

Satellite and Mobile Communications Fundamentals

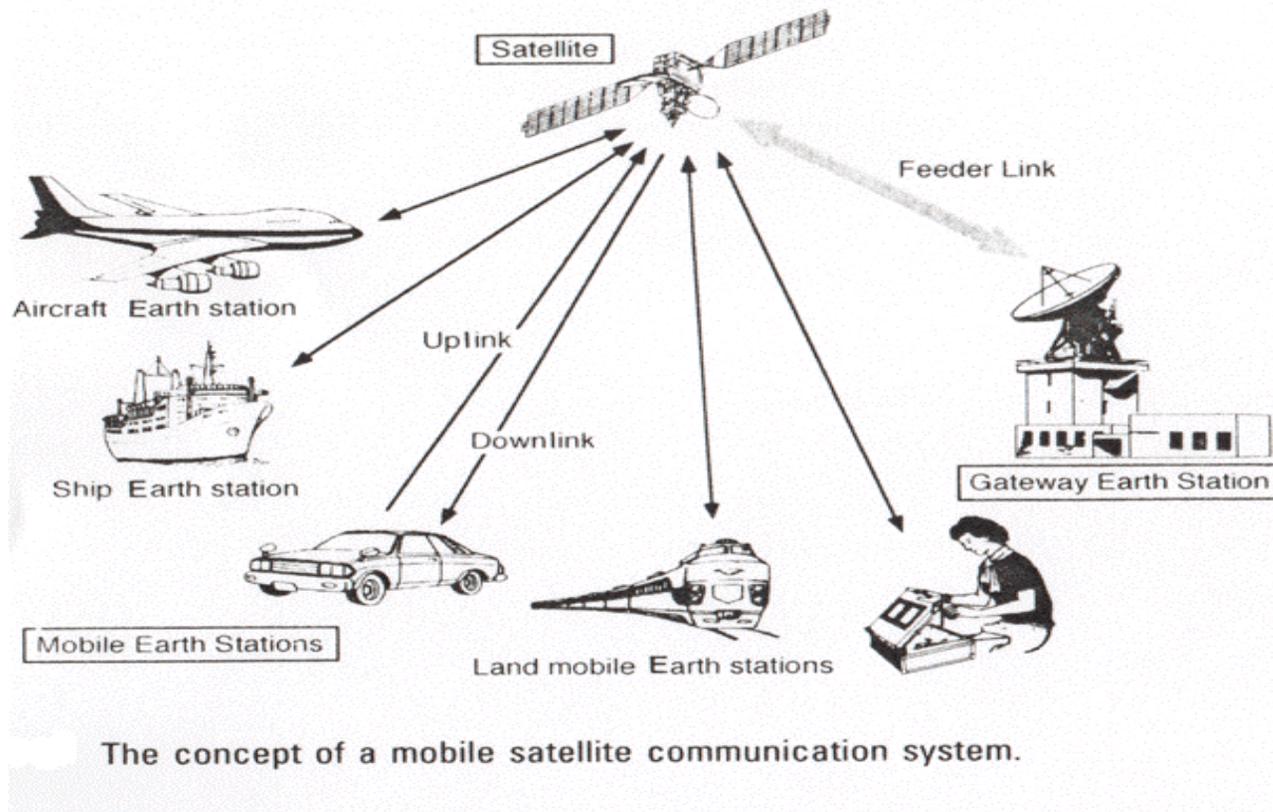
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Satellite Communications Systems

- Satellite communication systems use satellites to communicate between two remote terrestrial locations, a terrestrial location and a mobile station (aircraft, ship, land vehicles etc.) or two mobile stations.
- **Uplink** is a communication link from an Earth station to a satellite.
- **Downlink** is a communication link from a satellite to an Earth station.
- **Gateway Earth station** also called a base Earth station, connects satellite communication links to other communication systems.

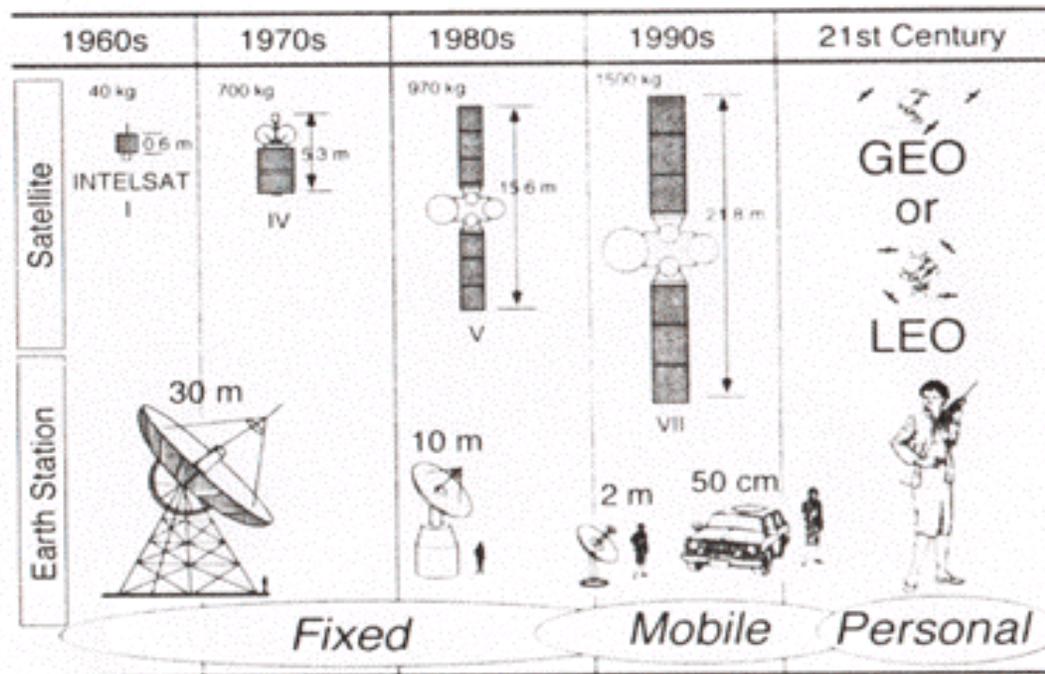
Satellite.....(Continued)

- A communication link between a gateway Earth station and a satellite is called a **Feeder** link.



Satellite.....(Continued)

- Three generations of satellite communication systems:



Three generations of satellite communication systems: fixed, mobile, and personal.

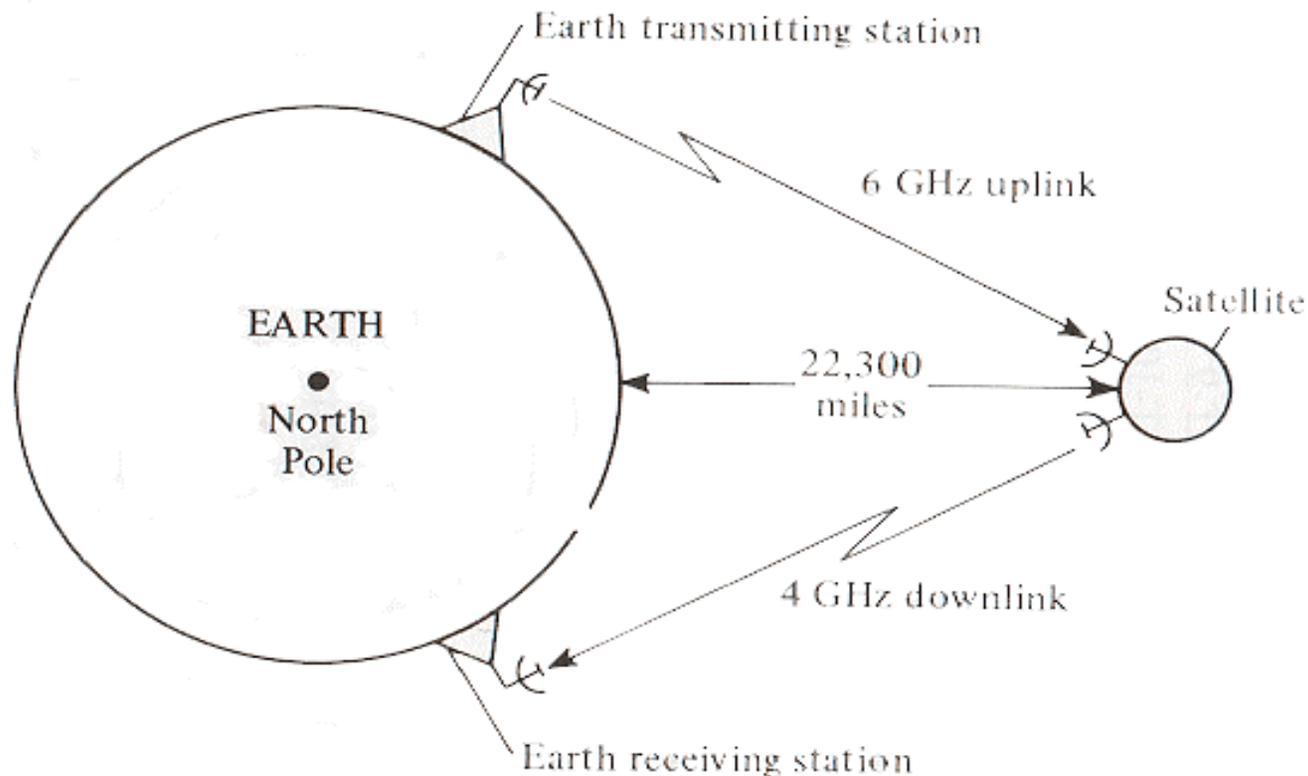
Satellite.....(Continued)

Link	Frequency
Uplink	1.60 GHz (L band)
Downlink	1.50 GHz (L band)
Feeder Uplink	6.0/14.0 GHz (C/Ku band)
Feeder Downlink	4.0/12.0 GHz (C/Ku band)

Satellite.....(Continued)

- Geosynchronous Orbits:

- This is a circular orbit in Earth's equatorial plane, located 22,300 miles above the equator so that the orbital period is the same as that of Earth.



Satellite.....(Continued)

- Due to large distance from Earth, the satellite needs to have sufficiently high power to communicate with compact ground antennas.
- **Nongeostationary Orbits:**
 - Non-geostationary orbiting satellites have orbits relatively close to Earth; however, multiple satellites are needed in each orbit for effective communication.

Satellite.....(Continued)

- Examples of Non-geostationary Satellite Systems:

Satellite System	Orbit	Number of Satellites
Iridium (LEO)	780 Km	66
Globalstar (LEO)	1,400 Km	48
Odyssey (MEO)	10,354 Km	12

- Low Earth orbit (LEO) is less than 10,000 Km above Earth.
- Medium Earth orbit (MEO) is more than 10,000 Km but less than a Geostationary orbit.

Multiple Access

- Multiple access is a technique to use a radio communications channel efficiently by sharing the resources.
- Frequency division multiple access (FDMA):
 - In this technique, transmitted signals occupy non-overlapping frequency bands.
 - A *guard band* between two signals helps in avoiding inter-channel interference.
 - **Drawback:** *Inter-modulation products* are generated (degrading signal fidelity) due to the nonlinear amplification when the satellite transponder is operated close to its saturation.

Multiple Access (Continued)

- Therefore, FDMA systems need to be operated less than full capacity.
- Time division multiple access (TDMA):
 - In this technique, transmitted signals occupy non-overlapping time slots with a guard band between two successive signals.
 - TDMA does not have inter-modulation interference. This permits the satellite amplifier to be operated in full saturation.
 - Time slot assignments are easier to adjust than frequency channel assignments (TDMA is more flexible than FDMA).

Fundamentals of Cellular Telephony

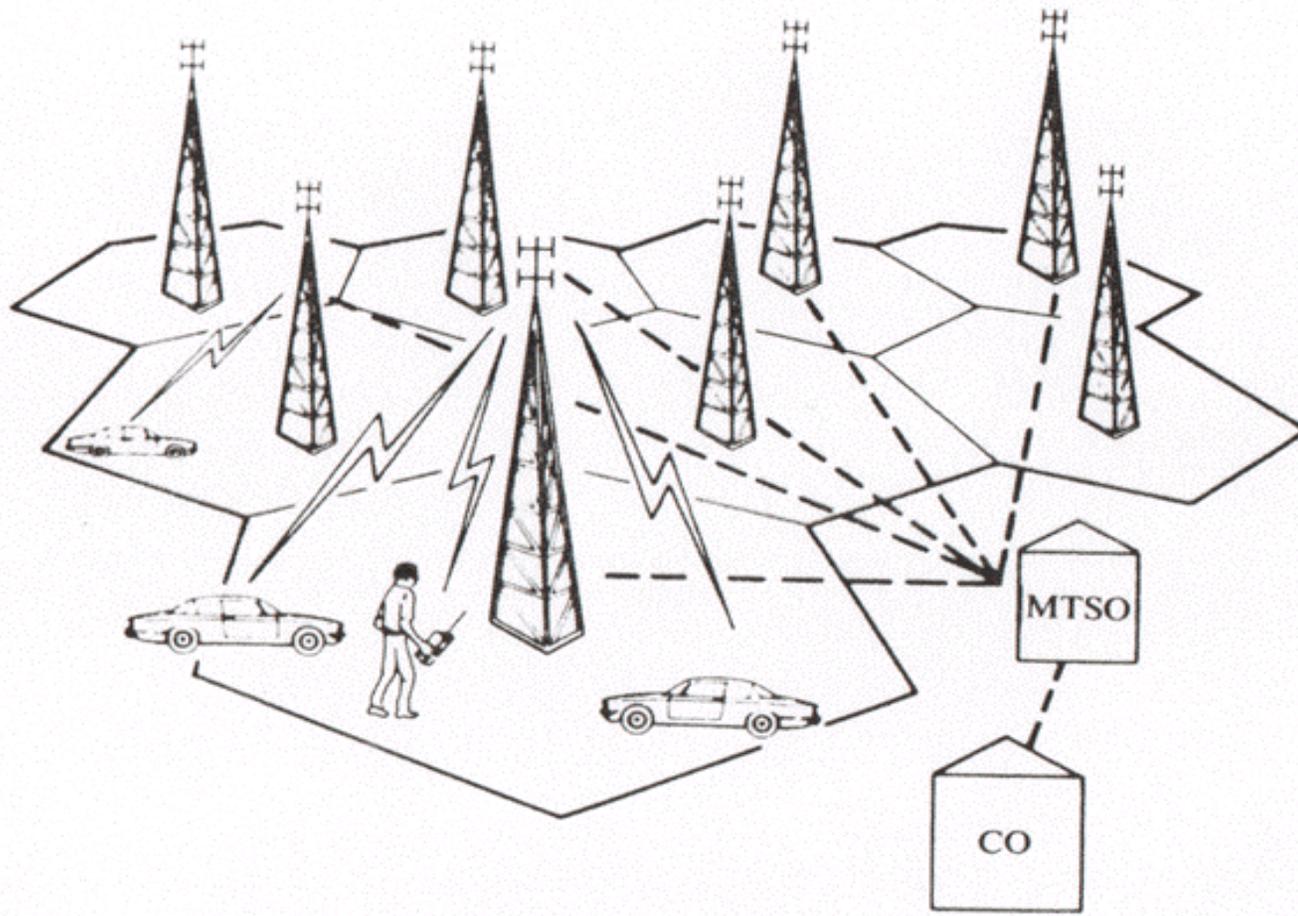
- Normal telephone connection is established over a *private line* from the home/office to the nearest service point.
- Similarly, cellular telephony also requires the assignment of a private radio channel for each subscriber.
- Problem:
 - Permanent assignment of the private-line radio channel to a subscriber is prohibitively expensive.

Cellular Telephony (Continued)

- Fix:
 - Radio channel must be shared *on demand* (FDMA), where a particular channel is assigned to a user only when a telephone call is in progress.
- Operation:
 - Each user communicates through a radio channel from a cellular telephone set to the call-site base station.
 - The base station is connected to the mobile telephone switching office (MTSO) through the telephone lines.

Cellular Telephony (Continued)

- MTSO connects the user to the called party.



Cellular Telephony (Continued)

- For the land based called party, the connection is made through central office (CO) to the terrestrial telephone network.
- For the mobile called party, the connection is made to the cell site covering the area of called party's current location.
- As the mobile user travels from one cell to another, the MTO automatically switches the user to an available channel in the new cell, thereby maintaining an uninterrupted telephone conversation.

Cellular Telephony (Continued)

- Advantages:

- Large subscriber capacity (number of cell times number of channels per cell)
- Highly effective use of radio spectrum
- Nationwide compatibility
- Service to handheld devices as well as to vehicles
- High quality telephone and data service to mobile users at relatively low cost

Cellular Telephony (Continued)

- US Cellular System:

- United states uses advanced mobile phone system (AMPS) developed by AT&T and Motorola.
- It uses frequencies from 806 to 890 MHz.
- Two competitors are licensed in each geographical region.
 - ✓ One licensee is a conventional telephone company called *B service or wireline service*.
 - ✓ Other licensee is a non-telephone company common carrier, called *A service or non-wireline service*.
- Have fully duplex services (different frequencies for sending and receiving carriers).

Cellular Telephony (Continued)

- 416 total channels (21 are used for paging and control)
- Detailed Operation:
 - Each Cell phone contains a PROM (or EPROM) called a numeric assignment module (NAM).
 - NAM is programmed to contain:
 1. Telephone number, also called electronic service number of the phone
 2. Manufacturer assigned serial number
 3. Personal codes to prevent unauthorized use of the phone

Cellular Telephony (Continued)

- Whenever a phone is turned on, its receiver scans the paging channel to find the strongest cell site and locks onto it.
- On-the-air phone automatically transmits its serial number to MTSO, which locks out phone service to a reported stolen phone.
- When a call is placed on a cell phone, MTSO verifies that the telephone number is valid and then assigns a radio channel to use for the call.
- MTSO then sends out signals to ring the desired telephone number (all of which occurs within ten seconds).

Cellular Telephony (Continued)

- Billing information is initiated when the called party answers.
- Billing is stopped when one of the party hangs up and MTSO frees the radio channel in use.
- **Hand-off sequence:**
 - It is a series of operations by MTSO during an active cellular telephone connection if the signal drops below certain level.

Cellular Telephony (Continued)

- MTSO inquires about the signal strength as received at the adjacent cells.
- MTSO then switches the cellular phone to an appropriate channel in a new cell site receiving the signal at sufficiently large strength.
- This whole process usually takes less than 250 milliseconds and is unnoticeable to the subscriber.

Cellular Telephony (Continued)

Analog Cellular Telephone System

Item	A Service (Non-wire Line)	B Service (Wire Line)
Base cell station		
Transmit bands (MHz)	869-880, 890-891.5	880-890, 891.5-894
Mobile station		
Transmit bands (MHz)	824-835, 845-846.5	835-845, 846.5-849
Maximum power (watts)	3	3
Cell size, radius (Km)	2-20	2-20
Number of duplex channels	416	416
Channel bandwidth (KHz)	30	30
Modulation		
Voice	FM, 12 KHz peak deviation	FM, 12 KHz peak deviation
Control signals	FSK, 8KHz peak deviation 10 Kb/s	FSK, 8KHz peak deviation 10 Kb/s

Cellular Telephony (Continued)

- With the increased popularity of cellular telephony, wideband FM analog system does not seem to have enough capacity to accommodate the anticipated growth in number of future subscribers.
- Narrowband FM systems (with 10 KHz BW for voice and 30 KHz BW for paging) are replacing wideband FM systems on a channel-by-channel basis as the need arises.
- Digital cellular systems offer even a higher capacity.