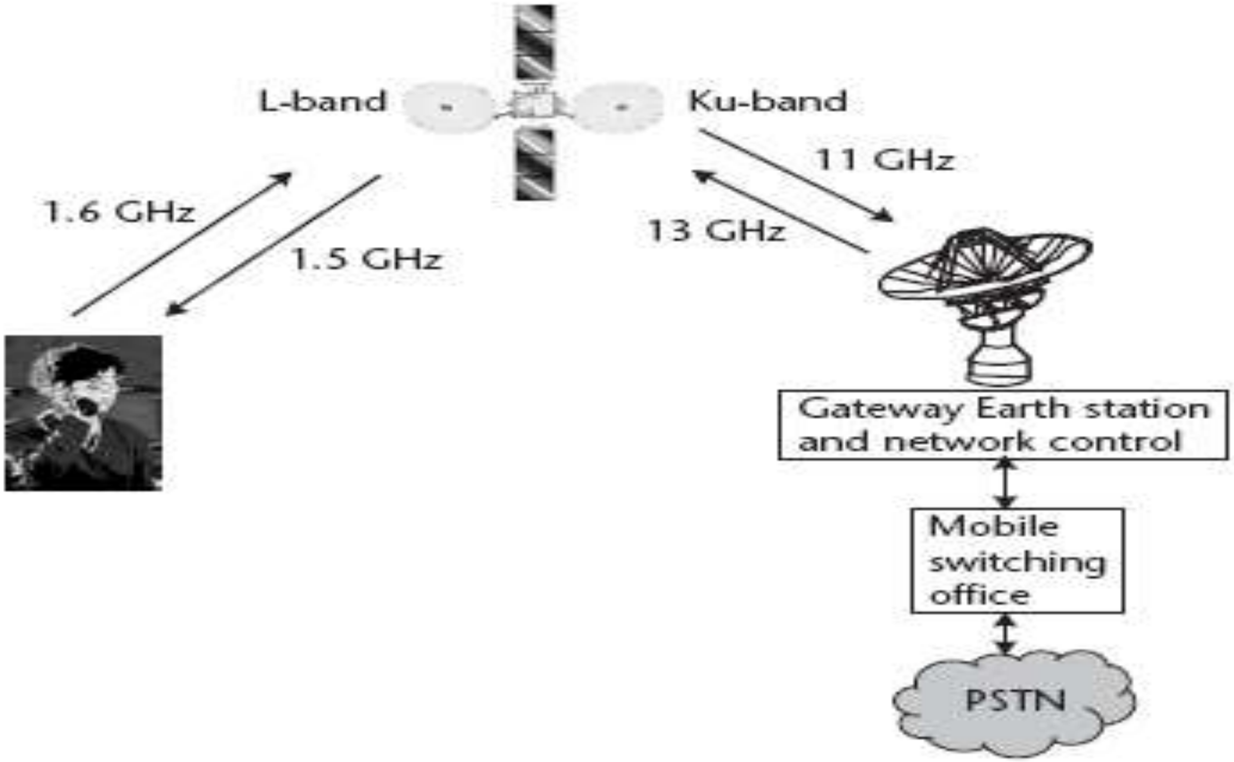
BAB X
Mobile Satellite System (MSS)

Mobile Satellite System

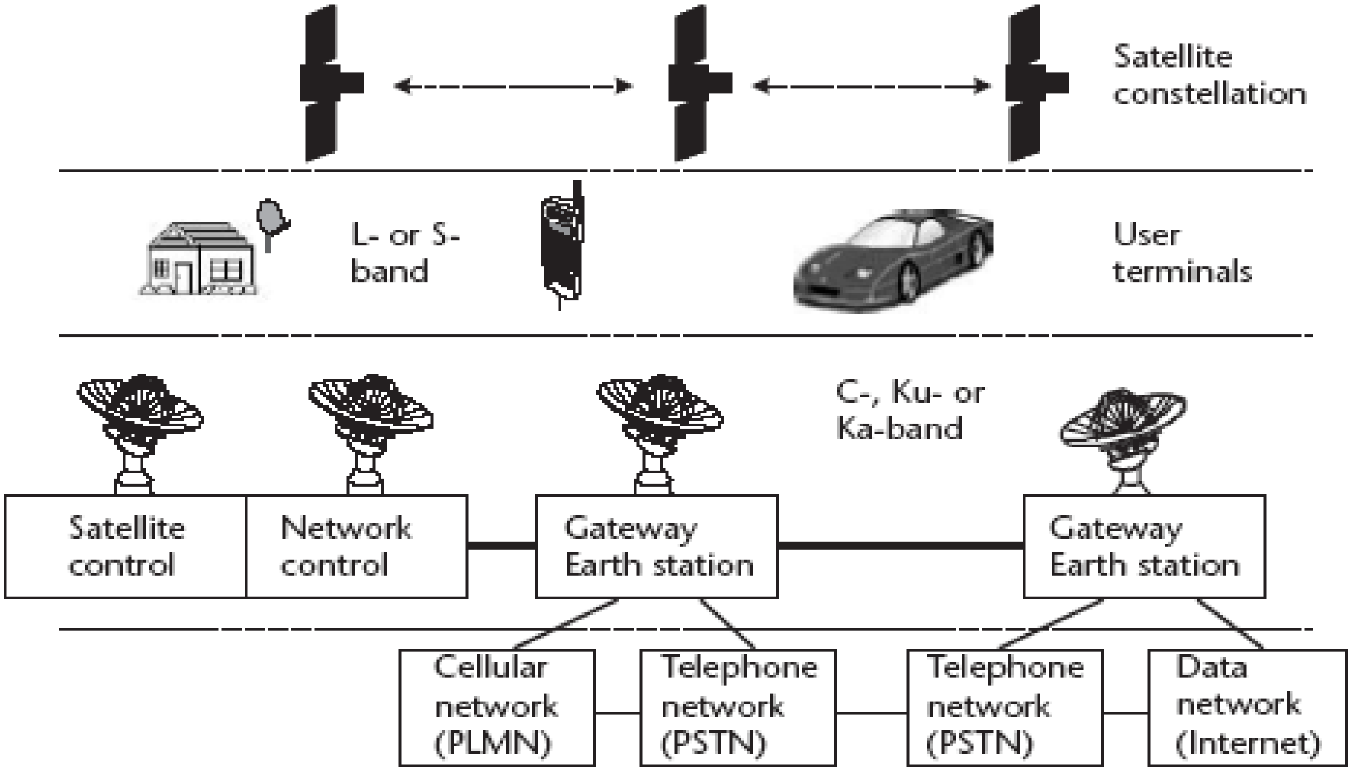
- The Mobile Satellite Service use spectrum at frequencies between 1 and 3 GHz, where simple antennas provide flexible access to the space segment.
- It is preferred because of its greater ability to penetrate foliage and nonmetallic structures and bend around obstacles. Frequencies above 3 GHz are easily blocked by natural and manmade obstacles and introduce practical difficulties when it comes to generating transmit power. Above 10 GHz, rain attenuation is too high.
- The MSS portion of the spectrum is limited to segments of around 50 MHz each due to the following factors:
  - A general lack of bandwidth to begin with, due to the lower frequency as compared to C-, Ku-, and Ka-bands;
  - Competition with land-based services such as cellular telephone, mobile data communications, and a wide variety of unlicensed services such as 802.11 wireless LAN, Wimax;
  - Reduced ability to achieve frequency reuse because user antennas have little or no gain and cannot easily discriminate among satellites within view.

Typical Link of MSS



- The mobile-to-fixed duplex link, using L band to communicate with the mobile subscriber and Ku-band feeder link to the gateway Earth station.
- The mobile subscriber can make and accept calls from the PSTN provided by the space segment; direct user-to-user connections may be possible on a single-hop basis.

Architecture of MSS



- Overall architecture of an MSS system, showing the four primary levels: the satellite constellation, the user terminals, gateway Earth stations and control systems, and the terrestrial networks.

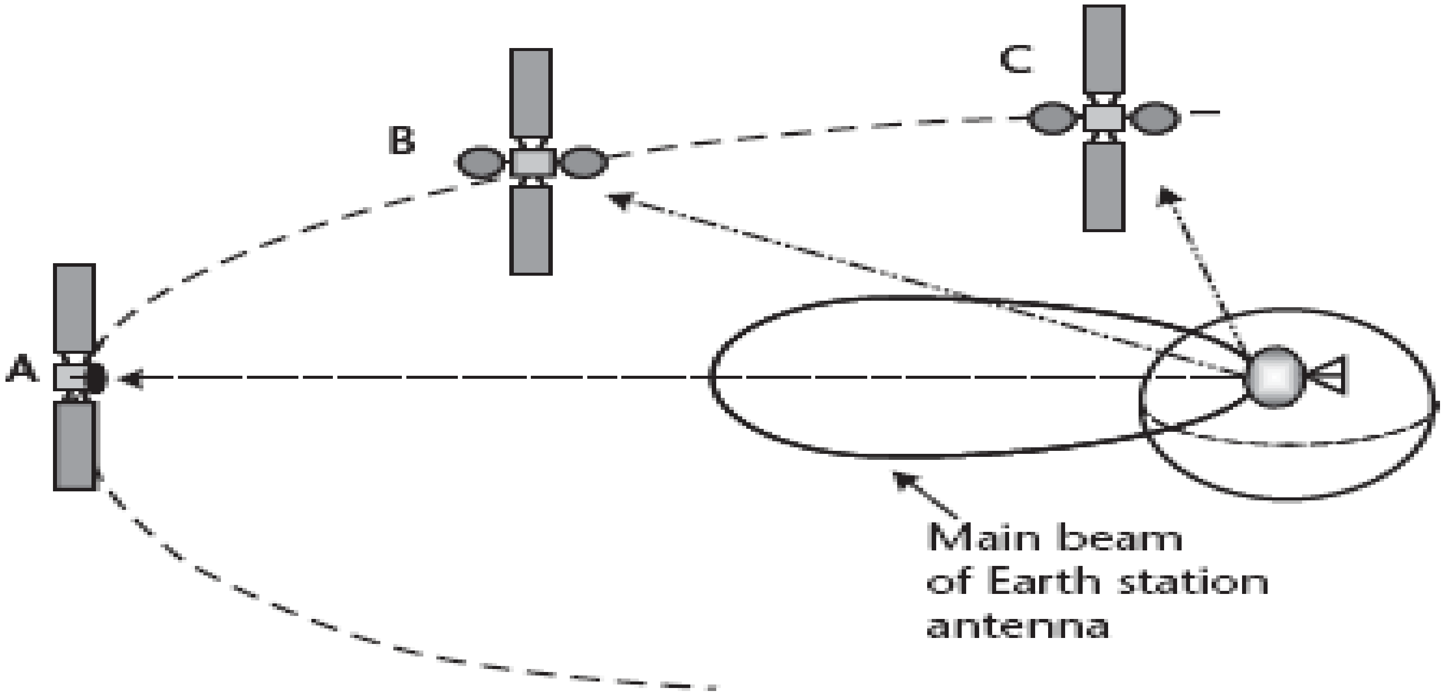
Architecture for MSS

- Each of these levels contributes heavily to the functionality and investment of the total system:
  - Satellite constellation, consisting of a quantity of operational satellites that deliver the service over the coverage area. These can employ any of the possible orbit constellation arrangements, with intersatellite links being optional.
  - User terminals of various types: vehicular, handheld, transportable, ship and aircraft, and fixed terminals.
  - Gateway Earth stations that allow traffic to pass between users and the public networks, and to manage the service on a consistent basis. Also considered are TT&C facilities to control and monitor the satellites.
  - Terrestrial networks to address the service needs of the users. These include the PSTN, the Internet, and other networks, both public and private.

MSS Link Design

- The satellite links design in MSS have many similarities to their counterparts in FSS and BSS. All employ microwave frequencies, experience the standard spreading loss in propagating at the speed of light through free space, and employ conventional low-noise and high-power amplifiers.
- The principal differences are due to limited bandwidth available at L (1-2 GHz) - and S (2-4 GHz) -bands and the dynamic behavior of mobile link fading.

Link Description



- For a mobile broad-beam Earth station antenna, signals from satellite B cause unacceptable interference even though it is many degrees away in orbit space. Satellite C is nearly below the horizon and cannot interfere.

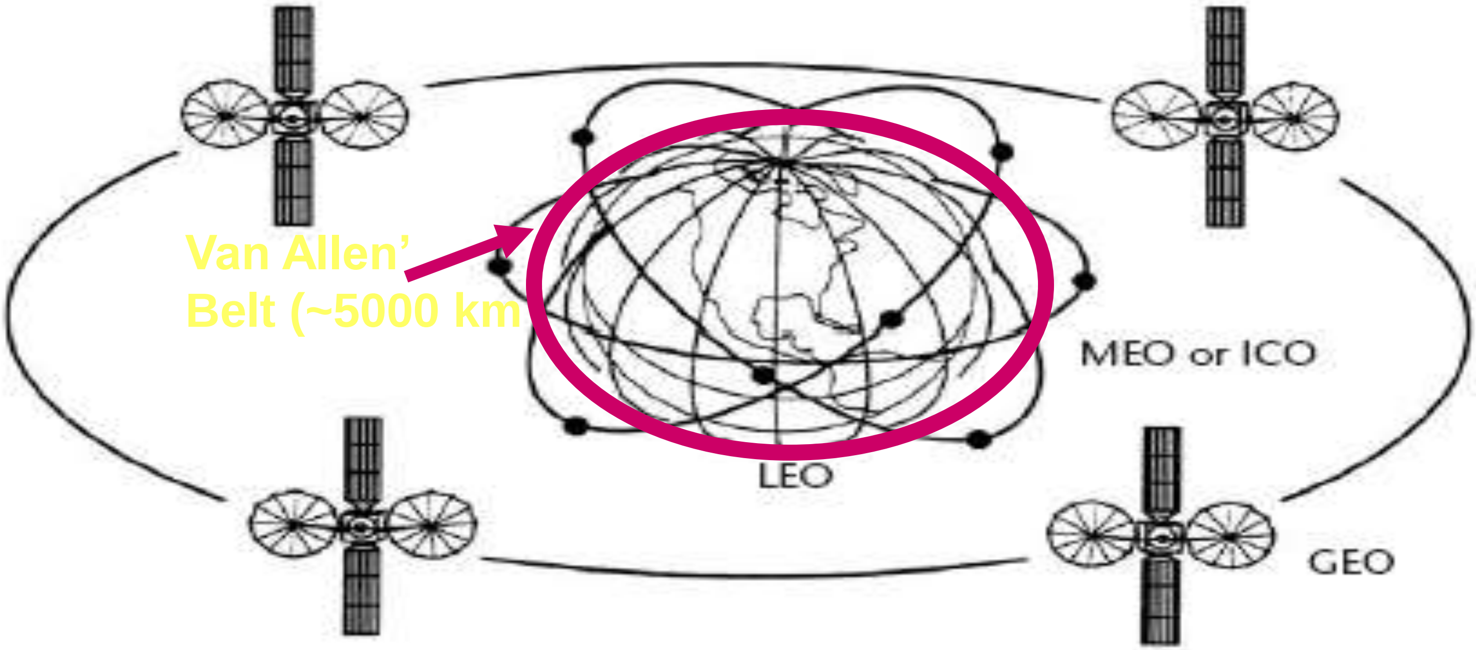
Simplified Link Budget for a GEO MSS Service to a Handheld UT

Parameter	*Forward Link*		*Return Link*		*Footnote*
	Up	*Down*	*Up*	*Down*	
TDMA carrier bandwidth, kHz	48	48	48	48	
Frequency, GHz	14.25	1.54	1.64	12.45	
Transmit antenna	11m	12m	Helix	2m	(1)
EIRP, total, dBW	72.60	63.00	2.70	42.00	
EIRP, per carrier, dBW	52.60	47.10	2.70	11.40	(2)
Path loss, dB	–207.00	–187.6	–188.1	–205.90	
Other losses	–0.25	–0.10	–0.13	–0.23	(3)
Receive G/T, dB/K	4.00	–23.90	20.00	40.00	
Receive C/T, dBW/K	–150.70	–164.50	–165.50	–154.70	
Noise bandwidth, dB(Hz)	–46.81	–46.81	–46.81	–46.81	
Boltzmann's constant	–228.60	–228.60	–228.60	–228.60	
C/N thermal, dB	31.14	17.29	16.26	27.06	
C/IM, dB	30.00	20.00	30.00	17.00	(4)
C/I, dB	20.00	20.00	23.00	20.00	
C/(N + I + IM) total, dB	19.29	14.13	15.28	14.96	
Combined C/(N + I + IM) (up and down), dB		12.97		12.10	
Required C/(N + I + IM), dB		5.00		5.00	
Margin, dB		7.97		7.10	

Link Budget (Cont..)

- *Note:* The IF routing repeater on the satellite transfers a 64 Kbps TDMA carrier in a bandwidth of 48 kHz using R = 0.8 turbo coding and QPSK modulation. Since the repeater provides a bent-pipe transmission path, uplink noise must be added to the downlink noise to determine overall C/N for the link.
- (1) Up is from Earth, down is from space.
- (2) 100 carriers in forward link; 4.1-dB compression due to amplifier saturation effects on forward downlink; ~1,000 carriers on return downlink.
- (3) Clear sky: variable propagation margins will be taken at the end of the link.
- (4) These values come from amplification chain characteristics.

Orbit Selection

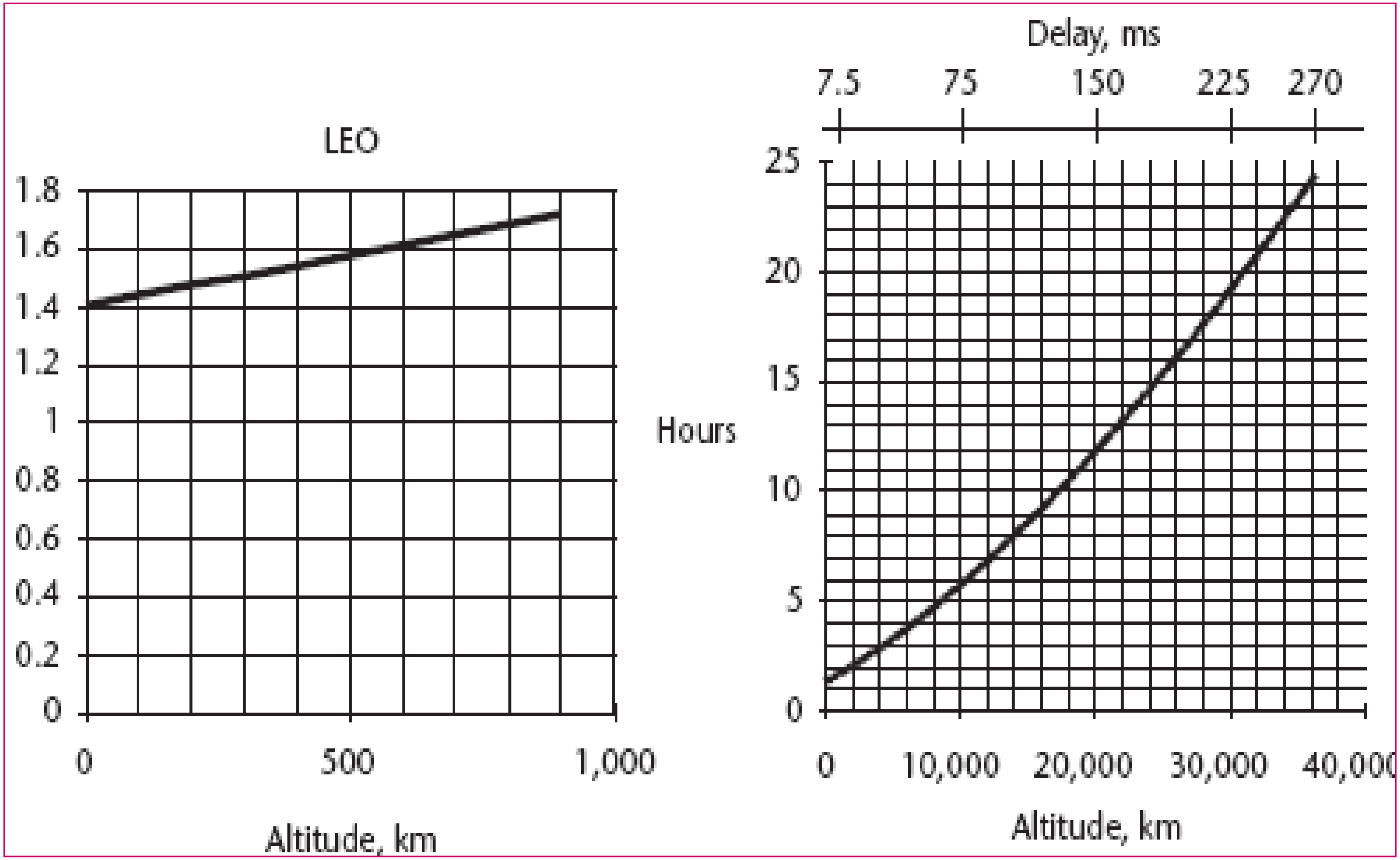


- The three orbits that are applied to MSS: GEO, MEO (also referred to as intermediate circular orbit), and LEO. As the altitude of the orbit is decreased from GEO, the number of satellites required for continuous coverage increases.
- The inclined geosynchronous orbit (not shown) is applied as well (e.g., Sirus Satellite Radio), since mobile antennas either are broad in beamwidth or have tracking mounts.

Orbit Characteristics

Orbit Definition	*Altitude Range (km)*	*Period (Hours)*
LEO	150 to 1,000	1.5 to 1.8
MEO	5,000 to 10,000	3.5 to 6
Geosynchronous orbit (e.g., synchronized to 24-hour rotation of the Earth but generally elliptical in shape; may or may not be inclined with respect to the equator)	36,000 mean altitude	24
GEO	36,000 precisely, in plane of the equator	24
Highly elliptical Earth orbit (HEO)	1,000 to 40,000	12 to 24

Orbit period and one-way (single-hop) time delay versus altitude.



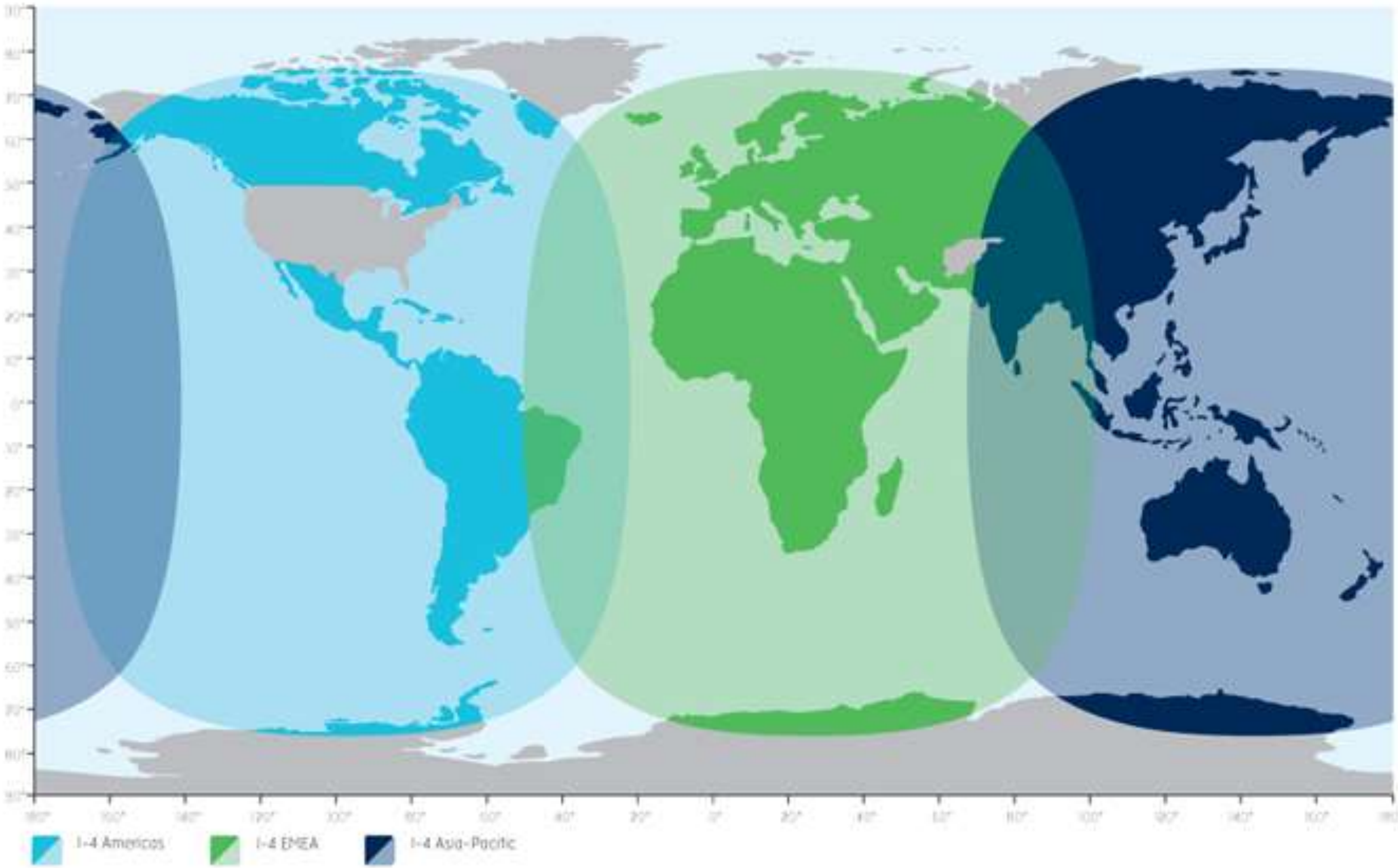
Summary of the Key Attributes of LEO, MEO, and GEO Orbits

LEO	*MEO*	*GEO*
20-dB net advantage over GEO; reduced latency favored for voice	Medium altitude is compromise between LEO and GEO; reduced latency relative to GEO	Simplest and lowest in cost to implement and operate; latency an issue in some applications
Large constellation needed	Small constellation or pairing	Single satellite
Limited coverage; favors cross-links	Each satellite covers large landmass or ocean; cross-links of limited value	Each satellite covers a hemisphere; little or no use for cross-links
Nearly three-quarters of satellites over oceans at a given time	Satellite coverage extends across oceans	Satellite coverage extends across oceans and continents

GEO MSS Systems

- GEO satellites have provided most of the MSS capabilities, in terms of land, sea, and air. The economy and simplicity of a single satellite along with the ability to use fixed antennas on the ground have allowed GEO to reach critical mass for the applications.
- In addition to the global capability of Inmarsat, a number of GEO MSS networks capable of serving handheld satellite telephones are in service.
- The major benefit of the lower orbits is reduced time delay for voice services. This factor is very important in terrestrial telephone networks, particularly with high-quality transmission as provided through fiber optic technology. Time delay is less of a factor in mobile communications.

INMARSAT COVERAGE



1. Inmarsat (Gen.3 and 4)

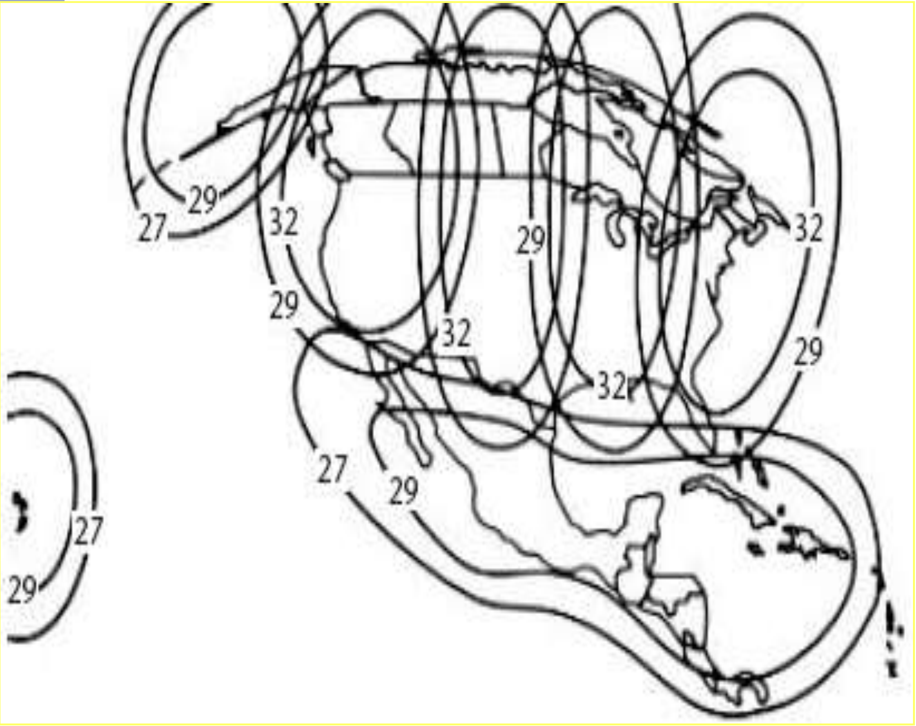
Year of Adoption	*Satellite Series*	*Service Capabilities*
1982	Inmarsat A	Analog telephone (FM-SCPC) and telex
1990	Inmarsat Aero	Aeronautical digital voice and low-speed data
1991	Inmarsat C	Low-speed data, briefcase keyboard terminals
1993	Inmarsat B	ISDN digital voice and data (64 Kbps), suitcase-sized land mobile terminals
1993	Inmarsat M	Compressed digital voice, briefcase terminals
1994	Global paging	Pocket size pagers
1995	Navigational services	Variety of specialized devices
1997	Mini-M	Laptop voice terminals
2003	Regional Broadband Global Area Network (B-GAN)	Palmtop medium data rate modem, ~144 Kbps, Europe, North Africa, the Middle East, and southern Asia
2005	B-GAN	Palmtop medium data rate modem, 144 Kbps, global footprint using Inmarsat 4
2013-14	I-5	downlink up to 50 Mbps uplink up to 5 Mbps

User Terminals for use on the Inmarsat system.

Regional BGAN
IP Modem (HNS)

1. Integral antenna
2. Compass
3. SIM card
4. Battery
5. External power
6. USB
7. Indicators
8. Ethernet

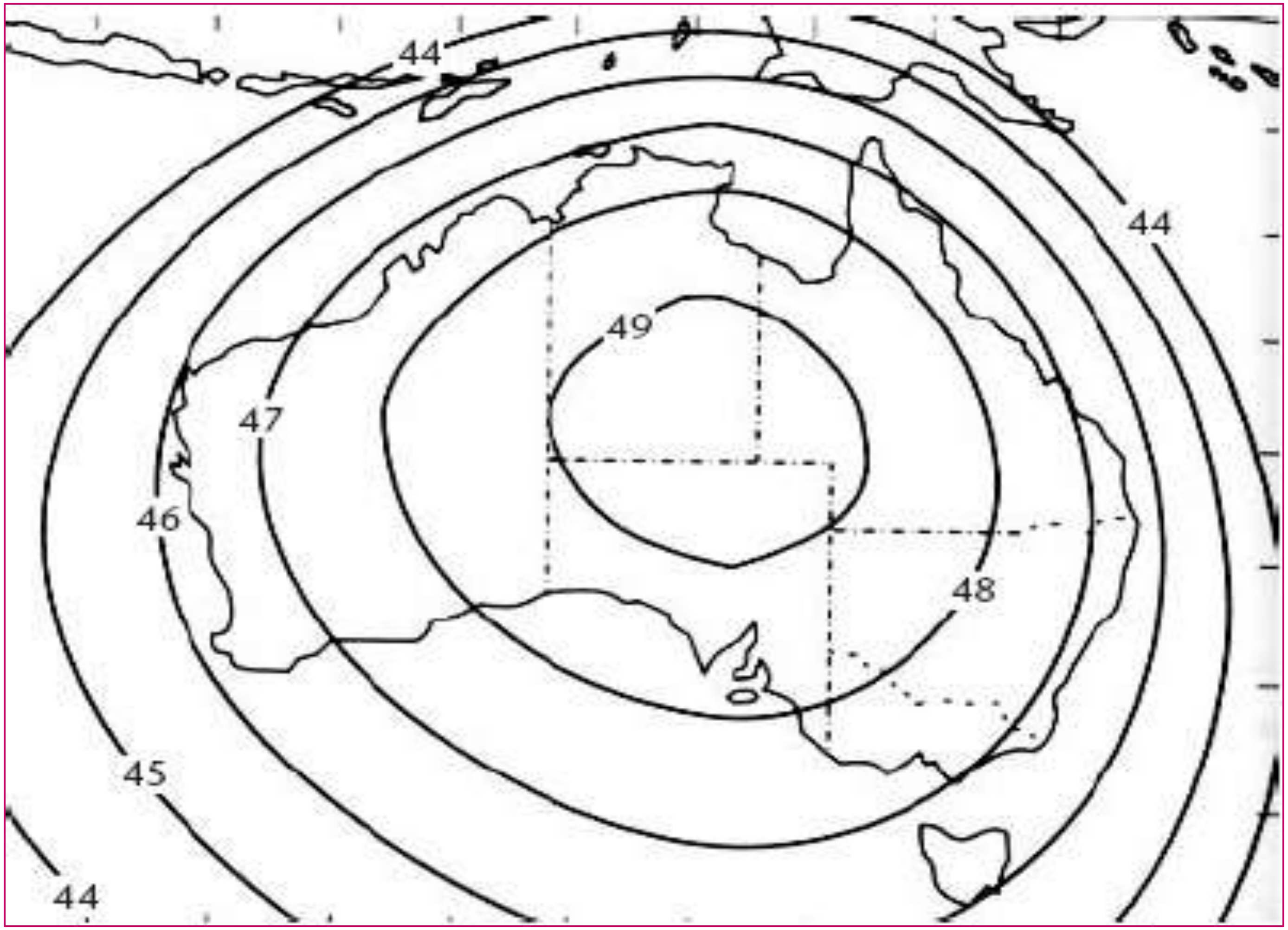
2. North American and Australian MSS Systems



- American Mobile Satellite Corporation (AMSC) was first to launch a GEO MSS in North America, using a medium power satellite called MSAT .
- The same MSAT platform was adopted for Canada by Telesat.
- Typical MSAT antenna gain showing six area beams that cover the 50 states, Canada, and Mexico. This arrangement offers limited frequency reuse

Typical MSAT mobile UTs.

Optus B L-band downlink EIRP.

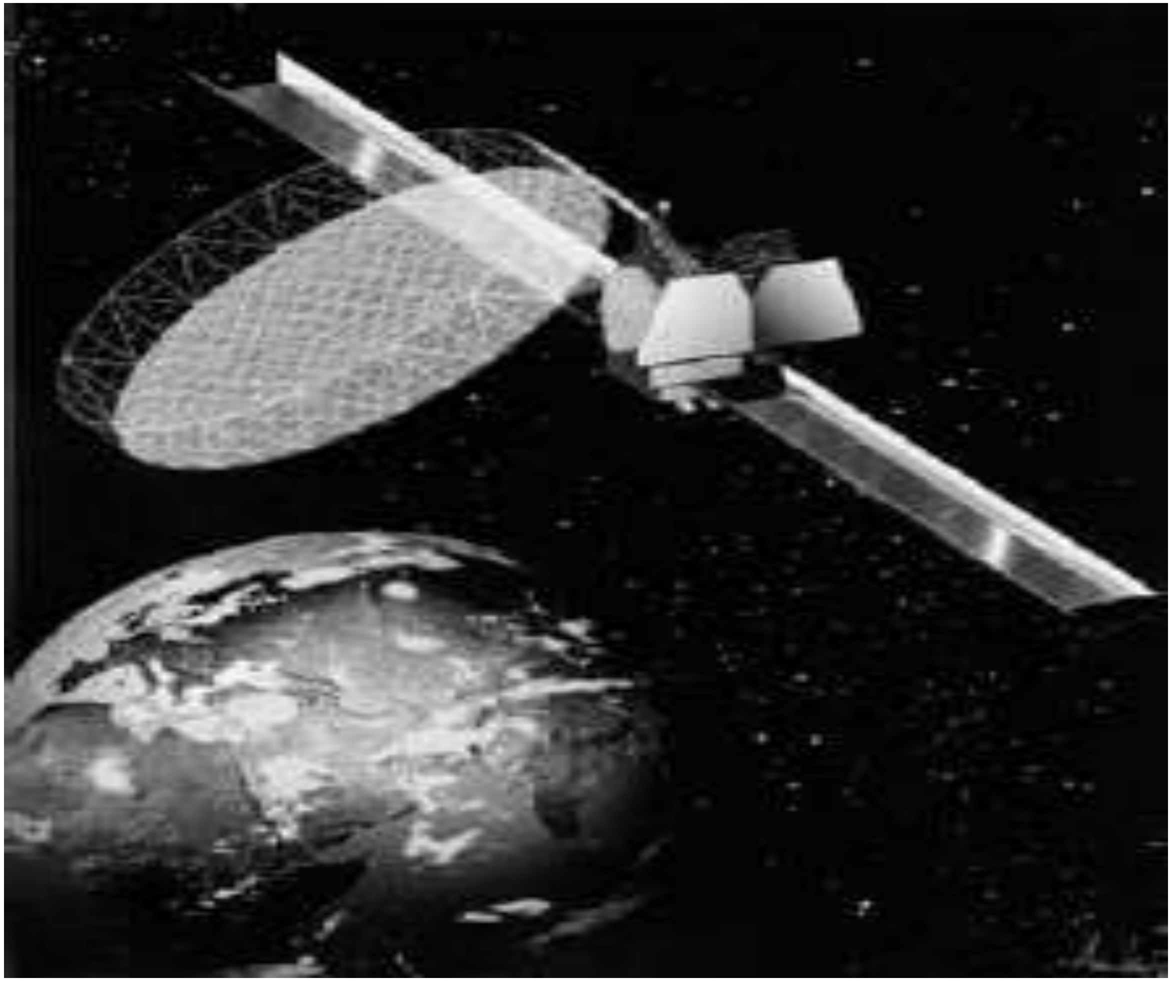


GEO MSS Systems Serving Handheld Terminals

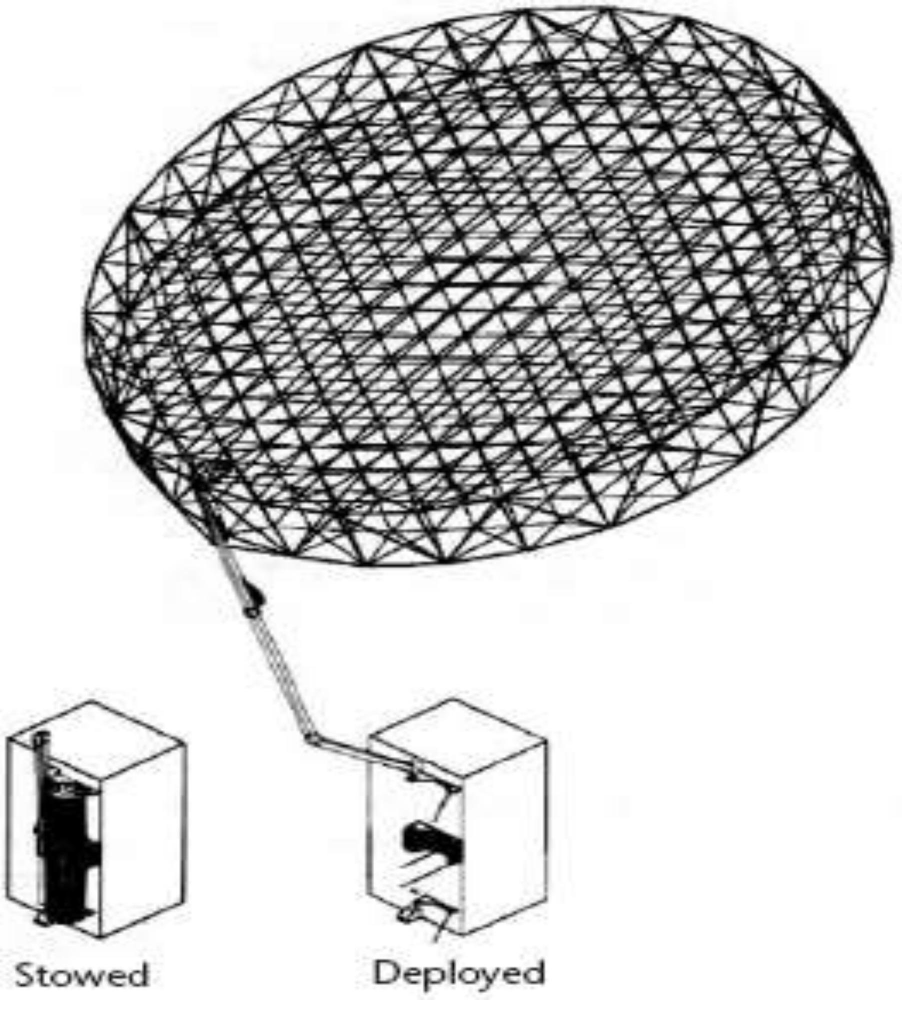
- E.g Thuraya (UAE), ACeS (PSN, Indonesia)

Characteristic	*Value*	*Units or Comments*
Frequency band		
Forward downlink	1,525–1,559	MHz (GEO MSS allocation)
Forward uplink	13,750–14,400	MHz (GEO MSS feeder link)
Return link downlink	10,250–10,900	MHz (GEO MSS feeder link)
Return link uplink	1,610–1,644	MHz (GEO MSS allocation)
Connectivity	Mobile to gateway	Connection to PSTN
	Mobile to mobile	Single hop, on demand
Services provided	Telephone	
	Fax	
	Circuit-switched data	Virtual private network
	Packet-switched data	Internet access
Satellite EIRP	72	dBW (aggregate, per beam)
Satellite G/T	15	dB/K
Polarization	Circular	
Station-keeping	0.1	Degrees, north/south and east/west; alternatively inclined orbit up to 6°
Channel capacity	13,750	Channels, mobile to PSTN
Call setup time	6	Seconds, to domestic PSTN

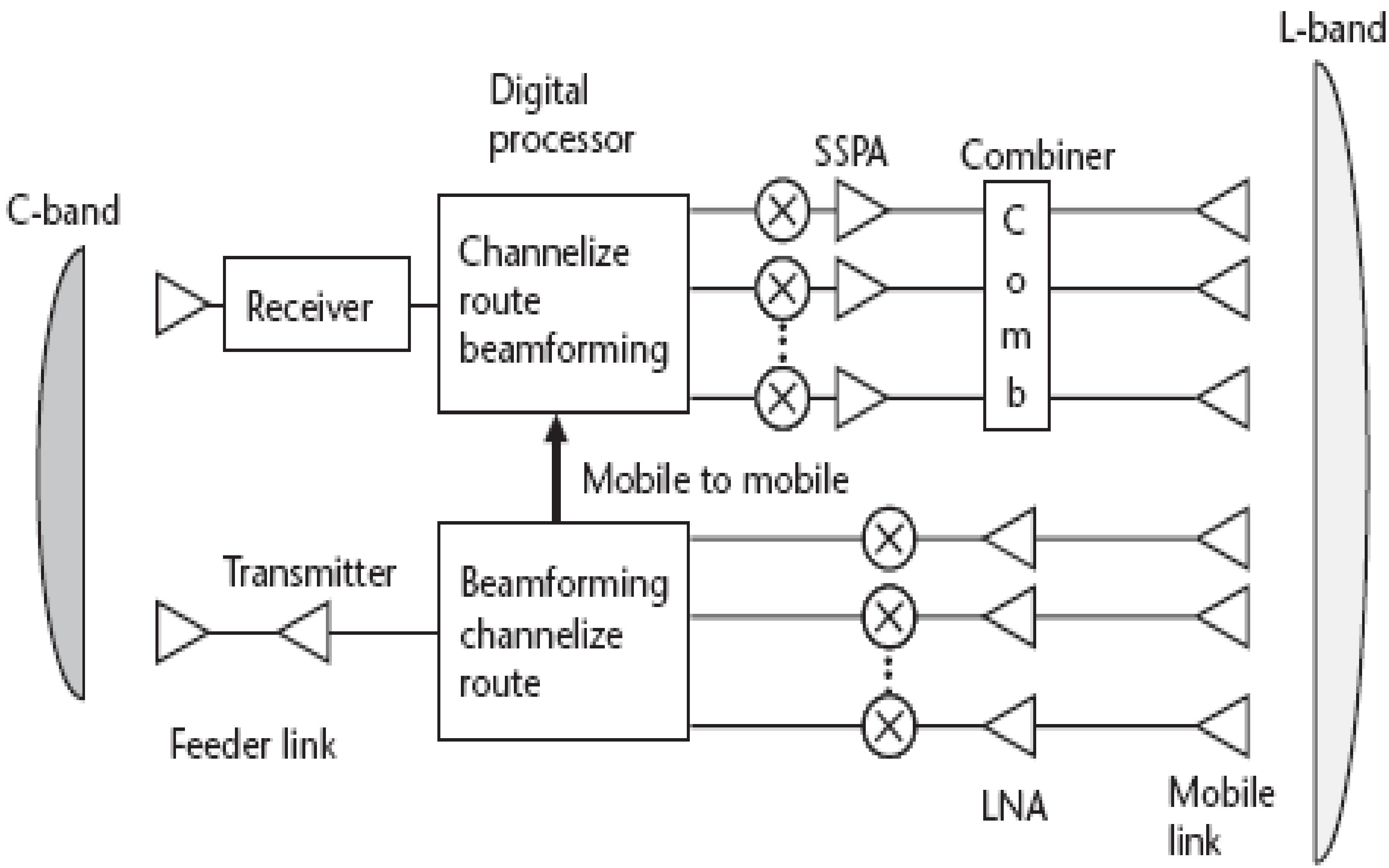
The Satellite (Thuraya)



The 12.25-m deployable antenna for Thuraya.



GEO Mobile Payload with low-level digital beam forming and mobile-to-mobile channel routing.



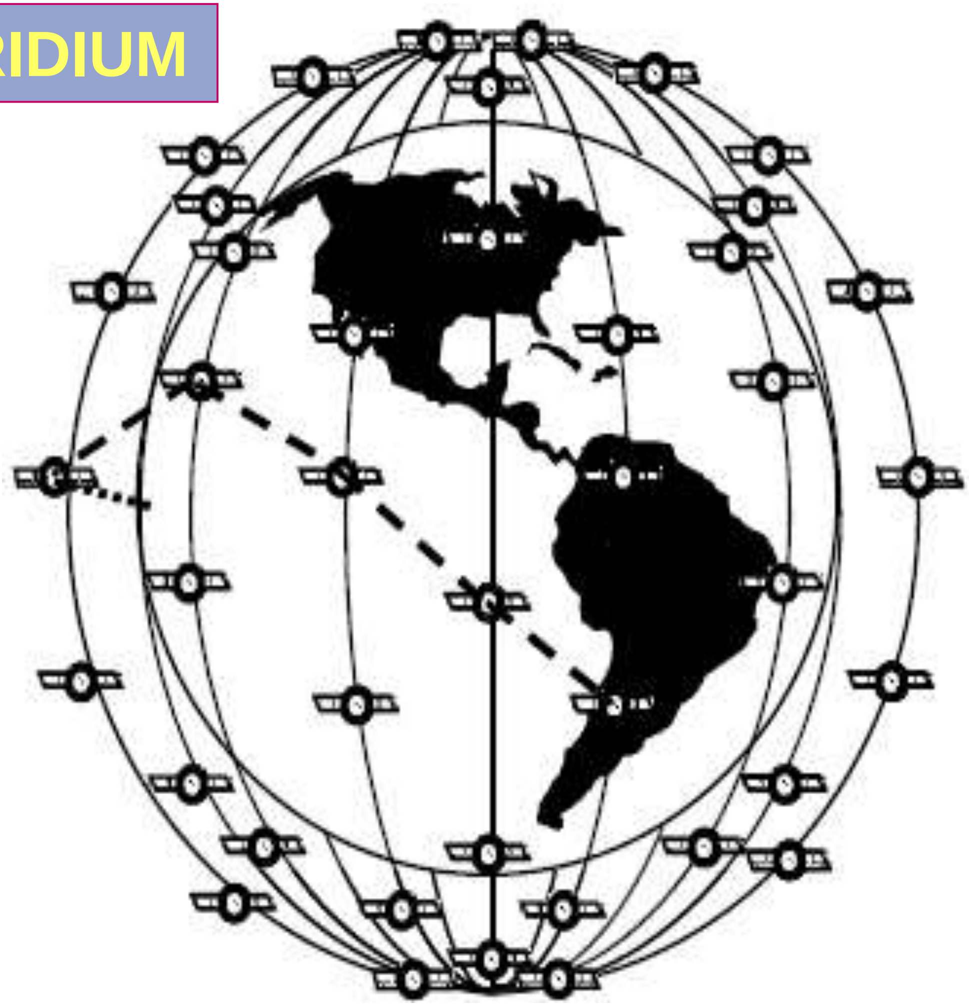
Specific Signal Characteristics of Thuraya' Service

- Transmissions between handheld UTs are made at L-band at 1,626.5 to 1,660.5 MHz through the 12.25-m antenna and the uplink from the gateway Earth station is at C-band at 6,425 to 6,725 MHz.
- The L-band downlink at 1,525 to 1,559 MHz employs 128 active SSPAs at 17W each, while the C-band return downlink at 3,400 to 3,625 MHz employs two 125-W TWTAs.
- The spot beams are created from only 128 individual dipole elements in the feed assembly; these are energized by the processor with appropriate amplitude and phase to produce the desired spots.
- The system reuses spectrum by up to 30 times, based on division of the 34 MHz of L-band downlink bandwidth over a 200 spot beam pattern with a division by 7 to account for adjacent beam isolation.
- Channel bandwidth of 27.7 kHz, capable of supporting a bit rate of 46.8 Kbps;
- Modulation with π/4 QPSK;
- TDMA within the individual FDMA channels for up to eight multiplexed voice channels;
- Provision of data transmission in increments of 4.3 Kbps up to the carrier maximum of 46.8 Kbps.

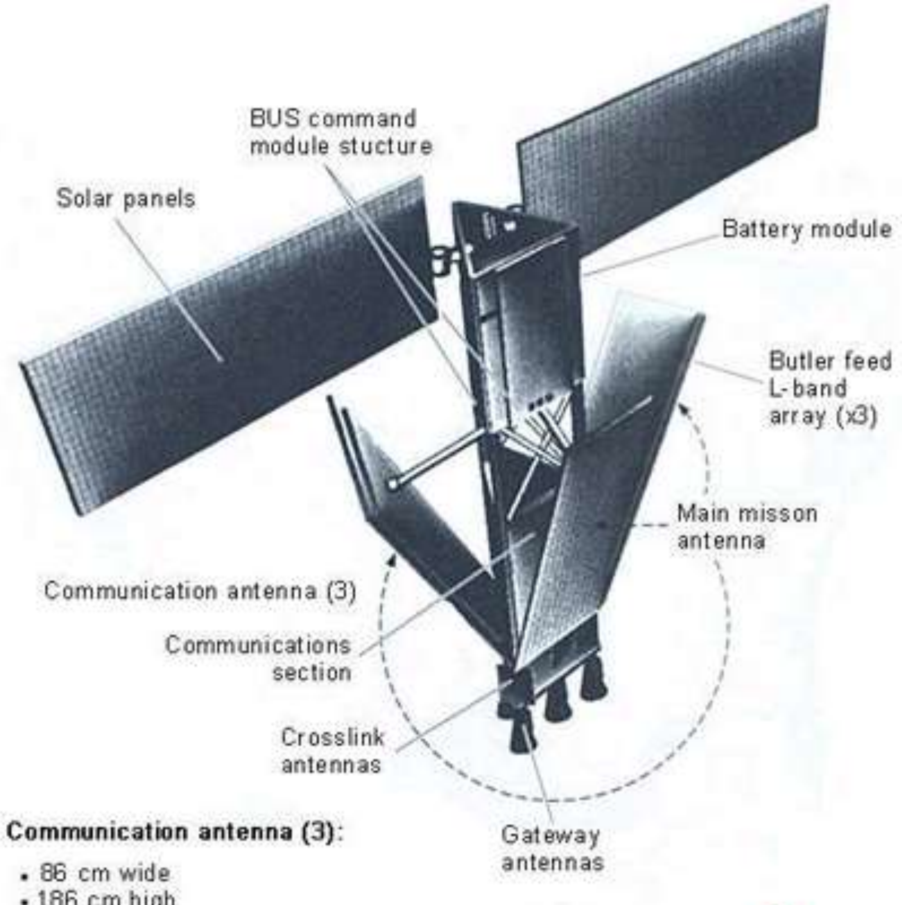
Non-GEO MSS Systems

- The polar LEO constellation for Iridium with 66 satellites in six polar orbit, designed to provide true global coverage with provision of intersatellite links.
- Single-frequency L-band in used for user links; intersatellite andgateway links are at Ka-band.

IRIDIUM



Satelit Iridium



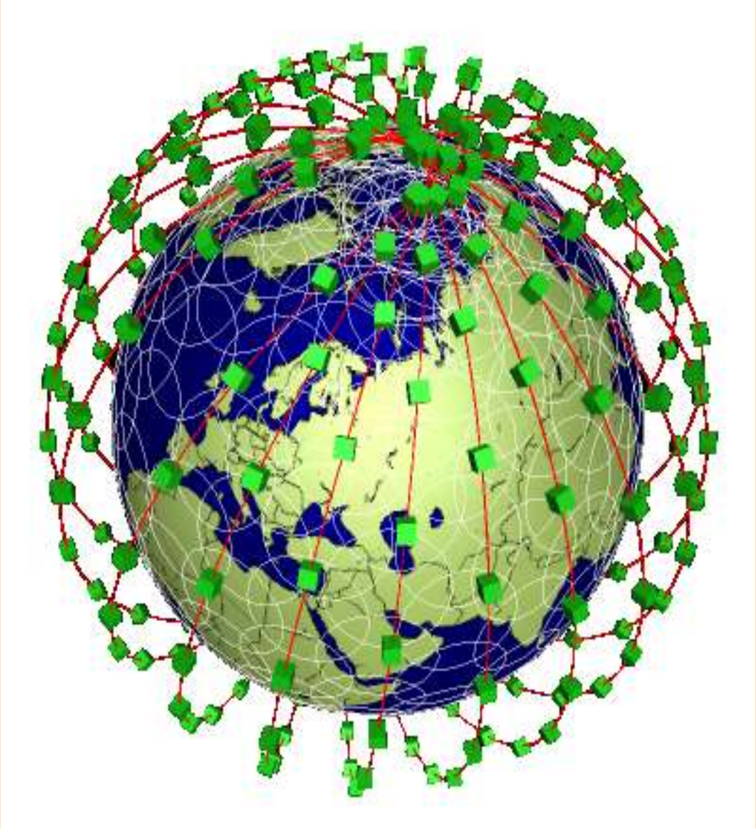
Communication antenna (3):

- 86 cm wide
- 186 cm high
- 4 cm thick
- 106 radiating elements
- 16 beams per antenna
- 48 beams juxtaposed

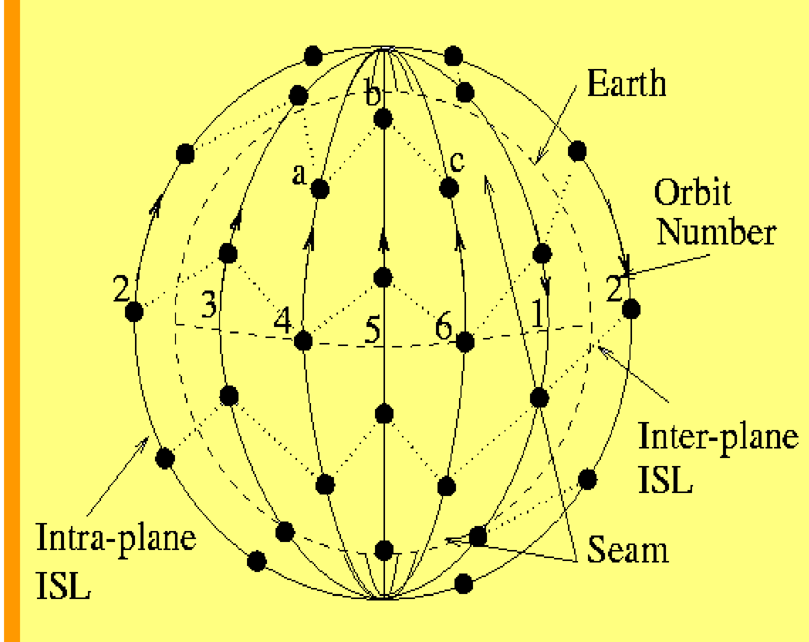
Summary of Key Characteristics of the Iridium System and Satellites

Characteristic	*Value or Comments*
Orbit altitude	780 km
Geometry	Polar orbits at 86.4° inclination
Number of orbits	6
Satellites per orbit	11
Total number of satellites	66 plus spares
Number of beams per satellite	48 at L-band
User links	1,616–1,626.5 MHz both up and down
Gateway downlinks	19.4–19.6 GHz
Gateway uplinks	29.1–29.3 GHz
Intersatellite links	Ka-band at 23.0–23.4 GHz to adjacent satellites in same plane and adjacent planes (total four ISLs per spacecraft)
Repeater design	Onboard digital processing of packets
Multiple access	TDMA (Time division duplex)
Satellite lifetime	6 to 8 years, subject to available fuel and battery performance
System capacity	72,600 circuits worldwide (effective capacity of 16,700 circuits)
Channel bandwidth	31.5 kHz
Channel data rate	50 Kbps
Modulation	QPSK
Channel coding	$K = 7$, $R = 3/4$
BER	10^{-5} after decoding
User link margin	16 dB

Teledesic



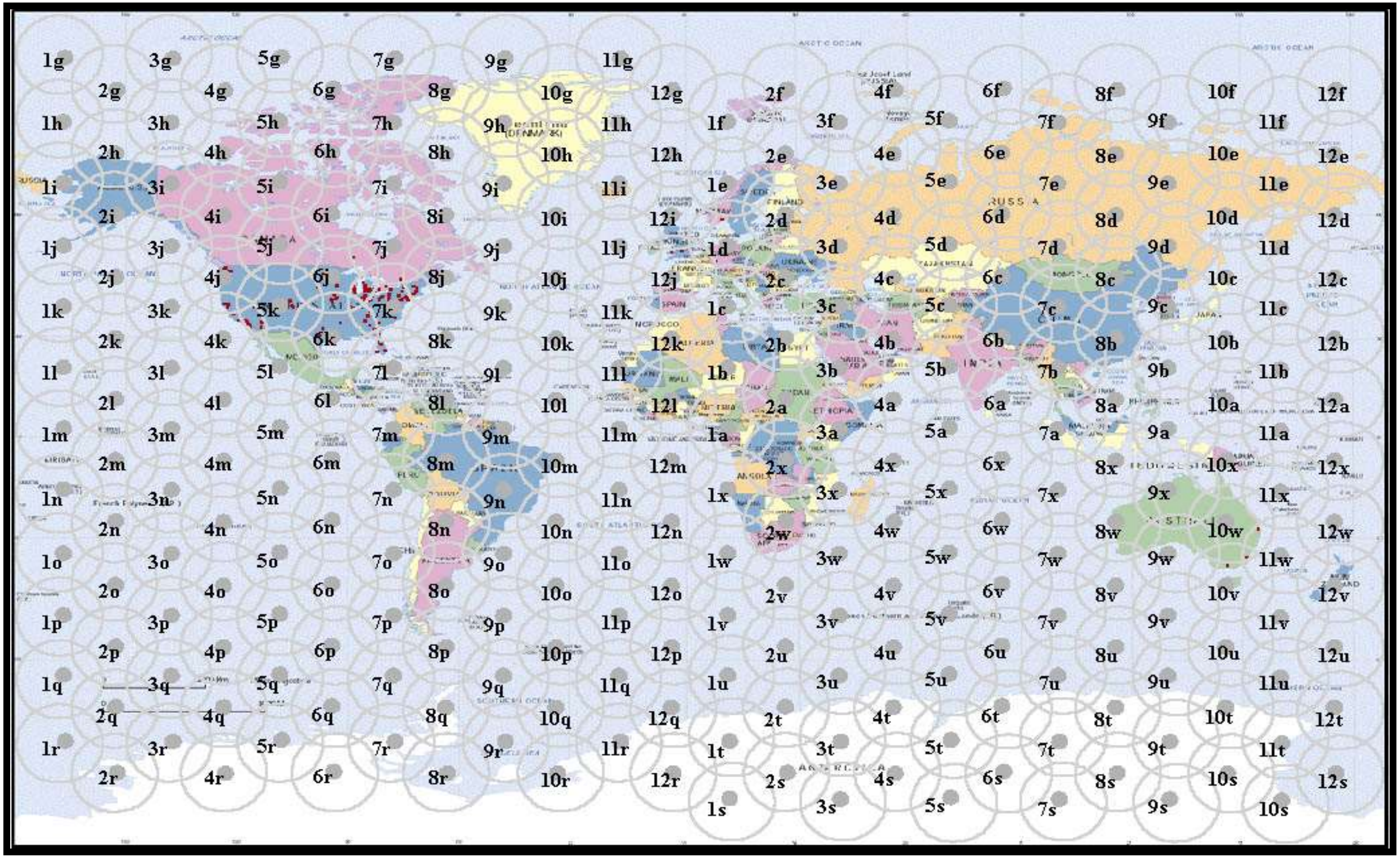
Constellation



ISL

Teledesic Coverage

Telkom University



Footprint of Teledesic

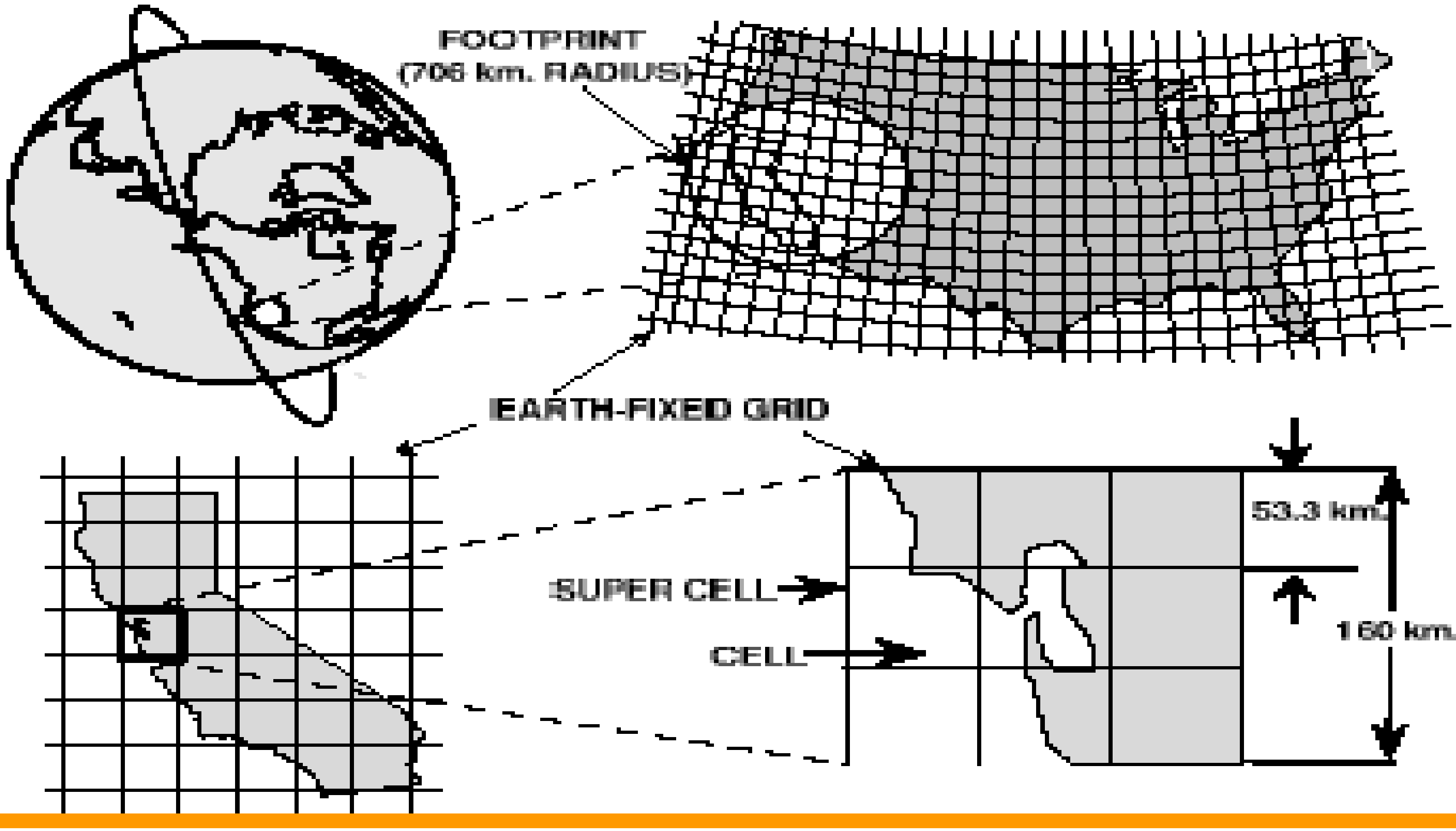
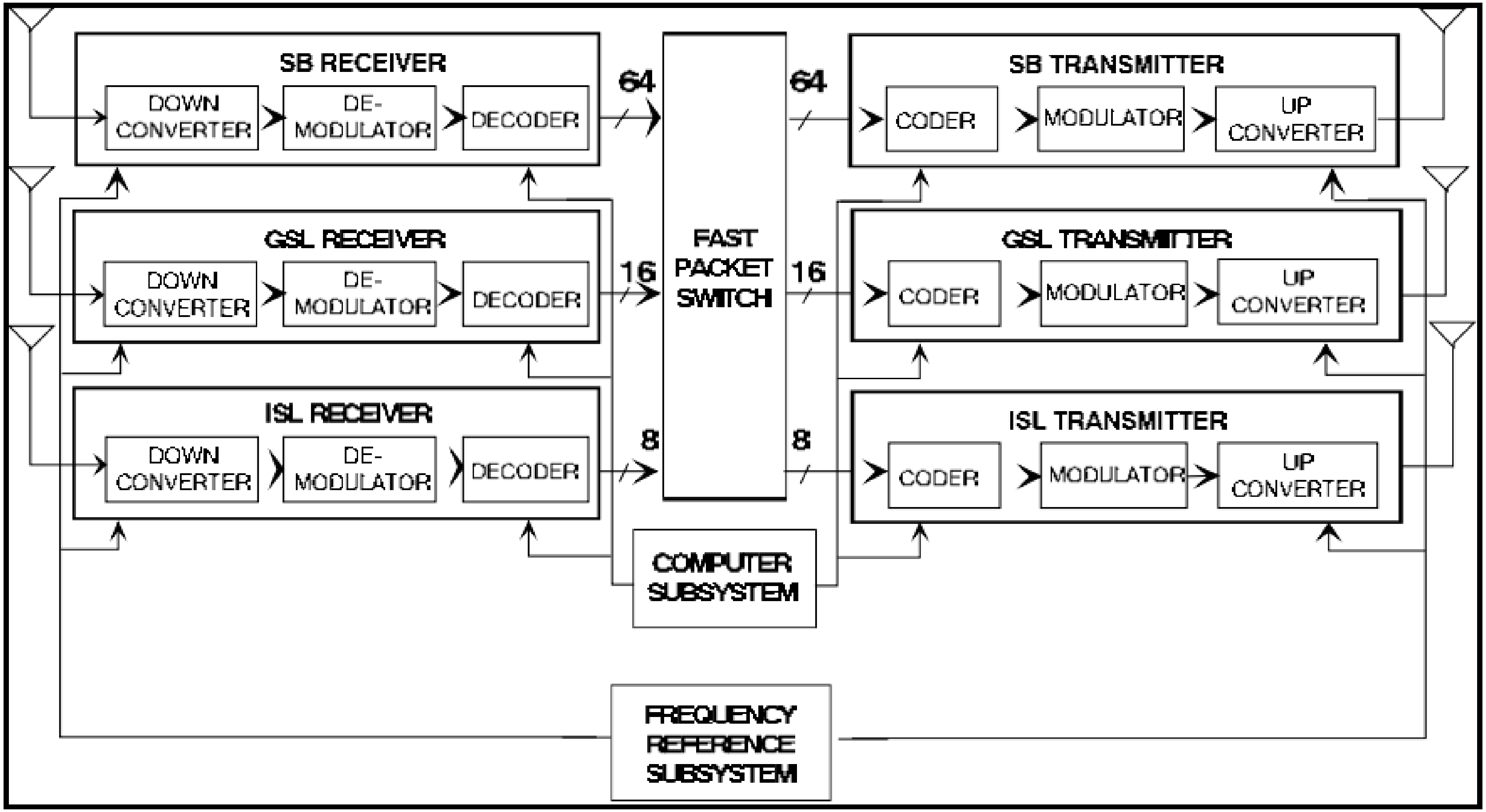


Diagram Blok Satelit



Jaringan Teledesic

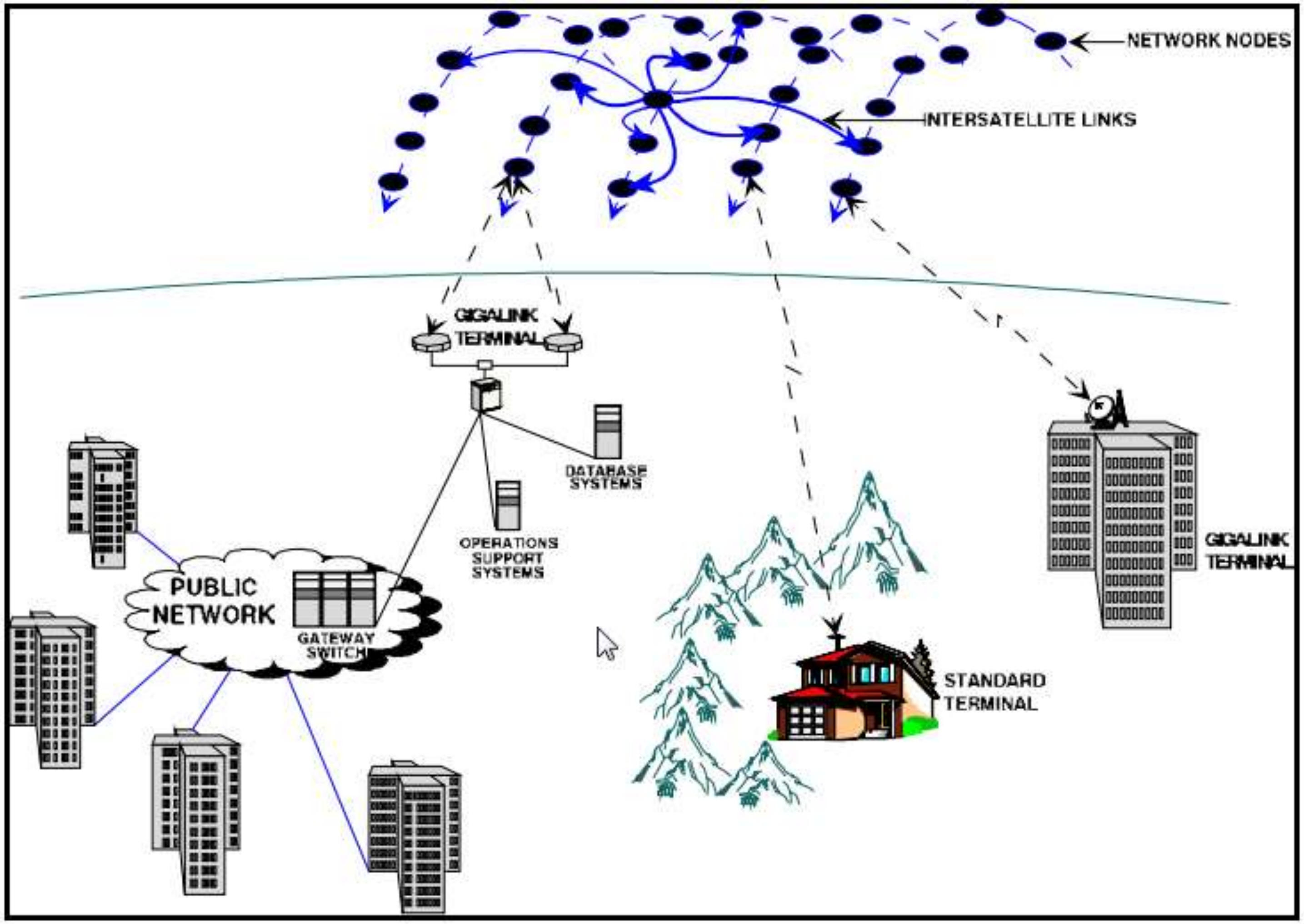


Table 1. Phase-Array Antenna Requirements

Type	*Frequency (GHz)*	*Gain (dBi)*	*Quantity*
Satellite SB REC	30	30	64,000
Satellite SB XTM	20	30	64,000
Satellite GSL REC	30	41	16,000
Satellite GSL XTM	20	41	16,000
Satellite ISL REC	60	48	8,000
Satellite ISL XTM	60	48	8,000
Standard Terminal	30/20	various	2 million
GigaLink Terminal	30/20	various	10,000

SB : Scanning Beam
GSL : Ground Station Link
ISL : Inter Satellite Link
Gigalink : Gateway ➔ Connection to public

Charasteristics of Teledesic

CONSTELLATION DESCRIPTION	
Number of Satellites	288 Active
Geometry	12 planes, 24 satellites each
Orbit	LEO - 1375 km (828 miles) circular, 84.7 deg. inc
Orbit Period	113.2 minutes
Coverage	Global
Initiation of Operations	2003
PAYLOAD CAPABILITIES	
Types of Services	Broadband Data and Voice
Uplink Data Rate	16kbps to 2Mbps
Downlink Data Rate	16kbps to 64Mbps
On-board processing	Yes
Mobile uplink frequencies	28.6-29.1 GHz (Ka-Band)
Mobile downlink frequencies	18.8-19.3 GHz (Ka-Band)
Multiple access scheme	FDMA/TDMA
Channels / Satellite	100,000 at 16kbps

THE END