SATELLITE PRINCIPLES

The Orbital Revolution

The Beginnings

The idea of communications satellites in geostationary orbit was first published by Arthur C Clarke in the 1940s. As the technology developed over the next decades, it became possible to fulfil his dream and today there are hundreds of satellites around the world broadcasting services to millions of people.

Consumer reception equipment is explored in specific sections later. This section looks at the principles which make satellite TV possible.

TV Studio

Naturally, all this assumes broadcasters creating TV channels for transmission.

Uplink

The signals from the broadcasters need to be sent up to the satellite.

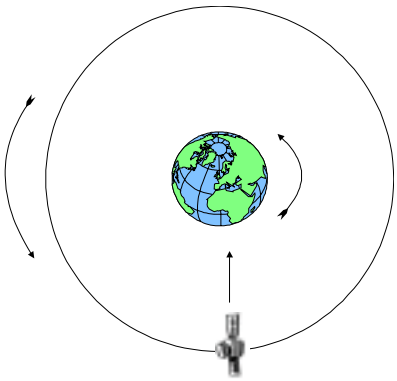
Geostationary Satellite

The satellite receives the signals uplinked by broadcasters and retransmits them to Earth.

Geostationary

Objects, such as satellites, can orbit the Earth at any distance. This distance - the height of the orbit - dictates the speed at which they circle the Earth.

A satellite flying just over 22,000 miles high (~36,000 km) takes 24 hours for each orbit. Since the Earth also takes 24 hours to rotate once, such a satellite appears, from the ground, to be hanging stationary in the sky. This orbit is known as “geostationary” and has two important benefits.



Coverage

Signals from the satellite can be received over a very large portion of the Earth’s surface. For EUTELSAT’s HOT BIRD™ satellites, this area - the “Footprint” - extends far beyond Europe.

Receivable on a Fixed Dish

Since the satellite appears not to move, signals can be received on an inexpensive fixed dish.

Why use Satellites?

Building, launching and controlling satellites is extremely expensive and needs the very latest technology in transmission and reception equipment. It’s reasonable to ask why broadcasters did not just stick to the tried and tested terrestrial broadcasting methods.

There are two basic limitations to terrestrial transmission:

1 - Line-of-Sight

Radio waves such as those used to transmit TV can generally only travel in straight lines. Aerials which are below the horizon of the transmitter cannot receive its signals. The limit is a few tens of miles depending on the height of the transmitting and receiving aerials.

This means that to cover the UK, terrestrial broadcasters need to build and operate a network of hundreds of transmitters all over the country.

2 - Frequency Use

The use of frequencies is controlled by international agreements and governments. Blocks of frequencies are allocated for different purposes such as taxis, mobile phones and, of course, radio and TV.

There is, therefore, a limit on the number of frequencies which can be used for terrestrial TV. In the case of the UK this results in a maximum of five TV channels.

Satellite Versus Terrestrial

As technology has developed it has become possible to use much higher frequencies - in the Gigahertz (GHz) band as opposed to the Megahertz (MHz) band used for terrestrial TV. Enough frequencies were allocated to satellite TV to accommodate up to 100 analogue channels from a single satellite position.

Just like terrestrial transmissions, satellites operate on line-of-sight. But since they are up in orbit, a single satellite can “see” - and transmit to - the whole of Europe.

The development of satellite TV, therefore, allowed broadcasters to use a brand new transmission system and block of frequencies to deliver a whole new world of choice to hundreds of millions of customers.

The Transmission System

A Broadcaster

Broadcasters create their channels from a variety of sources: live studios, outside broadcasts, making their own programmes, buying-in programmes, films, adverts and much more. These different items are put into a running order in a central studio which also converts the live channel feed to the correct technical format for onward transmission and adds any extra services such as teletext, alternative soundtracks or radio stations to the signal.

A Signal

There are a number of analogue TV transmission standards in use throughout Europe: PAL, PAL+, SECAM, D2-MAC and others. EUTELSAT satellites can transmit in any standard that the broadcaster chooses. The satellite receiver must use the same standard and also output the signal in the right standard for the customer's TV/VCR.

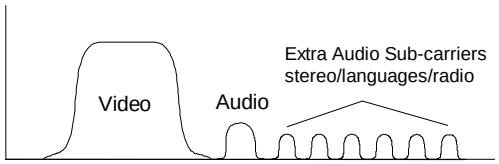
Most analogue transmissions intended for the UK and Eire use the PAL standard. Hence, so do most receivers. Specialist receivers which use different standards for reception and output are available.

Satellite FM Versus Terrestrial AM

Satellite TV signals are Frequency Modulated - FM - as opposed to terrestrial TV's system of Amplitude Modulation - AM. This has two major advantages:

- Picture Quality. FM signals are less prone to multi-path interference which gives rise to the "ghosting" on terrestrial TV. FM is also less susceptible to other forms of interference and has a better noise performance than AM. This means that a correctly set-up satellite system should deliver better quality pictures than terrestrial TV.
- Extra Bandwidth. The satellite FM signal has a wider bandwidth than the terrestrial AM signal. This gives extra room for added services such as the extra audio sub-carriers.

These can be for a number of services including alternative language soundtracks, stereo sound and radio.



Other satellite TV standards include the now largely defunct D-MAC system which was used some years ago by BSB. D2-MAC is still used by a number of satellite channels because its Conditional Access (CA) system - Eurocrypt - is the most common, non-proprietary analogue CA system available today.

The new European standard for digital TV - DVB MPEG-2 - is covered later, in the digital section.

An Uplink

The uplink station receives the channel from the broadcaster and converts it into the correct frequency band for transmission to the

satellite. Uplink stations can receive multiple channels and combine them to be uplinked to the same satellite on a single dish. Other services can also be added at this stage.

The signal is amplified and fed, via wave-guides, to the transmitter on the uplink dish which is pointed at the satellite.

A Control System

Satellites in orbit can drift slightly from their required position. An operations centre monitors this and, by firing on-board thrusters, keeps the satellite on-station. All the satellite's on-board electronics and systems are also monitored and controlled from the centre, which does not have to be on the same site as the uplink.

The TV signals are continually monitored at both the uplink and operations centre to ensure the best possible quality for viewers.

An Orbital Position

Before launching a satellite, an orbital position must be allocated to it. Because there is only one geostationary orbit - also known as the Clarke Belt in honour of the originator of the concept - there is a limit to the number of satellites which can occupy it.

These positions are referred to by the longitude of the spot on the Earth directly below them: for example, 13 Degrees East which is directly over the Gulf of Guinea.

The positions are allocated to countries by international agreements through bodies such as the ITU (International Telecommunication Union).

As the largest satellite operator in Europe, EUTELSAT uses several orbital positions for a variety of services. The most important one for

satellite TV is 13 degrees East - the HOT BIRD™ position. There are currently five EUTELSAT satellites in this position, with the HOT BIRD™ 5 satellite replacing EUTELSAT II-F1 after its launch on October 9 1998.

Frequency Bands

Frequencies are similarly co-ordinated to ensure a high quality of service by avoiding potential interference with any terrestrial services and other satellites.

The frequencies used by EUTELSAT at the HOT BIRD™ position are between 10.70 GHz and 12.75 GHz (Ku band).

A Satellite

A typical satellite used for TV broadcasting weighs 3 to 4 tonnes. Its solar panels, which power all the on-board electronics, give it a wing-span of about 20 metres. It carries a supply of fuel to power the thrusters which keep it stabilised and in the correct position.

It acts as a “mirror” in space by: receiving the uplinked signals via its antennas, amplifying them and retransmitting them to Earth.

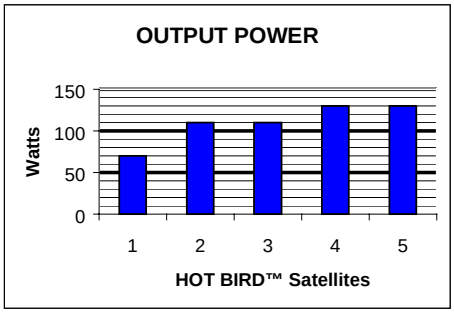
The shape of the satellite’s antennas dictates the shape of the footprint and signal power received on Earth. A tight beam gives a high signal level over a smaller area while a wide beam gives wider coverage with lower power.

It can transmit many TV channels depending on how many transponders it carries.

A Transponder

EUTELSAT's HOT BIRD™ satellites have between 16 - 22 operational transponders each. Each transponder receives, amplifies and frequency-converts an incoming signal for retransmission.

The bandwidth of transponders is designed to be suitable for the signals it carries. Typically, one 33 MHz transponder can be used for one analogue TV channel. EUTELSAT also uses other "sizes" of transponder - up to 72 MHz - for added flexibility. With EUTELSAT's Simulcast technique, a 36 MHz transponder can carry both a digital channel and a 27 MHz analogue channel.



The power received on the ground depends on the shape of the satellite's dish and on the power of the on-board amplifiers (TWTAs - Travelling Wave Tube Amplifiers).

Co-location

The lifting power of the launcher limits the size and mass of the satellite that can be sent into orbit. This limits the number of transponders which can be carried and hence the number of channels which can be transmitted. Currently this limit is about 22 analogue TV channels per satellite.

Satellite operators can deliver more channels than this to the same fixed dish by positioning satellites very close together. If several satellites are within a few tens of miles of each other, they can all be received by the same dish on the ground.

This technique is known as co-location. For example, the HOT BIRD™ fleet allows any dish aimed at 13 degrees to receive signals from 98 transponders carried on five different satellites.

Consumer Equipment

Once EUTELSAT has transmitted a broadcaster's channels as high-quality signals from its system, all the consumer needs is standard equipment readily available from retailers. Consumer equipment has its own section later but here's a summary:

A Dish

For the UK and Eire, an 80 cm dish is big enough to receive all transmissions from EUTELSAT's HOT BIRD™ position at 13 degrees East as well as allowing for dual-feed (see later).

An LNB

A Low Noise Block down converter (LNB) receives a wide band of frequencies - a "block" - amplifies and converts them to lower frequencies which can be sent down the cable to be received by the tuner in the satellite receiver.

A Suitable Cable

The cable which connects the LNB (on the dish) to the receiver (in the home) needs to comply with the satellite cable standard BS5425. This standard, unlike ordinary TV aerial cable, is designed to pass the correct satellite frequencies, LNB power and control signals such as DiSEqC™ and reduce interference.

A Receiver

A satellite receiver is aptly named - it receives the satellite signals passed to it from the LNB and turns them into standard TV signals which can be used by a standard TV or VCR. Typically, it also contains a CA system.

A Conditional Access System

Broadcasters choose to use a CA system for three main reasons: to comply with any national regulations, to protect the copyright of the programmes they have made or bought and, for those broadcasters of subscription TV, to ensure that channels are restricted to those viewers who have the right to receive them.

A Television

Of course! And, since satellite receivers are compatible with current TV standards, they can be connected to video-recorders, hi-fi's, home cinema systems and just about any other item of home entertainment equipment.

CHECKLIST

- ☑ Geostationary satellites transmit TV for reception on inexpensive, small, fixed dishes.

- ☑ Satellite TV broadcasting uses new frequencies to extend viewer choice beyond terrestrial limitations.

- ☑ Satellite TV FM signals deliver higher picture quality than terrestrial UHF AM TV.

- ☑ Orbital positions and frequencies are co-ordinated internationally to avoid interference with all other services.

- ☑ Co-location of satellites - as at EUTELSAT's HOT BIRD™ position - dramatically increases the number of channels available on a fixed dish.