SVF Satellite. Solutions. The World.

MahdiBagh COMPUTERS PVT. LTD. MBC

ITU Satellite Symposium - Geneva, Switzerland
28th to 30th November 2018



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Mentored Satellite Communications Sessions

TOPICS

Introduction to Satellite Communication

Evolving Architecture & Application Market

New System Technologies

Technology Trends in Satellite Systems

Satellite and Launch Vehicles

Satcom Value Chain

Regulatory Considerations & Interference Reduction

Vision for Satcom Growth



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INTRODUCTION TO SATELLITE COMMUNICATION

Development Of Communications

1837 – Telegraph : first electronic communication system which transfer information in the form of dots, dash and space (Samuel Morse)
1837 – Telephone – transfer of human conversation (Alexander Graham Bell, Thomas Watson)
1880 – Optical communication – the earliest, basic form of optical communication was invented
1894 – First wireless communication with radio signals (Marconi)
1908 – Triode – first vacuum tube amplifier (Lee Frost)
1920 – AM Radio broadcasting
1933 – FM modulation (Edwin Howard Armstrong)
1936 – TV Broadcasting (video) FM broadcasting
1947 – Discovery of transistor
1960 – Digital communication
1965 – First commercial satellite
1970 – Fiber optical communication
1970 – First internet node
1980 – Development of TCP/IP protocol
1990 – First digital mobile system
1993 – invention of the web



Figure 002-1-7 - Vintage Telegraph



Figure 003-1-7 - Vintage Telephone

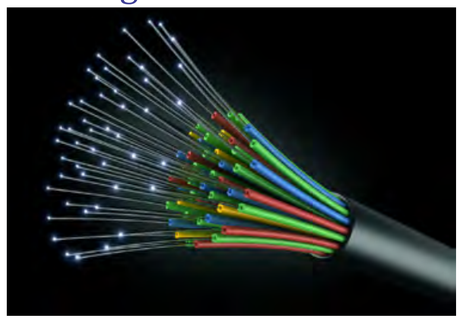


Figure 004-1-7-Fibre Optic Cable

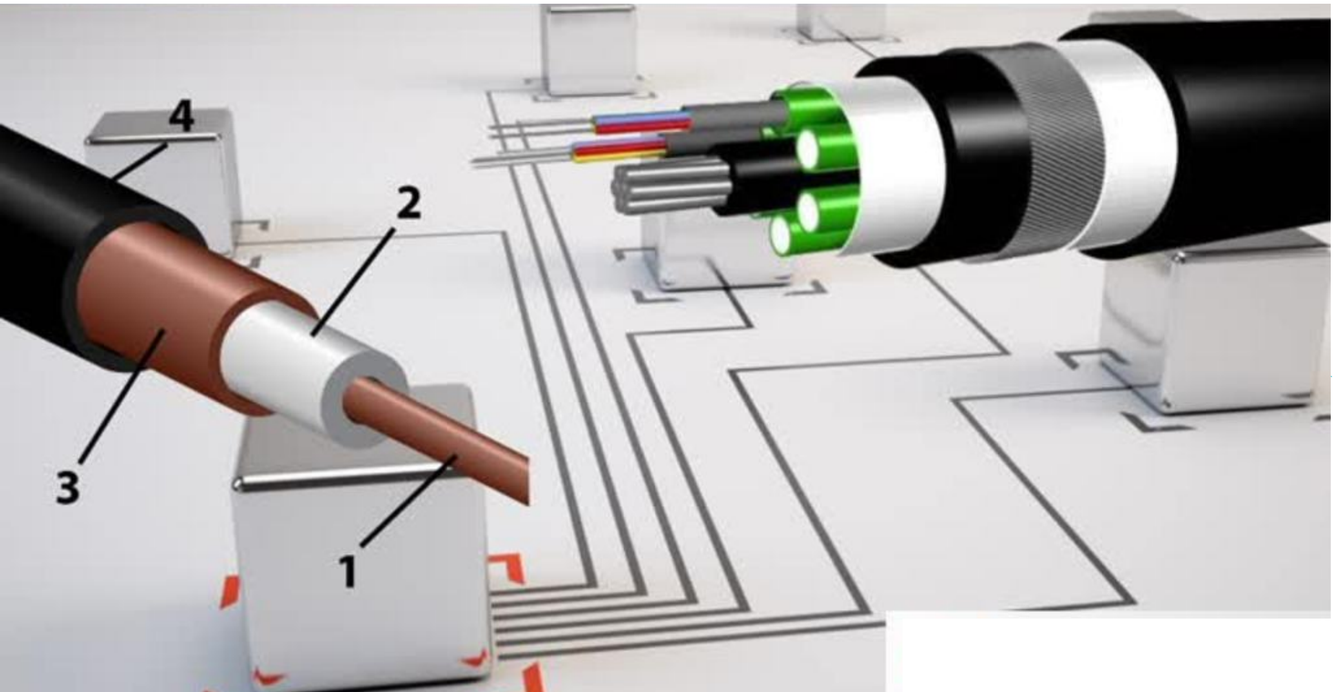
Wired Communications

In order to communicate copper wires were laid between two points which required to communicate with each other.



© M.

Wired Communications

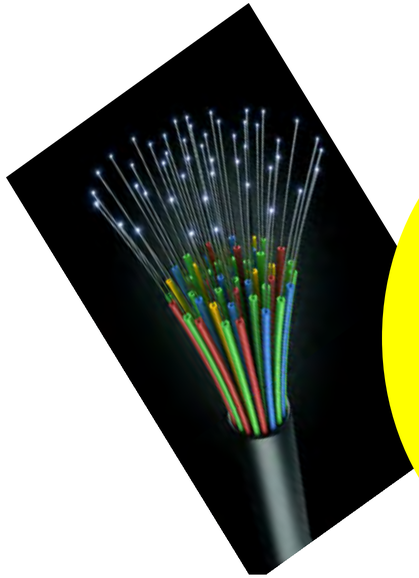


Copper wires were replaced by shielded cables known as coaxial cables in order to increase the capacity and the distance.



Wired Communications

With the developments in Fibre optics, these cables provide a much higher signal carrying capacity and they were laid to provide significantly higher communication signal transfer speeds and capacity.



A copper wire can carry about 3,000 calls, while a single optical fiber could carry approximately 31,000 calls!

Limitations Of Wired Communications



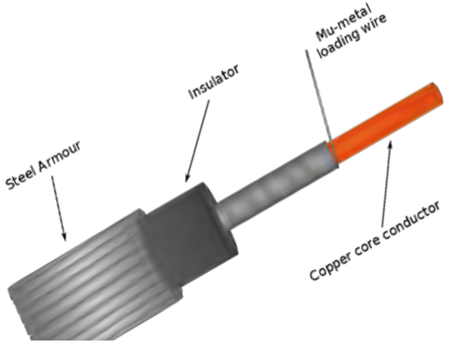
Copper using Analogue Techniques

- Due to attenuation of signals, the distance of communication is limited
- A number of active repeaters are required for long distance communication, due to which the quality of the signal becomes poor as the distance increases
- Open-wire systems have limited bandwidth so can carry limited traffic – can be improved by using coaxial cables
- Not optimal for high-speed digital communication networks
- Undersea cables are required to connect continents
- Network roll-out and maintenance is expensive

Inter-continental communication

Undersea cables were established for inter-continental communication

This system sufferers from low bandwidth and poor reliability





Fibre optic cables do away with most of the limitations of the other cable systems, however, they are fragile, and the loss due to damage can be considerable.

Limitations Of Wireless

Radio waves travel in a straight line and can not bend around obstacles

In order to reach long distances there are two approaches -

1 Use low frequencies

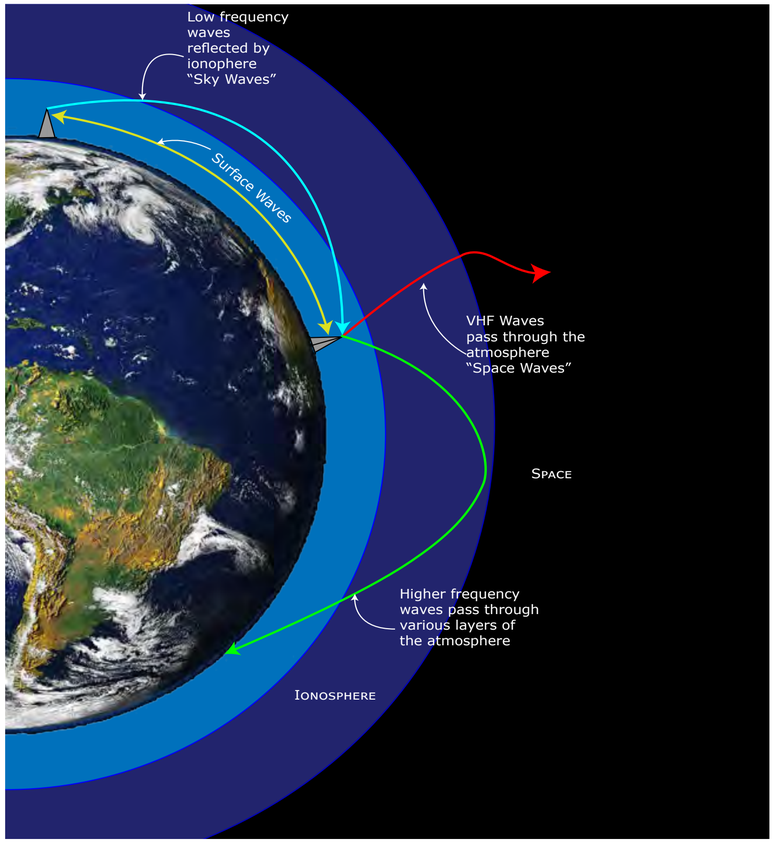
Disadvantages -

- Low bandwidth
- Large antennas
- Effects of man-made noise
- Terrain restrictions
- Difficult to share bandwidth

2 Frequencies below 30 MHz

Disadvantages -

- Reflected by troposphere
- Require many repeaters
- Subject to sun activity
- Subject to stability of troposphere
- Terrain limitations



Satellite Communications



Figure 006-1-20 - Arthur C Clarke (Image: biography.com)

In 1945 Sir Arthur C. Clarke wrote in Wireless World that an artificial satellite about 36,000 Km above the equator will have the same time period as the earth and will appear stable in the sky.

An inexpensive system can be created to relay radio signals from one point on earth to another with simple non-tracking antenna pointed in a fixed direction.

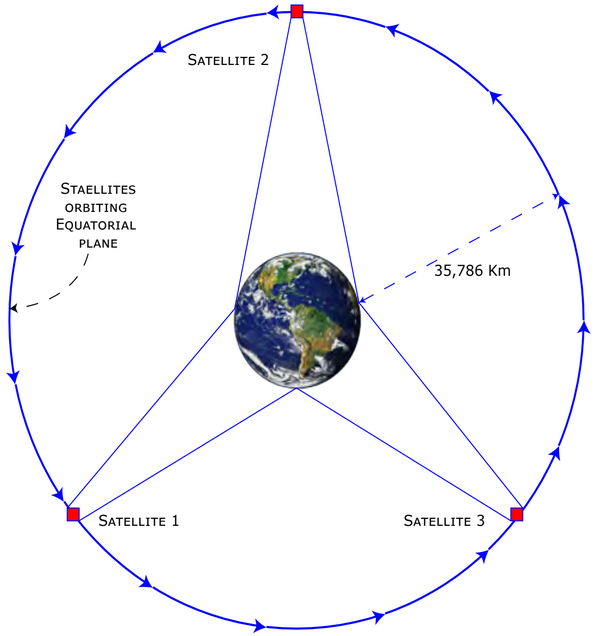


Figure 007-1-20 - Arthur C Clark's proposal for Sat-com (Image: SHH)

Three such satellites 120 degrees apart on the equatorial plane can connect any two points on earth within 2 hops.

However, capabilities did not exist to put such a satellite into orbit at that time.

Satellite Communications

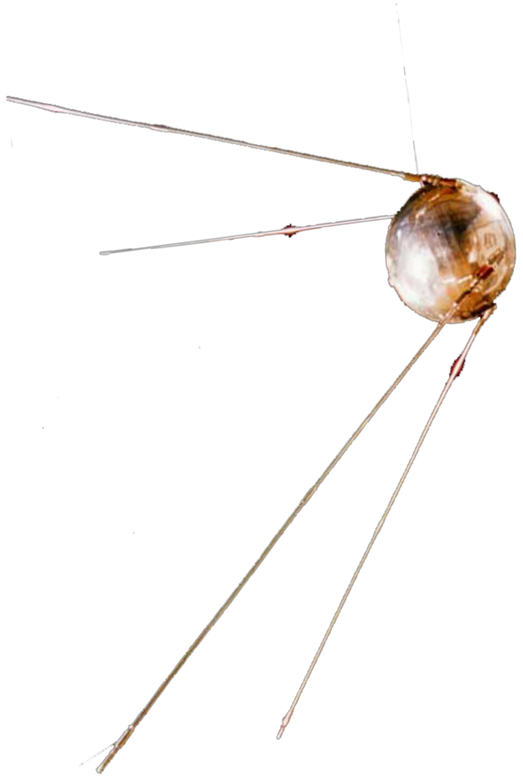


Figure 008-1-21— Sputnik (Image: NASA)

1957 - First artificial satellite, Sputnik, was launched.

1960 - First communication satellite echo was demonstrated.

1963 - First geosynchronous satellite SYNCOM was developed.

1965 - First geosynchronous communications satellite Early Bird - Intelsat1 was launched with TV and Telephone capabilities.

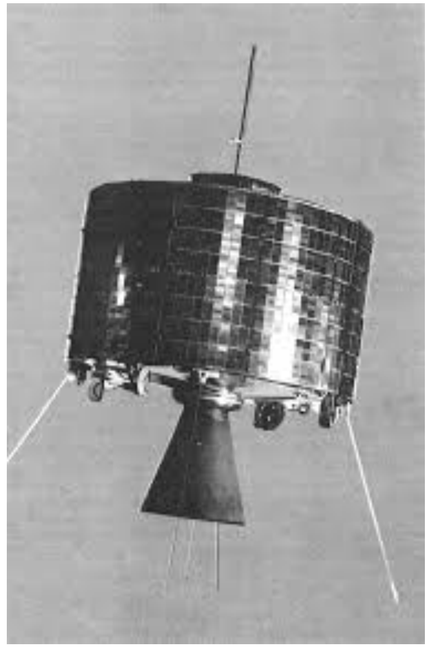
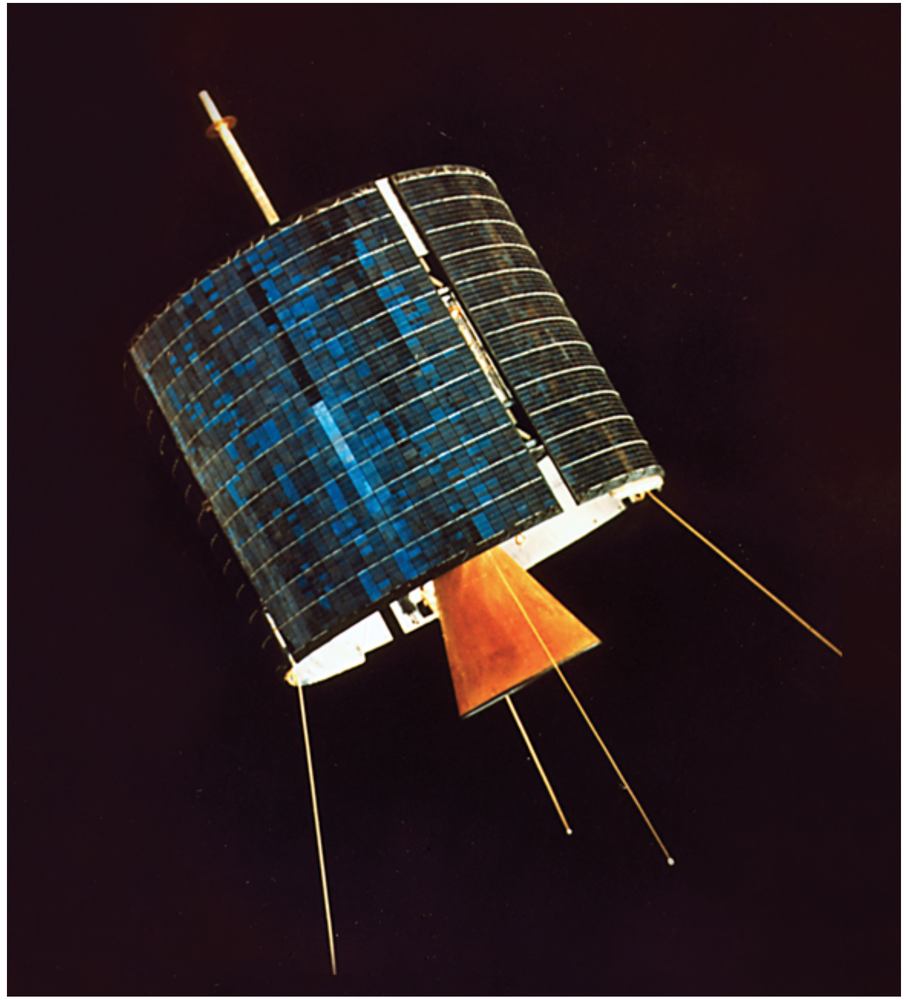


Figure 009-1-21—Syncom 3 (Image: NASA)

First Commercial Geosynchronous Satellite

- Year 1965 – INTELSAT-1 Early Bird built by then Space and Communications Group of Hughes Aircraft Company for COMSAT.
- Television, telephone, and facsimile transmission Between Europe and North America.
- Post Intelsat-1 numerous launches in the 1960s 1970s.
- Intelsat-3 supported 1500 Voice circuits of 4 TV channels.
- Intelsat enabled 4000 Voice circuits in its time.
- Such innovations of those times brought world community together Through networking and connection.



Early Bird INTELSAT-1 Satellite
76 x 61 cm 34.5 Kg
Payload: 6W transponders,50 MHz BW
Antenna : coaxial slotted array

COMMUNICATION SERVICES

Service Networks:

- Technological innovations has been the prime mover in finding solutions for providing various types of communication services.

- Every service application achieves its effectiveness by performing a microwave repeater for Earth stations located within its coverage area.

- Applications are delivered through a network architecture that falls into one of the three categories:
  - Point-to-Point (mesh)
  - Point-to-multipoint (broadcast)
  - Multipoint interactive(VSAT)


Backhaul


Maritime


Oil & Gas

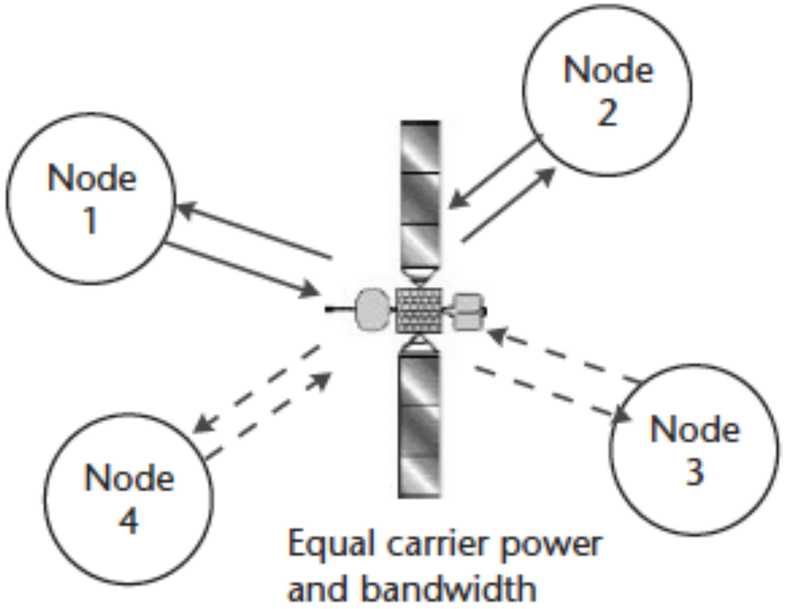

Aeronautical

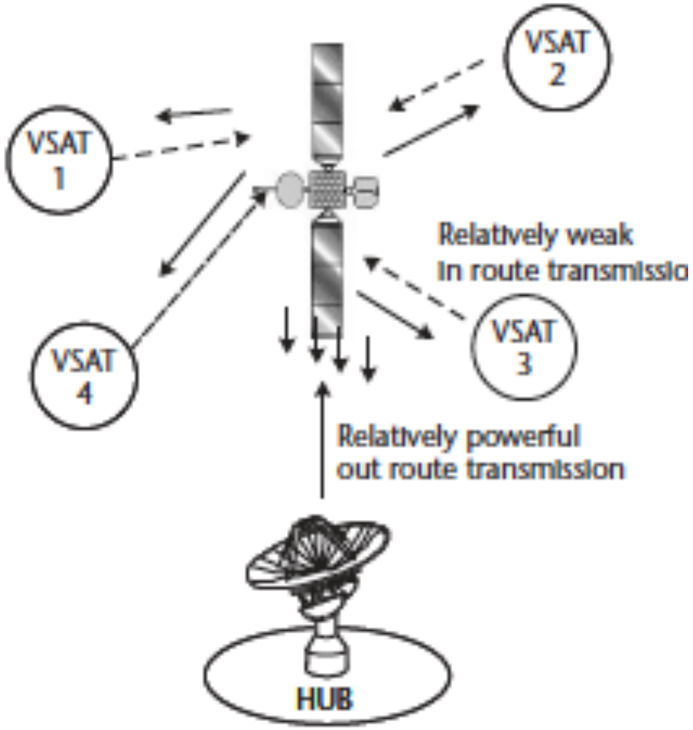

Disaster Com.


Enterprise

Interactive Data Networks:

- Mesh-type networks mirror the telephone network…communicate on a one-to-one basis.
- Broadcast feature – satellite communication is very efficient in distribution of information to a very large base of users.
- VSAT network for interactive data communication applications has proven successful in many lines of business and public.
- A Hub and spoke network using VSATs is equivalent to terrestrial wide area network topology that provides the same result.
- Other application is point-to-point like Telephone network.
- A new generation of satellites and ground equipment which involves very low=cost VSATs have resulted in mass market satellite networks.



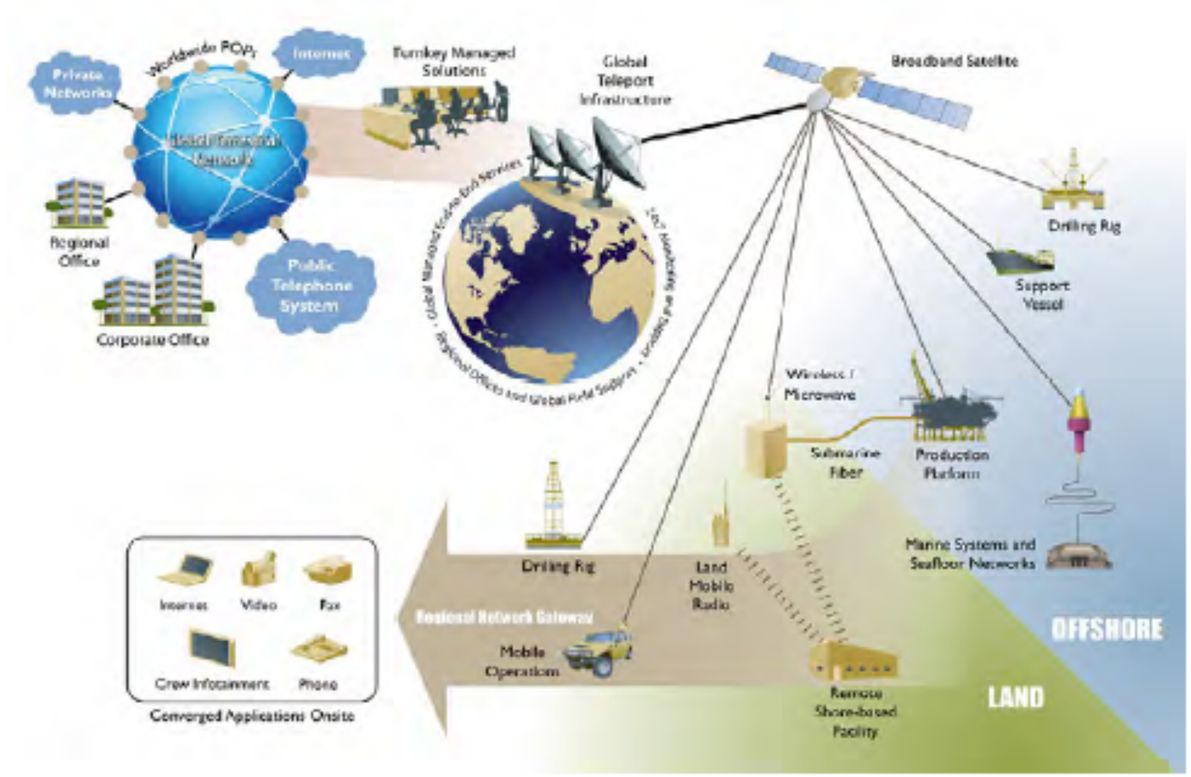


Point-to-point Connectivity

Multipoint-to-point Star Connectivity

Maritime Communication:

- Ship to Shore, Shore to Ship Voice – a full range of telephony
- Location based reporting – to provide GPS, Speed, course etc to the headquarters or Government agencies
- Ship to Shore emergency requests
- Global Maritime Distress Calling
- E-mail, messaging, Web accessing

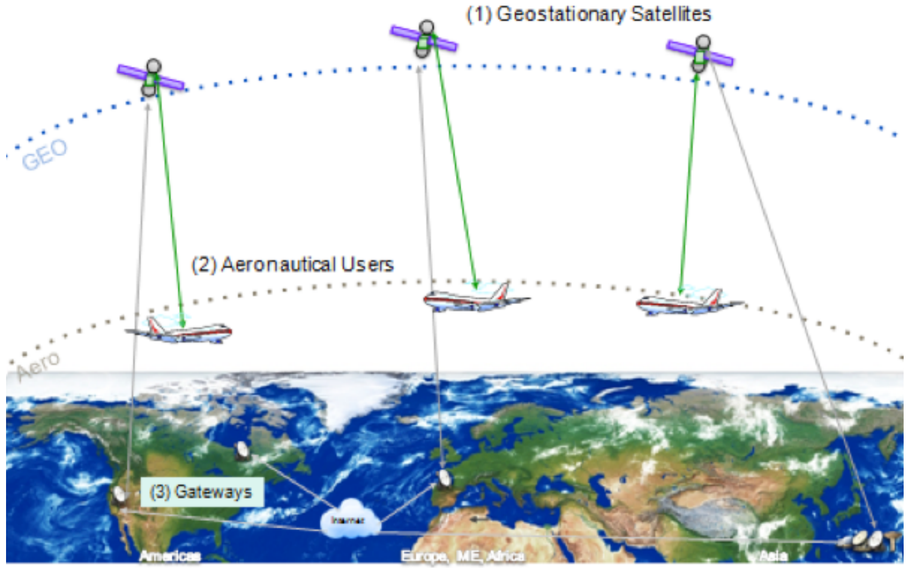


Aeronautical Broadband Internet service

“WiFi in the Sky”

Many commercial flights have this service

- Geostationary satellite footprint beams cover the flight paths to act as relay Between aircraft and ground.
- Gateway stations on ground to transfer data to the internet.
- Aircraft uses phased array antenna technology with ability to point and maintain contact with the ground.

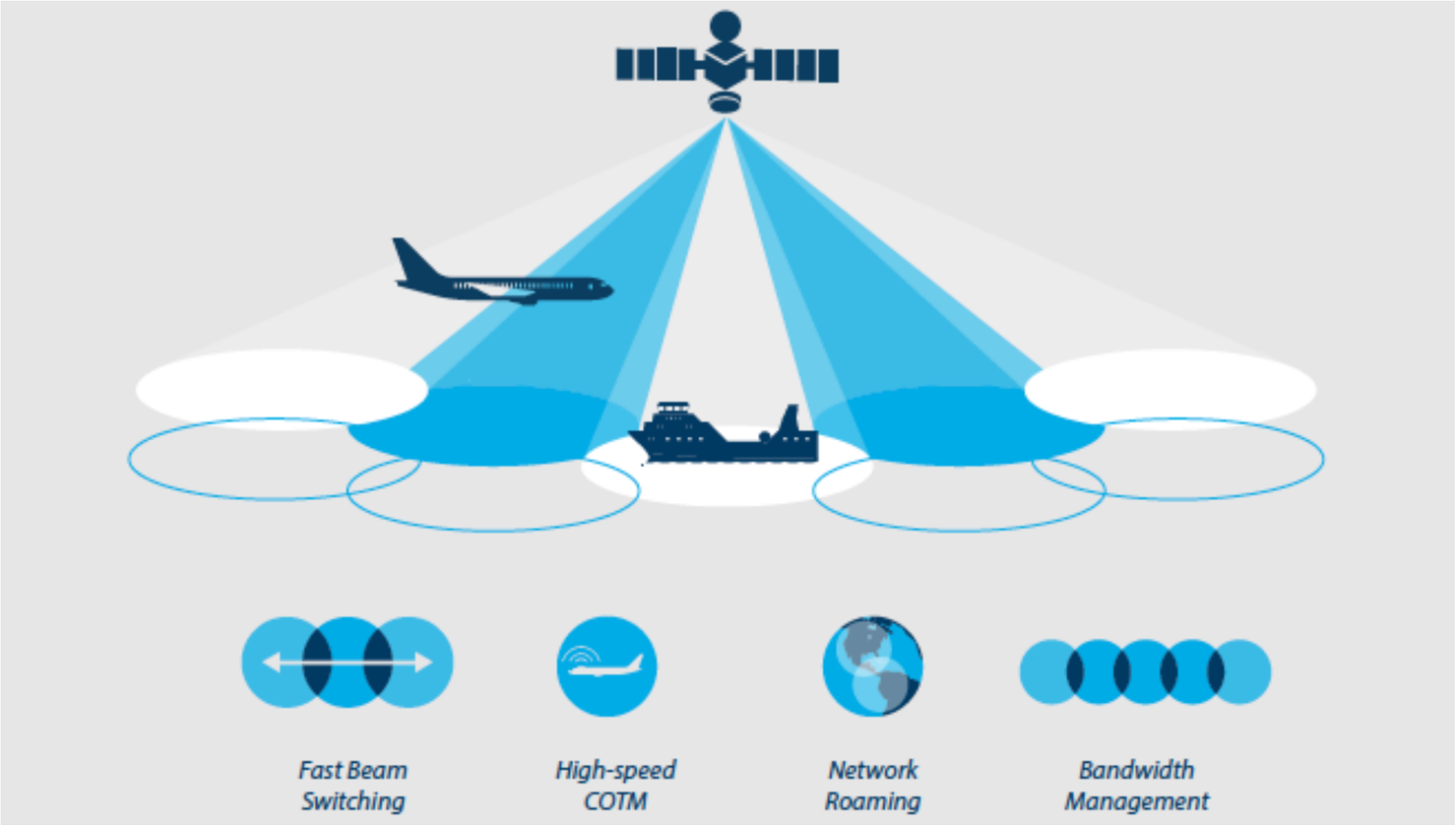


Airborne SATCOM connectivity architecture



Mobility - Aero, marine or land mobiles

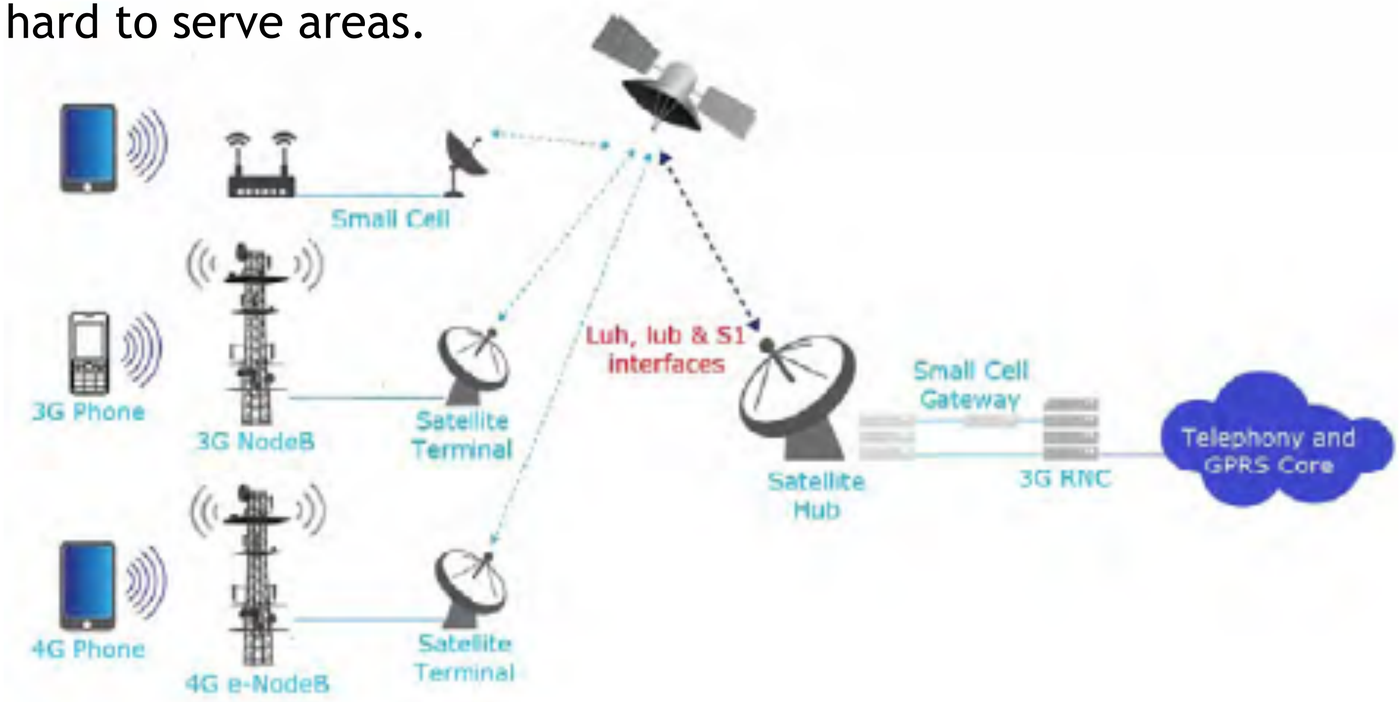
- Remotes that travel between spot beams or satellites
- Advanced mobility capabilities that enable fast-moving remotes to automatically cross multiple beams.



Cellular Backhaul:

Mobile network expansion for growing demand for voice and data services in metro, metro-edge, and rural areas.

Cellular back haul over satellite is often the viable option due to prohibitive costs and excessive time to deploy terrestrial backhaul networks to islands, mountainous regions and other hard to serve areas.

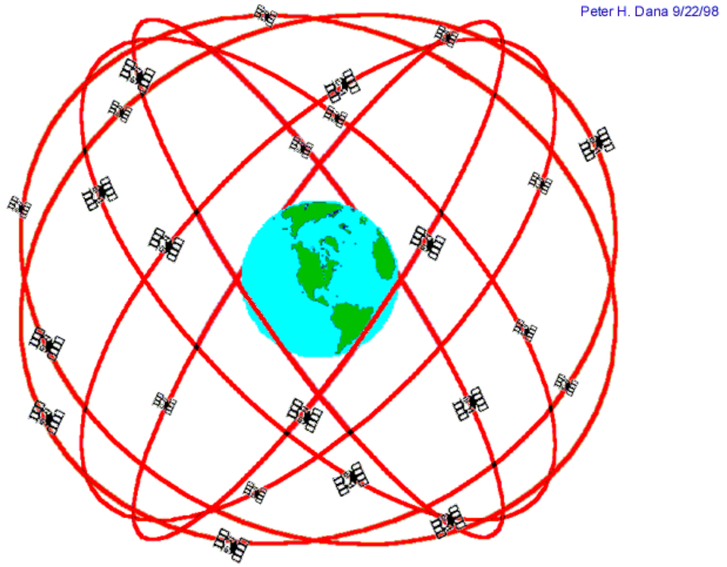


VSAT backhaul for Mobile network

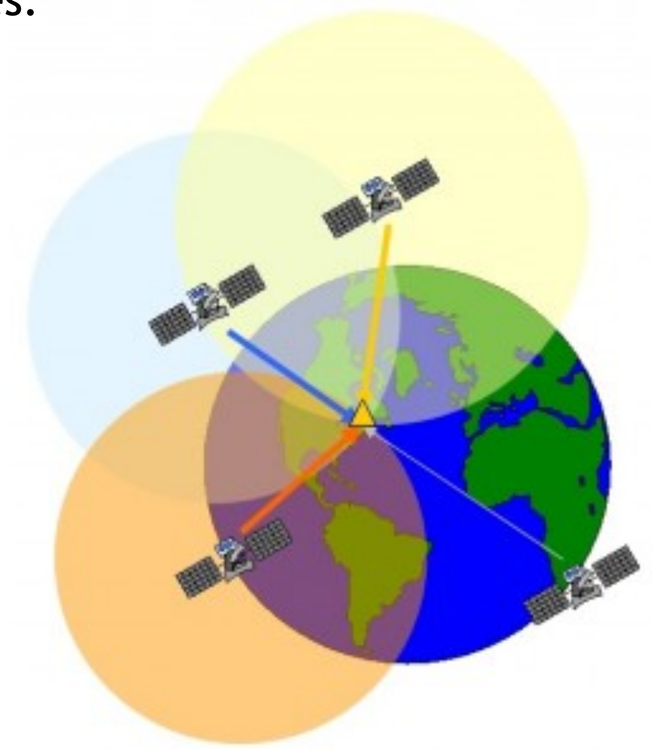
Global Positioning System (GPS): Satellite-based Navigation Services:

- Each satellite an autonomous navigation beacon in space – continuously broadcasts low-power radio signals that identify it and provide information about its location in space, as well as timing and other data.

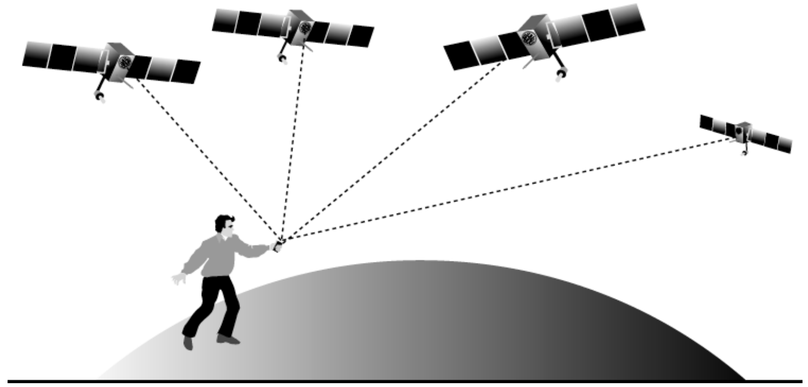
- The signals are broadcast in L-band frequencies.

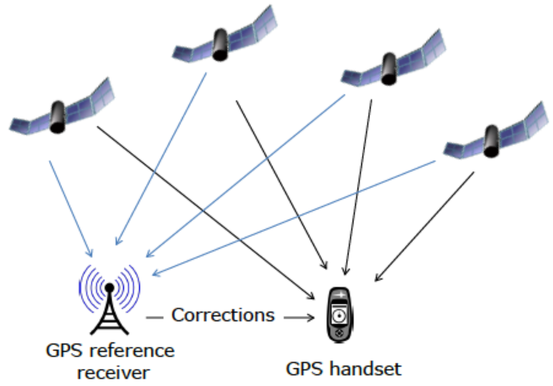


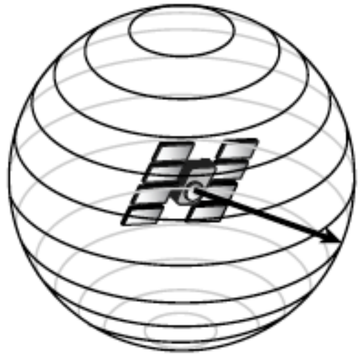
GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination



Differential GPS architecture

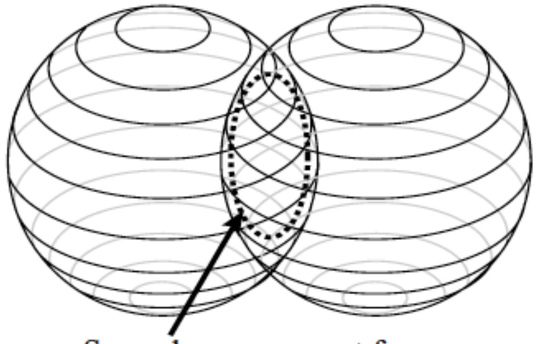






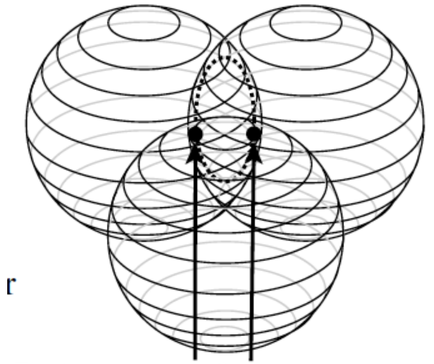
First measurement puts us somewhere on this sphere.

One Satellite



Second measurement from a second satellite shows we are somewhere on this circle.

Two Satellites



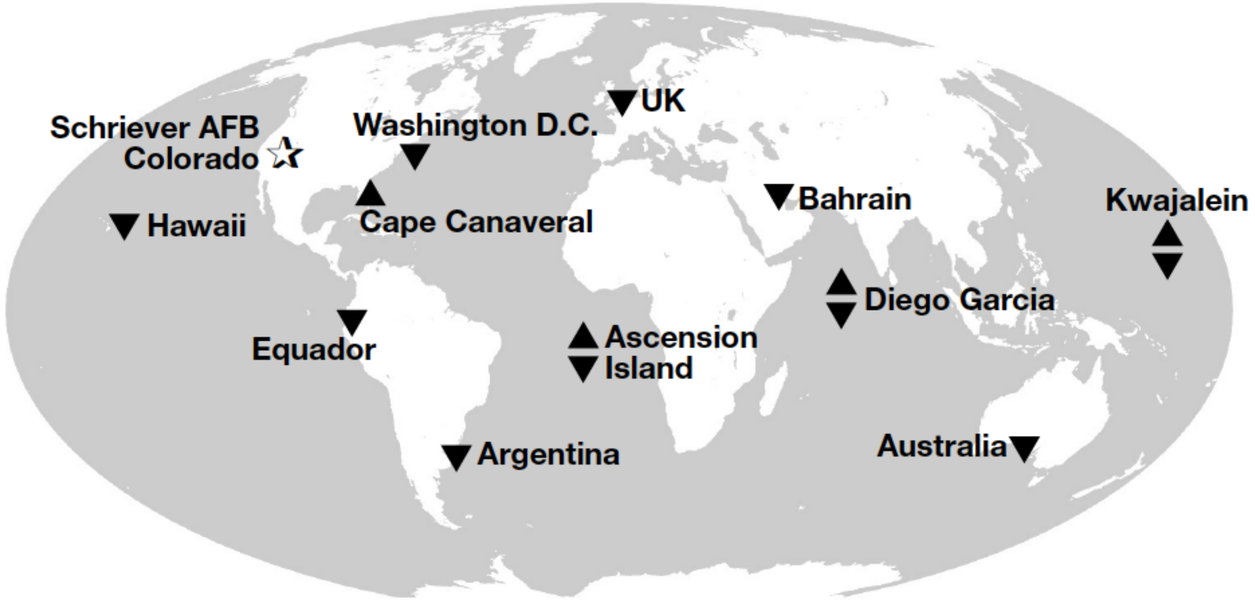
Third measurement from another satellite puts us at one of two points where all three spheres intersect.

Three Satellites

GPS Control Segment – Ground Stations:

Track the navigation signals from all satellites, compute orbit position projections for each satellite in the constellation, as well as correction to the satellites' on-board-clocks.

Master Control Station transmits these navigation signals to the satellites for the satellites to broadcast to the users on ground.



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EVOLVING ARCHITECTURE & APPLICATION MARKETS

Broadening of Services and Applications:

- Traditionally satellite services – to businesses connected with large telecommunication carriers and TV distribution.
- Over the period there has been a broadening in the services and applications provided by satellites.
- The shift in the market has been to bring consumers and business more directly in contact with satellite service providers.
- Direct Broadcast Systems(DBS)- TV & Radio, Mobile Communication, Broadband Multimedia systems are on global scale today.
- This is the trend of direct-to-consumer architecture in DTH(Direct To Home) TV, Satellite DBS-Digital Audio Broadcast, High Throughput System for Broadband services.

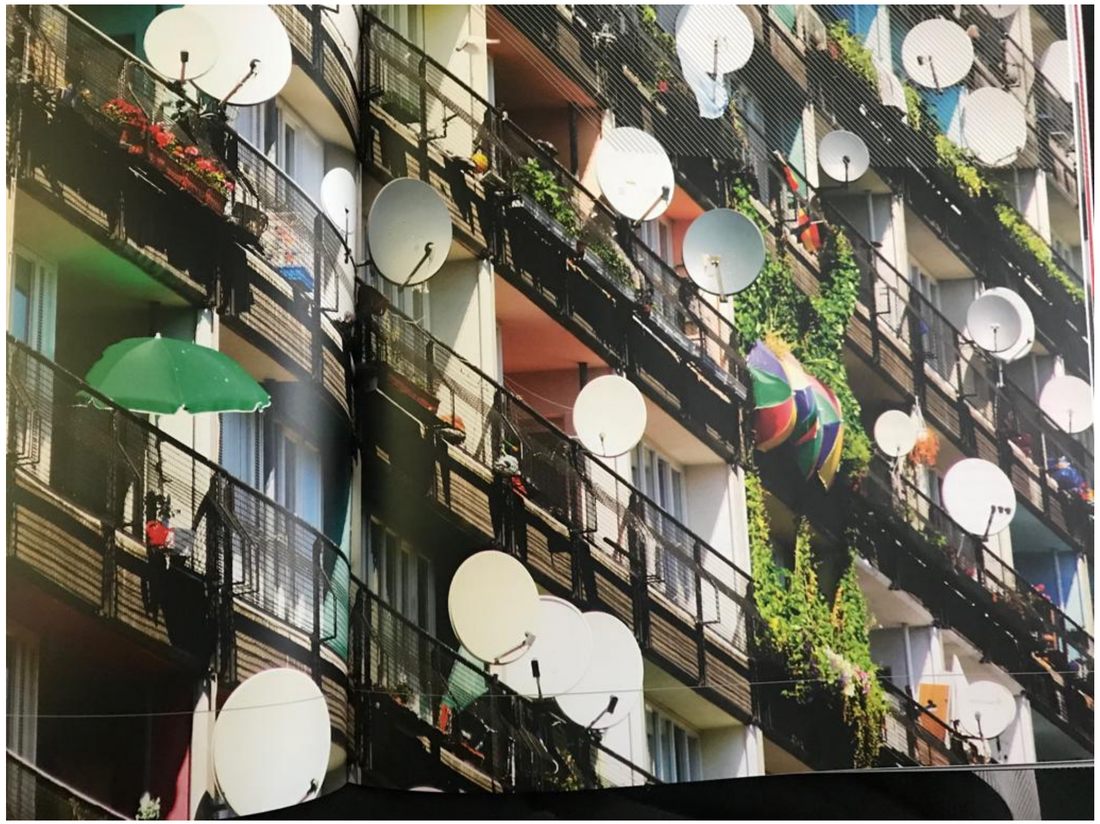
❖ Direct Broadcast Systems(DBS)

✓ DTH(Direct To Home) TV

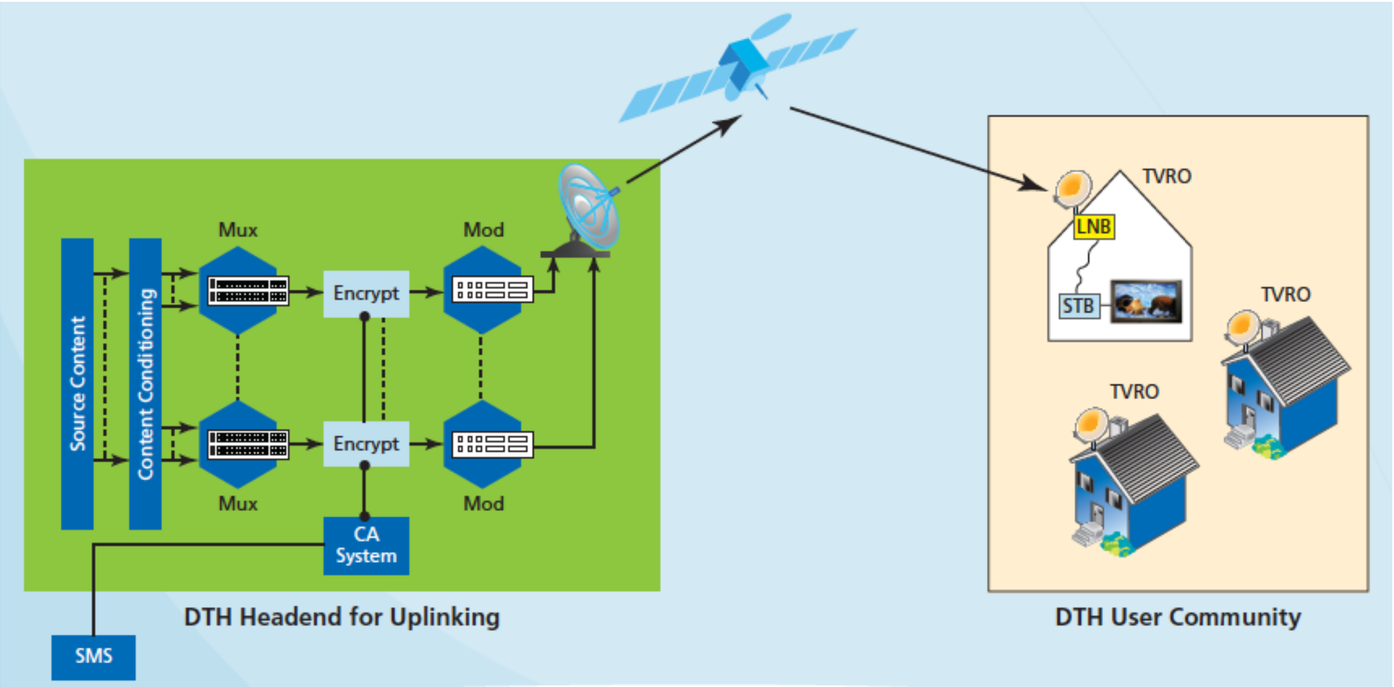
- This is a direct-to-consumer architecture – the development witnessed all over, National and Regional systems.
- High DTH subscriber growth seen for this popular service.
- Enabling technologies of increased power generation, large diameter antennas in Satellite :

✦Digital compression algorithms for video & audio.

✦Evolution of low-cost receive-only terminals on ground for mass communication – Low Noise Block Convertor(LNBC) in the form of Monolithic Microwave Integrated Circuit (MMIC).

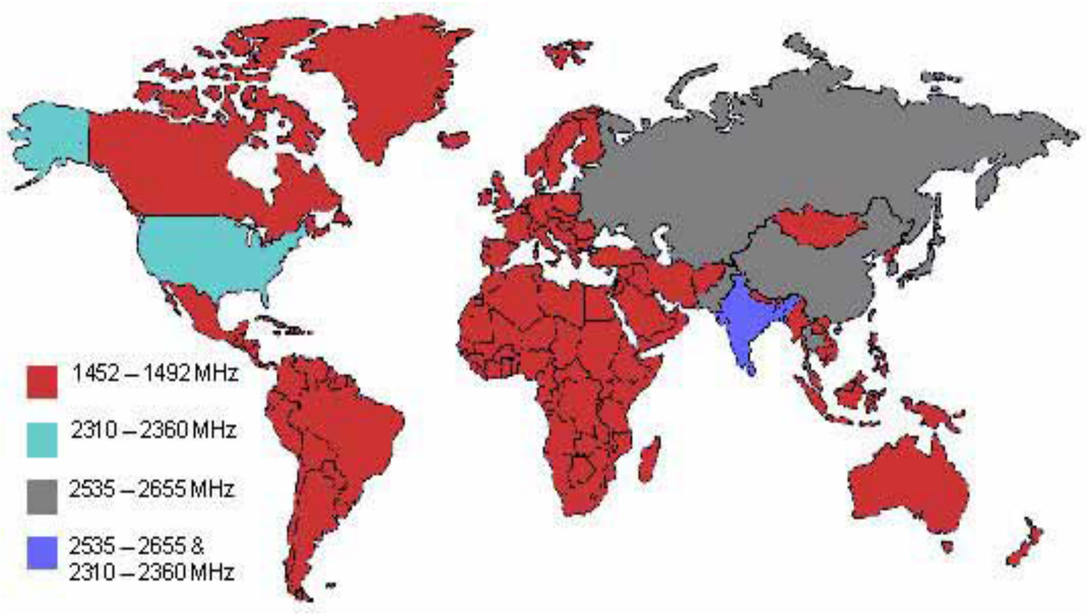


- The function of DTH head-end is to aggregate content – for broadcasting direct to customers.
- Content is encrypted to preclude unauthorised viewing
- Content modulated and transmitted to satellite
- TVRO antenna, LNBC and an authorised STB



✓ Satellite DBS - Digital Audio Broadcast(DAB)

As compared to AM/FM Terrestrial ,the motivation for broadcasting by satellite is the wide area coverage. In comparison, several terrestrial networks are needed to coverage such area.



Worldwide allocations for satellite Digital Sound Broadcasting (DSB).

✓ DBS Systems :

- WorldSpace : Afristar over Africa ; AsiaStar over Asia ; AmeriStar over Latin America
- Sirius : USA
- XM : USA
- Global Radio : Europe

Each of these systems have ….Different business plans, programming channels for a number of national languages, multimedia services along with radio channels.

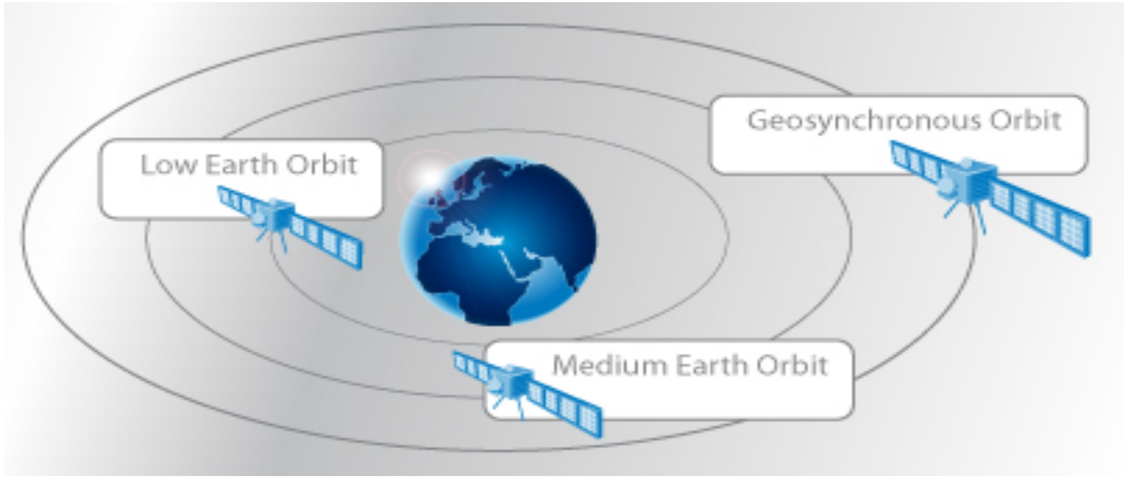
The receivers make use of DSP technology of terrestrial DAB(T-DAB) receivers and can be integrated with mobile phones and personal digital assistants.





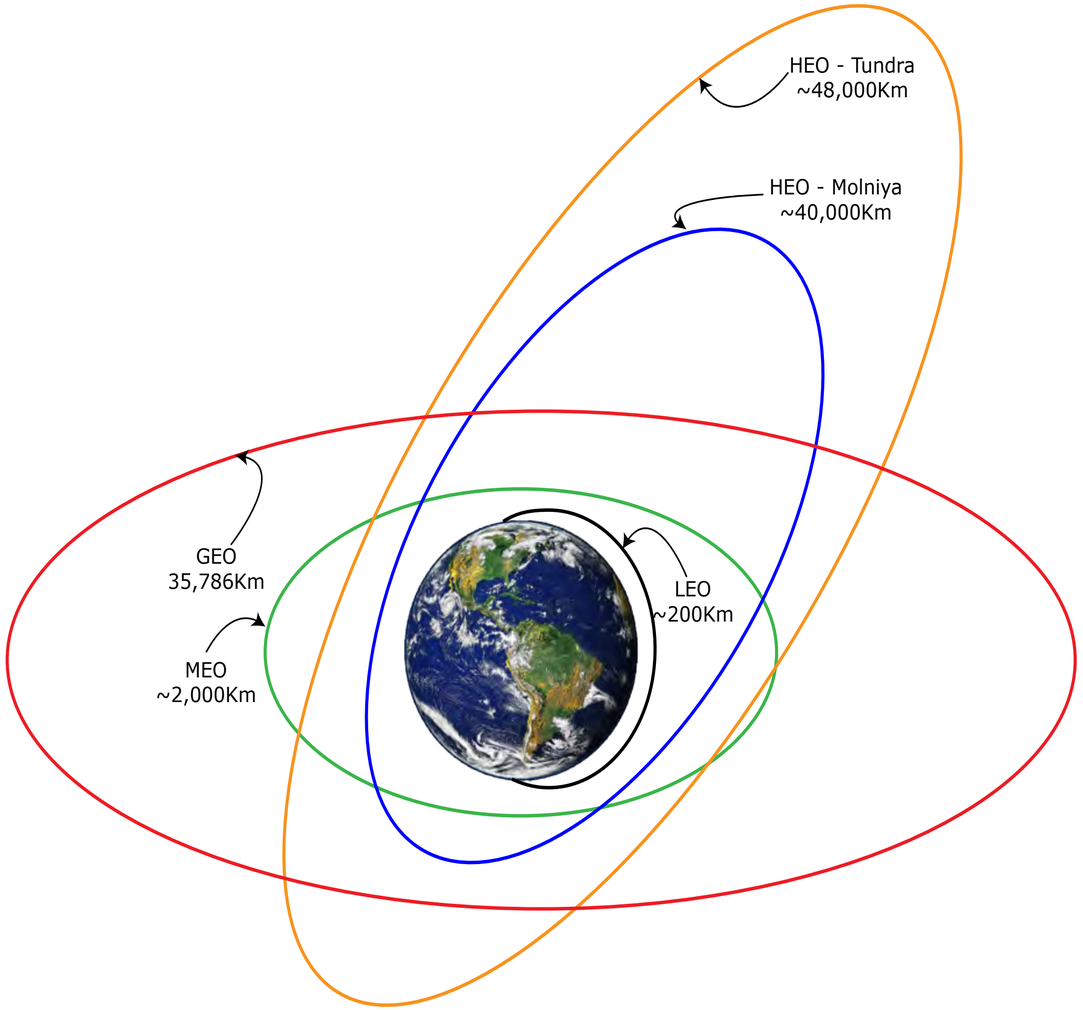
❖ Mobile Satellite Systems

- Direct to the consumer satellite architecture is also reflected in mobile satellite systems.
- These are a combination of navigational , messaging and voice/data mobile systems.
- A combination of satellite orbits based on the altitude of the orbits are GEO, MEO, and LEO systems.



- ✦ GEO – Geostationary orbit : 35,786 Km orbit ; appear to the earth as fixed in the sky. Majority of commercial communications; longer latency.
- ✦ LEO – Low Earth orbit : 160-2000Km orbit ; take approx.. 1.5 hrs for a full orbit and cover a portion of the earth's surface, therefore a network or constellation of satellites to provide global and continuous coverage; lower latency.
- ✦ MEO – Medium Earth Orbit: located above LEO and below GEO; typically travel in an elliptical orbit over North and South pole or in an equatorial orbit; traditionally used for GPS navigation systems; a constellation required to provide continuous coverage.

Satellite Orbit Types

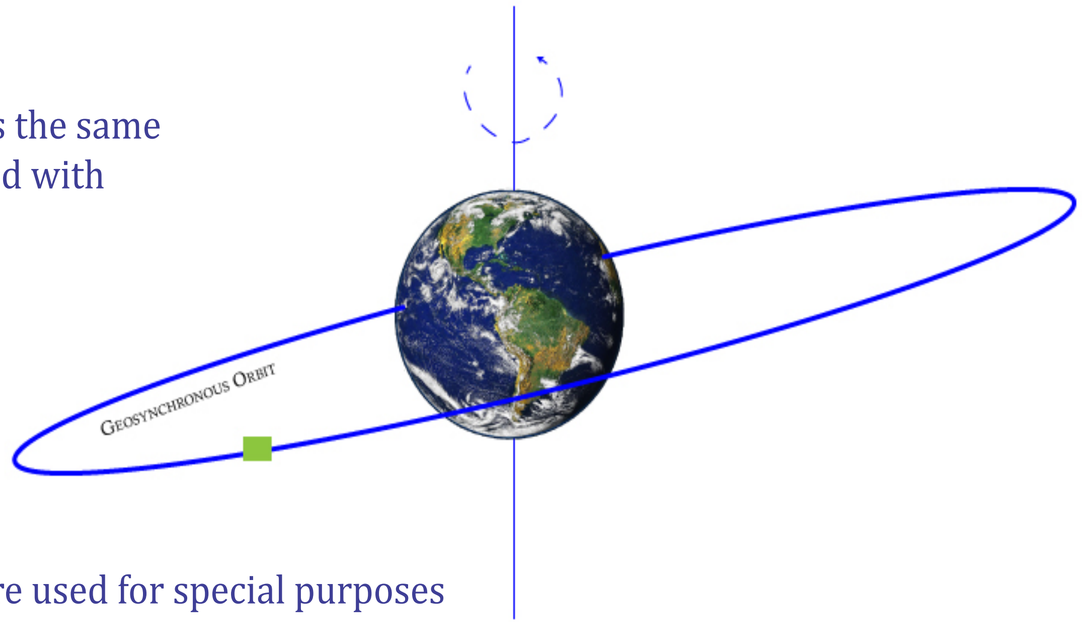


Classification of Satellite Orbits

LEO	Low Earth Orbit	200 - 1,500 Km
MEO	Medium Earth Orbit	5,000 - 10,000 Km
GEO	Geosynchronous Earth Orbit	35,786 Km
HEO - Molniya	Highly Elliptical Orbit	~40,000 Km
HEO - Tundra	Highly Elliptical Orbit	~48,000 Km

Satellite Orbit Types

Geosynchronous satellite orbit has the same period as the Earth, and is inclined with respect to the equatorial plane.



These satellites are used for special purposes like navigation

Figure 012-1-26 - Geosynchronous Orbit (Image: SHH)

Satellite Orbit Types

Advantages of Geostationary Orbits

- Three satellites kept in geostationary orbit can connect any point on earth to any other point.
- Cost effective to reach population with very low density
- Once the satellite is in orbit the roll out of the communication network is very fast
- Not affected by natural calamities like floods, typhoons etc.
- Stationary position
- Multiple access
- Suitability for intercontinental telecommunications, broadcasting, mobile and thin route communications.
- Frequency reuse capability
- Very low Doppler shift
- Reliability

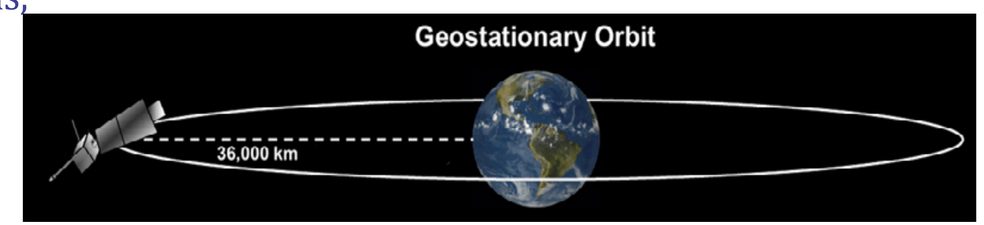
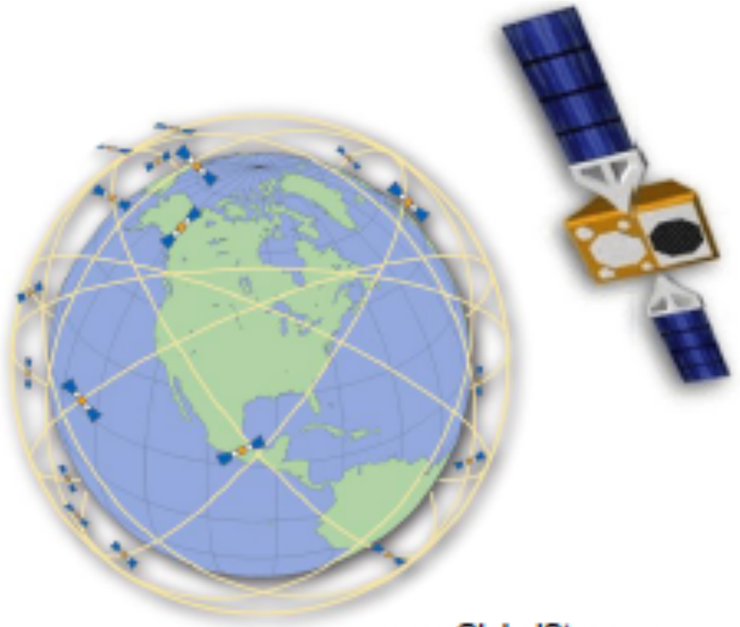


Figure 016-1-30— Geostationary Orbit (Image: SHH)

Globalstar Satellites

LEO Satellite Constellation



www.GlobalStar.com

I. Features:

1. Use: Satellite telephone & low-speed data communications: Voice, data, messaging.
2. Simple transparent 'bent-pipe' repeater onboard.
3. Mobile User Antenna: One 16-beam L-band phased-array antenna on each satellite.
2. No intersatellite link: Ground gateways provide connectivity from satellites to PSTN & Internet.
4. Globalstar operational since February 2000.

II. Characteristics:

1. Constellation: 48 satellites + 4 spare satellites.
2. Orbits: 8 inclined planes at 52° from equator, 6 satellites per plane. No polar coverage.
3. Altitude: ~ 1,410 km (876 miles): LEO orbit.
4. Orbital period: ~ 1.9 hours.
5. Visible time with User terminal: ~ 16 min.
6. Satellite Link Frequencies:
   a. Mobile User Uplink: 1,616 to 1,626.5 MHz.
   b. Mobile User Down : 2,484 to 2,500 MHz.
   c. Gateway Uplink : 5.025 to 5.225 GHz.
   d. Gateway Downlink: 6.875 to 7.075 GHz.
   e. Inter-Satellite cross-links: None.

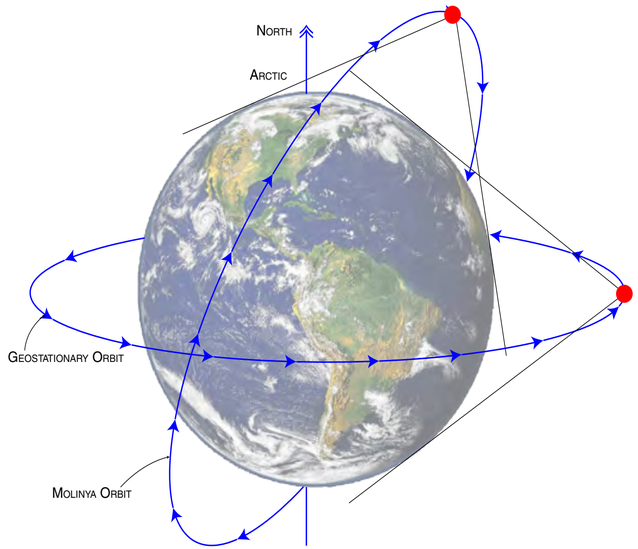
III. Advantages:

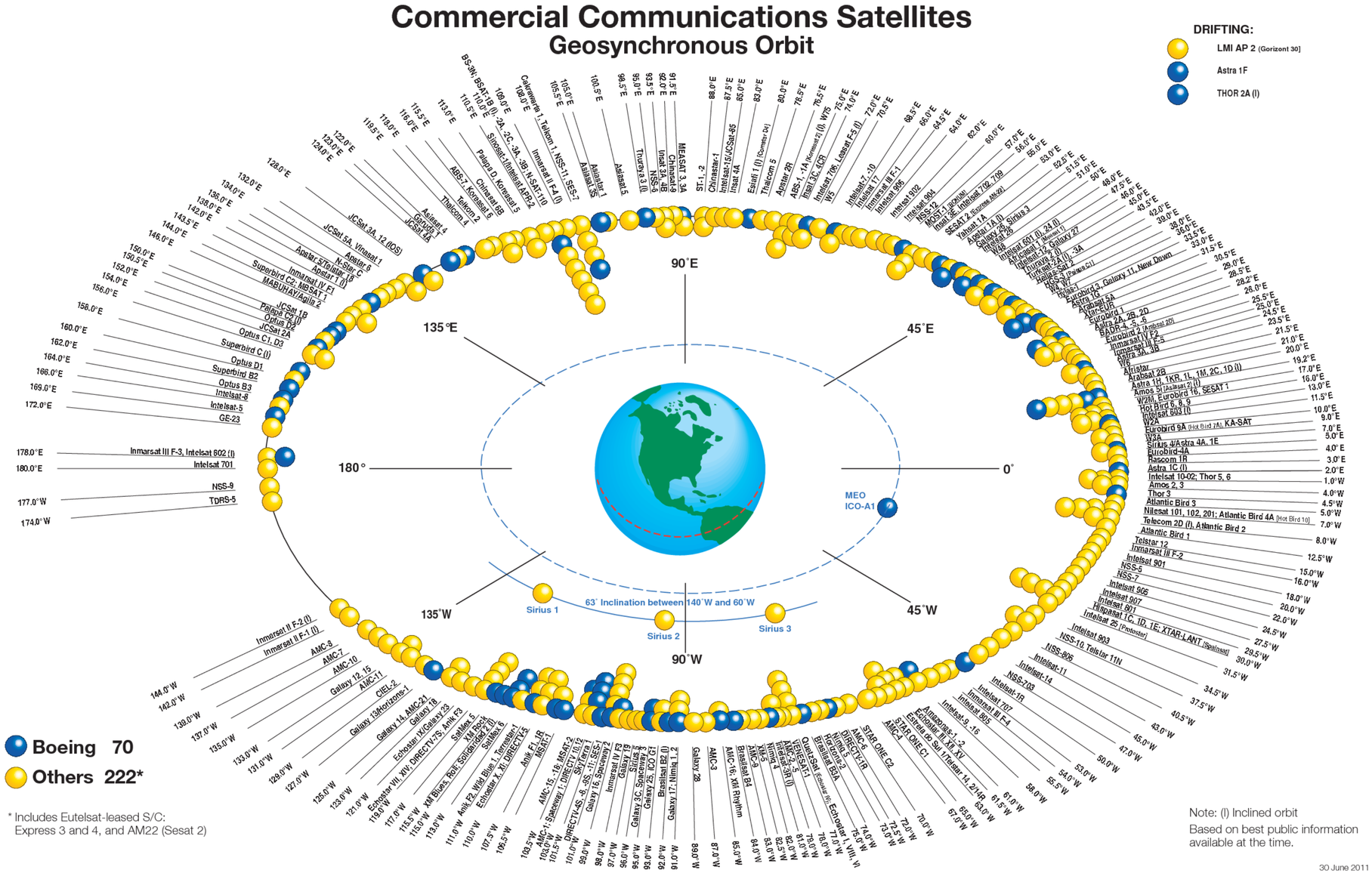
1. Global roaming coverage.
2. One phone for both cellular & satellite calls.
3. Short message service (SMS).
4. Signal latency: < 60 ms.
5. Signal Capacity Allocation: CDMA.
6. Digital voice & data services up to 9.6 kbps.

Satellite Orbit Types

Advantages of Non-Geostationary Orbits

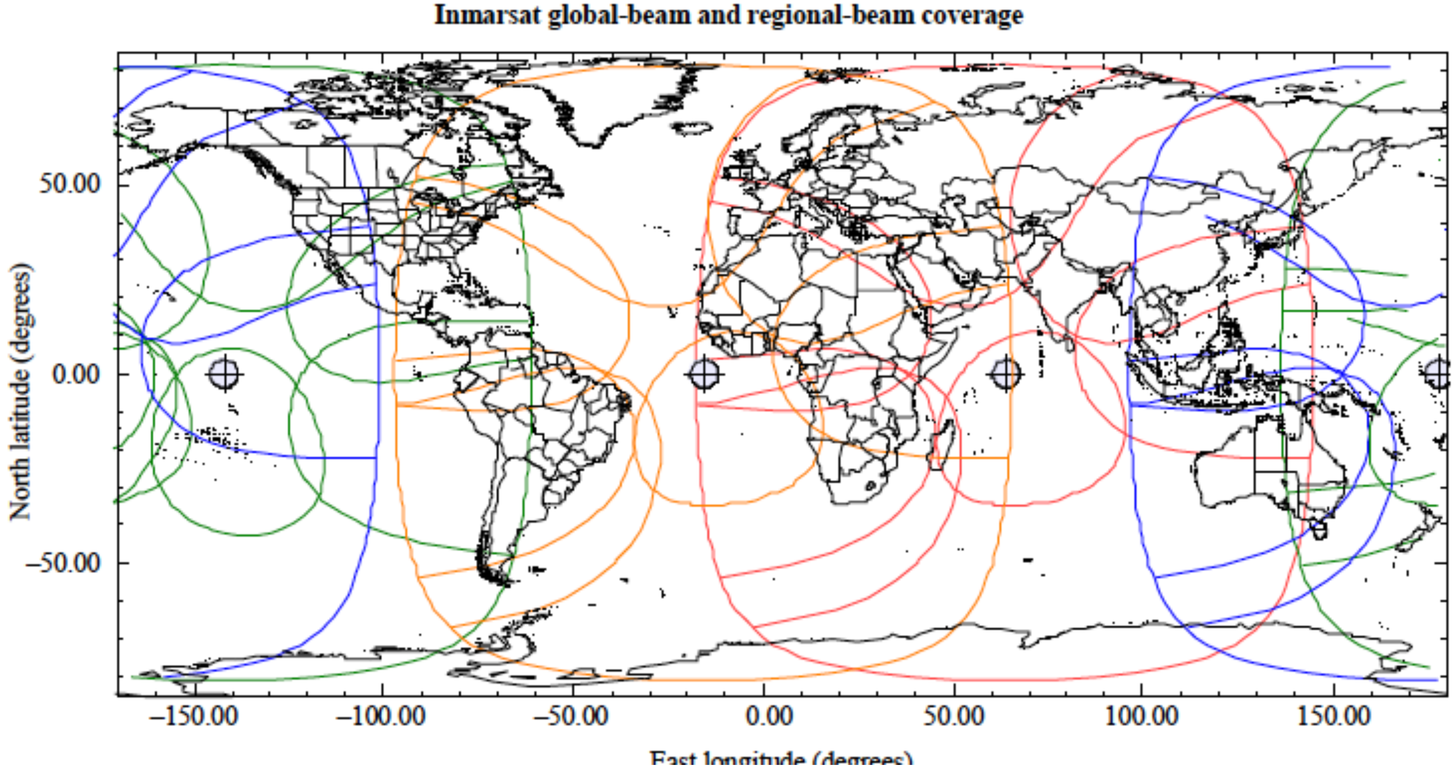
- Less booster power required to put a satellite in lower orbit
- Less space loss for signal propagation at lower altitudes (<10,000 km) leading to lower on-board power requirement
- Less delay in transmission path – reduced problem of echo in voice communications
- Complete coverage of the earth
- Low latency
- Simple hand held equipment
- This satellite system is a global system and everybody on the earth can use it
- Suitability for providing service at higher latitude
- Lower cost to build and launch satellites at NGSO




Commercial Communications Satellites
Geosynchronous Orbit
DRIFTING:
LMI AP 2 (Gorizont 30)
Astra 1F
THOR 2A (I)
90°E
135°E
45°E
180°
0°
135°W
45°W
90°W
MEO
ICO-A1
63° Inclination between 140°W and 60°W
Sirius 1
Sirius 2
Sirius 3
Boeing 70
Others 222*
* Includes Eutelsat-leased S/C:
Express 3 and 4, and AM22 (Sesat 2)
Note: (I) Inclined orbit
Based on best public information
available at the time.
30 June 2011
208710-001.ai

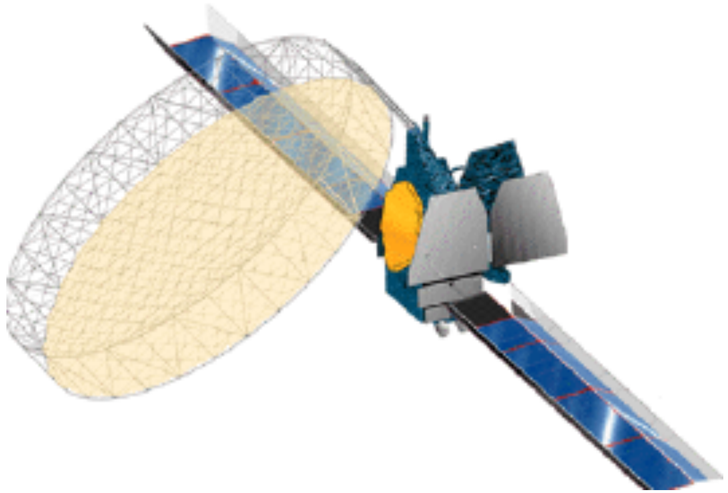
❖ Inmarsat Mobile Satellite Services – GEO platform Satellites:

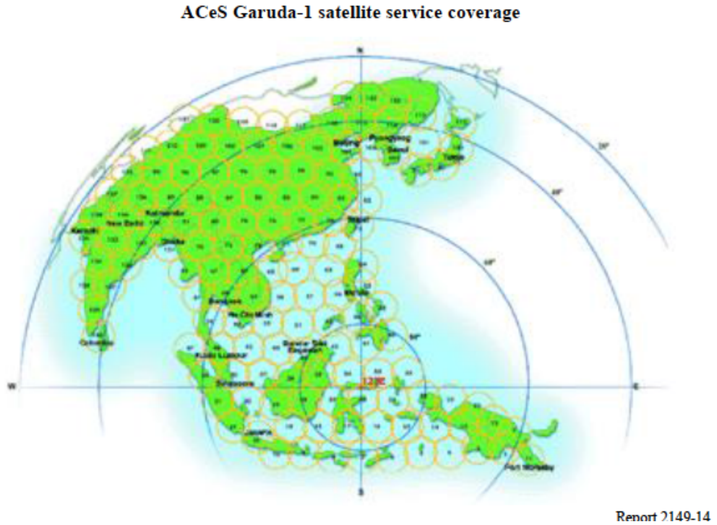
- A constellation of satellites for services on their global, regional and narrow spot beams
- Voice , data, ISDN services
- The only Provider of voice & data for Global maritime distress and safety(GMDSS) system.



❖ AceS (Asia Cellular Satellite) GARUDA-1 - GEO platform Regional service

- World's first personal handheld MSS with coverage area of South-East Asia
- The system operates on L-band frequency using with dual mode (GSM/Satellite) capability that allows the user to roam on any GSM network.
- Large reflector antenna technology is used onboard to generate 140 satellite spot beams.
- Service for voice, data and tracking

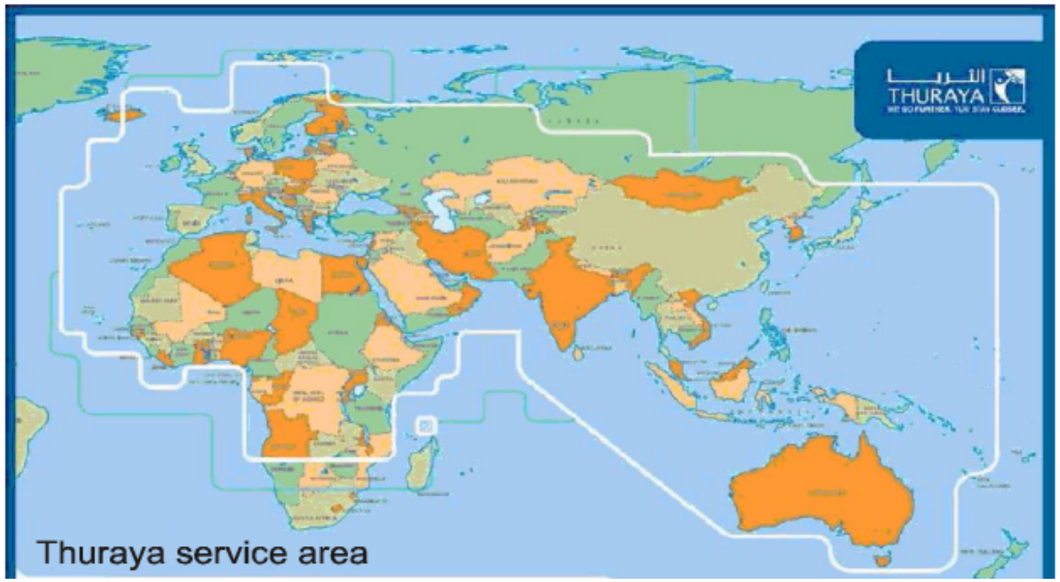




❖ Thuraya Mobile Satellite Service

- GEO platform satellites – geographical coverage of around 140 countries
- Operates on a Global Mobile Personal Communications by Satellite(GMPCS) system.
- Uses advanced satellite technology – Spot beams, digital beam forming Capability, on-board processing.
- Services – voice, low rate data, high-speed data and location based services (based on GPS).
- Thuraya's handheld terminals with built-in GPS receiver facilitates Rescue operation and disaster management.

Thuraya coverage area



❖ Globalstar – LEO constellation MSS System:

- Complex coverage of landmasses and some ocean areas using 48 satellites.
- Services – handheld, vehicular and fixed terminals, two-way data communications.

