above the equator.

An immediate antecedent of the geostationary satellites was Hughes' Syncom 2, launched on July 26, 1963. Syncom 2 revolved around the earth once per day at constant speed, but because it still had north-south motion, special equipment was needed to track it.

Geostationary orbits



Geostationary orbit

A satellite in a geostationary orbit appears to be in a fixed position to an earth-based observer. A geostationary satellite revolves around the earth at the same angular velocity of the earth itself, 360 degrees every 24 hours in an equatorial orbit, and therfore it seems to be in a fixed position over the equator.The launch of Anik A-1 in 1972, made Canada the first country in the world to establish its own domestic geostationary communication satellite network.

The geostationary orbit is useful for communications applications because ground based antennas, which must be directed toward the satellite, can operate effectively without the need for expensive equipment to track the satellite's motion. Especially for applications that require a large number of ground antennas (such as direct TV distribution), the savings in ground equipment can more than justify the extra cost and onboard complexity of lifting a satellite into the relatively high geostationary orbit. The main drawback of a geostationary satellite, however, is that it cannot be "seen" from polar regions, so it cannot provide commumications to extreme northerly or southerly areas of the globe. Another drawback of GEO satellites is their distance from earth (~37,000 kilometers), which requires more powerful transmitters, larger (usually dish) antennas, and high sensitivity receivers to Satellite Earth Stations. This distance also introduces a large (~0.25 second) delay into satellite communications link which has to be taken into account.

The concept of the geostationary communications satellite was first proposed by Arthur C. Clarke, building on work by Konstantin Tsiolkovsky and on the 1929 work by Herman Potočnik (writing as Herman Noordung) *Das Problem der Befahrung des Weltraums - der Raketen-motor*. In October 1945 Clarke published an article titled "Extra-terrestrial Relays" in the British magazine *Wireless World*. The article described the fundamentals behind the deployment of artificial satellites in geostationary orbits for the purpose of relaying radio signals. Thus Arthur C. Clarke is often quoted as being the inventor of the communications satellite.

Syncom 3, launched on August 19, 1964. It was placed in orbit at 180° east longitude, over the International Date Line. It was used that same year to relay experimental television coverage of the 1964 Summer Olympics in Tokyo, Japan to the United States, making these Olympic games the first to be broadcast internationally. Although Syncom 3 is sometimes credited with the first television transmission to cross the Pacific Ocean, the Relay 1 satellite first broadcast from the United States to Japan on November 22, 1963.

Shortly after Syncom 3, Intelsat I, aka *Early Bird*, was launched on April 6, 1965 and placed in orbit at 28° west longitude. It was the first geostationary satellite for telecommunications over the Atlantic Ocean.

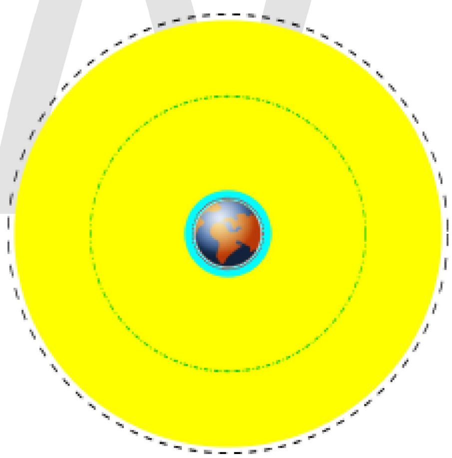
On November 9, 1972, Canada's first geostationary satellite serving the continent, Anik A1, was launched by Telesat Canada, with the United States following suit with the launch of Westar 1 by Western Union on April 13, 1974.

On May 30, 1974, the first geostationary communications satellite in the world to be three-axis stabilized was launched: the experimental satellite ATS-6 built for NASA

After the launches of Telstar, Syncom 3, Early Bird, Anik A1, and Westar 1, RCA Americom (later GE Americom, now SES Americom) launched Satcom 1 in 1975. It was Satcom 1 that was instrumental in helping early cable TV channels such as WTBS (now TBS Superstation), HBO, CBN (now ABC Family), and The Weather Channel become successful, because these channels distributed their programming to all of the local cable TV headends using the satellite. Additionally, it was the first satellite used by broadcast television networks in the United States, like ABC, NBC, and CBS, to distribute programming to their local affiliate stations. Satcom 1 was widely used because it had twice the communications capacity of the competing Westar 1 in America (24 transponders as opposed to the 12 of Westar 1), resulting in lower transponder-usage costs. Satellites in later decades tended to have even higher transponder numbers.

By 2000, Hughes Space and Communications (now Boeing Satellite Development Center) had built nearly 40 percent of the more than one hundred satellites in service worldwide. Other major satellite manufacturers include Space Systems/Loral, Orbital Sciences Corporation with the STAR Bus series, Indian Space Research Organization, Lockheed Martin (owns the former RCA Astro Electronics/GE Astro Space business), Northrop Grumman, Alcatel Space, now Thales Alenia Space, with the Spacebus series, and Astrium.

Low-Earth-orbiting satellites



Low Earth orbit in Cyan

A Low Earth Orbit (LEO) typically is a circular orbit about 400 kilometres above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes. Because of their low altitude, these satellites are only visible from within a radius of roughly 1000 kilometres from the sub-satellite point. In addition, satellites in low earth orbit change their position relative to the ground position quickly. So even for local applications, a large number of satellites are needed if the mission requires uninterrupted connectivity.

Low earth orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to proximity to the ground, do not require as high signal strength (Recall that signal strength falls off as the square of the distance from the source, so the effect is dramatic). Thus there is a trade off between the number of satellites and their cost. In addition, there are important differences in the onboard and ground equipment needed to support the two types of missions.

A group of satellites working in concert is known as a satellite constellation. Two such constellations, intended to provide satellite phone services, primarily to remote areas, are the Iridium and Globalstar systems. The Iridium system has 66 satellites. Another LEO satellite constellation known as Teledesic, with backing from Microsoft entrepreneur Paul Allen, was to have over 840 satellites. This was later scaled back to 288 and ultimately ended up only launching one test satellite.

It is also possible to offer discontinuous coverage using a low Earth orbit satellite capable of storing data received while passing over one part of Earth and transmitting it later while passing over another part. This will be the case with the CASCADE system of Canada's CASSIOPE communications satellite. Another system using this store and forward method is Orbcomm.

Molniya satellites

Geostationary satellites must operate above the equator and will therefore appear lower on the horizon as the receiver gets the farther from the equator. This will cause problems for extreme northerly lattitudes, affecting connectivity and causing multipath (interference caused by signals reflecting off the ground and into the ground antenna). For areas close to the North (and South) Pole, a geostationary satellite may appear below the horizon. Therefore Molniya orbit satellite have been launched, mainly in Russia, to alleviate this problem. The first satellite of the Molniya series was launched on April 23, 1965 and was used for experimental transmission of TV signal from a Moscow uplink station to downlink stations located in Siberia and the Russian Far East, in Norilsk, Khabarovsk, Magadan and Vladivostok. In November 1967 Soviet engineers created a unique system of national TV network of satellite television, called Orbita, that was based on Molniya satellites.

Molniya orbits can be an appealing alternative in such cases. The Molniya orbit is highly inclined, guaranteeing good elevation over selected positions during the northern portion of the orbit. (Elevation is the extent of the satellite's position above the horizon. Thus, a satellite at the horizon has zero elevation and a satellite directly overhead has elevation of 90 degrees).

The Molniya orbit is designed so that the satellite spends the great majority of its time over the far northern latitudes, during which its ground footprint moves only slightly. Its period is one half day, so that the satellite is available for operation over the targeted region for six to nine hours every second revolution. In this way a constellation of three Molniya satellites (plus in-orbit spares) can provide uninterrupted coverage.

Structure of a Communications Satellite

Communications Satellites are usually composed of the following subsystems:

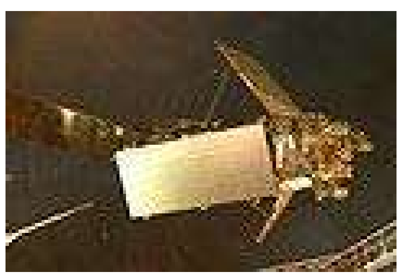
- Communication Payload, normally composed of transponders, antenna and switching systems
- Engines used to bring the satellite to its desired orbit
- Station Keeping Tracking and stabilization subsystem used to keep the satellite in the right orbit, with its antennas pointed in the right direction, and its power system pointed towards the sun
- Power subsystem, used to power the Satellite systems, normally composed of Solar Cell, and batteries that maintain power during Solar Eclipse
- Command and Control subsystem, which maintains communications with ground control stations, The ground control earth stations monitor the satellite performance and control its functionality during various phases of its life-cycle.

Bandwidth of a satellite

The bandwidth available from a satellite depends upon the number of transponders provided by the satellite. Each service (TV, Voice, Internet, radio) requires a different amount of bandwidth for transmission. The bandwidth of transponder is used to carry these services

Satellite Applications

Telephone



An Iridium satellite

The first and historically most important application for communication satellites was in intercontinental long distance telephony. The fixed Public Switched Telephone Network relays telephone calls from land line telephones to an earth station, where they are then transmitted to a geostationary satellite. The downlink follows an analogous path. Improvements in submarine communications cables, through the use of fiber-optics, caused some decline in the use of satellites for fixed telephony in the late 20th century, but they still serve remote islands such as Ascension Island, Saint Helena, Diego Garcia, and Easter Island, where no submarine cables are in service. There are also regions of some continents and countries where landline telecommunications are rare to nonexistent, for example large regions of South America, Africa, Canada, China, Russia, and Australia. Satellite communications also provide connection to the edges of Antarctica and Greenland.

Satellite phones connect directly to a constellation of either geostationary or low-earth-orbit satellites. Calls are then forwarded to a satellite teleport connected to the Public Switched Telephone Network

Satellite television

As television became the main market, its demand for simultaneous delivery of relatively few signals of large bandwidth to many receivers being a more precise match for the capabilities of geosynchronous comsats. Two satellite types are used for North American television and radio: Direct Broadcast Satellite (DBS), and Fixed Service Satellite (FSS)

The definitions of FSS and DBS satellites outside of North America, especially in Europe, are a bit more ambiguous. Most satellites used for direct-to-home television in Europe have the same high power output as DBS-class satellites in North America, but use the same linear polarization as FSS-class satellites. Examples of these are the Astra, Eutelsat, and Hotbird spacecraft in orbit over the European continent. Because of this, the terms FSS and DBS are more so used throughout the North American continent, and are uncommon in Europe.

Fixed Service Satellite

Fixed Service Satellites use the C band, and the lower portions of the K_u bands. They are normally used for broadcast feeds to and from television networks and local affiliate stations (such as program feeds for network and syndicated programming, live shots, and backhauls), as well as being used for distance learning by schools and universities, business television (BTV), Videoconferencing, and general commercial telecommunications. FSS satellites are also used to distribute national cable channels to cable television headends.

Free-to-air satellite TV channels are also usually distributed on FSS satellites in the K_u band. The Intelsat Americas 5, Galaxy 10R and AMC 3 satellites over North America provide a quite large amount of FTA channels on their K_u band transponders.

The American DISH Network DBS service has also recently utilized FSS technology as well for their programming packages requiring their SuperDish antenna, due to Dish Network needing more capacity to carry local television stations per the FCC's "must-carry" regulations, and for more bandwidth to carry HDTV channels.

Direct broadcast satellite

A **direct broadcast satellite** is a communications satellite that transmits to small DBS satellite dishes (usually 18 to 24 inches or 45 to 60 cm in diameter). Direct broadcast satellites generally operate in the upper portion of the microwave K_u band. DBS technology is used for DTH-oriented (Direct-To-Home) satellite TV services, such as DirecTV and DISH Network in the United States, Bell TV and Shaw Direct in Canada, Freesat and Sky Digital in the UK, the Republic of Ireland, and New Zealand and DSTV in South Africa.

Operating at lower frequency and lower power than DBS, FSS satellites require a much larger dish for reception (3 to 8 feet (1 to 2.5m) in diameter for K_u band, and 12 feet (3.6m) or larger for C band). They use linear polarization for each of the transponders' RF input and output (as opposed to circular polarization used by DBS satellites), but this is a minor technical difference that users do not notice. FSS satellite technology was also originally used for DTH satellite TV from the late 1970s to the early 1990s in the United States in the form of TVRO (TeleVision Receive Only) receivers and dishes. It was also used in its K_u band form for the now-defunct Primestar satellite TV service.

Satellites for communication have now been launched that have transponders in the K_a band, such as DirecTV's SPACEWAY-1 satellite, and Anik F2. NASA as well has launched experimental satellites using the K_a band recently.

Mobile satellite technologies

Initially available for broadcast to stationary TV receivers, by 2004 popular mobile direct broadcast applications made their appearance with that arrival of two satellite radio systems in the United States: Sirius and XM Satellite Radio Holdings. Some manufacturers have also introduced special antennas for mobile reception of DBS television. Using Global Positioning System (GPS) technology as a reference, these antennas automatically re-aim to the satellite no matter where or how the vehicle (on which the antenna is mounted) is situated. These mobile satellite antennas are popular with some recreational vehicle owners. Such mobile DBS antennas are also used by JetBlue Airways for DirecTV (supplied by LiveTV, a subsidiary of JetBlue), which passengers can view on-board on LCD screens mounted in the seats.

Satellite radio

Satellite radio offers audio services in some countries, notably the United States. Mobile services allow listeners to roam a continent, listening to the same audio programming anywhere.

A satellite radio or subscription radio (SR) is a digital radio signal that is broadcast by a communications satellite, which covers a much wider geographical range than terrestrial radio signals.

Satellite radio offers a meaningful alternative to ground-based radio services in some countries, notably the United States. Mobile services, such as Sirius, XM, and Worldspace, allow listeners to roam across an entire continent, listening to the same audio programming anywhere they go. Other services, such as Music Choice or Muzak's satellite-delivered content, require a fixed-location receiver and a dish antenna. In all cases, the antenna must have a clear view to the satellites. In areas where tall buildings, bridges, or even parking garages obscure the signal, repeaters can be placed to make the signal available to listeners.

Radio services are usually provided by commercial ventures and are subscription-based. The various services are proprietary signals, requiring specialized hardware for decoding and playback. Providers usually carry a variety of news, weather, sports, and music channels, with the music channels generally being commercial-free.

In areas with a relatively high population density, it is easier and less expensive to reach the bulk of the population with terrestrial broadcasts. Thus in the UK and some other countries, the contemporary evolution of radio services is focused on Digital Audio Broadcasting (DAB) services or HD Radio, rather than satellite radio.

Amateur radio

Amateur radio operators have access to the OSCAR satellites that have been designed specifically to carry amateur radio traffic. Most such satellites operate as spaceborne repeaters, and are generally accessed by amateurs equipped with UHF or VHF radio equipment and highly directional antennas such as Yagis or dish antennas. Due to launch costs, most current amateur satellites are launched into fairly low Earth orbits, and are designed to deal with only a limited number of brief contacts at any given time. Some satellites also provide data-forwarding services using the AX.25 or similar protocols.

Satellite Internet

After the 1990s, satellite communication technology has been used as a means to connect to the Internet via broadband data connections. This can be very useful for users who are located in remote areas, and cannot access a broadband connection, or require high availability of services.

Military uses

Communications satellites are used for military communications applications, such as Global Command and Control Systems. Examples of military systems that use communication satellites are the MILSTAR, the DSCS, and the FLTSATCOM of the United States, NATO satellites, United Kingdom satellites, and satellites of the former Soviet Union. Many military satellites operate in the X-band, and some also use UHF radio links, while MILSTAR also utilizes K_a band.

Chapter- 2

Satellite Television

Satellite television is television delivered by the means of communications satellite and received by a satellite dish and set-top box. In many areas of the world it provides a wide range of channels and services, often to areas that are not serviced by terrestrial or cable providers.

History

The first satellite television signal was relayed from Europe to the Telstar satellite over North America in 1962. The first geosynchronous communication satellite, Syncom 2, was launched in 1963. The world's first commercial communication satellite, called Intelsat I (nicknamed Early Bird), was launched into synchronous orbit on April 6, 1965. The first national network of satellite television, called Orbita, was created in Soviet Union in 1967, and was based on the principle of using the highly elliptical Molniya satellite for re-broadcasting and delivering of TV signal to ground downlink stations. The first domestic North American satellite to carry television was Canada's geostationary Anik 1, which was launched in 1972. ATS-6, the world's first experimental educational and Direct Broadcast Satellite, was launched in 1974. The first Soviet geostationary satellite to carry Direct-To-Home television, called Ekran, was launched in 1976.

Technology

Satellites used for television signals are generally in either naturally highly elliptical (with inclination of +/-63.4 degrees and orbital period of about 12 hours, also known as Molniya orbit) or geostationary orbit 37,000 km (22,300 miles) above the earth's equator.

Satellite television, like other communications relayed by satellite, starts with a transmitting antenna located at an uplink facility. Uplink satellite dishes are very large, as much as 9 to 12 meters (30 to 40 feet) in diameter. The increased diameter results in more accurate aiming and increased signal strength at the satellite. The uplink dish is pointed toward a specific satellite and the uplinked signals are transmitted within a specific frequency range, so as to be received by one of the transponders tuned to that frequency range aboard that satellite. The transponder 'retransmits' the signals back to Earth but at a different frequency band (a process known as translation, used to avoid interference with the uplink signal), typically in the C-band (4–8 GHz) or K_u-band (12–18 GHz) or both.

The leg of the signal path from the satellite to the receiving Earth station is called the downlink.

A typical satellite has up to 32 transponders for Ku-band and up to 24 for a C-band only satellite, or more for hybrid satellites. Typical transponders each have a bandwidth between 27 MHz and 50 MHz. Each geo-stationary C-band satellite needs to be spaced 2 degrees from the next satellite (to avoid interference). For K_u the spacing can be 1 degree. This means that there is an upper limit of 360/2 = 180 geostationary C-band satellites and 360/1 = 360 geostationary K_u-band satellites. C-band transmission is susceptible to terrestrial interference while K_u-band transmission is affected by rain (as water is an excellent absorber of microwaves at this particular frequency).

The downlinked satellite signal, quite weak after traveling the great distance, is collected by a parabolic receiving dish, which reflects the weak signal to the dish's focal point. Mounted on brackets at the dish's focal point is a device called a feedhorn. This feedhorn is essentially the flared front-end of a section of waveguide that gathers the signals at or near the focal point and 'conducts' them to a probe or pickup connected to a low-noise block downconverter or LNB. The LNB amplifies the relatively weak signals, filters the block of frequencies in which the satellite TV signals are transmitted, and converts the block of frequencies to a lower frequency range in the L-band range. The evolution of LNBs was one of necessity and invention.

The original C-Band satellite TV systems used a Low Noise Amplifier connected to the feedhorn at the focal point of the dish. The amplified signal was then fed via very expensive and sometimes 50 ohm impedance gas filled hardline coaxial cable to an indoor receiver or, in other designs, fed to a downconverter (a mixer and a voltage tuned oscillator with some filter circuitry) for downconversion to an intermediate frequency. The channel selection was controlled, typically by a voltage tuned oscillator with the tuning voltage being fed via a separate cable to the headend. But this design evolved.

Designs for microstrip based converters for Amateur Radio frequencies were adapted for the 4 GHz C-Band. Central to these designs was concept of block downconversion of a range of frequencies to a lower, and technologically more easily handled block of frequencies (intermediate frequency).

The advantages of using an LNB are that cheaper cable could be used to connect the indoor receiver with the satellite TV dish and LNB, and that the technology for handling the signal at L-Band and UHF was far cheaper than that for handling the signal at C-Band frequencies. The shift to cheaper technology from the 50 Ohm impedance cable and N-Connectors of the early C-Band systems to the cheaper 75 Ohm technology and F-Connectors allowed the early satellite TV receivers to use, what were in reality, modified UHF TV tuners which selected the satellite television channel for down conversion to another lower intermediate frequency centered on 70 MHz where it was demodulated. This shift allowed the satellite television DTH industry to change from being a largely hobbyist one where receivers were built in low numbers and complete systems were expensive (costing thousands of Dollars) to a far more commercial one of mass production.

Direct broadcast satellite dishes are fitted with an LNBF, which integrates the feedhorn with the LNB.

In the United States, service providers use the intermediate frequency ranges of 950-2150 MHz to carry the signal to the receiver. This allows for transmission of UHF band signals along the same span of coaxial wire at the same time. In some applications, (DirecTV AU9-S and AT-9) ranges the lower B-Band and upper 2250-3000 MHz, are used. Newer LNBFs in use by DirecTV referred to as SWM, use a more limited frequency range of 950-1800 MHz.

The satellite receiver or [Set-top box] demodulates and converts the signals to the desired form (outputs for television, audio, data, etc.). Sometimes, the receiver includes the capability to unscramble or decrypt the received signal; the receiver is then called an Integrated receiver/decoder or IRD. The cable connecting the receiver to the LNBF or LNB should be of the low loss type RG-6, quad shield RG-6 or RG-11, etc. RG-59 is not recommended for this application as it is not technically designed to carry frequencies above 950 MHz, but will work in many circumstances, depending on the quality of the coaxial wire.

Standards

Analog television distributed via satellite is usually sent scrambled or unscrambled in NTSC, PAL, or SECAM television broadcast standards. The analog signal is frequency modulated and is converted from an FM signal to what is referred to as baseband. This baseband comprises the video signal and the audio subcarrier(s). The audio subcarrier is further demodulated to provide a raw audio signal.

If the signal is a digitized television signal or multiplex of signals, it is typically QPSK.

In general, digital television, including that transmitted via satellites, are generally based on open standards such as MPEG and DVB-S or ISDB-S.

The conditional access encryption/scrambling methods include BISS, Conax, Digicipher, Irdeto, Nagravision, PowerVu, Viaccess, Videocipher, and VideoGuard. Many conditional access systems have been compromised.

Categories of usage

There are three primary types of satellite television usage: reception direct by the viewer, reception by local television affiliates, or reception by headends for distribution across terrestrial cable systems.

Direct to the viewer reception includes direct broadcast satellite or DBS and television receive-only or TVRO, both used for homes and businesses including hotels, etc.

Direct broadcast via satellite

Direct broadcast satellite, (DBS) also known as "Direct-To-Home" can either refer to the communications satellites themselves that deliver DBS service or the actual television service. DBS systems are commonly referred to as "mini-dish" systems. DBS uses the upper portion of the K_u band, as well as portions of the K_a band.

Modified DBS systems can also run on C-band satellites and have been used by some networks in the past to get around legislation by some countries against reception of K_u-band transmissions.

Most of the DBS systems use the DVB-S standard for transmission. With Pay-TV services, the datastream is encrypted and requires proprietary reception equipment. While the underlying reception technology is similar, the Pay-TV technology is proprietary, often consisting of a Conditional Access Module and smart card.

This measure assures satellite television providers that only authorised, paying subscribers have access to Pay TV content but at the same time can allow free-to-air (FTA) channels to be viewed even by the people with standard equipment (DBS receivers without the Conditional Access Modules) available in the market.

Television receive-only

The term Television receive-only, or TVRO, arose during the early days of satellite television reception to differentiate it from commercial satellite television uplink and downlink operations (transmit and receive). This was before there was a DTH satellite television broadcast industry. Satellite television channels at that time were intended to be used by cable television networks rather than received by home viewers. Satellite TV receiver systems were largely constructed by hobbyists and engineers. These TVRO systems operated mainly on the C band frequencies and the dishes required were large; typically over 3 meters (10 ft) in diameter. Consequently TVRO is often referred to as "big dish" or "Big Ugly Dish" (BUD) satellite television.

TVRO systems are designed to receive analog and digital satellite feeds of both television or audio from both C-band and K_u-band transponders on FSS-type satellites. The higher frequency K_u-band systems tend to be Direct To Home systems and can use a smaller dish antenna because of the higher power transmissions and greater antenna gain.

TVRO systems tend to use larger rather than smaller satellite dish antennas, since it is more likely that the owner of a TVRO system would have a C-band-only setup rather than a K_u band-only setup. Additional receiver boxes allow for different types of digital satellite signal reception, such as DVB/MPEG-2 and 4DTV.

The narrow beam width of a normal parabolic satellite antenna means it can only receive signals from a single satellite at a time. Simulsat or the Vertex-RSI TORUS, is a quasi-parabolic satellite earthstation antenna that is capable of receiving satellite transmissions from 35 or more C- and K_u-band satellites simultaneously.

Direct to Home television

Many satellite TV customers in developed television markets get their programming through a direct broadcast satellite (DBS) provider. The provider selects programs and broadcasts them to subscribers as a set package. Basically, the provider's goal is to bring dozens or even hundreds of channels to the customers television in a form that approximates the competition from Cable TV. Unlike earlier programming, the provider's broadcast is completely digital, which means it has high picture and stereo sound quality. Early satellite television services broadcast in C-band - radio in the 3.7 GigaHertz (GHz) to 4.2 GHz frequency range. Digital broadcast satellite transmits programming in the K_u frequency range (10 GHz to 14 GHz).

Programming sources are simply the channels that provide programming for broadcast. The provider (the DTH platform) doesn't create original programming itself. The broadcast center is the central hub of the system. At the broadcast center, the television provider receives signals from various programming sources, compresses these signals using digital compression (encryption if necessary), and sends a broadcast signal to the proper satellite.

Satellite television by region and country

Africa

South African-based Multichoice's DStv is the main digital satellite television provider in sub-Saharan Africa, broadcasting principally in English, but also in Portuguese, German and Afrikaans. Canal Horizons, owned by France's Canal+, is the main provider in French-speaking Africa. Another entrant into the satellite television circuit in Africa is MyTvAfrica, a subsidiary of Dubai based Strong Technologies. Satellite television has been far more successful in Africa than cable, primarily because the infrastructure for cable television does not exist and would be expensive to install since majority of Africans cannot afford paid cable television. Furthermore, maintaining a cable network is expensive due to the need to cover larger and more sparsely populated areas though there are some terrestrial pay-TV and MMDS services.

The launch of Free2view has made satellite TV available to the masses in Africa. Free2view currently broadcasts MSNBC as its exclusive news channel and is about to roll out additional channels.

GTV, a British-based company, has become the second in sub-saharan Africa providing digital satellite television with the focus first on Kenya Uganda, Tanzania, Zimbabwe, Congo ETC.

Nigeria

Traditionally DStv had held a monopoly over Nigeria's Satellite television sector but three new companies, HiTV, mytv and trend tv are starting to compete in this sector

Sudan

Sudan TV, the government-owned national network, is available by satellite as well as broadcast.

The Americas

United States

U.S. residential satellite TV receiver dishes

Currently, there are two primary satellite television providers of subscription based service available to United States consumers: DirecTV and Dish Network.

Over the past three decades, various U.S. satellite services have come and gone or combined to form the current primary services. In 1975 RCA created Satcom 1, the first satellite built especially for use by the then three national television networks (CBS, NBC, and ABC). Later that same year, HBO leased a transponder on Satcom 1 and began transmission of television programs via satellite to cable systems. Owners of cable systems paid $10,000 to install 3-meter dishes to receive TV signals in C-band. In 1976 Taylor Howard built an amateur system, which consisted of a converted military surplus radar dish and a satellite receiver designed and built by Howard, for home satellite reception. Taylor's system could be used for receiving TV programs both from American and Soviet communication satellites. In 1977 Pat Robertson launched the first satellite-delivered basic cable service called the CBN Cable Network. In 1979, the Satellite Home Viewers Act allowed homeowners in the US to own and operate their own home satellite system, consisting of C-band equipment from a multitude of manufacturers who were making parts for systems such as Taylor Howard's, and began a large controversy of which channels could be received by whom.

USSB was a direct-to-home service founded in 1981. In the early 1990s they partnered with Hughes and continued operation until purchased in 1998 by DirecTV.

In 1991 Primestar launched as the first North American DBS service. Hughes's DirecTV, the first national high-powered upper K_u-band DBS system, went online in 1994. The DirecTV system became the new delivery vehicle for USSB. In 1996, EchoStar's Dish Network went online in the United States and has gone on to similar success as DirecTV's primary competitor. The AlphaStar service launched in 1996 and went into bankruptcy in 1997. Dominion Video Satellite Inc's Sky Angel also went online in the United States in 1996 with its DBS service geared towards "faith and family". Primestar sold its assets to Hughes in 1999 and switched from DBS to an IPTV platform.

In 2004, Cablevision's Voom service went online, specifically catering to the emerging market of HDTV owners and aficionados, but folded in April 2005. The service's "exclusive" high-definition channels were migrated to the Dish Network system. Commercial DBS services are the primary competition to cable television service, although the two types of service have significantly different regulatory requirements (for example, cable television has public access requirements, and the two types of distribution have different regulations regarding carriage of local stations).

90cm multiple-LNA toroidal satellite dish

The majority of ethnic-language broadcasts in North America are carried on K_u band free-to-air. The largest concentration of ethnic programming is on Galaxy 19 at 97° W. Pittsburgh International Telecommunications and GlobeCast World TV offers a mix of free and pay-TV ethnic channels in the internationally-standard DVB-S format, as do others. Home2US Communications Inc. also offers several ethnic channels on AMC-4 at 101° W, as well as other free and pay-TV channels. Several U.S.-English language network affiliates (representing CBS, NBC, ABC, PBS, FOX, the CW (formerly the WB and UPN), ION Network and MyNetworkTV) are available as free-to-air broadcasts, as are the three U.S.-Spanish language networks (Univisión, Telefutura and Telemundo). The number of free-to-air specialty channels is otherwise rather limited. Specific FTA offerings tend to appear and disappear rather often and typically with little or no notice, although sites such as LyngSat do track the changing availability of both free and pay channels worldwide.

On October 7, 2009, NAB TV Board chair Paul Karpowicz planned to testify before the Senate Communications Subcommittee that broadcasters would be willing to allow subscribers of distant signals to continue to do so even if the digital transition resulted in those subscribers receiving stations that they could not before. The NAB did oppose offering new distant signals if a digital signal was available. The Satellite TV Modernization Act had to be passed by the end of 2009. The House bill also allowed Dish Network to offer distant signals. On November 5, Senate Judiciary Committee chairman Patrick Leahy said he hoped for a "short-time agreement" on the bill passed out of committee September 24. If the Senate approves, the House will have to approve the bill, and if the two versions cannot be reconciled, the license to import signals that expires at the end of the year could be extended. The House version included an agreement with Echostar that, where possible, all 210 markets could receive signals, and Echostar could once again deliver distant signals.

The Senate Commerce Committee approved a version of the bill on November 19, without an amendment requiring local signals in all markets in three years, though a study would be conducted on why 30 markets still had a problem. Before Senate approval, the two versions of the bill will have to be reconciled; the Judiciary Committee had a short market fix, while the Commerce committee bill required PBS in HD sooner.

The House approved the Satellite Home Viewer Reauthorization Act December 3. It included both the House Commerce Committee and House Judiciary Committee versions and renewed the ability to use distant signals for five years, allowed Dish Network to offer distant signals again, and required 28 markets to receive signals not available locally. The bill also dealt with some copyright issues and required Dish Network to offer HD noncommercial signals by 2011 instead of 2013.

One potential problem: determining who cannot receive a signal is still based on analog rather than digital TV.

On February 11, 2010, Senate Majority Leader Harry Reid said the satellite reauthorization was part of a jobs bill. Rick Boucher, House chairman for communications and the Internet, believed the bill would pass. The deadline is March, since it has been extended 60 days. Sen. Jim Bunning blocked the legislation in the Senate on Feb. 25, even though it passed the House. On March 1, 2010, The Satellite Television Extension and Localism Act of 2010, scheduled to expire in 2014, became part of a jobs bill with help from Sen. Patrick Leahy.

Canada

Currently, there are two primary satellite television providers of subscription based service available to Canadian consumers: Bell TV and Shaw Direct. The CRTC has refused to license American satellite services, but nonetheless hundreds of thousands (up to a million by some estimates) of Canadians access or have accessed American services — usually these services have to be billed to an American address and are paid for in U.S. dollars, although some viewers receive American signals through pirate decryption.

Whether such activity is grey market or black market is the source of often heated debate between those who would like greater choice and those who argue that the protection of Canadian firms and Canadian culture is more important. In October 2004, Quebec Judge Danièle Côté ruled Canada's Radiocommunication Act to be in direct violation of the Canadian Charter of Rights and Freedoms, insofar as it bans reception of unlicensed foreign television services. The judgment gave the federal government a one-year deadline to remedy this breach of the Constitution. However, this contradicts prior Supreme Court of Canada decisions and was overturned on appeal. A Supreme Court of Canada decision in the case of Bell ExpressVu v. Richard Rex, made on April 26, 2002, confirms that provisions in the Radiocommunication Act forbid the illegal decoding of satellite television programming. Canadian satellite providers continue to be plagued by the unquestionably black market devices which "pirate" or "steal" their signals as well as by a number of otherwise completely lawful devices which can be reprogrammed to receive pirate TV. Although there are no official statistics, the use of American satellite services in Canada appears to be declining as of 2004 Some would claim that this is probably due to a combination of increasingly aggressive police enforcement and an unfavourable exchange rate between the Canadian and U.S. currencies. As the U.S. dollar has been declining as of 2005 versus other international currencies, the decline in DirecTV viewership in Canada may well be related not to a cost difference as much as to the series of smart card swaps which have rendered the first three generations of DirecTV access cards (F, H and HU) all obsolete. Recently, Bell has begun to phase out satellite receivers in urban areas, replacing it with IPTV transmitted over regular telephone lines.

Latin America

Latin America's main satellite system are SKY Latin America, which has approximately 1.4 million subscribers in each of Brazil and Mexico and DirecTV Latin America, which provides service to the rest of the Americas, with a total of approximately 1.3 million subscribers. Pay-TV is not popular among Latin Americans because fees are expensive in PPP terms.

The service offered in Brazil includes Digital TV with full Dolby Digital surround support, mts and multiple subtitle options, a first for the Brazilian market. A recent update to Sky's services in Brazil is Sky+ which allows the customer to record a program while watching another one and also Sky HD which currently provides up to 29 high definition channels. Services are however relatively expensive, therefore market penetration is still limited.

Asia

Bangladesh

There are several satellite providers in Bangladesh. The main ones are listed below:

1. Bangla Vision
2. NTV

3. RTV
4. ATN Bangla
5. Channel I
6. Channel One
7. Kasturi
8. DD
9. Boishaki TV
10. ETV
11. Desh TV
12. Diganta Television
13. Islamic TV
14. STVUS

Kazakhstan

The first satellite TV channel in Kazakstan, CaspioNet, was launched by the Khabar news agency in 2002.

Malaysia

Astro's "mini-dish"

Malaysia's sole satellite television operator, Measat Broadcast Network Systems (a subsidiary of Astro All Asia Networks plc) launched Astro in 1996. It currently holds exclusive rights from the Malaysian government to offer satellite television broadcasting services in the country through the year 2017.

Mongolia

The Naran station (aka Orbit Station) is first satellite television in Mongolia. In 1991, Naran Station broadcast one channel, which is MNB. In 2005, Naran station extended the channel list up to 4 FTA channels. In 2010 they stopped television broadcast. Government has decided to allow private company does the service in 2008. DDishTV broadcast 18 channels, including 15 local channels and 3 foreign channels since 2008. DDishTV is the satellite television operator in Mongolia.

Japan

The medium-scale Broadcasting Satellite for Experimental Purposes (BSE) was planned by Ministry of Posts and Telecommunications (MOPT) and developed by the National Space Development Agency of Japan (NASDA) since 1974. After that, the first Japanese experimental broadcasting satellite, called BSE or Yuri, was launched in 1978. NHK started experimental broadcasting of TV program using BS-2a satellite on May, 1984. The satellite BS-2a was launched in preparation for the start of full scale 2-channel broadcasts. Broadcasting Satellite BS-2a was the first national DBS (direct broadcasting satellite), transmitting signals directly into the home of TV viewers. Attitude control of the satellite was conducted using the 3 axial method (zero momentum), and design life was 5 years. The TV transponder units are designed to sufficiently amplify transmitted signals to enable reception by small, 40 or 60 cm home-use parabolic antennas. The satellite was equipped with 3 TV transponders (including reserve units). However, one transponder malfunctioned 2 months after launch (March 23, 1984) and a second transponder malfunctioned 3 months after launch (May 3, 1984). So, the scheduled satellite broadcasting had to be hastily adjusted to test broadcasting on a single channel. Later, NHK started regular service (NTSC) and experimental HDTV broadcasting using BS-2b on June, 1989. Some Japanese producers of home electronic consumer devices began to deliver TVsets, VCRs and even home acoustic systems equipped by built-in satellite tuners or receivers. Such electronic goods had a specific *BS* logo. On April, 1991, Japanese company JSB started pay TV service while BS-3 communication satellite was in use. In 1996 total number of households that receive satellite broadcasting exceeded 10 million. The modern two satellite systems in use in Japan are BSAT and JCSAT; the modern WOWOW Broadcasting Satellite digital service uses BSAT satellites, while other system of digital TV broadcasting SKY PerfecTV! uses JCSAT satellites.

India

Over 300 TV Satellite television channels are broadcast in India. This includes channels from the state-owned Doordarshan, News Corporation owned STAR TV, Sony owned

Sony Entertainment Television, Sun Network and Zee TV. Direct To Home service is provided by DishTv, Airtel Digital Tv, Reliance BIG TV, DD Direct Plus, Videocon d2h, Sun Direct DTH and TataSky. Few of them have already satrted their premium HD services.

These services are provided by locally built satellites from ISRO such as INSAT 4CR, INSAT 4A, INSAT-2E, INSAT-3C and INSAT-3E as well as private satellites such as the Dutch-based SES, Global-owned NSS 6, Thaicom-2 and Telstar 10.

Pakistan

In the recent years, there has been a lot of investment in television industry in Pakistan. There are more than 90 Satellite channels operating directly inside Pakistan and about 40 operating their broadcasting from Dubai, Thailand, Bangkok and UK.

Philippines

- Dream Satellite TV is pay DTH service of Philippine Multimedia Service Inc. (PMSI)
- Cignal Digital TV is pay DTH service of Mediascape Inc.
- G Sat is pay DTH service of FUBC.

Thailand

TrueVisions is the leading pay TV service of Thailand which operate cable TV in Bangkok and satellite TV across the country. TrueVisions is owned by True Corporation. VIet Nam sat is just launched in 4/2008 and GMM Grammy is the second pay TV service of Thailand.

Oceania

Australia

Satellite television in Australia has proven to be a far more feasible option than cable television, due to the vast distances between population centres. The first service to come online in Australia was Galaxy, which was later taken over by Cable Television giant Foxtel, which now operates both cable and satellite services to all state capital cities (except Darwin and Hobart) and the whole of Western Australia. Its main metropolitan rival was Optus Vision, while rural areas are served by Austar, both of which just rebroadcast Foxtel as of 2005. In 2006 SelecTV began operating, aiming at providing comparatively low cost packages and catering to specialised market segments.

New Zealand

In New Zealand, SKY Network Television offers multichannel digital satellite TV, and once offered non-digital terrestrial UHF service which was shutdown progressivley during the first half of 2010. The newly released Freeview service is also available on the Optus D1 satellite, as well as a High Definition digital terrestrial service.

Europe

Continental Western Europe

In Europe, DBS satellite services are found mainly on Astra satellites and Hotbird (operated by Eutelsat.) BSkyB (known as Sky) serves the UK. SKY Italia, Canal Digitaal and UPC being the main providers in Italy, the Netherlands and Central Europe.

The overall market share of DBS satellite services in 2004 was 21.4% of all TV homes, however this highly varies from country to country. For example, in Germany, with many free-to-air TV-stations, DBS market share is almost 40%, and in Belgium and the Netherlands, it’s only about 7%, due to the widespread cable networks with exclusive content.

Russian Federation

The first Soviet communication satellite, called Molniya (Молния, or "Lightning"), was launched in 1965. By November, 1967 the national system of satellite television, called Orbita was deployed. The system consisted of 3 highly elliptical Molniya satellites, Moscow-based ground uplink facilities and about 20 downlink stations, located in cities and towns of remote regions of Siberia and Far East. Each station had a 12-meter receiving parabolic antenna and transmitters for re-broadcasting TV signal to local householders.

However, a large part of Soviet central regions were still not covered by transponders of Molniya satellites. By 1976 Soviet engineers developed a relatively simple and inexpensive system of satellite television (especially for Central and Northern Siberia). It included geostationary satellites called Ekran equipped with powerful 300 W UHF transponders, a broadcasting uplink station and various simple receiving stations located in various towns and villages of Siberian region. The typical receiving station, also called *Ekran*, represented itself as a home-use analog satellite receiver equipped with simple Yagi-Uda antenna. Later, Ekran satellites were replaced by more advanced Ekran-M series satellites.

In 1979 Soviet engineers developed *Moskva* (or Moscow) system of broadcasting and delivering of TV signal via satellites. New type of geostationary communication satellites, called Gorizont, were launched. They were equipped by powerful onboard transponders, so the size of receiving parabolic antennas of downlink stations was reduced to 4 and 2.5 meters (in comparison of early 12- meter dishes of standard orbital downlink stations).

By 1989 an improved version of *Moskva* system of satellite television has been called *Moskva Global'naya* (or Moscow Global). The system included a few geostationary

Gorizont and Express type of communication satellites. TV signal from Moscow Global's satellites could be received in any country of planet except Canada and North-West of the USA.

Modern Russian satellite broadcasting services based on powerful geostationary buses such as Gals, Express, Yamal and Eutelsat which provide a large quantity of free-to-air television channels to millions of householders. Pay-TV is growing in popularity amongst Russian TV viewers. The NTV Russia news company, owned by Gazprom, broadcasts the NTV Plus package to 560,000 households, reaching over 1.5 million viewers.

Tricolor TV (Russian: Триколор ТВ) the biggest satellite television operator. It broadcasts a pack of TV channels in the European part of Russia and most of Siberian, Ural and Far East regions. Broadcasting in the European part has been held since December 2005 from esv Eutelsat W4. Broadcasting in the Eastern regions began in December 2007.

The principle difference between Tricolor TV and other Russian salellite TV operators is a pack of free channels broadcasts by Tricolor TV. There are 12 federal channels including "Pervy", "Rossiya", "NTV", "STS", "Bibigon" and others in the free "Basic" pack. Except these, there are 19 more TV channels for the whole family. The budget pack of satellite channels turned to be very popular among Russian viewers. The number of Tricolor TV's subscribers is the largest in Russia. In December 2009 the audience of Tricolor TV has reached a number of 6 000 000 households.

United Kingdom and Ireland

Sky Digital "mini-dish"

The first commercial DBS service in the United Kingdom, Sky Television, was launched in 1989 and used the newly launched ASTRA satellite, providing 4 analogue TV channels. The channels and subsequent VideoCrypt video encryption system used the existing PAL broadcast standard. This gave Sky a distinct advantage over the winner of the UK state DBS licence, BSB.

In the following year, after many delays, BSB was launched, broadcasting five channels (Now, Galaxy, The Movie Channel, The Power Station and The Sports Channel) in D-MAC format and using the EuroCypher video encryption system which was based heavily on the General Instruments VideoCipher system used in the USA. While the BSB system was technologically more advanced than the PAL system and one of the main selling points of the BSB offering was the Squarial, an expensive flat plate antenna and LNB. Sky's system used conventional and cheap dish and LNB technology.

The competition between the two companies was fierce and bidding wars over the UK rights to movies. Sky kept costs to a bare minimum, operating from an industrial park in Isleworth in West London. BSB had expensive offices in London (Marco Polo House). The two services subsequently merged to form British Sky Broadcasting (BSkyB) though the new BSkyB was really Sky. The technologically more advanced BSB D-MAC/EuroCypher system was gradually replaced with Sky's VideoCrypt video encryption system.

In 1994 17% of the group was floated on the London Stock Exchange (with ADRs listed on the New York Stock Exchange), and Rupert Murdoch's News Corporation owns a 35% stake.

By 1999, following the launch of several more satellites (at 19.2°E by SES Astra), the number of channels had increased to around 60 and BSkyB launched the first subscription-based digital television platform in the UK, offering a range of 300 channels broadcast from the ASTRA satellites at 28.2°E under the brand name Sky Digital. BSkyB's analogue service was discontinued on 31 December 2001 and all customers have migrated to Sky Digital.

In May 2008, a free-to-air satellite service from the BBC and ITV was launched under the brand name Freesat, carrying a variety of channels, including some content in HD formats.

Nordic countries

The first satellite service specifically set to the Nordic region was TV3 which launched in 1987. With the launch of Astra 1A, getting the TV3 channel got easier. The first Nordic-specific satellite, Tele-X, was launched in 1989. The services directed at Scandinavia were then scattered among several satellites. In 1993, the former BSB satellites were bought by a Swedish and a Norwegian company, respectively. These two satellites were renamed Thor 1 and Sirius 1, moved to new positions and started broadcasting services intended for people in the Nordic region. With the launch of additional Thor and Sirius satellites later in the 1990s, Astra and other satellites were abandoned by the Nordic services with almost all Nordic satellite television migrating to the Sirius and Thor satellites.

Initially the basic channels were free-to-air. This caused several rights problems since viewers throughout Europe were able to see very much acquired English language programming as well as sports for free on the Nordic channels, although the channels only held broadcasting rights for specific countries. One way of avoiding that was to switch from PAL to the D2-MAC standard, hardly used anywhere outside the Nordic region. An unencrypted channel could still be seen in all the Nordic satellite homes, so eventually all channels went encrypted (several of them only being available in one country). There are two competing satellite services: Canal Digital (Norwegian Telenor) and Viasat (Kinnevik). Canal Digital launched in 1997 and was digital from the start, broadcasting from Thor. Kinnevik had been operating an analogue subscription service since the late 1980s, but waited until the year 2000 before launching a digital service. All analogue services from Thor and Sirius will have ceased in 2006, when the three remaining Danish channels go digital-only. The competition between Viasat and Canal Digital has caused some homes in Scandinavia to have to buy two set-top boxes and have two subscriptions to get the full range of channels. Viasat doesn't provide their own channels (TV3, TV3+, ZTV, TV1000 and the Viasat-branded channels) on the Canal Digital platform. Canal Digital does however have exclusive distribution of channels from SBS Broadcasting, Discovery, TV2 Denmark and Eurosport; for several years the Swedish SVT and TV4 channels were also exclusive to Canal Digital.

Middle East & North Africa

The Middle East has a high penetration of homes receiving TV channels via DTH satellite. One of the pioneers of free-to-air digital satellite television is considered to be MBC, which began broadcasting in c band through [Arabsat] and is the first network in the world to offer a free-to-air Western based English language movie channel to the Middle East audience via its spinoff channel MBC 2. Its direct rival is considered to be Dubai, UAE based One TV, earlier called Channel 33, which was the first channel in the Middle East to provide English language general entertainment programming for the expatriate community.

Nourmina Channel is the first satellite channel owned by a Jordanian national of the private sector, which broadcasts on Nile Sat reluctantly 12303H, which covers all the Arab countries, Africa and most parts of Europe - The first digital DTH pay-TV network to provide Indian Entertainment was Orbit Satellite Television and Radio Network broadcasting via Eurobird 2 (Ku band), later on Showtime Arabia a joint venture between Viacom (21% stake) and KIPCO (79% stake) started broadcasting, via PanAmSat (C band), but later switched over to Nilesat (KU band). Arab Radio and Television Network(ART) now known as Arab Digital Distribution although a late comer, gained ground by broadcasting exclusive sports events. Most of the popular channels are transmitting from these satellites and orbital positions: Arabsat at 26°E, AsiaSat at 100.5°E and 105.5°E, Eutelsat Hot Bird at 13°E, Nilesat at 7°W, and PanAmSat at 68.5°E. + Currently, there are two primary satellite television providers of subscription based service available to Canadians consumers: Bell TV and Shaw Direct.

In Israel, Satellite TV services were introduced by YES! company, using Israeli based Amos.

Chapter- 3

Fixed Service and Direct Broadcast Satellite

Fixed Service Satellite

Fixed Service Satellite (or **FSS**), is the official classification (used chiefly in North America) for geostationary communications satellites used for broadcast feeds for television and radio stations and networks, as well as for telephony and data communications.

FSS satellites have also been used for Direct-To-Home (DTH) satellite TV channels in North America since the late 1970s. This role has been mostly supplanted by direct broadcast satellite (DBS) television systems starting in 1994 when DirecTV launched the first DBS television system. However, FSS satellites in North America are also used to relay channels of cable tv networks from their originating studios to local cable headends and to the operations centers of DBS services (such as DirecTV and Dish Network) to be re-broadcast over their DBS systems.

FSS satellites were the first geosynchronous communications satellites launched in space (such as Intelsat 1 (Early Bird), Syncom 3, Anik 1, Westar 1, Satcom 1 and Ekran) and new ones are still being launched and utilized to this day.

FSS satellites operate in either the C band (from 3.7 to 4.2 GHz) or the FSS K_u bands (from 11.45 to 11.7 and 12.5 to 12.75 GHz in Europe, and 11.7 to 12.2 GHz in the United States).

FSS satellites operate at a lower power than DBS satellites, requiring a much larger dish than a DBS system, usually 3 to 8 feet (0.91 to 2.4 m) for K_u band, and 12 feet (3.7 m) or larger for C band (compared to 18 to 24 inches (460 to 610 mm) for DBS dishes). Also, unlike DBS satellites which use circular polarization on their transponders, FSS satellite transponders use linear polarization.

Systems used to receive television channels and other feeds from FSS satellites are usually referred to as TVRO (Television Receive Only) systems, as well as being referred to as big-dish systems (due to the much larger dish size compared to systems for DBS satellite reception), or, more pejoratively, BUD, or big ugly dish systems.

The Canadian Shaw Direct satellite TV service relies on FSS satellite technology in the K_u band. Primestar in the USA used K_u transponders on an FSS satellite as well for its delivery to subscribing households, until Primestar was acquired by DirecTV in 1999.

FSS and the rest of the world

The term of **Fixed Service Satellite** is chiefly a North American one, and is seldom used outside of the North American continent. This is because most satellites used for direct-to-home television in Europe, Asia, and elsewhere have the same high power output as DBS-class satellites in North America, but use the same linear polarization as FSS-class satellites.

Dish Network and FSS

The Dish Network satellite TV service also relies on FSS satellite technology in the K_u band to provide the necessary additional capacity to handle local channels required by FCC must-carry rules and make room for HDTV resolution. The old SuperDish system that Dish ceased manufacture of years ago, receives circularly-polarized DBS 12.7 GHz from both 110-degree (the Echostar 8 & 10 satellites) and 119-degree (the Echostar 7 satellite) orbital locations as well as linearly-polarized FSS 11.7 GHz from either the 121-degree (Echostar 9) or 105-degree (AMC 15) orbital locations depending on consumer choice. Those FSS satellites are no longer used for Dish Network home subscribers, and are now used exclusively for commercial or corporate services. Dish now uses the 118.7-degree (Anik-F3 -FSS) on their Dish 500+ and Dish 1000+ dishes. It has an oval LNB called a DP DBS/FSS Dual Band. This LNB will receive both the 119-degree and 118.7-degree satellites.

While the original Dish Network satellites use circular polarity at 12.7 GHz, the newer Intelsat 13/Echostar 9 satellite at 121-degrees uses the older FSS technology to broadcast commercial and corporate services. As a result, newer DiSH Network receivers are designed to receive both circular and linearly-polarized signals at two different intermediate frequencies from up to five different orbital locations.

The SuperDish had three low-noise block downconverters to accommodate the three satellites and two different technologies. SuperDish came in two configurations: SuperDiSH 121 was for international programming (but is now used exclusively for commercial and corporate services) and SuperDiSH 105 (also used today exclusively for commercial and corporate services) was used for high definition and for those customers in areas whose local channels are only available on the 105-degree satellite. As with other FSS technologies these signals are much lower power and as a result the SuperDISH is a very large and lopsided appendage. However, since the SuperDISH is under 1-meter in width it cannot be banned by homeowners' associations.

Direct-broadcast satellite

Direct broadcast satellite (DBS) is a term used to refer to satellite television broadcasts intended for home reception.

A designation broader than DBS would be **direct-to-home** signals, or DTH. This was initially meant to distinguish the transmissions directly intended for home viewers from cable television distribution services that sometimes carried on the same satellite. The term DTH predates DBS and is often used in reference to services carried by lower power satellites which required larger dishes (1.7m diameter or greater) for reception.

In Europe, prior to the launch of Astra 1A in 1988, the term DBS was commonly used to describe the nationally-commissioned satellites planned and launched to provide TV broadcasts to the home within several European countries (e.g. BSB in the UK, TV-Sat in Germany). These services were to use the D-Mac and D2-Mac format and BSS frequencies with circular polarization from orbital positions allocated to each country. Before these DBS satellites, home satellite television in Europe was limited to a few channels, really intended for cable distribution, and requiring dishes typically of 1.2m SES Astra launched the Astra 1A satellite to provide services to homes across Europe receivable on dishes of just 60 cm-80 cm and, although these mostly used PAL video format and FSS frequencies with linear polarization, the DBS name slowly came to applied to all Astra satellites and services too.

Terminology confusion

As a technical matter, DBS (also known by the International Telecommunications Union as Broadcasting Satellite Service, or BSS) refers only to services transmitted by satellite in specific frequency bands: 11.7-12.2 GHz in ITU Region 3 (Asia, Australia), 10.7 - 12.75 GHz in ITU Region 1 (Europe, Russia, Africa), and 12.2-12.7 GHz ITU Region 2 (North and South America). In 1977, the ITU adopted an international BSS Plan under which each country was allocated specific frequencies at specific orbital locations for domestic service. Over the years, this plan has been modified to, for example, accommodate new countries, increase coverage areas, and reflect digital (rather than analog) technology. At present, numerous countries have brought into use their BSS Plan allocations.

By contrast, DTH can apply to similar services transmitted over a wider range of frequencies (including standard K_u band and K_a band) transmitted from satellites that are not part of any internationally planned band. Nonetheless, the term DBS is often used interchangeably with DTH to cover both analog and digital video and audio services (including video-on-demand and interactive features) received by relatively small dishes (less than 1 meter). A "DBS service" usually refers to either a commercial service, or a group of free channels available from one orbital position targeting one country. In certain regions of the world, especially in North America, DBS is used to refer to providers of subscription satellite packages, and has become applied to the entire equipment chain involved.

Commercial DBS services

The second commercial DBS service, Sky Television plc (now BSkyB after its merger with British Satellite Broadcasting's five-channel network), was launched in 1989. Sky TV started as a four-channel free-to-air analogue service on the Astra 1A satellite, serving the United Kingdom and Republic of Ireland. By 1991, Sky had changed to a conditional access pay model, and launched a digital service, Sky Digital, in 1998, with analogue transmission ceasing in 2001. Since the DBS nomenclature is rarely used in the UK or Ireland, the popularity of Sky's service has caused the terms "minidish" and "digibox" to be applied to products other than Sky's hardware. BSkyB is controlled by News Corporation.

PrimeStar began transmitting an analog service to North America in 1991, and was joined by DirecTV (then owned by a division of General Motors, GM Hughes Electronics), in 1994. At the time, DirecTV's introduction was the most successful consumer electronics debut in American history. Although PrimeStar transitioned to a digital system in 1994, it was ultimately unable to compete with DirecTV, which required a smaller satellite dish and could deliver more programming. DirecTV purchased PrimeStar in 1999 and moved all PrimeStar subscribers to DirecTV equipment. In a series of transactions consummated in 2003, Hughes Electronics was spun out of GM and the News Corporation purchased a controlling interest in the new company, which was renamed The DIRECTV Group. In 2008, Liberty Media Corporation purchased News Corporation's controlling interest in DIRECTV.

In 1996, EchoStar's Dish Network went online in the United States and, as DirecTV's primary competitor, achieved similar success. AlphaStar also started but soon went under. Astro was also started, using a direct broadcast satellite system.

Dominion Video Satellite Inc.'s Sky Angel also went online in the United States in 1996 with its DBS service geared toward the faith and family market. It has since grown from six to 36 TV and radio channels of family entertainment, Christian-inspirational programming, and 24-hour news. Dominion, under its former corporate name Video Satellite Systems Inc., was actually the second from among the first nine companies to apply to the FCC for a high-power DBS license in 1981, and it is the sole surviving DBS pioneer from that first round of forward-thinking applicants. Sky Angel, although a separate and independent DBS service, uses the same satellites, transmission facilities, & receiving equipment used for Dish Network through an agreement with Echostar. Because of this, Sky Angel subscribers also have the option of subscribing to Dish Network's channels as well.

In 2003, EchoStar attempted to purchase DirecTV, but the FCC and U.S. Department of Justice denied the purchase based on anti-competitive concerns.

As of 2010, India has the most competitive Direct-broadcast satellite market with 7 operators vying for more than 110 million TV homes. India is set to overtake the USA as the world's largest Direct-broadcast satellite market by 2012. "Thinking blue sky", *Business Today*, July 21, 2010.

Free DBS services

By Jay Ar Decenella Germany is likely the leader in free-to-air (FTA) DBS, with approximately 40 analogue and 100 digital channels broadcast from the SES Astra 1 position at 19.2E. These are not marketed as a DBS service, but are received in approximately 12 million homes, as well as in any home using the German commercial DBS system, *Sky Deutschland*.

The United Kingdom has approximately 160 digital channels (including the regional variations of BBC and ITV channels) broadcasting without encryption from the Astra 28.2°E satellite position, and receivable on any DVB-compliant receiver. Most of these channels are included within the Sky Digital EPG, and an increasing number within the Freesat EPG. They include a handful of FTA HDTV channels.

India's national broadcaster, Doordarshan, promotes a free-to-air DBS package as "DD Direct Plus", which is provided as in-fill for the country's terrestrial transmission network. It is broadcasted from Insat 4B at 91.5°E and contains about 100 FTA channels.

While originally launched as backhaul for their digital terrestrial television service, a large number of French channels are free-to-air on 5W, and have recently been announced as being official in-fill for the DTT network.

In North America (USA, Canada and Mexico) there are over 80 FTA digital channels available on Galaxy 19. (The majority of them are ethnic or religious.) Other popular FTA satellites include AMC-4, AMC-6, Galaxy 18, and Satmex 5. A company called GloryStar promotes FTA religious broadcasters on G-19 and AMC-4.

Chapter- 4

Satellite Radio

Satellite radio is an analogue or digital radio signal that is relayed through one or more satellites and thus can be received in a much wider geographical area than terrestrial FM radio stations. While in Europe many primarily-FM radio stations provide an additional unencrypted satellite feed, there are also subscription based digital packages of numerous channels that do not broadcast terrestrially, notably in the US. In Europe, FM radio is used by many suppliers that use a network of several local FM repeaters to broadcast a single programme to a large area, usually a whole nation. Many of those have an additional satellite signal that can be heard in many parts of the continent. In contrast, US terrestrial stations are always local and each of them has a unique programme, albeit they are sometimes interconnected for syndicated contents; but each local station still carries its own commercial and news breaks even then. This means that a national distribution of the contents of original terrestrial stations via satellite makes no real sense in the US, wherefore satellite radio is used in a different way there.

Mobile services, such as Sirius, XM, and Worldspace, allow listeners to roam across an entire continent, listening to the same audio programming anywhere they go. Other services, such as Music Choice or Muzak's satellite-delivered content, require a fixed-location receiver and a dish antenna. In all cases, the antenna must have a clear view to the satellites. In areas where tall buildings, bridges, or even parking garages obscure the signal, repeaters can be placed to make the signal available to listeners.

Radio services are usually provided by commercial ventures and are subscription-based. The various services are proprietary signals, requiring specialized hardware for decoding and playback. Providers usually carry a variety of news, weather, sports, and music channels, with the music channels generally being commercial-free.

In areas with a relatively high population density, it is easier and less expensive to reach the bulk of the population with terrestrial broadcasts. Thus in the UK and some other countries, the contemporary evolution of radio services is focused on Digital Audio Broadcasting (DAB) services or HD Radio, rather than satellite radio.

Business applications

Satellite radio, particularly in the United States, has become a major provider of background music to businesses such as hotels, retail chains, and restaurants. Compared to old-line competitors such as Muzak, satellite radio's significantly lower price, commercial-free channel variety, and more reliable technology make it a very attractive option. Both North American satellite radio providers offer business subscriptions, though given the merger of XM Satellite Radio with Sirius, the future of XM for Business is uncertain. Sirius's commercial services are provided nationally by third-party partner Applied Media Technologies Corporation.

System design

Satellite radio uses the 2.3 GHz S band in North America and generally shares the 1.4 GHz L band with local Digital Audio Broadcasting (DAB) stations elsewhere. It is a type of direct broadcast satellite and is strong enough that it requires no satellite dish to receive. Curvature of the earth limits the reach of the signal, but due to the high orbit of the satellites, two or three are usually sufficient to provide coverage for an entire continent.

Local repeaters similar to broadcast translator boosters enable signals to be available even if the view of the satellite is blocked, for example, by skyscrapers in a large town. Major tunnels can also have repeaters. This method also allows local programming to be transmitted such as traffic and weather in most major metropolitan areas, as of March 2004.

Each receiver has an Electronic Serial Number (ESN) Radio ID to identify it. When a unit is activated with a subscription, an authorization code is sent in the digital stream telling the receiver to allow access to the blocked channels. Most services have at least one "free to air" or "in the clear" (ITC) channel as a test. For example, Sirius uses channel 184, Sirius Weather & Emergency.

Most (if not all) of the systems in use now are proprietary, using different codecs for audio data compression, different modulation techniques, and/or different methods for encryption and conditional access.

Like other radio services, satellite radio also transmits program-associated data (PAD or metadata), with the artist and title of each song or program and possibly the name of the channel.

Satellite radio vs. other formats

Satellite radio differs from AM or FM radio and digital television radio (or DTR) in the following ways. The table applies primarily to the United States.

Radio format	Satellite radio	AM/FM	Digital television radio (DTR)
Monthly fees	US$6.95 and up	None	Very low — DTR represents a small portion of the total monthly television fee.
Portability	Available	Prominent	None — a typical set consists of a stereo attached to a television set-top box (the primary function of the set top-box is normally designed for cable or satellite television viewing).
Listening availability	Very high — a satellite signal's footprint covers millions of square kilometres.	Low to moderate — implementation of FM service requires moderate to high population densities and is thus not practical in rural and/or remote locales; AM travels great distances at night.	Very high
Sound quality	Varies[2]	AM: Usually very low, but can be the highest FM: Usually Moderate, but can be very high	Varies[2]
Variety and depth of programming	Highest	Variable — highly dependent upon economic/demographic factors	Variable - dependent on the television provider and the various packages they provide and on the user's subscription.
Frequency of programming interruptions (by DJs or commercial advertising)[3]	None to high - mostly dependent on the channels, some of which have DJs; most channels are advertisement-free because of the paid subscription model	Highest[4]	None to low - dependent on the provider; however, it is common that some stations will have DJs. Usually no advertisements (DirecTV and Dish Network both claim

	of satellite radio.		to provide advertisement-free content).
Governmental regulation	Yes[5]	Yes — significant governmental regulations regarding content[6]	Low to none [5]

[2] The sound quality with both satellite radio providers and DTR providers varies with each channel. Some channels have near CD-quality audio, and others use low-bandwidth audio suitable only for speech. Since only a certain amount of bandwidth is available within the licenses available, adding more channels means that the quality on some channels must be reduced. Both the frequency response and the dynamic range of satellite channels can be superior to most, but not all AM or FM radio stations, as most AM and FM stations clip the audio peaks to sound louder; even the worst channels are still superior to most AM radios, but a very few AM tuners are equal to or better than the best FM or satellite broadcasts when tuned to a local station, even if not capable of stereo. AM does not suffer from multipath distortion or flutter in a moving vehicle like FM, nor does it become silent as you go behind a big hill like satellite radio.

[3] Some satellite radio services and DTR services act as *in situ* repeaters for local AM/FM stations and thus feature a high frequency of interruption.

[4] Nonprofit stations and public radio networks such as CBC/Radio-Canada, NPR, and PRI-affiliated stations and the BBC are commercial-free. In the US, all stations are required to have periodic station identifications and public service announcements.

[5] In the United States, the FCC regulates technical broadcast spectrum only. Program content is unregulated. However, the FCC has tried in the past to expand its reach to regulate content to satellite radio and cable television, and its options are still open to attempt such in the future. The FCC does issue licenses to both satellite radio providers (XM and Sirius) and controls who holds these licenses to broadcast.

[6] Degree of content regulation varies by country; however, the majority of industrialized nations have regulations regarding obscene and/or objectionable content.

Portable Satellite Radio

Portable satellite radios let you listen to satellite radio just about anywhere you go. They are very similar to standard portable music players, designed for music on the go. These however, feature built-in antennas that receive the satellite signal, and come with rechargeable batteries. In fact, all you have to do is plug in headphones, and you can easily listen to and carry them around easily. Reception can be tricky however, being blocked by buildings and tall trees, and sometimes by your own body depending you the way you are facing and how you are carrying it. However, the best reception will be received outdoors in the open.

United States

In the United States and Canada, one holding company, Sirius XM Radio, operates the two satellite radio services, after a merger (technically the acquisition of XM by Sirius) in July 2008. A monthly fee is charged for both services (as of 2005, Sirius also offers a one-time fee of nearly $500 valid for the lifetime of the equipment; however, there is a $70.00 USD fee for switching receiver, and this may be done only three times ever). Some XM music channels have commercials, while Sirius is commercial-free. Both services have commercial-free music stations, as well as talk and news stations, some of which include commercials. XM uses fixed-location geostationary satellites in two positions, and Sirius uses three geosynchronous satellites in highly elliptical orbits passing over North and South America, to transmit the digital streams. The net difference is that the Sirius signal comes from a higher elevation angle in the northern part of the U.S. and even more so in Canada. (This higher angle makes Sirius' signal less likely to drop out on cities, but more likely to drop out in parking garages, gas stations, tunnels, and other covered spaces.)

Both services are available mainly via portable receivers in automobiles, but both have many accessories so one can listen at home through a home stereo, with a portable boombox, or online through a personal computer. Both services now have some form of receiver that is completely portable.

Satellite radio's chief asset is the fact that it is not localized: drivers can receive the same programming anywhere in the footprint of the service. A stop at any truck stop will demonstrate the popularity of Sirius XM among long-haul drivers. In addition, both XM and Sirius carry programming that is simply not feasible on commercial radio stations. Specialty stations cover things such as family talk, radio drama, classical music, and live events.

The footprint of both Sirius and XM is only the United States (not including Alaska), Canada, and the upper third of Mexico; it does not cover Hawaii as satellite TV does.

Success so far

As of July 29, 2008 Sirius XM claims over 18.5 million subscribers. One critical factor for the success of satellite radio is the deployment of in-car receivers. Sirius XM has attempted to convince automakers to equip vehicles with their receiver. As of 2008, the following manufacturers offer satellite radio as original equipment:

Provider	BMW MINI Rolls-	Chrysler Dodge Mercedes-Benz	Ford Lincoln Mercury Volvo	GM Cadillac Chevrolet Buick	Honda Acura	Hyundai Kia	Mitsubishi	Nissan Infiniti	Porsche	Toyota Lexus Scion	VW Audi Bentley	Suzuki

	Royce	Jeep	Land Rover Jaguar Mazda	Pontiac GMC Saturn Saab								
Sirius	Yes	Yes	Yes	No	No	Yes	Yes	?	No	Yes	Yes	No
XM	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes

Sirius has an exclusive contract for VW and Audi vehicles from 2007 through 2012. Those brands previously offered both services. GM, Honda and Suzuki are all major investors in XM; Sirius is not offered as options in their vehicles. Bentley and Rolls-Royce come not only with receivers but lifetime subscriptions for Sirius service as well. XM is featured in select Harley-Davidson motorcycle models, while Sirius can be heard in several brands of recreational vehicles and boats.

One of the challenges for satellite radio has been to move away from cars and into the homes of consumers. Several portable satellite radio receivers have been made for this purpose. XM satellite radio has developed the XM2go line of "Walkman-like" portable receivers, such as the Delphi MyFi, the Pioneer AirWare and Giant International's Tao. Polk Audio makes a component-style home XM Reference Tuner and a tabletop entertainment system, the I-Sonic, with XM capability. Sirius has developed the Kenwood Portable Satellite Radio Tuner, Sirius S50, Here2Anywhere and the Sirius Stiletto 100. The Pioneer Inno and Samsung Helix for XM were among the first portable receivers to offer the ability of recording live content for playback later. Thus allowing for satellite radio to compete more fully with MP3 players.

While key agreements with automobile manufacturers are still being made, both companies have made the leap away from satellite radio only in the car and into the homes of consumers. One bump in the road to becoming more widely used in the home was both Sirius and XM running into legal issues in early 2006 with the FCC about their internal FM Transmitters. This required Sirius and XM to pull several of their models off the shelf and fix the problem. The FCC was claiming that the emissions of the internal FM Transmitters were too powerful and needed to be lowered. With these changes any customer buying a new satellite radio receiver doesn't achieve nearly the broadcast distance as the old models. Since this is a key point in the ability to use a satellite radio in the home (i.e. by taking the signal received and then broadcasting it to multiple points throughout the home at the same time and avoid having to bring the satellite radio with them as they move around the home) it has led many subscribers to use an external Personal FM transmitter like the Whole House FM Transmitter, C. Crane Company, Griffin Technology, etc. to replace the lower powered internal FM Transmitter. Since these external FM Transmitters are Part 15 compliant they can broadcast the signal further than the new internal FM Transmitters now included in the satellite radios and still be legal. These external FM transmitters may prevent a slow down in the progress already made into the home consumer market for Sirius and XM satellite radio.

Satellite radio technology was inducted into the Space Foundation Space Technology Hall of Fame in 2002.

Canada

On November 1, 2004, the Canadian Radio-television and Telecommunications Commission (CRTC) began hearing applications for Canada's first satellite radio operations. Three applications were filed: one by Standard Broadcasting and the CBC in partnership with Sirius, one by Canadian Satellite Radio in partnership with XM, and one at the last minute by CHUM Limited and Astral Media.

The first two would use the same systems already set up for the U.S., while CHUM's application was for a subscription radio service delivered through existing terrestrial DAB transmitters rather than directly by satellite (although satellites would be used to deliver programming to the transmitters). The CHUM service is all-Canadian; the other two applications propose to offer a mix of Canadian-produced channels and existing channels from their American partner services.

A small "grey market" already exists for Sirius and XM receivers in Canada in which a Canadian would have an American order their receiver and setup.

On June 16, 2005, the CRTC approved all three services.

In its decision, the CRTC required the following conditions from the satellite radio licensees:

- A minimum of eight channels must be produced in Canada, and for each Canadian channel, nine foreign channels can be broadcast.
- At least 85% of the content on the Canadian-produced channels (whether musical or spoken word) must be Canadian.
- At least 25% of the Canadian channels must be French-language stations.
- At least 25% of the music aired on the Canadian channels must be new Canadian music.
- At least 25% of the music played on the Canadian channels must be from up-and-coming Canadian artists.

These conditions were an extension of the existing Canadian content rules applicable to all broadcasters in Canada. The applicants had until 13 November 2005, to notify the CRTC of their decision. Both companies managed to negotiate the standards a little to their favor, and in return, they would instead play 50% French content as opposed to 25%. Also, XM Canada succeeded in getting an extra five channels of National Hockey League Play-by-Play onto their platform, without an additional channel creation, by agreeing to cover every Canadian team's game during the season.

CHUM appealed the decision, claiming they would not survive if Sirius and XM both were allowed in the Canadian market, and that the licence conditions regarding Canadian content imposed on Canadian Satellite Radio and Sirius Canada were too lax. Canadian Satellite Radio and Sirius Canada countered that CHUM was simply trying to create a monopoly in the Canadian market.

In late August 2005, Heritage Minister Liza Frulla asked the Federal Cabinet to review the CRTC decision and possibly send it back to the CRTC for further review. Lobbyists complained that the CRTC decision did not require enough Canadian content from the broadcasters. The broadcasters responded by promising to add additional Canadian and French content.

After vigorous lobbying from both sides, the federal cabinet officially accepted the CRTC decision on September 10, 2005.

XM satellite radio was launched in Canada on November 29, 2005. Sirius followed later on December 1, 2005. Monthly subscription rates are $12.99 for XM (85 channels) with a one-time activation fee of $19.99 and $14.99 for Sirius with a one-time activation fee of $19.99 (100 channels). (All prices are in Canadian dollars.) The CHUM/Astral service never launched, and its license expired on June 16, 2007.

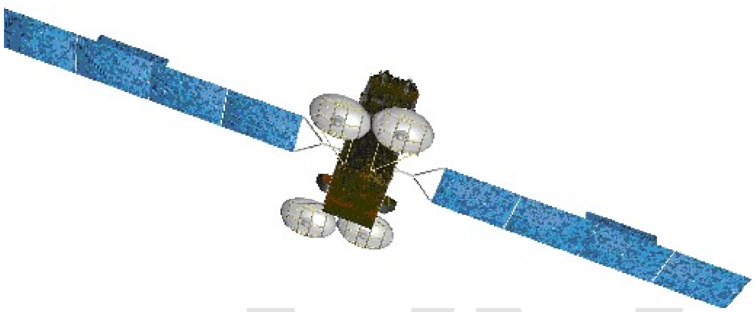
Europe

Eutelsat W2A satellite carrying a Solaris Mobile (an Eutelsat and SES Astra joint venture) DVB-SH S band payload was launched on 3 April 2009.

WorldSpace Europe () and ONDAS Media () will use ETSI SDR for their new networks covering Europe.

Chapter- 5

Satellite Internet Access



Medium	Air or Vacuum
License	ITU
Maximum download rate	1 Gbps
Maximum upload rate	10 Mbps
Average download rate	1 Mbps
Average upload rate	256 Kbps
Latency (one-way)	Up to 900 ms
Frequency bands	L, C, Ku, Ka
Coverage	100 - 6,000km
Additional services	VoIP, SDTV, HDTV, VOD, Datacast
Average CPE price	€300 (modem + satellite dish)

Satellite Internet access is Internet access provided through satellites. The service can be provided to users world-wide through Low Earth Orbit (LEO) satellites. Geostationary satellites can offer higher data speeds, but their signals can not reach some polar regions of the world. Different types of satellite systems have a wide range of different features and technical limitations, which can greatly affect their usefulness and performance in specific applications.

Mechanics and limitations of satellite communication

Signal latency

Satellite Internet access via VSAT in Ghana

Latency is the delay between requesting data and the receipt of a response, or in the case of one-way communication, between the actual moment of a signal's broadcast and the time received at its destination. Compared to ground-based communication, all geostationary satellite communications experience high latency due to the signal having to travel 35,786 km (22,236 mi) to a satellite in geostationary orbit and back to Earth again. Even at the speed of light (about 300,000 km/s or 186,000 miles per second), this delay can be significant. If all other signaling delays could be eliminated it still takes a radio signal about 250 milliseconds, or about a quarter of a second, to travel to the satellite and back to the ground. For an internet packet, that delay is doubled before a reply is received. That is the theoretical minimum. Factoring in other normal delays from network sources gives a typical one-way connection latency of 500–700 ms from the user to the ISP, or about 1,000–1,400 milliseconds latency for the total Round Trip Time (RTT) back to the user. This is far worse than most dial-up modem users' experience, at typically only 150–200 ms total latency.

This latency makes Satellite Internet service essentially unusable for applications requiring real-time user input, such as online games or remote surgery. This delay can also be irritating with interactive applications, such as VoIP, videoconferencing, or other person to person communication. The functionality of live interactive access to a distant computer can also be subject to the problems caused by high latency. However these problems are more than tolerable for basic email access and web browsing, and in most cases are barely noticeable.

For geostationary satellites there is no way to eliminate latency, but the problem can be somewhat mitigated in Internet communications with TCP acceleration features that shorten the round trip time (RTT) per packet by splitting the feedback loop between the sender and the receiver. Such acceleration features are usually present in recent technology developments embedded in new satellite Internet services.

Medium Earth Orbit (MEO) and Low Earth Orbit (LEO) satellites do not have such great delays. The current LEO constellations of Globalstar and Iridium satellites have delays of less than 40 ms round trip, but their throughput is less than broadband at 64 kbit/s per channel. The Globalstar constellation orbits 1,420 km above the earth and Iridium orbits at 670 km altitude. The proposed O3b Networks MEO constellation scheduled for deployment in 2010 would orbit at 8,062 km, with RTT latency of approximately 125 ms. The proposed new network is also designed for much higher throughput with links well in excess of 1 Gbps (Gigabits per second).

A proposed alternative to geostationary relay satellites is a special-purpose solar-powered ultralight aircraft, which would fly along a circular path above a fixed ground location, operating under autonomous computer control at a height of approximately 20,000 meters. Onboard batteries would be charged during daylight hours by solar panels covering the wings, and would provide power to the plane during night. Ground-based satellite dishes would relay signals to and from the aircraft, resulting in a greatly reduced round-trip signal latency of only 0.25 milliseconds. The planes could then run forever without refueling. Several such schemes involving various types of aircraft have been proposed in the past.

Rain fade

A foldable Bigpond Satellite Internet dish

Satellite communications are affected by moisture and various forms of precipitation (such as rain or snow) in the signal path between end users or ground stations and the satellite being utilized. The effects are less pronounced on the lower frequency 'L' and 'C' bands, but can become quite severe on the higher frequency 'Ku' and 'Ka' band. For satellite Internet services in tropical areas with heavy rain, use of the C band (4/6 GHz) with a circular polarisation satellite is popular. Satellite communications on the Ka band (19/29 GHz) can use special techniques such as large *rain margins*, *adaptive uplink power control* and *reduced bit rates* during precipitation.

"Rain margins" are the extra communication link requirements needed to account for signal degradations due to moisture and precipitation, and are of acute importance on all systems operating at frequencies over 10 GHz.

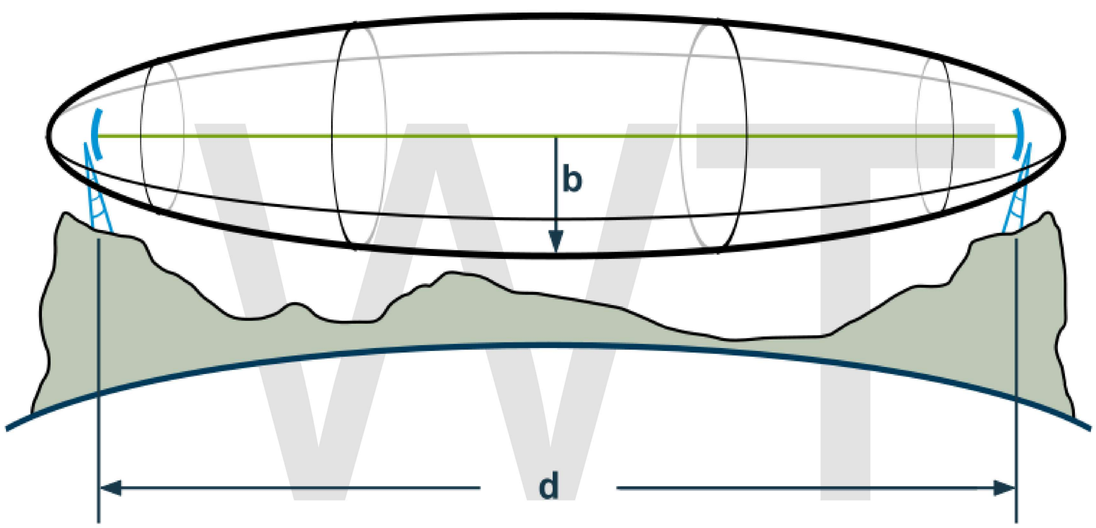
The amount of time during which service is lost can be reduced by increasing the size of the satellite communication dish so as to gather more of the satellite signal on the downlink and also to produce a more intense transmission on the uplink.

Modern consumer-grade dish antennas tend to be fairly small, which reduces the rain margin or increases the required satellite downlink power and cost.

Large commercial dishes of 3.7m to 13m diameter are used to achieve large rain margins and also to reduce the cost per bit by requiring far less power from the satellite.

Modern download DVB-S2 carriers, with RCS feedback, are intended to allow the modulation method to be dynamically altered, in response to rain problems at a receive site. This allows the bit rates to be increased substantially during normal clear sky conditions, thus reducing overall costs per bit.

Line of sight



Fresnel zone. d is the distance between the transmitter and the receiver, b is the radius of the Fresnel zone.

Typically a completely clear line of sight between the dish and the satellite is required for the system to work. In addition to the signal being susceptible to absorption and scattering by moisture, the signal is similarly impacted by the presence of trees and other vegetation in the path of the signal. As the radio frequency decreases, to below 900 MHz, penetration through vegetation increases, but most satellite communications operate above 2 GHz making them sensitive to even minor obstructions such as tree foliage. A dish installation in the winter must factor in plant foliage growth that will appear in the spring and summer.

Fresnel zone

The radio signal width between two ground satellite dish receivers is not perfectly straight and uniform, as if it were a beam of light. Instead as the signal propagates away from the transmitting dish, it widens towards the centerpoint between the two dishes and then narrows again as it approaches the receiving dish. This is known as the fresnel zone, and limits the usefulness of satellite dishes in locations where there is extremely limited open sky for signal reception. The signal path through space must be clear not only for direct line of sight, but must also be clear for the expanding fresnel zone, which may be several meters larger in diameter than the ground-based satellite dish.

Two-way satellite-only communication

The back panel of a satellite modem, with coaxial connections for both incoming and outgoing signals, and an Ethernet port for connection to the internal network.

Two-way satellite Internet service involves both sending and receiving data from the remote VSAT site via satellite to a hub teleport, which then relays data via the terrestrial Internet. The satellite dish at each location must be precisely pointed to avoid interference with other satellites. Some providers oblige the customer to pay for a member of the provider's staff to install the system and correctly align the dish—although the European ASTRA2Connect system encourages user-installation and provides detailed instructions for this. Many customers in the Middle East and Africa are also encouraged to do self installs. At each VSAT site the uplink frequency, bit rate and power must be accurately set, under control of the service provider hub.

There are several types of two way satellite Internet services, including time division multiple access (TDMA) and single channel per carrier (SCPC). Two-way systems can be simple VSAT terminals with a 60–100 cm dish and output power of only a few watts intended for consumers and small business or larger systems which provide more bandwidth. Such systems are frequently marketed as "satellite broadband" and can cost two to three times as much per month as land-based systems such as ADSL. The modems required for this service are often proprietary, but some are compatible with several different providers. They are also expensive, costing in the range of US$600 to $2000.

The two-way "iLNB" used on the ASTRA2Connect

The two-way "iLNB" used on the ASTRA2Connect terminal dish has a 500 mW transmitter and single-polarity receive LNB, both operating in the Ku band. Pricing for Astra2Connect modems range from 299 to 350€. These types of system are generally unsuitable for use on moving vehicles, although some dishes may be fitted to an automatic pan and tilt mechanism to continuously re-align the dish—but these are cumbersome and very expensive. The technology for ASTRA2Connect was delivered by a Belgian company called Newtec.

The Tooway satellite modem

Bandwidth

Satellite internet customers range from individual home users with one PC to large remote business sites with several hundred PCs.

Home users tend to make use of shared satellite capacity, to reduce the cost, while still allowing high peak bit rates when congestion is absent. There are usually restrictive time based bandwidth allowances so that each user gets their fair share, according to their payment. When a user exceeds their Mbytes allowances, the company may slow down their access, deprioritise their traffic or charge for the excess bandwidth used. For consumer satellite internet, the allowance can range from 200 MB per day to 17,000 MB per month. A shared download carrier may have a bit rate of 1 to 40 Mbit/s and be shared by up to 100 to 4000 end users. Note that the average bit rate per end user PC is only about 10 - 20kbit/s.

The uplink direction for shared user customers is normally TDMA, which involves transmitting occasional short packet bursts in between other users (similar to how a cellphone shares a cell tower)

Business users tend to opt for dedicated bandwidth services where any congestion is under their local control.

Each remote location may also be equipped with a telephone modem; the connections for this are as with a conventional dial-up ISP. Two-way satellite systems may sometimes use the modem channel in both directions for data where latency is more important than bandwidth, reserving the satellite channel for download data where bandwidth is more important than latency, such as for file transfers.

In 2006 the European Commission sponsored the UNIC project which aims at developing an end-to-end scientific test bed for the distribution of new broadband interactive TV-centric services delivered over low-cost two-way satellite to actual end-users in the home. The UNIC architecture employs DVB-S2 standard for downlink and DVB-RCS standard for uplink.

Normal VSAT dishes (1.2 - 2.4m dia) are widely used for VoIP phone services. A voice call is sent by means of packets via the satellite and internet. Using coding and compression techniques the bit rate needed per call is only 10.8 kbit/s each way.

Portable satellite Internet

Portable satellite modem

These usually come in the shape of a self-contained flat rectangular box that needs to be pointed in the general direction of the satellite—unlike VSAT the alignment need not be very precise and the modems have built in signal strength meters to help the user align the device properly. The modems have commonly used connectors such as Ethernet or Universal serial bus. Some also have an integrated Bluetooth transceiver and double as a satellite phone. The modems also tend to have their own batteries so they can be connected to a laptop without draining its battery. The most common such system is INMARSAT's BGAN—these terminals are about the size of a briefcase and have near-symmetric connection speeds of around 350–500 kbit/s. Smaller modems exist like those offered by Thuraya but only connect at 144 kbit/s in a limited coverage area.

Using such a modem is extremely expensive—bandwidth costs between $5 and $7 per megabyte. The modems themselves are also expensive, usually costing between $1000 and $5000.

Internet via satellite phone

For many years now satellite phones have been able to connect to the internet. Bandwidth varies from about 2400 bit/s for Iridium network satellites and ACeS based phones to 15 kbit/s upstream and 60 kbit/s downstream for Thuraya handsets. Globalstar also provides internet access at 9600 bit/s—like Iridium and ACeS a dial-up connection is required and is billed per minute, however both Globalstar and Iridium are planning to launch new satellites offering always-on data services at higher speeds. With Thuraya phones the 9600 bit/s dial-up connection is also possible, the 60 kbit/s service is always-on and the user is billed for data transferred (about $5 per megabyte). The phones can be connected to a laptop or other computer using a USB or RS-232 interface. Due to the low bandwidths involved it is extremely slow to browse the web with such a connection, but useful for sending email, Secure Shell data and using other low-bandwidth protocols.

Since satellite phones tend to have omnidirectional antennas no alignment is required as long as there is a line of sight between the phone and the satellite.

One-way receive, with terrestrial transmit

One-way terrestrial return satellite Internet systems are used with traditional dial-up access to the Internet, with outbound data traveling through a telephone modem, but downloads sent via satellite at a speed near that of broadband Internet access. In the U.S., an FCC license is required for the uplink station only; no license is required for the users.

Another type of 1-way satellite internet system involves the use of General Packet Radio Service (GPRS) for the back-channel. By utilizing a connection that is offered in standard GPRS or EDGE, the upload volume is very low and since this service is not per-time charged, but charged by volume uploaded, users are able to surf and download in broadband speeds. Another view of using GPRS as return would be the mobility when the service is provided by a satellite that transmits in the field of 50 to 53 dBW. Using a 33 cm wide satellite dish, a notebook and a normal GPRS equipped GSM phone, users can get mobile satellite broadband.

System hardware components

The transmitting station (also called "teleport", "head end", "uplink facility", or "hub") has two components:

- Internet connection: The ISP's routers connect to proxy servers which can enforce quality of service (QoS) bandwidth limits and guarantees for user traffic. These are then connected to a DVB encapsulator which is then connected to a DVB-S modulator. The radio frequency (RF) signal from the DVB-S modulator is connected to an up converter which is connected via feed line to the outdoor unit.
- Satellite uplink: The block upconverter (BUC) and optional low-noise block converter (LNB), which may use a waveguide to connect to the optional orthomode transducer (OMT) which is bolted to the feed horn which is connected by metal supports to the satellite dish and mount.

At the remote location (Earth station) the setup consists of:

- Outdoor unit
  - Satellite dish with mount
  - Feedhorn
  - Universal LNB, for Ku-band.
  - Feed line
- Indoor unit
  - DVB-S Peripheral Component Interconnect (PCI) card internal to a computer
  - or, DVB external modem where an 8P8C (RJ-45) Ethernet port or a Universal Serial Bus (USB) port connects the modem to the computer

System software components

Remote sites require a minimum of programming to provide authentication and set proxy server settings. Filtering is usually provided by the DVB card driver.

Often, non-standard IP stacks are used to address the latency and asymmetry problems of the satellite connection. Data sent over the satellite link is generally also encrypted, as otherwise it would be accessible to anyone with a satellite receiver.

Many IP-over-satellite implementations use paired proxy servers at both endpoints so that certain communications between clients and servers do not need to accept the latency inherent in a satellite connection. For similar reasons, there exist special Virtual private network (VPN) implementations designed for use over satellite links because standard VPN software cannot handle the long packet travel times.

Upload speeds are limited by the user's dial-up modem, and latency is high, as it is for any satellite based Internet (minimum of 240 ms one-way, resulting in a minimum round-trip time of almost 500ms). Download speeds can be very fast compared to dial-up.

Theory of operation

Remote sites use proxy server or(and) Virtual private network servers at the earth station (teleport), which is configured to route all outbound traffic to the QoS server, which makes sure no user exceeds their allotted bandwidth or monthly traffic limits. Traffic is then sent to the encapsulator, which puts the IP packets inside of DVB packets. The DVB packets are then sent to the DVB modem and then to the transmitter (BUC).

One-way multicast, receive only

One-way multicast satellite Internet systems are used for Internet Protocol (IP) multicast-based data, audio and video distribution. In the U.S., a Federal Communications Commission (FCC) license is required only for the uplink station and no license is required for users. Note that most Internet protocols will not work correctly over one-way access, since they require a return channel. However, Internet content such as web pages can still be distributed over a one-way system by "pushing" them out to local storage at end user sites, though full interactivity is not possible. This is much like TV or radio content which offers little user interface.

System hardware components

Similar to one-way terrestrial return, satellite Internet access may include interfaces to the public switched telephone network for squawk box applications. An Internet connection is not required, but many applications include a File Transfer Protocol (FTP) server to queue data for broadcast.

System software components

Most one-way multicast applications require custom programming at the remote sites. The software at the remote site must filter, store, present a selection interface to and display the data. The software at the transmitting station must provide access control, priority queuing, sending, and encapsulating of the data.

Efficiency increases

Reducing satellite latency

Much of the slowdown associated with satellite Internet is that for each request, many roundtrips must be completed before any useful data can be received by the requester. Special IP stacks and proxies can also reduce latency through lessening the number of roundtrips, or simplifying and reducing the length of protocol headers. These types of technologies are generally referred to as TCP acceleration, HTTP pre-fetching and DNS caching.

Elimination of advertising materials

While also effective for terrestrial communications, the use of ad-blocking software such as Adblock for Firefox is exceptionally beneficial for satellite Internet, as most Internet advertising websites use cache busting in order to render the browser and ISP's cache useless, by displaying advertisements (for the purpose of maximizing the number of ad views seen by the affiliate marketing company's server).

List of communications satellite firsts

Early milestones in the history of communications satellites.

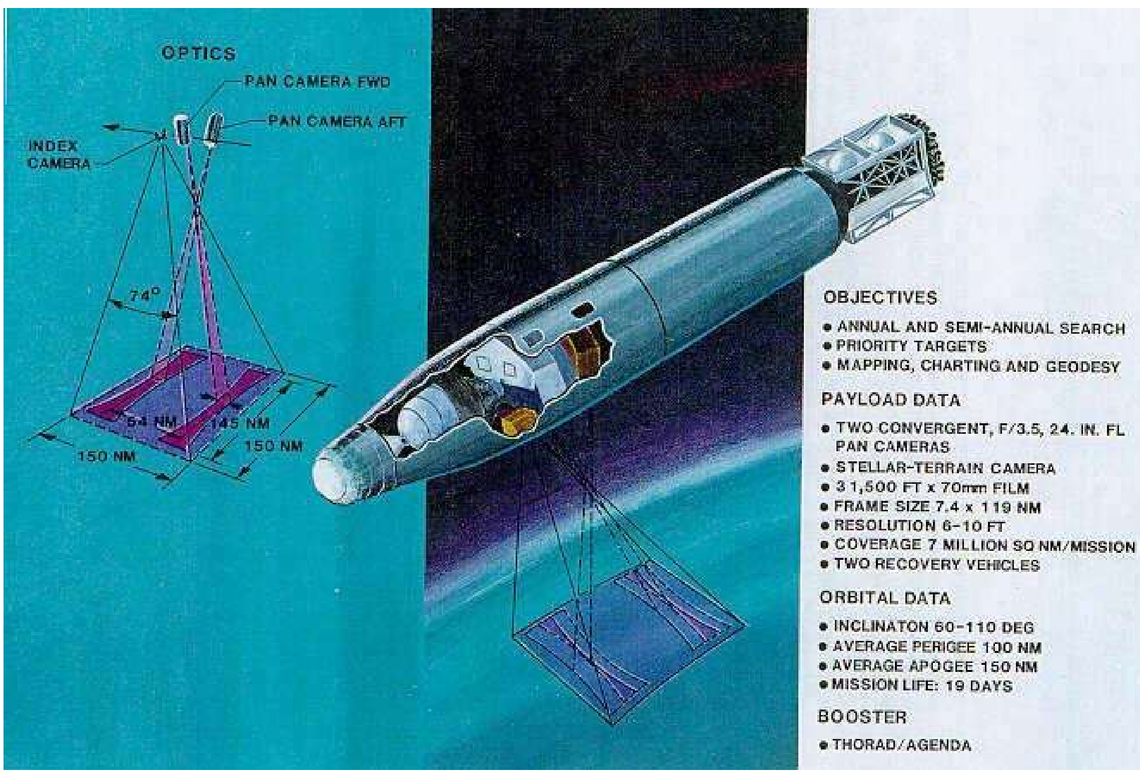
Satellite	First	Launched
Sputnik 1	First satellite equipped with radio transmitters	October 4, 1957
Project SCORE	First communications satellite	1958
Echo I	First passive reflector satellite	August 1960
Courier 1B	First active repeater satellite	October 1960
Telstar	First satellite designed to transmit television and high-speed data communications; first transatlantic television	July 1962

Relay 1	First transpacific television (news of JFK assassination and funeral procession); first tandem satellite broadcast (with Syncom 3)	December 1962
Syncom 2	First communications satellite in geosynchronous orbit	July 1963
Syncom 3	First communications satellite in geostationary orbit; first Olympic broadcast to international audiences; first tandem satellite broadcast (with Relay 1)	August 1964
OSCAR-III	First amateur radio communications satellite (relay/transponder) powered by solar cells	March 1965
Molniya	First Soviet communication satellite, highly elliptic orbit	October 1965
Early Bird	INTELSAT's first satellite for commercial service	April 1965
Orbita	First national TV network based on satellite television (Soviet Union)	November 1967
Anik 1	First domestic communications satellite system using geosynchronous orbit (Canada)	November 9, 1972
Westar 1	USA's first commercial geostationary communications satellite	April 1974
Symphonie	First geostationary communications satellite to be three-axis stabilized	19 December 1974
Aryabhata	First Indian satellite	19 April 1975
Ekran	First serial Direct-To-Home TV communication satellite	1976
Palapa A1	First Indonesian communications satellite	July 8 1976
TDRSS	First satellite designed to provide communications relay services for other spacecraft	1983
Arabsat-1A	First communications satellite for the Arab League	2 February 1985
Turksat 1B	First communications satellite for Turkey	10 August 1994

Chapter- 6

Types and Applications of Communications Satellites

Spy satellite



KH-4B Corona satellite

U.S. Lacrosse radar spy satellite under construction

A model of a German SAR-Lupe reconnaissance satellite inside a Cosmos-3M rocket

A **spy satellite** (officially referred to as a **reconnaissance satellite**) is an Earth observation satellite or communications satellite deployed for military or intelligence applications.

These are essentially space telescopes that are pointed toward the Earth instead of toward the stars. The first generation type (i.e. Corona and Zenit) took photographs, then ejected canisters of photographic film, which would descend to earth.

Corona capsules were retrieved in mid-air as they floated down on parachutes. Later spacecraft had digital imaging systems and downloaded the images via encrypted radio links.

In the United States, most information available is on programs that existed up to 1972. Some information about programs prior to that time are still classified, and a small trickle of information is available on subsequent missions.

A few up-to-date reconnaissance satellite images have been declassified on occasion, or leaked, as in the case of KH-11 photographs which were sent to *Jane's Defence Weekly* in 1985.

Origins

On March 16, 1955, the United States Air Force officially ordered the development of an advanced reconnaissance satellite to provide continuous surveillance of 'preselected areas of the earth' in order 'to determine the status of a potential enemy's war-making capability'. In October 1957, the Russians launched Sputnik. It was the first man made object to be put into Earth orbit.

Missions

Examples of reconnaissance satellite missions:

- High resolution photography (IMINT)
- Measurement and Signature Intelligence (MASINT)
- Communications eavesdropping (SIGINT)
- Covert communications
- Monitoring of nuclear test ban compliance
- Detection of missile launches

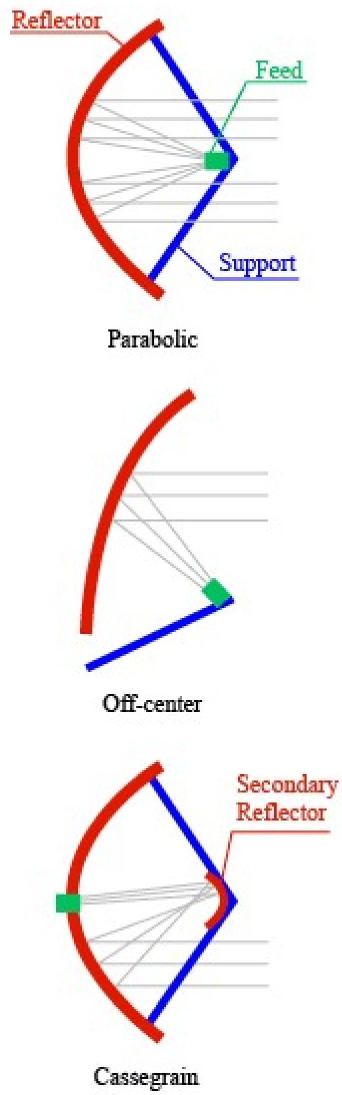
Satellite dish

A C band satellite dish

A mobile satellite dish used by TVNZ news reporters

A **satellite dish** is a dish-shaped type of parabolic antenna designed to receive microwaves from communications satellites, which transmit data transmissions or broadcasts, such as satellite television.

Principle of operation



Schematics of reflection principles used in dish receptors

The parabolic shape of a dish reflects the signal to the dish’s focal point. Mounted on brackets at the dish's focal point is a device called a feedhorn. This feedhorn is essentially the front-end of a waveguide that gathers the signals at or near the focal point and 'conducts' them to a low-noise block downconverter or LNB. The LNB converts the signals from electromagnetic or radio waves to electrical signals and shifts the signals from the downlinked C-band and/or K_u-band to the L-band range. Direct broadcast satellite dishes use an LNBF, which integrates the feedhorn with the LNB. (A new form of omnidirectional satellite antenna, which does not use a directed parabolic dish and can be used on a mobile platform such as a vehicle was announced by the University of Waterloo in 2004.

The theoretical gain (directive gain) of a dish increases as the frequency increases. The actual gain depends on many factors including surface finish, accuracy of shape, feedhorn matching. A typical value for a consumer type 60 cm satellite dish at 11.75 GHz is 37.50 dB.

With lower frequencies, C-band for example, dish designers have a wider choice of materials. The large size of dish required for lower frequencies led to the dishes being constructed from metal mesh on a metal framework. At higher frequencies, mesh type designs are rarer though some designs have used a solid dish with perforations.

A common misconception is that the LNBF (low-noise block/feedhorn), the device at the front of the dish, receives the signal directly from the atmosphere. For instance, one BBC News countdown shows a "red data stream" being received by the LNBF directly instead of being beamed to the dish, which because of its parabolic shape will collect the signal into a smaller area and deliver it to the LNBF.

Modern dishes intended for home television use are generally 43 cm (18 in) to 80 cm (31 in) in diameter, and are fixed in one position, for Ku-band reception from one orbital position. Prior to the existence of direct broadcast satellite services, home users would generally have a motorised C-band dish of up to 3 metres in diameter for reception of channels from different satellites. Overly small dishes can still cause problems, however, including rain fade and interference from adjacent satellites.

Europe

In Europe the frequencies used by DBS services are 10.7 - 12.75 GHz on two polarisations H (horizontal) and V (vertical). This range is divided into a "low band" with 10.7 - 11.7 GHz, and a "high band" with 11.7 - 12.75 GHz. This results in two frequency bands, each with a bandwidth of about 1 GHz, each with two possible polarizations. In the LNB they become down converted to 950 - 2150 MHz, which is the frequency range allocated for the satellite service on the coaxial cable between LNBF and receiver. Lower frequencies are allocated to cable and terrestrial TV, FM radio, etc. Only one of these frequency bands fits on the coaxial cable, so each of these bands needs a separate cable from the LNBF to a switching matrix or the receiver needs to select one of the 4 possibilities at a time.

Systems design

In a single receiver residential installation there is a single cable from receiver to LNB and the receiver uses different power supply voltages (14/18V) to select polarization and pilot tones (22 kHz) to instruct the LNB to select one of the two frequency bands. In larger installations each band and polarization is given its own cable, so there are 4 cables from the LNB to a switching matrix, which allows the connection of multiple receivers in a star topology using the same signalling method as in a single receiver installation.

Types

Motor-driven dish

A dish that is mounted on a pole and driven by a stepper motor or a servo can be controlled and rotated to face any satellite position in the sky. Motor-driven dishes are popular with enthusiasts. There are three competing standards: DiSEqC, USALS, and 36v positioners. Many receivers support all of these standards.

Multi-satellite

Special dish for up to 16 satellite positions (K_u-band)

Some designs enable simultaneous reception from multiple different satellite positions without re-positioning the dish. The vertical axis operates as an off-axis concave parabolic concave hyperbolic Cassegrain reflector, while the horizontal axis operates as a concave convex Cassegrain. The spot from the main dish wanders across the secondary, which corrects astigmatism by its varying curvature. The elliptic aperture of the primary is designed to fit the deformed illumination by the horns. Due to double spill-over, this makes more sense for a large dish.

VSAT

A common type of dish is the very small aperture terminal (VSAT). This provides two way satellite internet communications for both consumers and private networks for organisations. Today most VSATs operate in K_u band; C band is restricted to less populated regions of the world. There is a move which started in 2005 towards new K_a band satellites operating at higher frequencies, offering greater performance at lower cost. These antennas vary from 74 to 120 cm (29 to 47 in) in most applications though C-band VSATs may be as large as 4 m (13 ft).

Others

U.S. residential satellite TV receiver dishes

- Individual dishes serving one dwelling: Direct to Home (DTH).
- Collective dishes, shared by several dwellings: satellite master antenna television (SMATV) or communal antenna broadcast distribution (CABD).
- Automatic Tracking Satellite Dish
- Big ugly dish

Ad hoc

The dish is a reflector antenna and almost anything that reflects radio frequencies can be used as a reflector antenna. This has led to dustbin lids, woks and other items being used as "dishes". Coupled with low noise LNBs and the higher transmission power of DTH satellites, it is easier to get a usable signal on some of these "dishes".

Milstar

Milstar

Artist's impression of a Milstar-DFS spacecraft

General Information

Manufacturer	Lockheed Martin (prime) TRW Boeing (formerly Hughes)

Country of Origin	United States
Bus	Milstar Block I Milstar Block II
Applications	Military communications
Orbit regimes	Geosynchronous
Operator	US Air Force
Lifetime	10 years
Production	
Status	Out of production Active
Built	6
Launched	6
Operational	5
Lost	1
First launch	USA-99, 1994-02-07
Last launch	USA-169, 2003-04-08
Typical spacecraft	
Average mass	4,500 kg (9,900 lb)

Miltar, originally meaning **Military Strategic and Tactical Relay**, is a constellation of communications satellites in geostationary orbit, which are operated by the United States Air Force, and provide secure and jam resistant worldwide communications to meet the requirements of the Armed Forces of the United States. Six spacecraft were launched between 1994 and 2003, of which five are operational, and the sixth was lost in a launch failure.

History

The first Milstar satellite was launched on 7 February 1994 aboard the first Titan IV(401)A rocket. It as followed by a second spacecraft on 7 November 1995. The first two satellites were Block I spacecraft, also known as Milstar Development Flight Satellites, or Milstar-DFS. The four later satellites were Block II spacecraft, which featured an additional medium data-rate payload. The first Block II satellite was launched on 30 April 1999, using a Titan IV(401)B rocket. Due to a programming error affecting the Centaur upper stage of its carrier rocket, it was placed into an lower orbit than had been planned, and it could not be raised into its operational orbit. It was the third consecutive, and last, failure of a Titan IV rocket. The remaining three satellites were launched on 27 February 2001, 15 January 2002, and 8 April 2003.

The Milstar system consists of three segments; the space segment which consists of the five satellites, ground terminals and users, and stations to command and control the satellites. The Military Satellite Communications Systems Wing (MILSATCOM) division of the United States Air Force Space Command Space and Missile Systems Center, located at Los Angeles AFB was responsible for development and acquisition of the Milstar space and mission control segments. The Electronic Systems Center at Hanscom AFB is responsible for the US Air Force portion of the terminal segment development and acquisition. The 4th Space Operations Squadron at Schriever AFB and the 148th Space Operations Squadron at Vandenberg AFB are responsible for providing real-time satellite control and communications payload management.

In August 2010 control of the Milstar system was transferred to the Advanced Extremely High Frequency programme, in preparation for the launch of the first AEHF satellite, USA-214. Advanced Extremely High Frequency satellites are intended to replace Milstar.

Characteristics

Milstar satellites provide secure, jam resistant, worldwide communications to meet the requirements of the United States military. They were built by Lockheed Martin Missiles and Space Corporation, at a cost of US$800 million each. Each satellite has a design life of 10 years. Six were built, of which five successfully reached their operational geostationary orbits, and remain in service. Launches were made using Titan IV rockets with Centaur upper stages, and all six occurred from Space Launch Complex 40 at the Cape Canaveral Air Force Station. The satellites are designed to provide communications which are hard to detect and intercept, and to be survivable in the event of nuclear warfare.

The spacecraft have a mass of 4,500 kilograms (9,900 lb), and are equipped with solar panels which generate eight kilowatts of electric power to power its transponders. Both Block I and Block II satellites provide low data-rate communications at bandwidths between 75 bit/sec and 2,400 bit/sec, whilst the Block II spacecraft can also provide medium data-rate communications between 4.8 kbit/sec and 1.544 Mbit/sec. The satellites' uplinks operate in the Q band, whilst their downlinks operate within the Ka band. Both of these frequencies correspond to the super high frequency radio band.

Each Milstar satellite serves as a switchboard to direct traffic between terminals on the Earth. The satellites process the signals transmitted to them, and can link with other Milstar satellites through crosslinks, to reduce the requirement for ground-controlled switching. The spacecraft are used for encrypted voice, data, teletype, and facsimile communications, which are interoperable between the United States Army, Navy, Air Force, Marine Corps, and Coast Guard.

Spacecraft

Name	Block	Launch date/time (UTC)	COSPAR ID	Rocket	Remarks
USA-99	Block I	1994-02-07, 21:47:01	1994-009A	Titan IV(401)A	
USA-115	Block I	1995-11-06, 05:15:01	1995-060A	Titan IV(401)A	
USA-143	Block II	1999-04-30, 16:30:00	1999-023A	Titan IV(401)B	Launch failure
USA-157	Block II	2001-02-27, 21:20	2001-009A	Titan IV(401)B	
USA-164	Block II	2002-01-16, 00:30:00	2002-001A	Titan IV(401)B	
USA-169	Block II	2003-04-08, 13:43:00	2003-012A	Titan IV(401)B	

List of communication satellite companies

This is a list of all companies currently operating at least one commercial communication satellite or currently has one on order.

International

- Horizons
- RASCOM

Africa

Egypt — Nilesat

Nigeria — NASRDA

Asia and Oceania

Australia — SingTel Optus

People's Republic of China

- Chinasat
- ChinaStar

Europe

France

- Eutelsat
- France Télécom
- Stellat
- Télédiffusion de France

Germany

- Deutsche Telekom
- OHB System

Greece — Hellas-Sat

Luxembourg — SES

North America

Bermuda

- Intelsat

Canada

- Ciel Satellite Group (Ciel-2)
- Telesat

Mexico — Satmex

United States

- AirTV
- Astrolink

- Sinosat

Hong Kong

- APT Satellite Holdings Limited
- AsiaSat

India

- Agrani
- ISRO/Antrix (INSAT)
- ISRO/DECU (EDUSAT・GSAT)

Indonesia

- PT Datakom
- PT Pasifik Satelit Nusantara
- PT Telkom

Iran — Iranian Space Agency

Israel — Spacecom

Japan

- Broadcasting Satellite System Corporation
- NTT DoCoMo
- SKY Perfect JSAT Corporation

Kazakhstan — JSC KazSat

South Korea — KT

Malaysia

- Binariang Sdn. Bhd. (MEASAT)

Pakistan — Pakistan

Astra

Netherlands — SES World Skies

Norway — Telenor

Russia

- Russian Satellite Communication Company
- Gaskom
- Global Information Systems
- Intersputnik
- Media Most (Bonum)

Spain

- Hisdesat
- Hispasat

Sweden — Nordiska Satellitaktiebolaget

Turkey

- Eurasiasat SAM
- Turksat

United Kingdom

- ICO Satellite Management
- Inmarsat

- DirecTV
- EchoStar
- Globalstar
- Hughes Network Systems (Spaceway)
- Iridium Satellite LLC
- Loral Skynet
- Orbcomm
- PanAmSat
- SkyTerra
- Spacenet
- Sirius Satellite Radio
- Teledesic
- TerreStar
- 1worldspace
- WildBlue
- XM Satellite Radio
- XTAR

South America

Argentina

- AprizeSat (LatinSat)
- Nahuelsat

Venezuela

- Ministry of Science and Technology of Venezuela (Venesat-1)

Brazil

- Star One
- INPE

Space and Upper Atmosphere Research Commission (SUPARCO)

Philippines — Mabuhay

Saudi Arabia — Arabsat

Singapore — Singapore Telecommunications

Taiwan — Chunghwa Telecom

Thailand — Thaicom/formerly Shin Satellite

Tonga — TONGASAT

United Arab Emirates

- Thuraya
- YahSat

Vietnam — VNPT (VINASAT)