Tutorial
Satellite Communication

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1. Overview of Satellite Systems

Contents

What is Satellite Communication...

- A communication satellite is basically an electronic communication package placed in orbit whose prime objective is to initiate or assist another through space.
- Satellite communication is one of the most impressive spin-offs from the space programs and has made a major contribution to the pattern of international communication.
- The information transferred most often correspondence to voice (telephone), video (Television) and digital data.

Cont...

- Communication satellite are off-course only one means of telecommunication transmission. The traditional means include copper wire and microwave point-to-point links. Newer techniques involves use of optics either point-to-point infrared or fiber optics. Point-to-point radio system such as short wave radio may also be used.

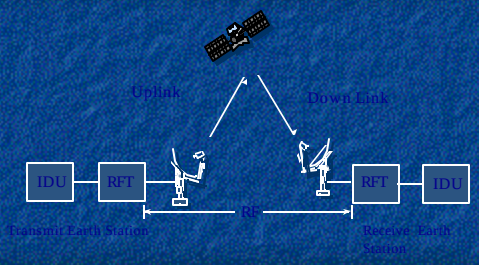
The origin of satellite

- The concept of using object in space to reflect signals for communication was proved by Naval Research Lab in Washington D.C. when it use the Moon to establish a very low data rate link between Washington and Hawaii in late 1940's.
- Russian started the Space age by successfully launching SPUTNIK the first artificial spacecraft to orbit the earth, which transmitted telemetry information for 21 days in Oct. 1957.
- The American followed by launching an experimental satellite EXPLORER In 1958.
- In 1960 two satellite were deployed "Echo" & "Courier"
- In 1963 first GSO "Syncom"
- The first commercial GSO (Intelsat & Molnya) in 1965 these provides video (Television) and voice (Telephone) for their audience

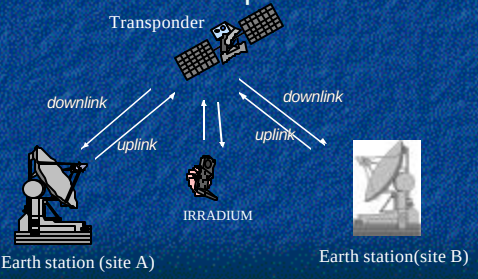
Elements of Satellite Communications

- The basic elements of a communication satellite service are divided between;
  - Space Segment
  - Ground Segment
- The space segment consist of the spacecraft & launch mechanism and ground segment comprises the earth station and network control center of entire satellite system.

Satellite Communications System



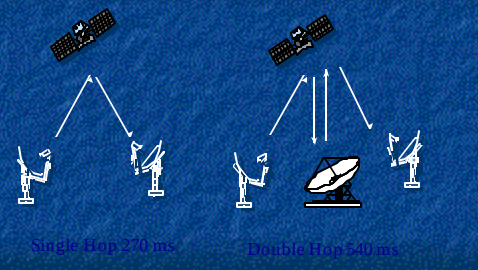
Concept



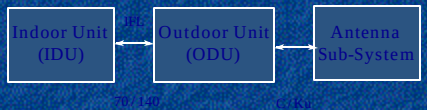
Applications

- Communication (truncking call)
- Teleconference
- Telemedicine
- TV Broadcasting
- Data communication
- Telemetry(TEC, remote sensing etc)
- Weather telecast
- Navigation
- GPS
- Security/Calamity monitoring
- Standard Time
- military

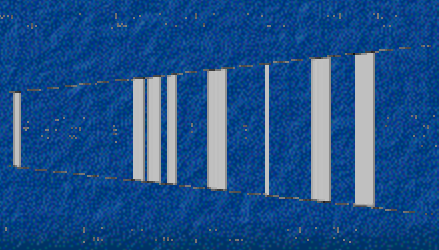
Propagation Delay



Ground Station _ Anatomy



Electromagnetic Spectrum



Radio Frequency Bands

Band Number	Band Name Frequency Range	Metric Subdivision
1	ELF - extra low frequency 30-300 Hz	Hectokilometric waves
2	VF - voice frequency 300-3000 Hz	Myriametric waves
3	VLF - very low frequency 3-30 kHz	Kilometric waves
4	LF - low frequency 30-300 kHz	Hectokilometric waves
5	MF - medium frequency 300-3000 kHz	Myriametric waves
6	HF - high frequency 3-30 MHz	Decametric waves
7	VHF - very high frequency 30-300 MHz	Metric waves
8	UHF - ultra high frequency 300-3000 MHz	Decimetric waves
9	SHF - super high frequency 3-30 GHz	Centimetric waves
10	EHF - extra high frequency 30-300 GHz	Millimetric waves

Satellite Operating Frequency Bands

Frequency Range (GHz)	Band	Category
0.39-1.55	L	MSS
1.55-5.2	S	FSS & BSS
3.9-6.2	C	FSS
5.2-10.9	X	Military
10.9-36.0	K	FSS & BSS
15.35-17.25	Ku	FSS & BSS
18.3-31.0	Ka	FSS

Early Satellites

Satellite	Launching Date	Country/Organization	Type	Height (miles)	Comments
RELAY	1962	USA/RCA & NASA	Active Duplex	942-5303	4.2/1.7 GHz satellite designed to carry telephone signals.
SYNCOM	1963	USA/NASA	Active Duplex	Geostationary	First Geostationary communication satellite used to transmit television signals from the Tokyo Olympics.
MOLNIYA	1965	U.S.S.R	Active Duplex	High altitude elliptical	First Soviet communication satellite used a high altitude elliptical orbit.
EARLY BIRD	1965	INTELSAT/COMSAT	Active	Geostationary	First commercial communication satellite; served the Atlantic ocean region; capacity to carry 240 voice channels
INTELSAT 2	1966	INTELSAT/COMSAT	Active	Geostationary	First multiple access commercial satellite with multidestination capability
INTELSAT 3	1968	INTELSAT/COMSAT	Active	Geostationary	3 generation designed to carry 1200 voice circuits

Early Satellites

Satellite	Launching Date	Country/Organization	Type	Height (miles)	Comments
Explorer	1958	USA/NASA	Broadcast	110 to 920	Very short life; Noted for re-broadcasting an on-board taped message from president Eennour
ECHO 1960	USA/NASA	Passive	1000	100-Foot diameter plastic balloon with an aluminum coating which reflect radio signals	
COURIER	1960	Department of defense	Store & Repast	600-700	First radio repeater satellite. It accepted and stored upto 360,000 teletype words as it passed overhead and then broadcast to ground stations further along the orbit; only operated for 17 days.
TELSTAR	1962	USA/AT&T	Active Duplex	682-4030	First satellite to receive and transmit simultaneously; Operated in 4/6 GHz band

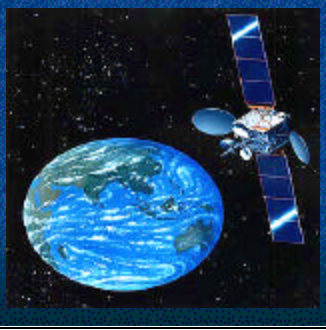
Early Satellites

Satellite	Launching Date	Country/Organization	Type	Height (miles)	Comments
INTELSAT 4	1971	INTELSAT/COMSAT	Active	Geostationary	COMSAT's 4th generation; designed to carry 6000 voice circuits.
ANIK 1	1972	Canada/Telesat	Active	Geostationary	World's first domestic satellite; 5000 voice circuits capacity.
WESTAR	1974	USA/Western Union	Active	Geostationary	First US domestic satellite

Satellite Services

- The ITU has grouped the satellite services in to three main groups
- Fixed Satellite Services (FSS)
- Broadcast Satellite Services (BSS)
- Mobile Satellite services (MSS)

Asiasat 2



Space Segment

- Space segment consist of a satellite in suitable orbit.
- Space segment classified on the basis of orbit;
  - LEO
  - MEO
  - HEO
  - GEO & GSO

Ground Segment

- The ground segment of each service has distinct characteristics.
- Services like;
  - FSS
  - BSS
  - MSS
    - Maritime, Aeronautical & Land base
  - DBS
  - Etc.

System Design Consideration

- Services or Application
- Selection of RF Band
- Finance
- Further technical design considerations are:-
  - Optimal modulation, coding scheme, type of service, permitted earth station size and complexity, shape of service area, landing rights, state of prevailing technology related both to spacecraft and ground station.

Advantages of Satellite

- Wide band capability
- Wide area coverage readily possible
- Distance-insensitive costs
- Counter inflationary cost history
- All user have same access possibilities
- Point to point, point to multipoint (broadcast) and multipoint to point (data collection) are all possible
- Inherently suited for mobile application.
- Compatible with all new technologies
- Service directly to the users permises

Limitation of Satellites

- High initial investment
- New investment require in Ground Segment
- Short life time (7-10 years)
- Spectrum crowding
- Regulatory aspects
- Launch vehicle reliability

Frequency Allocations

- Frequency bands for satellite services are shared with terrestrial services.
- Satellite signal strength is constrained to avoid interference by it to others.
- Thus a large antenna and sensitive receiver are needed at the earth station.
- Frequency sharing techniques are an important study area.
- Many satellites have to share a limited frequency band (and limited orbital arc) thus coordination in frequency and orbital location is important.
- Frequency allocation are done by international agreements

Frequency Allocation and Regulatory Aspects

- Domestic
  e.g. Federal communication Commission (FCC)
  National Telecommunication and Information Administration (NITA)
  In Pakistan, PTA (Pakistan Telecommunication Authority)
- International
  International Telecommunication Union (ITU)
  - Formed in 1932 from the International Telegraph Union
  - Consists of over 150 members nations
  - World Administrative Radio Conference (WARC)
  - International Radio Consultative Committee (CCIR) consists of 13 study groups.

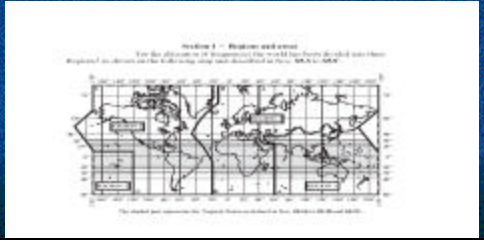
ITU Regions

ITU divides the surface area of the earth into three regions for the purpose of frequency allocation

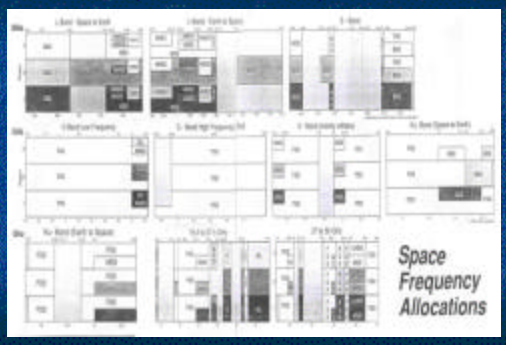
- Region 1: Pacific Ocean Region
  North and South America
  Greenland
- Region 2: Atlantic Ocean Region
  Europe
  Africa
  Middle East
  Central Asia

ITU Regions (Continued)

- Region 3: Indian Ocean Region
  Pakistan-India Sub-continent , South East Asia & Australia



Frequency Allocations to Satellite Services



The International Telecommunications Union

Examples of Satellite Radio Services:

- *Fixed Satellite Service* FSS
- *Mobile Satellite Service* MSS
- *Broadcast Satellite Service* BSS
- *Radio Navigation Sat. Serv.* RNSS
- *Radio location Sat. Service* RSS
- *Space Operation Service* SOS
- *Earth observation Sat. Serv.* ESS
- . . .

In total more than 18 radio services

The International Telecommunications Union

Article 5 Frequency Allocations

Region 1	Region 2	Region 3
19.7 - 20.1 GHz FIXED-SATELLITE (space-to-earth) Mobile-Satellite (space-to-earth) S5.524	19.7 - 20.1 GHz FIXED-SATELLITE (space-to-earth) MOBILE-SATELLITE (space-to-earth) S5.524, S5.525, S5.526 S5.527, S5.528, S5.529	19.7 - 20.1 GHz FIXED-SATELLITE (space-to-earth) Mobile-Satellite (space-to-earth) S5.524

The International Telecommunications Union

A license is required by every operator in order to operate a satellite system nationally; a licence may only be acquired if:

- the operator can show that he has a contract with the system owner to be his service provider

- the frequencies for the system have been cleared / coordinated / notified

- that system is fully registered with the ITU

-the operator has workers registered as operators

A licence will be cancelled if:

- there are no more registered operators to work the system

- the service provider has breached 'data protection laws'

2. Orbit and Launching Methods

Before the lecture

- Try to find out more by reading:
- http://ctd.grc.nasa.gov/rleonard/regcontents.html
- http://www.aticourses.com/iridium.htm
- http://www.aticourses.com/global_positioning_system.htm
- http://www.mlesat.com/Article9.html
- http://www.mlesat.com/tutorial.html

Orbits

- Circular orbits are simplest
- Inclined orbits are useful for coverage of equatorial regions
- Elliptical orbits can be used to give quasi stationary behaviour viewed from earth
  - using 3 or 4 satellites
- Orbit changes can be used to extend the life of satellites

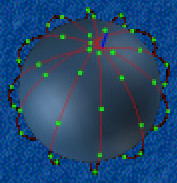
Satellites

Several types

- LEOs - Low Earth Orbit
- MEOs - Medium Earth Orbit
- HEOs – Highly Elliptical Orbit
- GSO - Geostationary Earth Orbit

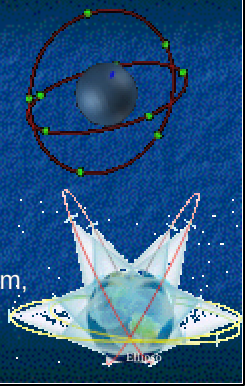
LEO

- Low Earth Orbit
- 200-3,000 km
- High orbit speed
- Many satellites
- Predominately mobile
- Iridium, Globalstar
- (space shuttle orbit)

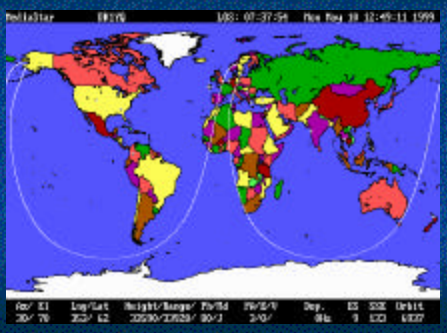


MEO

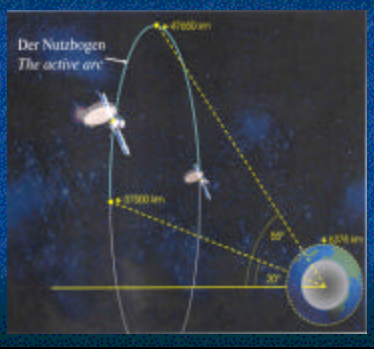
- Medium Earth Orbit
- 6,000 – 12,000km
- New generation
- About 12 satellites
- Voice and mobile
- ICO (Odyssey), Orbcomm, Ellipso



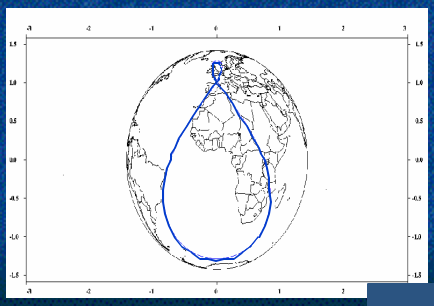
Sub-Satellite Track of a HEO



The 24 h HEO of Sirius



The 24 h HEO of Sirius



HEOs: Molnya and Tundra

	Molnya	Tundra
Period	12 h	24 h
Apogee	39 500 km	46 300 km
Perigee	1 000 km	25 300 km
Inclination	63.4°	63.4°

Satellite Orbits and Periods

Height of Orbit[1] (km)	*Period of Orbit* (h)	*Cell Diameter* (km)	*Visible Part of Earth* %	*# of Satellites* *	*Duration of Overflight* (min)
200	1.5	3 154	1.5	66	7
700	1.6	5 720	5.0	20	14
1000	1.8	6 719	6.8	15	18
1 414	1.9	7 806	9.1	11	22
10 000	5.8	14 935	30.5	4	130
20 000	11.9	16 922	37.9	3	300
35 786	24.0	18 100	42.4	3	24 h/d

[1]*above the surface of the earth*

**minimum necessary for 0° elevation and 0 redundancy*

GEOs

- Originally proposed by Arthur C. Clarke
- Circular orbits above the equator
- Angular separation about 2 degrees - allows 180 satellites
- Orbital height above the earth about 23000 miles/35786.16km
- Round trip time to satellite about 0.24 seconds

GEOs (2)

- GEO satellites require more power for communications
- The signal to noise ratio for GEOs is worse because of the distances involved
- A few GEOs can cover most of the surface of the earth
- Note that polar regions cannot be “seen” by GEOs

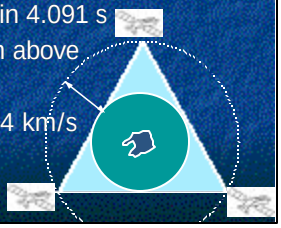
GEOs (3)

- Since they appear stationary, GEOs do not require tracking
- GEOs are good for broadcasting to wide areas
- Currently 329 GEO are in orbit

(ref: web site provided by Johnston)

The original vision

- 1945 Arthur C Clark envisaged "extraterrestrial relays"
- 3 satellites
- Period 23 h 56 min 4.091 s
- Height 36 000 km above equator
- Speed of flight 3.074 km/s



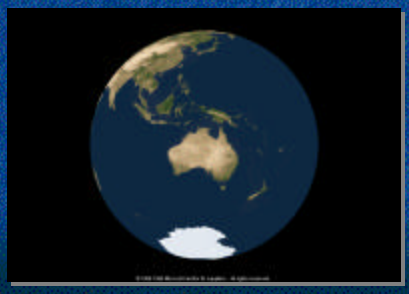
and then..

- 1957 Sputnik
- a rush of experimental satellites in many orbits
- Intelsat 1965 – 1st commercial GEO service
- over 800 objects registered so far

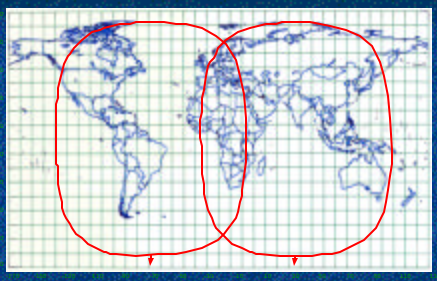
GEO - geostationary earth orbit

- characterised by:
  - delay (echo) ~0.5sec return
  - high power
  - 5-7 years life
- global and spot beams
- C and K band (4-6Ghz and 12-14Ghz)
- 2 – 3º spacing
- Currently more than 200 GEO satellites in operation

the view from 36,0000km



Earth coverage with 2 spacecraft



Coverage of the inhabited world except for Polynesia

some GEO's above us

- Optus * 3
- AsiaSat * 3
- PAS * 2
- Intelsat * 7
- Inmarsat * 2
- Palapa * 2

and others

Some Service Providers:

Netspeed Austar Optus Telstra iHug Newskies MediaSat NTL Heartland Xantic Stratos

National and Regional Systems

1 Anik, Canada
2 Morelos, Mexico
3 Panamsat, Americas
4 Brasilsat, Brazil
5 Eutelsat, Europe
6 Telecom, France
7 Kopernikus, Germany
8 Italsat, Italy
9 Arabsat, Arab League
10 Insat, India
11 Asiasat, East Asia
12 CS, Japan
13 Palapa, Indonesia
14 Aussat, Australia

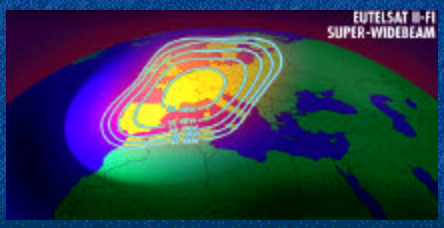
Satellite Footprints

Satellite beam their signals in a straight path to the earth. The satellite focus these microwaves signals onto the specified portions of the earth's surface to most effectively use the limited power of their transponders. These focused signals create unique beam patterns called "footprints."

Types of footprints:

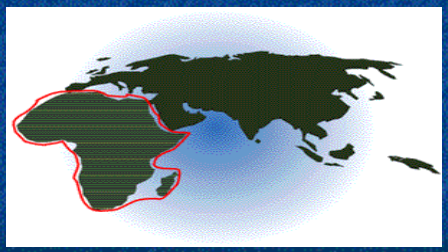
- Global beam footprint
- Hemispheric Beam Footprint
- Zone Beam Footprint

Satellite Footprints



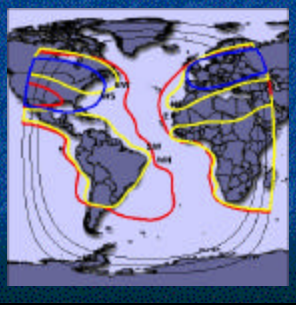
Satellite Footprints

Satellite Footprints



Satellite Footprints

Key Input Data...



Bands:
- C-Band ( )
- Ku-Band ( )

Beams:
- Global ( )
- Hemi ( )
- Zone ( )
- Spot ( )

Characteristics of a Geostationary Satellite Orbit

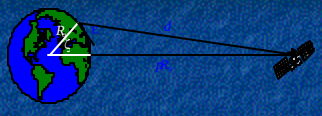
- **Eccentricity (e)** **0**
- **Inclination of the orbital plane (i)** **0°**
- **Period (T)** **23h 56m 4s**
- **Semi-major axis (a)** **42164 km**
- **Satellite altitude(R)** **35786 km**
- **Satellite velocity (Vs)** **3075 m/s**

$F=GMm/r^2$ $T=2\pi\sqrt{a^3/\mu}$ $\mu=Gm_e=3.986x10^{14}\ m^3/s^2$

$e=c/a$ $V=\mu(2/r-1/a)$ m/s

The GEO

Elevation , distance to the satellite



$K_{grav} = m M_e G / r^2$ $K_{zent} = m r \omega^2 = m v^2 / r$

Angular velocity $\omega = 2\pi / T$, T **Period,** v**velocity**

$K_{grav} = K_{zent}$ **und**

$m M_e g / r^2 = m r \omega^2$ **bzw.** $M_e g / r^2 = r \omega^2$

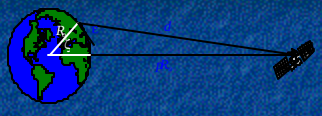
$r^3 = M_e g T^2 / (2\pi)^2$

The period T **of the circular orbit (**r **in km, m = 398 601.8 km³/s²) is**

$T = 2\pi\sqrt{r^3 / m} = 9.952\ 10^{-3}\sqrt{r^3}$ **/ km in Seconds**

$p = 6.611$

The GEO



Δlon = Longitude$_{E/S}$ - Longitude$_{satellite}$

Δlat = Latitude$_{E/S}$ - Latitude$_{satellite}$

Space angle α: $\cos(\alpha) = \cos(\Delta lon) * \cos(\Delta lat)$

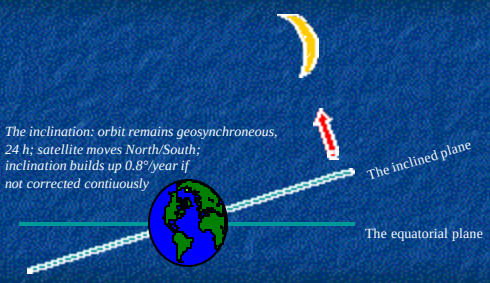
Distance d: $d = R_o\sqrt{6.611^2 - 2 * 6.611 * \cos\alpha + 1}$

Elevation ε: $\sin(\varepsilon) = [\,6.611^2 R_o^2 - R_o^2 - d^2\,) / (\,2 R_o d\,)\,]$

Test: $\alpha = 81.3°$ d = 41680 km and $\varepsilon = 0°$

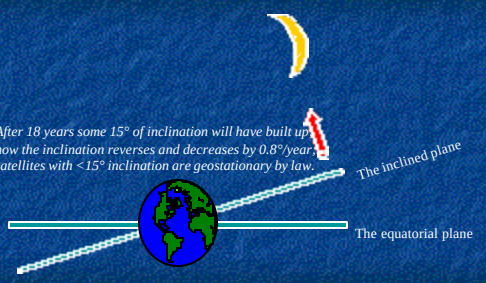
$\alpha = 0°$ d = 35787 km and $\varepsilon = 90°$

The inclination (1)



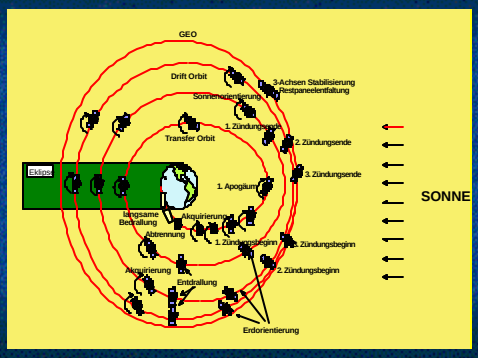
The inclination: orbit remains geosynchroneous, 24 h; satellite moves North/South; inclination builds up 0.8°/year if not corrected contiuously

The inclination (2)

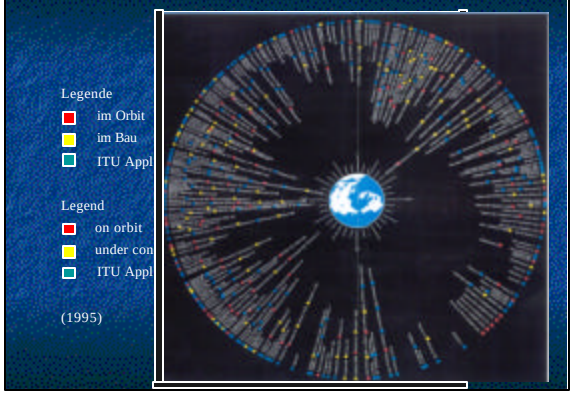


After 18 years some 15° of inclination will have built up; now the inclination reverses and decreases by 0.8°/years. satellites with <15° inclination are geostationary by law.

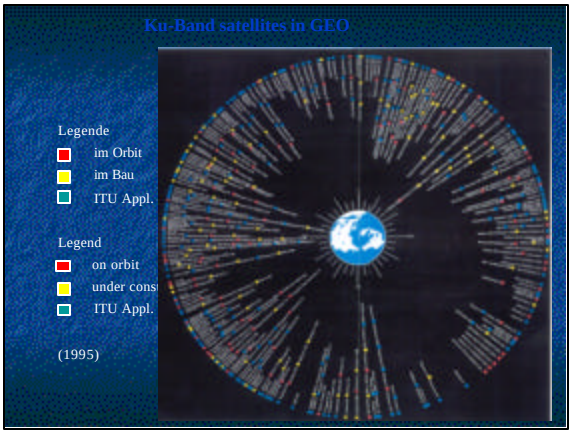
Transfer Orbits



C-Band satellites in GEO



Ku-Band satellites in GEO

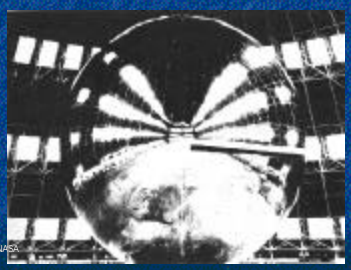


C and Ku-Band satellites in America

Early experiments

- US Navy bounced messages off the moon
- ECHO 1 “balloon” satellite - passive
- ECHO 2 - 2nd passive satellite
- All subsequent satellites used active communications

ECHO 1



- Photo from NASA

Early satellites

- Relay
  - 4000 miles orbit
- Telstar
  - Allowed live transmission across the Atlantic
- Syncom 2
  - First Geosynchronous satellite

TELSTAR

- Picture from NASA

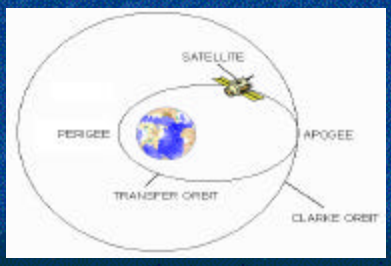
SYNCOM 2

- Picture from NASA

Major problems for satellites

- Positioning in orbit
- Stability
- Power
- Communications
- Harsh environment

Satellite Orbits



comparison chart

Features	GEO	MEO	LEO
Height (km's)	36,000	6,000-12,000	200-3000
Time per Orbit (hrs)	24	5-12	1.5
Speed (kms/hr)	11,000	19,000	27,000
Time delay (ms)	250	80	10
Time in site of Gateway	Always	2-4 hrs	< 15 min
Satellites for Global Coverage	3	10-12	50-70

Mega LEOs, MEOs, HEOs, and GEOs

1 *TELEDESIC of microSoft with 288 LEOs at Ka-Band*
2 *V-Band Supplement of TELEDESIC/microSoft with 72 LEOs im Q-Band*
3 *GS-40 of Globalstar LP with 80 LEOs at Q-Band*
4 *M-Star of Mororola with 72 LEOs at Q-Band*
5 *LEO ONE of LEO ONE Corp. with 48 LEOs at Q-Band*
6 *ORBLINK of Orblink LLC with 7 MEOs in Q-Band*
7 *SkyBridge of ALCATEL witt 64 LEOs and 9 GEOs in Ku-Band*
8 *WEST of MATRA with 10 MEOs and 12 GEOs in Ka-Band*
9 *GESN of TRW with 15 MEOs and 4 GEOs in Q-Band*
10 *CELESTRI of Motorola MOT with 63 LEOs and 10 GEOs in Ka-Band*
11 *SpaceWay of Hughes Communications with 20 LEOs and 16 GEOs in Ka-Band*
12 *StarLynx of Hughes Communications with 20 MEOs and 4 GEOs in Q-Band*
13 *DenAli Telecom LLC PenTriad in HEO im Ku-, Ka-, V-and W-Band*

back to GEOs

- given current-generation LEO's and MEO's are predominately used for mobile voice and low-speed data services (MPSS)
  - good voice coverage for remote regions
  - adjunct to GSM mobile networks ~ Globalstar

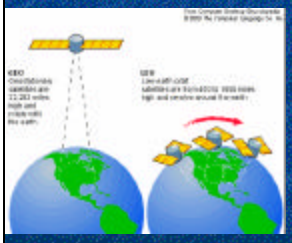
the future

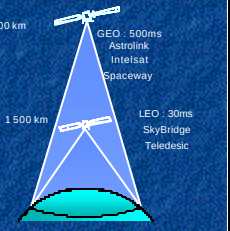
- continual development in VSAT (GEO) technology
  - bandwidth gains
  - multiple services = choice
- Broadband LEOs
  - Teledesic
    - fixed and transportable terminals
    - 64k – 2M – and above (Gb)
    - 288 satellites
    - 2005 launch??
  - SkyBridge
    - 80 satellites
    - 2004

what is SkyBridge?

- SkyBridge is an Alcatel controlled company planning to establish a constellation of 80 satellites to provide broadband data communications direct to business & residential premises.
- Satellites are Low Earth Orbit (LEO) at an altitude of 1500 km
- offers "last mile" broadband access from 2004
  - no long-haul trunking capability - connects users to terrestrial gateway
- System cost is approx US$4.8bn

broadband LEO – low latency





LEO round-trip propagation time comparable to terrestrial

Launching

Step 1: satellite is released in the Low Earth Orbit by launch vehicle

Step 2: The Payload Assist Module (PAM) rocket fires to place the satellite into the geostationary transfer orbit (GTO)

Launching (Continued)

Step 3: Several days after the satellite gets into the GTO the Apogee Kick Motor (AKM) fires to put the satellite into a nearly circular orbit.

Launching (Continued)

Step 4: Orbital Adjustment by firing the AKM to achieve a circular geosynchronus orbit

Launch Vehicles

Launch Vehicles	Atlas II	Delta II	Ariane-4	Proton	Long March-3	H-2
Country	USA	USA	Europe	Russia	China	JAPAN
Gross Weight			460 t	680 t	202 t	260 T
Boast to GTO	3636 Kg	1,819 Kg	2,200 Kg	2,000 Kg	650 Kg	2,200 kG

Launch Vehicle

Launch Vehicle

Summary of Launchers

Sea Launch

At the Equator

11 day travel, 3 days on site, 9 days back

1. and 2. stage fueled on launch site; 3. stage and satellite fueled in Long Beach

Sea Launch

Lift-Off!

Up to 6 t

3000 m deep water

Commander is

5 km away for laun

The Launch Service Alliance

ArianeSpace, Boeing Launch Services, and Mitsubishi Heavy Industries

mutual backup to mitigate schedule risks, range issues, etc.

Summary of Launchers

International Launch Services, ILS

Lockheed Martin, USA,

Khrunichev, RUS, Energia, RUS

Atlas-IIAR$_{s}$, Proton-M$_{si}$

Baikonur Launch Site

Types of Launches

The Evolution

Land Launch since the 60ies

Rail Launch since the 70ies

Air Launch since the 80ies

Sea Launch since the 90ies

Anatomy of a Satellite

A communication satellite consists of the following subsystems:

- Antenna_For receiving and transmitting signals.
- Transponder_It contains the electronics for receiving the signals, amplifying them, changing their frequency and retransmitting them.
- Power Generation and conditioning subsystem_For creating power and converting the generated power into a usable form to operate the satellite.
- Command and Telemetry_For transmitting data about the satellite (status, health etc.) to the earth and receiving commands from earth.
- Thrust subsystem_For making the adjustments to the satellite orbital position and altitude.
- Stabilization subsystem_For keeping the satellite antennas pointing in exactly the right direction.

Common Abbreviations

Orbits:
GEO = Geostationary Earth Orbit
HEO = Highly inclined Elliptical Orbit
MEO = Medium altitude Earth Orbit
LEO = Low altitude Earth Orbit
IGSO = Inclined Geo-Synchroneous Orbit
HAP = High Altitude Platform

Services:
BIG = Voice Telephony
Super = Voice telephony into mobiles from GEO
Little = Data only, typically store and forward
Mega = Mega-bit/s services
DBS = Direct Broadcast satellite television Service
Dab = Digital Audio Broadcast satellite service
Nav = Navigation service

glossary

GEO – geostationary earth orbit – 36,000km
MEO – Medium earth orbit – 6-12,000km
LEO – Low earth orbit – 200-3,000km
Broadcast – One to many simultaneous transmission, usually associated with older style analogue transmission
Multicast – In communications networks, to transmit a message to multiple recipients at the same time. Multicast is a one-to-many transmission similar to broadcasting, except that multicasting means sending to specific groups, whereas broadcasting implies sending to everybody. When sending large volumes of data, multicast saves considerable bandwidth, because the bulk of the data is transmitted once from its source through major backbones and is multiplied, or distributed out, at switching points closer to the end users.
2-way – Infers forward and reverse transmission via the satellite, usually but not always asymmetric, i.e. high-speed download from the satellite and low speed from client to the satellite
latency – The time between initiating a request for data and the beginning of the actual data transfer. A GEO satellite has a latency of approx 256ms resulting in a round trip delay of about half a second (echo)
IP – Internet Protocol – the language of the Internet. The protocol stack is referred to as TCP / IP
Fixed – refers to a satellite receiver being attached as a permanent mounting, as opposed to tracking.
Mobile – Refers to a mobile satellite receiver such as a personal communicator or mobile phone. Usually associated with LEO and MEO services.
Broadband – high speed transmission. The threshold is arguable, but is construed as being faster than dial-up – 64kbps and upwards. Some conventions suggest the threshold starts at 1.5 or 2Mbps.
Orbit – The path of a celestial body or an artificial satellite as it revolves around another body.
One complete revolution of such a body
VSAT – Very small aperture terminal, refers to a small dish service using a GEO satellite and a large central hub, usually 6 metres plus.
DTH – Direct to home. A service bypassing normal terrestrial infrastructure such as a satellite TV receiver. As opposed to community satellite service where local distribution from a satellite receiver is done by cable, radio or other means.