PENGENALAN TEKNIK TELEKOMUNIKASI

Modul : 12
Sistem Komunikasi Satelit

Faculty of Electrical Engineering

BANDUNG, 2015

Apakah Satelit itu ??

- Satelit adalah benda yang mengorbit benda lain dengan periode revolusi dan rotasi tertentu.
- Satelit ada 2 tipe yaitu aktif dan pasif :
  - Satelit aktif memiliki kemampuan untuk menerima dan mengirimkan kembali sinyal yang di dapat ke bumi.
  - Satelit pasif hanya berfungsi sebagai pemantul saja.

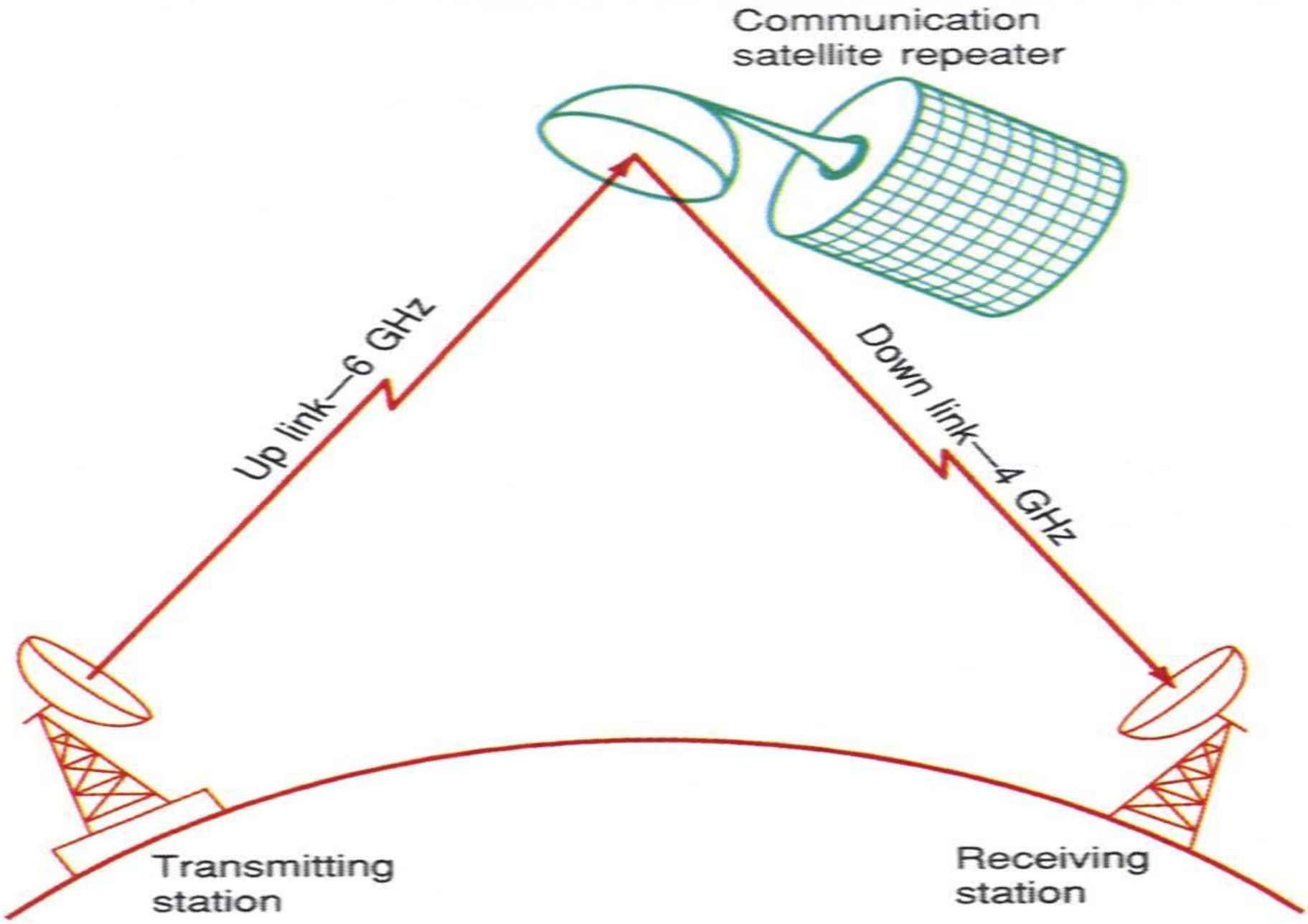
Satelit Komunikasi ??

- **Satelit komunikasi adalah** sebuah satelit buatan yang ditempatkan di angkasa dengan tujuan telekomunikasi menggunakan radio pada frekuensi gelombang mikro.
- Satelit komunikasi **di desain untuk menerima sinyal** dari stasiun pengirim di bumi **dan mengirimkannya ke stasiun penerima** yang terletak dimana pun.
- Kebanyakan satelit komunikasi menggunakan orbit geosinkron atau orbit geostasioner, meskipun beberapa tipe terbaru menggunakan satelit pengorbit Bumi rendah

Definisi Satelit

Satelit merupakan alat elektronik yang mengorbit di bumi dan mampu bertahan sendiri.

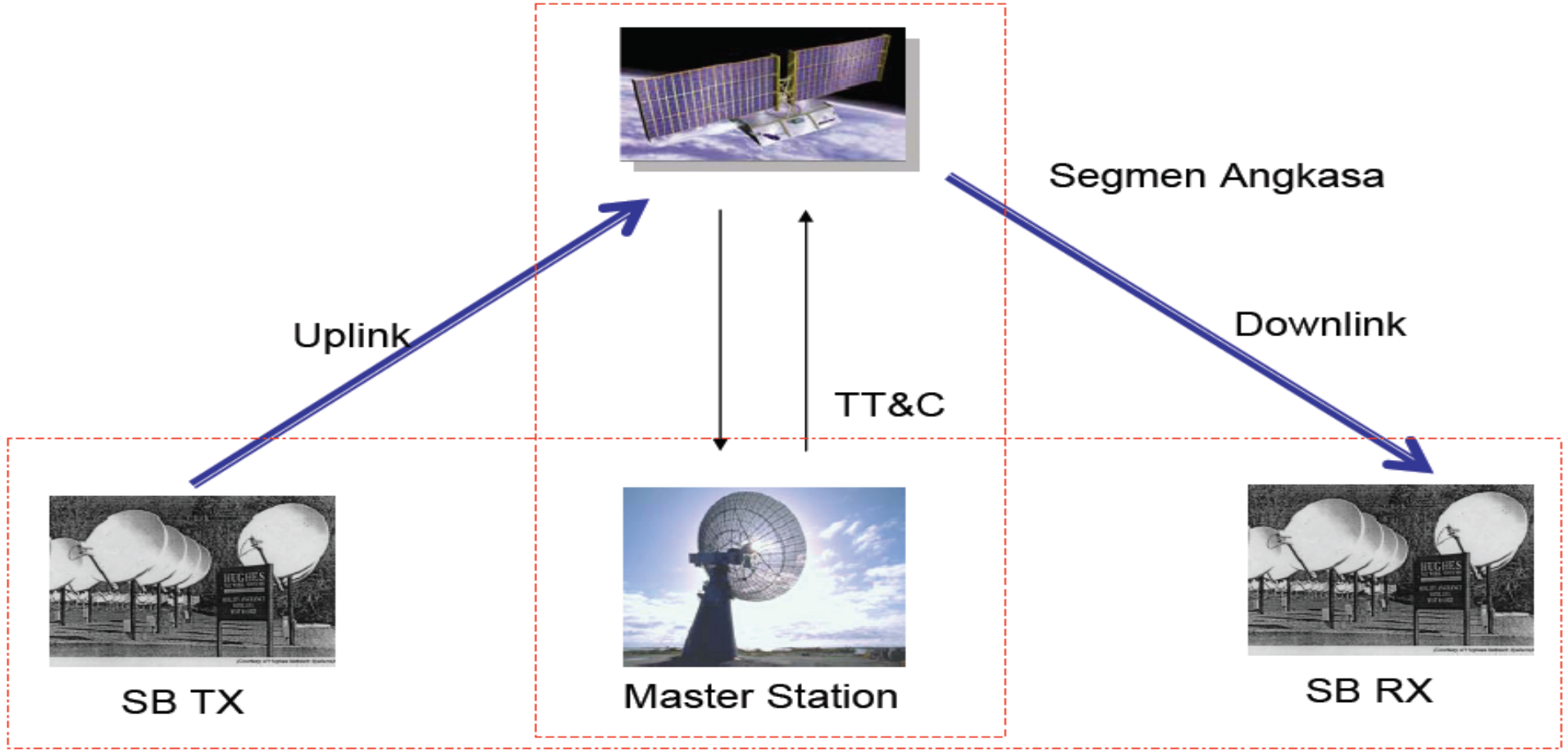
Dapat diartikan sebagai repeater yang berfungsi untuk menerima signal gelombang microwave dari stasiun bumi, ditranslasikan frekuensinya, kemuadian diperkuat untuk dipancarkan kembali ke arah bumi sesuai dengan coverage-nya yang merupakan lokasi stasiun bumi tujuan atau penerima.


Communication
satellite repeater
Up link—6 GHz
Down link—4 GHz
Transmitting
station
Receiving
station

Sistem Komunikasi Satelit

2 bagian penting yaitu **space segment** (bagian yang berada di angkasa) dan **ground segment** (biasa disebut stasiun bumi).

Arsitektur Komunikasi Satelit



Keunggulan Komunikasi Satelit

- Cakupan yang luas: satu negara, region, ataupun satu benua
- Bandwith yang tersedia cukup lebar;
- Independen dari infrastruktur terrestrial;
- instalasi jaringan segmen bumi yang cepat;
- Biaya relatif rendah per site;
- Karakteristik layanan yang seragam;
- Layanan total hanya dari satu provider;
- Layanan mobile/wireless yang independen terhadap lokasi.

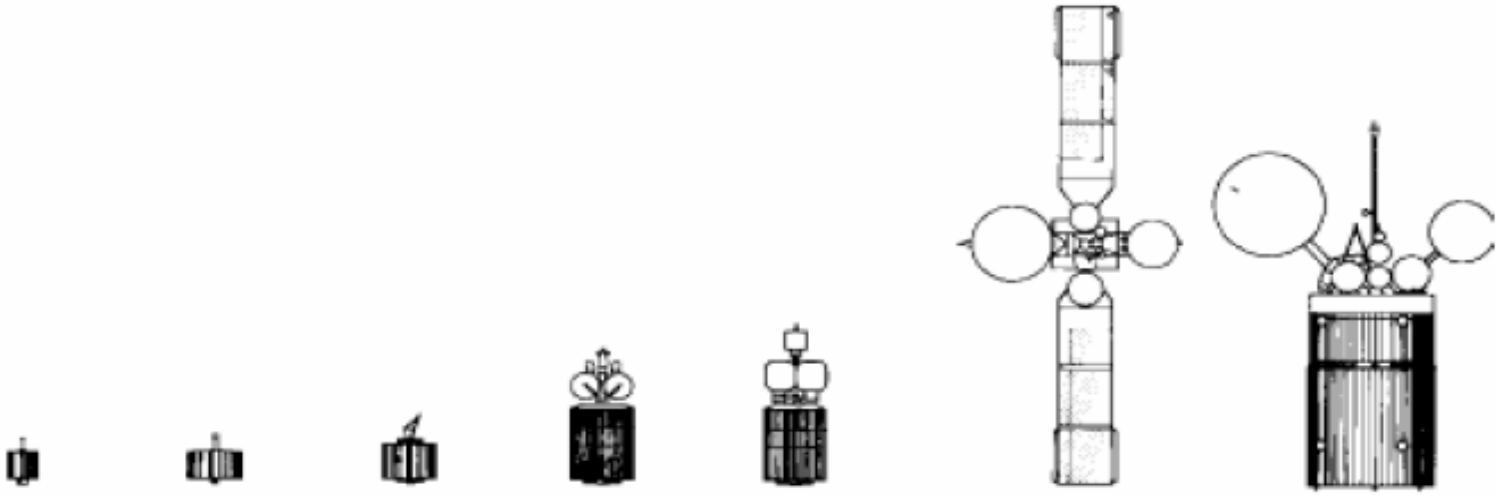
Kelemahan Komunikasi Satelit

- Delay propagasi besar.
- Rentan terhadap pengaruh armosfir, dll
- *Up Front Cost* tinggi: Contoh untuk Satelit GEO: Spacecraft, Ground Segment & Launch = US $ 200 jt, Asuransi : $ 50 jt.
- *Distance insensitive:* Biaya komunikasi untuk jarak pendek maupun jauh relatif sama.
- Hanya ekonomis jika jumlah User besar dan kapasitas digunakan secara intensif.

A Selective Communications Satellite Chronology

- 1945 Arthur C. Clarke Article: "Extra-Terrestrial Relays"
- 1955 John R. Pierce Article: "Orbital Radio Relays"
- 1956 First Trans-Atlantic Telephone Cable: TAT-1
- 1957 Sputnik: Russia launches the first earth satellite.
- 1960 1st Successful DELTA Launch Vehicle
- 1960 AT&T applies to FCC for experimental satellite communications license
- 1961 Formal start of TELSTAR, RELAY, and SYNCOM Programs
- 1962 TELSTAR and RELAY launched
- 1962 Communications Satellite Act (U.S.)
- 1963 SYNCOM launched
- 1964 INTELSAT formed
- 1965 COMSAT's EARLY BIRD: 1st commercial communications satellite
- 1969 INTELSAT-III series provides global coverage
- 1972 ANIK: 1st Domestic Communications Satellite (Canada)
- 1974 WESTAR: 1st U.S. Domestic Communications Satellite
- 1975 INTELSAT-IVA: 1st use of dual-polarization
- 1975 RCA SATCOM: 1st operational body-stabilized comm. satellite
- 1976 MARISAT: 1st mobile communications satellite
- 1976 PALAPA: 3rd country (Indonesia) to launch domestic comm. satellite
- 1979 INMARSAT formed.
- 1988 TAT-8: 1st Fiber-Optic Trans-Atlantic telephone cable
- 1999: Telkom-1 launched.

Evolusi Satelit Intelsat

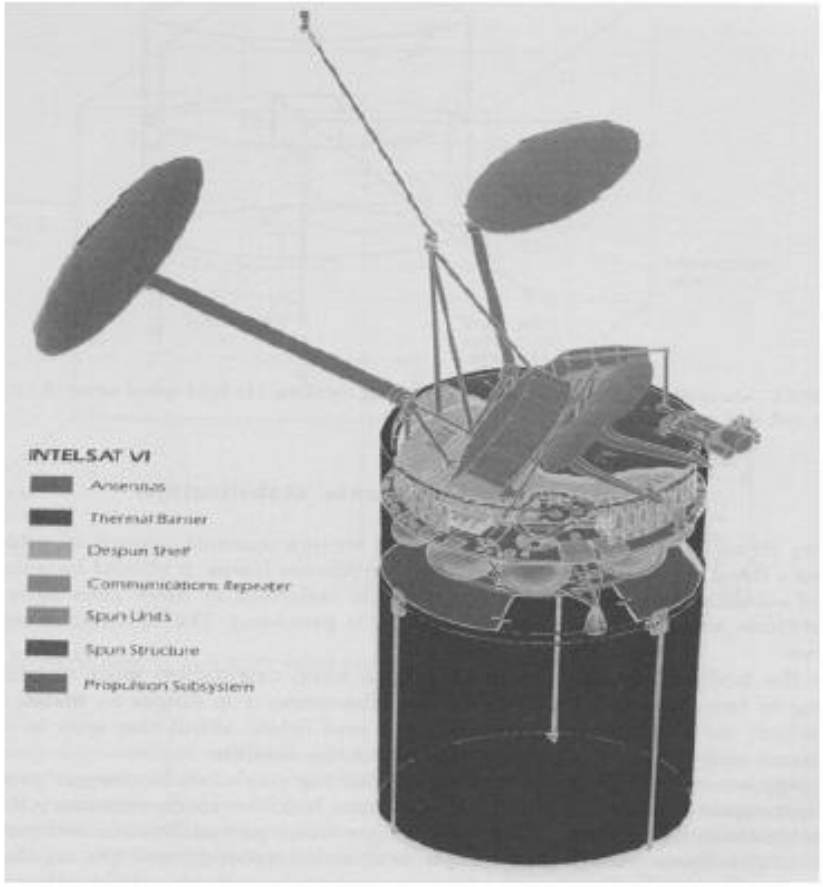


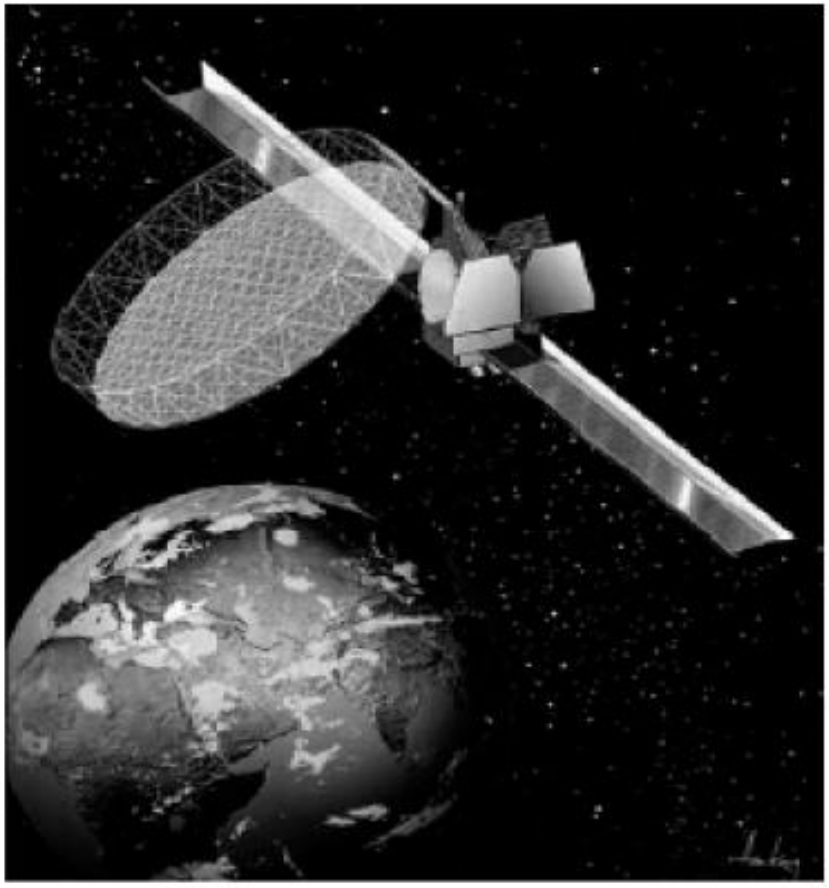
Designation: Intelsat	I	II	III	IV	IV A	V	V A/V B	VI
Year of first launch	1965	1966	1968	1971	1975	1980	1984/85	1985/87
Prime contractor	Hughes	Hughes	TRW	Hughes	Hughes	Ford Aerospace	Ford Aerospace	Hughes
Width (m)	0.7	1.4	1.4	2.4	2.4	2.0	2.0	3.6
Height (m)	0.6	0.7	1.0	5.3	6.8	6.4	6.4	6.4
Launch vehicles		Thor Delta		Atlas-Centaur		Atlas-Centaur and Ariane	Atlas-Centaur and Ariane	STS and Ariane
Spacecraft mass in transfer orbit (kg)	68	182	293	1385	1489	1946	2140	12,100/3720
Communications payload mass (kg)	13	36	56	185	190	235	280	800
End-of-life (EOL) power of equinox (W)	40	75	134	480	800	1270	1270	2200
Design lifetime (years)	1.5	3	5	7	7	7	7	10
Capacity (number of voice channels)	480	480	2400	8000	12,000	25,000	30,000	80,000
Bandwidth (MHz)	50	130	300	500	800	2137	2480	3520

Arsitektur Komunikasi Satelit

- Segmen Angkasa:
  - Struktur / Bus
  - Payload
  - Power Supply
  - Kontrol temperatur
  - Kontrol attitude dan orbit
  - Sistem propulsi
  - Telemetry, Tracking, & Command (TT&C)
- Segmen Bumi:
  - User Terminal, SB Master, dan Jaringan.

Jenis Spaceraft



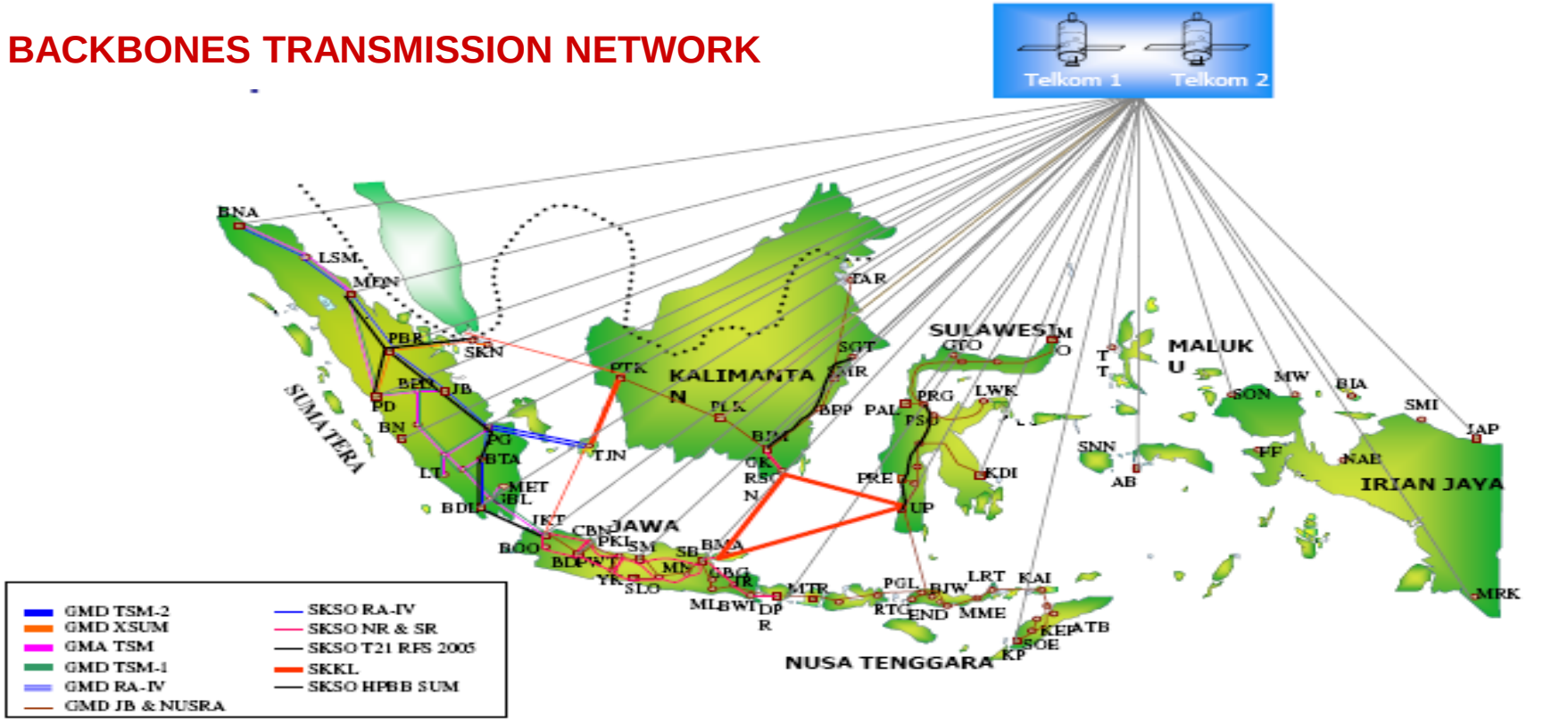


Spinning Stabilized Satellite, misalnya Palapa A, Measat, etc

3-axis Stabilized Satellite, misalnya Telkom-1, Thuraya (UEA), etc

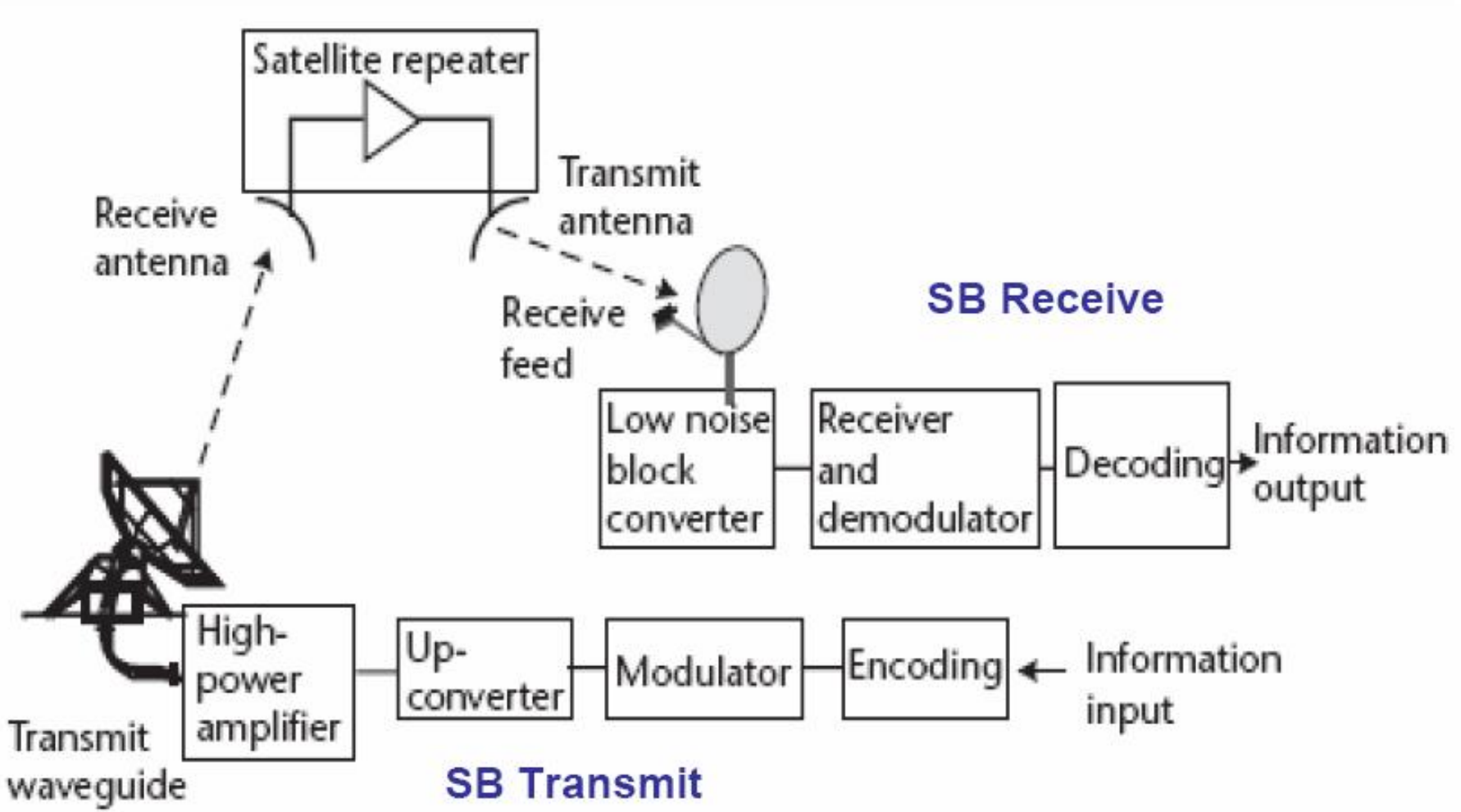
PT.Telkom INFRASTRUCTURE CONDITION

BACKBONES TRANSMISSION NETWORK



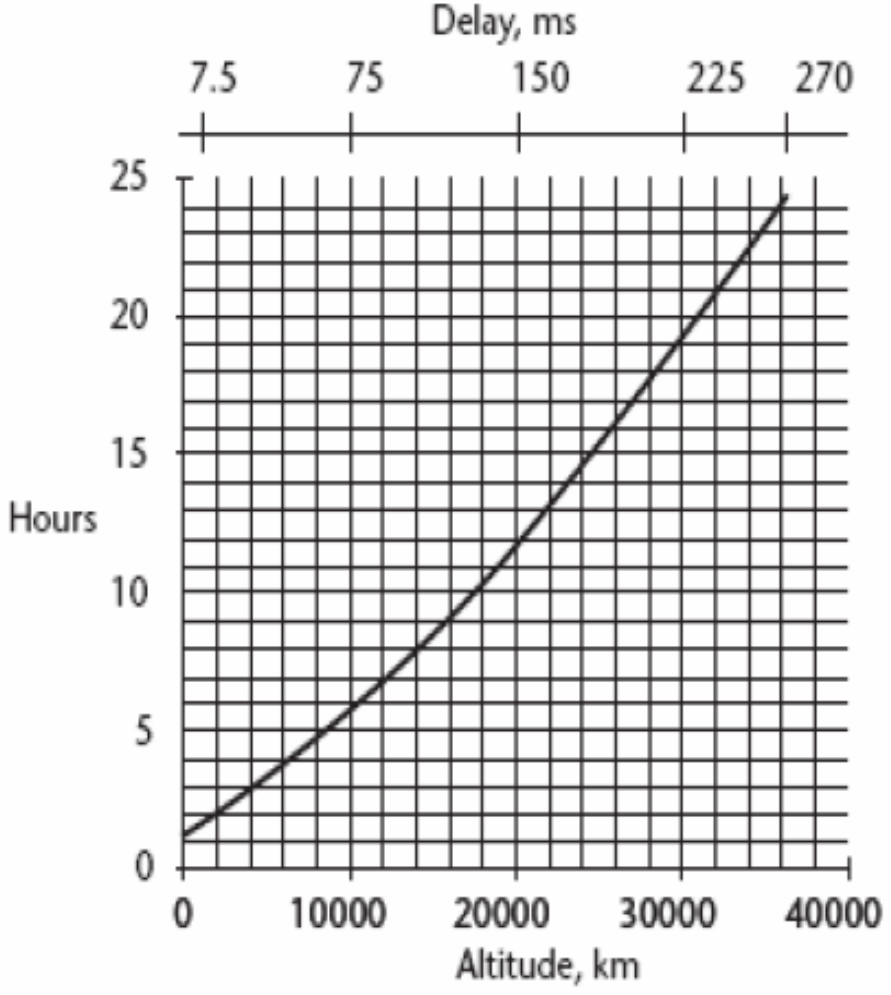
- **Trunk TDM Switching, Local TDM Switching, International GW, Internet GW**
- **Signalling Gateway, Intelligent Network**
- **Backbone & Metro Digital Radio Transmissions**
- **Backbone Submarine Cable, Backbone & Metro Optical Fiber Transmission**
- **Satellite Transponders and Control Center**
- **National Network Control Center**

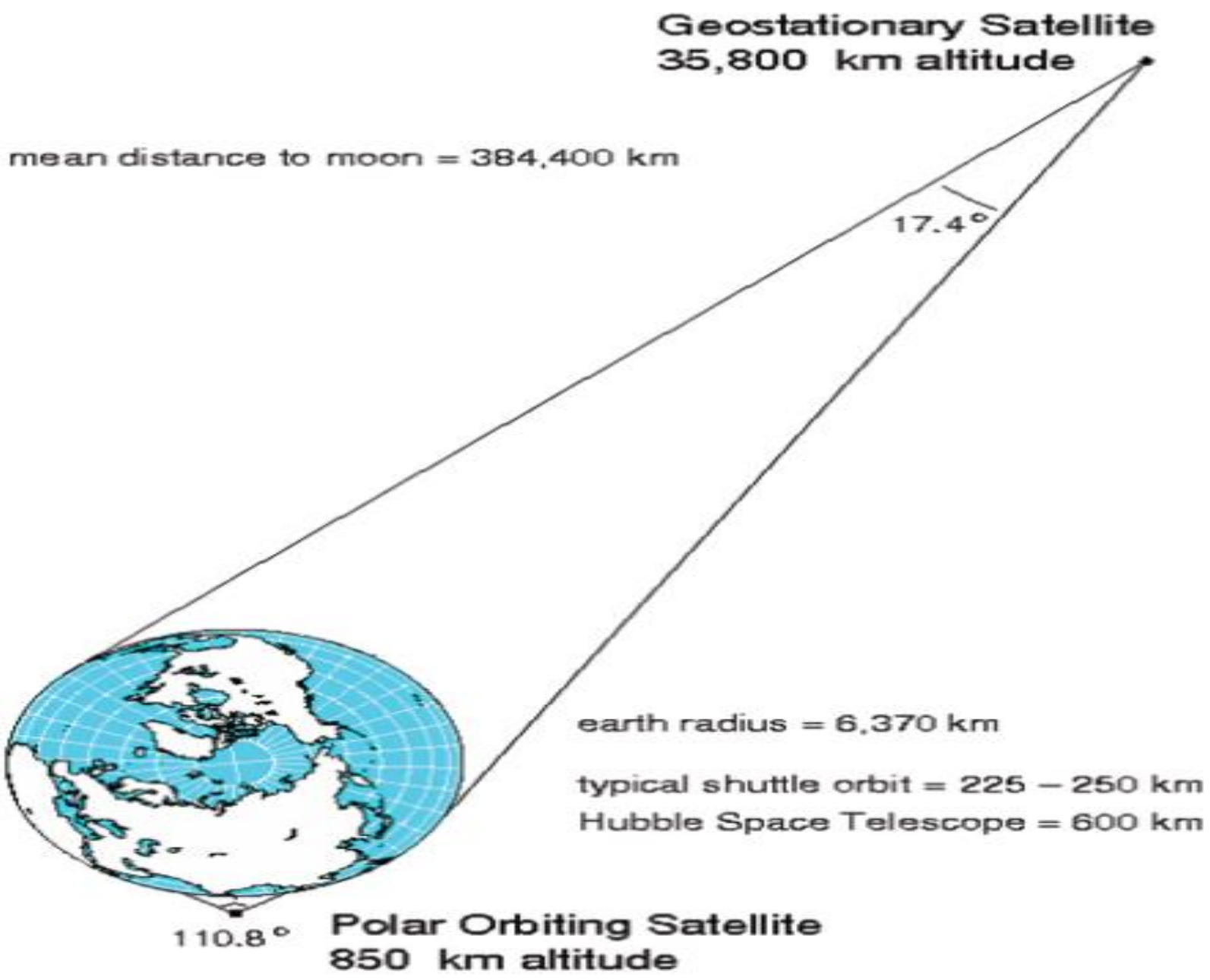
Komponen Dasar Link Satelit



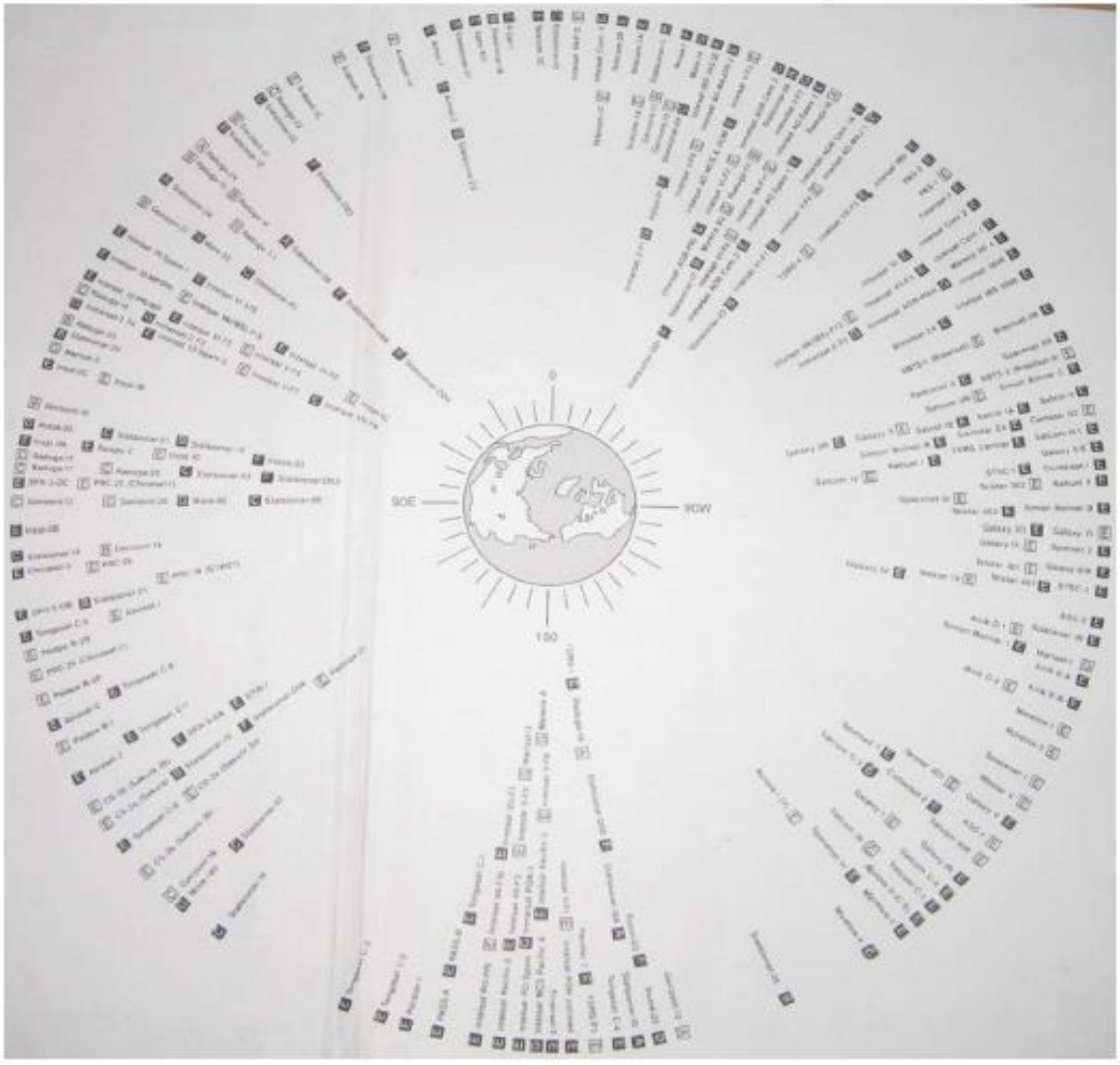
Tinggi Orbit dan delay

- Delay merupakan parameter penting yang menentukan kinerja link komunikasi.
- Periode orbit akan menentukan jenis komunikasi satelit, dan juga konstelasi terkait dengan desain cakupan komunikasi.



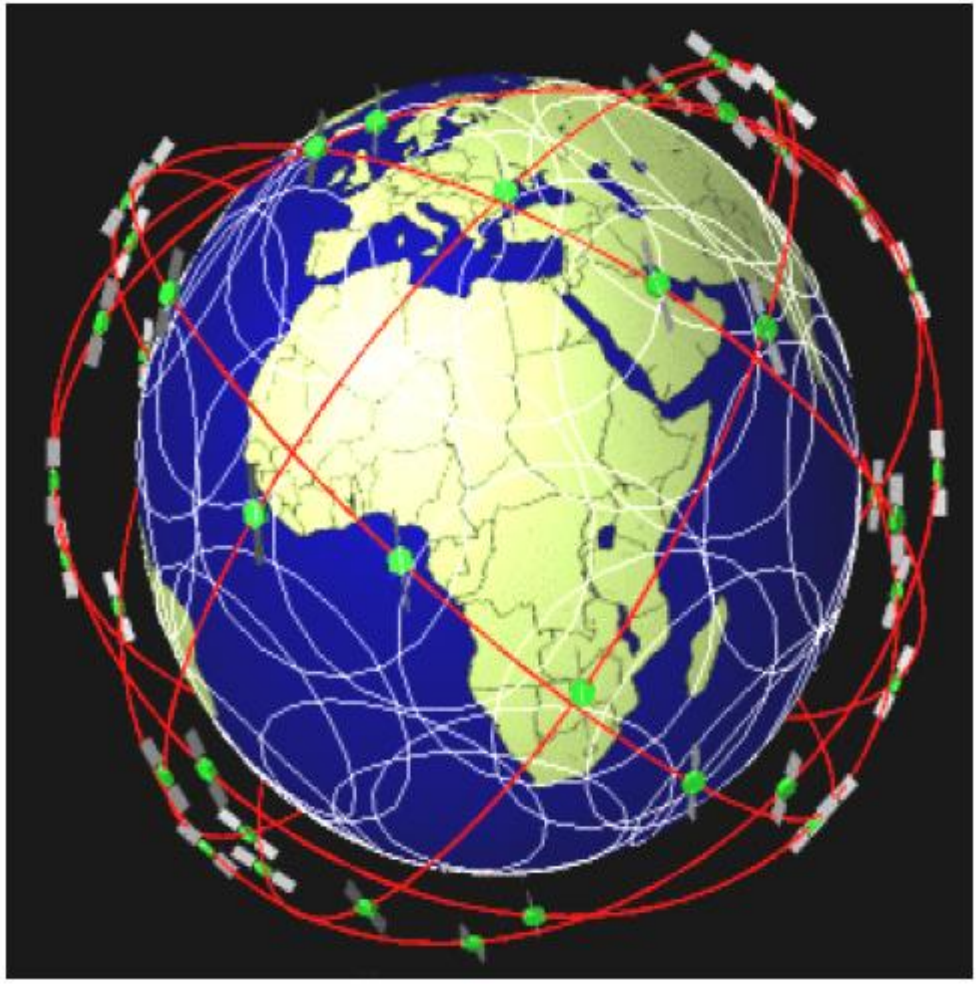

Geostationary Satellite
35,800 km altitude
mean distance to moon = 384,400 km
17.4°
earth radius = 6,370 km
typical shuttle orbit = 225 – 250 km
Hubble Space Telescope = 600 km
110.8°
Polar Orbiting Satellite
850 km altitude

Satelit di Orbit GEO (mid-1990)

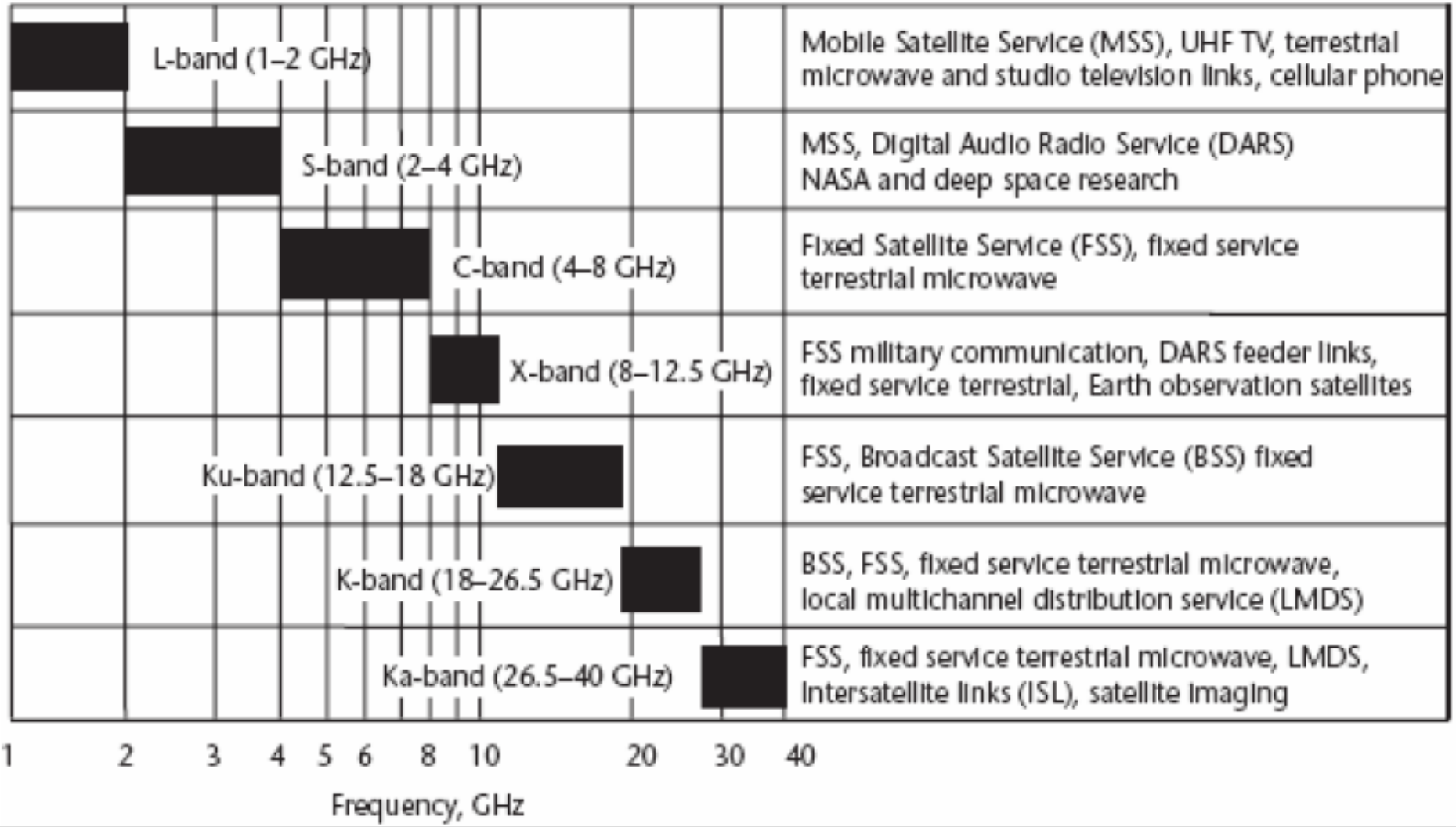


Konstelasi Satelit

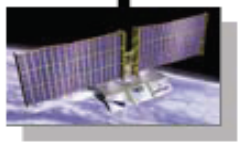
- Untuk cakupan Global biasanya dibutuhkan banyak satelit yang ditempatkan dalam beberapa bidang orbit, dan spasi antar satelit ditentukan.

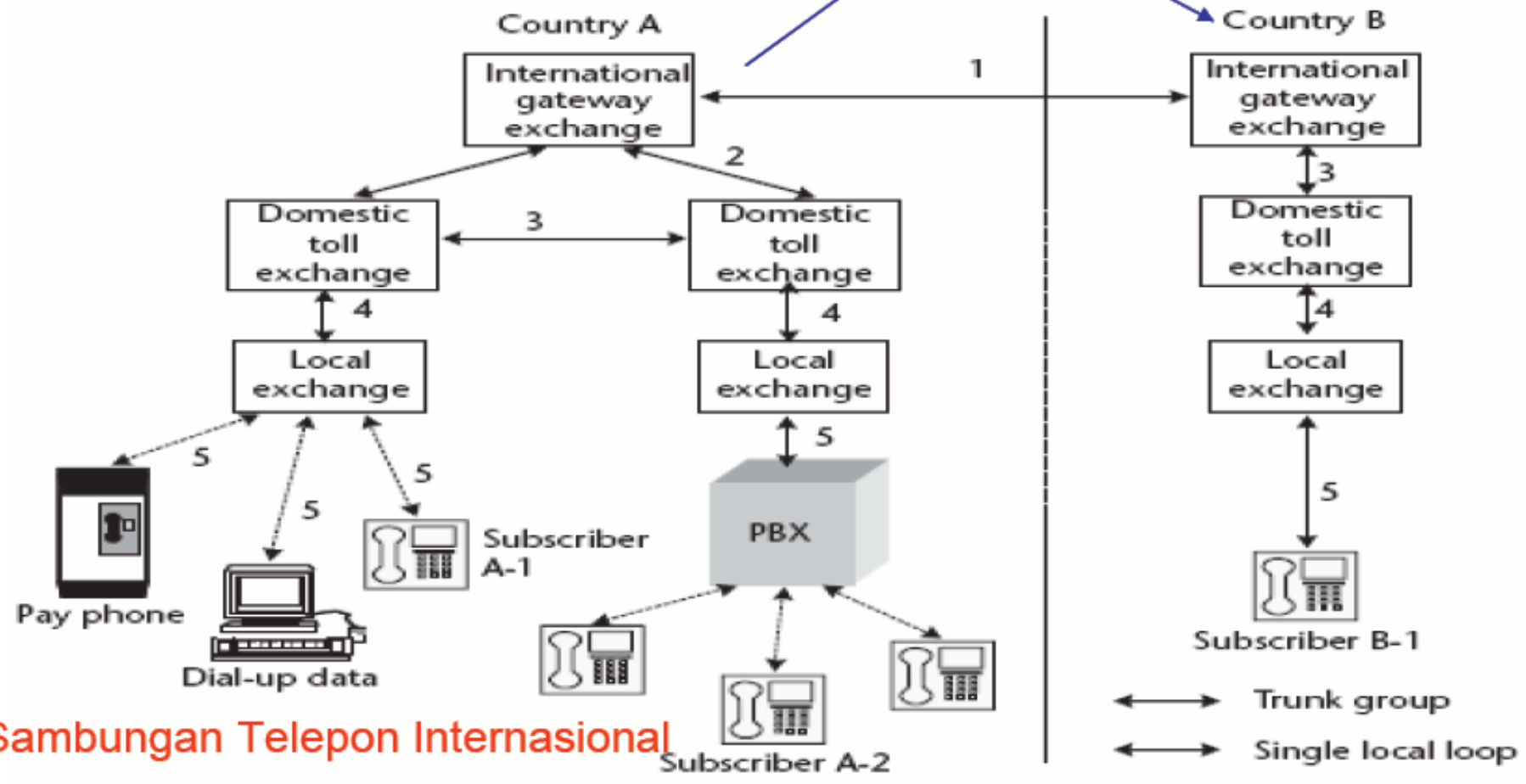


Alokasi spektrum dan Layanan komunikasi menurut ITU-R



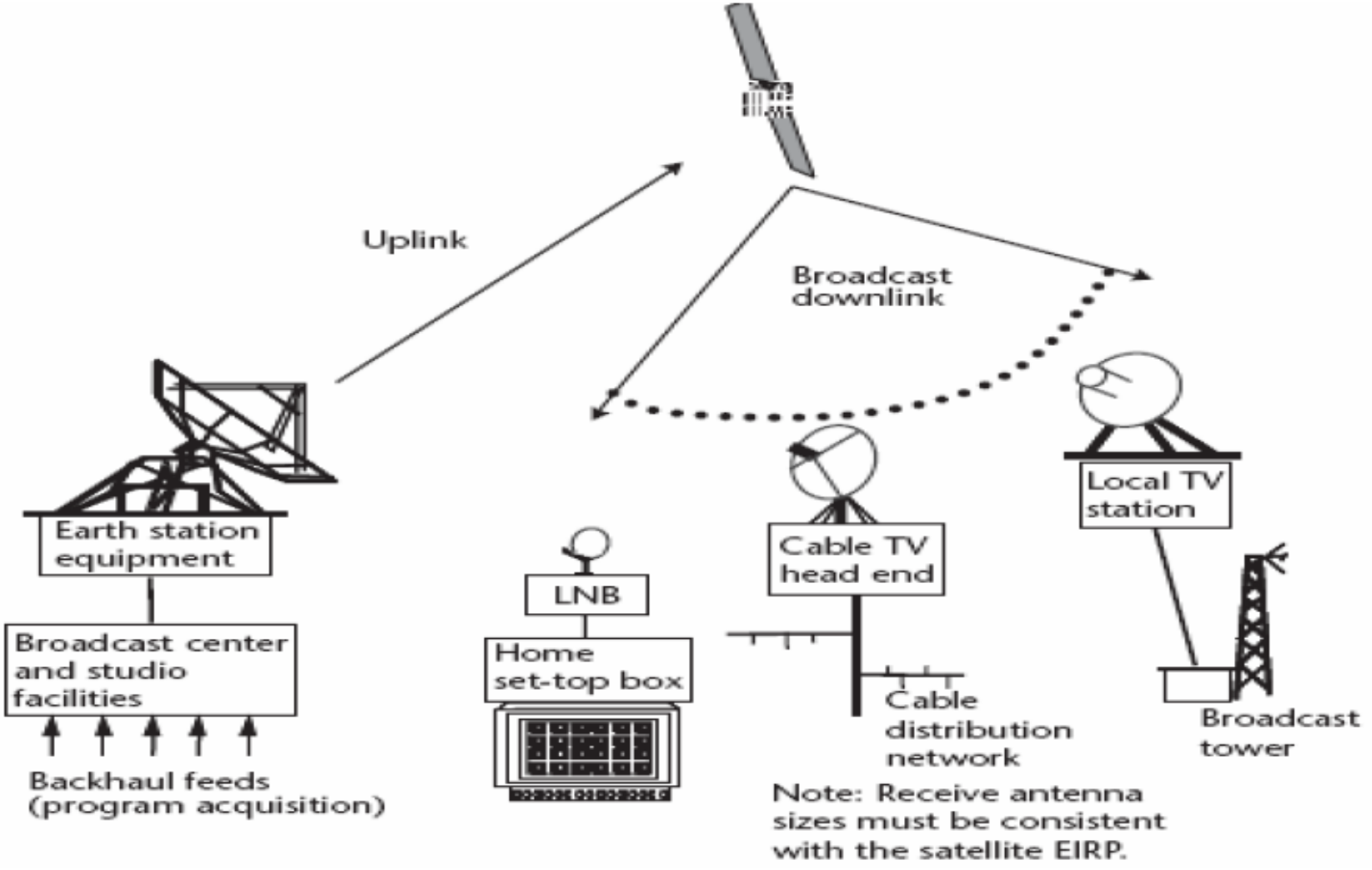
Komunikasi Telepon/data



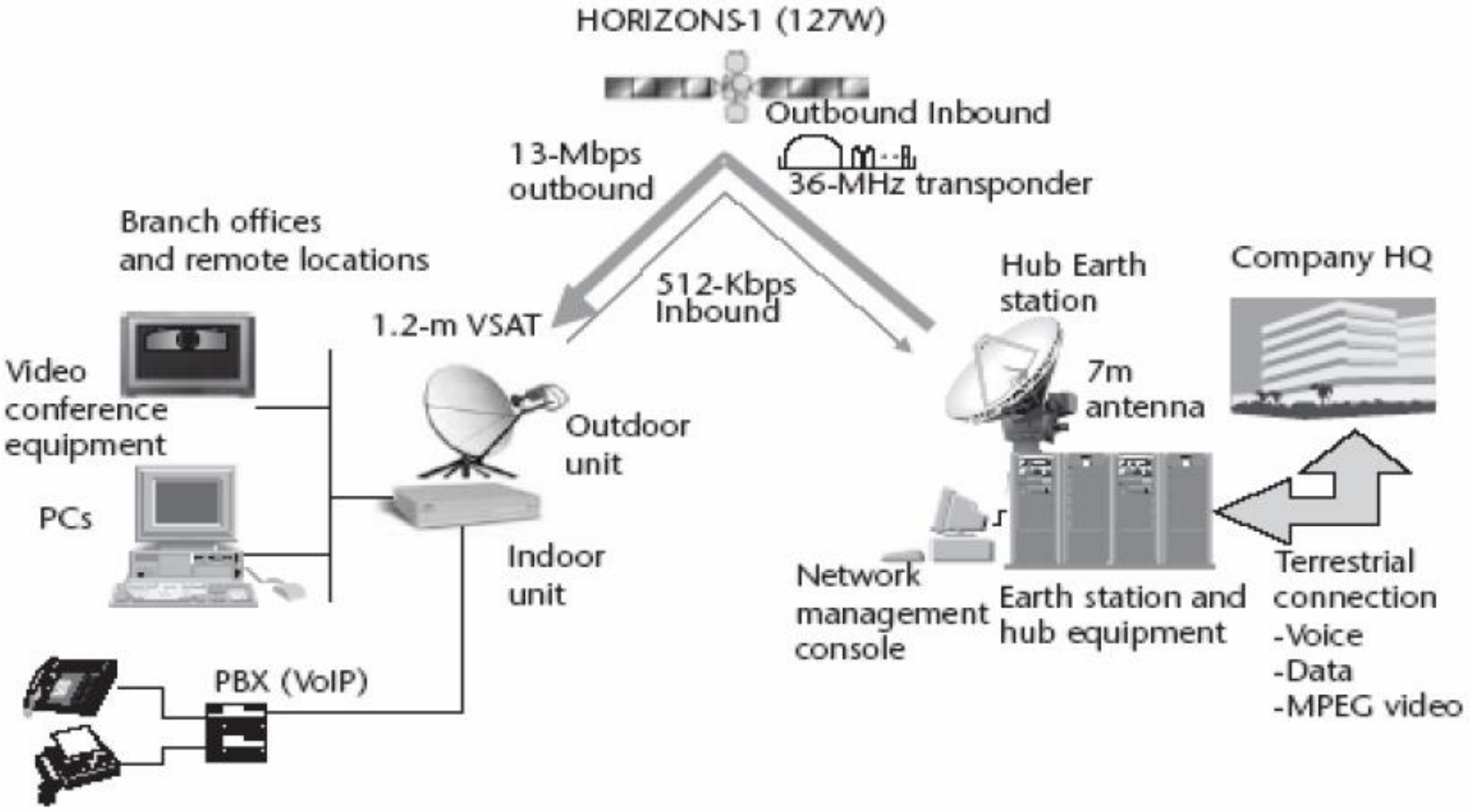


Sambungan Telepon Internasional

Direct Broadcasting Services (DBS)

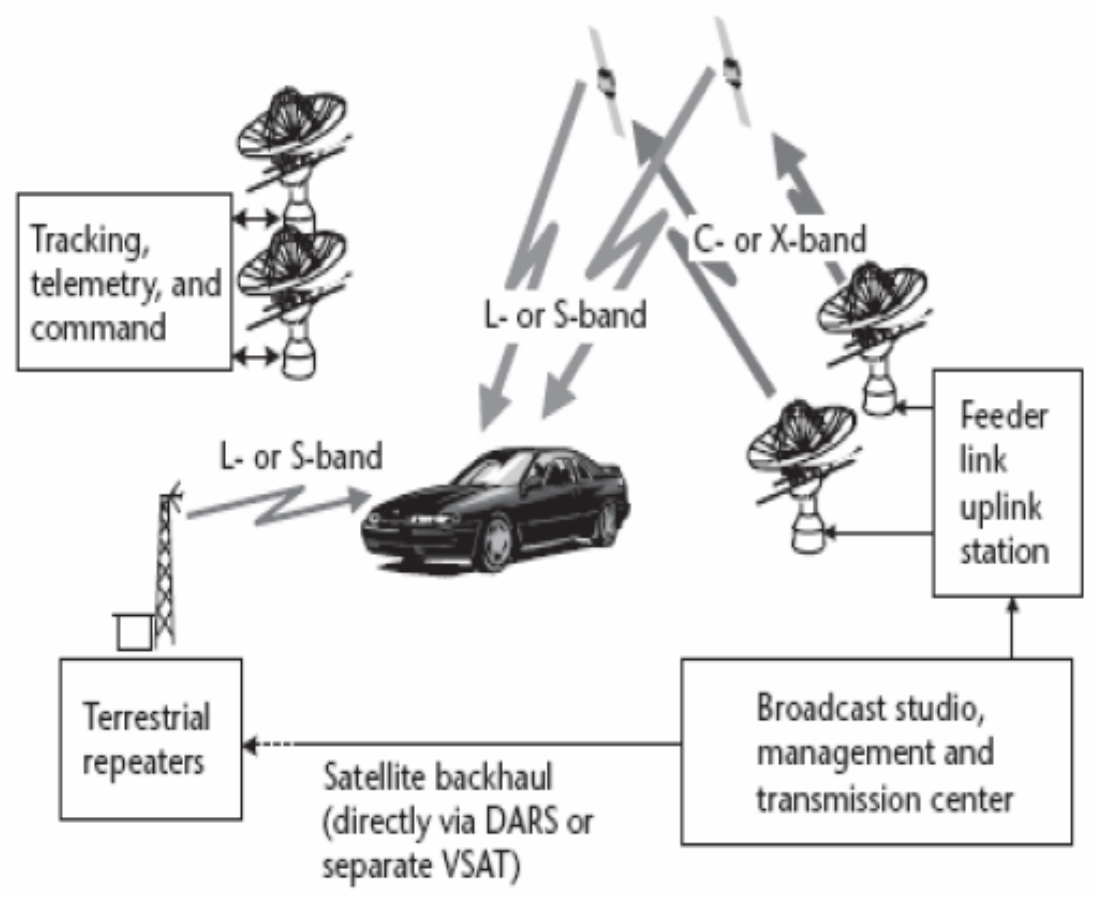


VSAT


HORIZONS-1 (127W)
Outbound Inbound
13-Mbps outbound
36-MHz transponder
Branch offices and remote locations
512-Kbps Inbound
Hub Earth station
Company HQ
1.2-m VSAT
Video conference equipment
Outdoor unit
7m antenna
PCs
Indoor unit
Network management console
Earth station and hub equipment
Terrestrial connection
-Voice
-Data
-MPEG video
PBX (VoIP)

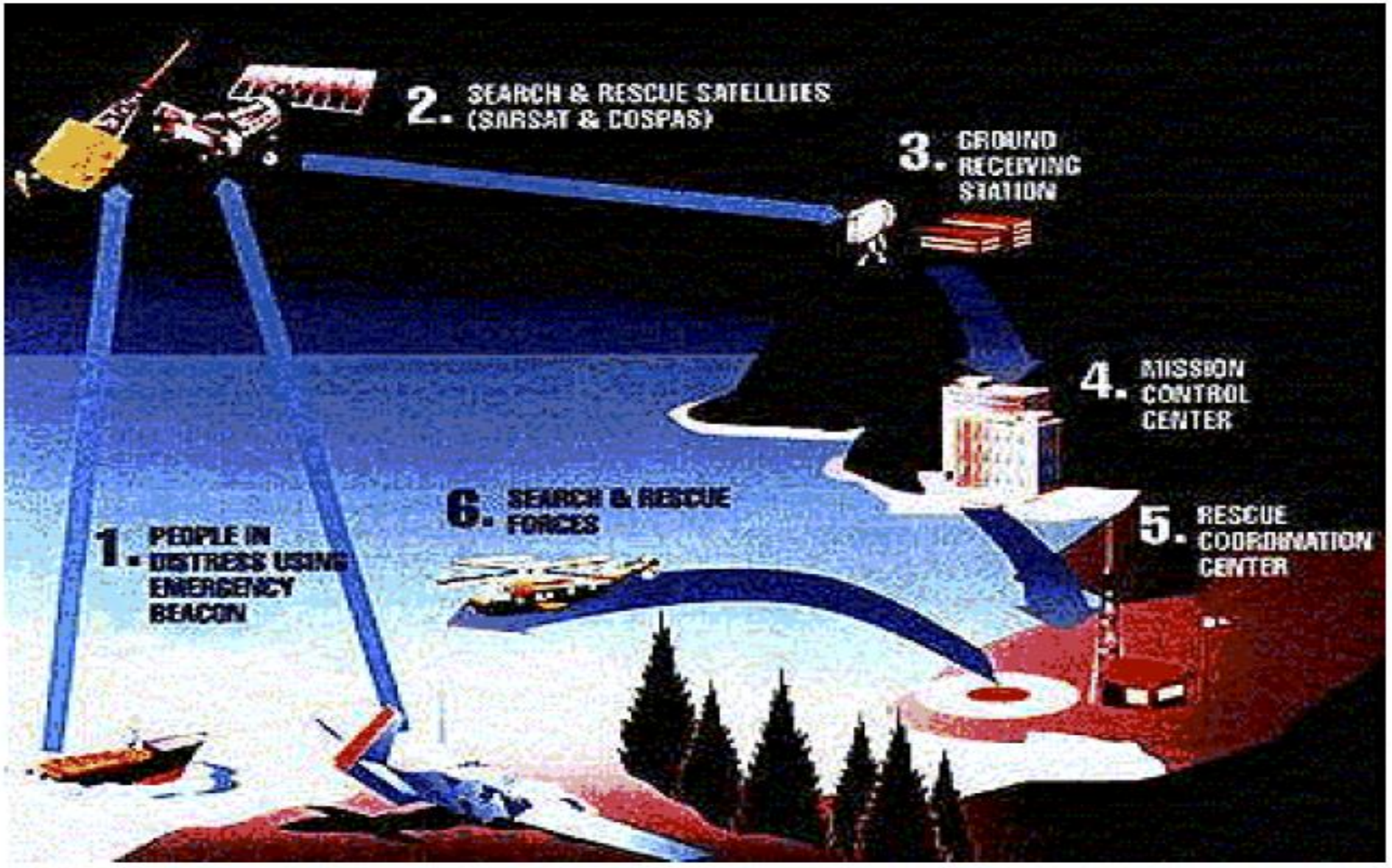
Direct Audio Broadcasting (DAB)

WorldSpace Receiver



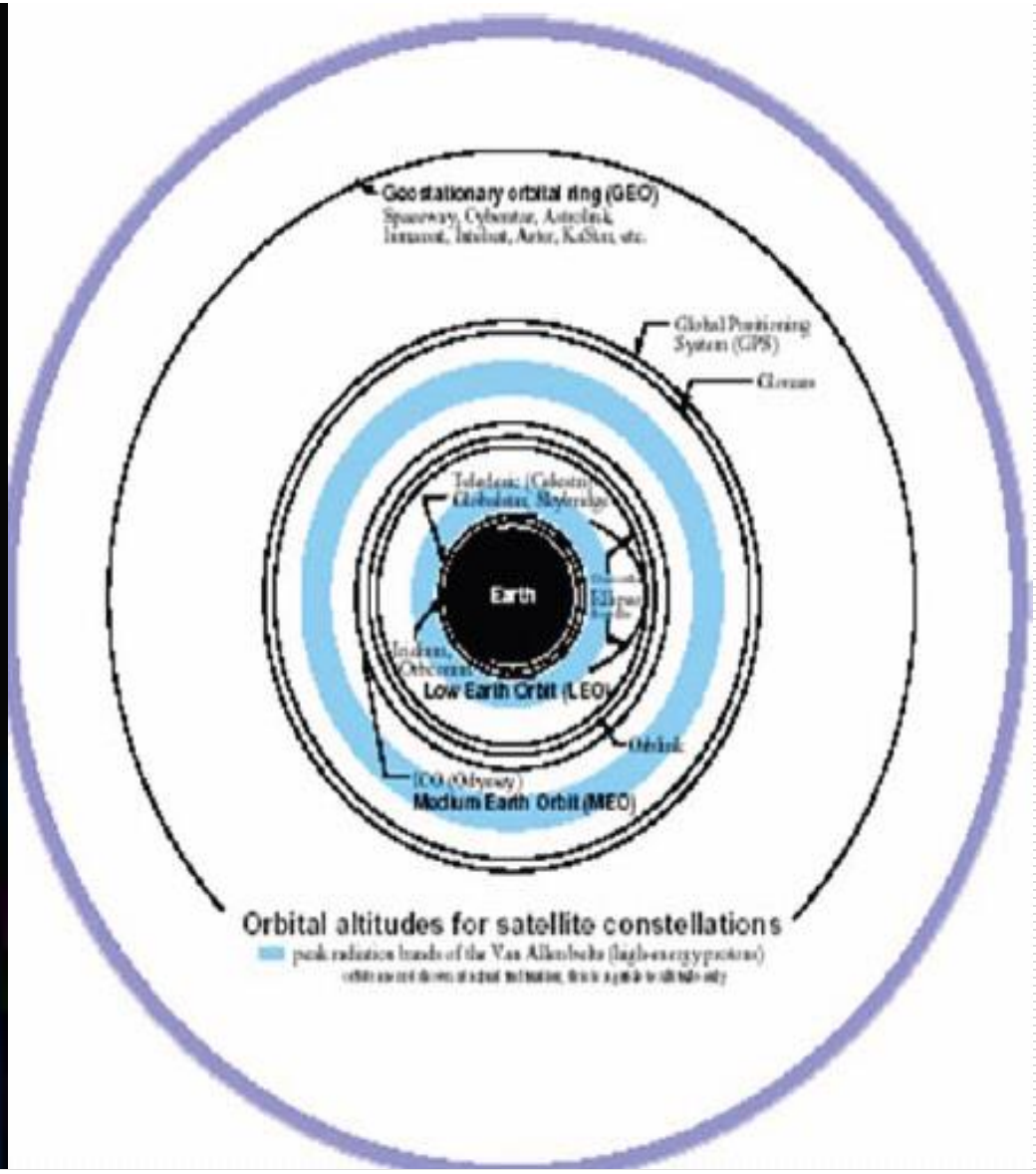
Basic arsitektur DAB

SAR

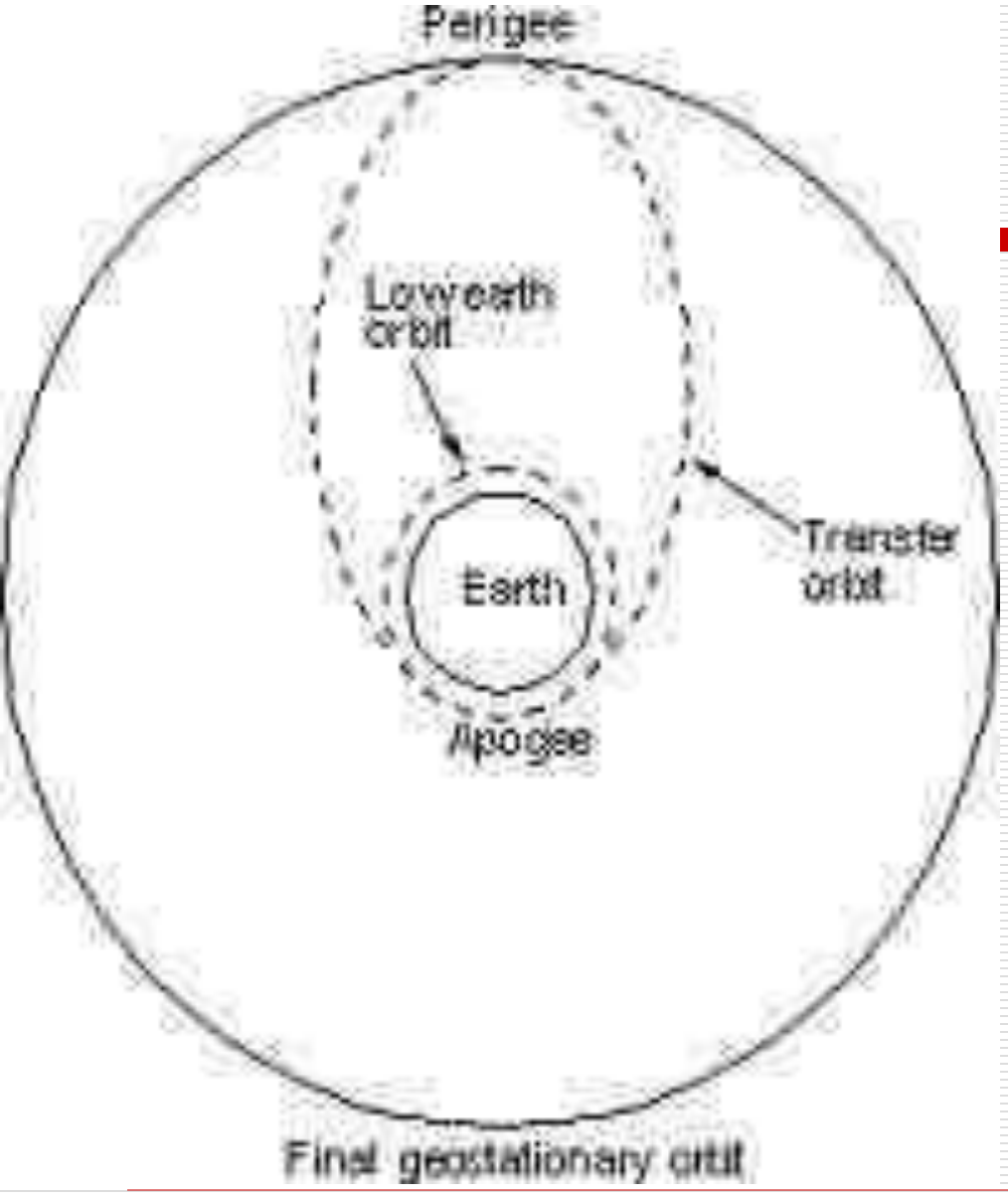

2. SEARCH & RESCUE SATELLITES (SARSAT & COSPAS)
3. GROUND RECEIVING STATION
4. MISSION CONTROL CENTER
5. RESCUE COORDINATION CENTER
6. SEARCH & RESCUE FORCES
1. PEOPLE IN DISTRESS USING EMERGENCY BEACON

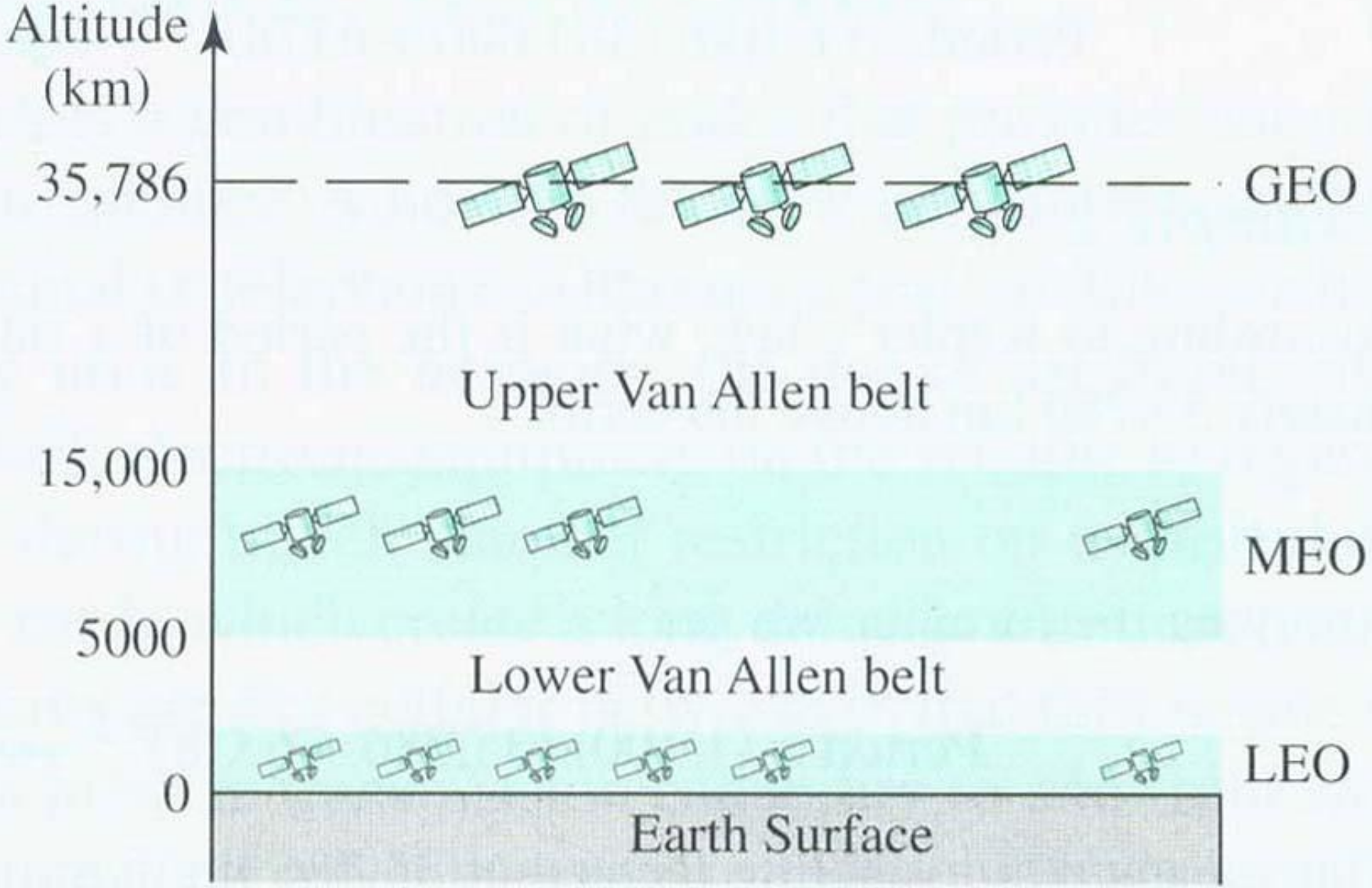
- Ilustrasi laser intersatellite link oleh satellite Artemis.

SatComm Basic

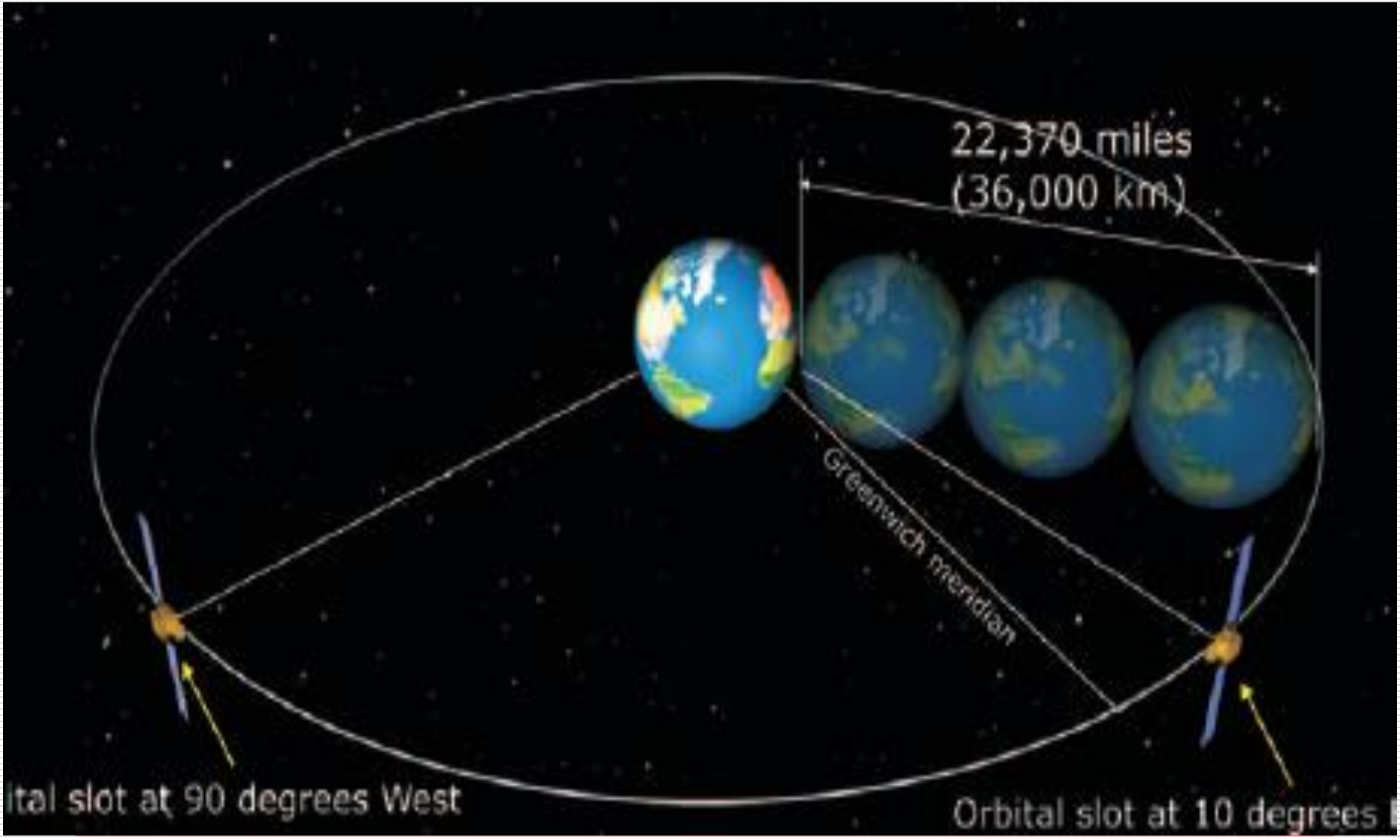


Satellite is Put In Orbit




Altitude
(km)
35,786
GEO
Upper Van Allen belt
15,000
MEO
5000
Lower Van Allen belt
LEO
0
Earth Surface

GSO Satellite Position

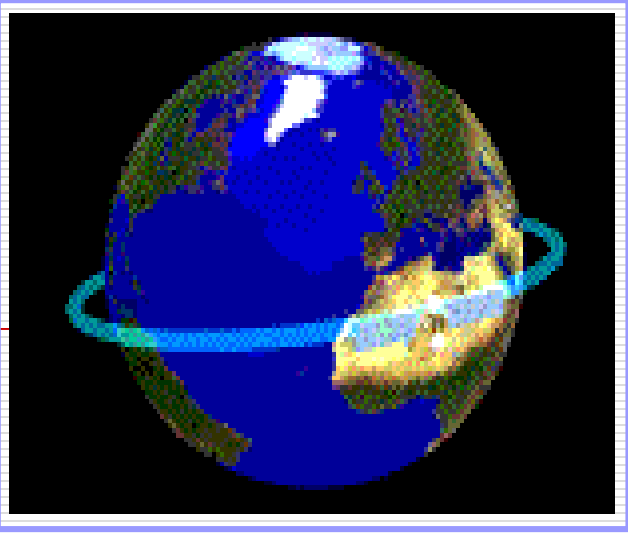


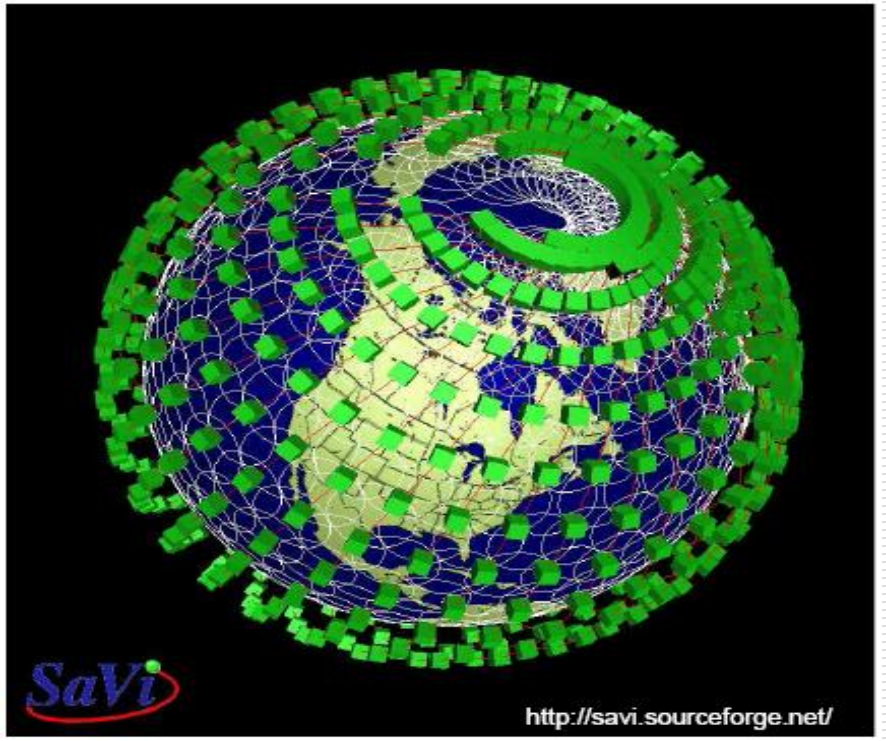
GSO (Geo-Synchronous Orbit)

- **Advantages:**
  - 24 hours relatively on the same position for observer on Earth.
  - Good for relay type communication, TV relay, DTH, SNG, VSAT, point to point communications.
  - Less complicated.
  - Lifetime is long average of 12-15 years.
  - Large capacity depending on launcher max lift off weight capability.
- **Disadvantages:**
  - Propagation delay due to distance of satellite to earth of around 36,000 km.
  - Footprint not global.
  - High risk, high cost of around USD 200 million.

Low Earth Orbit (LEO)

- Altitude of around 200-1400 km from Earth surface.
- Earth cycle periode of 90 min/cycle
- Small satellite dimension and light weight, easy to launch and cost less.
- Delay time is low, it is suitable for telephony or interactive applications.
- Variance: Big LEO, Little LEO, equatorial orbit, polar orbit etc.
- Applications: remote sensing, telephony, packet data.
- Constraints: low capacity, short life time, need more than 1 satellite for 7/24 services.

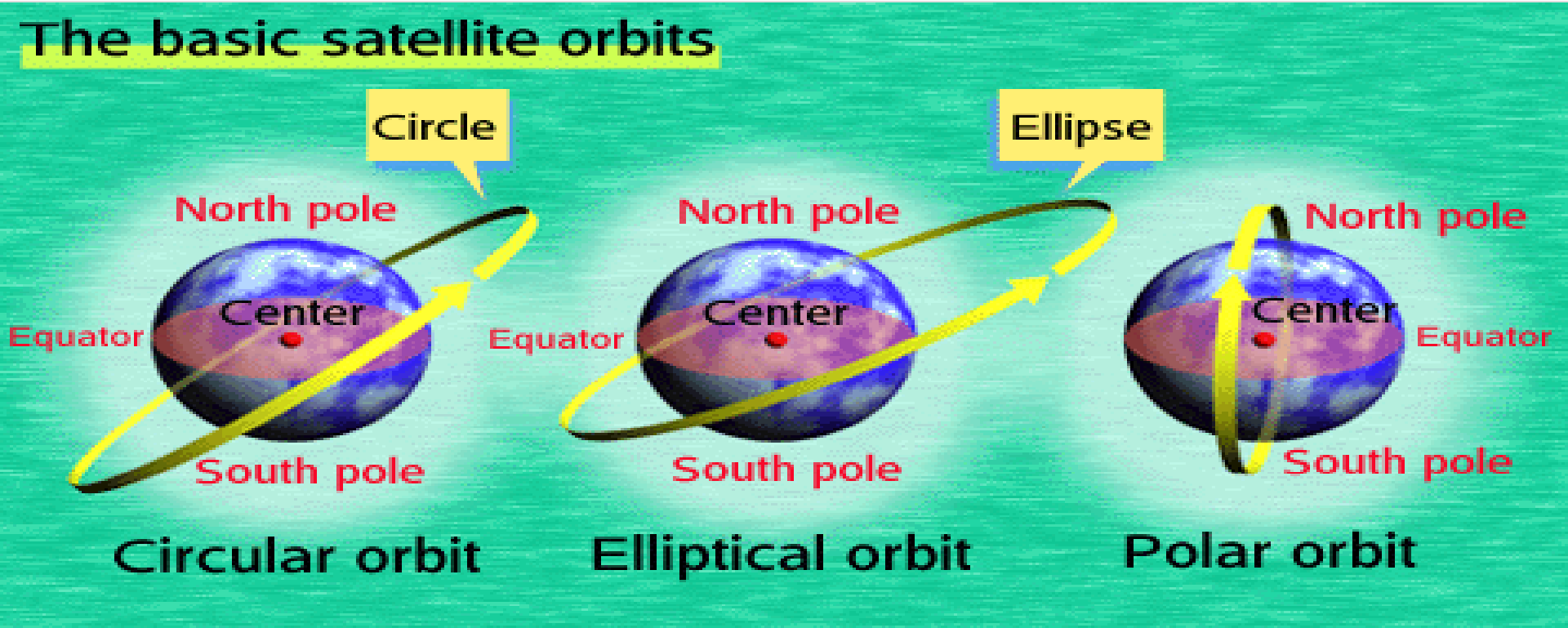




LEO-Satellite Orbital Model

- **Ellips** : a satellite's orbit trajectory that makes an angle of inclination to the Earth's equator with accentricity → sometimes called HEO/HIO

- **Circular** : a satellite's orbit trajectory around the Earth that makes an angle of inclination to the Earth's equator without accentricity;
- **Polar** : a satellite's orbit trajectory that makes an angle of inclination to the Earth's equator at around 90 degree without accentricity.



Medium Earth Orbit (MEO)

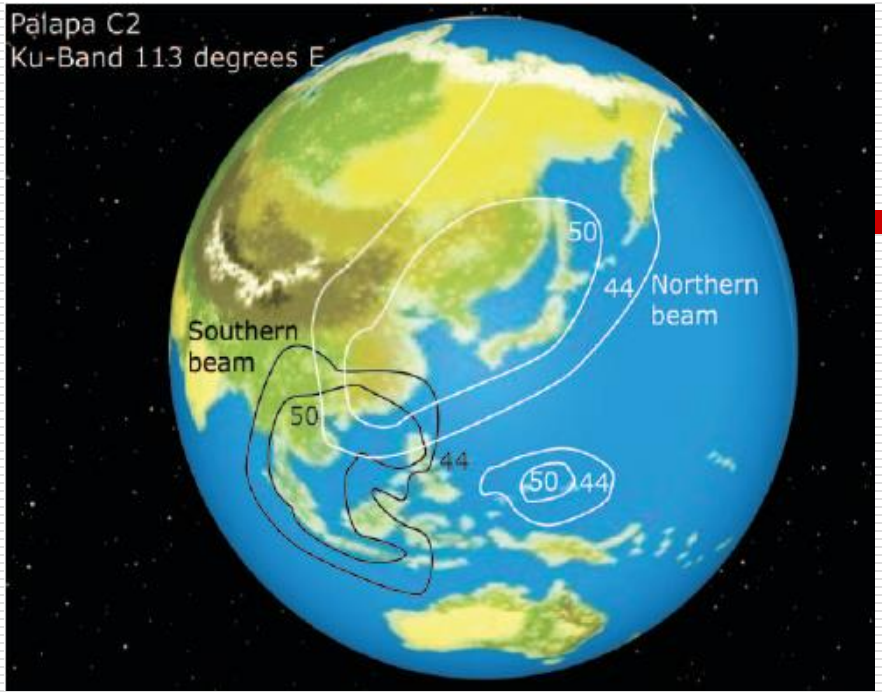
- Altitude of around 5 000 – 10 000 km from Earth surface.
- Delay time is higher than LEO still suitable for telephony.
- Earth cycle periode is highr than LEO, of around 6 hours/cycle.
- Applications: remote sensing, telephony, packet data, positioning.

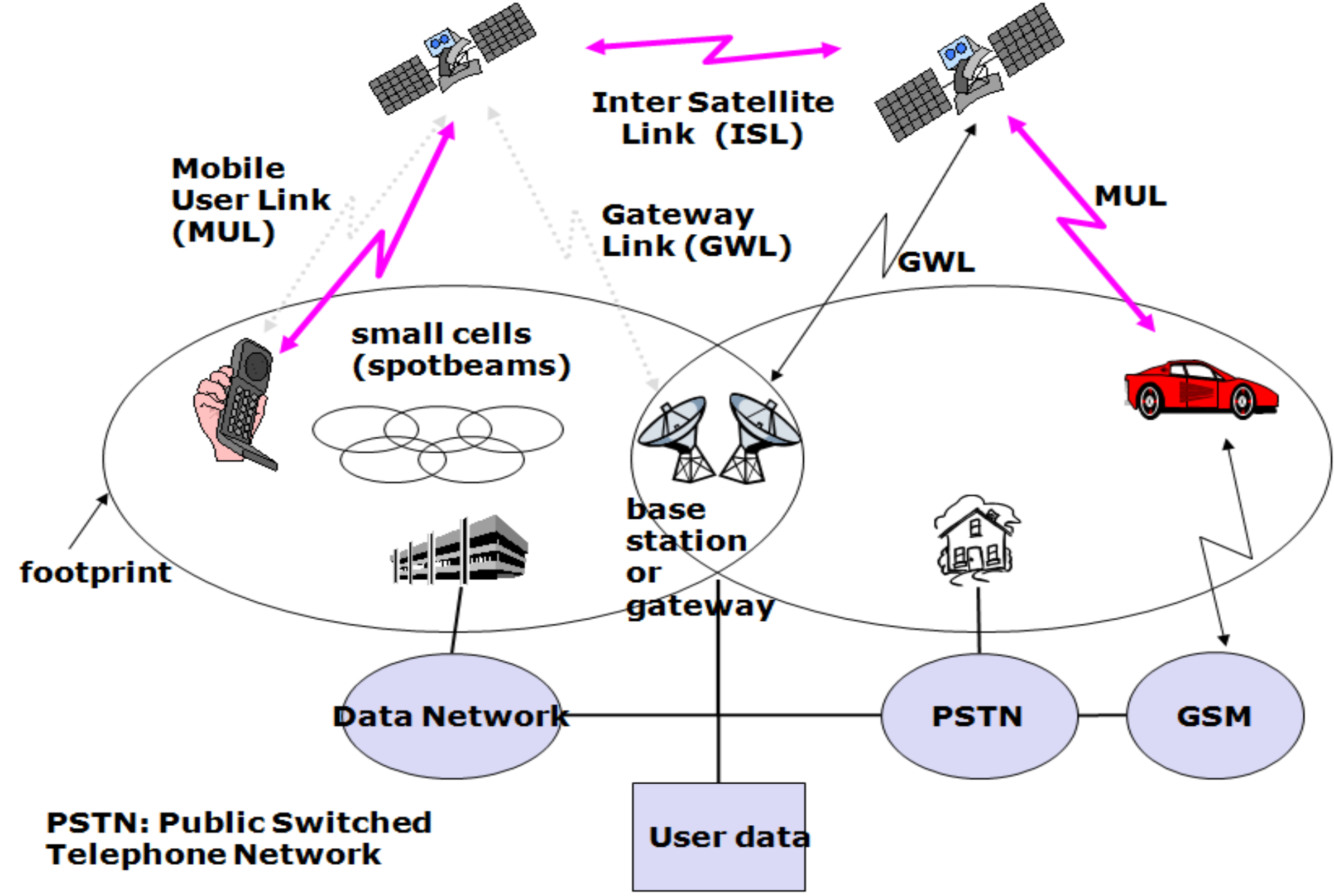
Constraints: medium capacity, better view time duration, needs more than 1 satellite for 7/24 service.

NGSO (LEO, MEO) – Non GSO

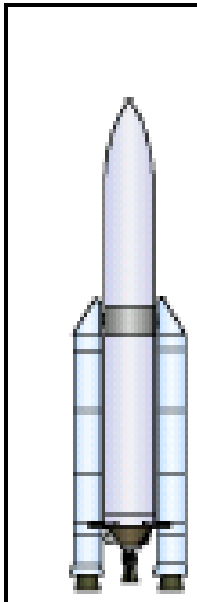
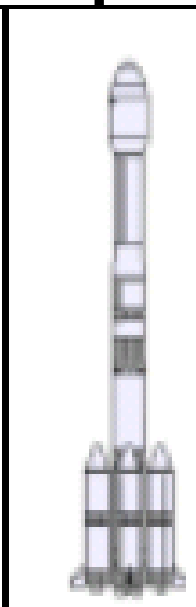
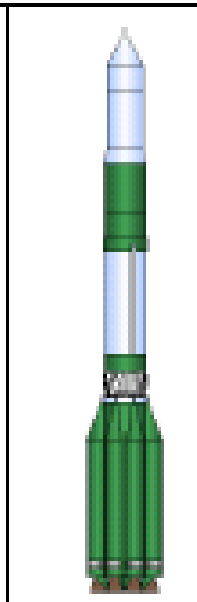
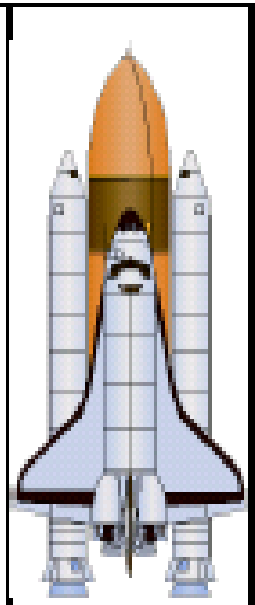
- Advantages:
  - Low propagation delay
  - Could be global coverage if inclination angle is higher than 85°
  - Less cost if non global 24 hours coverage.
- Disadvantages:
  - Limited capacity.
  - Needs in space handover using inter satellite link (ISL) or ground relay, this poses higher risk of drop calls/drop connection.
  - Satellite lifetime is limited to 3-5 years.

Satellite Coverage / Footprint




Inter Satellite
Link (ISL)
Mobile
User Link
(MUL)
Gateway
Link (GWL)
GWL
MUL
small cells
(spotbeams)
footprint
base
station
or
gateway
Data Network
PSTN
GSM
User data
PSTN: Public Switched
Telephone Network

Launcher Comparison

						
Vehicle name	Ariane 5G	Long March 3B	Proton	Space Shuttle	Zenit 2	Zenit 3SL
Country/Region of origin	Europe	China	Russia	USA	Ukraine	Multinational
LEO capacity lb (kg)	39,648 (18,000)	29,956 (13,600)	43,524 (19,760)	63,443 (28,803)	30,264 (13,740)	34,969 (15,876)
Reference LEO altitude km (mi)	342 (550)	124 (200)	124 (200)	127 (204)	124 (200)	124 (200)
GTO capacity lb (kg)	14,994 (6,800)	11,466 (5,200)	10,209 (4,630)	13,010 (5,900)	0	11,576 (5,250)
Reference site and inclination	Kourou 5.2 deg.	Xichang 28.5 deg.	Baikonur 51.6 deg.	KSC 28.5 deg.	Baikonur 51.4 deg.	Odyssey Launch Platform 0 deg.
Estimated launch price (2000 US$)	$165,000,000	$60,000,000	$85,000,000	$300,000,000	$42,500,000	$85,000,000
Estimated LEO payload cost per lb (kg)	$4,162 ($9,167)	$2,003 ($4,412)	$1,953 ($4,302)	$4,729 ($10,416)	$1,404 ($3,093)	$2,431 ($5,354)
Estimated GTO payload cost per lb (kg)	$11,004 ($24,265)	$5,233 ($11,536)	$8,326 ($18,359)	$23,060 ($50,847)	N/A	$7,343 ($16,190)

Choice of Services and Bands

- **Services:**
  - FSS (Fixed Satellite Services)
  - BSS (Broadcasting Satellite Services)
  - MSS (Mobile Satellite Services)
- **Bands:**
  - Planned band (only C and Ku band)
  - Non Planned band
- **Spectrum:**
  - L-band (incl. Ext L-band)
  - S-band
  - C-band (incl. Ext.C band)
  - X-band
  - Ku-band (incl. Ext. Ku-band)
  - Ka-band
- **Orbit:**
  - GSO (GEO)
  - NGSO (LEO, MEO)

FSS (Fixed Satellite Services)

- **Advantages:**
  - Multi telecommunication apllications:
    - VSAT / IP VSAT
    - SNG (satellite news gathering)
    - Trunking for Mobile Cellular, PSTN, Internet
    - TV Relay
    - DTH (direct to home) incl. IPTV
  - Coverage could be beyond national border.
- **Disadvantages:**
  - EIRP and PFD are very much pressured due to tight sat coordination since FSS is the lasrgest satellite service in the world.
  - Business competition is tight may go to price war.

BSS (Broadcasting Satellite Services)

- **Advantages:**
  - EIRP and PFD is high (see ITU RR)
  - Could be a candidate for "hot bird"
  - Less competition among BSS provider
  - Premium revenue since TV broadcasting enjoy premium revenue form commercial ad.
- **Disadvantages:**
  - Limited applications: TV relay, DTH and SNG
  - Mostly footprint is limited to national boundary
  - Ground equipment type and vendors may be limited relative to FSS.

MSS (Mobile Satellite Services)

- **Advantages:**
  - EIRP and PFD is high (see ITU RR)
  - Less competition
  - Niche and lucrative market segment
- **Disadvantages:**
  - Limited spectrum in terms of bandwidth
  - Limited terminal equipment – mostly proprietary
  - Limited applications.
- **Spectrum for MSS:** 1 518-1 544 MHz, 1 545-1 559 MHz, 1 610-1 645.5 MHz, 1646.5-1 660.5 MHz, 1 668-1 675 MHz, 1 980-2 010 MHz, 2 170-2 200 MHz, 2 483.5-2 520 MHz and 2 670-2 690 MHz

Satcomm. Spectrum Allocation

- L-band:
  - 1 518-1 525 MHz (DL)/1 610.6-1 613.8 MHz (UL)
  - 1 525-1 559 MHz (DL)/1 613.8-1 626.5 MHz (UL)
- S-band:
  - 2 520 – 2 670MHz (access link only)
- C-band:
  - 3 400 – 4 200 MHz (DL)/5 850-6 700 MHz (UL)
- X-band:
  - 7 250 – 7 750 MHz (DL)/7 900 – 8 400 MHz (UL)
- Ku-band:
  - 10.7-11.7 GHz, 12.2 -12.75 GHz (DL)/12.75-13.25 GHz, 14.3 -14.8 GHz (UL)
- Ka-band:
  - 18.1- 21.2 GHz (DL) / 27 - 31 GHz (UL)

INDONESIAN SATELLITE CAPACITY (Year 2010)

No	SATELIT NAME	ORBITAL LOCATION	OPERATOR	TXPDR
1	Telkom-1	108E	TELKOM	C-band = 24 Ext.C-band = 12
2	Telkom-2	118E	TELKOM	C-band = 24
3	Garuda-1	123E	PSN/ACeS	Typical
4	PALAPA PACIFIC/AGILA-2	146E	PSN	C-band = 24 Ext.C-band = 6 Ku-band = 24
5	INDOSTAR-1	107.7E	MCI	S-band = 5
6	PALAPA-D	113E	INDOSAT	C-band = 24 Ext.C-band = 11 Ku-band = 5
7	PALAPA-C2	150.5E	TELKOM /INDOSAT	C-band = 24 Ext.C-band = 6 Ku-band = 2 Ext.Ku-band = 2