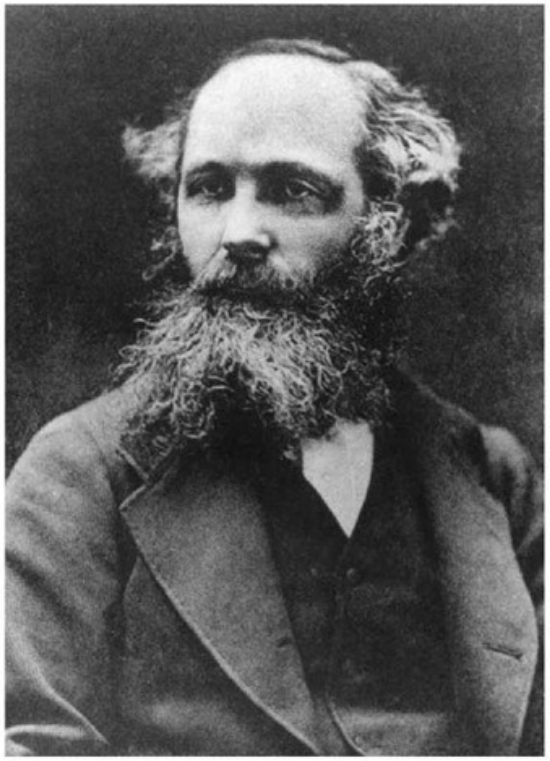
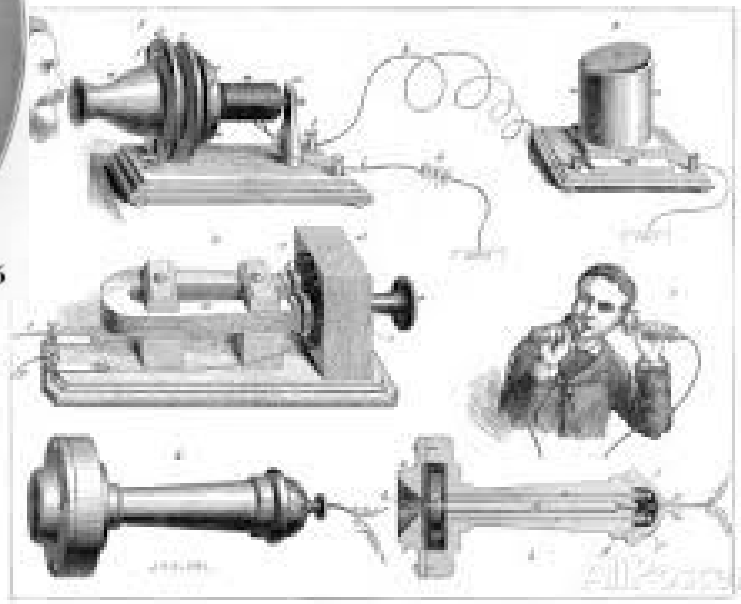
Wireless Communications

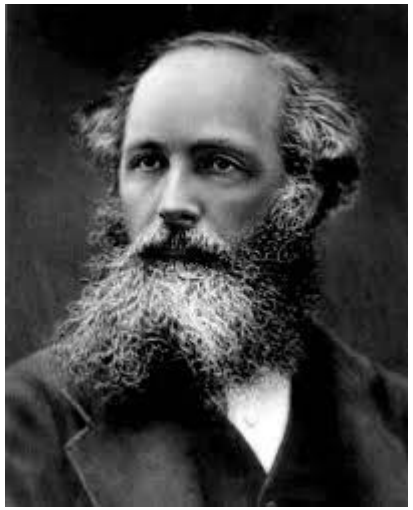


Communications

First Telegraph 1844



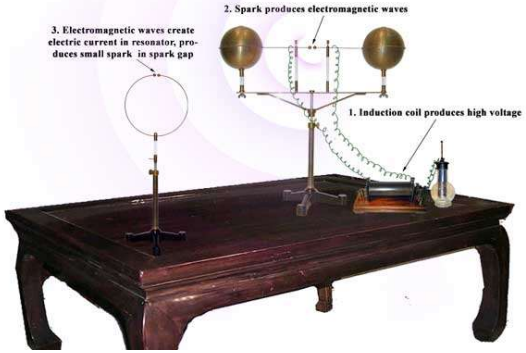
Wireless Communications



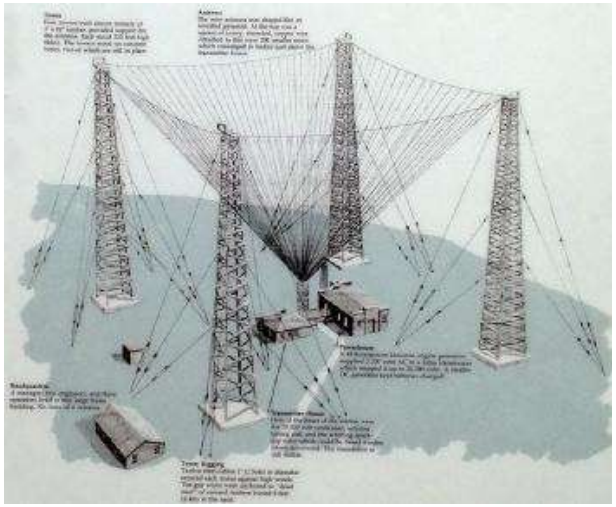
James Clerk Maxwell

Heinrich Hertz

Guglielmo Marconi



Spark Gap Experiment
1886-1889

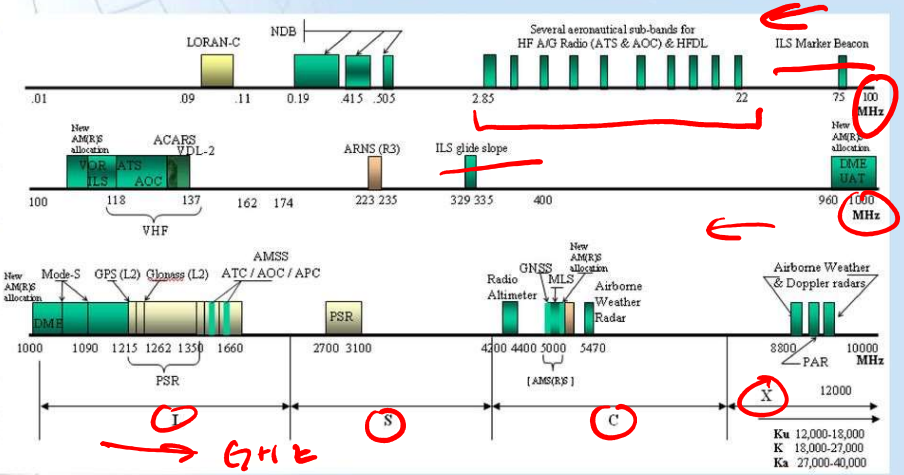


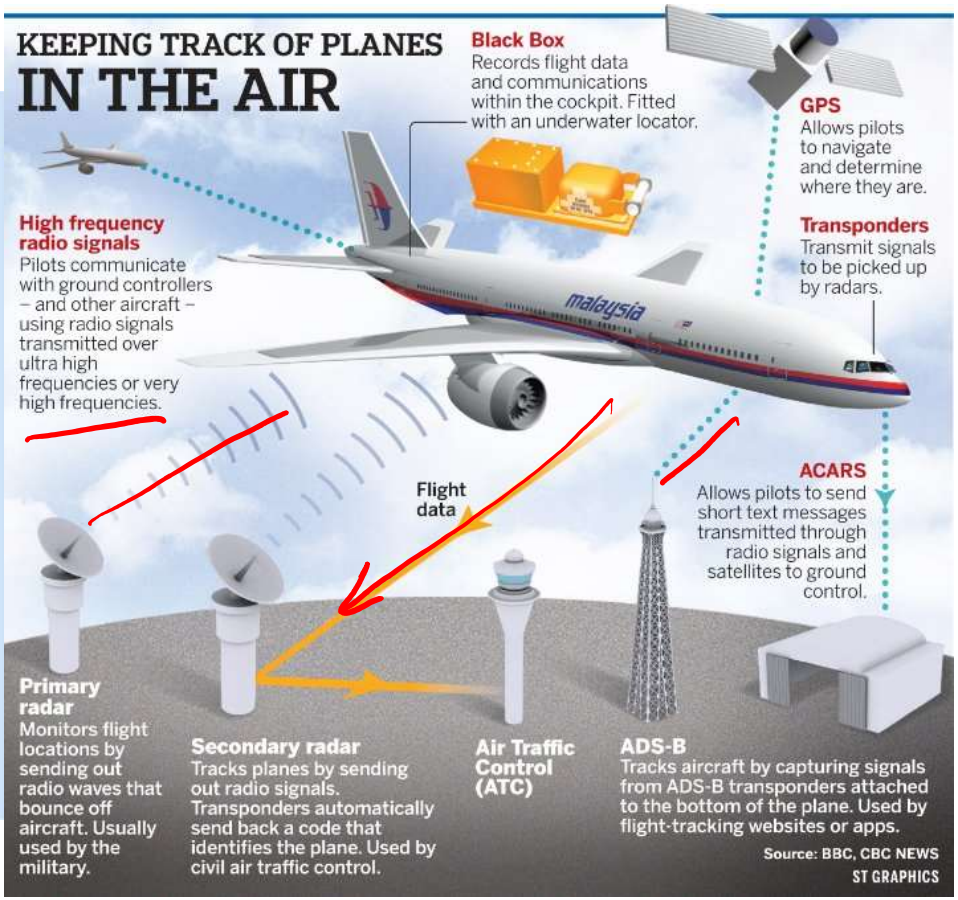
Transatlantic communication
1901

Aerospace RF systems

Aeronautical Frequency Spectrum Management

Overview of spectrum allocations to aeronautical services utilized by Civil Aviation



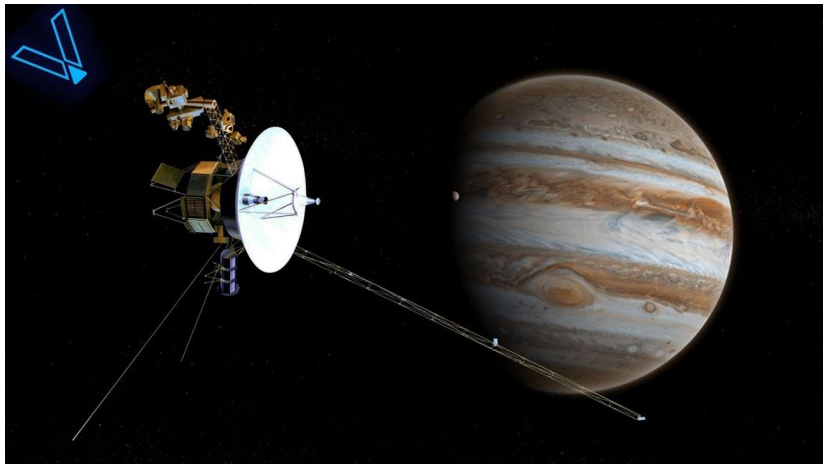


Aerospace RF systems

Iridium

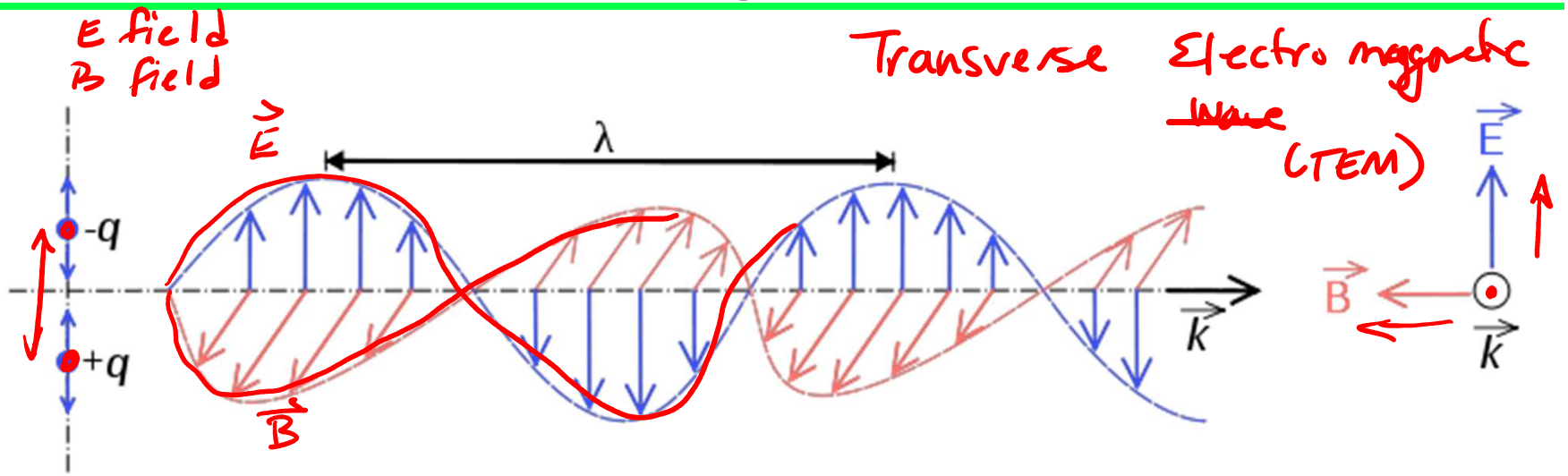
Satellite Television

USEI Brewster WA Teleport



Voyager spacecraft

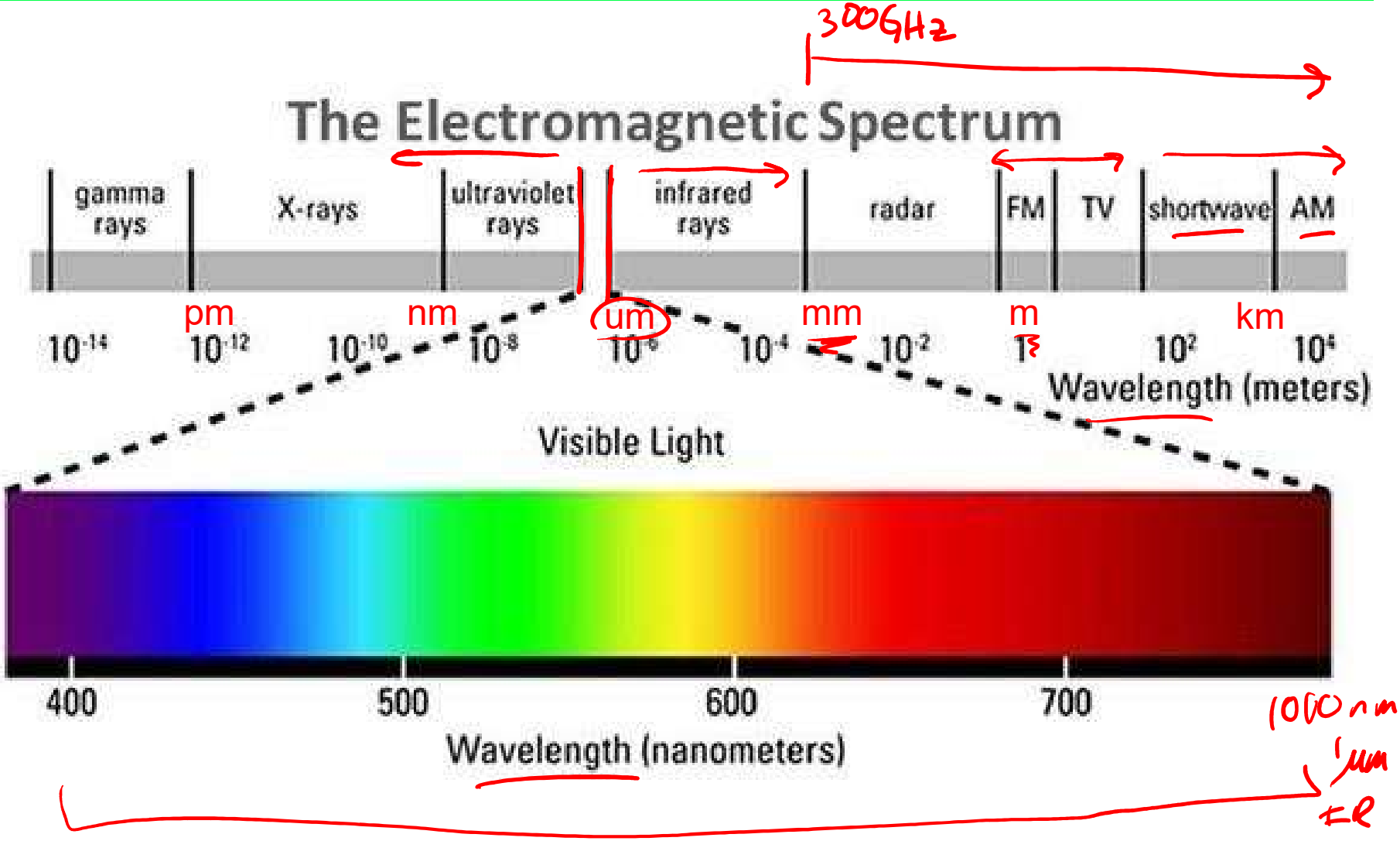
Electromagnetic Wave



$$\mathrm{E}(\mathrm{r},\mathrm{t}) = \mathrm{Re}\left\{E_0 e^{i(wt-\vec{k}r+\Phi)}\right\}$$

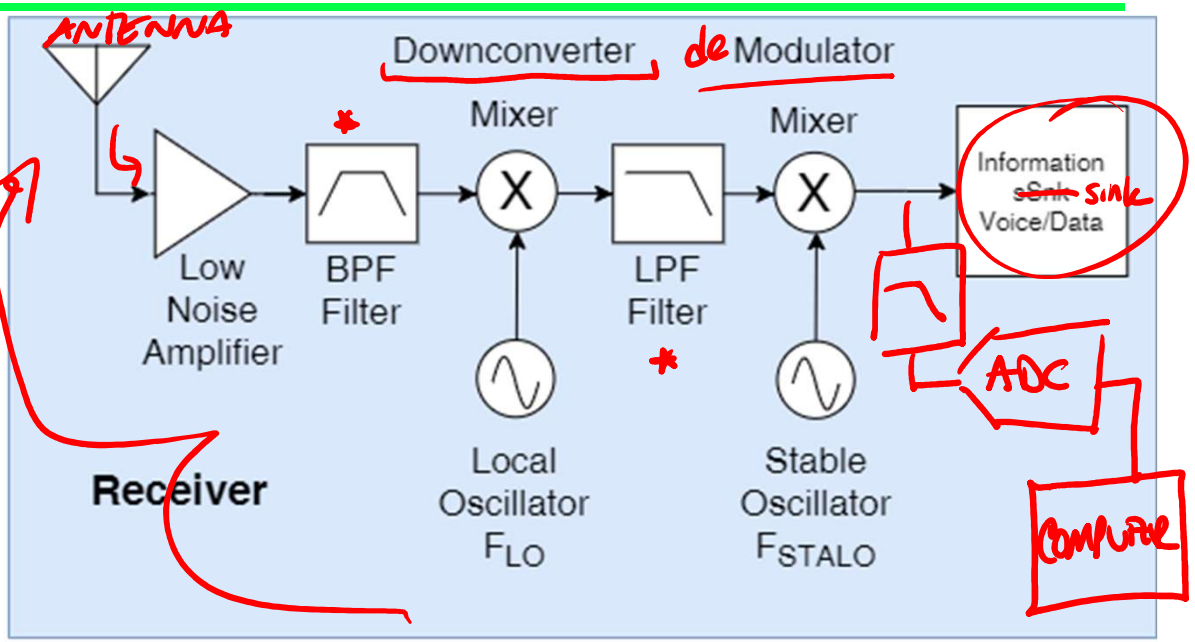
- Speed of propagation in a vacuum: c = 3x10^8 m/s
- c= λ*f ; λ = wavelength (m); f = frequency (Hz=1/s)
- The EM wave intensity changes in time and with location

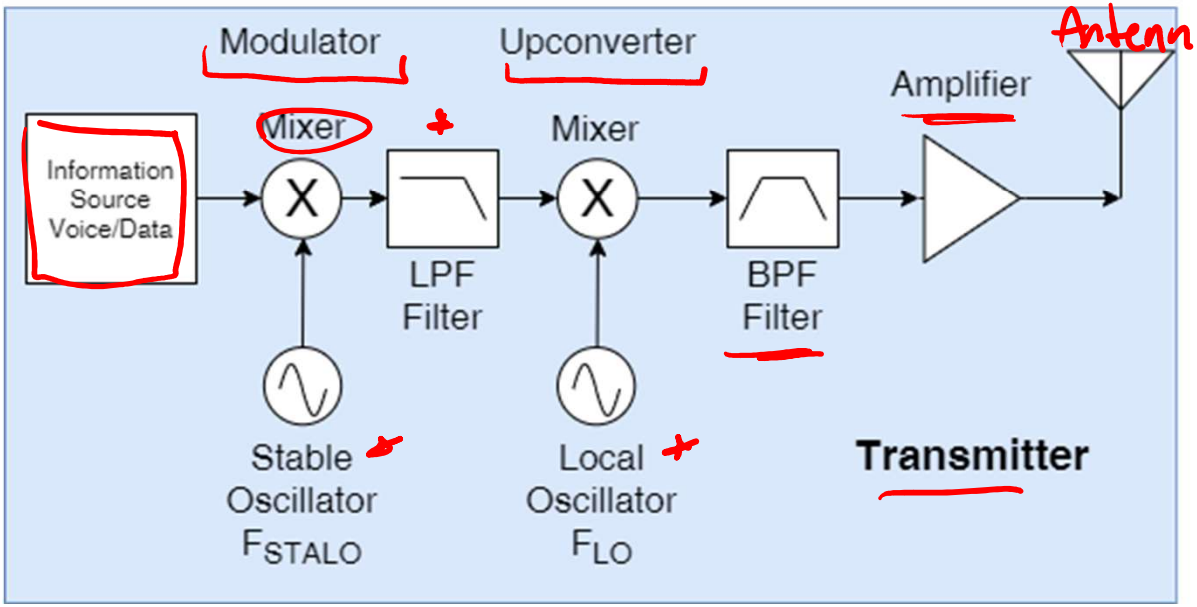
Electromagnetic Spectrum



Wireless Communication System Architecture

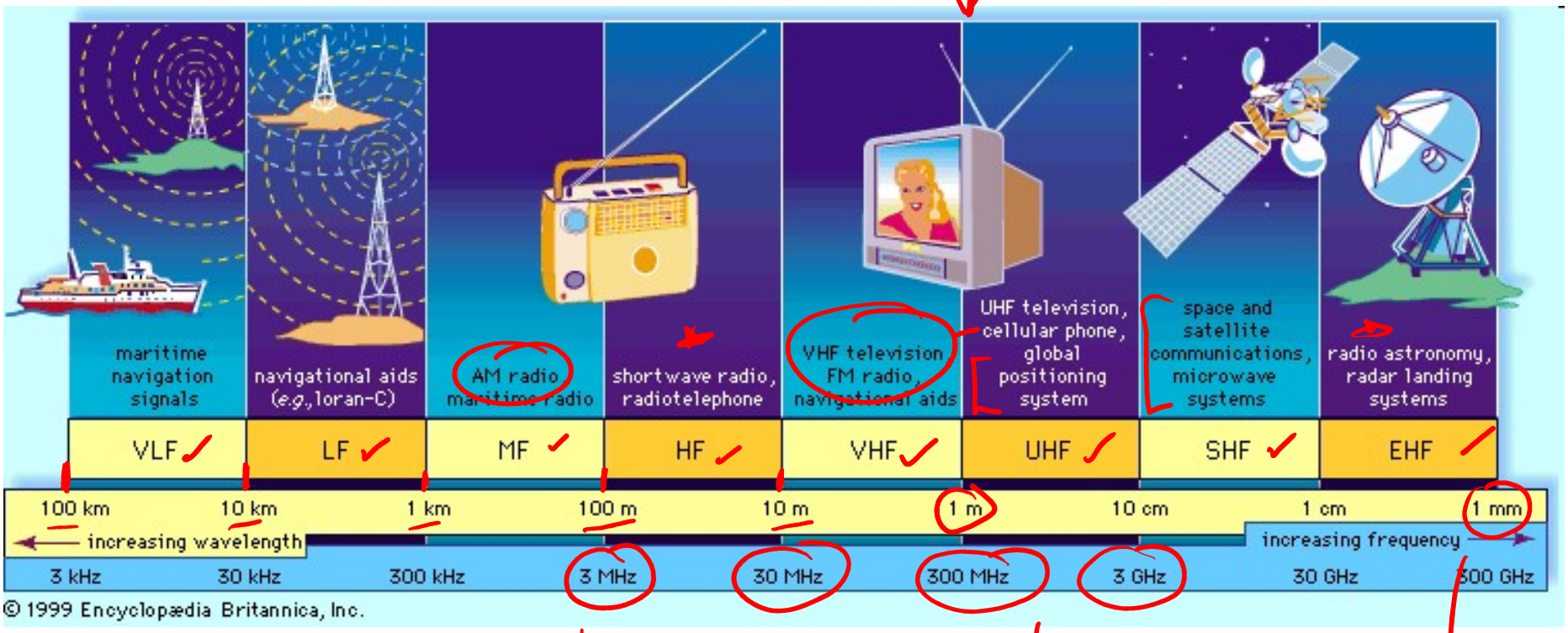
- Lab 10 Topics
  - Mixing
  - Analog Modulation
  - Analog Demodulation
  - Active Filtering
  - Digital Filtering





Lab 11 Topics
- Antennas
- Digital Modulation
- Noise
- Propagation
- Link budgets
- Bit errors

Radio Spectrum



V - very
L - Low
F. Frequency

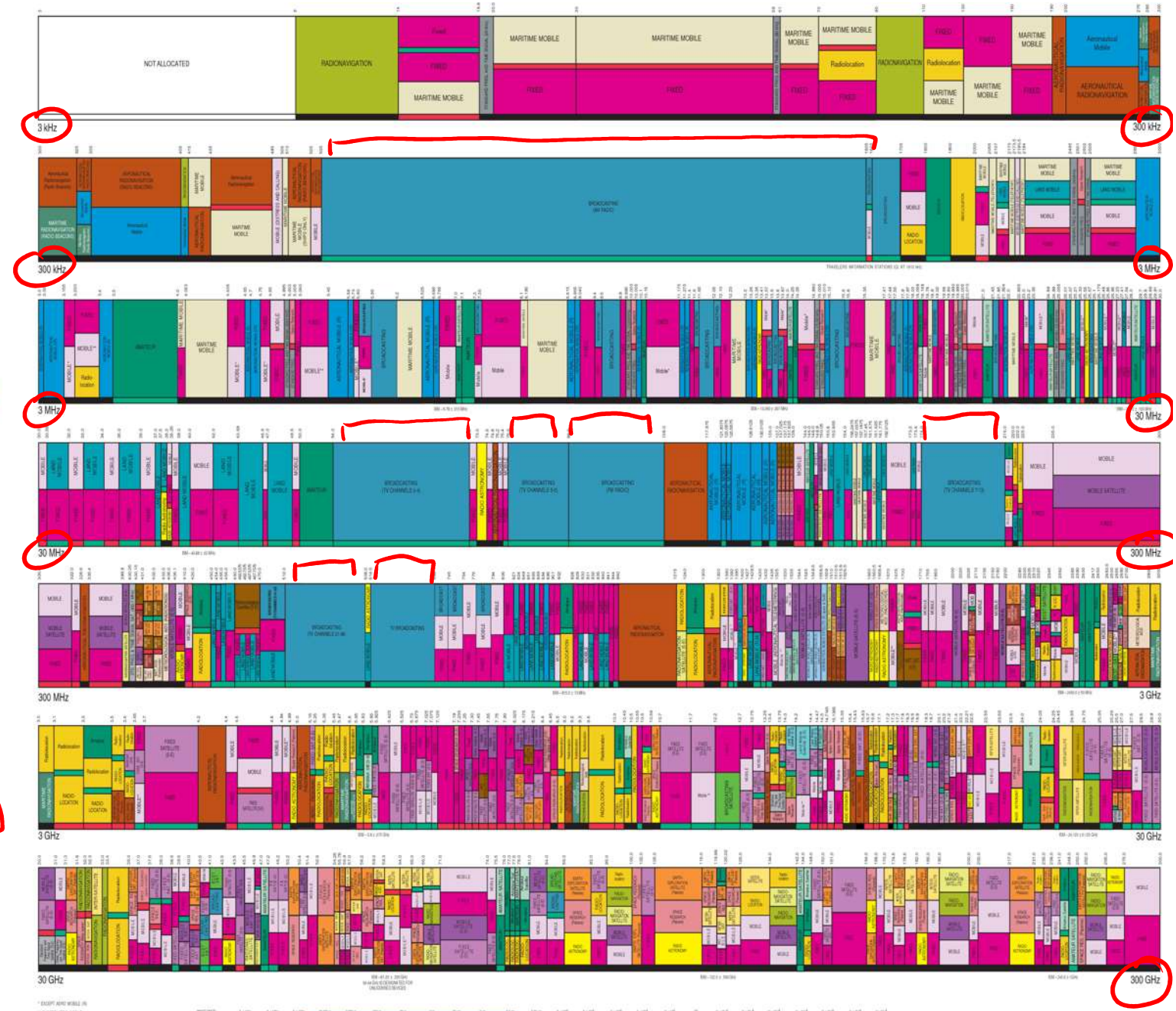
M - medium
U - ULTRA
S - super

E - extremely

mmWave

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM



RADIO SERVICES COLOR LEGEND

- AERONAUTICAL MOBILE
- AERONAUTICAL MOBILE SATELLITE
- AERONAUTICAL RADIONAVIGATION
- AMATEUR
- AMATEUR SATELLITE
- BROADCASTING
- BROADCASTING SATELLITE
- EARTH EXPLORATION SATELLITE
- FIXED
- FIXED SATELLITE
- INTER-SATELLITE
- LAND MOBILE
- LAND MOBILE SATELLITE
- MARITIME MOBILE
- MARITIME RADIONAVIGATION
- METEOROLOGICAL AIDS
- METEOROLOGICAL SATELLITE
- MOBILE
- MOBILE SATELLITE
- RADIO ASTRONOMY
- RADIODETERMINATION SATELLITE
- RADIOLOCATION
- RADIOLOCATION SATELLITE
- RADIONAVIGATION
- RADIONAVIGATION SATELLITE
- SPACE OPERATION
- SPACE RESEARCH
- STANDARD FREQUENCY AND TIME SIGNAL
- STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

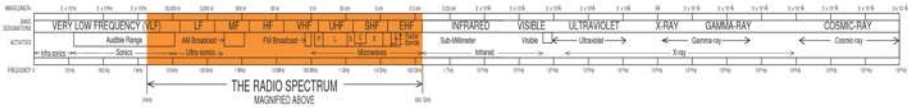
ACTIVITY CODE

- GOVERNMENT EXCLUSIVE
- GOVERNMENT/ NON-GOVERNMENT SHARED
- NON-GOVERNMENT EXCLUSIVE

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic single-point-in-time portrayal of the Table of Frequency Allocations used by the FCC and NTIA. As such, it does not completely reflect all aspects, i.e., footnotes and recent changes made to the Table of Frequency Allocations. Therefore, for complete information, users should consult the Table to determine the current status of U.S. allocations.



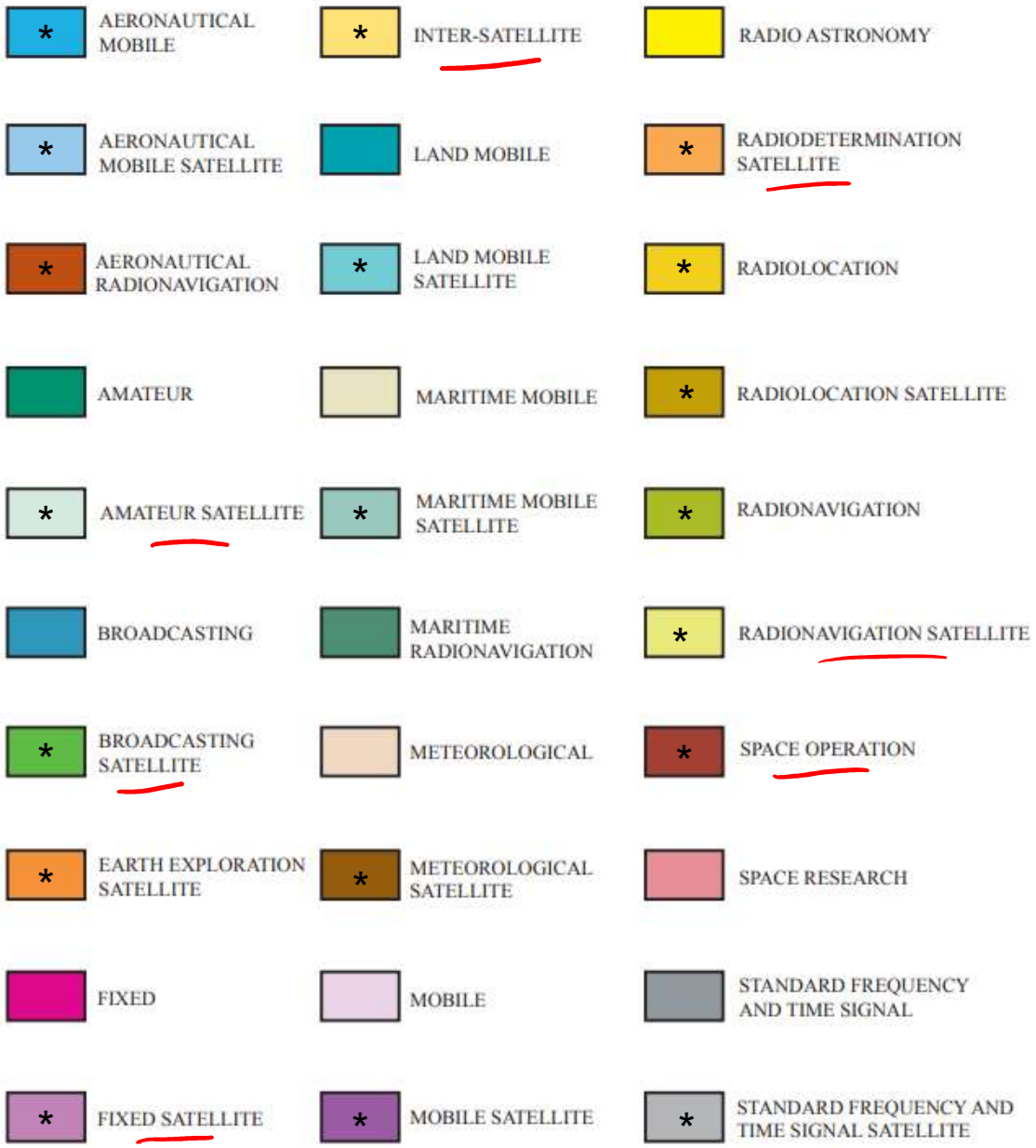
PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECTRUM SEGMENTS IS CHOSEN NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM OCCUPIED.

U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management

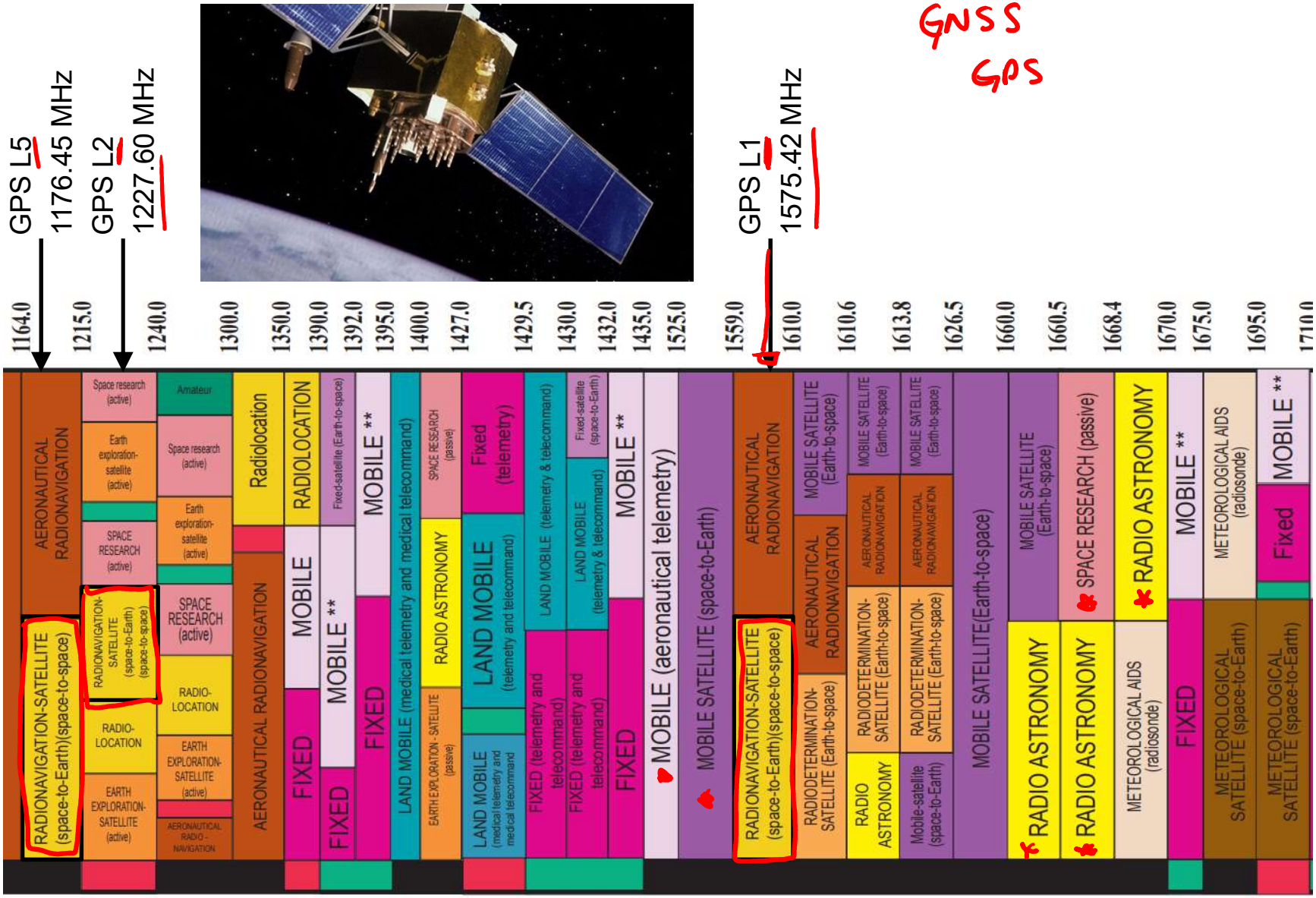
October 2003

*Aerospace Relevant Bands

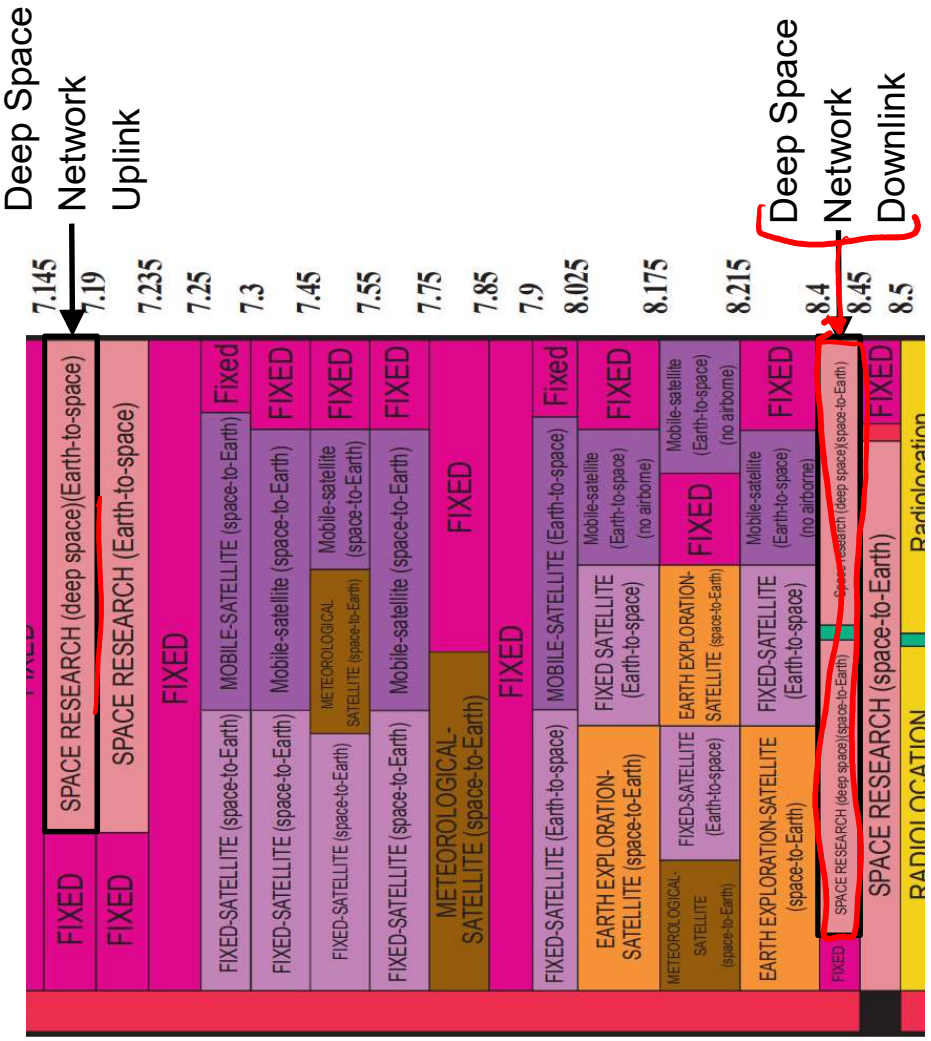
RADIO SERVICES COLOR LEGEND



GPS L-band Signals



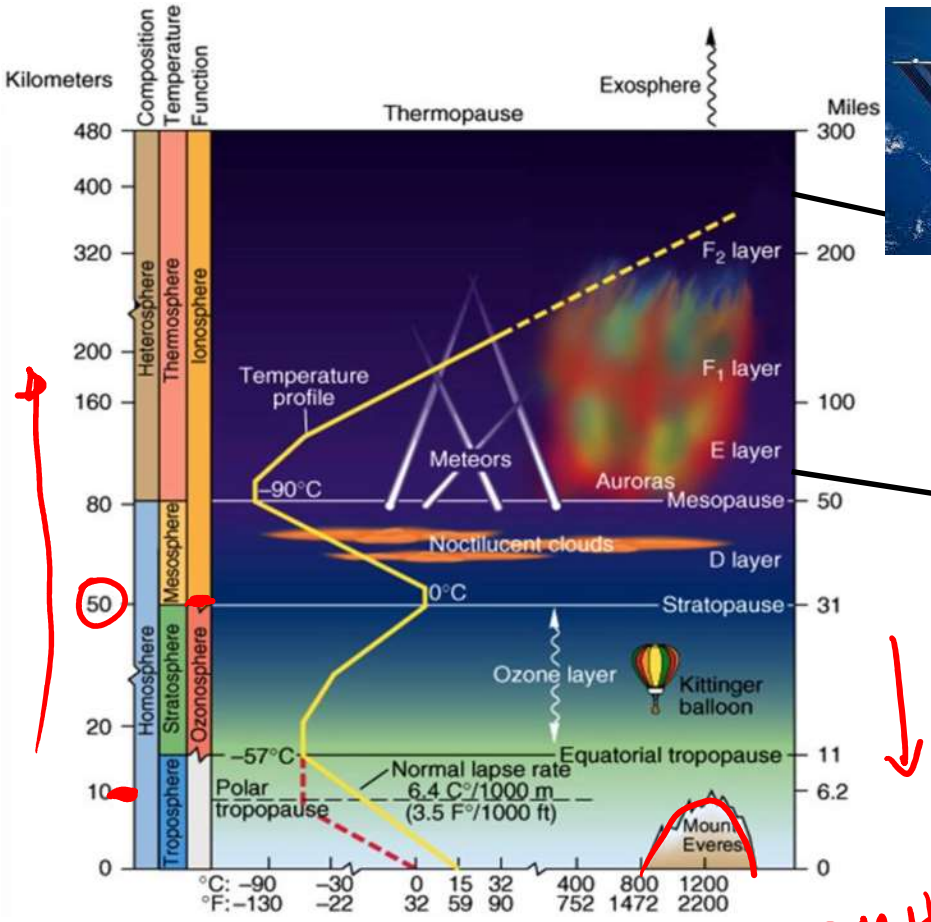
Deep Space X-band Communications

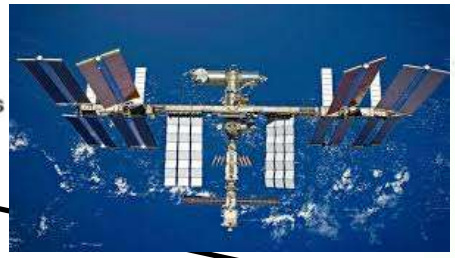


NASA JPL 70m
Deep Space Network Antenna

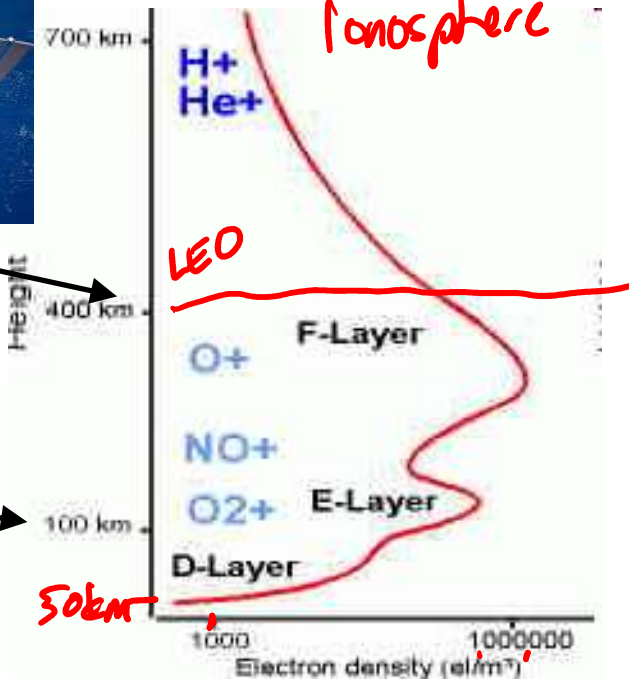
Deep Space Network Now

Radio Wave Propagation

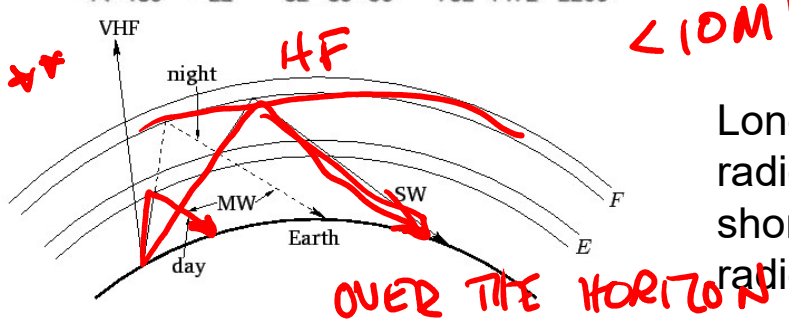




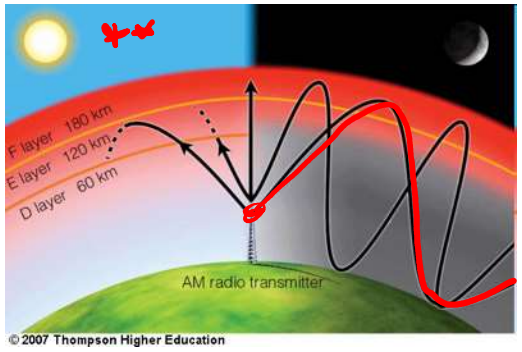
ISS @ ~400km



Plasma density in the Near Earth Space Environment (eg ionosphere)



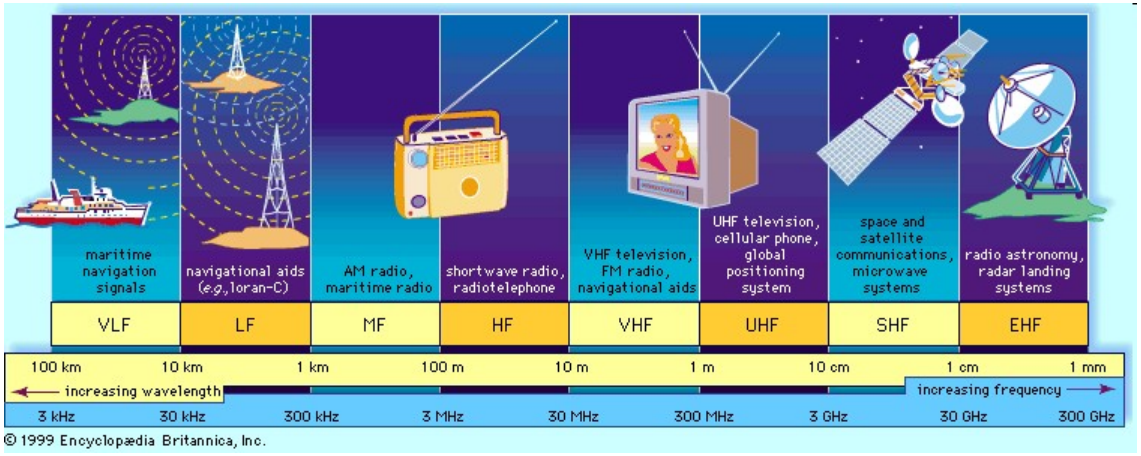
Longer wavelengths (AM radio, e.g.) are reflected, shorter wavelengths (FM radio, e.g.) pass through.



Modes of propagation

Radio frequencies and their primary mode of propagation

Band		Frequency	Wavelength	Propagation via
VLF	Very Low Frequency	3–30 kHz	100–10 km	Guided between the earth and the ionosphere.
LF	Low Frequency	30–300 kHz	10–1 km	Guided between the earth and the D layer of the ionosphere. Surface waves.
MF	Medium Frequency	300–3000 kHz	1000–100 m	Surface waves. E, F layer ionospheric refraction at night, when D layer absorption weakens.
HF	High Frequency (Short Wave)	3–30 MHz	100–10 m	E layer ionospheric refraction. F1, F2 layer ionospheric refraction.
VHF	Very High Frequency	30–300 MHz	10–1 m	Infrequent E ionospheric refraction. Extremely rare F1,F2 layer ionospheric refraction during high sunspot activity up to 80 MHz. Generally direct wave. Sometimes tropospheric ducting.
UHF	Ultra High Frequency	300–3000 MHz	100–10 cm	Direct wave. Sometimes tropospheric ducting.
SHF	Super High Frequency	3–30 GHz	10–1 cm	Direct wave.
EHF	Extremely High Frequency	30–300 GHz	10–1 mm	Direct wave limited by absorption.



3 basic propagation modes:

1. Surface wave
2. Ionospheric modes
3. Direct wave (line of sight)

IEEE Band Nomenclature

- L-band [1-2 GHz] GPS
- S-band [2-4 GHz]
- C-band [4-8 GHz]
- X-band [8-12 GHz] DSN
- Ku-band [12-18 GHz]
- K-band [18-27 GHz]
- Ka-band [27-40 GHz]
- Q-band [33-50 GHz]
- V-band [40-75 GHz]
- W-band [75-110 GHz]

Wireless Communications