Satellite Technical Overview

August 2004

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1. Satellite

What is a Satellite?

- A satellite is a specialized wireless receiver/transmitter that repeats radio-frequencies.

- It is launched by a rocket and placed in orbit around the earth.

- There are hundreds of commercial satellites in operation throughout the world.

- These satellites are used for a wide range of purposes including Internet access, television broadcasting, wide-area network communication, weather forecasting, amateur radio communications, and the Global Positioning System.

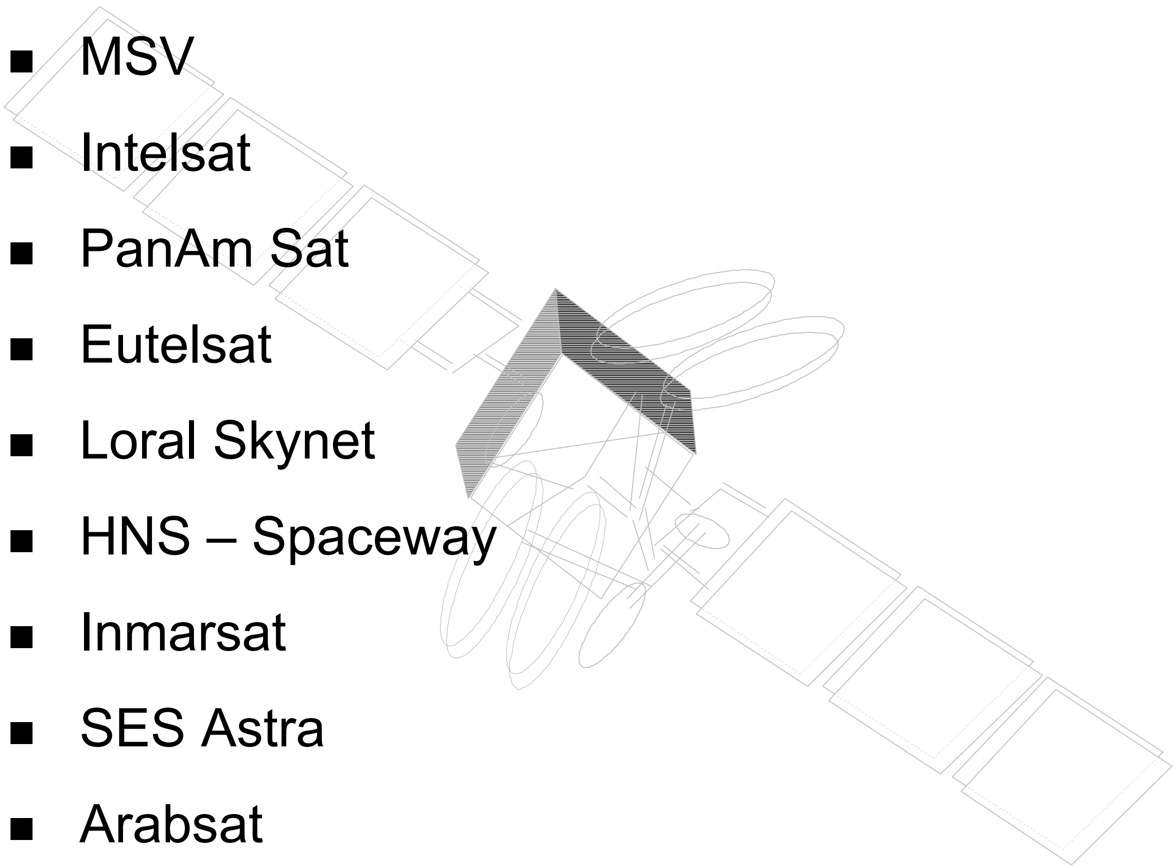
Satellite Manufacturers

- Lockheed Martin
- Boeing (Hughes Space & Communications)
- Space System Loral
- Astrium
- Alcatel Space
- Alenia Spazio
- EMS

How Big Is a Satellite?

- Satellites vary in size depending on the kind of satellite and particular use.
- Satellites weigh more at the beginning of life (BOL) in orbit than at the end because they carry fuel for the thruster engines that keep them in place in their orbits. As the fuel is burned, the satellite becomes lighter.
- Satellite typically vary in weight from 3500-6500 lbs, but can exceed 8000 lbs. Weight is based on their telecommunication payload. Smaller satellites used for direct broadcast TV and business communication networks weighs approx 3500-4000 lbs at their BOL in orbit. Larger more powerful satellites used for video distribution, satellite telephone, Internet services, and digital radio weigh approx 6500pounds at their BOL in orbit.
- When fully deployed the satellites solar panels vary in size from 85 - 160 feet.

Some World Satellite Carriers



- Telesat
- MSV
- Intelsat
- PanAm Sat
- Eutelsat
- Loral Skynet
- HNS – Spaceway
- Inmarsat
- SES Astra
- Arabsat
- SMART - ACeS

How Does a Satellite Get Into Space?

- The satellite is loaded onto a launch vehicle and carried into space by a rocket engine.

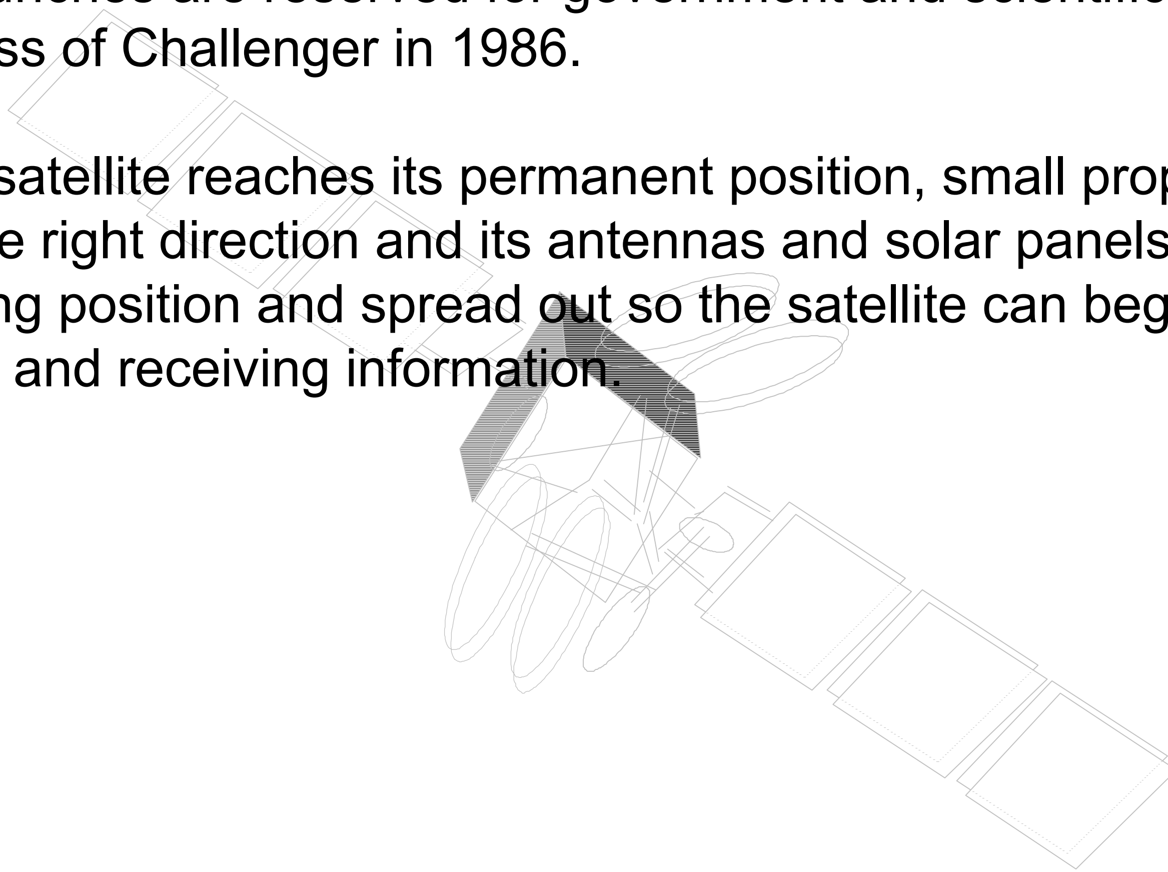
- Satellites are launched near the equator to maximize the launch efficiency, and near oceans, so that when the used launch vehicle falls away, it deploys safely in water.

- In the case of an expendable launcher, the launch vehicle's rockets lift the satellite off the launch pad and propel it into space, where it circles the earth in a transfer orbit. The first stage rockets are ejected few seconds after lift-off. The second stage motor burns until the satellite reaches the transfer orbit and is ejected, and motors attached to the satellite move it into its permanent orbit, be it geostationary or circular or elliptical high, medium or low altitude orbit. In the case of a shuttle launch, the shuttle brings the satellite on a low altitude orbit and the satellite along with its smaller second stage motor is lifted out of the shuttle and fired to go on its transfer orbit. The rest of the process is similar to that of the expandable launch.

How Does a Satellite Get Into Space? (…)

- Shuttle launches are reserved for government and scientific satellites since the loss of Challenger in 1986.

- When the satellite reaches its permanent position, small propulsion jets point it in the right direction and its antennas and solar panels unfold from their traveling position and spread out so the satellite can begin transmitting and receiving information.



What Is An Orbit?

- After launch, a satellite is placed in orbit around the earth.

- The earth's gravity holds the satellite in a certain path as it revolves around the earth.

- This path is called an "orbit."

- There are several kinds of orbits. They are:
  - (i) LEO, or Low Earth Orbit
  - (ii) MEO, or Medium Earth Orbit
  - (iii) GEO, or Geostationary Earth Orbit
  - (iv) HEO, or Highly Eliptical Orbit

LEO, or Low Earth Orbit

- A LEO is 100 - 300 miles above our planet's surface.

- The satellite must travel very fast, at 17,500 miles per hour , to avoid being pulled out of the low orbit by gravity and colliding with earth.

- Satellites in low earth orbit can circle the entire earth in approx 1.5 hours.

- Receivers on the ground must track these satellites.

- Examples include Iridium, Globalstar, International Space Station.

MEO, or Medium Earth Orbit

- A MEO is 6,000-12,000 miles above our planet's surface.

- MEO's can be elliptical as opposed to circular and can cover the North and South Poles.

- Receivers on the ground must track these satellites.

- The MEO satellites orbit is larger than LEOs and as a result they stay in sight of the ground receiving stations for a longer time.

- Example includes Global Positioning System (GPS) satellites.

GEO, or Geostationary Earth Orbit

- A GEO is 35,650 km above our planet’s surface.
- A satellite in geosynchronous orbit circles the earth in 24 hours—the same time it takes the earth to rotate once.
- These satellites are positioned over the equator and travel in the same direction and speed as the earth and therefore appear "fixed" with respect to a given spot on earth.
- In this high orbit, GEO satellites are always able to "see" the receiving stations below, and their signals can cover a large area of the earth.
- Three GEO satellites can cover the globe, except for the parts at the North and South poles.
- Most communication satellites

HEO, or Highly Elliptical Orbit

- HEO have very high apogee (maximum altitude) and low perigee (minimum altitude)
- HEO satellites can provide excellent coverage to extreme latitudes
- Many HEO orbits have a 24 hour period such that the satellite dwells for long periods of time at a fixed point over the earth
- With two or more satellites in the same orbit, one is always in the active window
- Example includes Sirius Digital Audio Radio Satellites

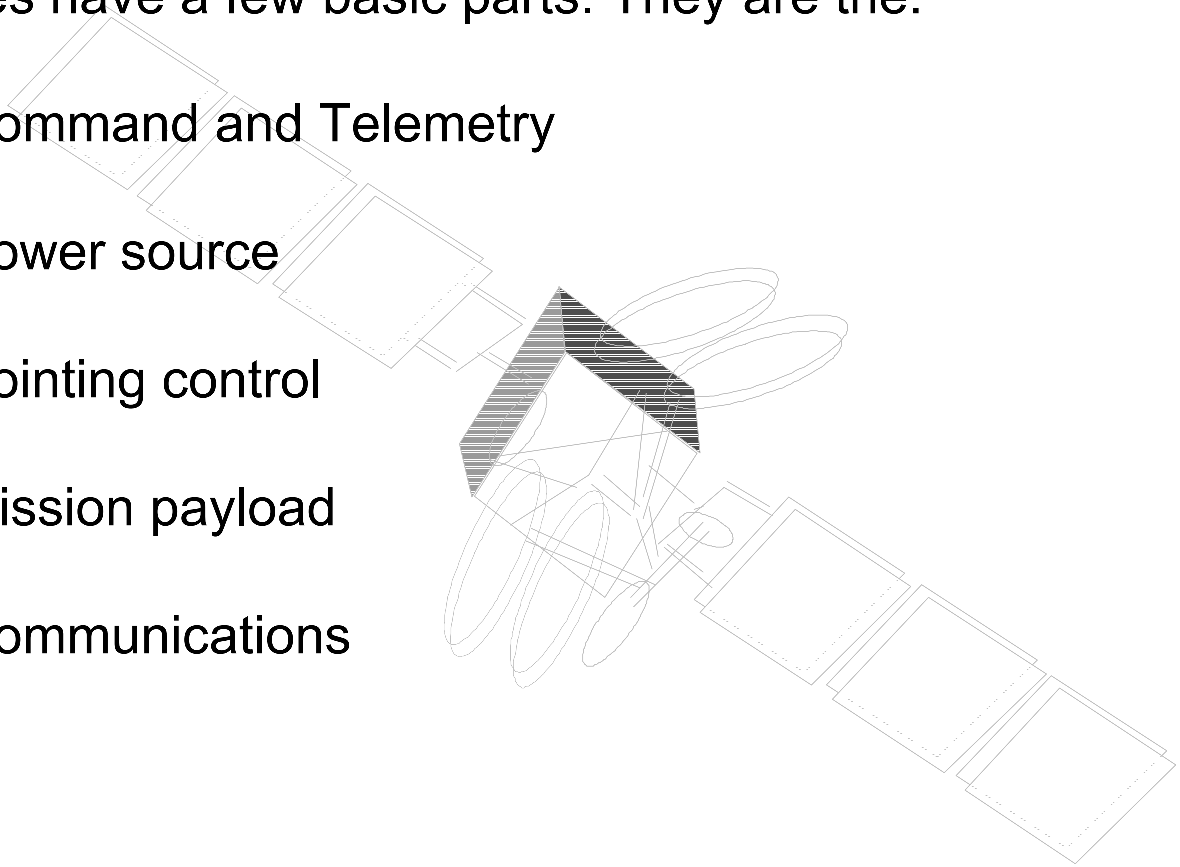
Satellite Launch Services

- ArianeSpace (Ariane) – French Guinea
- Boeing (Delta) – Cape Canaveral
- ILS (Atlas/Proton) – Cape Canaveral
- Lockheed Martin (Atlas) – Cape Canaveral
- Russian (Proton) - Baikonur Cosmodrome in Kazakhstan
- Boeing Sea Launch – Sea-based platform in the Pacific Ocean

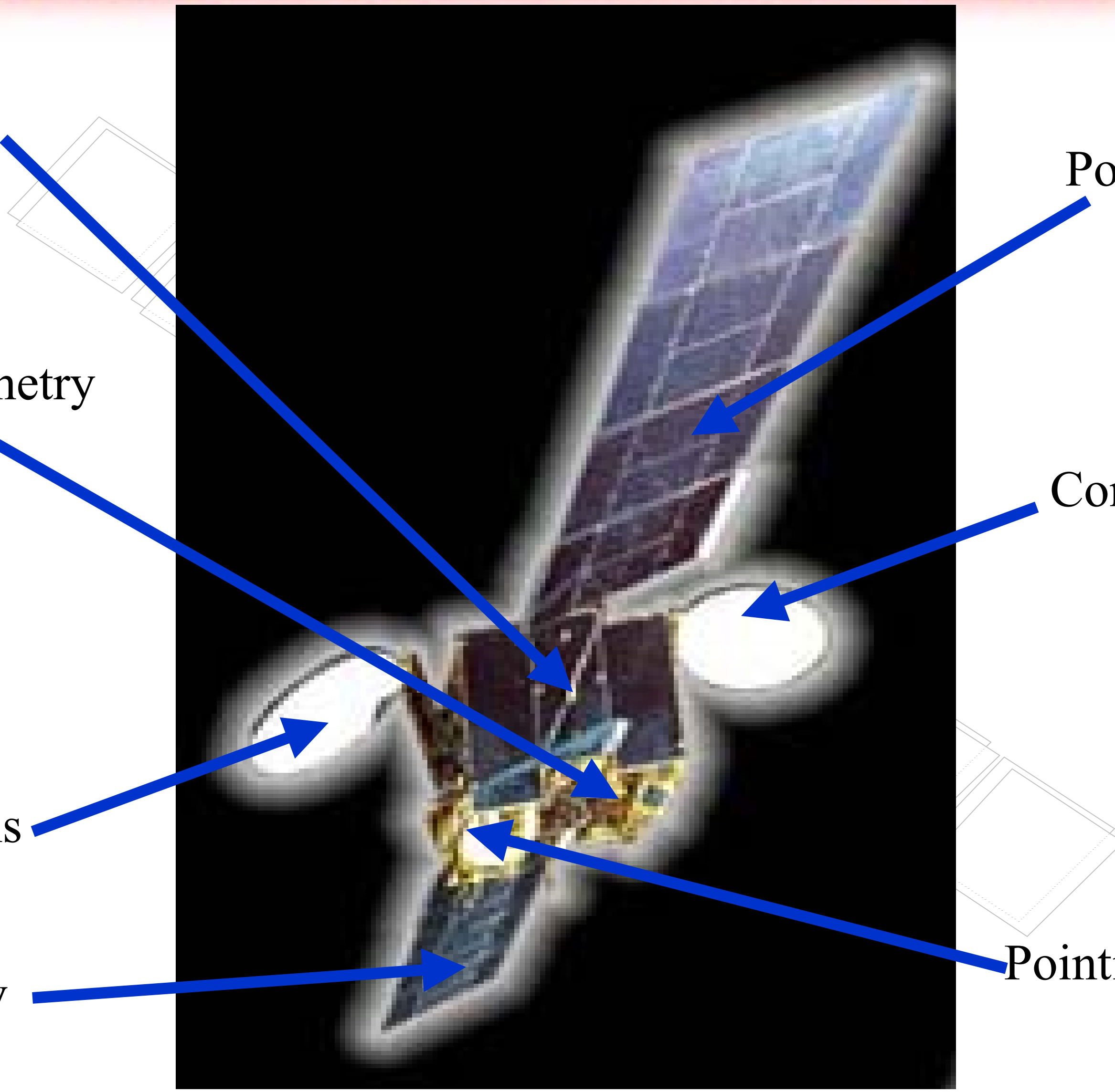
How a Satellite Works

Satellites have a few basic parts. They are the:

- Command and Telemetry
- Power source
- Pointing control
- Mission payload
- Communications



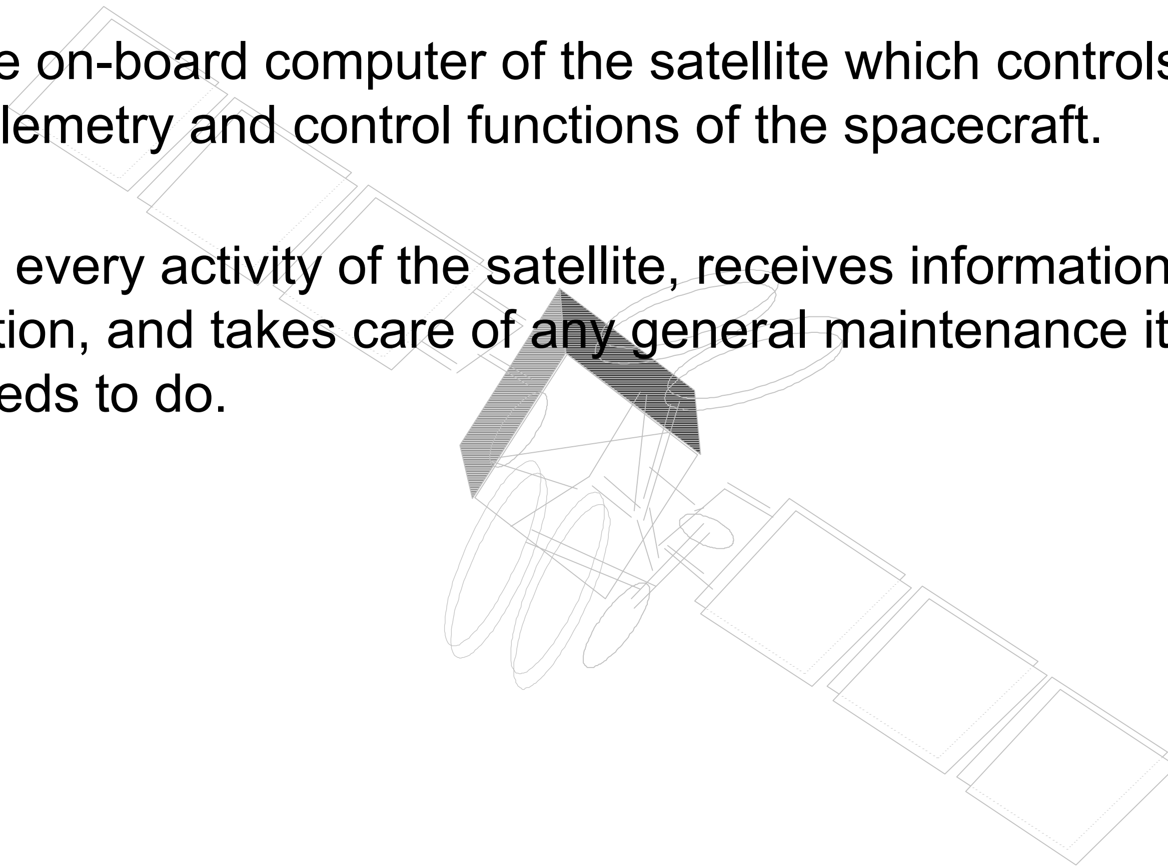
Anatomy of a Satellite



Tracking Telemetry and Control

- This is the on-board computer of the satellite which controls all the tracking, telemetry and control functions of the spacecraft.

- It records every activity of the satellite, receives information from the ground station, and takes care of any general maintenance items the satellite needs to do.

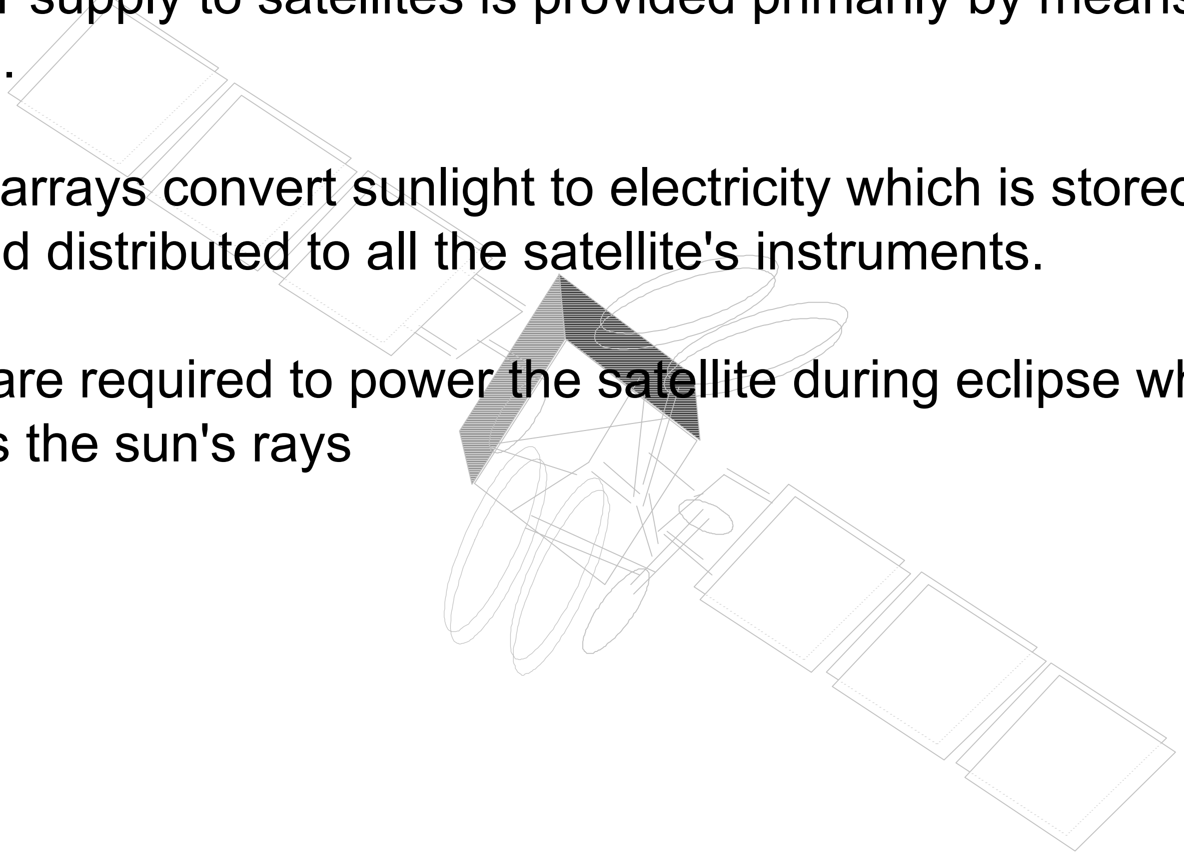


Power Supply

- The power supply to satellites is provided primarily by means of the solar arrays.

- The solar arrays convert sunlight to electricity which is stored in batteries and distributed to all the satellite's instruments.

- Batteries are required to power the satellite during eclipse when the earth blocks the sun's rays

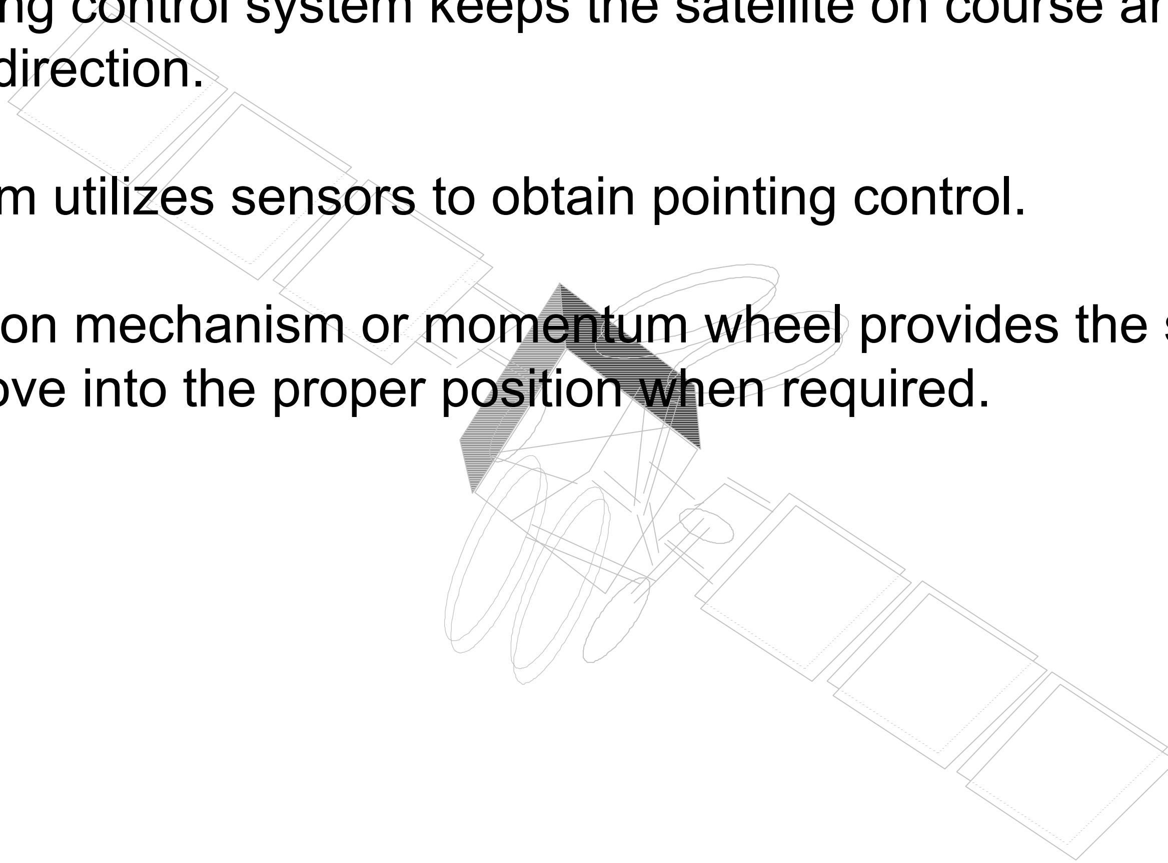


Pointing Control

- The pointing control system keeps the satellite on course and pointing in the correct direction.

- The system utilizes sensors to obtain pointing control.

- A propulsion mechanism or momentum wheel provides the satellite with a way to move into the proper position when required.

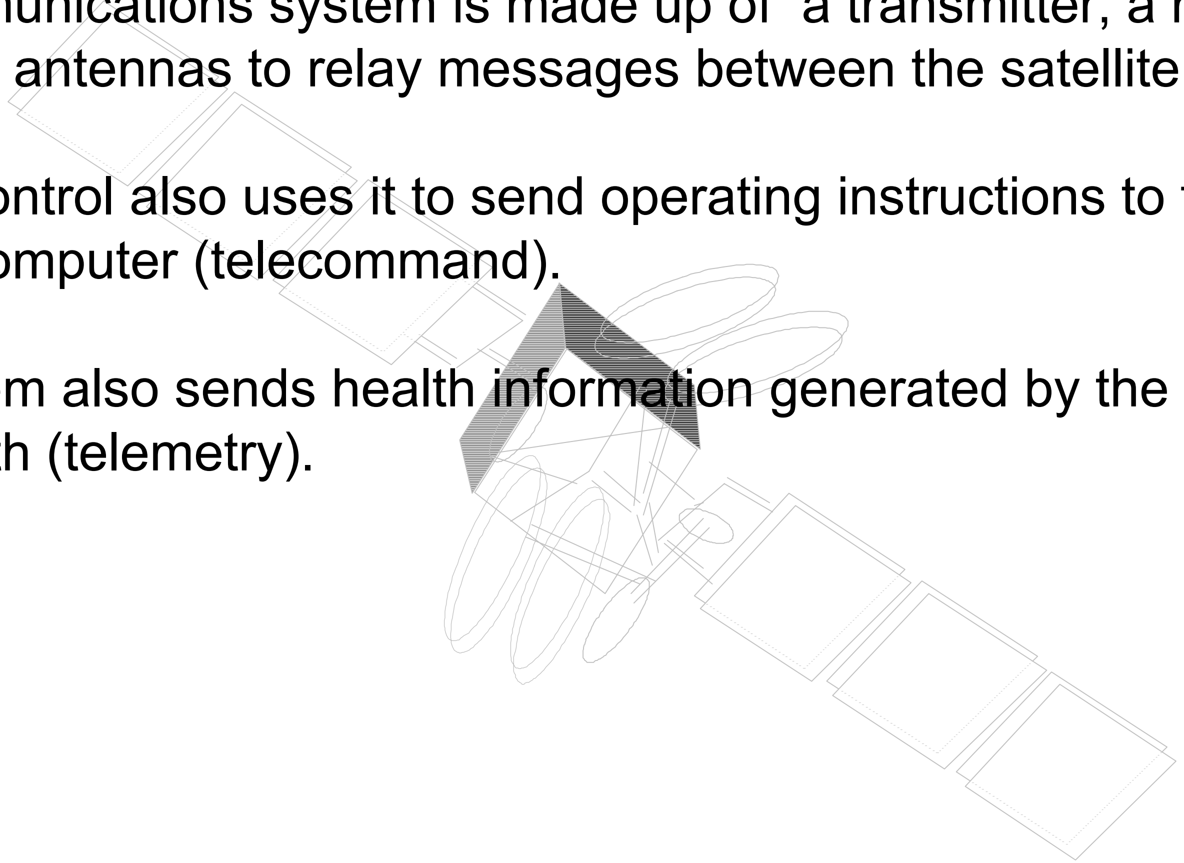


Communications

- The communications system is made up of a transmitter, a receiver, and several antennas to relay messages between the satellite and earth.

- Ground control also uses it to send operating instructions to the satellite's computer (telecommand).

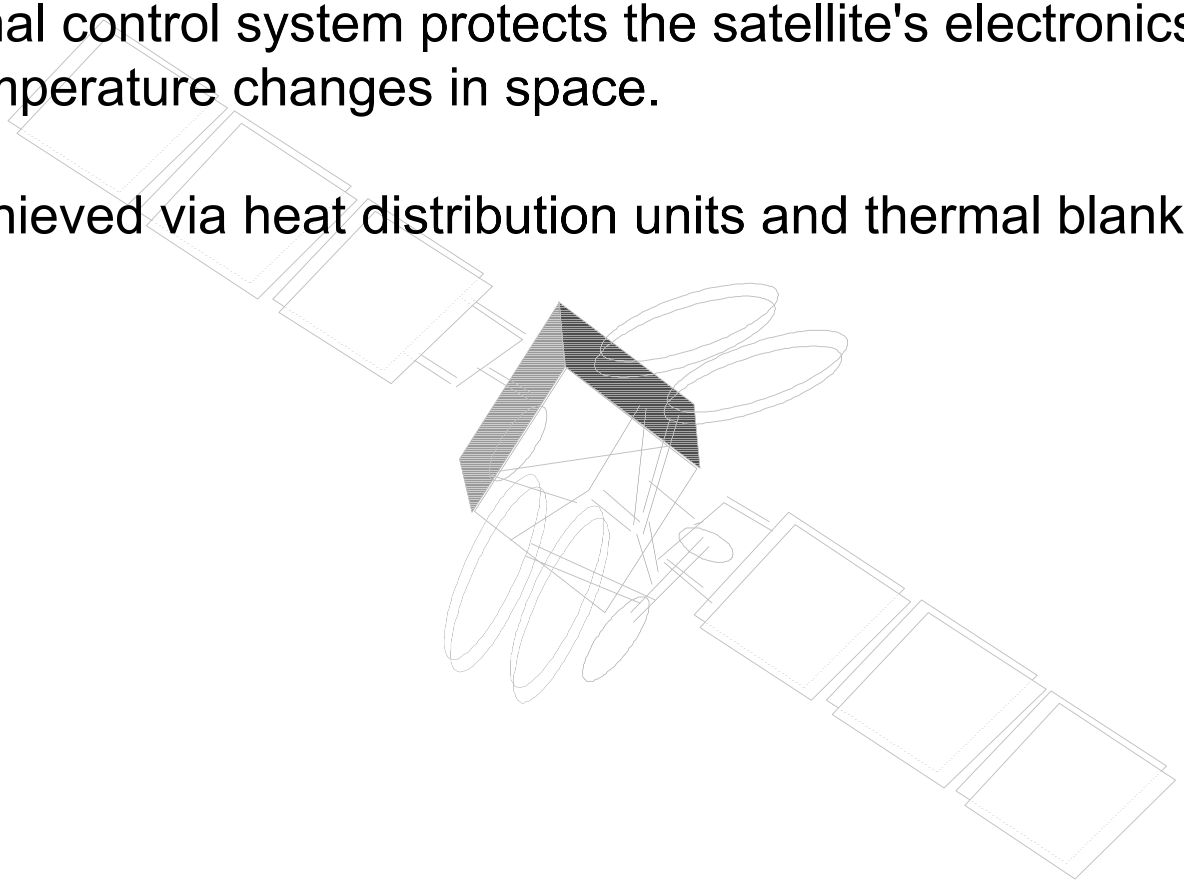
- This system also sends health information generated by the satellite back to earth (telemetry).



Thermal Control

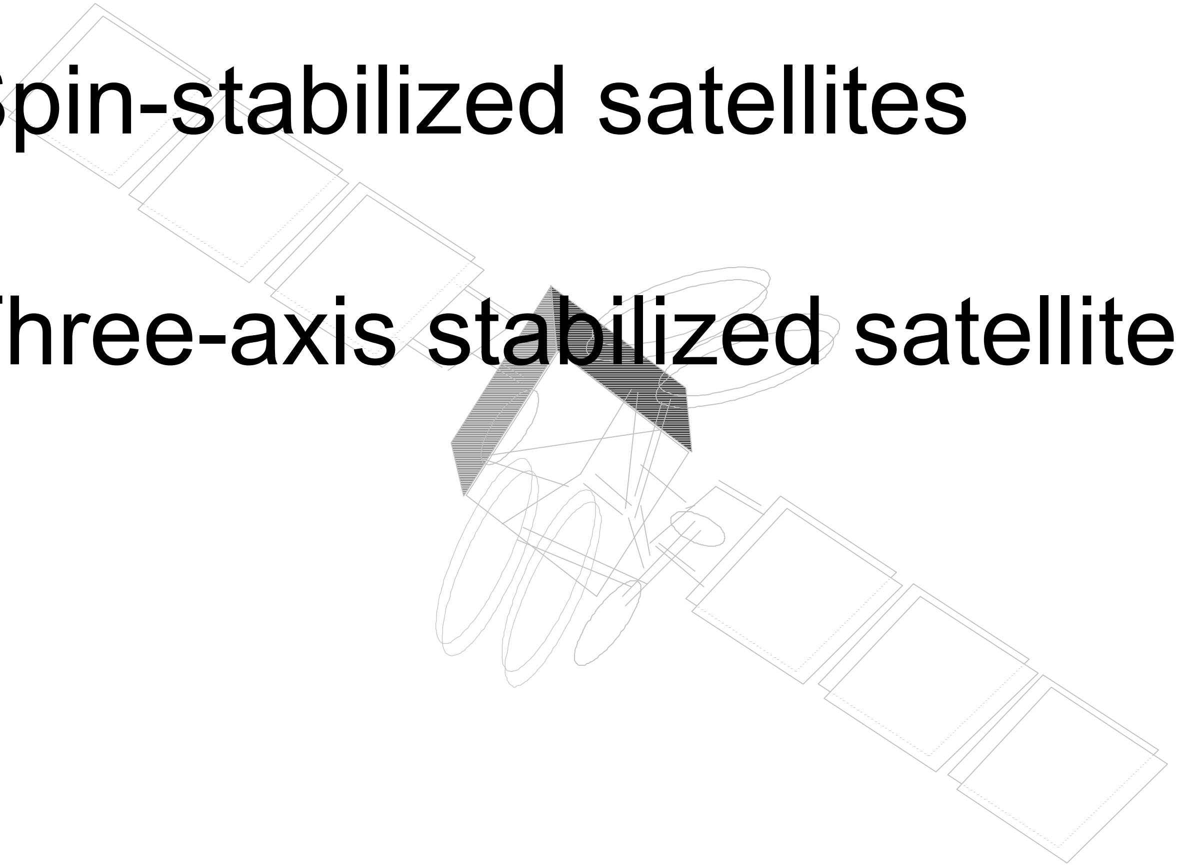
- The thermal control system protects the satellite's electronics from the extreme temperature changes in space.

- This is achieved via heat distribution units and thermal blankets.



Various Types of Satellites

- Spin-stabilized satellites
- Three-axis stabilized satellites



Spin-Stabilized Satellites

- A spin-stabilized satellite is cylindrical in shape and has two parts. One part is covered with solar panels and spins to absorb sunlight; the other part always faces the Earth so that the satellite can receive and transmit information.

- These satellites were used for almost every communications purpose requiring low to medium power including data, mobile and military communications because of the lower efficiency of their cylindrical panel in capturing the solar energy.

Three-Axis Stabilized Satellites

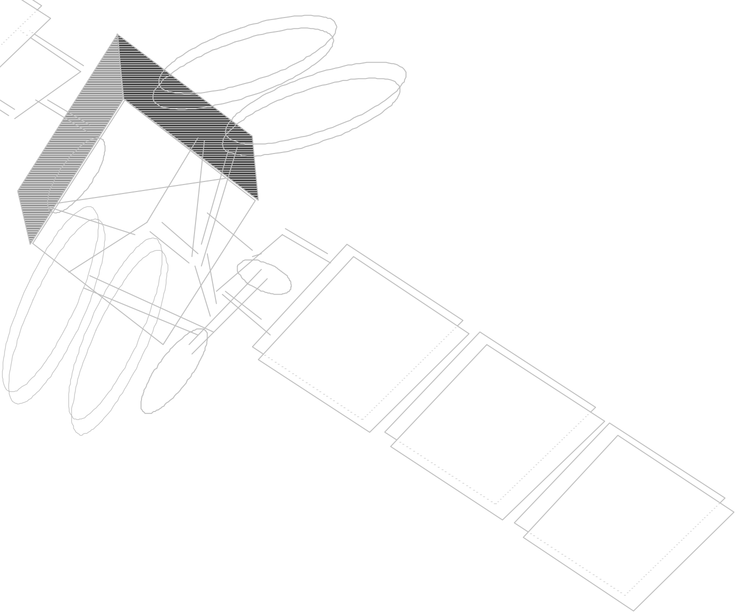
- A three-axis stabilized satellite is rectangular in shape and has no external spinning parts but rather internal spinning parts called reaction wheels to change the angular momentum.

- These satellites are used for almost all new applications including high power services such as direct television broadcasting and mobile communications.

Various Purposes For Satellites

Satellite are used for many purposes such as:

- Communications
- Remote Sensing
- Navigation
- Atmospheric Conditions
- Weather
- Search and Rescue
- Astronomy



Satellite Transponder Capacity

- A transponder is the part of the satellite that receives signals and transmits signals back to Earth.

- A typical Ku band satellite and C band satellite have 32 (27 MHz wide) transponders and 24 (36 MHz wide) transponders respectively.

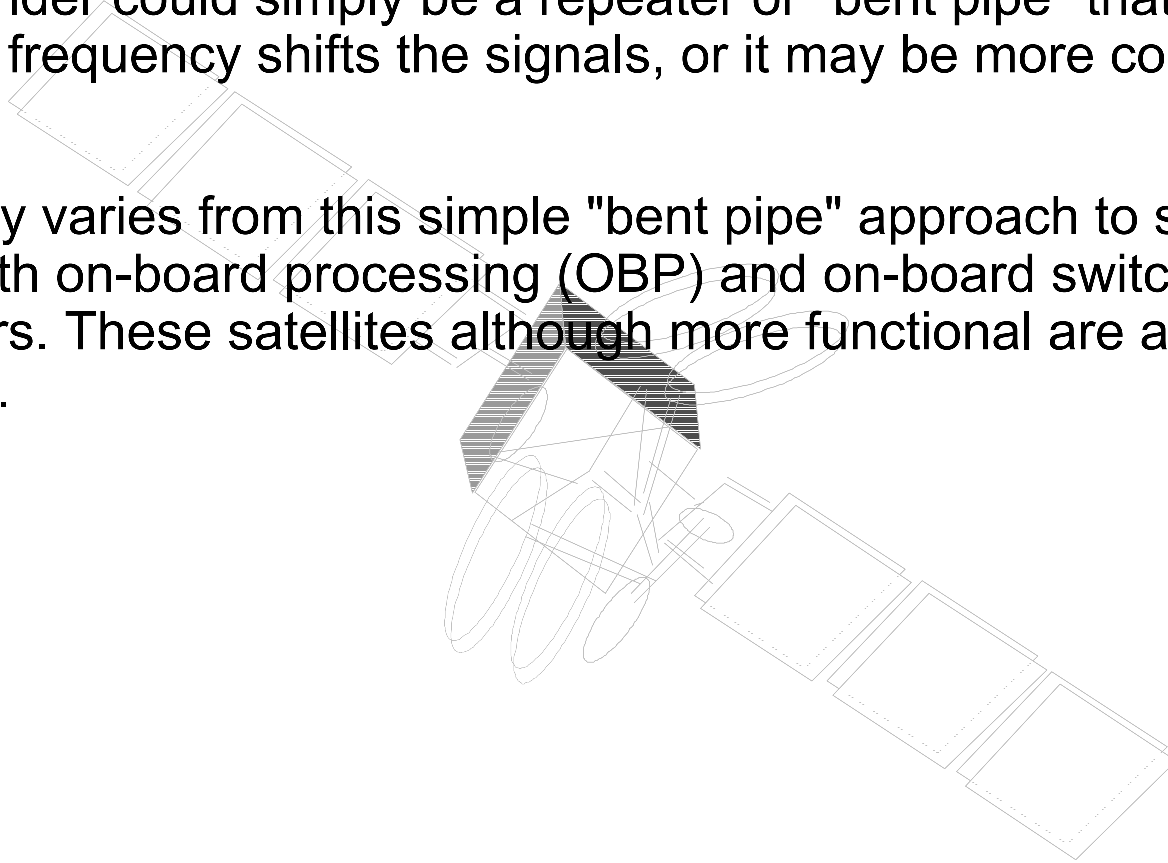
- A single transponder on one of these satellites is capable of handling an immense capacity of information which typically corresponds to the double of is bandwidth in million bits of information per second, i.e., 72 Mbit/s and 54 Mbit/s for C band and Ku band transponders respectively.

- Today's communication satellites are an ideal medium for transmitting and receiving almost any kind of content, from simple data to the most complex and bandwidth-intensive video, audio and data content.

Transponder Complexities

- A transponder could simply be a repeater or "bent pipe" that boosts the signals and frequency shifts the signals, or it may be more complex.

- Complexity varies from this simple "bent pipe" approach to smart satellites with on-board processing (OBP) and on-board switching (OBS) transponders. These satellites although more functional are also much more costly.



Transponder Interference and Efficiencies

- To avoid interference between transponder channels, a dividing bandwidth called a guard band is utilized to provide separation between each channel.

- In addition there are two sets of frequencies / transponders set at opposite polarities. This permits sharing of the same frequency or ‘frequency reuse’ without interference. To ensure no interference, each set of transponders is typically offset from each other by an amount equal to one-half of their bandwidth.

- Frequency reuse is further obtained by digitally compressing multiple channels per transponder and thereby putting more information into each uplink/downlink signal.

- On newer satellites, the bandwidth of individual channels within a transponder can be dynamically adapted from earth control stations to provide a customer with the required capacity.

Propagation Effects

- Atmospheric particles can negatively affect satellite communications, particularly in the higher satellite frequency bands such as Ku and Ka.

- Rain is the main factor that affects satellite communications.

- Other atmospheric conditions such as clouds, snow and fog can also effect satellite communications.

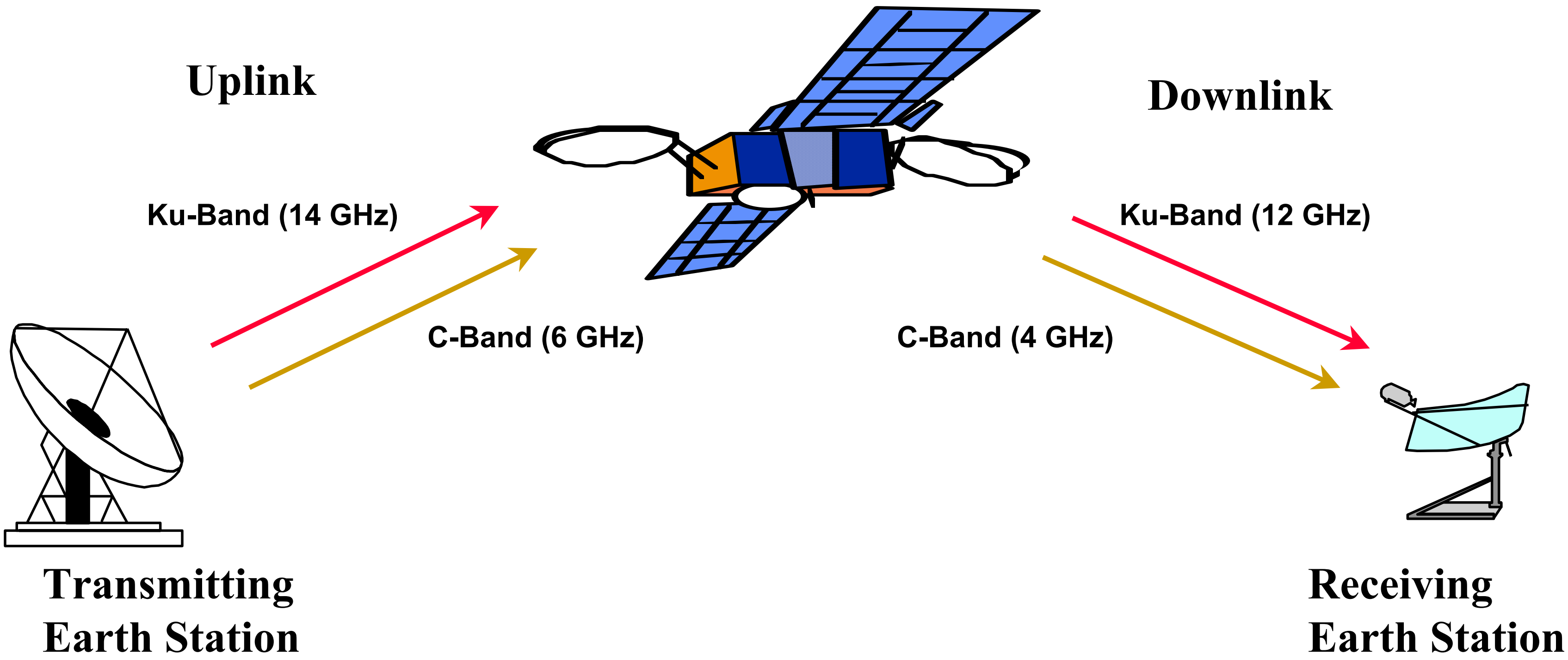
Uplink / Downlink

- An uplink is the transmission of a signal from an earth station to a satellite in orbit.

- A downlink is characterized by the satellite receiving the uplinked signal, amplifying it, shifting it to a lower frequency and then re-transmitting from the satellite antenna to an earth station(s) on the ground.

- C-band uplink frequencies are from 5.925GHz to 6.425GHz and the downlink frequencies are from 3.7GHz to 4.2GHz. Ku signals are uplinked in the 14.0-14.5GHz range and downlinked in the 10.7-12.2GHz range for the Fixed Satellite Service in North America, and 12.2-12.7 GHz for DBS.

Typical C and Ku Band Uplink/Downlink



Satellite Frequency Bands and Antenna Size

- Commonly used satellite frequency bands are L, C, and Ku.

- C and Ku are the most common frequencies for fixed satellite services such as video, data and voice.

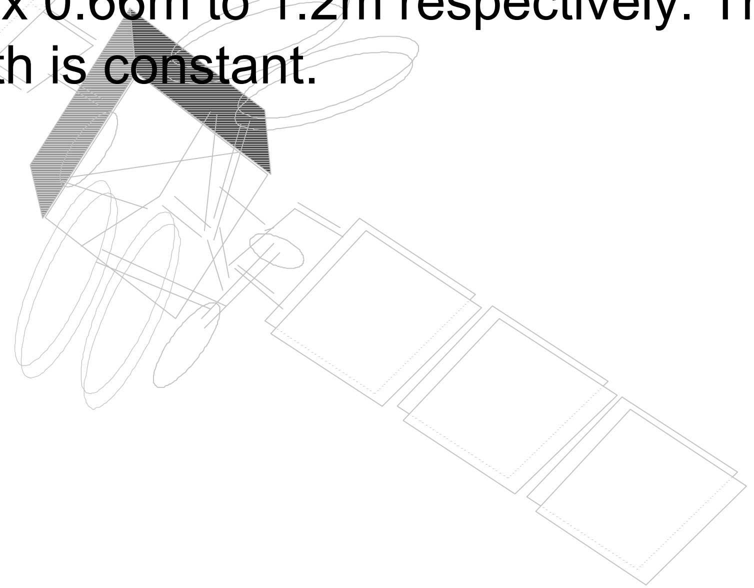
- L is the most common frequency for mobile satellite services such as voice and data.

- Ka-band will be used in the near future for video and data services.

- The frequency and power output of a satellite signal determine the size of the earth station antenna. When the frequency increases, the wavelength decreases. As wavelength increases, larger antennas are necessary to gather the signal.

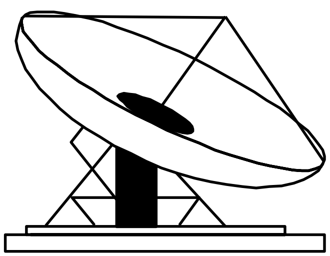
Satellite Frequency Bands and Antenna Size (…)

- For example, C band satellite transmissions are at a low frequency in the 4-6 GHz range with larger wavelengths than Ku band or Ka band. These larger wavelengths mean that a larger satellite antenna is required to gather the minimum signal strength typically a 1.8m to 3.7m for C band whereas Ka and Ku are approx 0.66m to 1.2m respectively. This statement of relativity assumes bandwidth is constant.



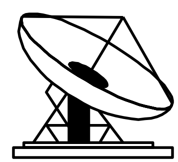
Typical Antenna Size

C band



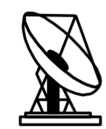
1.8m-3.7m

Ku Band



1.0m-1.2m

Ka Band



0.66m-0.75m

Satellite Footprint EIRP and G/T

- Satellites have uplink and downlink footprints, which are the areas on earth where the satellite can be used.

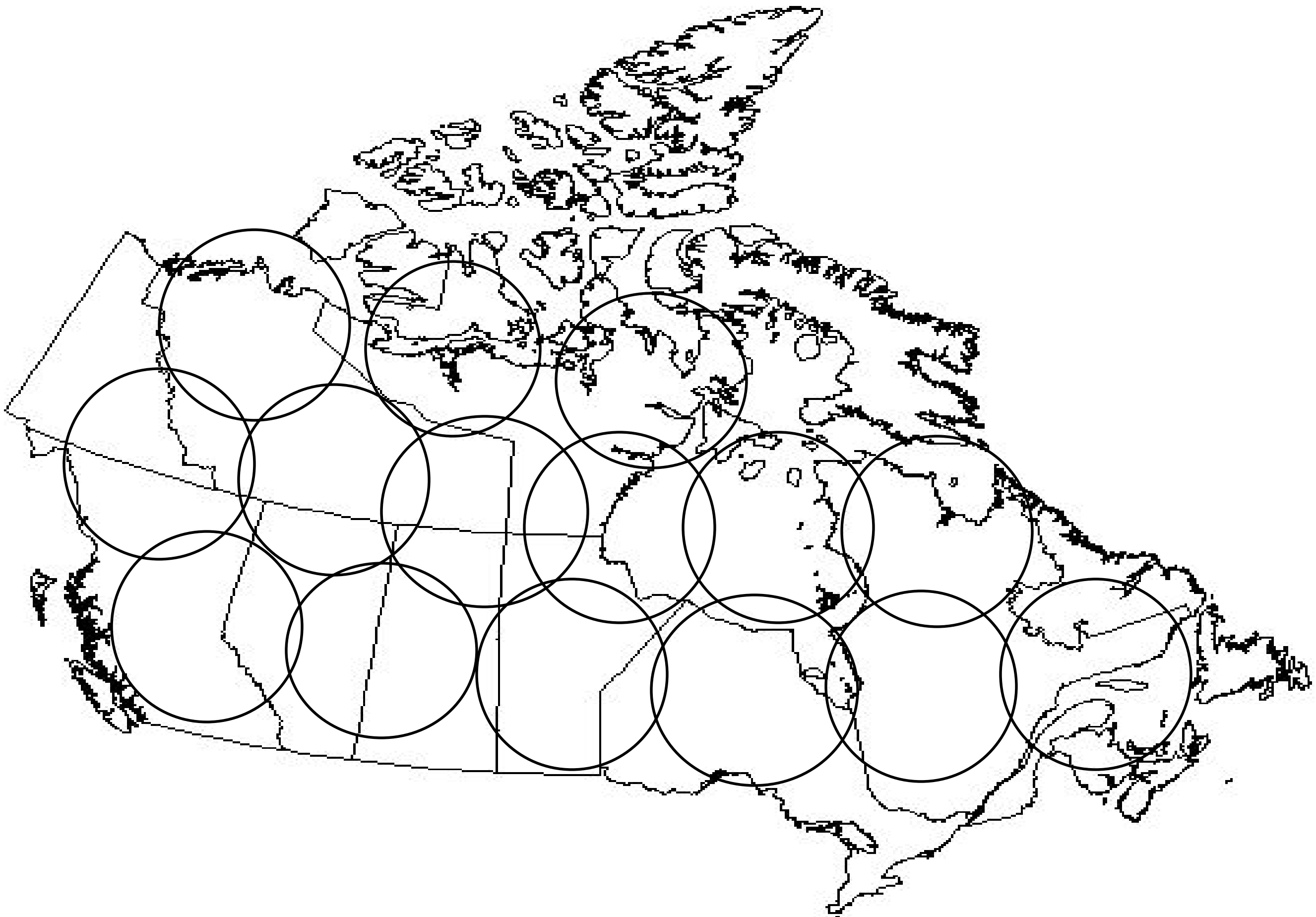
- Downlink footprints are measured by EIRP which is the power radiated to earth. These downlink footprints can be global broad beams , regional or national beams, and/or configured to target only a small area called a spot beam. EIRP maps are used by satellite system designers to calculate link budgets to determine the satellite dish size required to receive signals from a specific satellite.

- Uplink footprints are measured by G/T which is the sensitivity of the receiving capability of the satellite to accept signals from earth stations.

- Some satellites have the capability to be reconfigured on demand from control earth stations to change their footprints via flexible steerable beams.

Typical National Footprint

Typical Spot Beam Footprint



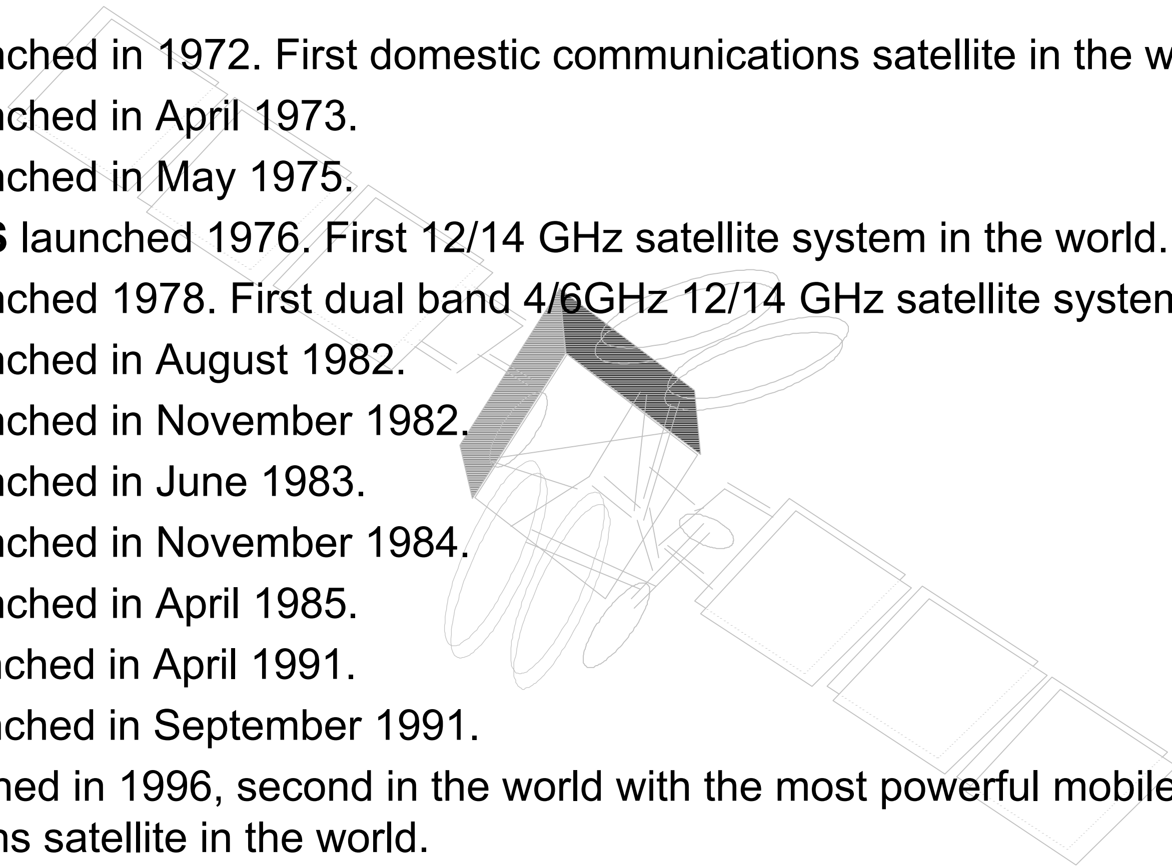
Security Aspects for Networks over Satellite

- A basic satellite communication link inherently offers few points for unauthorized access as compared to any terrestrial system, however the Radio Frequency signal can be intercepted anywhere within the satellite footprint.

- The earth stations are installed typically on the customer's premises, where the customer computer equipment is co-located. This makes it difficult for access by unauthorized persons.

- While the hardware used today by satellite systems makes it possible to intercept the satellite signals, Inbound and Outbound channels utilize various techniques to secure the data including encryption, encapsulation, bursty transmissions and frequency changes.

History of Satellite Programs in Canada



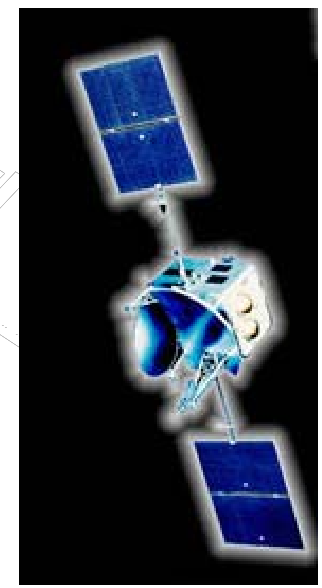
- **Allouette I** launched 1962. Ionospheric research-3rd nation in the world to launch a satellite.
- **Anik A1** launched in 1972. First domestic communications satellite in the world.
- **Anik A2** launched in April 1973.
- **Anik A3** launched in May 1975.
- **Hermes/CTS** launched 1976. First 12/14 GHz satellite system in the world.
- **Anik B1** launched 1978. First dual band 4/6GHz 12/14 GHz satellite system in the world.
- **Anik D1** launched in August 1982.
- **Anik C3** launched in November 1982.
- **Anik C2** launched in June 1983.
- **Anik D2** launched in November 1984.
- **Anik C1** launched in April 1985.
- **Anik E2** launched in April 1991.
- **Anik E1** launched in September 1991.
- **MSAT** launched in 1996, second in the world with the most powerful mobile communications satellite in the world.
- **Nimiq1** direct broadcast satellite launched in May 1999.
- **Anik F1** launched in November 2000.
- **Nimiq2** direct broadcast satellite launched in December 2002.

Canada Satellite Firsts

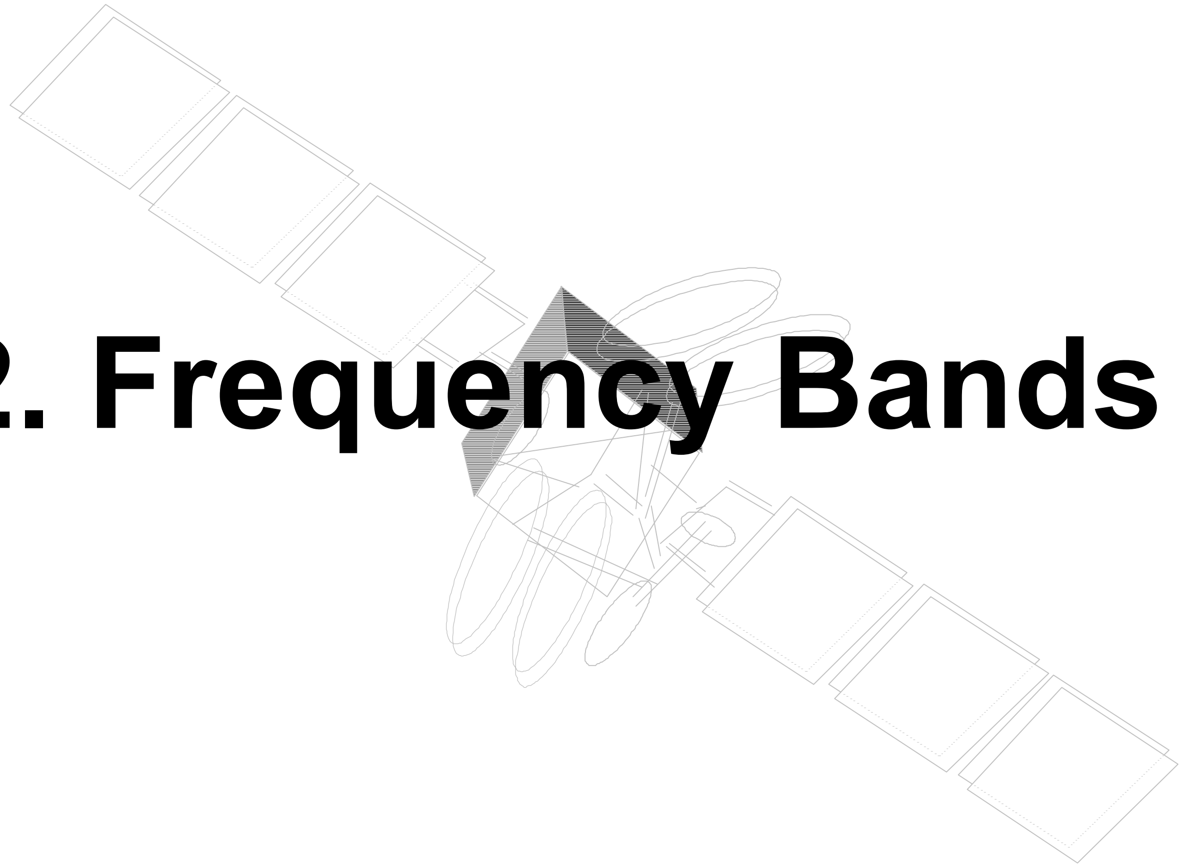
Alouette 1

Anik A1

Anik B1



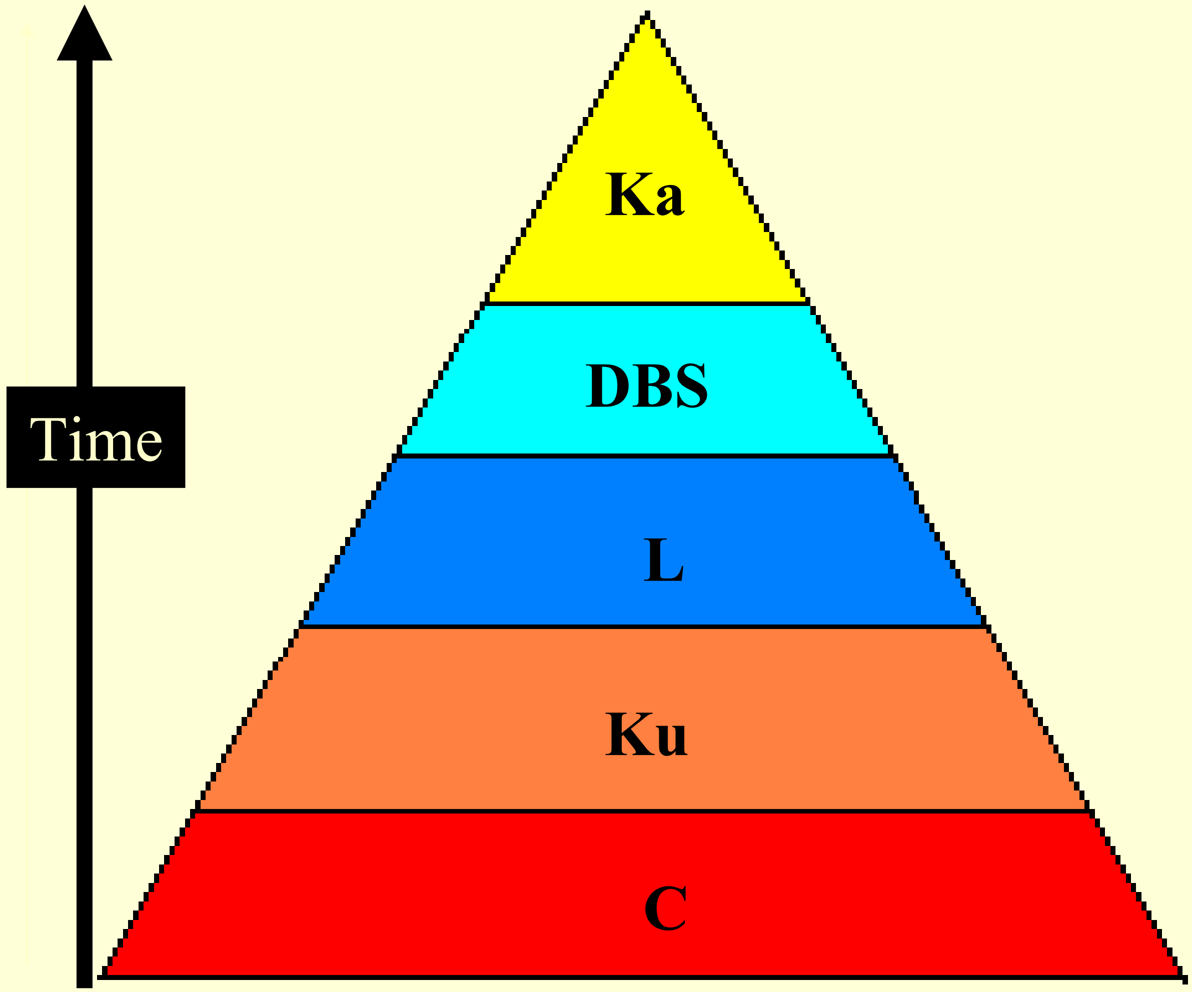
2. Frequency Bands



Partial Spectrum Chart

L-band	1200 MHz to 1600 MHz
Personal Communications Services (PCS)	1850 MHz to 1990 MHz
Superhigh Freq (SHF)(Microwave)	3 GHz to 30 GHz
C-band	3600 MHz to 7025 MHz
X-band	7.25 GHz to 8.4 GHz
Ku-band	10.7 GHz to 14.5 GHz
Ka-band	17.3 GHz to 31.0 GHz
Extremely High Frequencies (EHF)	30.0 GHz to 300.0 GHz
Additional Fixed Satellite: Several allocations between	38.6 GHz and 275 GHz
Infrared Radiation	300 GHz to 430 THz
Visible Light	430 THz to 750 THz

Satellite Frequency Bands



Evolution of Satellite Frequency Bands

Frequency Review: C-Band

- Introduced in the 1970's.
- Occupies the 4-6 GHz frequency band.
- Shared band with terrestrial microwave.
- C band channels are typically 36 MHz.
- Typically provides national domestic, regional or even global coverage.
- Characterized by higher availability links that are less susceptible to rain fade.
- Lower cost per MHz when compared to other frequency bands.
- Larger antennas required when compared to other frequency bands.

Frequency Review: Ku-Band

- Introduced in the 1980s.
- Occupies the 12-14 GHz frequency band.
- Ku is dedicated for satellite communications only and therefore no frequency coordination is required with terrestrial.
- Provides domestic & international coverage.
- Smaller earth stations manufactured at higher volumes bringing lower cost.
- Limited affect by rain causing a lower link availability when compared to C band.
- Ku band transponders are typically 27 MHz.

Frequency Review: L-Band

- Introduced in the 1990s.
- Shared band:
  - limited spectrum
  - results in high cost per bandwidth
- Provides domestic & international coverage.
- Smaller earth stations.
- Enables mobile applications.
- No affect by rain, but signal blockage due to natural and man-made obstacles is a consideration due to mobility of earth stations.

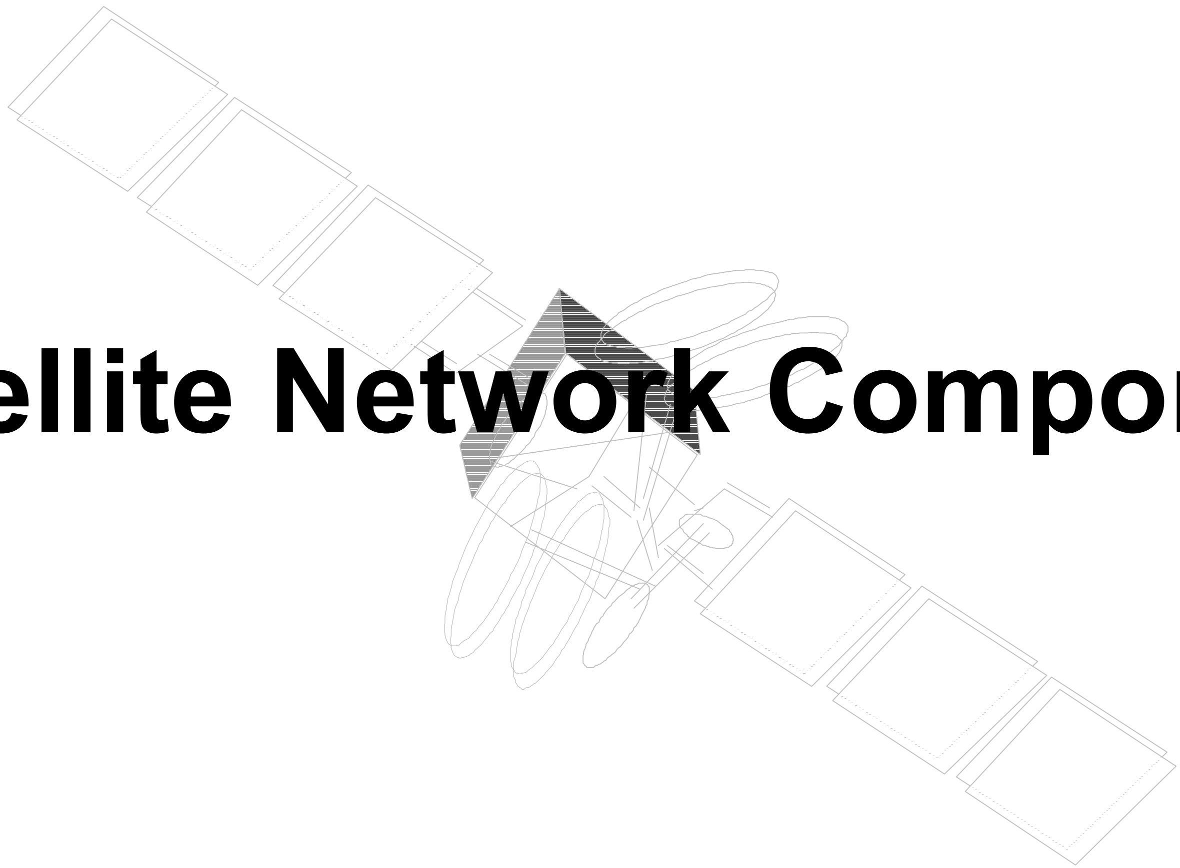
Frequency Review: DBS-Band

- Introduced in the late 1990's.
- Dedicated satellite band only and therefore no frequency coordination. is required with terrestrial.
- Provides domestic & international coverage.
- Very small Rx Only Earth Stations.
- High volume low cost receivers.
- Limited affect by rain.

Frequency Review: Ka-Band

- Introduced in the year 2004.
- Part of the band is dedicated to satellite band only and therefore no frequency coordination is required with terrestrial.
- Permits frequency re-use through spot beams.
- Lower costs per unit of bandwidth.
- Provides domestic & international coverage.
- Utilizes very small earth stations.
- Consumer, SME, and Enterprise are the target markets.
- Affected by rain to a greater degree than Ku band.
- Rate adaptation techniques required to mitigate rain effects.

3. Satellite Network Components



How Does a Star Satellite Network Work?

- A star satellite network has three components:
  - Hub (also called a master earth station)
  - Satellite
  - Earth stations in various locations across a country or continent

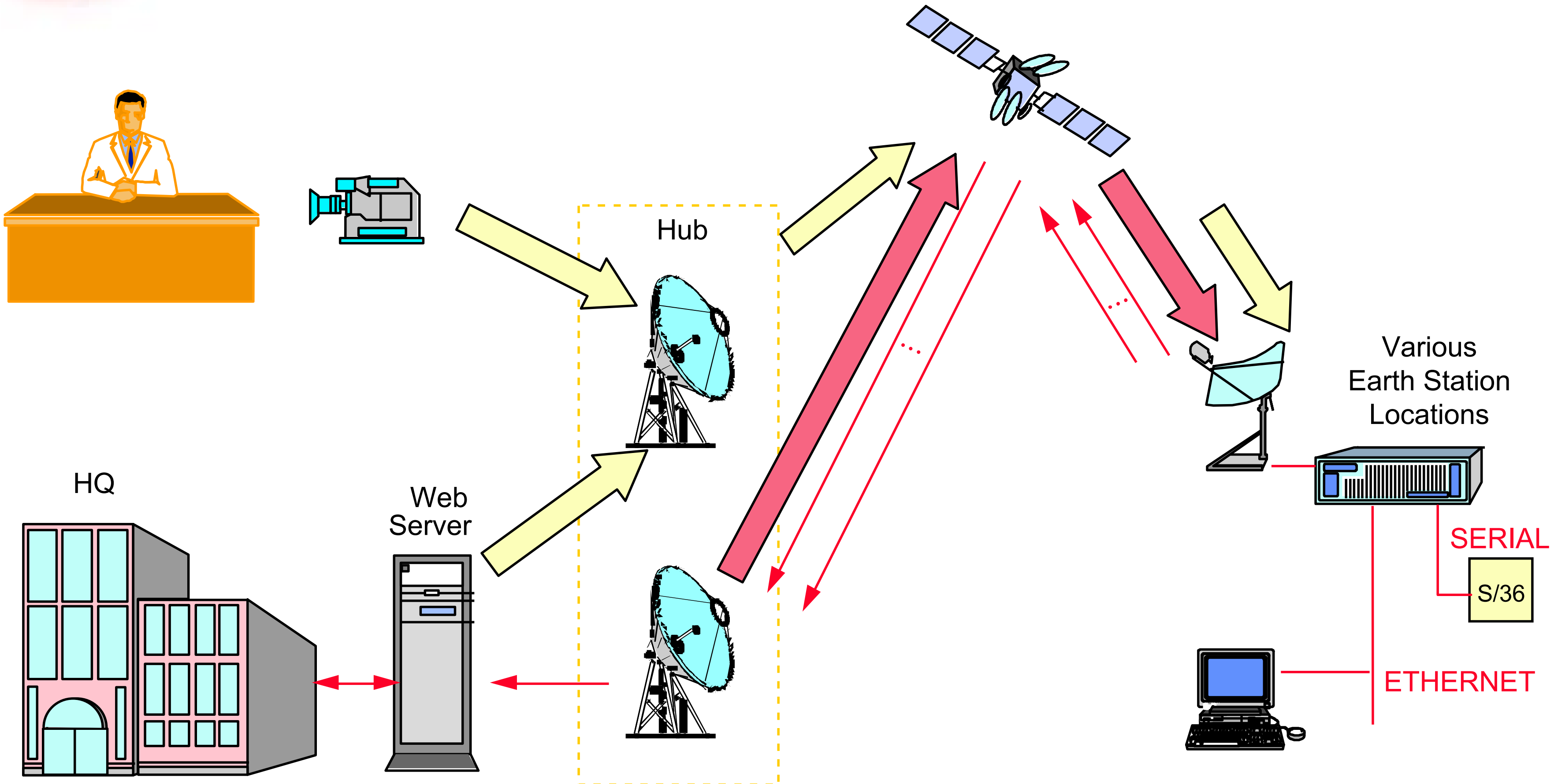
- Content originates at the hub, from a large 4.5m-11m antenna. The hub controls the network through a network management system (NMS), which allows a network operator to monitor and control all components of the network. The NMS operator can view, modify and download individual configuration information to the individual earth stations.

How Does a Star Satellite Network Work? (…)

- Outbound information (from the hub to the earth station) is sent up to the satellite transponder, which receives it, amplifies it and sends it back to earth for reception by the earth station. The earth station at the remote locations send information inbound (from the earth station to the hub) via the same or another satellite transponder to the hub station.

- This arrangement, where all network communication passes through the network's hub, is called a "star" configuration, with the hub station at the center of the star. One major advantage of this configuration is that there is virtually no limit on the number of remote earth station that can be connected the hub.

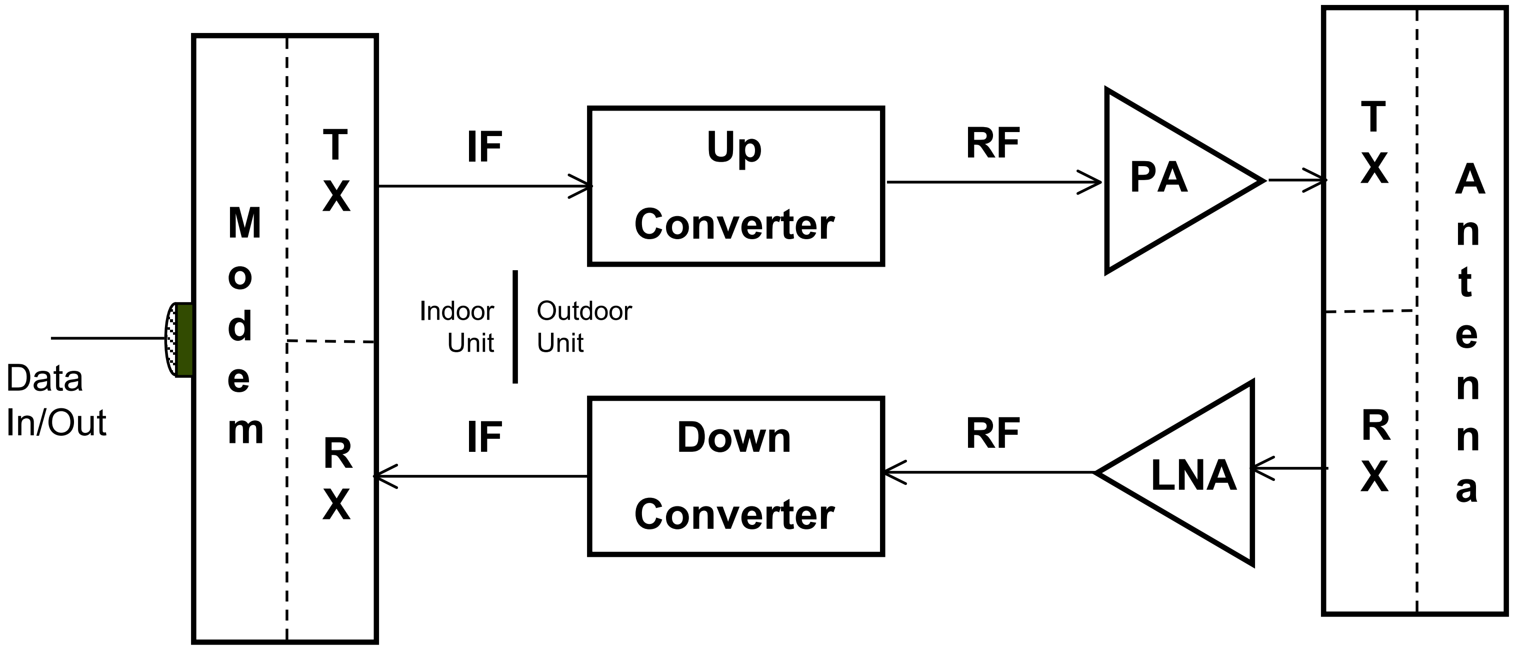
Satellite Network Star Architecture



The Basic Satellite Earth Station Link

- An earth station is used to transmit/receive satellite transmissions.
- An earth station dish antenna is typically about 0.66m –1.8 m in diameter- that is mounted on a roof, wall, or ground. This antenna, along with the attached low-noise blockdownconverter or LNB (which receives satellite signals) and the transmitter (which sends signals) make up the VSAT outdoor unit (ODU), one of the two components of a VSAT earth station.
- The second component of VSAT earth station is the indoor unit (IDU). The indoor unit is a small desktop box or PC that contains receiver and transmitter boards and an interface to communicate with the user's existing in-house equipment - LANs, servers, PCs, TVs, kiosks, etc. The indoor unit is connected to the outdoor unit with a pair of cables.

The Basic Satellite Earth Station Link



Outdoor Unit

Comprised of the following:

- Antenna - A device for transmitting and receiving radio waves, usually designed to focus the waves to or from one direction. The antenna is often referred to as a dish. The antenna also contains the feedhorn. The feedhorn is a piece of antenna hardware, located at the focal point of the parabolic reflector, that radiates RF energy toward the antenna reflector and collects (received) RF energy from the antenna reflector.
- PA (Power Amplifier) - A device that amplifies a specific band of frequencies by a large amount, sufficiently large to enable the antenna to beam them up to the satellite.
- Upconverter - A device that increases the frequency of the carrier, typically from Intermediate Frequency (IF) to Radio Frequency (RF).
- LNA (Low Noise Amplifier) - A device to amplify the received modulated carrier while minimizing noise.
- Downconverter - A device that lowers the frequency of the carrier, typically from Radio Frequency (RF) to Intermediate Frequency (IF).

Indoor Unit

Comprised of the following:

- <u>Receiver Electronics</u> - Equipment which allows a specific satellite signal to be separated from all others being received by an earth station, and converts the signal format into a format for video, voice or data. This equipment is comprised of a modem and possibly a router.

- <u>Modem</u> (modulator/demodulator) - A device that converts binary data streams, such as those from a PC, to communicate over an analog transmission medium such as telephone lines or on a carrier wave for wireless transmissions. The satellite modem can either connect to the computer serial port, or to a network device via an Ethernet connection.

- <u>Router</u> - A network layer device that determines the optimal path along which network traffic should be forwarded. Routers forward packets from one network to another based on network layer information.

Satellite Dish Efficiencies

- Most satellite dishes use a parabolic curve design.
- The parabolic curve permits the focusing and amplifying of the satellite signal.
- The ability of the parabolic antenna to amplify signals is directly related to the exactness of this parabolic curve as well as good antenna assembly techniques practiced during installation.

Earth Station Advantages

- Satellite earth stations can be installed anywhere within the satellite footprint as long as they have an unobstructed view of the satellite.
- Satellite earth stations are capable of sending and receiving video, data and audio content at the same high speed regardless of their distance from terrestrial switching offices and infrastructure.

Typical Earth Station

Teleports

- A teleport is comprised of one or many telecommunication hubs.

- It is a satellite communications centre capable of switching voice, image and data transmissions to and from any location. It provides customers with access to the satellite world of services and applications and access to the terrestrial world of services and applications.

- Teleports provides customers with the ability to share among many, the costs of teleport buildings, land, telecommunication equipment, redundancy and engineering support, therefore achieving economies of scale.

- Teleports offer customers flexibility.

- Teleports provide better service monitoring, equipment redundancy, standby power, signal protection and network management, all from one central location.

Teleports Components

Teleports share some common characteristics:

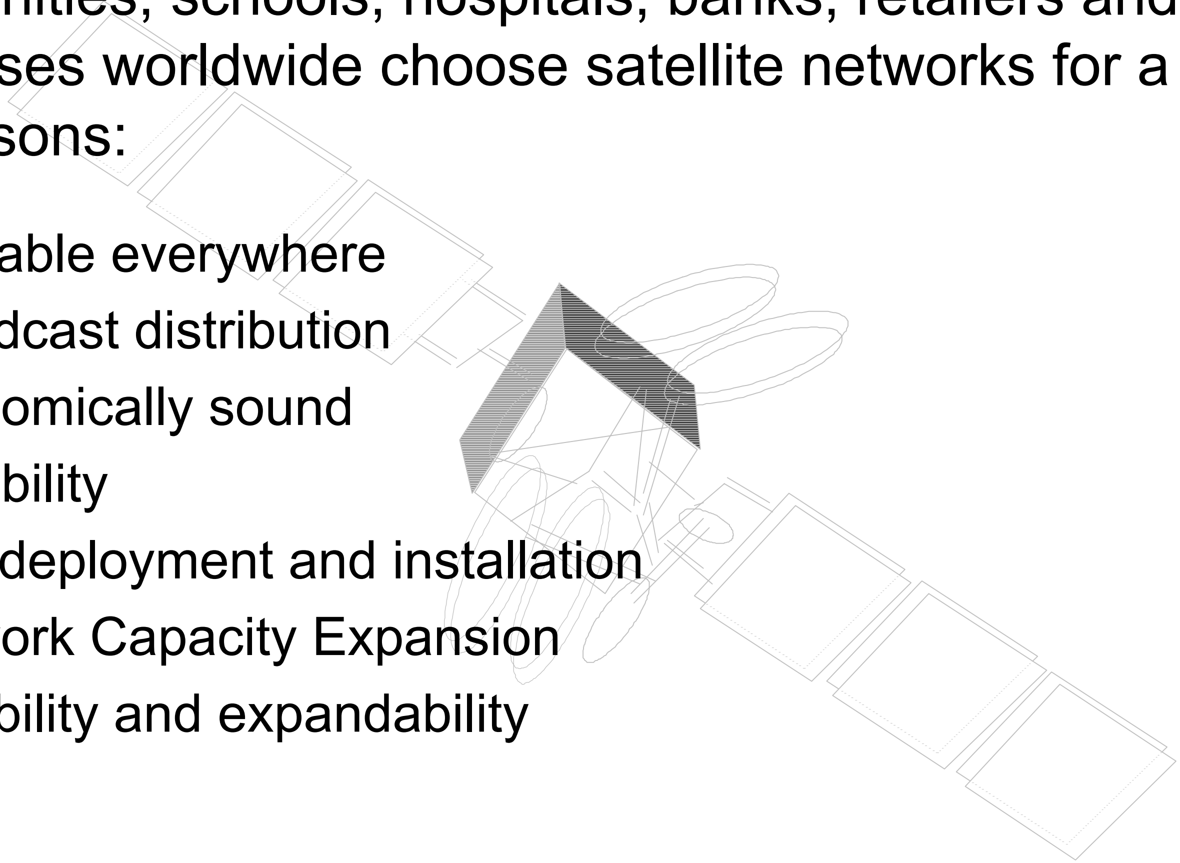
- A building which contains the earth station equipment, replacement equipment, support facilities, power supply and back-up power.
- Access to a regional communications distribution system and internet.
- Continuous equipment monitoring and maintenance by technicians.
- Economical shared use of Teleport services among clients and the use of hardware engineered to higher standards than would be practical at single-customer sites.
- Teleports may also offer adjoining office or broadcasting studio space.

Typical Teleport Facilities

4. Satellite Advantages

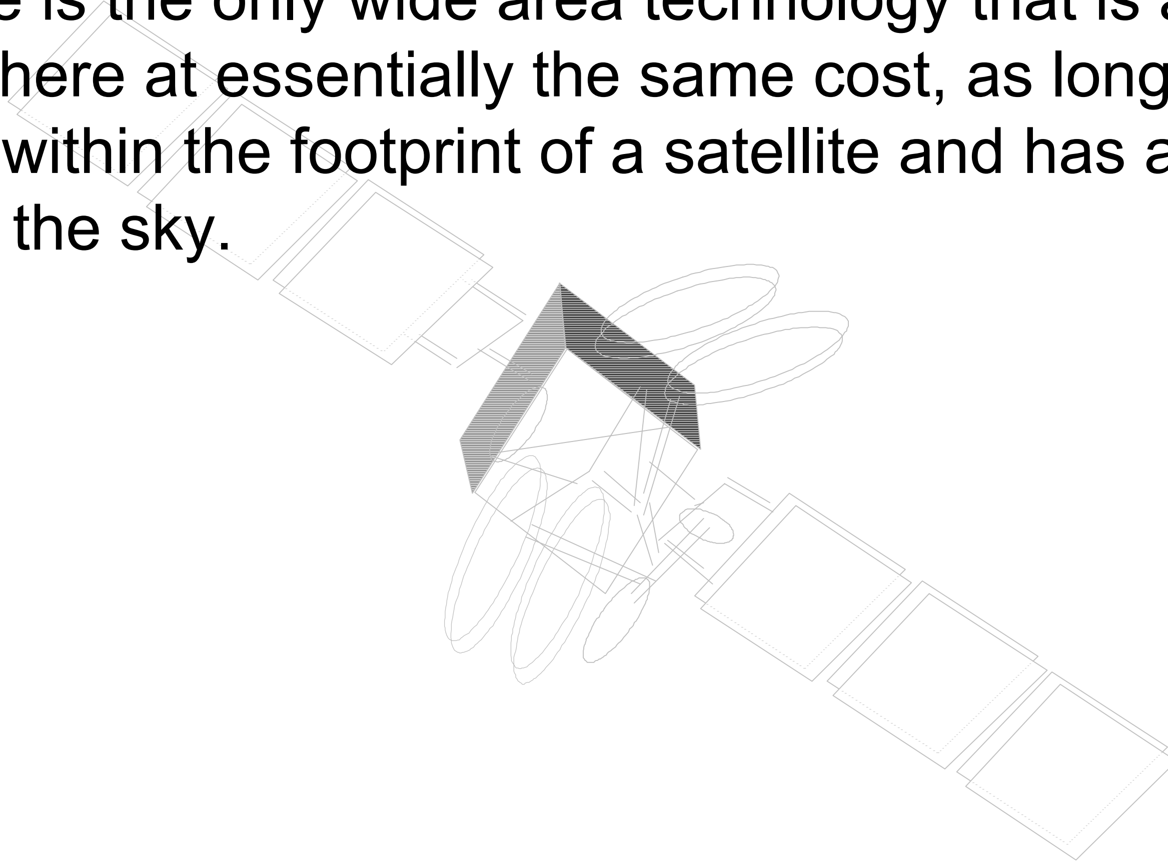
The Advantages of Satellite

- Communities, schools, hospitals, banks, retailers and other enterprises worldwide choose satellite networks for a number of key reasons:
  - Available everywhere
  - Broadcast distribution
  - Economically sound
  - Reliability
  - Fast deployment and installation
  - Network Capacity Expansion
  - Flexibility and expandability



Available Everywhere

- Satellite is the only wide area technology that is available everywhere at essentially the same cost, as long as the user is within the footprint of a satellite and has a clear view of the sky.



Broadcast Distribution

- Satellite's inherent strength is point to multipoint broadcasting of data, video or audio.

- Satellite can simultaneously deliver information to a virtually unlimited number of end-user locations - at high speeds up to 45 Mbps. This avoids duplicate transmissions and maximizes the efficiency of infrastructure and bandwidth.

Economically Sound

- Satellite networks are cost effective to deploy, maintain and operate.
- The individual remote earth stations can be relatively inexpensive (about the same cost as a router in a Frame Relay network) and can be quickly and easily installed by a field technician.
- Hub and satellite costs are shared among thousands of customer sites, so the per-site cost of equipment, maintenance and management is low - and gets lower as more sites are added to the network. As such, one remote earth station can aggregate all of a community’s telecommunication user requirements and achieve improved economics as a result.

Reliability

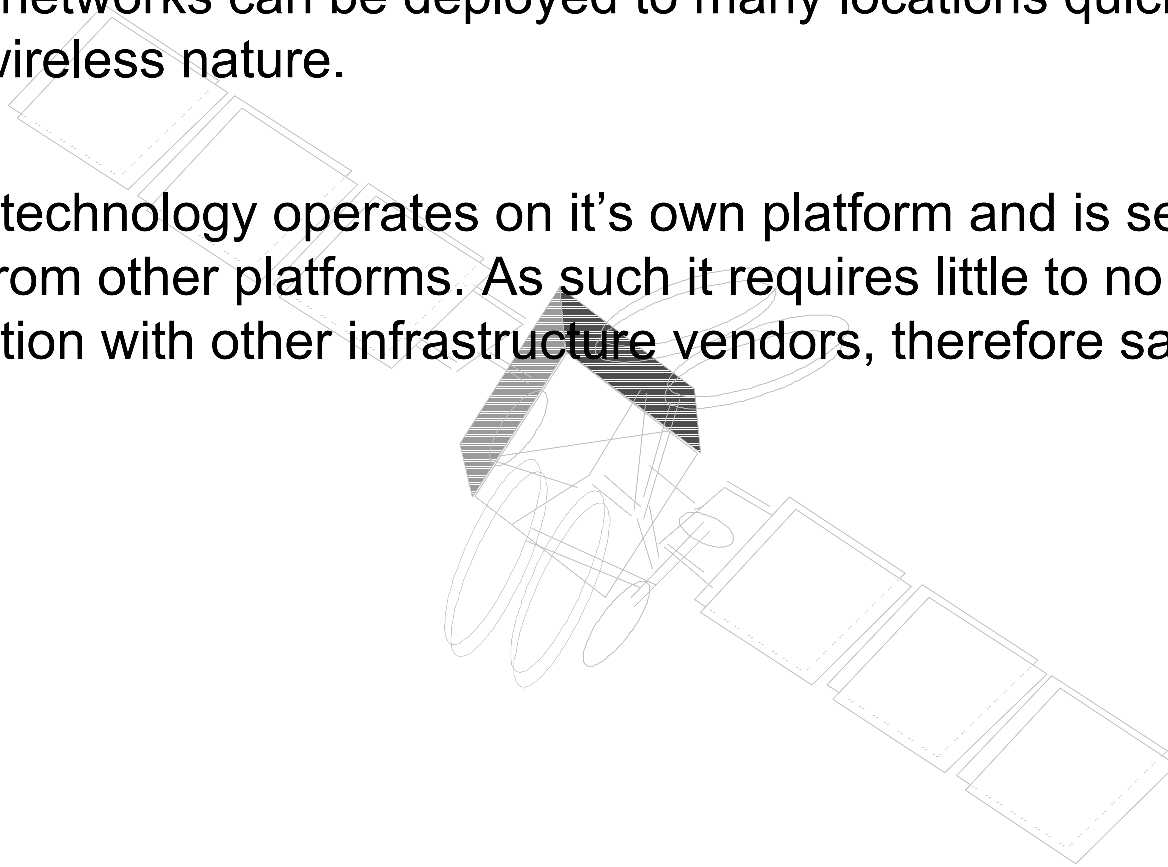
- Satellite networks are very reliable with few potential points of failure.

- The possible points of failure are at the satellite, the hub and the remote earth station. Each point has built-in redundancy and back-up. Total satellite failures (an extremely rare occurrence) have back-up capacity arrangements on other satellites. Hubs use online switching to redundant equipment in case of failure. The remote earth stations are very reliable pieces of equipment with mean-time-between-failures of up to 10 years.

Fast Deployment and Installation

- Satellite networks can be deployed to many locations quickly because of their wireless nature.

- Satellite technology operates on it's own platform and is separate and distinct from other platforms. As such it requires little to no coordination with other infrastructure vendors, therefore saving time.



Network Capacity Expansion

- Satellite technology easily and quickly facilitates network and bandwidth expansion.
- With a satellite network, network expansion is easy and cost effective since bandwidth allocation is controlled at the hub, increasing network capacity is as simple as increasing the amount of network bandwidth. Plus generally remote sites require no hardware changes or field work.

Flexibility and Expandability

- Satellite technology supports a wide range of hardware, applications and protocols. Individual platforms can provide voice, fax, data and Internet connectivity.

- Modular hub and earth station design allows for scalability and expandability not achievable with terrestrial networks.

- **Satellite's inherent broadcasting strength permits flexibility when expanding and adding sites to a broadcast network.**

5. Variety of Satellite Services

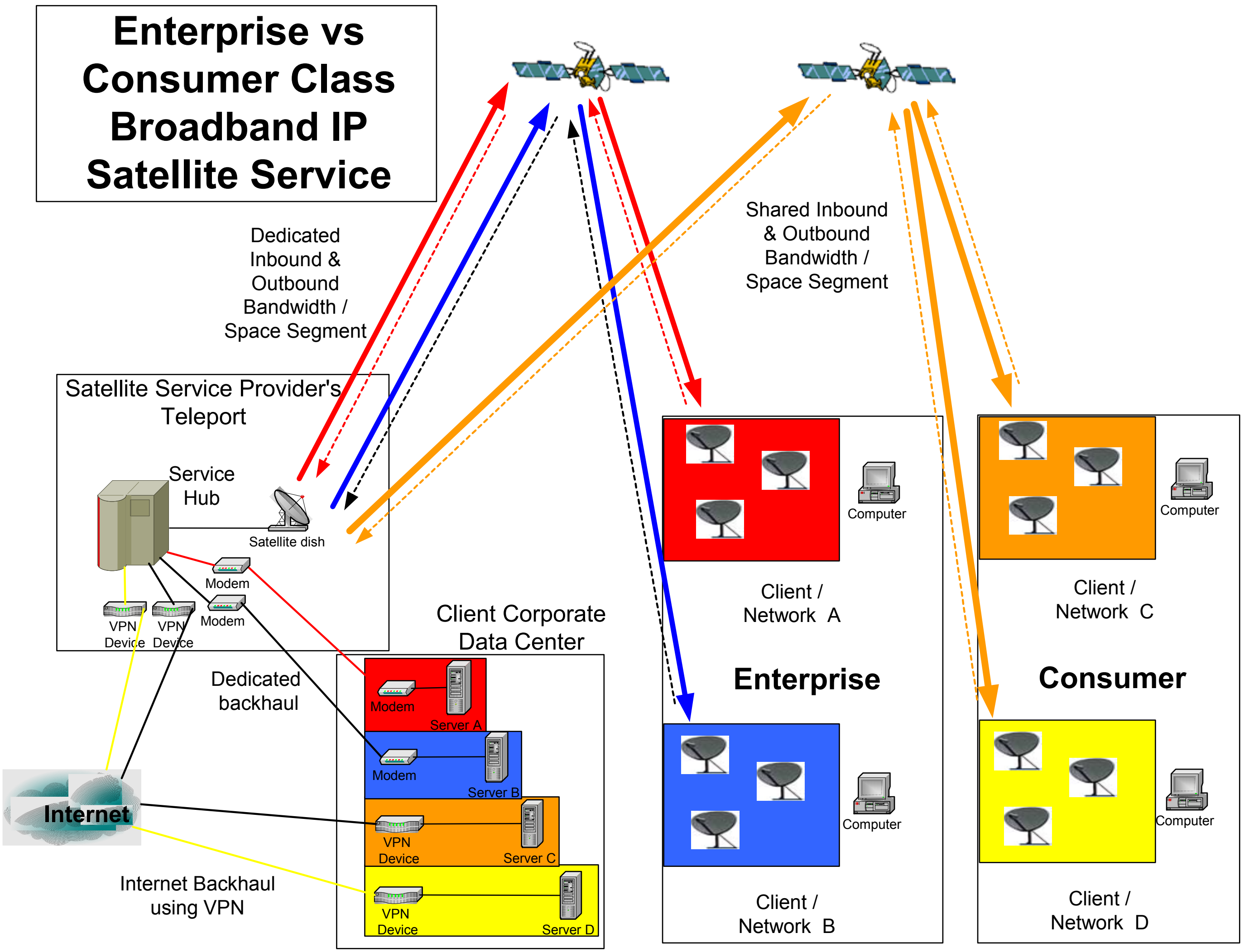
Enterprise Class of Service

- Suited for interactive Intranet-based applications.
- Dedicated space segment and backhaul bandwidth to user groups / Quality of Service (QoS).
- Remote terminals - higher degree of functionality.
- Private network and secure.
- For medium to larger-sized network.

Consumer Class of Service

- Suited for Web based applications.
- Shared space segment bandwidth among all users / Fair Access Policy.
- Delivers an expected rather than committed QoS to users.
- Uses public shared facilities / Virtual Private Network (VPN) for secure communications.
- For small to mid-sized networks.

Classes of Satellite Service



Components of a Satellite Service

- A satellite service is comprised of the following elements:

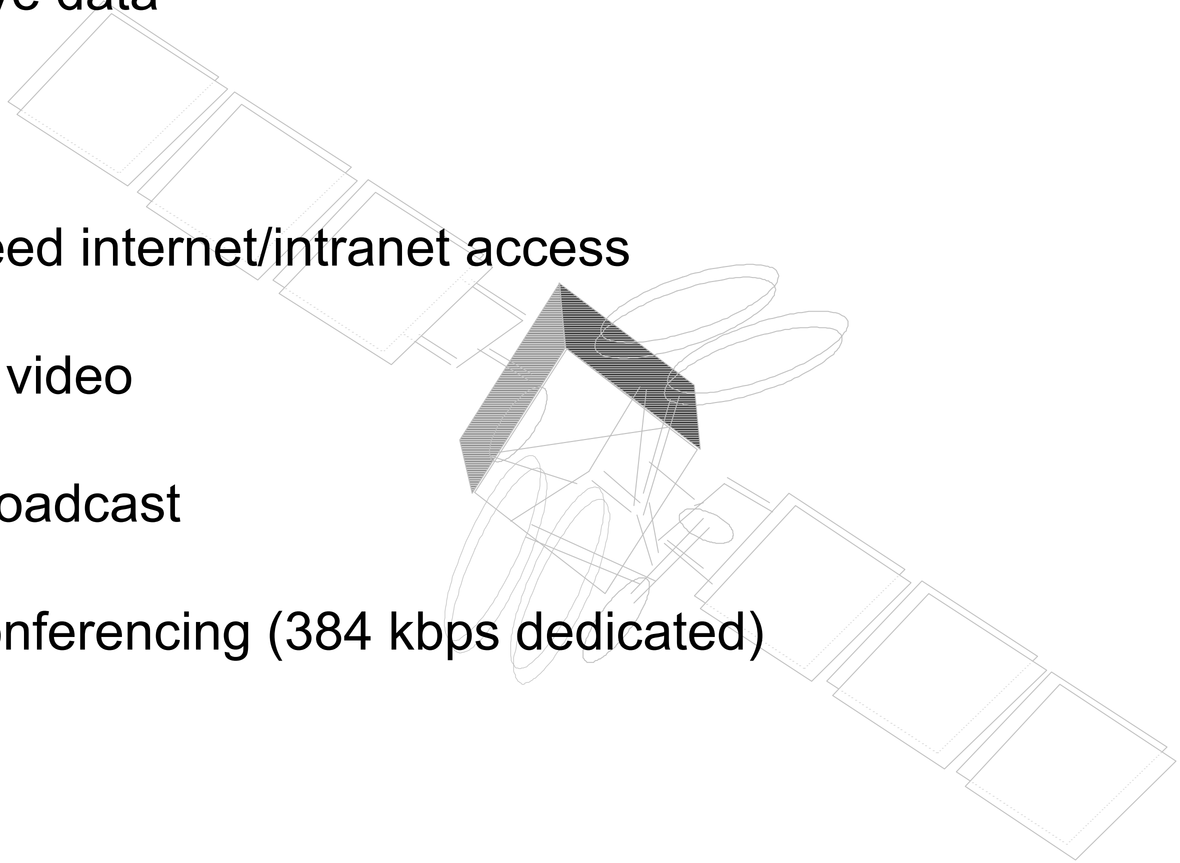
- <u>Earth Station</u>
    - Receive Earth Station Hardware
    - Site Survey
    - Installation
    - Operations & Maintenance
    - Licensing

- <u>Space Segment</u>
    - Inroute
    - Outroute

- <u>Hub</u>
    - Access-encompassing a portion of the shared hub facilities (land, power, communications equipment, engineering support, etc.).

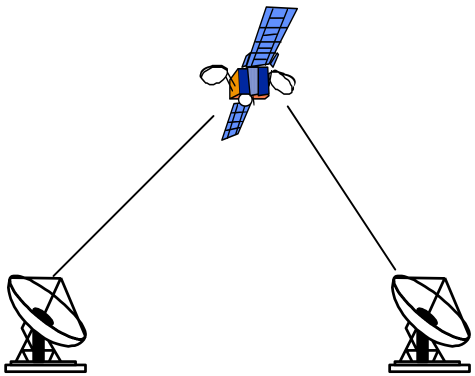
Applications Supported

- Interactive data
- Email
- High speed internet/intranet access
- Desktop video
- Video broadcast
- Video conferencing (384 kbps dedicated)
- Voice

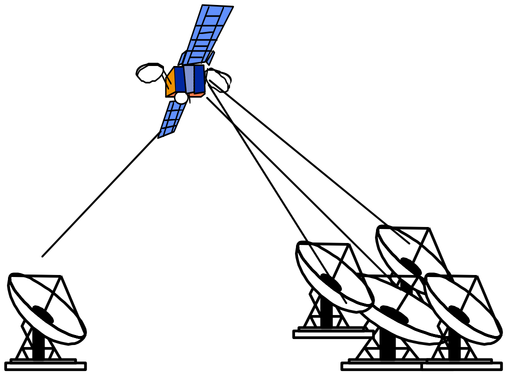


Types of Connectivity Supported

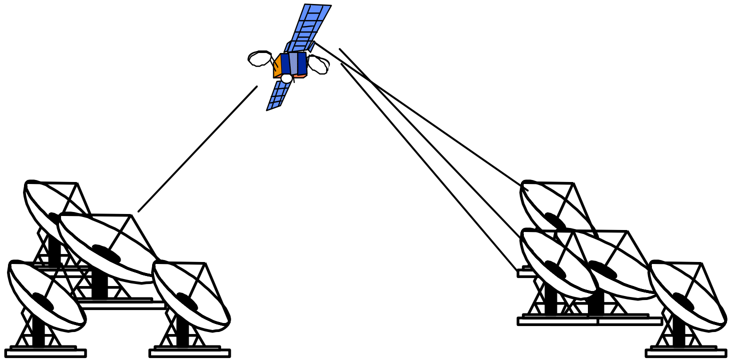
Point to Point



Point to Multipoint



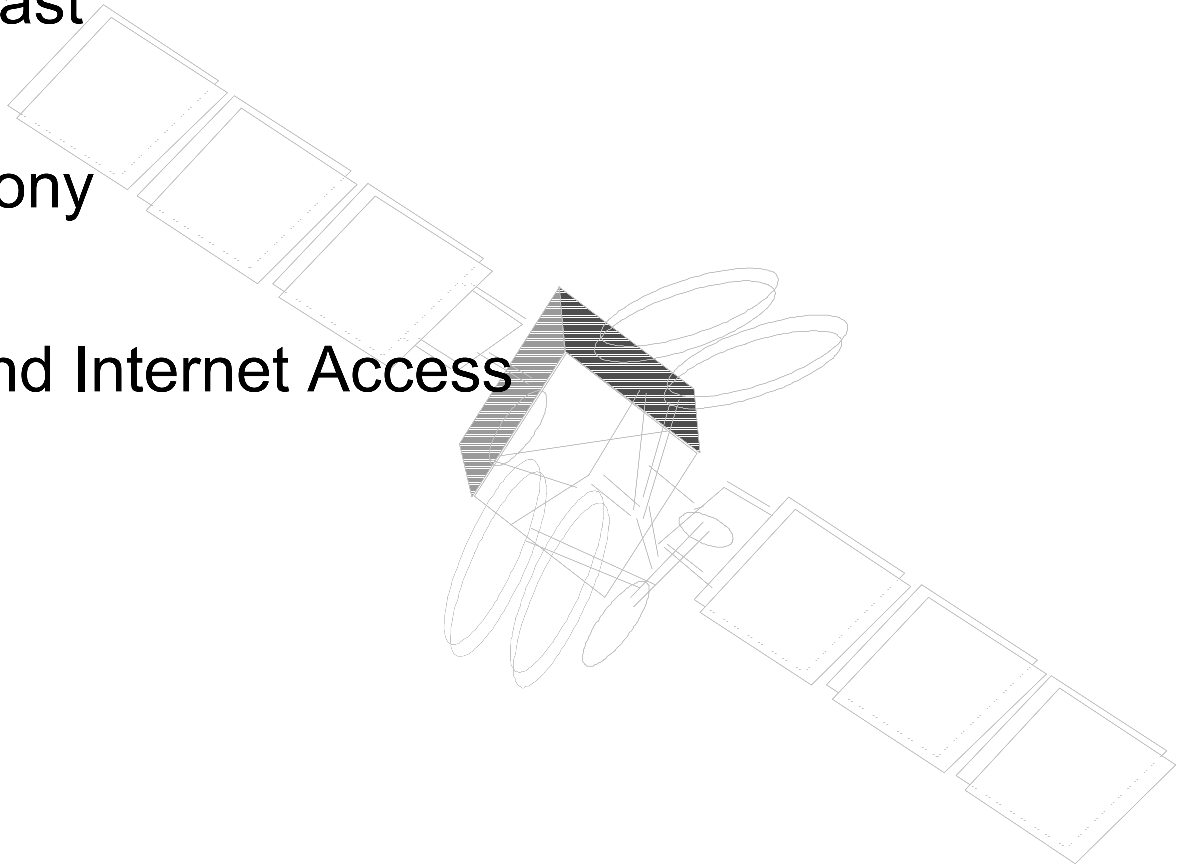
Multipoint to Multipoint



6. Satellite Technology Evolution

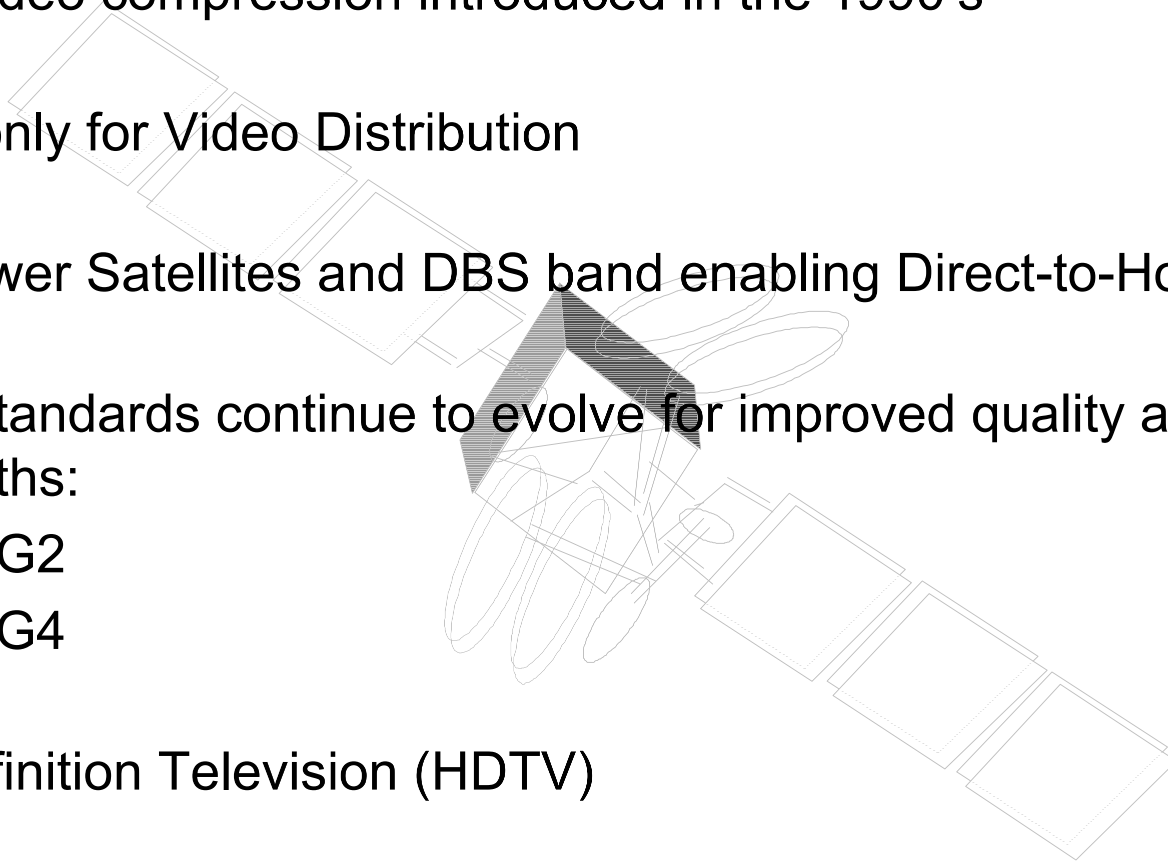
Technology Evolution

- Broadcast
- Telephony
- Data and Internet Access



Broadcast

- Digital video compression introduced in the 1990’s
- Initially only for Video Distribution
- High Power Satellites and DBS band enabling Direct-to-Home
- MPEG standards continue to evolve for improved quality at lower bandwidths:
  - MPEG2
  - MPEG4
- High Definition Television (HDTV)



Telephony

- Trunking in the 1970-present.
- Satellite switching in the 1990's
  - Initially multi-frequency switching in the mid-1990's
  - full mesh SS7 network
- Circuit switched networks optimal for voice but inadequate for growing data needs
- Telephony Earth Station (TES) technology delivers high-quality, digital voice and data communications
- Voice compression evolution
  - Analogue, 32 kbps ADPCM, 8 kbps G729
- Bandwidth on Demand technology
- VoIP
  - Becoming cost effective to change existing infrastructure

Data and Internet

VSATs (hardware suppliers)

- HNS	-EMS	
- ViaSat	-IDirect	
- Gilat	-Polarsat/NSI	- Etc.

- Broadcast (up to 45mbps) towards remote and low speed TDMA Inroutes ($\leq$ 128kbps)
- Legacy and/or Internet Protocol Support
- Including performance enhancements, caching TCP/IP optimization
- Improving and mitigating latency issues with internet access
- Supports Business Television, video streaming, video conferencing, etc.

7. Satellite Performance Enhancements

Performance Enhancements

- Due to the round trip satellite delay of about 1/2 second, native TCP/IP cannot achieve high throughputs. This is referred to as satellite latency.

- Without modifying the end user software, proxies are used to convert the protocol to a “satellite friendly” proprietary protocol in order to enhance the throughput and therefore mitigate latency.

- These proxies mitigate latency significantly. For some applications such as FTP, latency is mitigated by 100%.

Caching

- Moving web objects closer to end user.
- Pre-loading caches with popular content.
- Use Parent Cache at Gateway and Child Cache at user:
  - Parent Cache can pre-fetch objects from web
  - Child Cache can serve multiple clients

8. Bandwidth Efficiency Techniques

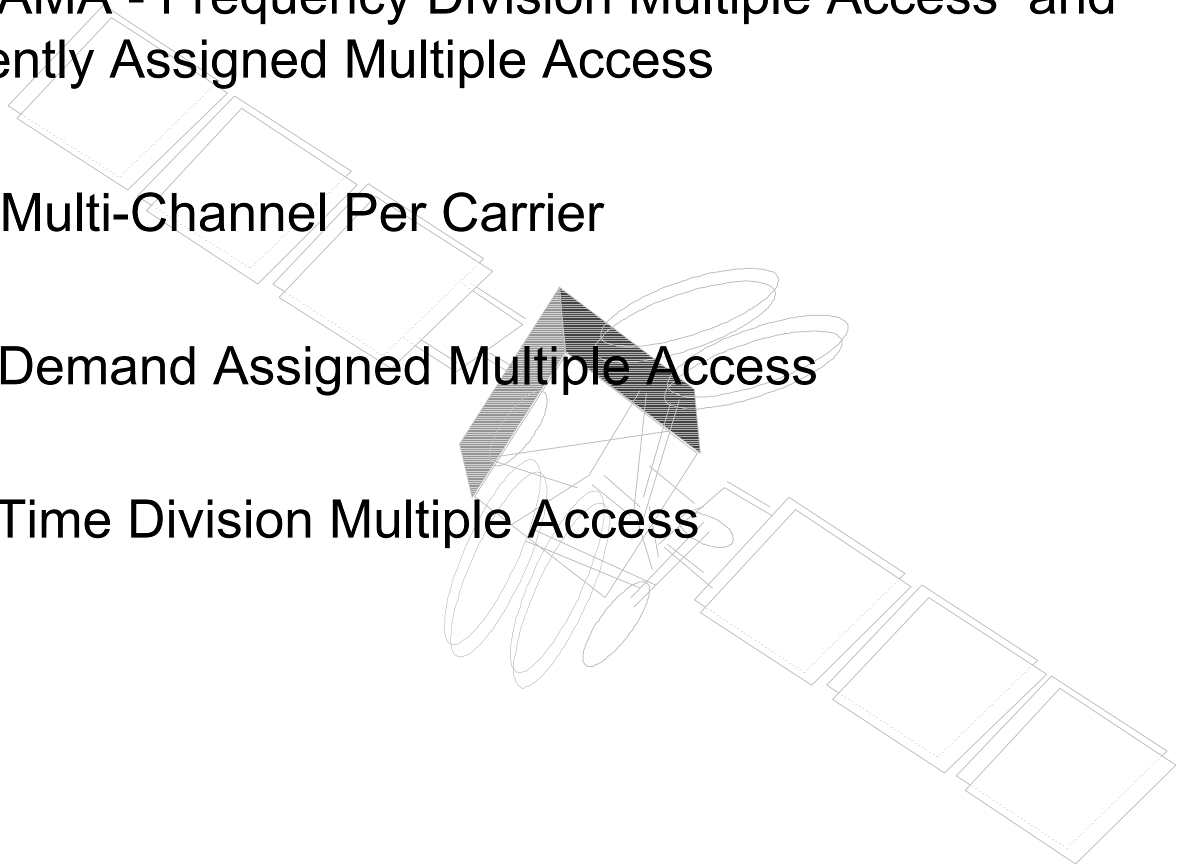
Bandwidth Efficiency Techniques

- Transponder bandwidth is an expensive scarce resource

- Many techniques have been developed to more efficiently and effectively use bandwidth. These techniques include:
  - Frequency multiplexing information into the same transponder bandwidth
  - Time multiplexing information and modulating into the same transponder bandwidth
  - Compressing information

Satellite Multiplexing Techniques

- FDMA/PAMA - Frequency Division Multiple Access and Permanently Assigned Multiple Access
- MCPC - Multi-Channel Per Carrier
- DAMA - Demand Assigned Multiple Access
- TDMA - Time Division Multiple Access



FDMA / PAMA

- Oldest form of satellite communication
- Dedicated & Point to Point
- Less complex hardware and typically lower cost. However reduced use and proliferation of this technology has increased costs
- Simple operation
- Earth Station is sized to the carrier bit rate (no overhead)

MCPC - Multi-Channel Per Carrier

- Addition of Multiplexers or, recently, Routers over FDMA
- Statistically consolidates the traffic
- Applicable to Outbounds/Outroutes and DVB-S*
  - typically point to multi-point

*DVB: European Standard for Digital Video Broadcasting over satellite: ETSI EN 300 421

DAMA - Demand Assigned Multiple Access

- Network Control System required to manage bandwidth
- Efficiently shares pool of resources
- Bandwidth allocated per call or session between any two or more earth terminals
- Permits full mesh routing, like a telco Central Office Switch
- More complex and costly baseband hardware
- Applicable for voice communications

TDMA - Time Division Multiple Access

- Network Control System required to manage bandwidth
- Historically the most complex baseband equipment
- Burst rates up to 120 Mbps
- Now, much lower rates and multi-frequency MF-TDMA are commercially available
- Much higher capital costs initially but today equipment proliferation has reduced costs to end-users
  - complex hardware with a control system, and
  - the Earth Station is sized to transmit much higher than its nominal throughput
- Well suited for Packet network requirements

Satellite Modulation Techniques

- Modern modems use varied modulation techniques and compression to achieve high data transfer rates.

- Below are the common satellite modulation techniques:

  •Binary Phase Shift Keying (BPSK) - modulation technique where the phase of the RF carrier is shifted 180 degrees in accordance with a digital bit stream

  •Quadrature Phase Shift Keying (QPSK) modulation technique where the phase of the RF carrier is shifted in 90 degree increments in accordance with a digital bit stream

  •Eight Phase Shift Keying (8-PSK) modulation technique where the phase of the RF carrier is shifted in 45 degree increments in accordance with a digital bit stream

  •Quadrature Amplitude Modulation (QAM) is an amplitude modulation technique primarily used for sending data downstream. QAM is very efficient, but QAM's susceptibility to interfering signals makes it ill-suited to noisy upstream transmissions

Digital Video Compression

- Digital Video Compression (DVC) has opened the door for satellite delivered Direct to Home (DTH) TV program distribution because it has caused a dramatic decrease in the operational costs for TV service providers.

- DVC television signals are transmitted in a compressed format that significantly reduces the amount of frequency bandwidth required without substantially degrading the quality of the received pictures and sound.

- The result has been a global proliferation of new satellite delivered DTH TV services, including, news, sports, movies, Pay Per View (PPV) special events, educational programming, and narrowcast offerings.

9. Benefits To Your Community

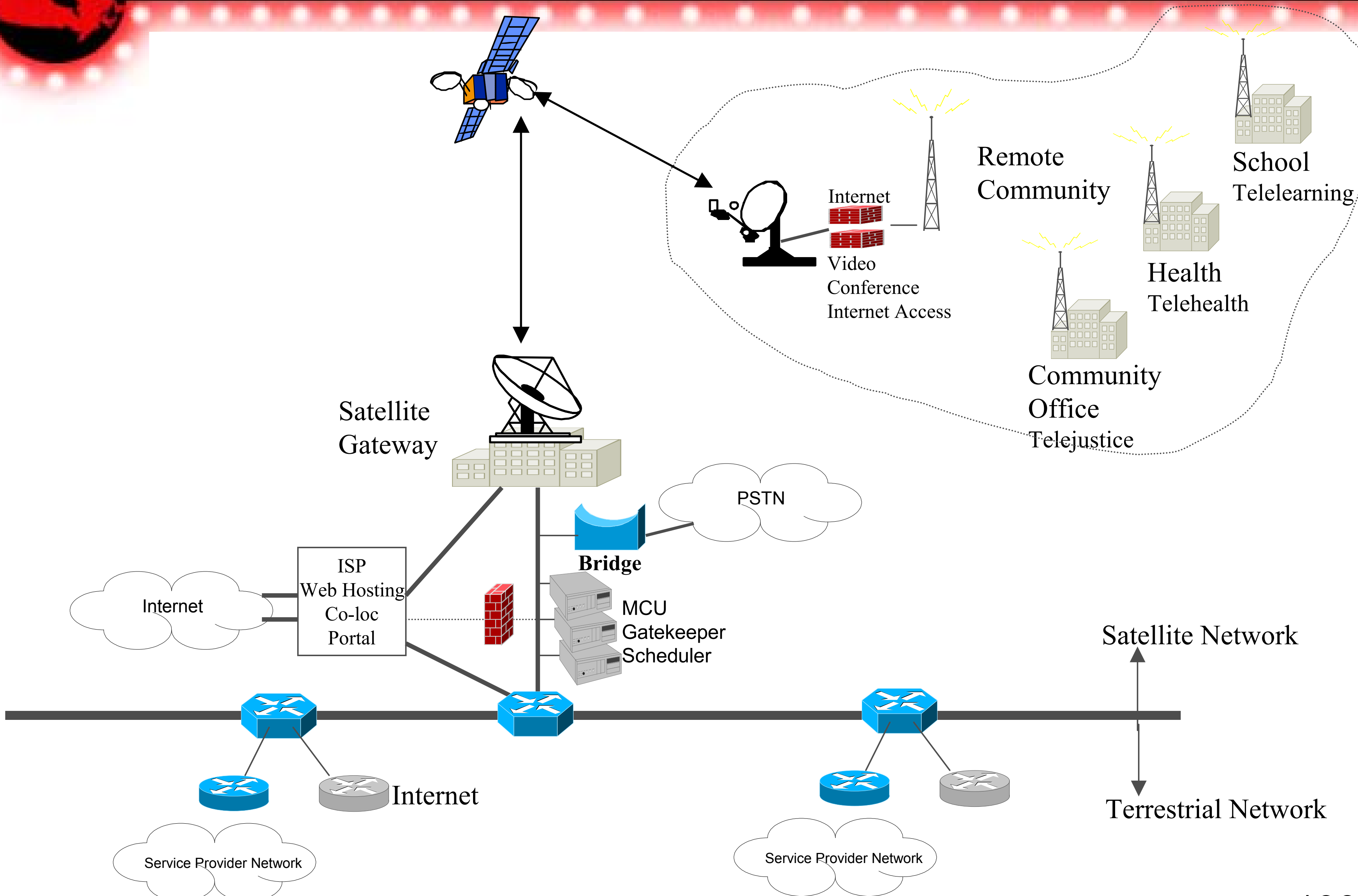
Benefits

- Serving total community needs
- Community sharing ensures cost effectiveness
- Providing telecommunication services for hospitals/schools/institutions
- Quick deployment
- Scaleable
- Stimulating community employment opportunities
- Narrowing the digital divide

Community Connectivity

- Typical community connectivity is characterized by a point to point aggregated broadband connection from a southern Canada located teleport to a community located earth station.
- The community gateway typically will be connected to a local distribution system comprised of a wireless and/or cable plant infrastructure that will provide access to local schools, hospitals, band offices, government offices, SOHO, residences, etc.

Typical Community Connectivity



Selection of a Satellite Service Provider

- Factors to consider:
  - Service Availability
  - Maintenance Support
  - Response Times
  - Sparing Capacity
  - Redundancy Capacity
  - Price/Contract Options
  - Help Desk/On-Going Support
  - Coverage
  - Service Flexibility/Choice
  - Upgradeability
  - Scalability
  - Industry Reputation

Satellite Service Providers

- Agnito
- Bell Nexxia
- C-Com
- Donna Cona
- Infosat
- K-Net
- LinCsat
- Northwestel
- Ramtelecom
- SixDion
- SSI Micro
- Stratos
- Telesat
- Vancouver Teleport
- Etc.

A Model of Typical Community Application Use and Bandwidth Requirements (KBPS)

	Residential		SOHO		School		Hospital		FN Band Office		Gov't Office		Total
Applications	Forward	Return	Forward	Return	Forward	Return	Forward	Return	Forward	Return	Forward	Return	
HTTP browsing	30	8	60	12	20	2	32	6	4	1	12	2	
Video/audio streaming	128	32	51	10	102	10	164	33	12	1	26	5	
Interactive data	78	20	48	10	39	4	70	14	5	1	17	3	
Video conferencing	-	-	-	-	25	25	384	384	6	6	31	31	
Telesurgery	-	-	-	-	-	-	23	23	-	-	-	-	
Overhead	40	10	40	8	20	2	32	7	4	1	8	1	
Total Forward	276		199		206		705		31		94		**1511**
Total Return		70		40		43		467		10		42	**672**

Assumptions

1.) There are 200 residential dwellings assumed.

2.)There are 10 SOHO offices each comprised of 5 people and 2 terminals

3.) Schools have 25-50 students

4.)Hospitals have 25-50 beds

5.) There is a First Nation band office having 1 to 3 assets

6.) There are two government offices each comprised of 2 people.

Community Telecommunications Example

Community Telecommunications Example

Community Telecommunications Example

Community Telecommunications Example

Community Telecommunications Example