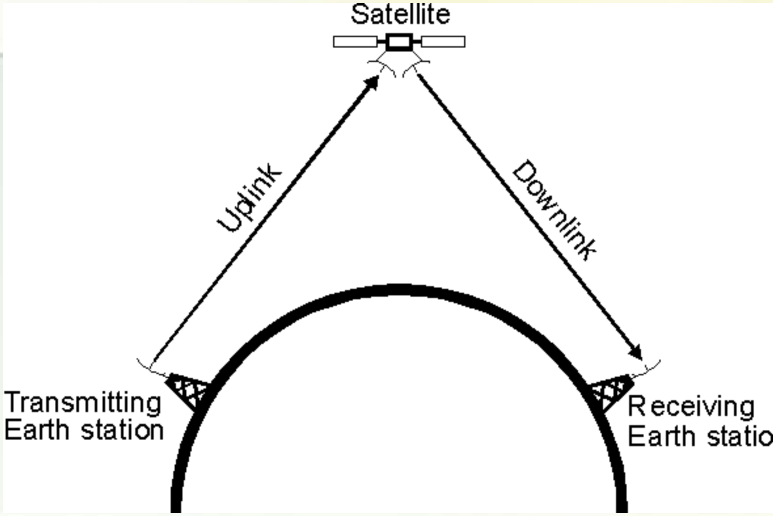
B1: Basics of Satellite Communications: Technology

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

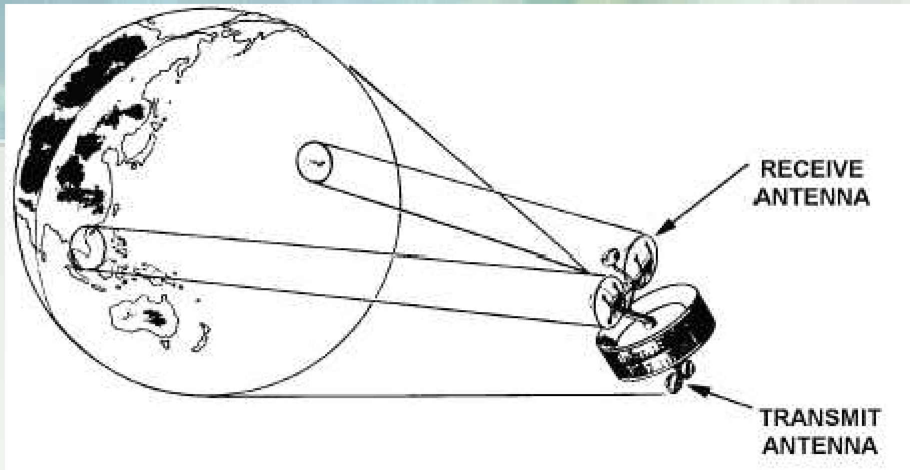
When used for communications, a satellite acts as a repeater. Its height above the Earth means that signals can be transmitted over distances that are very much greater than the line of sight. An earth station transmits the signal up to the satellite. This is called the up-link. The satellite receives 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

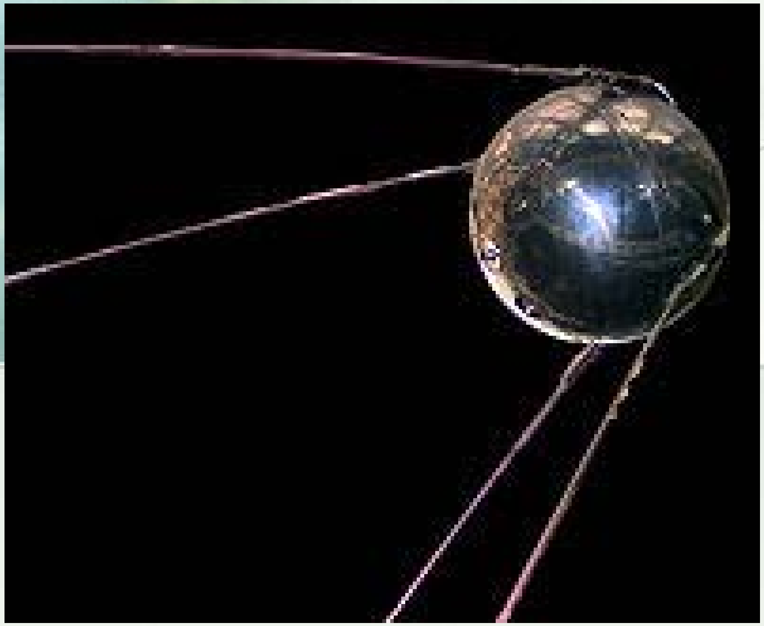
In the context of spaceflight, a **satellite** is an object which has been placed into orbit by human endeavor.

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



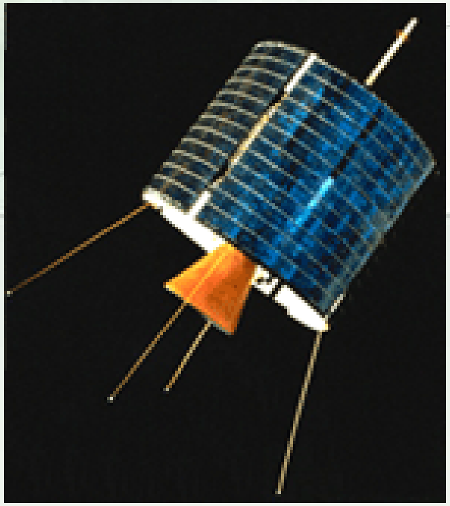
1- Birth of satellite communications

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)

1- Birth of satellite communications

Interest of satellites

Satellites are complementary to cable for the following reasons:

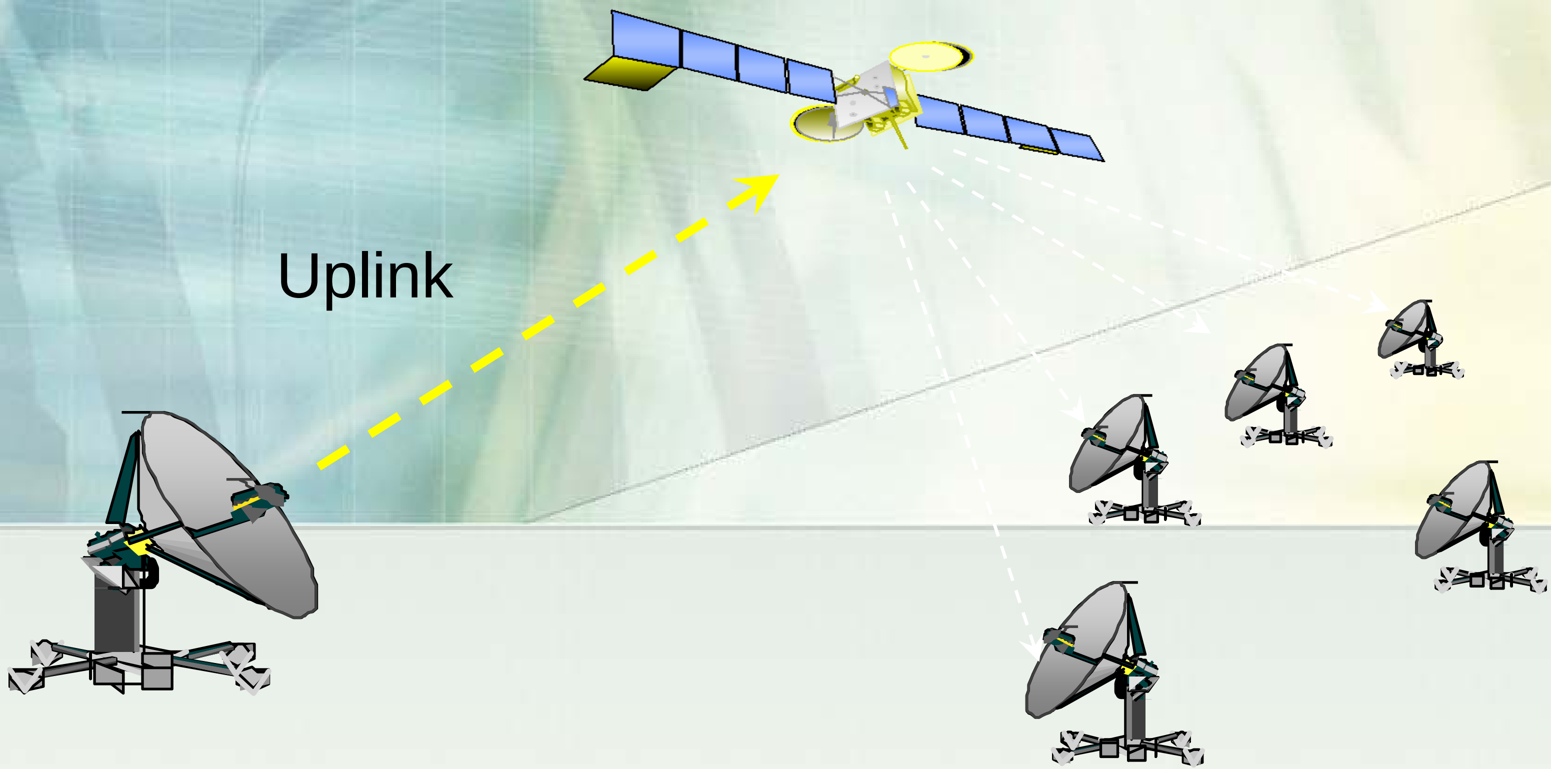
- Submarine cables (and landline fibre) are subject to cuts. Satellites provide an excellent means of back-up and should always be considered in any national plan as a means of resilience and network security
- There are satellite systems utilizing MEO (medium Earth orbit). The MEO satellites have both high capacity (in the range of 1.2Gbps per beam) and quality (low latency of 120 ms round trip) and cost ($750 per Mbps per month) factors that approach that of submarine cable.

1- Birth of satellite communications

Types of satellites

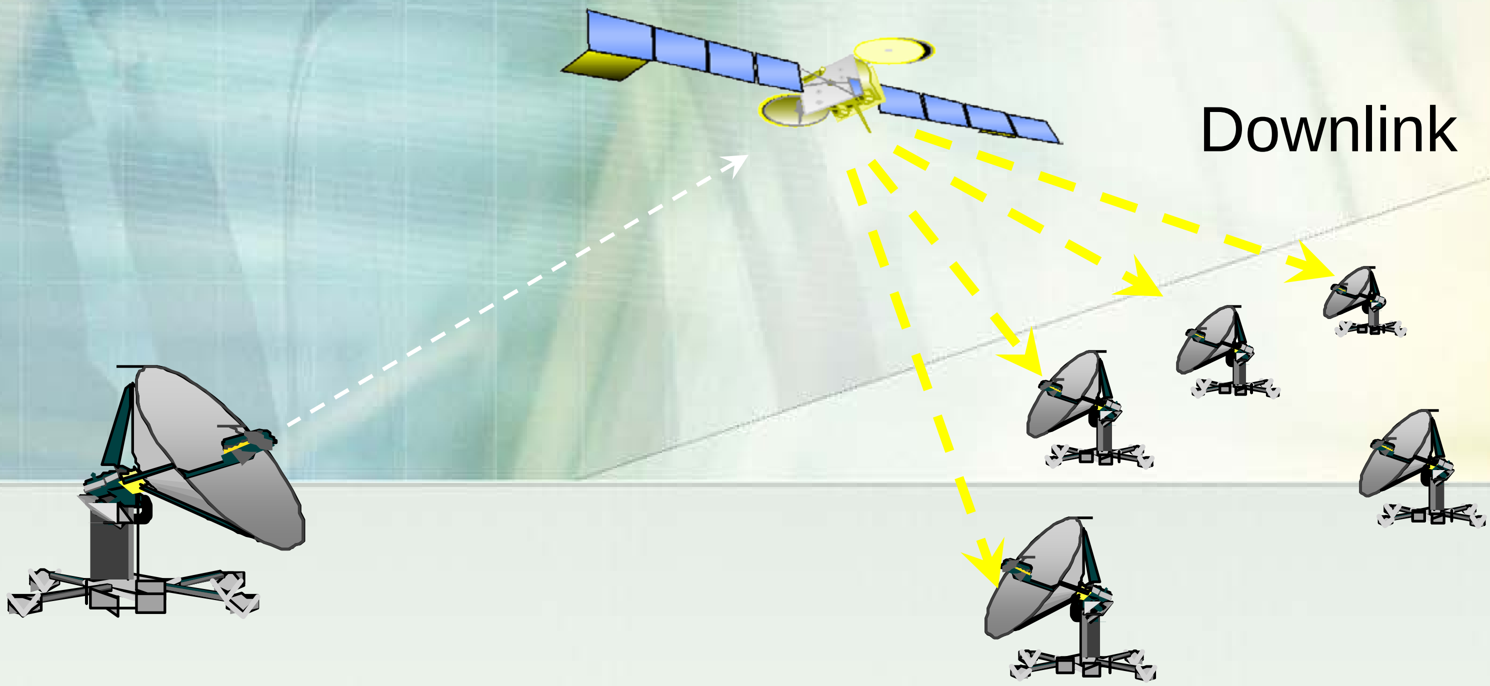
- **Earth observation satellites:** These satellites allow scientists to gather valuable data about the Earth's ecosystem
- **Navigation satellites:** Using GPS technology these satellites are able to provide a person's exact location on Earth to within a few meters
- **Broadcast satellites**: broadcast 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.
- **Military satellites**: are up there, but much of the actual application information remains secret

2- Communications links:
Uplink



Uplink - The transfer of information to the satellite

2-Communications links:
Downlink



Downlink - The transfer of information from the satellite

2-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- 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.

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-The space segment

Satellite design

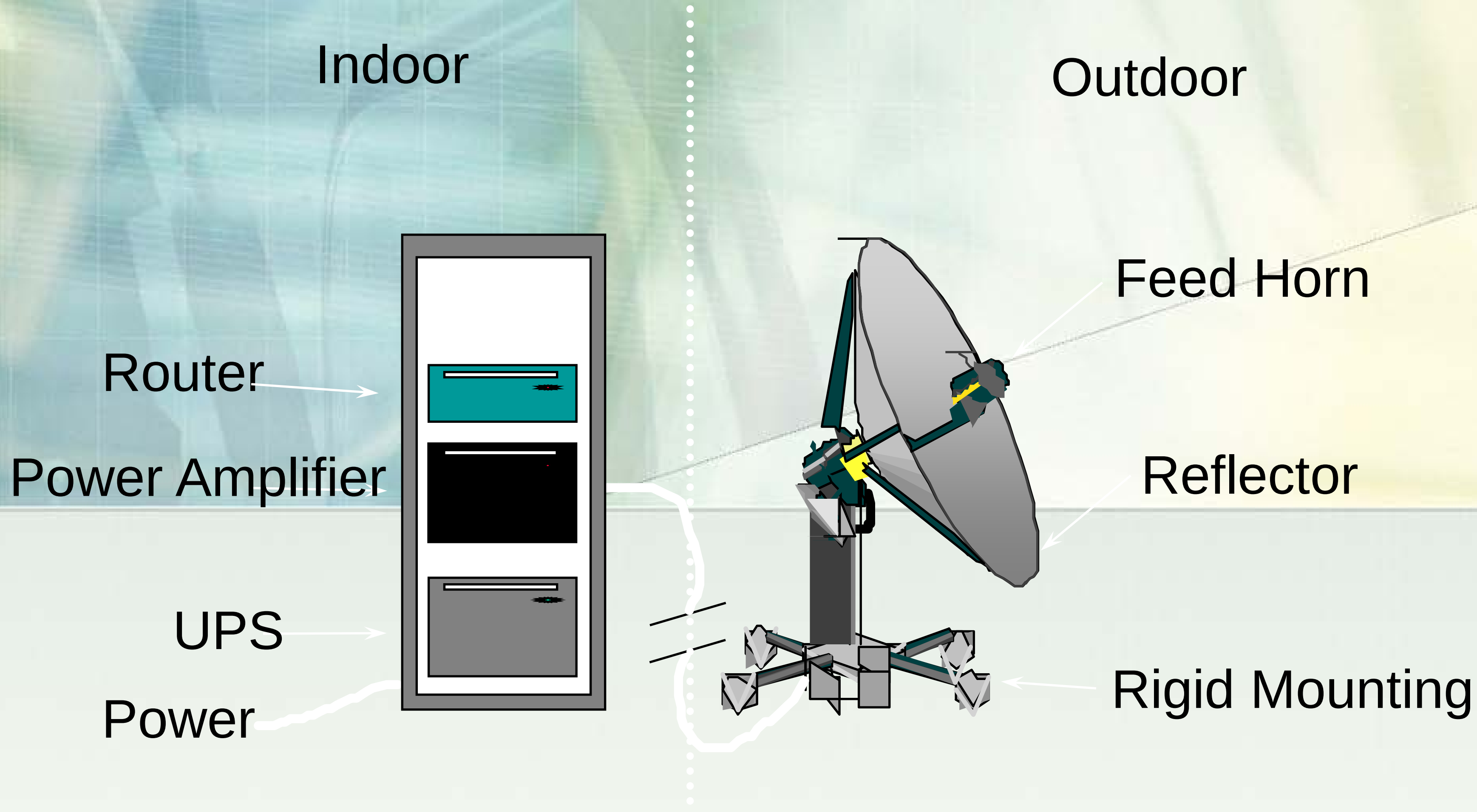
Satellite design parameters include those with respect to Payload (transponder and antenna subsystem) , Electrical Power, Attitude Control, Orbital Control , Thermal Control among others.

4- 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

4-The ground segment

Earth Station Components



Earth Station Components – generic simplified diagram

4- The ground segment

Earth Station Components

Reflector

Ground Mount with weights

4- 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

4- 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

4- 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

4- The ground segment

The differences between a Major Earth Station and a VSAT

4- 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?

5- Satellite orbits

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

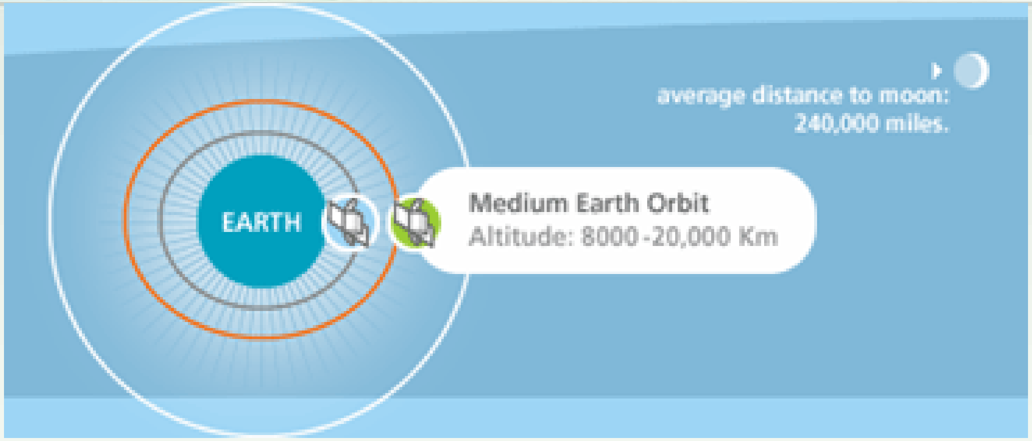
Orbiting at the height of 22,282 miles above the equator (35,786 km), the satellite travels in the same direction and at the same speed as the Earth's rotation on its axis, taking 24 hours to complete a full circle in its orbit. Thus, as long as a satellite is positioned over the Equator in an assigned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

The Operators of GEO satellites include Intelsat, Eutelsat, Inmarsat and RASCOM among others.

5- 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
- O3b Networks (www.o3bnetworks.com) operates a MEO constellation of communication satellites



5- 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
- Iridium (www.iridium.com) operates a LEO constellation of communication satellites

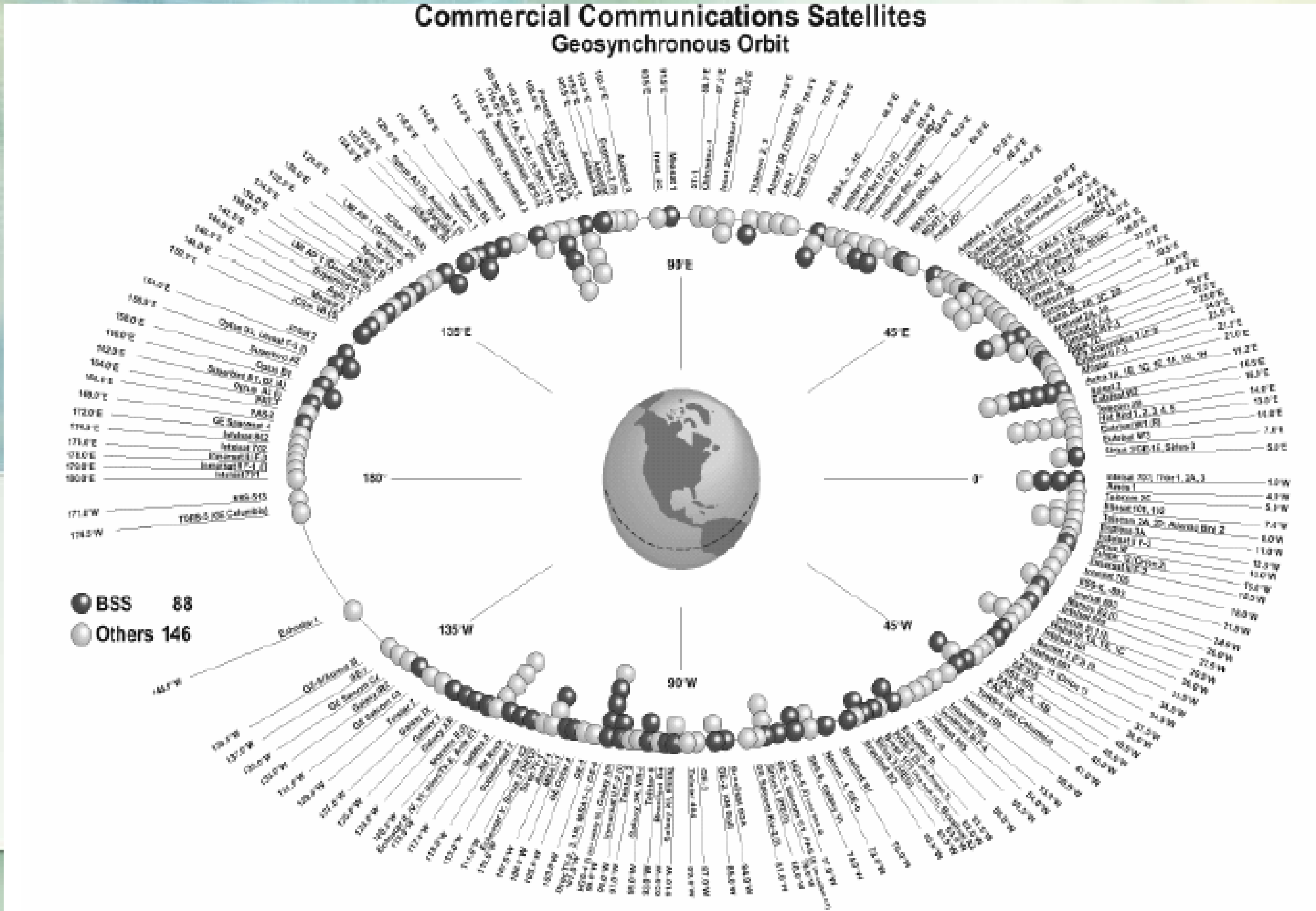
5- Satellite orbits

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- Satellite Orbits



6- 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.

6- 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".*

6- 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.

6- 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.

6- 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.

6- 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.

6- 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/

6- Orbital positions and radio interferences

EARTH STATION AND VSAT REGISTRATION

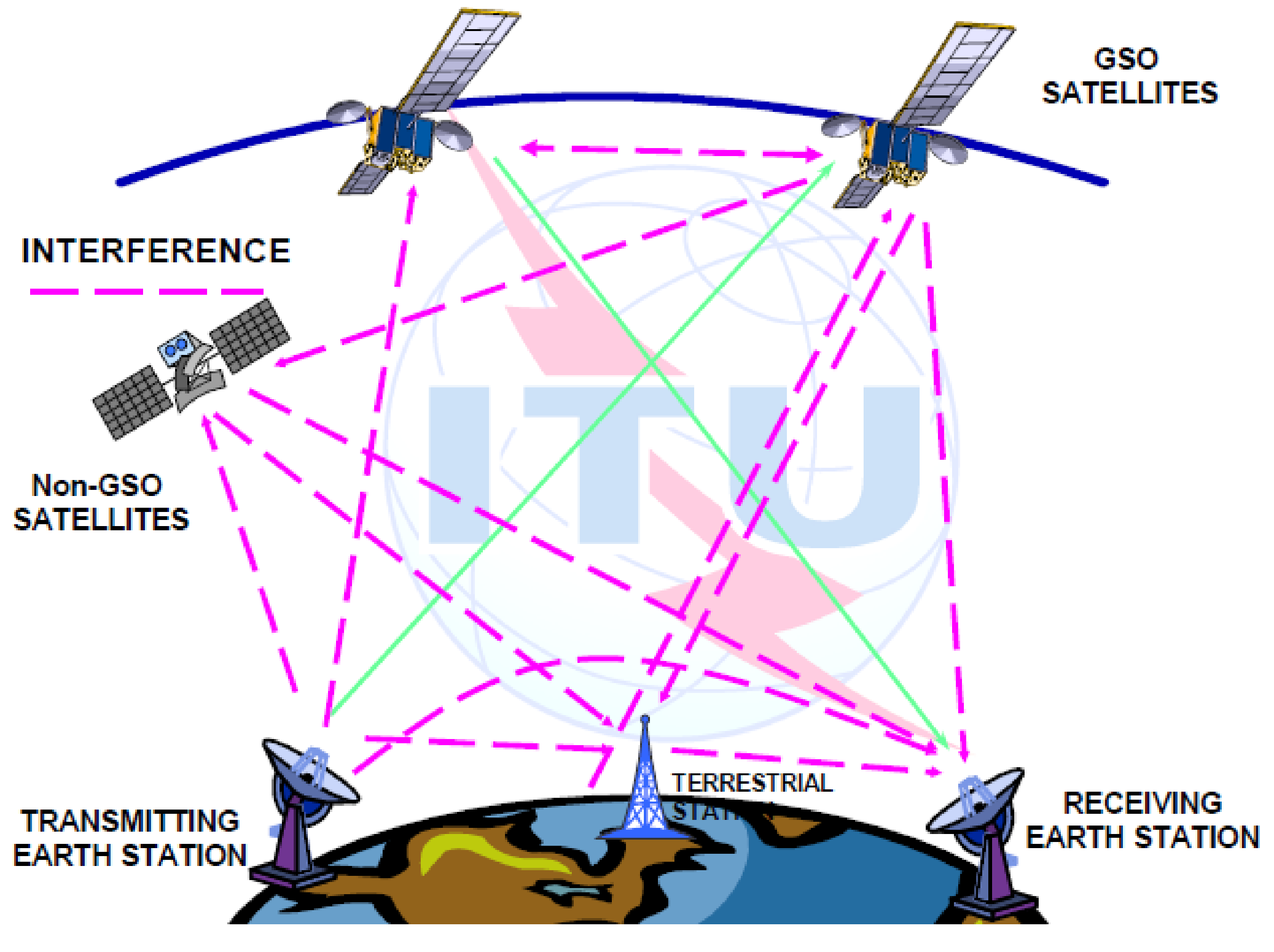
A licence usually entails the payment of a licence fee, which is most often in two parts: a one-time fee for the licensing work and an annual charge per station.

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.

6- Orbital positions and radio interferences

Interferences



7- Satellite Communications Market and Technology trends

There are many actors in the satellite communications market :

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

7- Satellite Communications Market and 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

7- Satellite Communications Market and 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

7- Satellite Communications Market and 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?

7- Satellite Communications Market and Technology trends

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

8- Satellite Operators

There are many actors in the satellite communications :

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

8- 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.

8- Satellite Operators

O3b is building a next-generation network that combines the reach of satellite with the speed of fiber. O3b satellites are placed in a Meduim Earth Orbit (MEO).

Higher capacity

O3b's satellite transponders have on average three to four times the capacity of those offered by GEO satellite systems.

Greater coverage

O3b's next-generation satellite network reach consumers, businesses and other organisations in more than 150 countries across Asia, Africa, Latin America and the Middle East.

Lower latency

Round-trip data transmission time of MEOs such as O3b satellites is reduced from well over 500 milliseconds of GEOs to approximately 100 milliseconds.

End of B1:

Basics of Satellite Communications: Technology

Thank You!