Unit (3) _ Satellite Communication

* مبدئياً كل الحد سلايد 12 هو بيتكلم عن تاريخ الـ Satellite من سنة 1945 لحد 2008
وطبعاً داخل امتحان تاريخ 😵

1) Satellite Operation:

* Old definition: "bent pipe" to relay data from ground station to ground station.

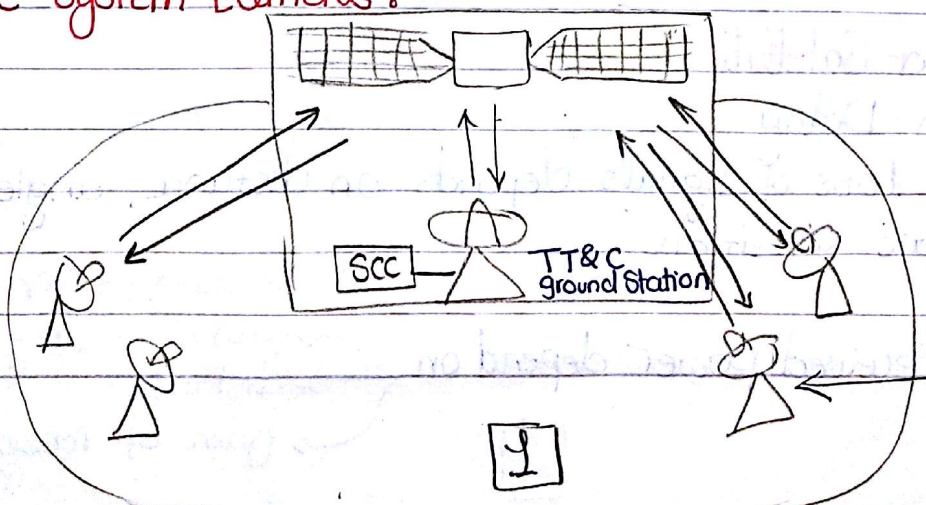
* New definition: Smart relay with onboard processors & inter-satellite links that can bypass ground stations & communicate directly with users.

1-b) Satellite Applications:

1- Weather forecasting
2- Radio and TV broadcast → Radio & TV programs available via satellite
3- Military Satellites
4- Navigation and localization → Almost all ships and aircraft rely on GPS
5- Telecommunications
- Global Telephone backbone: Satellite is increasingly replaced by fiber optics
- Connections for communication in remote places
- Global mobile communication
  - ↳ Geo satellites are not ideal for this, satellite in lower orbits are used

Purpose is extend area coverage not replace current network

2) Satellite System Elements:



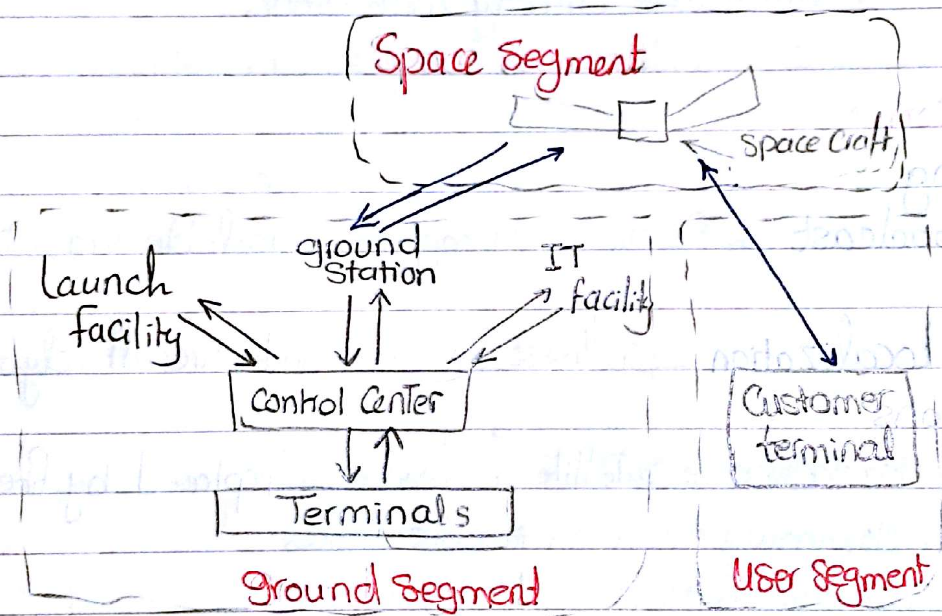
Space craft يعني الالة

(3) Space Segment → one of three opritional components of Satellite System

1. Satellite launching phase
2. Transfer orbit phase
3. Deployment
4. Operation
5. Retirement phase

→ TT&C (Tracking telemetry & command)
→ SSC (Satellite control center)
* OCC operational control center
* SCF → Satellite control Facility

(4) Ground Segment → consists of all ground based control elements of a Space craft system



→ ground Segment Servers to enable Control of space Craft, and distribution of Payload data

← شوفوا رسمة الـ 20

Link problems of Satellite:

1) propagation Delay
2) " Loss of Signals depends on distance, angle and atmospheric Condition
3) Attenuation/received Power depend on
   - → Sending power
   - → gain of Sending antenna
   - → distance
   - → gain of receiving antenna

4) Varying strength of received signal due to multipath propagation
5) interruptions due to shadowing of signal

↳ Possible Solutions: Satellite diversity (usage of several visible satellites at same time) → Sending Power ↓

(5) Communication Satellites:

↳ Communication satellite provide means for comm. between 2 widely separte points on the ground that are difficult to access by other communication means.

نقدر نعتبره مثلاً large microwave repeater

↳ It contains several transponders which listen to some portion of spectrum, amplifies incoming signal and broadcasts it in another frequency to avoid Interference.

← لما بنستخدم ال Satellite مع المسافات الطويلة بنعتبره as repeater لل earth station بيبعت السيجنال للستلايت (uplink) وهو بيـ retransmit (repeat) ال signal ل ال receiver وبنستخدم (downlink)
كل ال up/down freq.

↳ nature of it make it attractive for services (Ex: TV)

Categorisation:

1) Coverage area → global, regional or national. Larger systems require more satellites.

2) Service Type →
- Fixed Satellite Service (FSS)
- Broadcast " " (BSS)
- Mobile " " (MSS)

3) Configurations →
- point to point (2 earth stations & 1 satellite) — Trans. / Recev.
- Broad cast link (1 transmitter, 1 satellite, many receivers)

Footprint ← المنطقة من الارض اللي ال Satellite مغطيها وال Signals بيستقبلها بنسميها

Scanned by CamScanner

transponder → in Satellite comm, transponder receives Signals over a range of uplink freqs (usually mn el ground Station) and amplifies them & retransmits them on a different set of down link freqs. to receiver حاجة كدا زي :

So → typically separated freqs for uplink and downlink
→ transponder for send/receive and shift of freqs
→ transparent transponder : only for shift
→ regenerative " : additionally signal regeneration

Satellite Signals used to : transmit signals (long distance)
↳ weather forcasting , TV broadcasting , Internet , GPS

* Design Considerations :
1) Area/Coverage ; as before some Satellites can cover almost 33% of earth's surface بيتحطوا حواليه الارض بينهم زاوية 120
, transmission cost becomes invariant of distance.

2) Bandwidth ; Very limited resource → دي بالبيانات 8D
3) Transmission Quality ; Very high _ Delay up to 1/4 Sec.

* Satellite frequency Bands : الاهم الارقام (مهم) بتاعة الbands

	Band	Downlink	uplink
most frequently used →	C	3700 _ 4200 MHZ	5925 _ 6425 MHZ
reserved exclusively for satellite comm	Ku	11.7 _ 12.2 GHZ	14.0 _ 14.5 GHZ
	Ka	17.7 _ 21.2 GHZ	27.5 _ 31.0 GHZ
	V-Band	47.2 _ 50.2 GHz	50.4 _ 51.4 GHZ

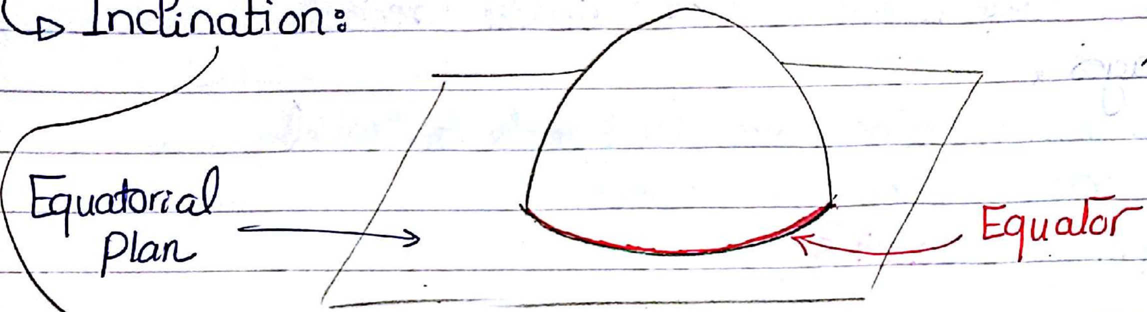
(6) Satellite Orbits :

(شوفوا الرسمة سلايد 35، 36 مهمة)

- Elliptical or Circular orbits
- Complete rotation time depend on "Distance Satellite – earth"

- Inclination:

"Mb3rfsh arsm :V"



→ angle between orbit and equator

* Elevation: angle between satellite and horizon (high elevation needed)
* Line of sight (LOS): necessary for connection

Types of Satellite Orbits:

- Based on inclination (i)
  1) Equatorial orbits above earth's equator ($i=0°$)
  2) Polar orbits pass over both poles ($i=90°$)
  3) others → inclined orbits ($0° < i < 90°$)

- Based on Eccentricity:
  1) Circular with Centre at the earth's Centre
  2) Elliptical with one foci at earth's centre.

(7) Types of Satellite based Networks

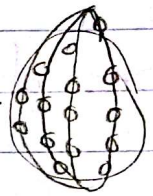
1- GEO - Geostationary Orbits:

- 36000 km equatorial, High latency (36 km above surface)
- In the equatorial plane.
- Orbital period = 23h 56m 4.091 s
- Satellite appears to be stationary over any point on equator:
  - earth rotate at same speed as satellite
  - Radius of orbit = orbital height + Radius of earth
  - avg earth radius : 6378.14 km

- Advantages:
  - Relative stationary property means frequency changes are not a problem.
  - Tracking by earth station is Simple
  - Can see huge areas, less Satellite needed.
- Disadvantages:
  - 36000 km is along way for signals to travel
  - Polar regions not well served
  - Long delay ≈0.24 s

2_LEO_ Low earth Orbits

- Low power, Low latency, More satellites, Small footprint
- 500-1500 km
- Circular/Elliptical orbit under 2k km
- Often in polar orbit at 500 to 1500 km altitude
- Low delay ≈ 20 ms
- Only visible to earth station for about 20 minutes
- Freqs change with movement
- Satellite travels across sky from horizon to horizon in 15-15 min
  - need handoff
- Earth Stations must track satellites or have Omnidirectional Antenna
- Large constellation of satellites needed for continu. Comm
  - ≃ 66 Satellite to cover earth
- Requires Complex architecture & tracking at ground



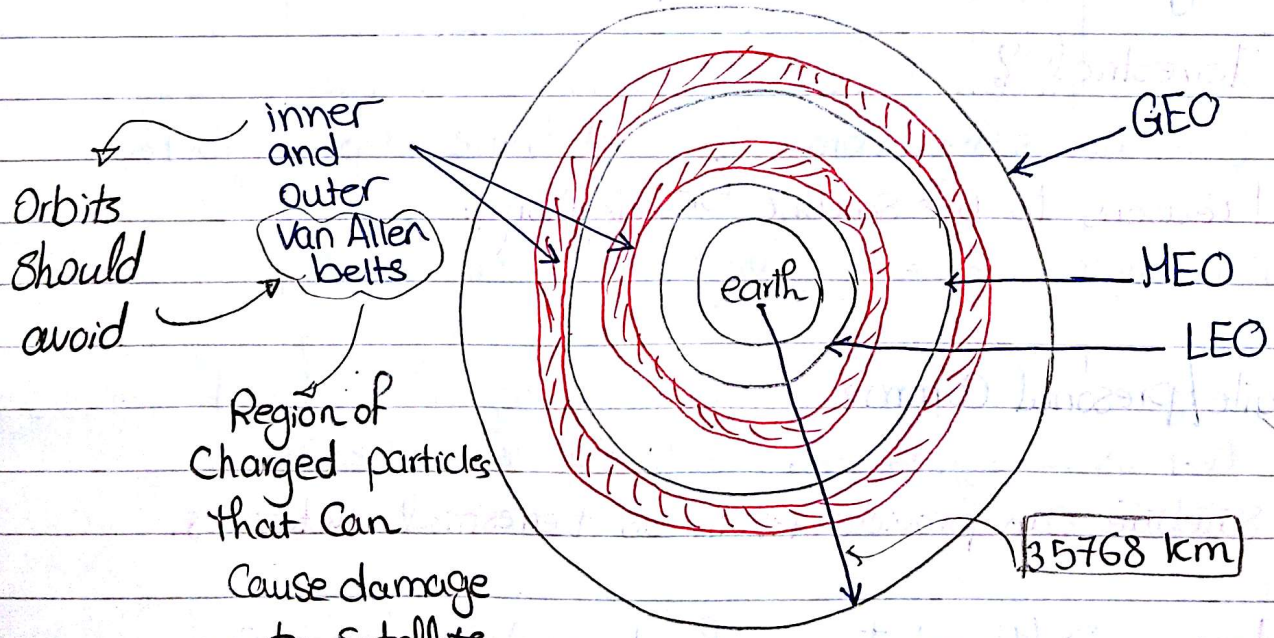
3_MEO_ Medium earth Orbits (ICO: intermediate Circular orbit)

- High BW, High power, high latency
- 6000 - 20.000 km altitude
- 6 hour orbits
- Coverage diameter: 10.000 to 15.000 km
- Signal delay < 80 ms
- Visible To few hours
- proposed for Data communication services

MEO Compared to LEO Systems:

- Slower moving satellites
- Simpler design
- for many Connections, no handover needed
- Special antennas for small footprints needed
- less satellites needes
- higher latency (70-80 ms)

-	LEO	MEO	GEO
latitude	< 1500 km	10 k - 20k km	37,786 km
Cost	Max	Min	Medium
life	3-7 years	10-15 years	10-15 years
Hand Held unit	yes	yes	possible
propagation delay	Short	Medium	large
" loss	low	"	high
Network Complex.	Complex	"	simple
Hand-off	very	"	NO
Develop. period	long	Short	long
Visibility	Short	Medium	always.



↳ occur at ~2000-4000 km & ~13000 - 25000 km

* Satellite Communications

Advantages	Disadvantages
• Reach over large geographical area • flexible (if transparent transponders) • Easy to install new circuits • Circuit cost doesn't depend on distance • Broadcast possiblities • Temp. apps • Niche apps • Mobile // • Terrestrial Network • provision of service to remote areas • User has control over own network • 1-N multipoint standby possiblites	• large up front capital costs (space segment & launch) • Terrestrial break even distance expanding • Interference & propagation delay • Congestion of freqs. and Orbits

When to use Satellites ?

↳ Unique feautres of it make it attractive
↳ Costs are lower than terrestrial routing
↳ it's the only soln.

When to use Terrestrial ?

(1) PSTN: Satellite is uneconomic for most trunk telephony routes
↳ good reasons to use satellite for telephony:
thin routes, diversity, very long distance traffic, remote loc.

(2) Land Mobile/presoned Comm: in urban areas of developed countries
↳ new terrestrial infrastructure is likely to domenate
↳ but Satellite can provide fill-in as terrestrial networks.

Atmospheric losses: Different types of atmospheric losses can distrabut radio wave transmission in Satellite System
↳ Atmospheric absorption/attenuation, Travelling ionospheric disturbances