APPLICATION OF PHYSICS IN WIRELESS COMMUNICATIONS

Presented By:

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AGENDA

- What is Wireless Communications?
- Physics in Wireless Communications
- Areas of Application

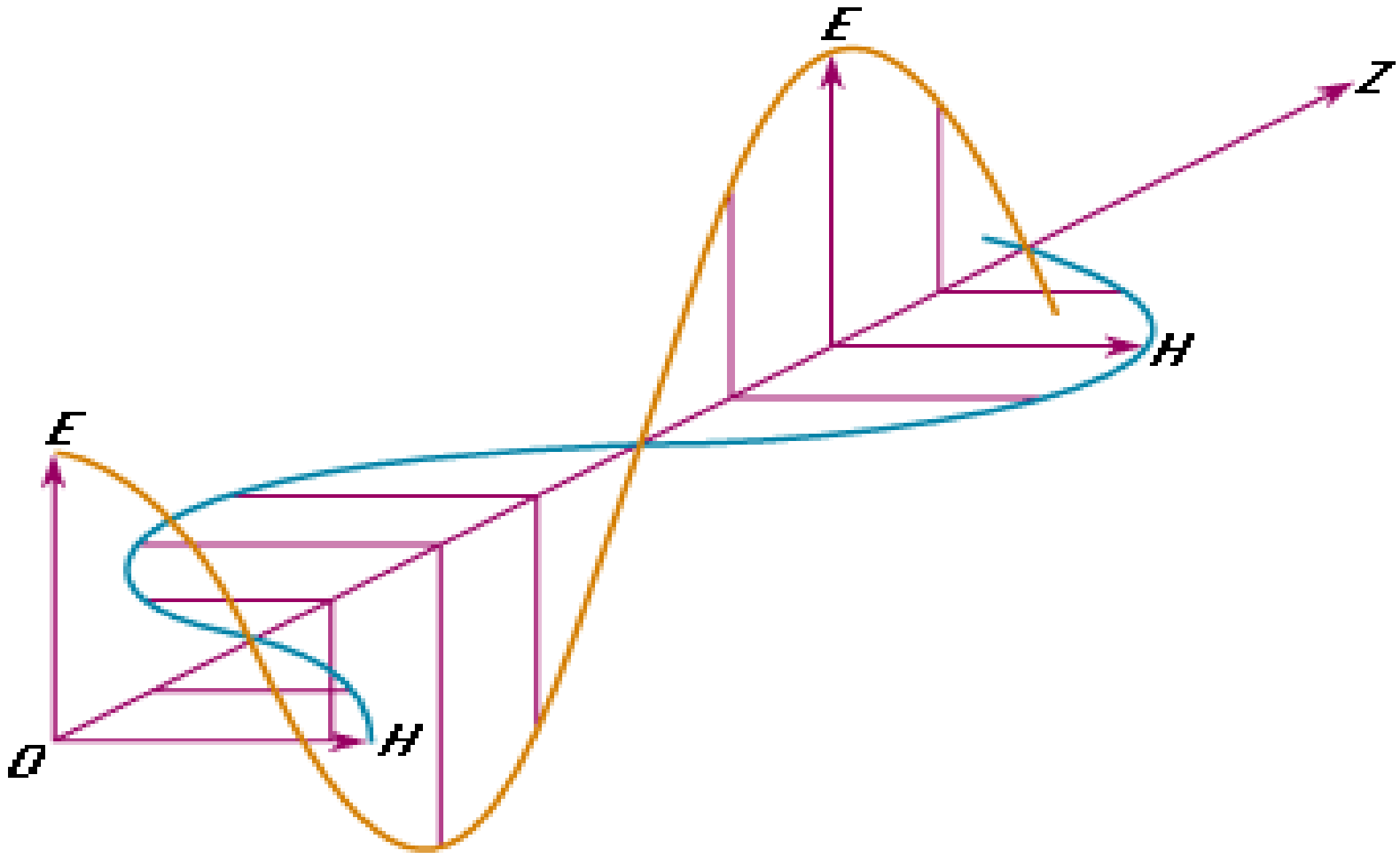
WIRELESS COMMUNICATIONS

What is Wireless Communications?

The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls, etc.) that use some form of energy (e.g. radio waves, acoustic energy, etc.) to transfer information without the use of wires over both short and long distances. Wireless operations permit services, such as long-range communications, that are otherwise impossible (or impractical) to implement with the use of wires. Below are some definitions:

- Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor.
- Wireless communication is communication that occurs without the use of cables or cords attaching the communications device to any base, wall, or other relatively static object
- Communication without wires – Basically the transfer of information / data / signals, without the help of a physical medium.

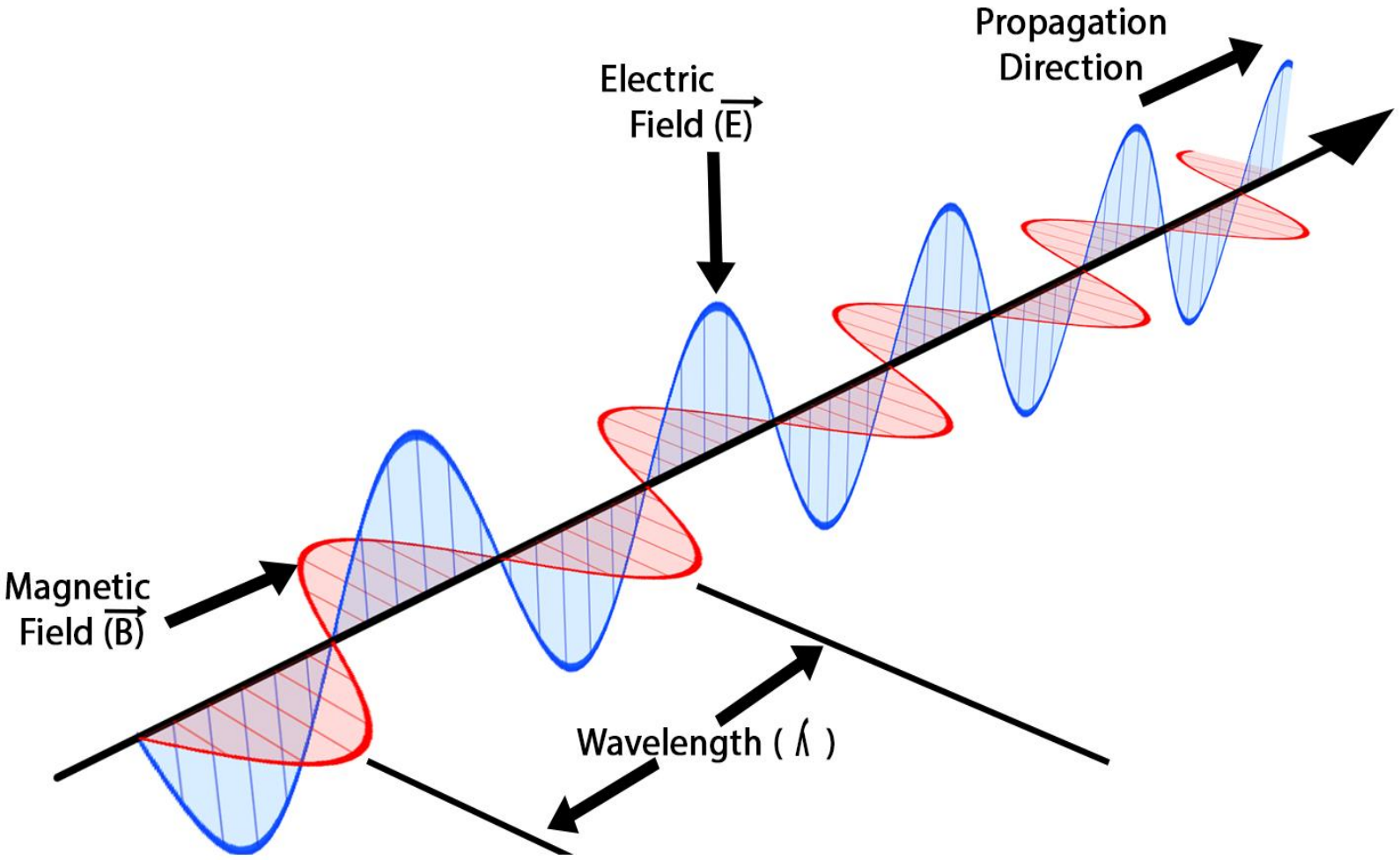
PHYSICS IN WIRELESS COMMUNICATIONS



Wireless Communications Fundamentals

- Wireless communications rely on radio waves which are electromagnetic waves.
- An electromagnetic wave consists of an electric field component and a magnetic field component, the electric field & the magnetic field components are perpendicular to each other, and they are in phase.
- When the electric field component of the wave is perpendicular to the earth surface then the wave is vertically polarized. When the electric field is parallel to the earth surface then it is horizontally polarized
- Radio waves are generated by radio transmitters and received by radio receivers. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere; long waves can diffract around obstacles like mountains and follow the contour of the earth (ground waves), shorter waves can reflect off the ionosphere and return to earth beyond the horizon (skywaves), while much shorter wavelengths bend or diffract very little and travel on a line of sight, so their propagation distances are limited to the visual horizon.

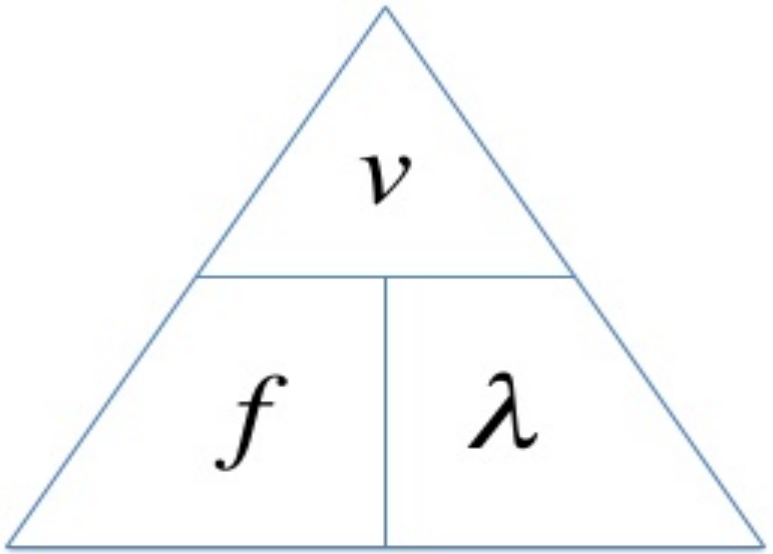
Wireless Communications Fundamentals



Wireless Communications Fundamentals

The wave equation (f)

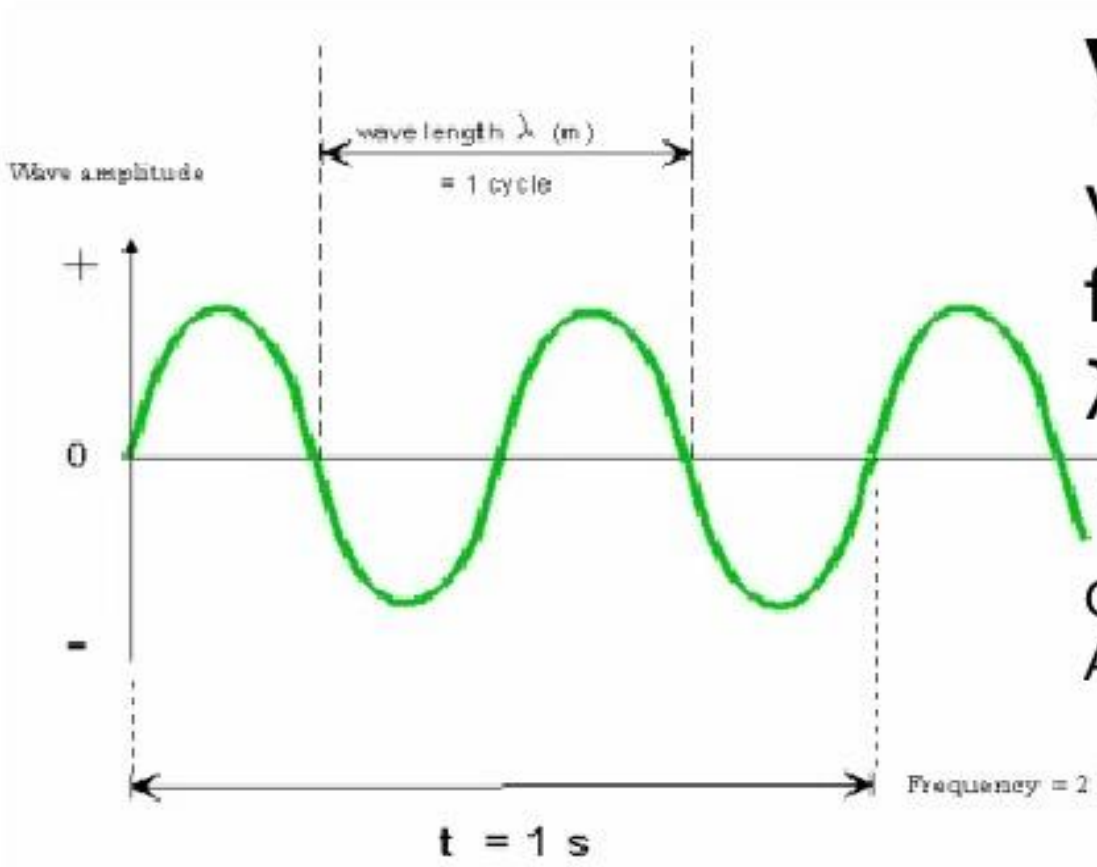
- The wave equation relates three properties of waves:
  - Frequency (*f*)
  - Velocity (*v*)
  - Wavelength (λ)



$$v = f\lambda$$

Wireless Communications Fundamentals

EM Radiation as a Wave



$$v = f\lambda$$

v = velocity

f = frequency

λ = wavelength

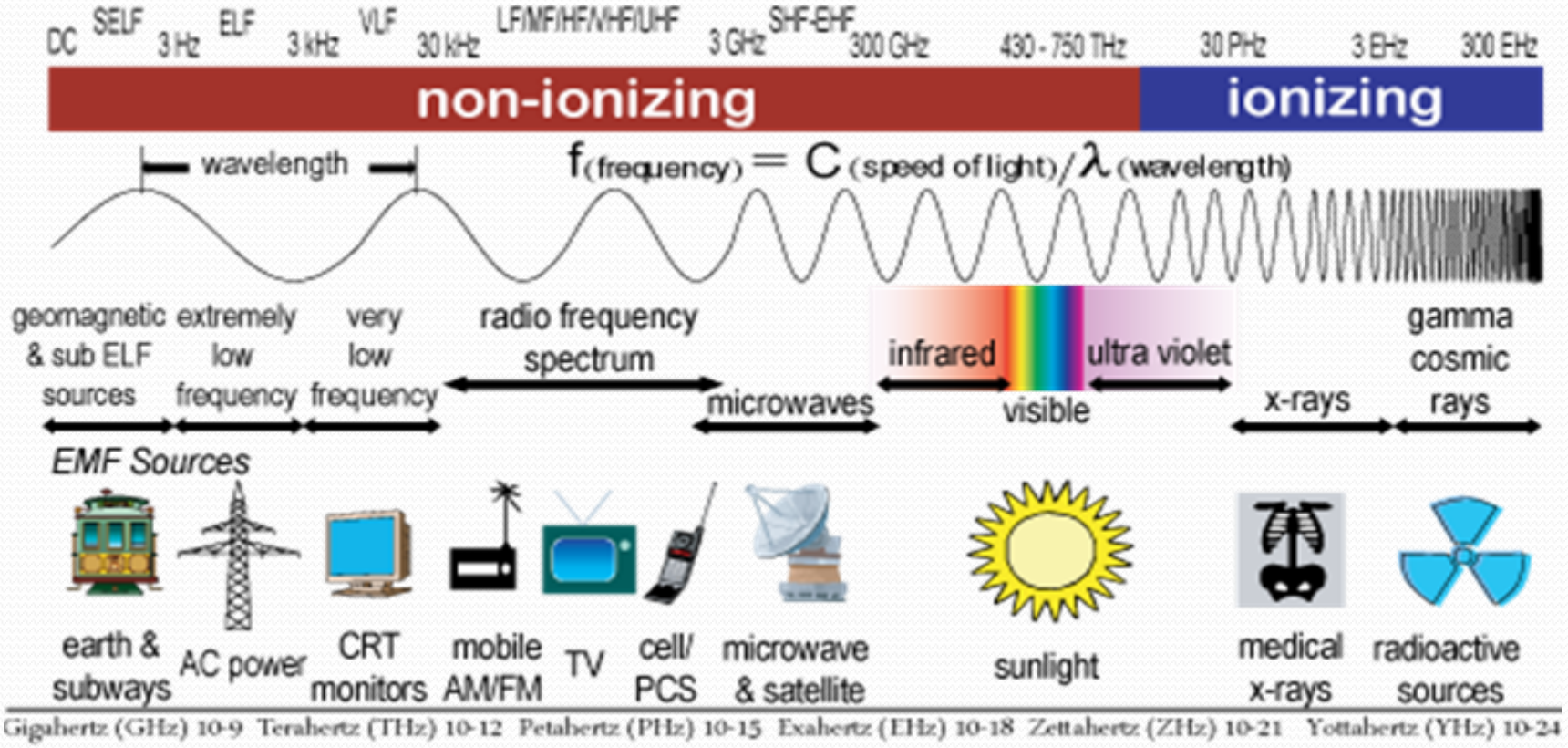
Q: What is v for light?

A: c, the speed of light

$= 3 \times 10^8$ m/s

= 186,400 miles/s

The Electro-Magnetic Spectrum

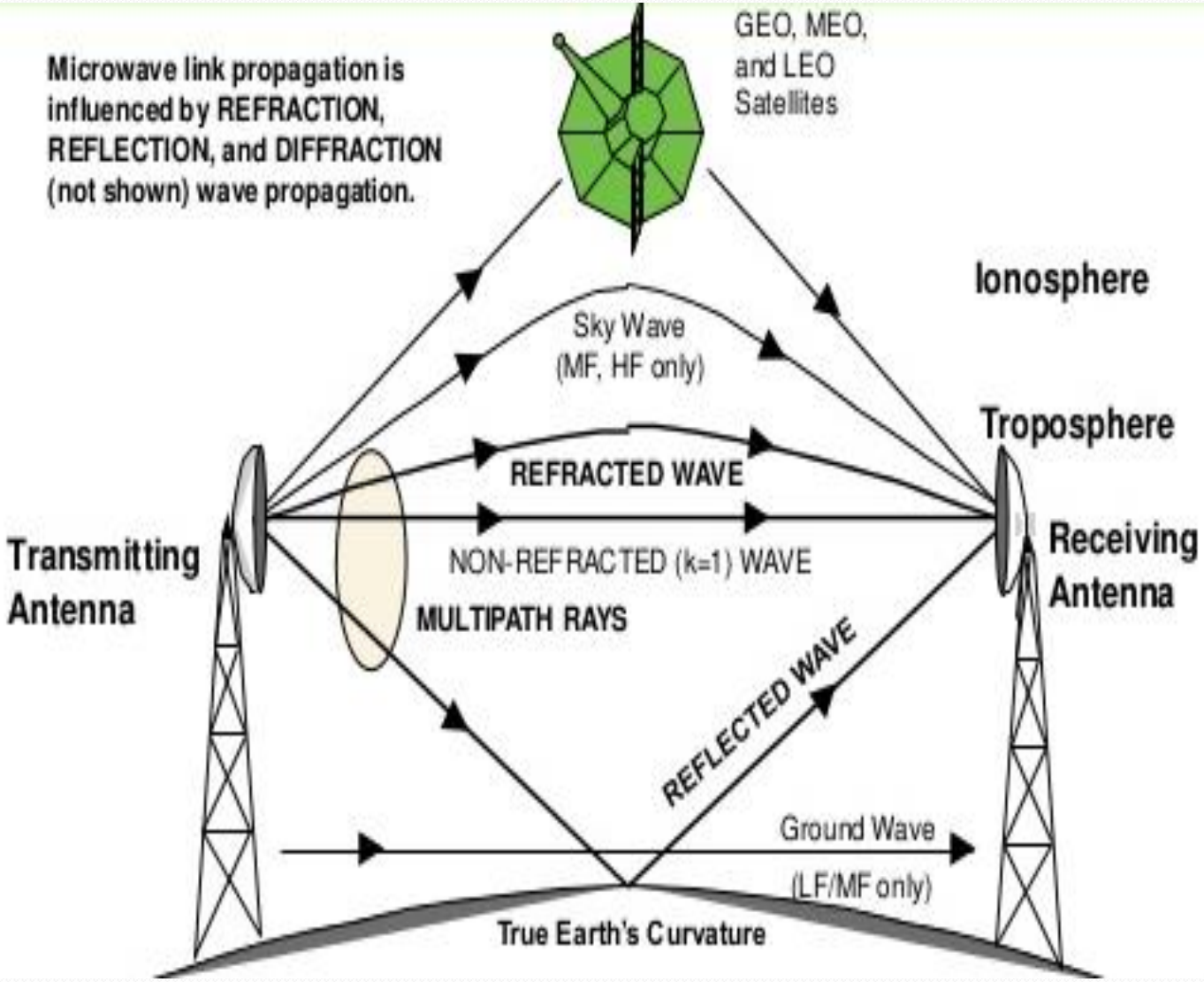


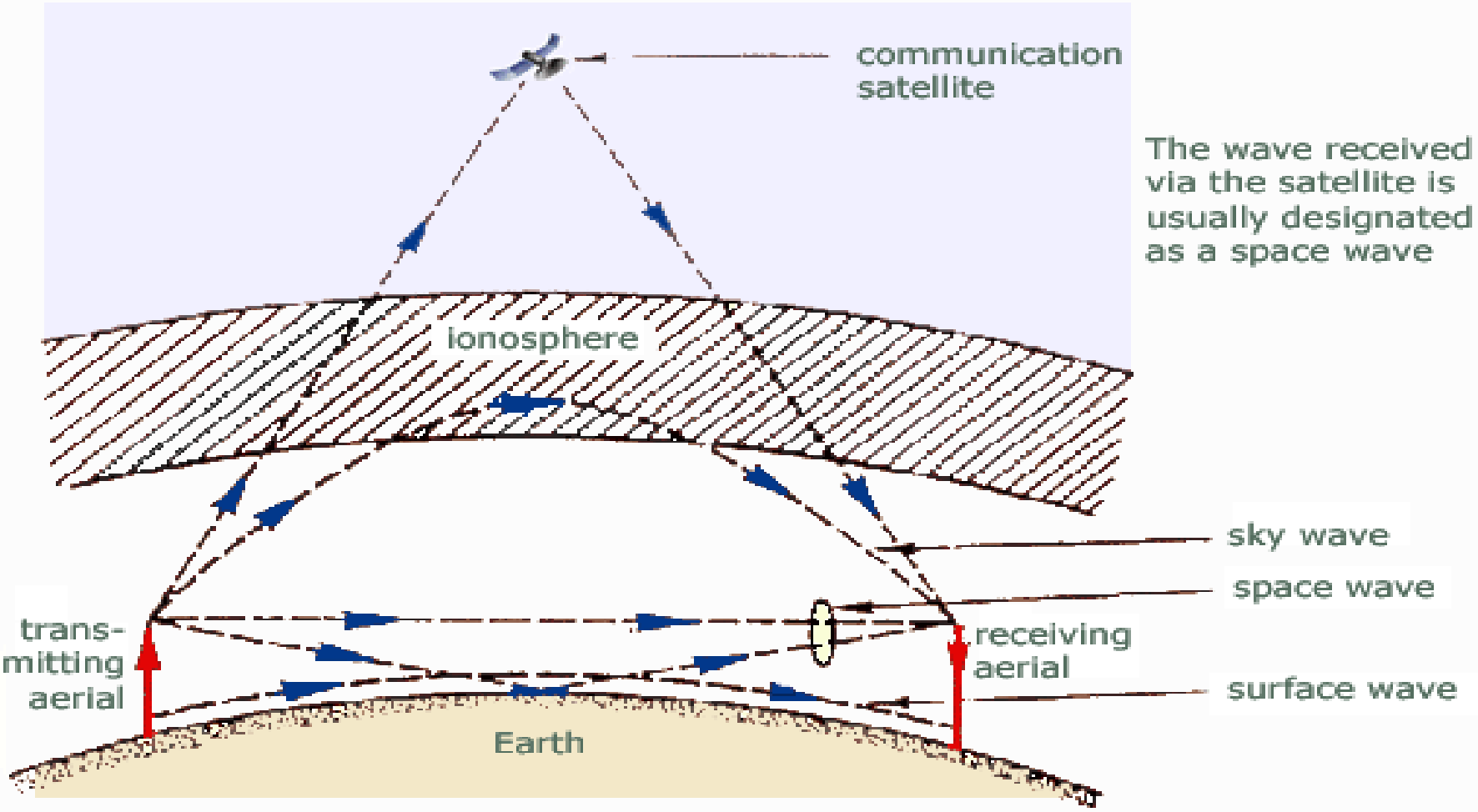
Characteristics of Waves

All waves behave in certain characteristic ways. They can undergo:

- √ Reflection: the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.
- √ Refraction: the change in direction of propagation of a wave due to a change in its transmission medium.
- √ Diffraction: refers to a change in direction of waves as they pass through an opening or around a barrier in their path. low frequency signals diffract more markedly than higher frequency ones. Interference: a phenomenon in which two waves superpose to form a resultant wave of greater or lower amplitude

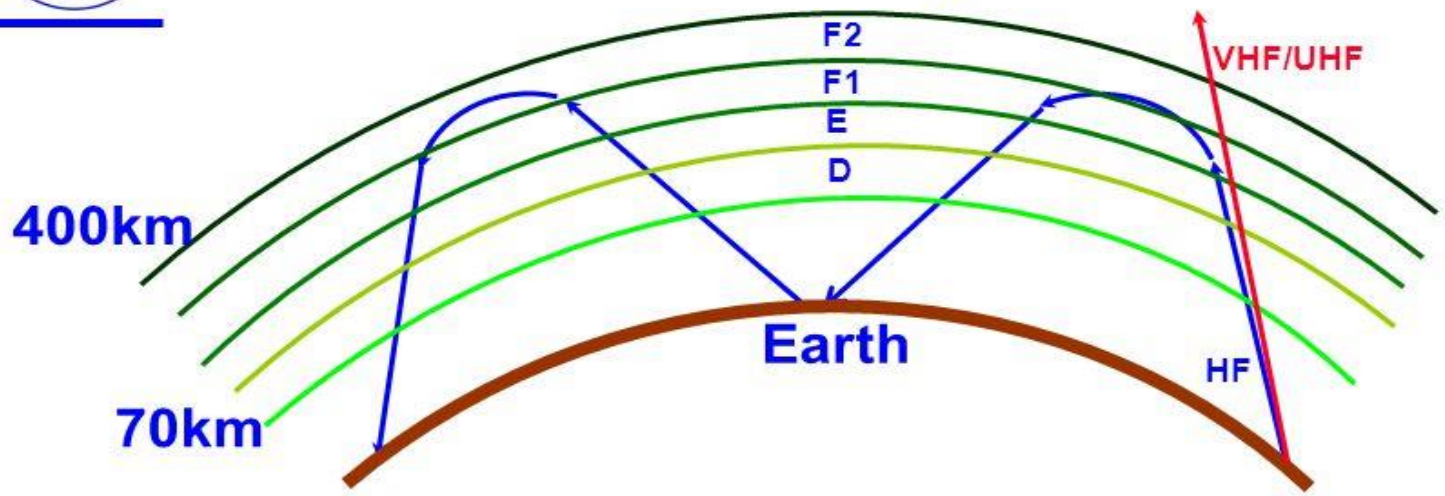
These four basic characteristics define the behaviour of a wave – anything that reflects, refracts, diffracts and interferes is labelled a wave. The apply to both mechanical and electromagnetic waves.


Microwave link propagation is influenced by REFRACTION, REFLECTION, and DIFFRACTION (not shown) wave propagation.
GEO, MEO, and LEO Satellites
Ionosphere
Sky Wave (MF, HF only)
Troposphere
REFRACTED WAVE
Transmitting Antenna
NON-REFRACTED (k=1) WAVE
Receiving Antenna
MULTIPATH RAYS
REFLECTED WAVE
Ground Wave
(LF/MF only)
True Earth's Curvature



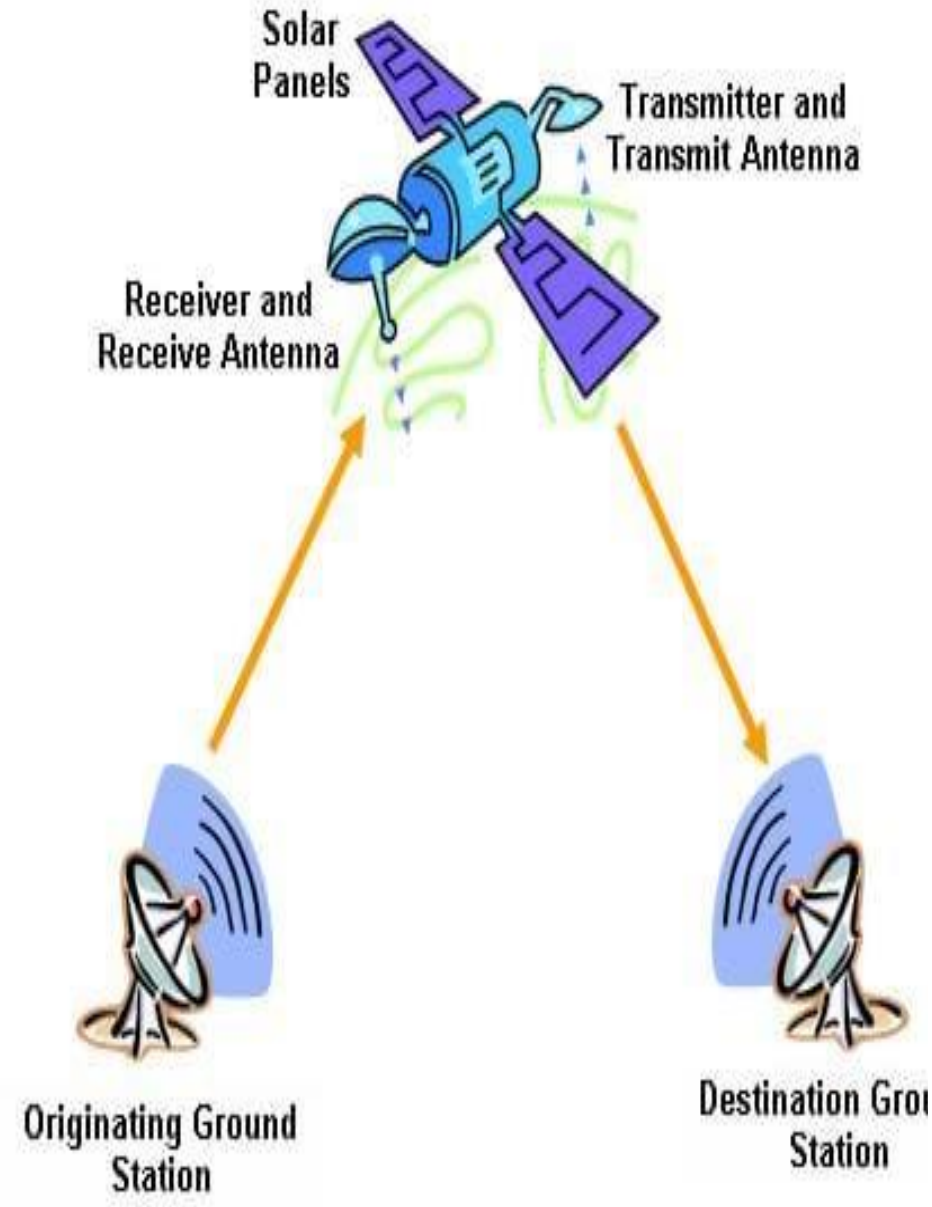
The transmission paths for radio waves: surface waves, space waves and sky waves

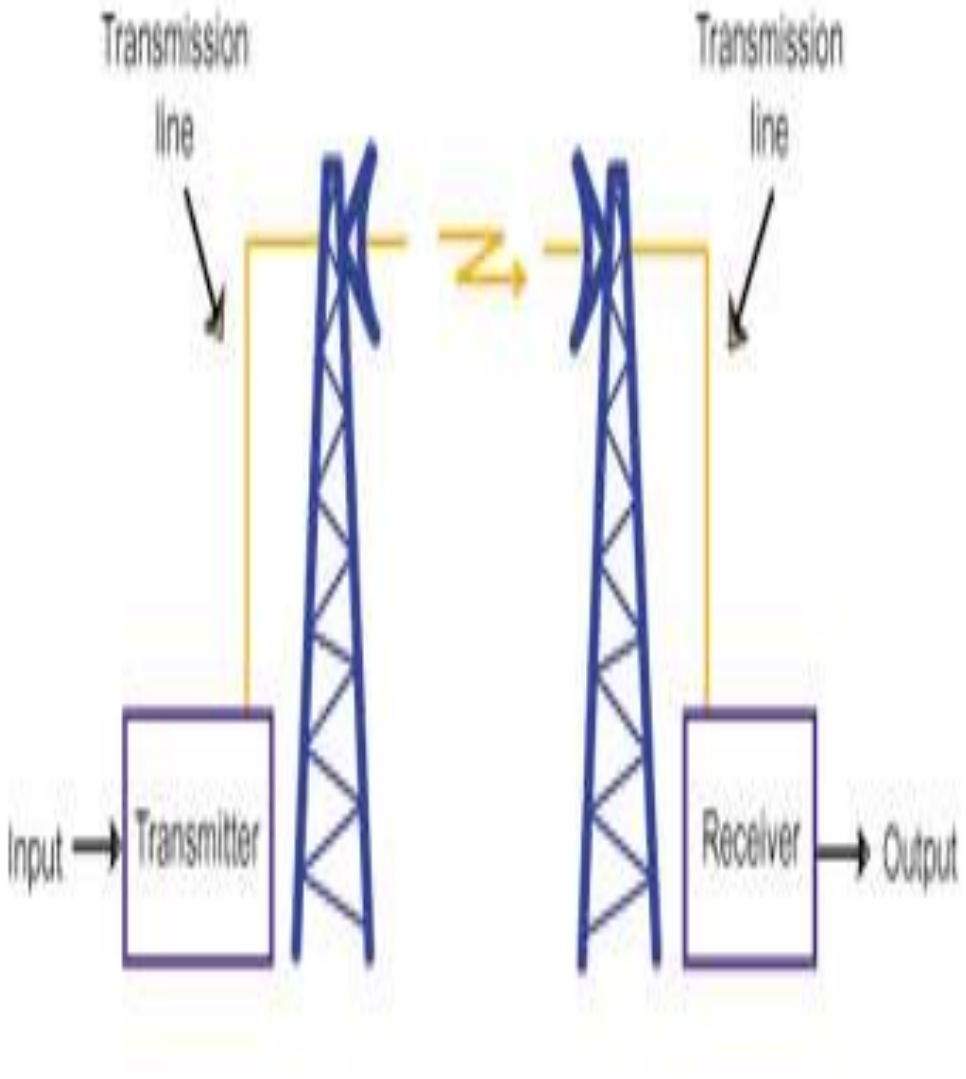
HF and the Ionosphere



- Ionosphere is layers of Ionised Air: 70 - 400km above earth
- HF is bent by ionosphere (refraction) - VHF+ passes through
- Four Layers: D, E, F1, F2 – created by and vary with Solar input
- Layers change with day/night, season, flares, sunspots etc

AREAS OF APPLICATION





Areas of Application

- ✓ Satellite Communications –for data networking, remote sensing (maps, weather satellites) , navigation(GPS) distance learning and digital television etc. at C-band , Ku Band and Ka Band transmission -6/4 GHz, 14/11 GHz and 30/20 GHz (Uplink/Downlink)
- ✓ Terrestrial Microwave Communications – short haul and long haul, point to point, point-to- multipoint transmission systems for data and digital television.
- ✓ Mobile Cellular Wireless Communications – 2G, 2.5G, 3G, 4G (LTE) and new 5G systems
- ✓ Optical Communications – Infrared, Free Space optical communication links etc

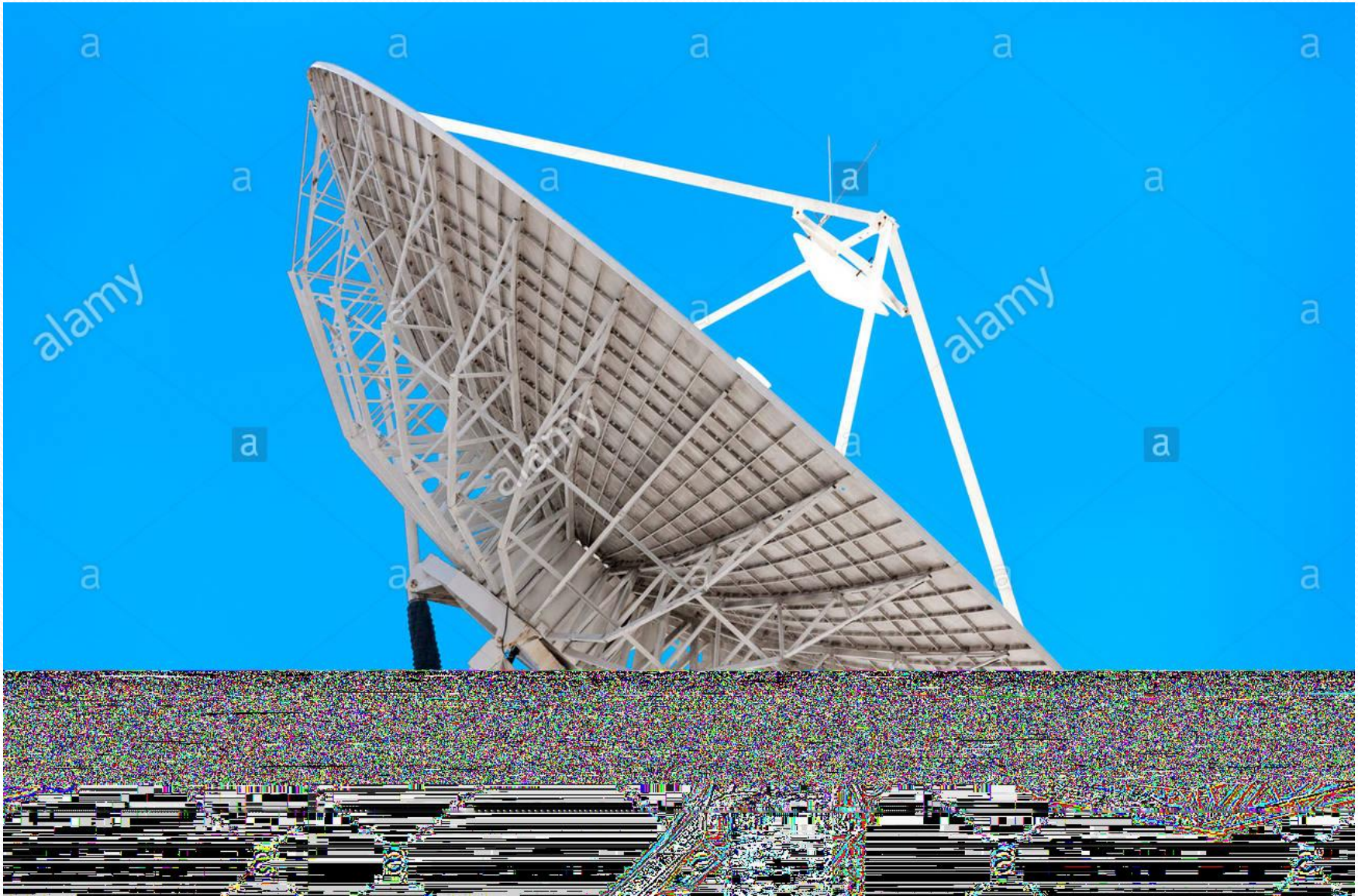
The physics of electromagnetic wave propagation is applicable in the following areas:

- ✓ Antenna Design – e.g waveguides in satellite and terestrial microwave communcations

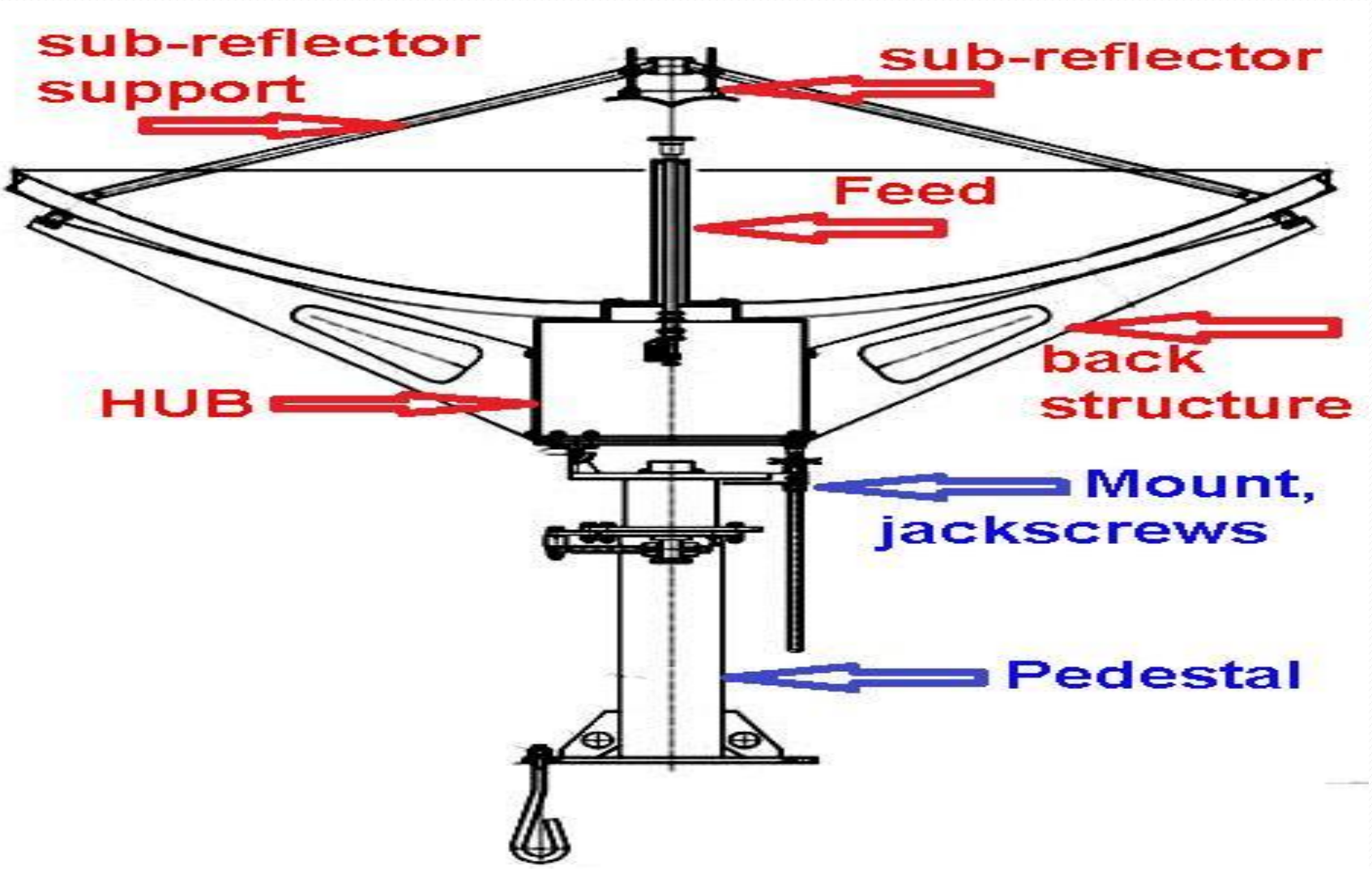
Areas of Application (Contd.)

- ✓ Polarisation of signals – Linear Polarisation (microwave and satellite communications and Circular Polarisation (satellite communications
- ✓ Rain attenuation predictions (satellite and terrestrial microwave communications). Rain attenuation is very critical for frequencies above 10 GHz
- ✓ Radio transmission planning – interference cancellation techniques, frequency re-use in cellular wireless communications.

Satellite Antenna Systems



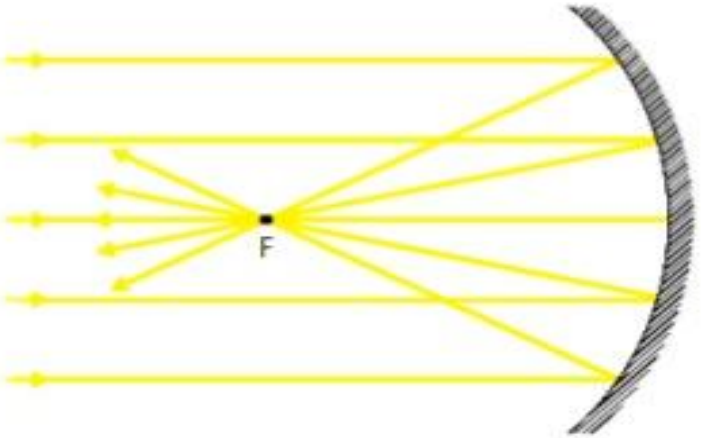
Satellite Antenna Systems



Satellite Antenna Systems

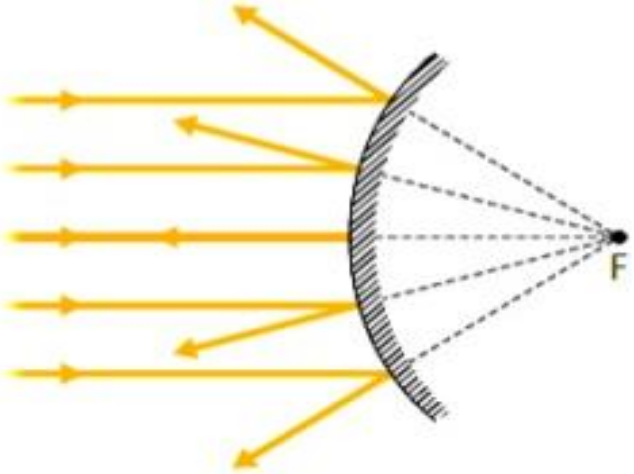
Curved Mirrors

Concave



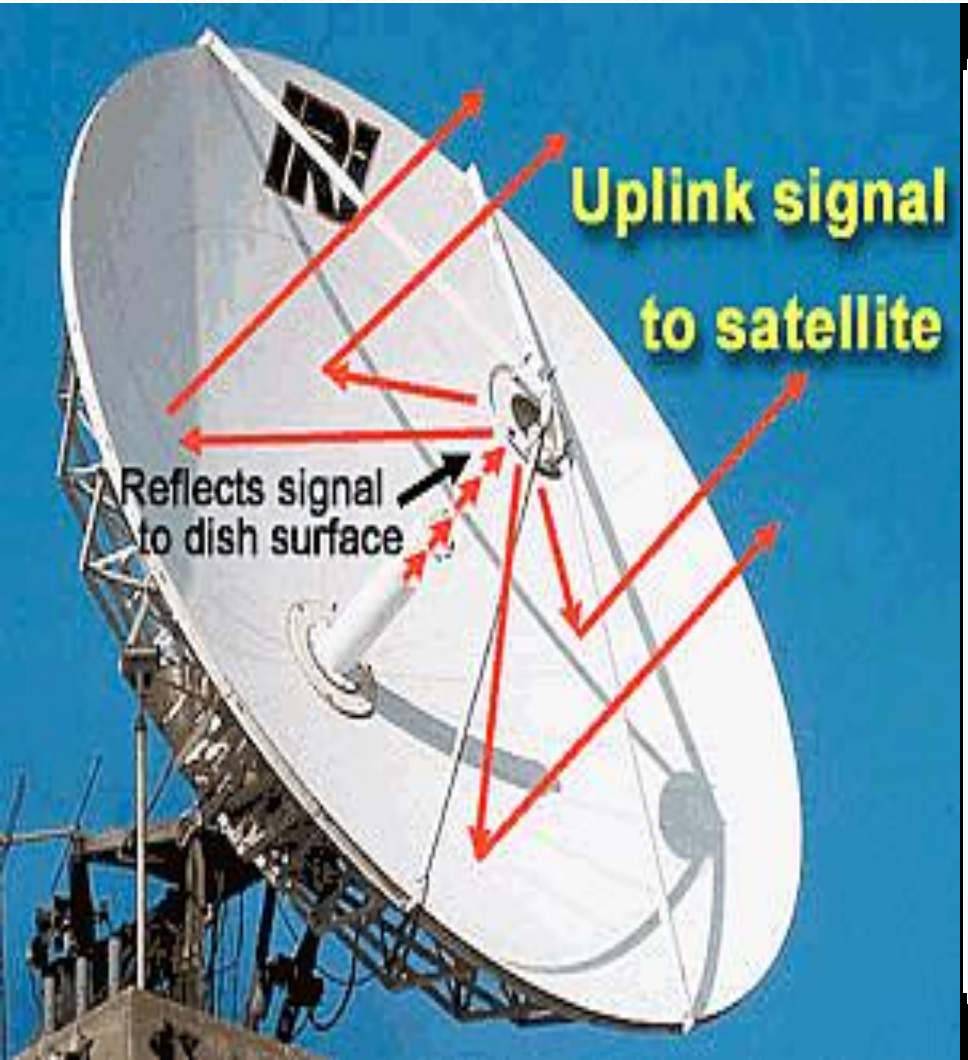
"converging" mirror

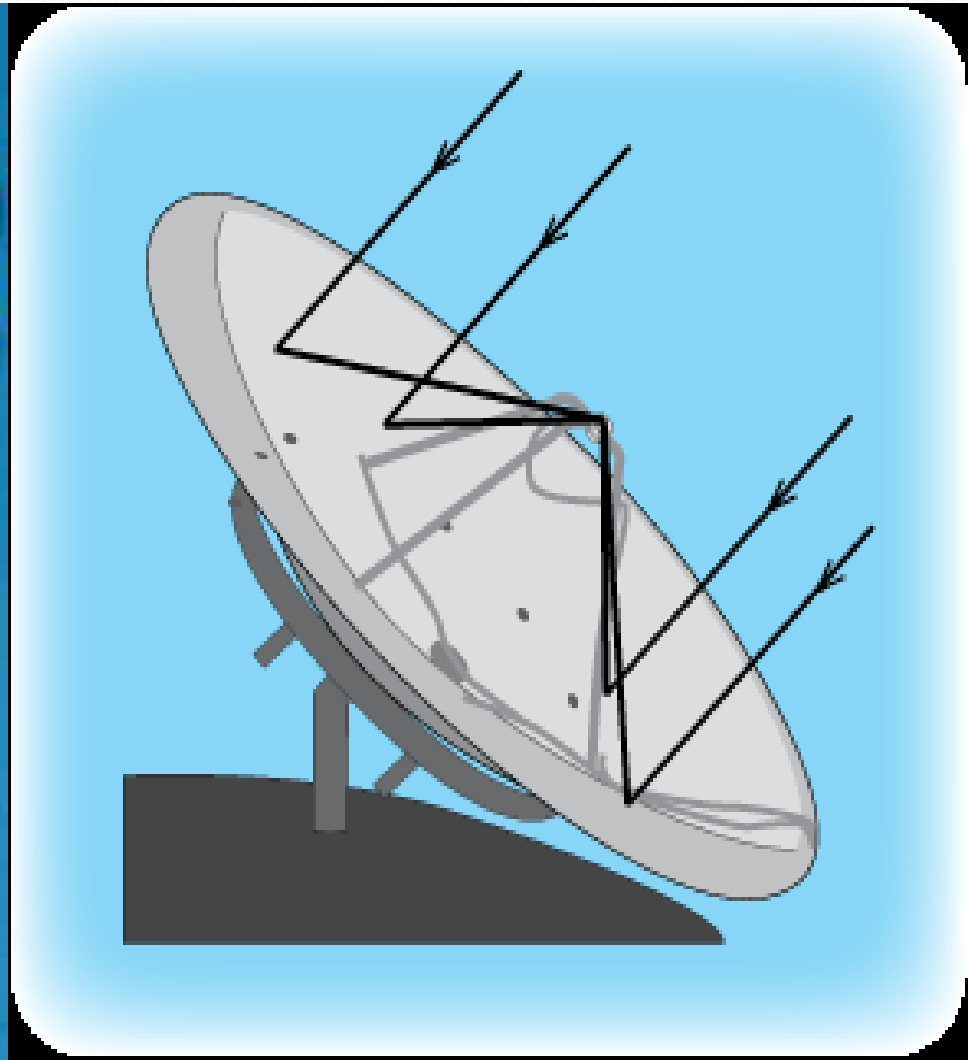
Convex



"diverging" mirror

Satellite Antenna Systems





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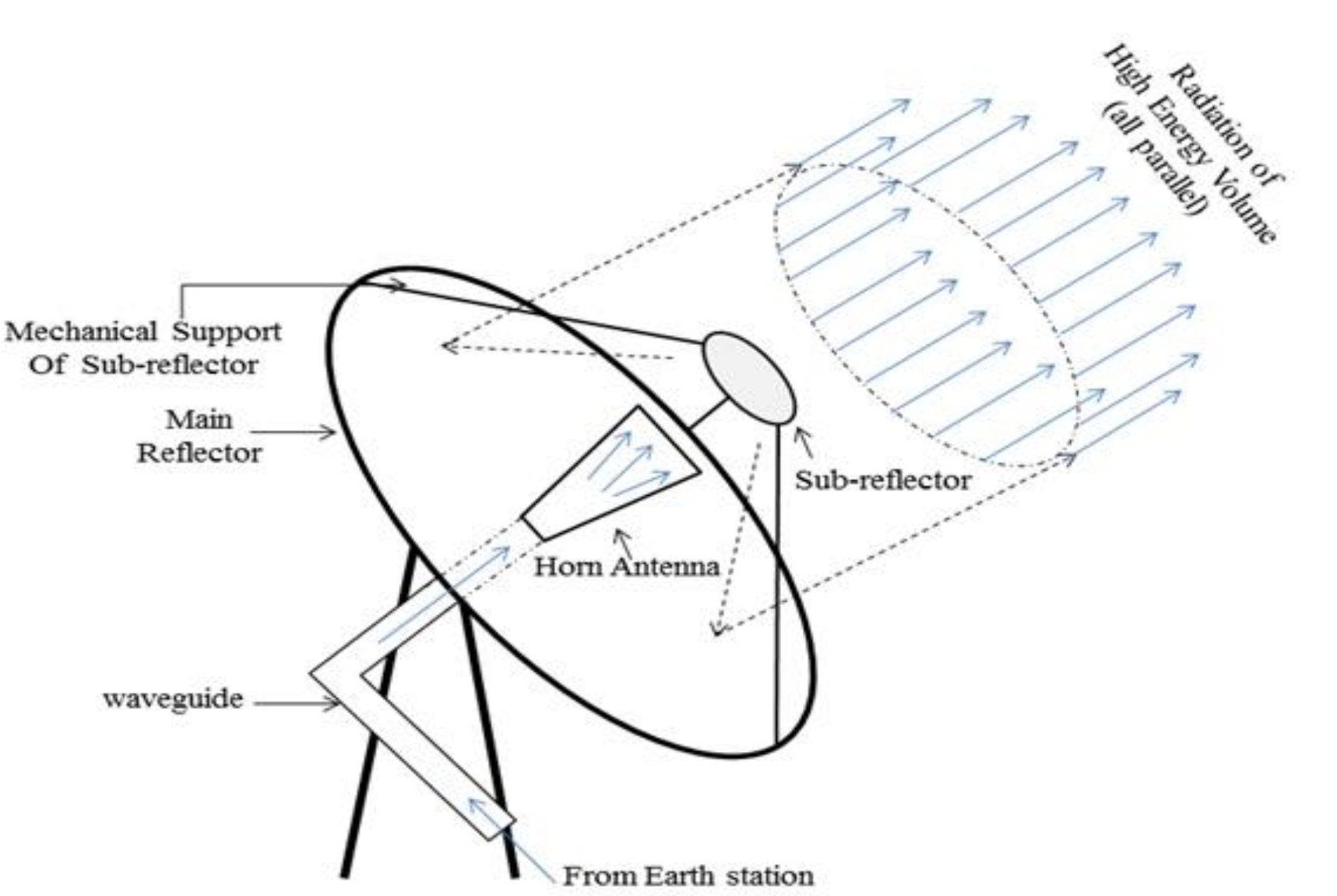
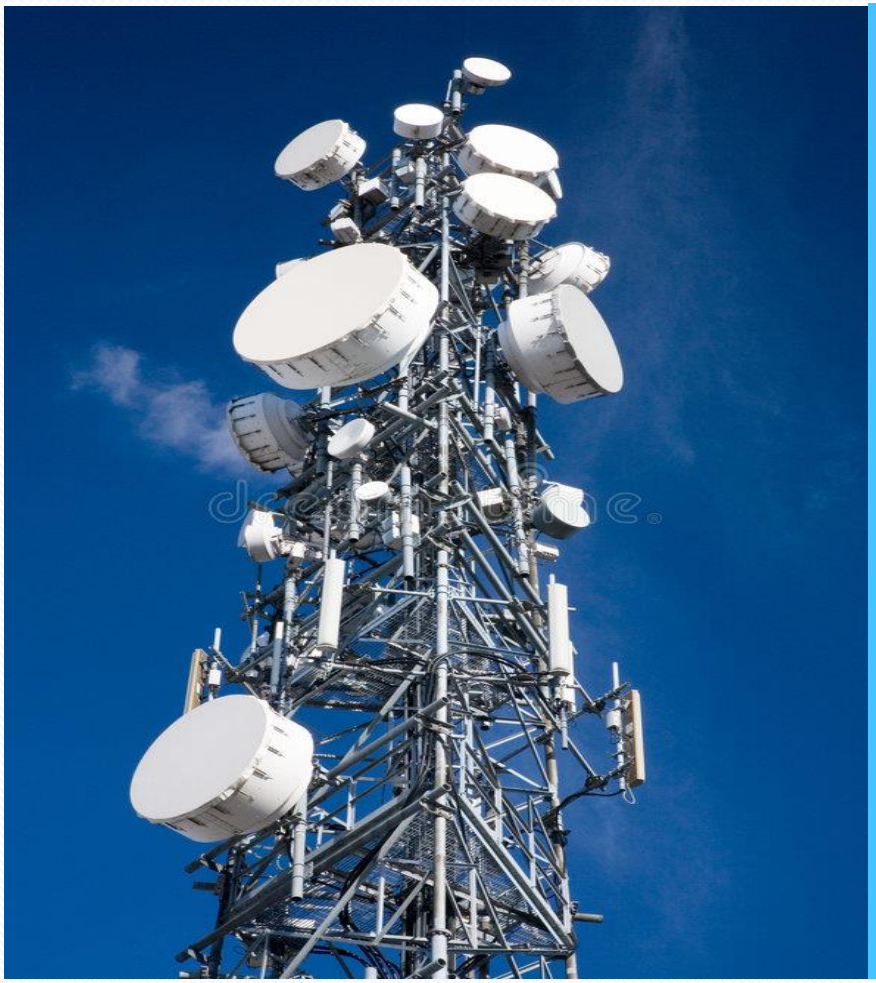


Terrestrial Microwave Antenna Systems



Terrestrial Microwave Antenna Systems

[Transmission and reception using Parabolic Reflector Antenna]


THANK
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