Day 1 course

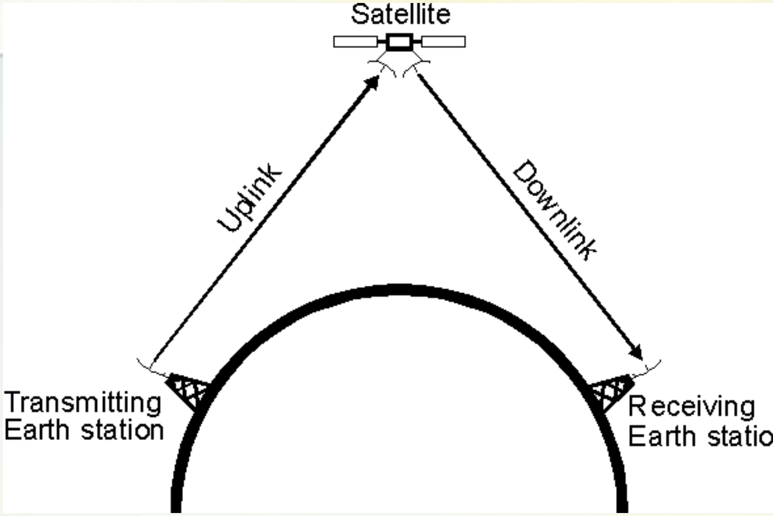
Basics of satellite communications

1- Birth of satellite communications

Satellites are able to fulfill a number of roles. One of the major roles is for satellite communications. Here the satellite enables communications to be established over large distances - well beyond the line of sight. Communications satellites may be used for many applications including relaying telephone calls, providing communications to remote areas of the Earth, TV direct to user broadcasting, providing satellite communications to ships, aircraft and other mobile vehicles, and there are many more ways in which communications satellites can be used.

1- Birth of satellite communications

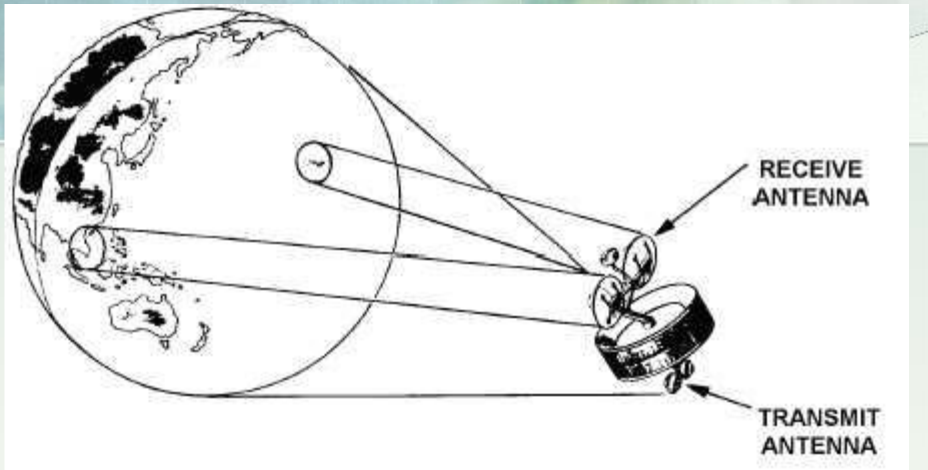
When used for communications, a satellite acts as a repeater. Its height above the Earth means that signals can be transmitted over distances that are very much greater than the line of sight. An earth station transmits the signal up to the satellite. This is called the up-link. The satellite receives the signal and retransmits it on what is termed the down link. To avoid interference, the uplink and downlink are on different frequency bands.



1- Birth of satellite communications

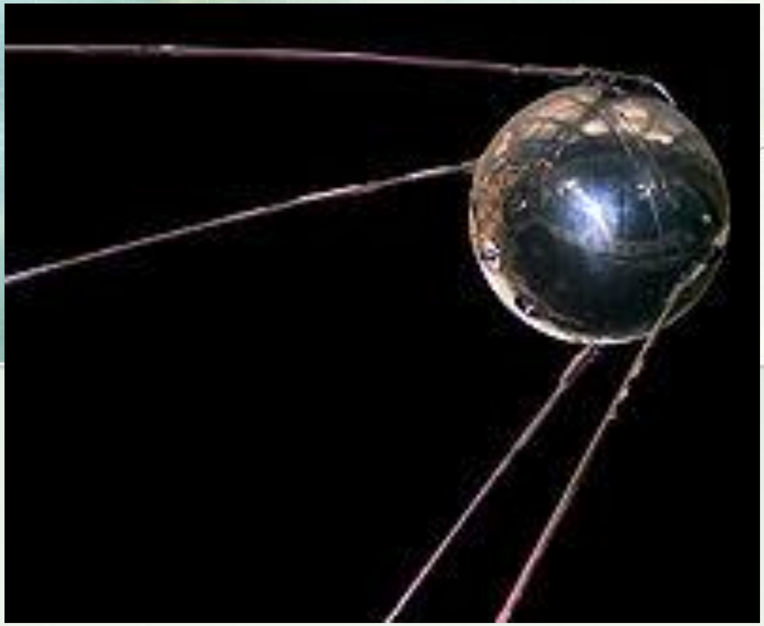
In the context of spaceflight, a **satellite** is an object which has been placed into orbit by human endeavor.

Such objects are sometimes called **artificial satellites** to distinguish them from natural satellites such as the Moon.



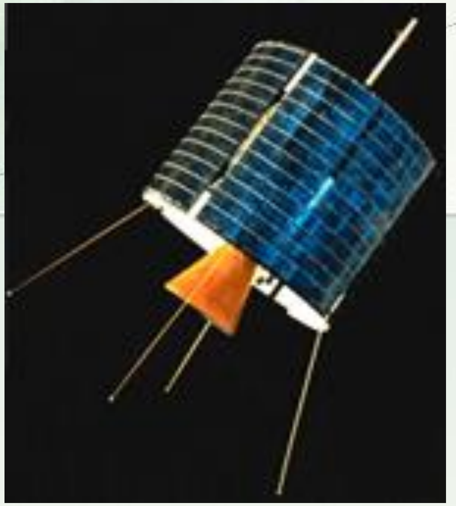
1- Birth of satellite communications

First satellite was launched in 1957 by Russia. It was Sputnik 1.



1- Birth of satellite communications

INTELSAT I (nicknamed **Early Bird** for the proverb "The early bird catches the worm") was the first (commercial) communications satellite to be placed in geosynchronous orbit, on April 6, 1965.



1- Birth of satellite communications

Benefits of satellites

Satellites Provide Some Capabilities Not EASILY Available with Terrestrial Communication Systems

- Adaptable to the needs of different customers
- Mobility
- Cost advantage over building land lines for a limited population
- No geographical obstructions that prohibit landlines
- Quick implementation – e.g. News Gathering
- Alternate routing or redundancy as required
- Cost is independent of distance
- Cost effective for short term requirements e.g. Sporting Events
- Variable Data Speeds (Information Rates) secret7

1- Birth of satellite communications

Interest of satellites

Satellites are complementary to cable for the following reasons:

- 1) Submarine cables (and landline fibre) are subject to cuts. Satellites provide an excellent means of back-up and should always be considered in any national plan as a means of resilience and network security
- 2) Although a lot of countries are getting access to fibre, they have problems distributing that large bandwidth to centers far away from the cable landing. Microwave or landline fibre may not be cost effective in the short run or may take a long time to reach upcountry locations. The interim solution is to have a VSAT network utilizing satellites for cellular backhaul and internet trunking until terrestrial capacity on microwave or fibre can reach the remote locations
- 3) There are certain satellite systems utilizing MEO (medium Earth orbit) which are about to be launched which will have both high capacity (1.2Gb*ps* per beam) and quality (low latency of 120 ms round trip) and cost ($750 per Mb*ps* per month) factors that approach that of submarine cable.

1- Birth of satellite communications

Types of satellites

- **Communications satellites:** A communications satellite is a radio relay station in orbit above the earth that receives, amplifies, and redirects analog and digital signals carried on a specific radio frequency.

In addition to communications satellites, there are other types of satellites:

- **Weather satellites:** These satellites provide meteorologists with scientific data to predict weather conditions and are equipped with advanced instruments

1- Birth of satellite communications

Types of satellites

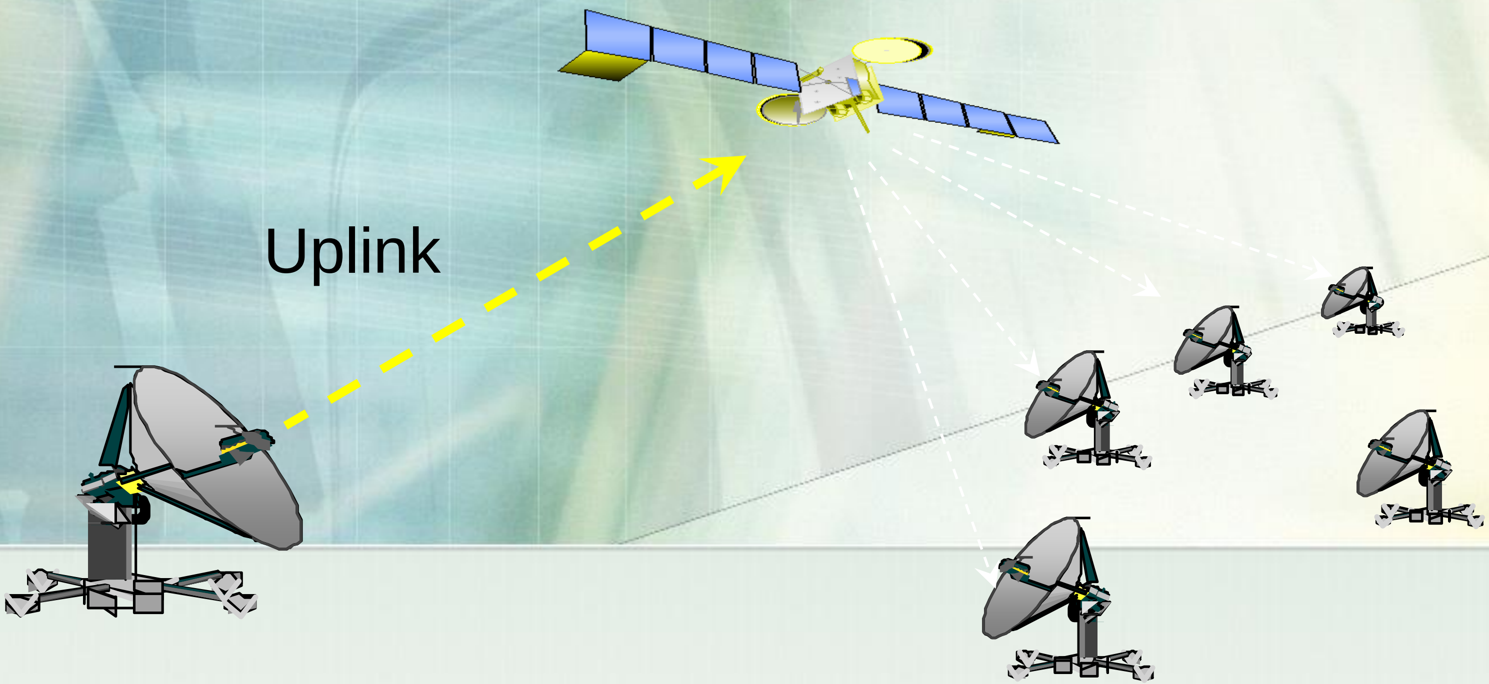
- **Earth observation satellites:** These satellites allow scientists to gather valuable data about the Earth's ecosystem
- **Navigation satellites:** Using GPS technology these satellites are able to provide a person's exact location on Earth to within a few meters
- **Broadcast satellites:** broadcast television signals from one point to another (similar to communications satellites).
- **Scientific satellites :** perform a variety of scientific missions. The Hubble Space Telescope is the most famous scientific satellite, but there are many others looking at everything from sun spots to gamma rays.

1- Birth of satellite communications

Types of satellites

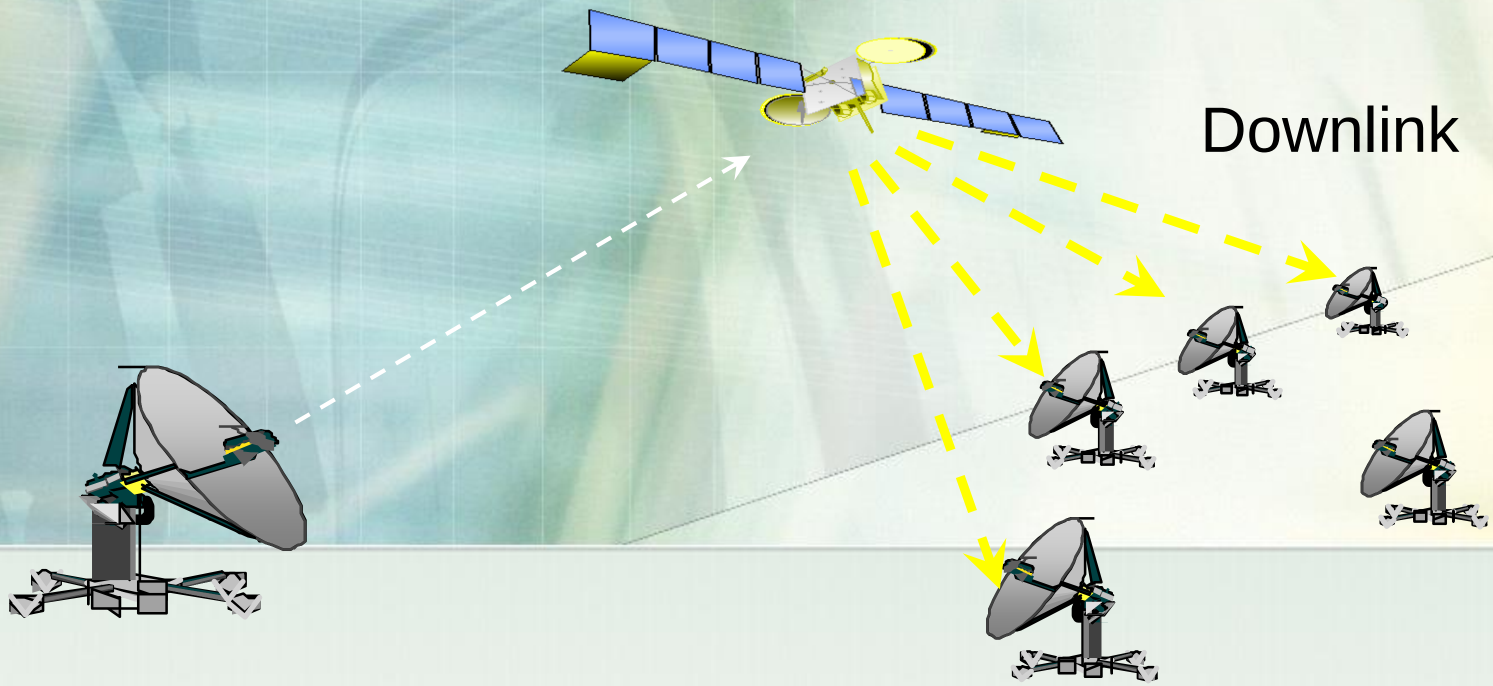
- **Military satellites:** are up there, but much of the actual application information remains secret. Intelligence-gathering possibilities using high-tech electronic and sophisticated photographic-equipment reconnaissance are endless. Applications may include:
  - Relaying encrypted communications
  - Nuclear monitoring
  - Observing enemy movements
  - Early warning of missile launches
  - Eavesdropping on terrestrial radio links
  - Radar imaging
  - Photography (using what are essentially large telescopes that take pictures of militarily interesting areas)

3.1- Communications links
Uplink



Uplink - The transfer of information to the satellite

3.1- Communications links
Downlink



Downlink - The transfer of information from the satellite

3.1- Communications links
Uplink and Downlinks

- NOTE:
  - Satellites receive at a different frequency than they transmit at
  - Different wavelengths give different radiation patterns on the antennae
  - This causes slightly different footprints for uplink and downlink
  - For marketing reasons the patterns may be different

3.2- The space segment

The equipment carried aboard the satellite also can be classified according to function.

The payload refers to the equipment used to provide the service for which the satellite has been launched.

The bus refers not only to the vehicle which carries the payload but also to the various subsystems which provide the power, attitude control, orbital control, thermal control, and command and telemetry functions required to service the payload.

3.2- The space segment

In a communications satellite, the equipment which provides the connecting link between the satellite's transmit and receive antennas is referred to as the transponder.

The transponder forms one of the main sections of the payload, the other being the antenna subsystems.

3.2- The space segment

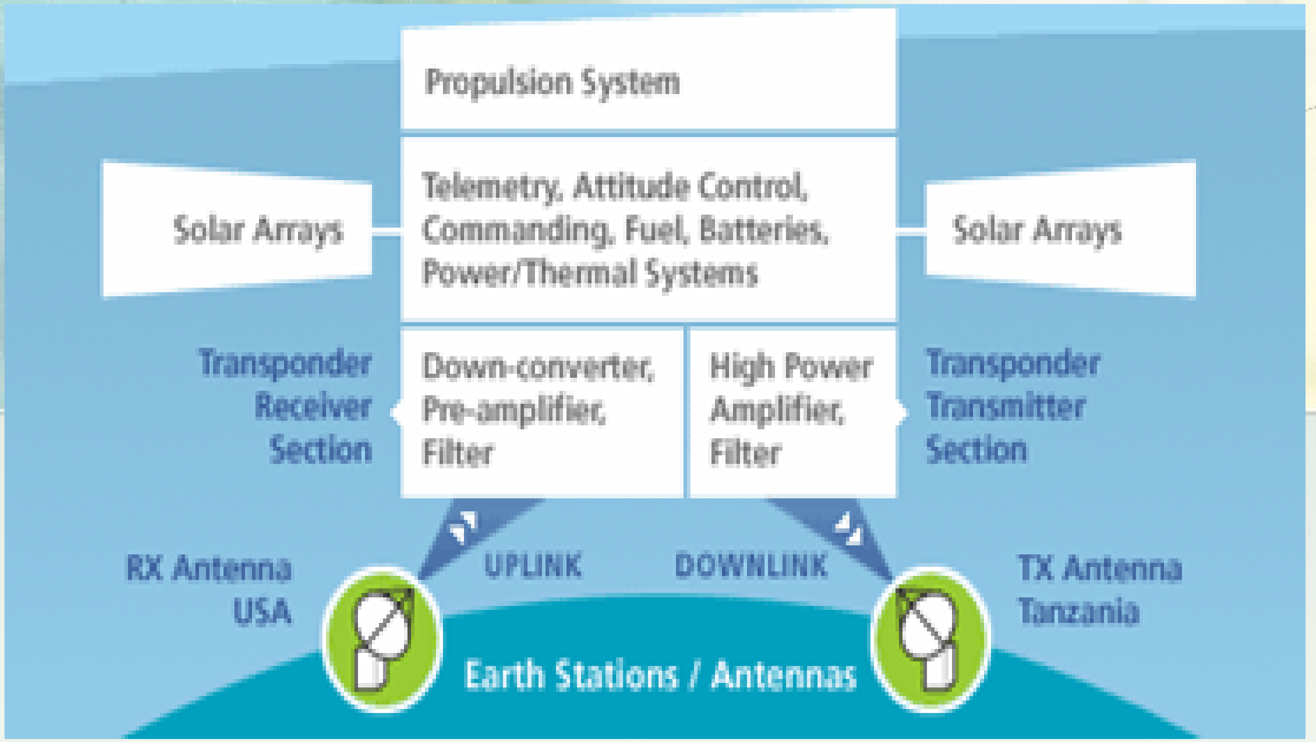
Communications data passes through a satellite using a signal path known as a transponder.

Typically satellites have between 24 and 72 transponders. A single transponder is capable of handling up to 155 million bits of information per second.

With this immense capacity, today's communication satellites are an ideal medium for transmitting and receiving almost any kind of content - from simple voice or data to the most complex and bandwidth-intensive video, audio and Internet content.

3.2- The space segment

Diagrammatic Representation of a Satellite



3.2- The space segment

TRANSPONDER

The circuitry in the satellite that acts as the receiver, frequency changer, and transmitter is called a transponder.

This basically consists of a low noise amplifier, a frequency changer consisting a mixer and local oscillator, and then a high power amplifier. The filter on the input is used to make sure that any out of band signals such as the transponder output are reduced to acceptable levels so that the amplifier is not overloaded.

Similarly the output from the amplifiers is filtered to make sure that spurious signals are reduced to acceptable levels.

3.2- The space segment

TRANSPONDER

Figures used in here are the same as those mentioned earlier, and are only given as an example.

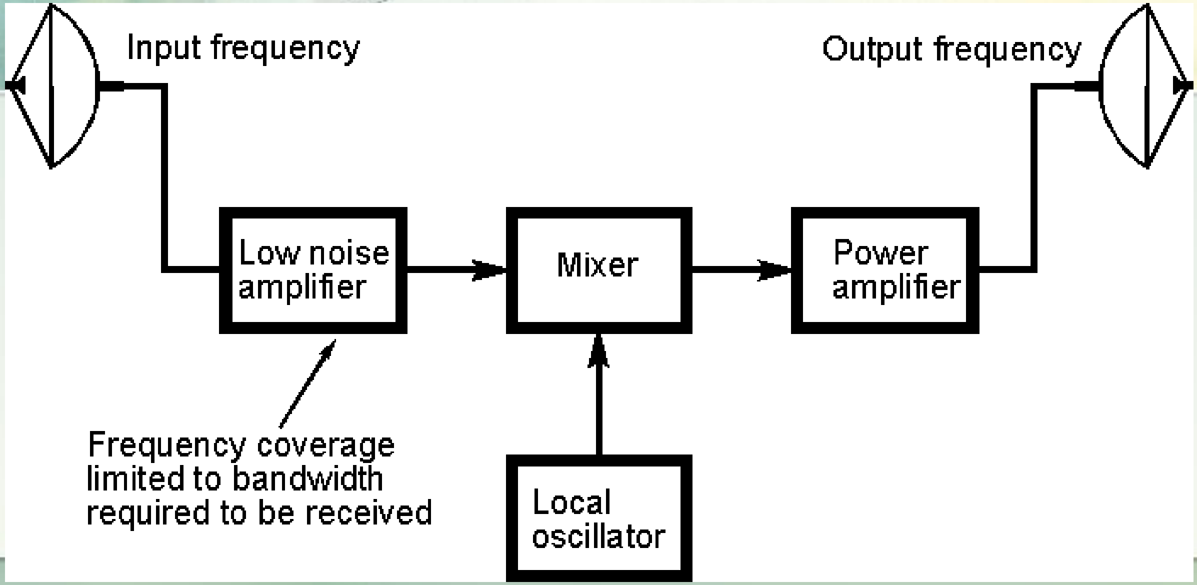
The signal is received and amplified to a suitable level. It is then applied to the mixer to change the frequency in the same way that occurs in a super heterodyne radio receiver.

As a result the communications satellite receives in one band of frequencies and transmits in another.

3.2- The space segment

TRANSPONDER

In view of the fact that the receiver and transmitter are operating at the same time and in close proximity, care has to be taken in the design of the satellite that the transmitter does not interfere with the receiver. This might result from spurious signals arising from the transmitter, or the receiver may become de-sensitised by the strong signal being received from the transmitter. The filters already mentioned are used to reduce these effects.



3.2- The space segment
Satellite design (electrical power)

Early communications satellites were severely limited by the lack of suitable power sources. This severely limited the output power of the satellite transmitter.

The only source of power available within early weight restrictions was a very inefficient panel of solar cells without battery backup.

A major disadvantage of this type of power source is that the satellite has no power when it is in ECLIPSE (not in view of the Sun). For continuous communications, this outage is unacceptable.

3.2- The space segment

Satellite design (electrical power)

A combination of solar cells and storage batteries is a better prime power source. This is a practical choice, even though the result is far from an ideal power source.

About ten percent of the energy of the sunlight that strikes the solar cells is converted to electrical power. This low rate is sometimes decreased even further.

3.2- The space segment
Satellite design (electrical power)

Early satellites had over 8,500 solar cells mounted on the surface of the satellite, which supplied about 42 watts of power. No battery backup was provided in these satellites.

Newer communications satellites have about 32,000 solar cells mounted on the surface of the satellite, and they supply about 520 watts. A nickel cadmium battery is used for backup power during eclipses.

Nuclear power sources have been used in space for special purposes, but their use stops there. Technology has not progressed sufficiently for nuclear power sources to be used as a power source.

3.2- The space segment

Satellite design (electrical power)

3.2- The space segment
Satellite design (Attitude control)

The *attitude* of a satellite refers to its orientation in space. Much of the equipment carried aboard a satellite is there for the purpose of controlling its attitude.

Attitude control is necessary, for example, to ensure that directional antennas point in the proper directions. In the case of earth environmental satellites, the earth-sensing instruments must cover the required regions of the Earth, which also requires attitude control.

A number of forces, referred to as *disturbance torques*, can alter the attitude, some examples being the gravitational fields of the Earth and the Moon, solar radiation, and meteorite impacts.

3.2- The space segment
Satellite design (Attitude control)

Attitude control must not be confused with *station keeping*, which is the term used for maintaining a satellite in its correct orbital position, although the two are closely related.

Infrared sensors, referred to as horizon detectors, are used to detect the rim of the earth against the background of space. With the use of four such sensors, one for each quadrant, the center of the earth can be readily established as a reference point.

Any shift in orientation is detected by one or other of the sensors, and a corresponding control signal is generated which activates a restoring torque.

3.2- The space segment

Satellite design (Orbital control)

In addition to having its attitude controlled, it is important that a geostationary satellite be kept in its correct orbital slot.

The equatorial ellipticity of the earth causes geostationary satellites to drift slowly along the orbit, to one of two stable points, at 75°E and 105°W.

To counter this drift, an oppositely directed velocity component is imparted to the satellite by means of jets, which are pulsed once every 2 or 3 weeks.

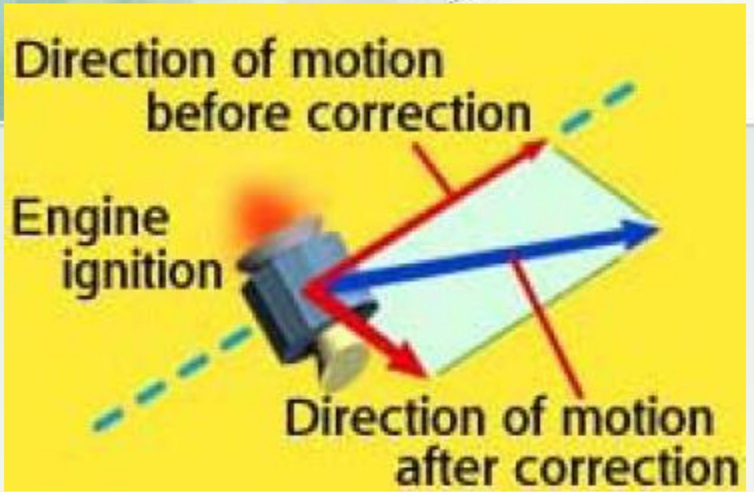
This results in the satellite drifting back through its nominal station position, coming to a stop, and recommencing the drift along the orbit until the jets are pulsed once again.

3.2- The space segment
Satellite design (Orbital control)

Orbital correction is carried out by command from the TT&C earth station, which monitors the satellite position. East-west and north south station-keeping maneuvers are usually carried out using the same thrusters as are used for attitude control.

3.2- The space segment
Satellite design (Orbital control)

In order for a geostationary communications satellite to continue to function, it must remain stationary with respect to all the earth station antennas that are pointed at it. To correct for the orbital fluctuations that all satellites are subject to, each satellite carries a thrust subsystem to give it an occasional nudge to keep it "On Station."

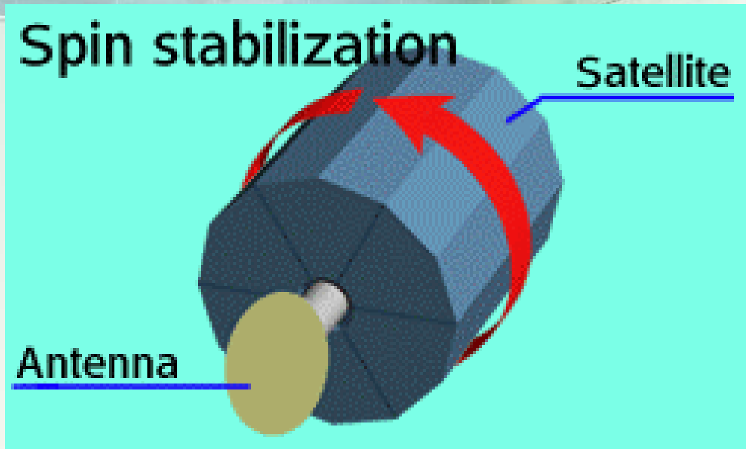


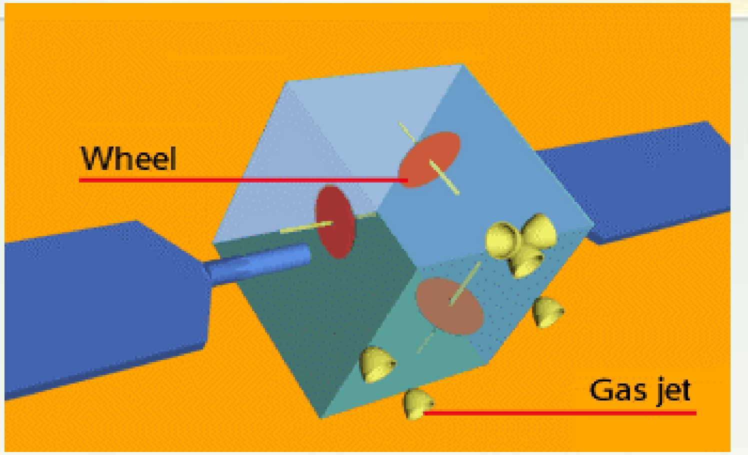
3.2- The space segment

Satellite design (Orbital control)

Remaining on-station is only half the battle. Additionally, the satellite's antennas must always be aimed at the same spot on the Earth's surface. This requires gyroscopic stabilization of the satellite body. This is accomplished with gyroscopes in one of two configurations:

- Spin stabilization, in which the entire satellite body is spun (antennas are de-spun), or
- Internal gyroscopes





3.2- The space segment
Satellite design (Thermal control)

Satellites are subject to large thermal gradients, receiving the sun's radiation on one side while the other side faces into space.

In addition, thermal radiation from the earth and the earth's albedo, which is the fraction of the radiation falling on earth which is reflected, can be significant for low-altitude earth-orbiting satellites, although it is negligible for geostationary satellites.

Equipment in the satellite also generates heat which has to be removed. The most important consideration is that the satellite's equipment should operate as nearly as possible in a stable temperature environment.

3.2- The space segment
Satellite design (Thermal control)

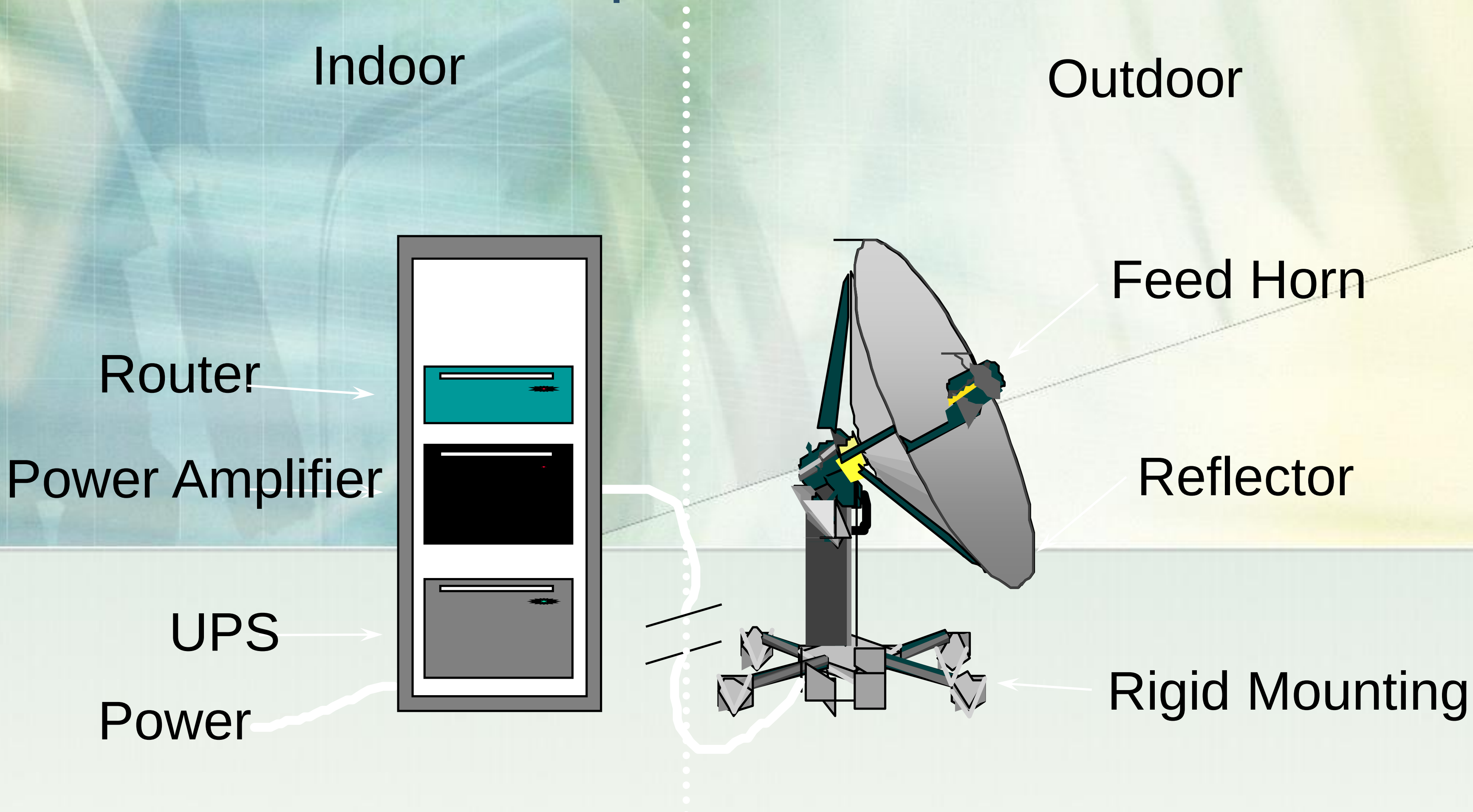
In order to maintain constant temperature conditions, heaters may be switched on (usually on command from ground) to make up for the heat reduction which occurs when transponders are switched off.

In INTELSAT VI, heaters are used to maintain propulsion thrusters and line temperatures.

3.3- The ground segment

- Earth station components
- Factors governing antenna sizes
- The differences between a major earth station and a VSAT
- Permissions required to install and operate a VSAT / Earth station

3.3- The ground segment
Earth Station Components



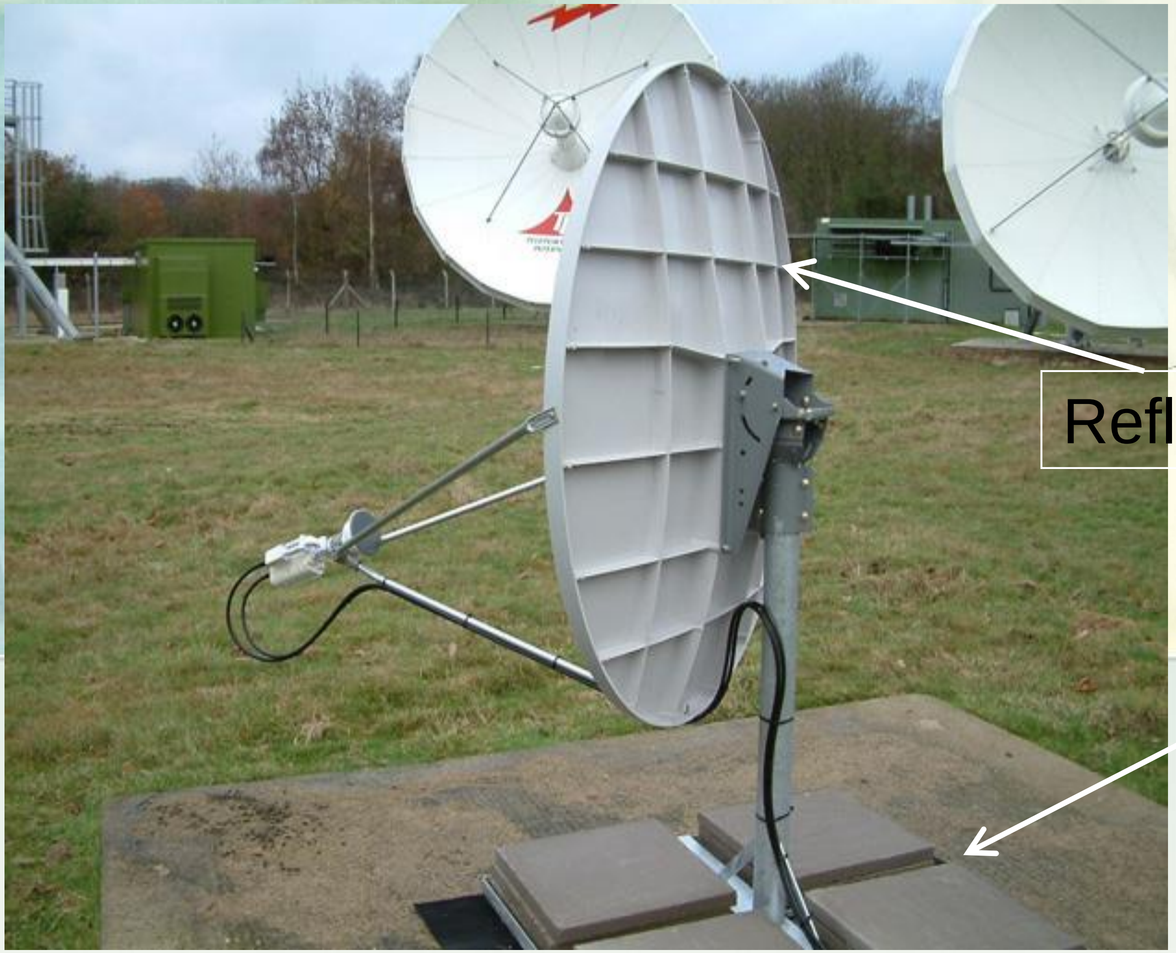
Earth Station Components – generic simplified diagram

3.3- The ground segment

Earth Station Components

- Reflector – Physical reflecting piece – focuses signal into the LNB assembly and / or focuses the transmission signal towards the satellite
- Feed horn – Device to accept the focussed RF signals into the LNB or conversely to output the RF signal to the satellite
- Power amplifier – Device that accepts a signal from the modem and boosts it to a suitable level for onward transmission to the satellite
- LNA,B or C – Low Noise Amplifier – Receives the signal from the satellite,
- Modem – Converts a data signal to one suitable for transmission to the satellite
- UPS / Power – Un-interruptible Power Supply - Power input to the devices
- Rigid Mounting – Some form of mounting to hold the antenna assembly vertical and pointed correctly under most normal condition

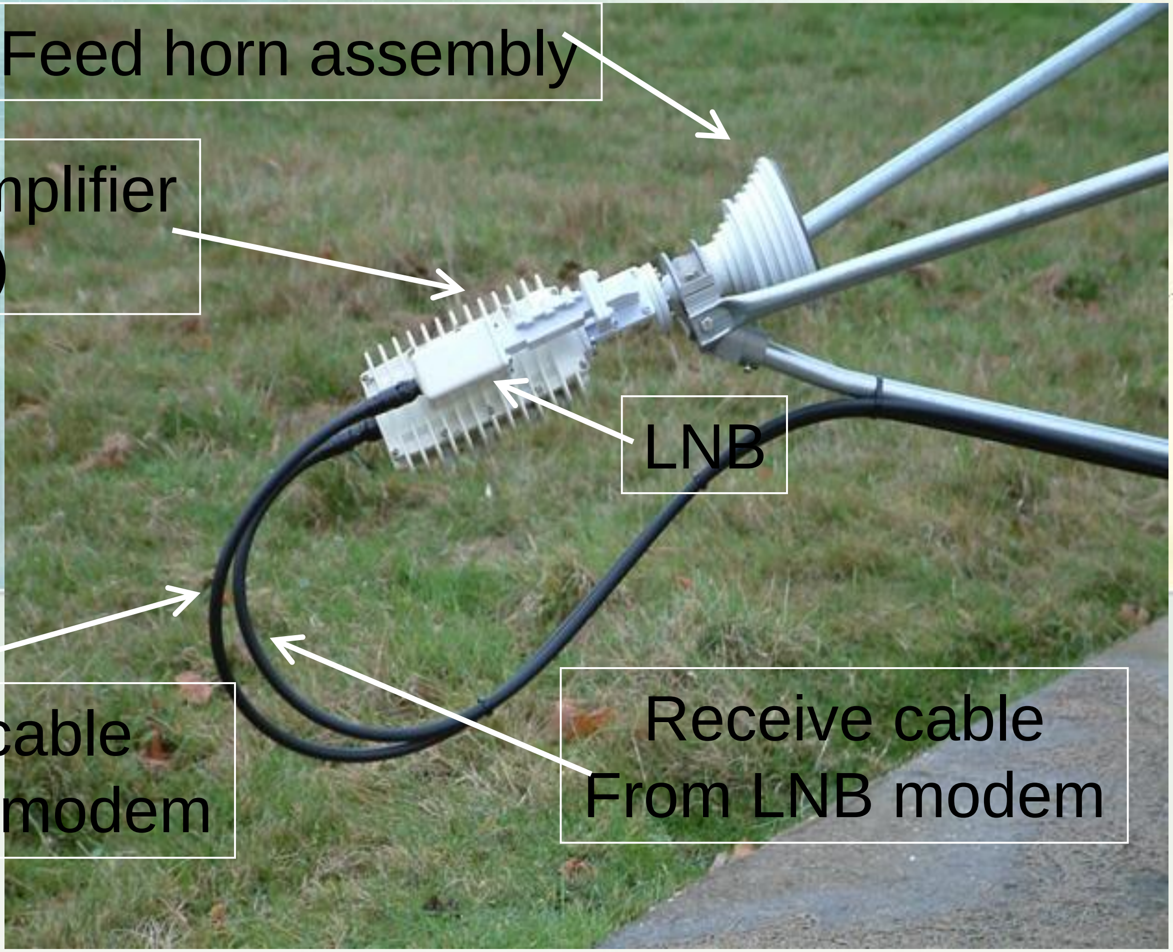
3.3- The ground segment
Earth Station Components



Reflector

Ground Mount with weights

3.3- The ground segment
Earth Station Components



3.3- The ground segment

Factors governing Reflector sizes

Why install a large antenna when a small one would do the job?

- Transmission:
  - ✓Large earth stations have smaller BEAM Width's therefore point more accurately
  - ✓ Less RF signal wastage
  - ✓ Less co-satellite interference
  - ✓ Link budget requirement
  - ✓ Cost factors
    - – Larger antenna may be less than the cost of a lease with a smaller antenna

3.3- The ground segment

Factors governing Reflector sizes (2)

- Receiving:
  - ✓Antenna Gain dictated by the Link Budget
  - ✓Large earth station can receive a weaker signal than the equivalent small antenna
  - ✓Cost implications with the Link Budget
  - ✓Planning permission

    e.g. Europe 0.9M is the minimum size

3.3- The ground segment

The differences between a Major Earth Station and a VSAT

- VSAT – Very Small Aperture Terminal
- A VSAT is typically a small earth station 0.7M to 3.7M
- Usually operates a single service or application

- Major Earth Station
- Typically A Major Earth station is sized from 3.7M to 16M+ weighing 20 T or mo re costing $1M+
- Basically same components in each station
- Supports multiple services
- All components redundant
- Can transmit and receive in multiple polarisations
- Usually configured with large RF power amplifiers
- Always connected to suitable Power supplies
- Usually connected to multiple terrestrial paths

3.3- The ground segment

The differences between a Major Earth Station and a VSAT

3.3- The ground segment

Permissions required to install & operate a VSAT / Earth station

- Just because it can work does not necessarily mean you may go out install and operate!

- Planning permission
  - ✓ Local Authority building departments
  - ✓ Zoning issues
- Landlord's permission

  Will the landlord permit your activity?
- Regulatory authority

  Does the law allow you to build and operate?

3.3- The ground segment
A Typical Teleport

Typical services provided by a teleport :

- Multiple large earth stations
- Well specified antennas
- Good power systems
- Ample Rack space for ancillary equipment
- 24X7 staff on-site to maintain systems
- Quality support and technical staff to assist with design, install and operation
- Good terrestrial connectivity
- Preferably to more than a single fibre supplier

3.3- The ground segment
A Typical Teleport

4- Satellite orbits

Geosynchronous Orbit (GEO): 35,786 km above the earth

Orbiting at the height of 22,282 miles above the equator (35,786 km), the satellite travels in the same direction and at the same speed as the Earth's rotation on its axis, taking 24 hours to complete a full circle in its orbit. Thus, as long as a satellite is positioned over the Equator in an assigned orbital location, it will appear to be "stationary" with respect to a specific location on the Earth.

4- Satellite orbits

Geosynchronous Orbit (GEO): 35,786 km above the earth

A single geostationary satellite can view approximately one third of the Earth's surface. If three satellites are placed at the proper longitude, the height of this orbit allows almost all of the Earth's surface to be covered by the satellites.

4- Satellite orbits

Medium Earth Orbit (MEO): 8,000-20,000 km above the earth

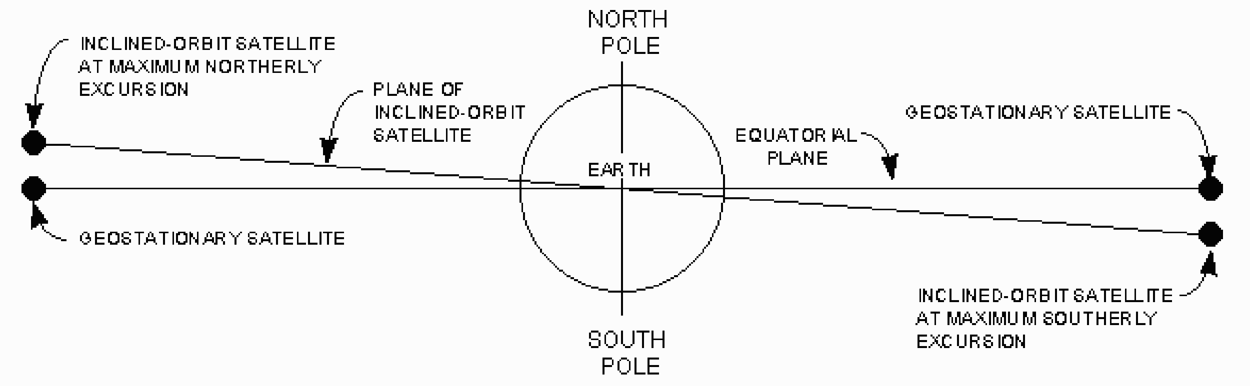
- These orbits are primarily reserved for communications satellites that cover the North and South Pole
- Unlike the circular orbit of the geostationary satellites, MEO's are placed in an elliptical (oval-shaped) orbit

4- Satellite orbits

Low Earth Orbit (LEO): 500-2,000 km above the earth

- These orbits are much closer to the Earth, requiring satellites to travel at a very high speed in order to avoid being pulled out of orbit by Earth's gravity
- At LEO, a satellite can circle the Earth in approximately one and a half hours

4- Satellite orbits



Inclined orbits

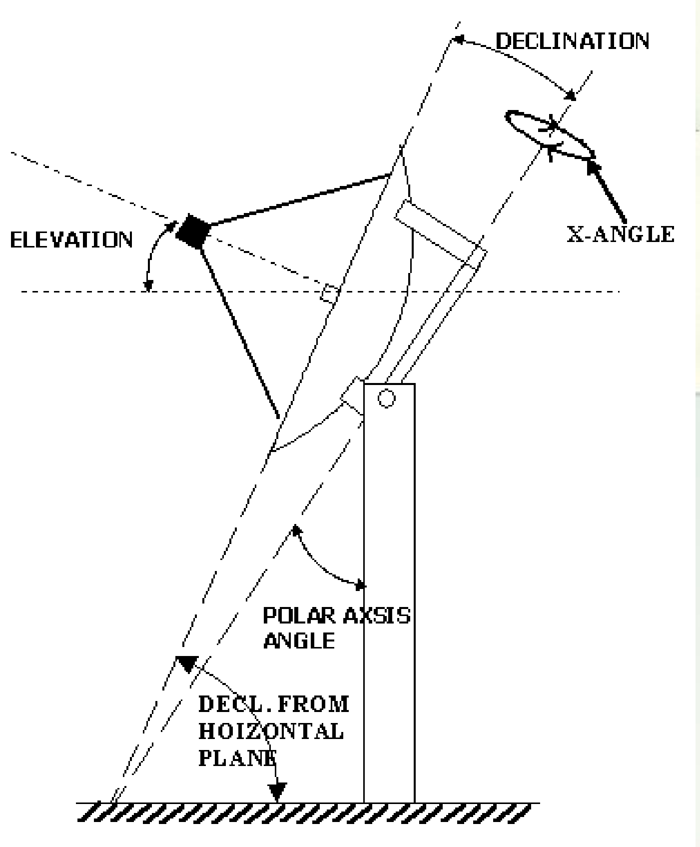
Once a satellite has been placed accurately into its geostationary orbit position it gradually starts to drift north-south on a daily basis due to the influence of the sun and moon. There is a gradual increase in the inclination of the orbit. If left alone, a satellite that has initial zero inclination will have its inclination increase at the rate of 0.8 deg per year.

With some old satellites the lifetime can be prolonged by saving fuel for orbital north/south maneuvers which result the satellite drifting in the Latitude. In the extreme some satellites are 15 degrees inclined which means they move inside a +/-15 degree box not a +/-0.03 degree box like in the Astra 1B example.

4- Satellite orbits

Inclined orbits (Implications for earth station inclination tracking)

During the inclined orbit years earth stations must have tracking systems so that their pointing is adjusted to aim at the satellite all during the day.



4- Satellite orbits

Inclined orbits (Implications for earth station inclination tracking)

To avoid loss of service, the earth stations need to track the satellite following the daily sinusoidal movements. If you are located on the same longitude as the satellite the north-south daily movement will be up and down. If you are on the equator then all the satellites are in a straight line across the sky from east to west, via directly overhead. North-south movement of all these satellites will be a sideways movement. Anywhere else and you have daily diagonal movements to contend with, which means using two motors for an azimuth-elevation mount or a declination only motor on a polar mount dish.

Due to the problems with tracking and the uncertainty of operation of old satellites that have exceeded their regular life, the prices charged for transponder capacity on these satellites are lower.

4- Satellite orbits

GEO vs. MEO vs. LEO

- Most communications satellites in use today for commercial purposes are placed in the geostationary orbit, because of the following advantages:

✓ One satellite can cover almost 1/3 of Earth's surface, offering a reach far more extensive than what any terrestrial network can achieve

✓ Communications require the use of fixed antennas. Since geosynchronous satellites remain stationary over the same orbital location, users can point their satellite dishes in the right direction, without costly tracking activities, making communications reliable and secure

✓ GEO satellites are proven, reliable and secure - with a lifespan of 10-15 years

5- Orbital positions and radio interferences

LICENSING

The ITU Member States have established a legal regime, which is codified through the ITU Constitution and Convention, including the Radio Regulations. These instruments contain the main principles and lay down the specific regulations governing the following major elements:

- frequency spectrum allocations to different categories of radio communication services;
- rights and obligations of Member administrations in obtaining access to the spectrum/orbit resources;
- international recognition of these rights by recording frequency assignments and, as appropriate, orbital positions used or intended to be used in the Master International Frequency Register.

5- Orbital positions and radio interferences

LICENSING

The above regulations are based on the main principles of efficient use of and equitable access to the spectrum/orbit resources laid down in No. 196 of the ITU Constitution (Article 44), which stipulates that *"In using frequency bands for radio services, Members shall bear in mind that radio frequencies and the geostationary-satellite orbit are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to both, taking into account the special needs of the developing countries and the geographical situation of particular countries"*.

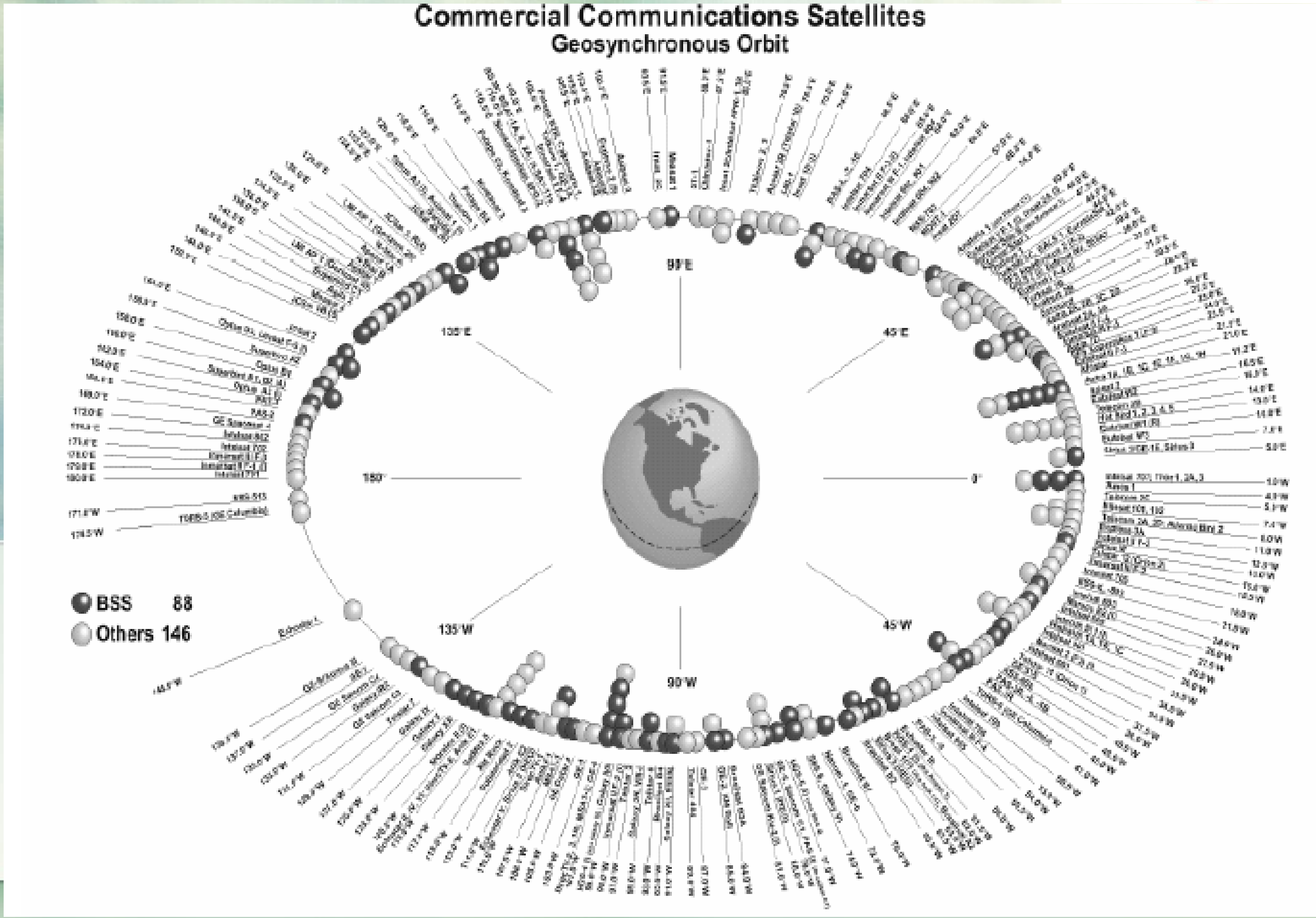
5- Orbital positions and radio interferences

ORBITAL SLOT REGISTRATION

The UN agency that regulates the use of geosynchronous orbit satelites is the International Telecommunications Union. Regulation of these satellites is necessary, because there are a limited number of places to put them in orbit without the risk of interference with other satellites or collision with space debris. In addition, the “orbital slots” (where the satellites are placed) over industrialized areas are in much more demand than in lesser developed areas.

Slots over less developed countries with a location that would give a satellite coverage of industrialized countries are also in demand.

1- Regulatory factors



5- Orbital positions and radio interferences

ORBITAL SLOT REGISTRATION

In 1988, the ITU acknowledged that all countries, including lesser developed countries, have an equal right to orbital slots. However, Article II of the Outer Space Treaty forbids any claim of sovereignty by any country in space, which would not allow countries to establish dominion over the orbital slots above their territory. At conferences in 1985 and 1988, the ITU did give all countries the rights to an orbital slot directly over their territory, which would ensure at least some access to these satellites to all countries.

The actual orbital slots themselves are dispensed on what could be described as a first come, first served basis with some consideration given to the country making the request. There is no mandatory system to deal with disputes over orbital slots, but there are countries that have entered into an optional method to deal with disputes within the ITU.

5- Orbital positions and radio interferences

FREQUENCY REGISTRATION

The orbital slots issue is just one of the issues that the ITU addresses. The frequencies on which the satellites broadcast are also regulated by the ITU.

This is a very important aspect, because satellites that broadcast in the wrong frequencies can interfere with neighboring satellites or even radio or television transmissions on the ground.

Currently, the ITU has assigned about 87,000 frequencies to about 600 satellite networks in orbit (some of which are geostationary satellites).

5- Orbital positions and radio interferences

INTERSYTEM COODINATION

Another important organ of the ITU is the International Frequency Registration Board (IFRB), which is responsible for intersystem coordination at an international level.

This applies to the coordination of terrestrial systems with satellite systems, and to the coordination of a new satellite system with existing ones or systems simply registered at the IFRB at the time the new system is submitted to IFRB.

5- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

The ITU controls frequency allocations, permitted power levels and modes of operation. These restrictions are intended primarily to prevent interference between all types of systems employing radio communications and to protect some telecommunications services, such as emergency services.

In addition to that, many governments currently impose restrictions and regulations on service providers and users. These national regulations are specific to each particular country.

5- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

Due to the increasing uptake of sophisticated telecommunications systems, that are sold and used in all countries, the licensing regime for end-user equipment (such as VSAT terminals) is becoming simpler and less costly.

You will find the procedures and regulations that rule the installation and operation of VSAT terminals in regulatory agencies in the countries or on ITU web site.

5- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

A licence is required by the national telecommunications authority of a country where any earth station as a part of a network, be it the hub, a control station or a VSAT, is planned to be installed and operated.

The concern reflected here is to ensure compatibility between radio networks by avoiding harmful interference between different systems.

By doing so, any licensed operator within a certain frequency band is recognized as not causing unacceptable interference to others, and is protected from interference caused by others.

In the past, national telecommunication authorities have required licensing of individual VSAT terminals in addition to requiring a network operator’s license. Then, the US Federal Communication Commission (FCC) implemented with success a *blanket licensing* approach for VSATs operated within the US.

5- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

With blanket licensing, VSATs are configured based upon technical criteria (power level, frequency, etc.) to eliminate the risk of interference, so a single license can be issued covering a large number of VSAT terminals.

Blanket licensing has since gained interest among national telecommunications authorities all over the world, as a result of equipment manufacturers complying with the recommendations issued by international standardization bodies, such as the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI). Relevant documentation from these bodies is available at http://www.itu.int/home/index.html and http://www.etsi.org/.

5- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

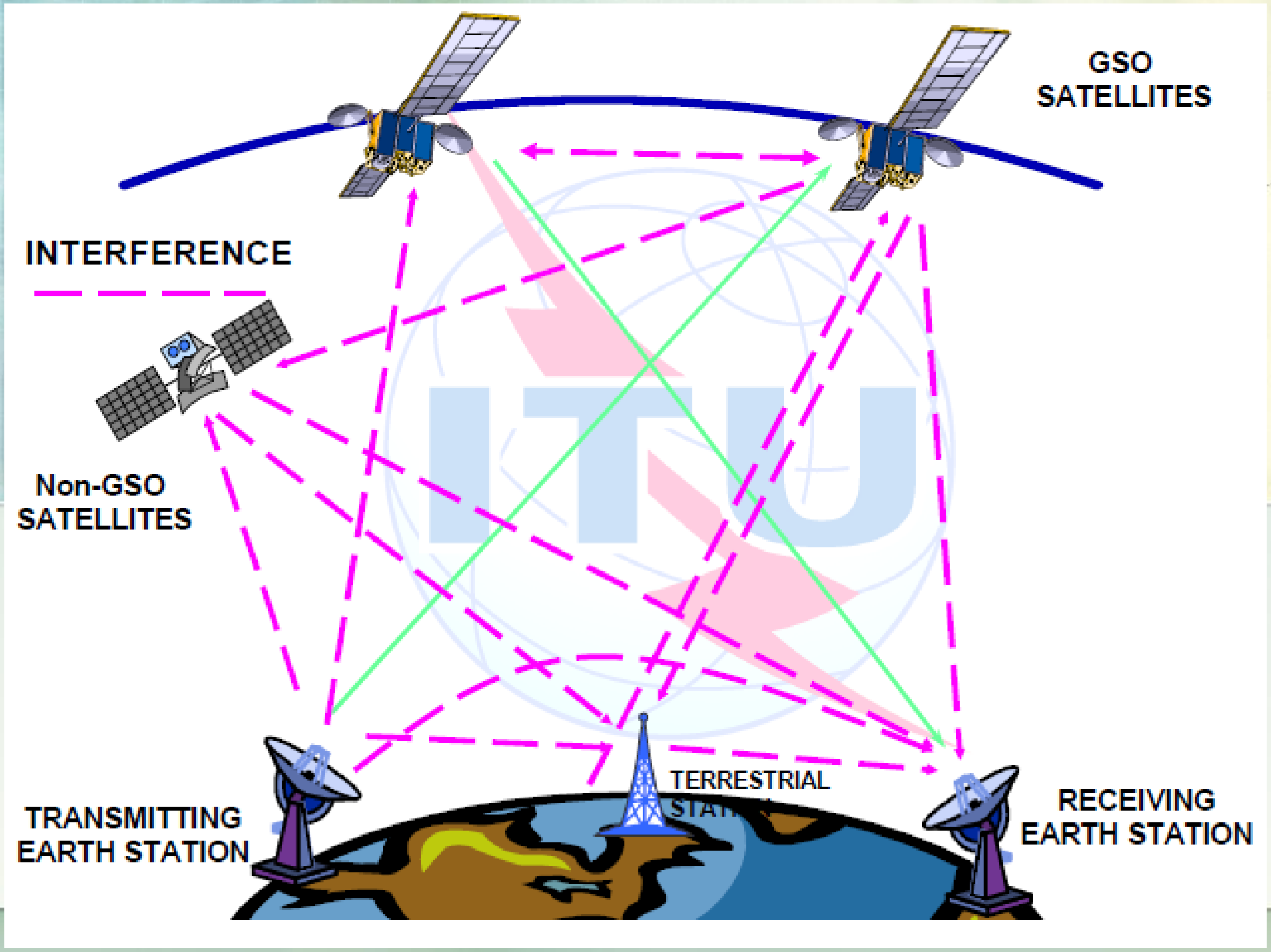
A licence usually entails the payment of a licence fee, which is most often in two parts: a one-time fee for the licensing work and an annual charge per station.

The licensing procedure is simpler when the network is national, as only one telecom authority is involved.

For transborder networks, licences must be obtained from the national authorities of the different countries where the relevant earth stations are planned to be installed and operated, and rules often differ from one country to another. To facilitate the access to these rules, telecommunications authorities around the world have begun posting data related to their nations' VSAT regulatory conditions on the World Wide Web.

5- Orbital positions and radio interferences

Interferences



5- Orbital positions and radio interferences

Interference-free operation

Propagation of Radio waves

- Laws of physics
- Radio waves do not stop at national borders

↓

Interference

- possible between radio stations of different countries
- This risk is high in Space Radiocommunications

↓

Radio Regulations (RR)

- One of its main purposes - Interference-free operation of RadioComms

5- Orbital positions and radio interferences

Control of Interference

ALLOCATION

Frequency separation of stations of different services

REGULATORY PROTECTION

e.g. No. 22.2: Non-GSO to protect GSO (FSS and BSS)

POWER LIMITS

PFD to protect TERR services / EIRP to protect SPACE services / EPFD to protect GSO from Non-GSO

COORDINATION

between Administrations to ensure interference-free operations conditions

5- Orbital positions and radio interferences

INTERFERENCE BETWEEN C-BAND AND WIMAX

The “extended” C band frequencies (3.4 to 3.7 GHz) have already been identified by several national administrations for use by new services like Broadband Wireless Access (BWA) and WiMax.

In addition, other administrations are looking to deploy these new terrestrial services in the “standard” C band frequencies (3.7 to 4.2 GHz). In countries where WiMax services have been introduced, there have been significant in-band and out-of-band interference issues and services interruptions for satellite ground stations and their related services.

Where some other interferences may occur, it is important to do electromagnetic survey before installation and make sure to have a valid license.

6- Radio regulations

There are many actors in the satellite communications :

- Satellite Service Providers (O3b, Rascom, Intelsat, Gilat, Astrasat,…)
- VSAT Installers (Libercom, Skytel,…)
- Regulators (FCC, ARCE,…)

6- Radio regulations

Among the regulations agencies you have :

- International regulators (ITU)
- Continental regulators associations (CITEL, APT, ATRN)
- Regional regulators (Regulatel, Comtelca, ARTAO, TRASA …)
- National regulators (FCC, NTIA,…)
- International Organizations (ITSO,…)

ITU is an international organization within the United Nations system. As well as responsibility for Telecommunications matters, they are also responsible for global regulations for all radio uses• The ITU is based in Geneva, Switzerland.

6- Radio regulations

Continental and Regional Regulators associations

The ITU Radio Regulations form a framework for Radio Regulations, but are not sufficient for complete Regulation•

Almost all countries / territories fall within a Regional Regulatory group

– *IRG for Europe*

– *CITEL across the Americas*

– *APT across Asia Pacific Region*

– *Arab States*

These groups often provide more detailed regulation, specific to the needs of their respective region.

6- Radio regulations

Continental and Regional Regulators associations

The continental and regional associations have different degrees of maturity and competencies.

They can rarely impose their decisions to their members, despite a consensual decision making, some of them can advance or even facilitate the adoption of common positions including during regional international meetings of the International Telecommunication Union (ITU) or the World Trade Organization (WTO)

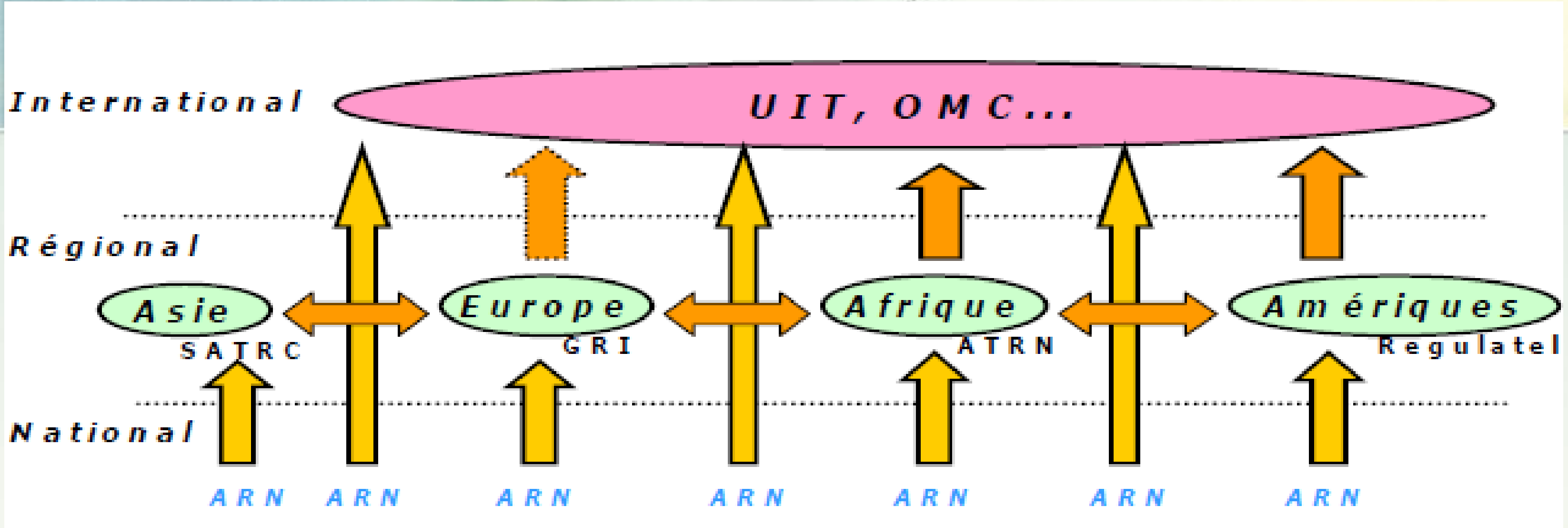
6- Radio regulations

National Regulation

Ultimately the responsibility for licensing falls to a National Regulatory Authority (a Government department), e.g.

– *Ofcom in the United Kingdom*

– *FCC & NTIA in the USA*



6- Radio regulations

ITSO

ITSO is the continuation of INTELSAT, the intergovernmental organization established by treaty in 1973.On July 18, 2001, the satellite fleet, customer contracts and other operational assets of the Organization were transferred to Intelsat Ltd, a new private company now registered in Luxembourg and various amendments to the ITSO Agreement took effect.

Under the ITSO Agreement, as amended , ITSO's primary role was that of supervising and monitoring Intelsat's provision of public telecommunications satellite services as specified in the Public Services Agreement(PSA) entered into between ITSO and Intelsat. In addition, the Director General , on behalf of the Organization, must consider all issues related to the Common Heritage. ITSO currently has 149 Member States."

6- Radio regulations

ITSO

The **International Telecommunications Satellite Organization** is an intergovernmental organization charged with overseeing the public service obligations of Intelsat.

GVF

Global VSAT Forum is an association of key companies involved in the business of delivering advanced digital fixed satellite systems and services.

6- Radio regulations

Satellite Operators

Intelsat, Ltd. is a communications satellite services provider. Originally formed as **International Telecommunications Satellite Organization** (**INTELSAT**), it was an intergovernmental consortium owning and managing a constellation of communications satellites providing international broadcast services. As of March 2011, Intelsat owned and operated a fleet of 52 communications satellites.

Eutelsat S.A. is a French-based satellite provider. Providing coverage over the entire European continent, as well as the Middle East, Africa, India and significant parts of Asia and the Americas, it is one of the world's three leading satellite operators in terms of revenues.

6- Radio regulations

Satellite Operators

O3b is building a next-generation network that combines the reach of satellite with the speed of fiber.

Higher capacity

O3b's satellite transponders have on average three to four times the capacity of those offered by GEO satellite systems. This translates into three to four times more bandwidth – and a fiber-like experience for customers.

Greater coverage

Satellite technology can deliver Internet connectivity to any location on the planet. O3b's next-generation satellite network will reach consumers, businesses and other organisations in more than 150 countries across Asia, Africa, Latin America and the Middle East.

6- Radio regulations

Satellite Operators

Lower latency

O3b’s unique network of Medium Earth Orbit (MEO) satellites virtually eliminates the delay caused by standard Geosynchronous (GEO) satellites.

Round-trip data transmission time is reduced from well over 500 milliseconds to approximately 100 milliseconds.

This creates a web experience significantly closer to terrestrial systems such as DSL or Optical Fiber.

6- Radio regulations

International Organization

The **International Mobile Satellite Organization (IMSO)** is the intergovernmental organization that oversees certain public satellite safety and security communication services provided via the Inmarsat satellites. These public services include:

services for maritime safety within the Global Maritime Distress and Safety System (GMDSS) established by the International Maritime Organization (IMO)

- distress alerting
- search and rescue co-ordinating communications
- maritime safety information (MSI) broadcasts
- general communications

6- Radio regulations

International Organization

The **International Mobile Satellite Organization (IMSO)**

- aeronautical safety AMS(R)S services through compliance with the Standards and Recommended Practices (SARPs) established by the International Civil Aviation Organization (ICAO)

IMSO also acts as the International LRIT Coordinator, appointed by IMO to coordinate the establishment and operation of the international system for the Long Range Identification and Tracking of Ships (LRIT) worldwide.

6- Radio regulations

Satellite operations (SatOps) are conducted to:

- Verify and maintain satellite health
- Reconfigure and command the spacecraft
- Detect, identify and resolve anomalies
- Perform launch and early orbit operations.

7- Services

The Commercial Satellite Industry

Voice/Video/Data Communications

- Rural Telephony
- News Gathering/Distribution
- Internet Trunking
- Corporate VSAT Networks
- Tele-Medicine
- Distance-Learning
- Mobile Telephony
- Videoconferencing
- Business Television
- Broadcast and Cable Relay
- VOIP & Multi-media over IP

Direct-To-Consumer

- Broadband IP
- DTH/DBS Television
- Digital Audio Radio
- Interactive Entertainment & Games
- Video & Data to handhelds

GPS/Navigation

- Position Location
- Timing
- Search and Rescue
- Mapping
- Fleet Management
- Security & Database Access
- Emergency Services

Remote Sensing

- Pipeline Monitoring
- Infrastructure Planning
- Forest Fire Prevention
- Urban Planning
- Flood and Storm watches
- Air Pollution Management
- Geo-spatial Services

7- Satellite lifecycle management

In principle, geostationary satellites occupy a fixed position in space and consequently the ground-based antennas do not need to be constantly redirected to follow the satellite’s movements.

The fact that the orientation of ground-based antennas is fixed is a major advantage of the geostationary satellite orbit used by satellite broadcasters.

In practice however, the satellite wanders slightly around its nominal orbital position under the gravitational influence of bodies such as the Sun and the Moon, as well as other influences such as Sun radiation pressure and Earth asymmetry.

7- Satellite lifecycle management

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

As long as the satellite has enough fuel left to operate its thrusters, it can be kept in the correct position. Typically this is 10 – 15 years. As soon as the satellite is out of fuel, it will drift out of control and into space, which brings an end to its operational life.

7- Satellite lifecycle management

The satellite service operator can decide to save on fuel (and by consequence extend the lifetime expectancy of a satellite) by allowing the satellite to drift a little bit.

This is known as an inclined orbit operation. Although this may bring down the costs for the communication via this satellite, there is a consequence on the Earth station side. These stations have to be equipped for tracking (following the drift of) the satellite.

8- Technology trends

- Market trends for capacity
- – continues to grow despite fibre deployment
- Potential shortage of capacity in some areas for certain types of capacity due to heavy cutbacks in launches
- Bandwidth is ever increasing on a per link basis

8- Technology trends

User demands

- Smaller terminals
- High throughput
- Enhanced capability
- Constellations
- Responsive space
- Lower costs - $1000 now and lower!
- Easier access to space segment
- Easier licensing regimes
- Open standards

8- Technology trends

- Open Standards
- All agree
- Satellite Operators
- Network Operators
- Equipment manufacturers
- End-users

- Yes – but which one is the best one or is it a multitude of answers and solutions?

8- Technology trends

- Global usage and coordination
- Ka / Ku/ C Band
- Interference issues
- Global Regional frequency coordination

End of Day 1 course

Satellite Technology: Satellites fundamentals, Orbits, Satellite design, Operation, Life Cycle Management, Tracking Telemetry and Control (TTCM)