1. Details of Module and its structure

Module Detail	
Subject Name	Physics
Course Name	Physics 04 (Physics Part-2, Class XII)
Module Name/Title	Unit-10, Module-02: Propagation of electromagnetic wave Chapter-15: Communication systems
Module Id	leph_201502_eContent
Pre-requisites	Brief history of electronic communication Frequency, bandwidth, signal, modulation, attenuation
Objectives	After going through this module student will be able to: • Understand the mode of propagation of electromagnetic waves • Ground wave propagation • Sky wave propagation • Space wave propagation • Satellite communication
Keywords	Frequency, attenuation, antenna, total internal reflection, bandwidth, transmitter and receiver, propagation of electromagnetic waves, ground waves, sky waves, space waves, satellite communication

2. Development Team

Role	Name	Affiliation
National MOOC Coordinator (NMC)	Prof. Amarender P. Behera	Central Institute of Educational Technology, NCERT, New Delhi
Programme Coordinator	Dr. Mohd Mamur Ali	Central Institute of Educational Technology, NCERT, New Delhi
Course Coordinator / (PI)	Anuradha Mathur	Central Institute of Educational Technology, NCERT, New Delhi
Subject Matter Expert (SME)	Dinesh Tyagi	Army Public School Hindon
Review Team	Prof. V. B. Bhatia (Retd.) Associate Prof. N.K. Sehgal (Retd.) Prof. B.K. Sharma (Retd.)	Delhi University Delhi University DESM, NCERT, New Delhi

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Unit 10: Communication Systems

Chapter 15: Communication Systems

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2. MODULE WISE DISTRIBUTION OF UNIT SYLLABUS 6 MODULES

Module 1	• **History of communication** • **Special vocabulary** • **Signals and bandwidth**
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MODULE 2

3. WORDS YOU MUST KNOW

Communication: The process of putting across ideas through words and pictures

Audio communication: Communication by means of speech/sound or messages that can be received by our ears

Video communication- Communication by means of pictures, still or moving or messages that can be received by our eyes

Audio video communication- Communication by means of speech/sound or messages that can be received by our ears

Device- an apparatus designed for special functions

Mode of transfer of information- method of transfer of information

Antenna- a device designed to send out and receive electromagnetic waves.

Electromagnetic waves-

The range of electromagnetic signals encompassing all frequencies is referred to as the electromagnetic spectrum

Frequency: It is defined as number of cycles per second or number of waves per second.

Wavelength is the distance occupied by one cycle of a wave and is usually expressed in meters. Wavelength is also the distance traveled by an electromagnetic wave during the time of one cycle. The wavelength of a signal is represented by the Greek letter lambda (λ).

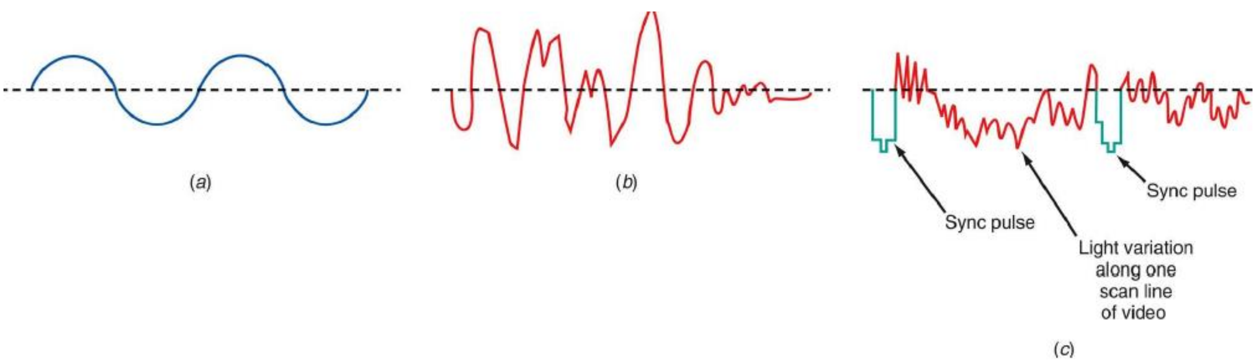
Transducer: An electrical transducer may be defined as a device that converts some physical variable (pressure, displacement, force, temperature, etc.) into corresponding variations in the electrical signal at its output. For example, a microphone converts sound energy into electrical energy.

Signal: Information converted in electrical form and suitable for transmission is called a signal. Signals can be either **analog or digital**.

Analog signals are continuous variations of voltage or current. *They are essentially single-valued functions of time*. Sine wave is a fundamental analog signal.

All other analog signals can be fully understood in terms of their sine wave components.

Sound and picture signals in TV are analog in nature.



Analog signals (a) Sine wave "tone." (b) Voice. (c) Video (TV) signal.

Digital signals are those which can take only discrete stepwise values.
Binary system that is extensively used in digital electronics employs just two levels of a signal. '0' corresponds to a low level and '1' corresponds to a high level of voltage/ current.

Digital signals (a) Telegraph (Morse code). (b) Continuous-wave (CW) code. (c) Serial binary code

Technically speaking, a signal is a wave, amplitude or frequency of which varies with time and the signal can be analog or digital.

NOISE: These are unwanted signals having same or similar frequency as that of required signal. They distort the transmission and receiving process. A virus in a computer is example of noise. A virus is an unwanted program in the same language in which your required program is, it disrupts your program.

Communication channel: The **communication channel** is the medium by which the electronic signal is sent from one place to another. Types of media include electrical conductors, Optical media, Free space, and System-specific media (e.g., water is the medium for sonar).

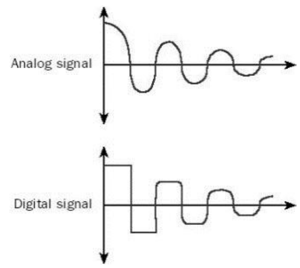
Transmitter: It is the device that converts the information (message) into a form suitable for transmission. In above example the online shopping company is the transmitter.

Receiver: It is the device that retrieves the information from received signal. In shopping example, you are the receiver. A **receiver** is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back into a form understandable by humans. Receivers contain **amplifiers, oscillators, mixers, tuned circuits** and **filters**, and a detector that recovers the original intelligence signal from the modulated carrier

Transceivers: A **transceiver** is an electronic unit that incorporates circuits that both send and receive signals. Examples are: Telephones, Fax machines, radios, Cell, mobile phones, computers.

Amplification: It is the process of increasing the strength of signal. Amplification compensates for attenuation. Amplification is done by electronic circuit.

Attenuation: It refers to loss in strength of signal while propagating from transmitter to receiver Signal **attenuation,** or degradation, exists in all media of wireless transmission. It is usually proportional to the square of the distance between the transmitter and receiver



Range: It is the maximum distance that a signal can travel with sufficient strength.

Band width: It is the frequency range over which a system works. It is calculated as highest frequency – lowest frequency. For example, the human audio frequency range is 20 Hz to 20,000 Hz, so audio bandwidth = 20,000 – 20 = 19,980 Hz **Bandwidth is** that portion of the electromagnetic spectrum occupied by a signal. **Channel bandwidth** refers to the range of frequencies required to transmit the desired information.

Band width of transmission medium the transmission channels are of three types

Wires, free space and optical fiber

Repeater: repeater station is equipped with Receiver, Amplifier and Transmitter.

The mobile phone towers in your area are repeater stations.

Communication satellites are repeater stations in space. They receive signal from one ground station amplify it and transmit it to another ground station.

Antenna: It is the device through which transmission and receiving process are done. The dish connected to your TV set is an antenna in itself.

Carrier wave: A **carrier** is a high frequency signal that is modulated by audio, video, or data. A **radio-frequency (RF) wave** is an electromagnetic signal that is able to travel long distances through space

Broadcasting is the distribution of audio or video content to a dispersed audience via any electronic mass communications medium, but typically one using the electromagnetic spectrum (radio waves), in a one-to-many model,

4. INTRODUCTION

In communication using radio waves, an antenna at the transmitter end radiates the electromagnetic waves (electromagnetic waves), which travels through the space and reach the receiving antenna at the other end.

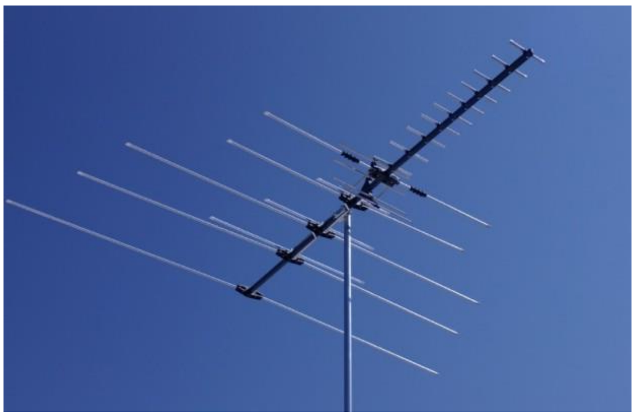
By ends we mean source end and observer end.

An antenna is an important component of any communication system.

It is employed at both the transmitting as well as receiving end; the transmitter radiates electromagnetic waves into the free space. While at the receiving end the antenna picks up the transmitted signal.
Audio video and data signals are too low in intensity and cannot travel long distances. The electrical signal cannot be transmitted directly; it has to be modulated. So they are coupled with high frequency electromagnetic waves (radio waves) with the help of transducers. The process as we have said, is called modulation
An antenna basically is a length of conductor and acts as a conversion device. The electrical energy is converted into electromagnetic waves. At the receiving end it does exactly the reverse. The length of the antenna should be such that it acts as a resonant circuit at the frequency. Generally, its length is $\lambda/2$, where λ is the wavelength of the radio frequency (carrier wave) applied.

There are many types of antennas depending upon frequency of carrier waves and directional need of the transmission.

The antennas may be mounted on **tall towers** to keep the signal energy from being lost in collisions with trees, buildings etc. the **parabolic antennas** or **dish antenna** are employed wherever the direction is very important.



https://en.m.wikipedia.org/wiki/File:Digital-tv-antenna-620x400.jpg

https://upload.wikimedia.org/wikipedia/commons/4/40/Erdfunkstelle_Raisting_2.jpg

In order to estimate the size of the required antenna

Let us calculate the length of a dipole antenna for transmission of 300 MHz

$f = 300 \times 10^6$ Hz

$$\lambda = \frac{\text{velocity of em wave}}{\text{frequency of em wave}} = \frac{3 \times 10^8 m/s}{3 \times 10^8 Hz} = 1m$$

Hence size of antenna is 0.5 m

It can be easily seen that the size of the antenna decreases with increases with frequency of the carrier wave

As the EM waves travel away from the transmitter, the strength of wave keeps on decreasing (called **attenuation)**. In this module let us study the role of atmosphere in propagation of electromagnetic signal waves.

We will now consider propagation of electromagnetic waves in atmosphere

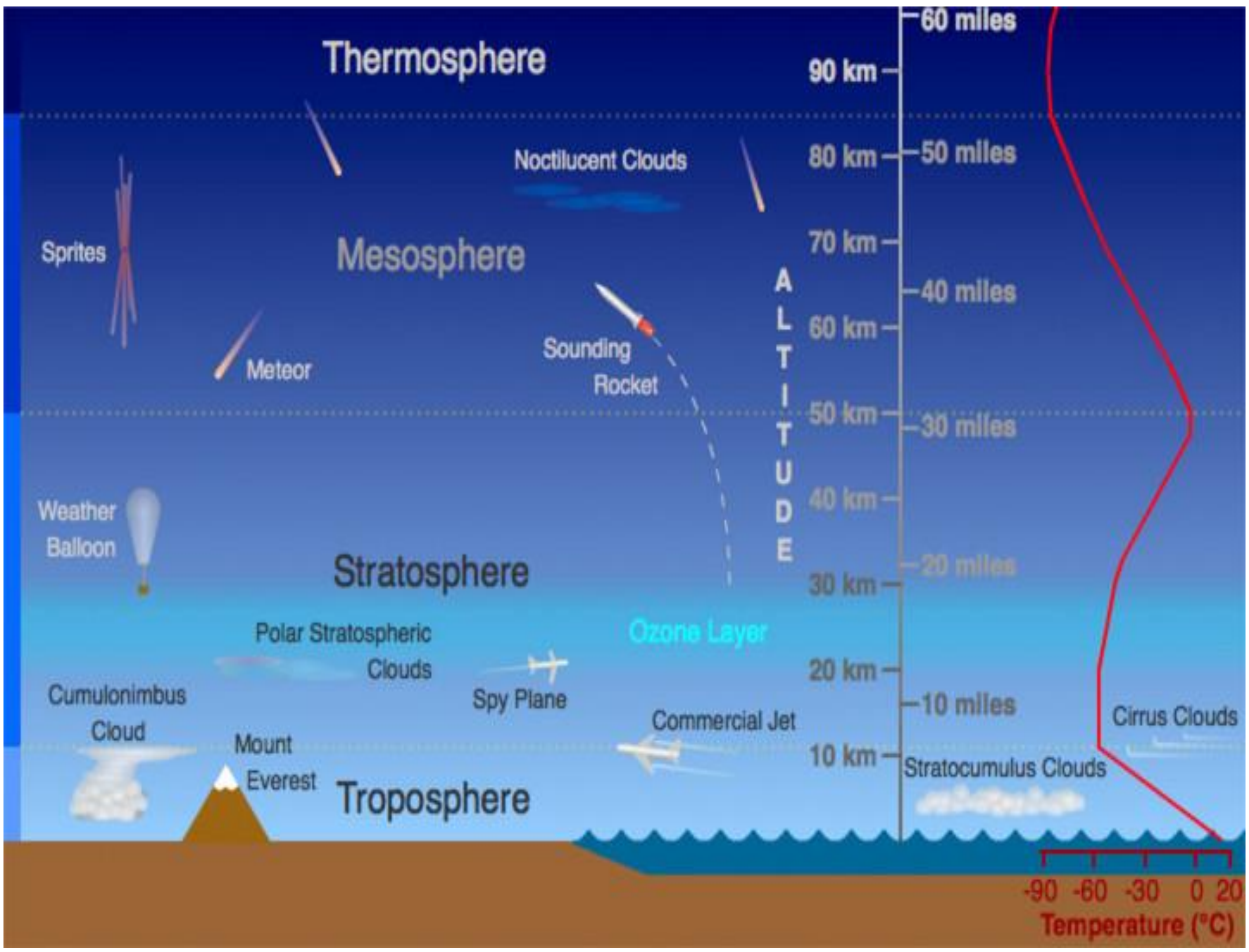
5. INFLUENCE OF ATOMOSPHERE OF THE EARTH

The atmosphere surrounding the earth is complex; its composition and density vary with altitude and seasonal conditions.

Several factors influence the propagation of EM wave and the path they follow.

At this point it is important to mention that earth's atmosphere also plays a vital role in propagation of EM waves (recall that during clouds or rain your TV signals gets disrupted).

In order to understand the effect, let us first consider the different layers of the atmosphere



https://upload.wikimedia.org/wikipedia/commons/3/36/Atmosphere_layers.jpgA

As you can see our atmosphere has layers, depending upon the distance from the surface of the earth of course there is no clear boundaries. it extends up to 350 km

These layers are-

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere

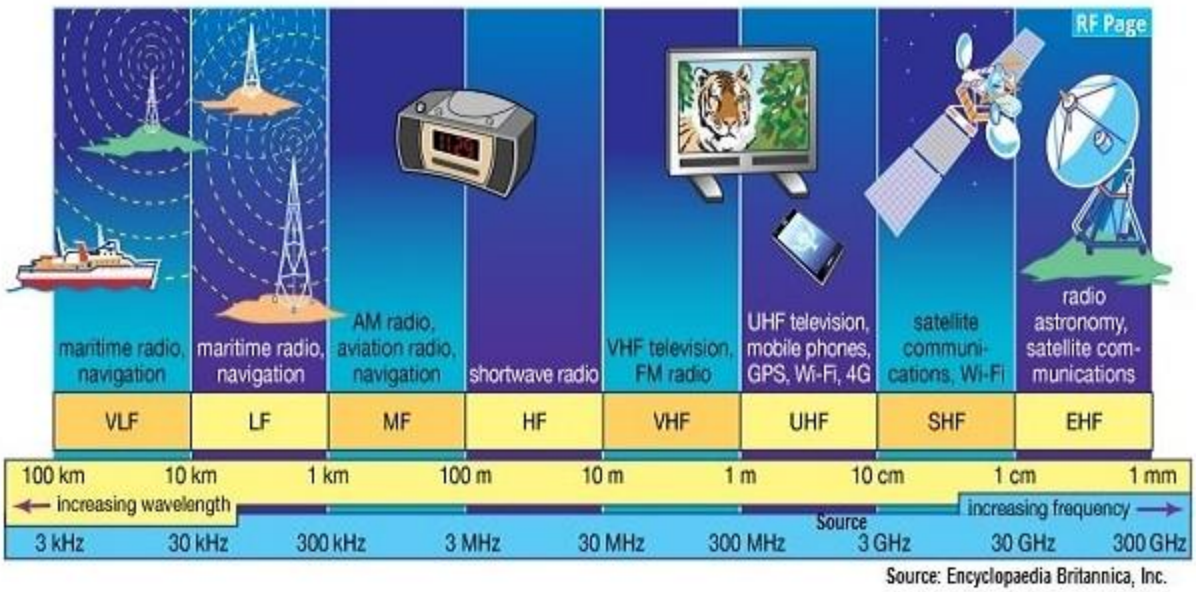
The temperature, density and composition of the layers changes as we go away from the surface of the earth. The composition of different layers in the atmosphere is not the same. Water vapor for example, is confined to the lowest layer whereas ozone is in the layers 50-80 km above the surface of the earth. The ionosphere extends from about 60-350 km, plays an important role in communication. It is subdivided into layers as C, D, E, F1 and F2

Read this table to recognize some everyday terms like AM – FM as in AM, FM radio, radio mirchi.

The values given are only to familiarize you with the wavelengths, some special names and the main applications

Frequency band	name	Wavelength range	Analog data		Digital data	Main application
			Modulation	bandwidth	Data rate	
30-300 kHz	LF	1-10km			0.1-100bps	navigation
300-3000kHz	MF	100m-1m	AM	Upto 4 kHz	10-1000bps	Commercial AM radio
3-30MHz	HF	10-100m	AM	Upto4kHz	10-3000bps	radio
30-300MHz	VHF	1-10m	AM,FM	5kHz-5MHz	To 100kbps	VHFTV FM radio
300-3000MHz	UHF	10cm--1m	AM-FM	Upto 20 MHz	10Mbps	HD TV terrestrial microwave
3-30 GHz 30-300GHz	SHF-EHF	1-10cm 1mm-1cm	FM	Upto 500MHz	100Mbps	Terrestrial microwave satellite microwave ,mobile phones internet

OR



kHz=10^3Hz
MHz=10^6Hz
GHz=10^9Hz

LF low frequency
HF high frequency
VHF very high frequency
UHF ultra high frequency
SHF super high frequency
EHF extremely high frequency

AM amplitude modulated
FM frequency modulated

What is Radio Frequency?

RF is the lowest portion in the electromagnetic spectrum familiar as a medium of analogue and modern digital wireless communication system. It spreads in the range between 3 KHz and 300 GHz. All known transmission systems works in the RF spectrum range including analogue radio, aircraft navigation, marine radio, amateur radio, TV broadcasting, mobile networks and satellite systems. Let’s take a look on each of the RF sub bands and the areas of RF spectrum uses.

Why are we considering antennas and atmosphere?

Imagine holding out your hand and catching words, pictures, and information passing by. That's more or less what an antenna (sometimes called an aerial) does: it's the metal rod or dish that catches radio waves and turns them into electrical signals. These are attached to mobile phones radio sets television internet. The term Wi-Fi that we use so commonly is for the radio waves which are picked up by devices without any cables or wires. Antennas like this are sometimes called receivers.

A transmitter is a different kind of antenna that does the opposite job to a receiver: it turns electrical signals into radio waves so they can travel sometimes thousands of kilometers around the Earth or even into space and back.

Antennas and transmitters are the key to virtually all forms of modern telecommunication. Let's take a closer look at what they are and how they work!

The **atmosphere** is transparent to visible radiations since we see the sun and stars through this however the atmosphere absorbs most infrared radiation. The ozone layer is found to block UV radiations. This information should help us realize that the atmosphere must be behaving differently towards radio waves as well.

The behaviour of waves of wavelength 10^3m and higher is of interest in communication systems

The table gives the activity of different band widths in the different layers of the atmosphere.

Different layers of atmosphere and their interaction with the propagating electromagnetic waves

The choice of carrier wave frequency depends on the nature of the signal to be transmitted.

To say it easily

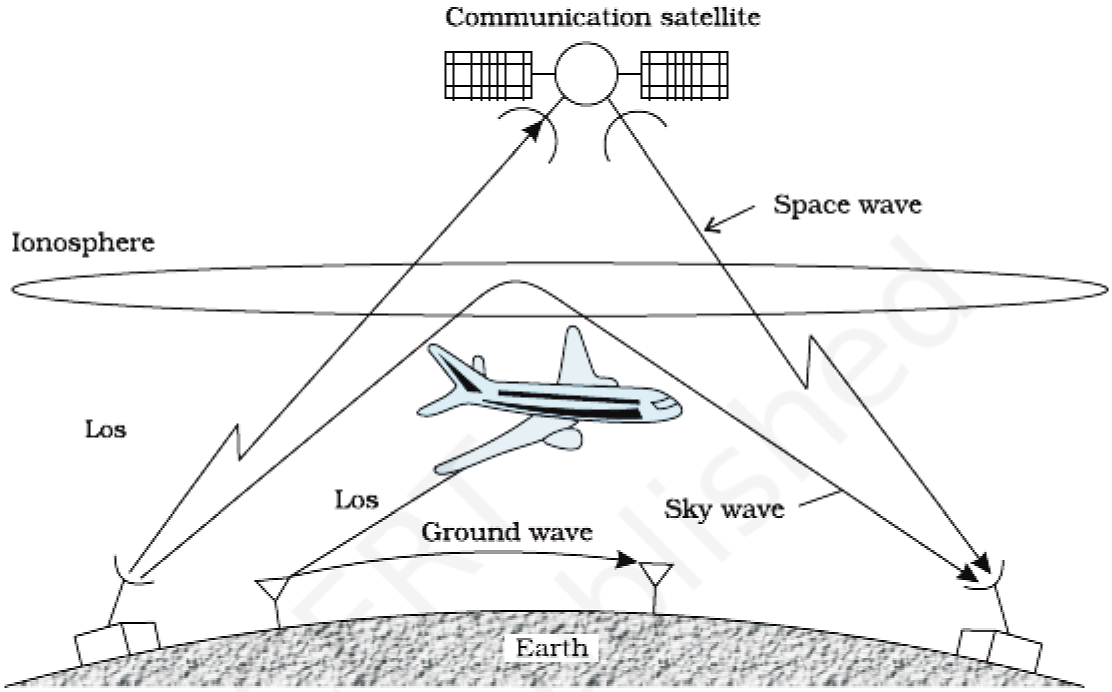
Role of atmosphere on propagation of electromagnetic (em or EM) waves:

- **(i)** Earth's atmosphere allows em waves of visible range to pass through it that is why sunlight reaches the earth.
- **(ii)** The atmosphere's ozone layer blocks UV radiations.
- **(iii)** The clouds block infra-red radiations, that is why it is warmer on cloudy days and night.
- **(iv)** EM waves up to 40 MHz are reflected back by different layers of ionosphere.
- **(v)** EM waves above 40MHz penetrate through the ionosphere and travel in a straight line. These are used in satellite communication.
- **(vi)** EM waves of few KHz to 3MHz glides near the earth surface.

6. PROPAGATION OF ELECTROMAGNETIC WAVE

In a communication set up EM waves travel in **three modes**:

- **Ground wave propagation**
- **Sky wave propagation and**
- **Space wave propagation.**



Various propagation modes for electromagnetic waves

Let us discuss each one of these in some detail. The idea here is not to go into technical details but get a general idea of how em waves would travel in atmosphere.

In wireless communication a signal is emitted from a transmitter antenna and received by another antenna at the receiver. An electromagnetic wave after being radiated by the transmitting antenna may be divided into various parts.one part travels along the surface and is called surface or ground wave. The remainder moves upwards towards the sky and space and is called sky waves and space waves.

a) GROUND WAVE PROPAGATION OF EM WAVE

Ground wave or surface wave propagation is a mode of propagation in which the wave moves close to earth's surface. These waves travel parallel or at lower angles with the earth's surface after they are radiated from a transmitting antenna. As ground wave passes over the surface of the earth, its energy is absorbed by earth's atmosphere. The energy decreases and the signal die down. The absorption there fore does not allow the wave to propagate and sustain its amplitude over large distances from the transmitting antenna.

It is suitable for low frequencies few KHz to 3MHz.

The mode of propagation is called surface wave propagation and the wave glides over the surface of the earth.

https://c.pxhere.com/photos/da/04/transmission_tower_send_radio_reception_antenna_telecommunications_masts_radio_antenna_wireless_technology-1061351.jpg!d

As **wave glides over the surface of earth, a large amount of energy of wave is absorbed by the ground. This loss in strength of wave is called attenuation.** A wave induces current in the ground over which it passes and it is attenuated as a result of absorption of energy by the earth. The attenuation of surface waves increases very rapidly with increase in frequency. The maximum range of coverage depends on the transmitted power and frequency (less than a few MHz).notice the multiple parabolic antennas used to transmit and receive radio signals from preferred directions.

Also, due to surface nature of propagation, the wave bends around the edges of an obstacle falling in their way. This phenomenon of bending around the edges of an object is called Diffraction.

To radiate signals with high efficiency, the antennas should have a size comparable to the wavelength λ of the signal (at least ~ $\lambda/4$). At longer wavelengths (i.e., at lower frequencies), the antennas have large physical size and they are located on or very near to the ground.

EXAMPLE

Calculate the height of antenna required to transmit waves of frequency 500Hz.

SOLUTION

Wavelength for the em wave of frequency 500Hz =

$$\frac{velocity}{frequency} = \frac{3\,x10^5 km/s}{500Hz} = 6\,x10^2 km$$

Size of antenna will be

$$\frac{\lambda}{4} = \frac{600}{4} = 150\ km$$

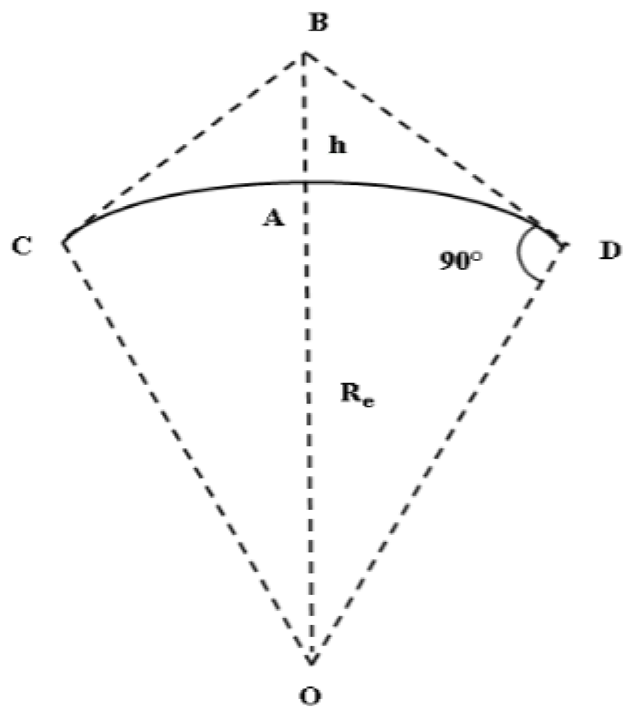
This is practically impossible!!

EXAMPLE

A TV antenna is of height 'h' estimating the covering range of the antenna. Take radius of the earth as R.

SOLUTION

TV signals are high frequency signals; they are not reflected back by the atmosphere.



Consider

AB be a tower of height h and

R, radius of earth

If broadcast is made from the top B of tower (AB), no reception of direct signals is possible beyond points C and D as shown in the figure.

The distance up to which signals can be received AC=AD is limited due to the curvature of the earth and is called the range of the antenna.

Let this be the range = d

The signals may be received in the region CAD

Let us relate d to h and R

In right angled triangle BOD

$$\angle BDO = 90^0$$

$$BO^2 = (OD)^2 + (BD)^2$$

$$(R+h)^2 = (R)^2 + (BD)^2$$

As height h of the antenna tower is very small as compared to radius R of the earth, hence point S will be close to A or we can say

$$BD \sim AD = d$$
$$(R+h)^2 = (R)^2 + (d)^2$$
$$d^2 = (R+h)^2 - (R)^2 = 2Rh + h^2$$

Now since h <<R hence $h^2 \ll 2Rh$

$$d^2 \backsimeq 2Rh$$

Height of transmitting antenna

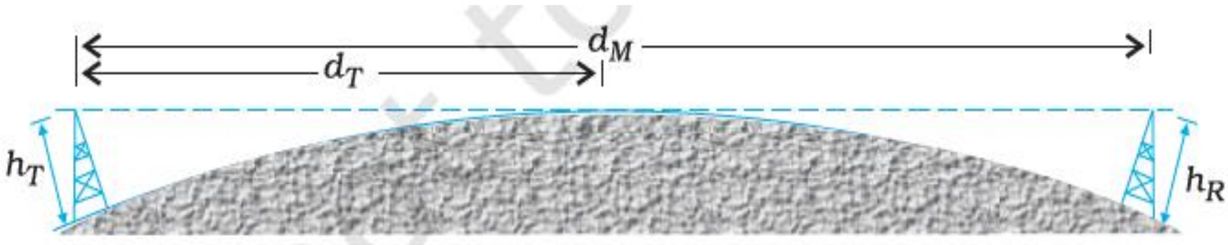
$$\mathbf{h = \frac{d^2}{2R}}$$

Covering range of the TV antenna is

$$\mathbf{d = \sqrt{2Rh}}$$

LINE OF SIGHT COMMUNICATION

It is the mode of propagation in which wave travels in a straight line from transmitting antenna to receiving antenna through space.



Line of sight communication by space waves

Waves having frequency above 40 MHz are not suitable for ground wave propagation because of very large attenuation. Also they cannot be reflected by ionosphere as they penetrate through the ionosphere and travel in a straight line.

Sky waves travels in a straight line from transmitting antenna to the receiving antenna. Sky waves are used for **line-of-sight (LOS)** communication as well as satellite communication.

At frequencies above 40 MHz, communication is essentially limited to line-of-sight paths.

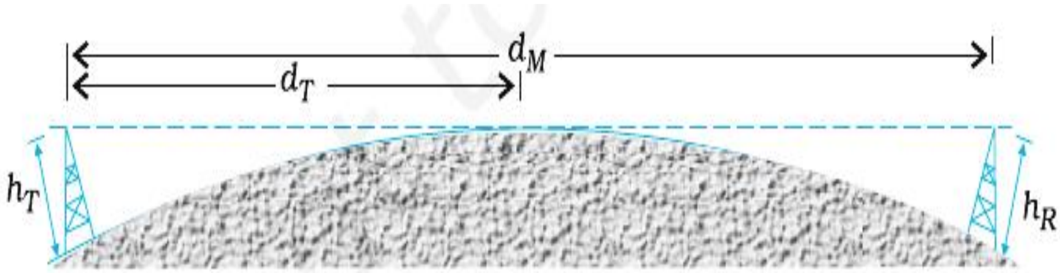
At these frequencies, the antennas are relatively smaller and can be placed at heights of many wavelengths above the ground. Because of line-of-sight nature of propagation, direct waves get blocked at some point by the curvature of the earth as illustrated in Fig

Television tower of Doordarshan Kendra, Chennai

Since the waves travel in a straight line from transmitting antenna to receiving antenna, these sky waves are used for **line of sight (LOS)** communication.

Space and sky waves are also used for television broadcast, microwave link, cell phones and satellite communication.

What is the advantage of high antennas?



d_M = maximum line of sight distance between transmitting antenna and receiving antenna.

d_T = **radio horizon** of transmitting antenna (it is the radius up to which the transmitting antenna can send the signal)

d_R = radio horizon of receiving antenna (it is the radius up to which the receiving antenna can pick the signal)

h_T = height of transmitting antenna

h_R = height of receiving antenna

R = radius of earth = 6.4 x 10^6 m

$$d_M = d_T + d_R$$

$$\mathbf{d_M = \sqrt{2R}\,h_T + \sqrt{2R}\,h_R}$$

Note :

Signal transfer from transmitting antenna to receiving antenna is like a relay race. The transmitter sends signal up to vicinity of receiving antenna from there the receiving antenna picks the signal. So, range of communication depends not only on the strength of transmitter but also on strength of receiver.

Radio horizon means the radius up to which the transmitting antenna can send the signal

EXAMPLE

The TV transmission tower in Delhi has a height of 240 m. Calculate the distance up to which the broadcast can be received by line of sight communication. take the radius of the earth to be 6.4 x 10^6m.

SOLUTION

h=240m

R=6.4 x 10^6 m

d =$\sqrt{2Rh}$

$$= \sqrt{2 \times [6.43 \times 10^6] \times 240}$$

= 55.4km

Due to attenuation and diffraction, this mode of propagation is suitable for local broadcast like AM broadcast of **medium wave band** of frequency range 530KHz to 1710Khz.

Local radio stations with coverage of a few square km.

EXAMPLE:

A transmitting antenna at the top of a tower has a height of 32m. Find the no. of people receiving the transmission if population density is 10,000 people per sq.km.

Given radius of earth R = 6.4 x 10^6 m and $\sqrt{10} = \pi$

SOLUTION:

Range of transmitting antenna (radio horizon of transmitting antenna)

$$d_T = \sqrt{2R\,h_T}$$

$$= (2 \text{ x } 6.4 \times 10^6 \times 32)^{1/2}$$

$$= 64 \text{ x } 10^2 \sqrt{10}$$

$$= 64 \times 10^2 \times \pi \text{ meter}$$

$$\mathbf{= 6.4 \times \pi \text{ km}}$$

Population covered = population density x area covered

$$= 10{,}000 \times \pi\, d_T^2$$

$$= 10{,}000 \times \pi^3 \times 6.4 \times 6.4$$

$$= 100 \times 10 \times 3.14 \times 64 \times 64$$

= 12,861,440 people

EXAMPLE

A TV tower has a height of 150m. How much population the TV broadcast covers if the average population density around the tower is 1000km^{-2}. Radius of the earth = 6.4 x 10^6 m

SOLUTION

The radio horizon of the tower is = $d = \sqrt{2Rh}$

Area of the region covered = $\pi d^2 = \pi \times 2Rh = \pi \times 2 \times 6.4 \times 10^6 \times 150\text{m}^2$

Population covered = $\mathbf{12.8\pi \times 150 \times 1000 = 60.32\ lakhs}$

EXAMPLE

A transmitting antenna at the top of a tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in LOS mode? Given radius of earth 6.4 × 10^6 m.

SOLUTION

$$d_m = \sqrt{2 \times 64 \times 10^5 \times 32} + \sqrt{2 \times 64 \times 10^5 \times 50}$$

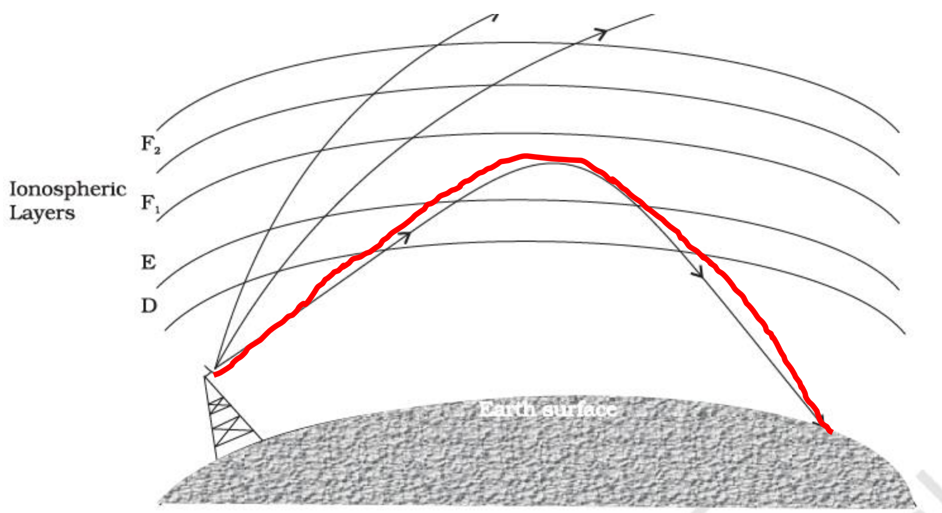
$$= 64 \times 10^2 \times \sqrt{10} + 8 \times 10^3 \times \sqrt{10}$$
$$= 144 \times 10^2 \times \sqrt{10}\ \text{m} = \mathbf{45.5\ km}$$

This attenuation increases rapidly with increase in frequency of wave and with increase in distance. So, high frequencies and long distance transmission are not suitable for this mode of propagation.

- The maximum range of coverage depends upon power of transmitter and frequency used for a given frequency of wave the range can be increased by increasing power of transmitter.
- **This mode of communication is used at airports by ground staff, marine staff on the ship, trade fairs, shopping malls or local melas.**

b) SKY WAVE PROPAGATION OF WAVE

It is the mode of wave propagation in which the waves reach receiver antenna after reflection from ionosphere.



Marked in red is Sky wave propagation

This mode of propagation is suitable for frequency range 3MHz to 40MHz.

Due to reflection from ionosphere, this mode of propagation is useful for long distance communication. So, it is used for **short wave broadcast** services.

The frequency bands employed in space communication is given in the table.

Name of the stratum (layer)		Approximate height over earth's surface	Exists during	Frequencies most affected
Troposphere		10 km	Day and night	VHF (up to several GHz)
D (part of stratosphere)	PARTS OF IONOSPHERE	65-75 km	Day only	Reflects LF, absorbs MF and HF to some degree
E (part of Stratosphere)		100 km	Day only	Helps surface waves, reflects HF
F_1 (Part of Mesosphere)		170-190 km	Daytime, merges with F_2 at night	Partially absorbs HF waves yet allowing them to reach F_2
F_2 (Thermosphere)		300 km at night, 250-400 km during daytime	Day and night	Efficiently reflects HF waves, particularly at night

Different frequencies are reflected by different layers of ionosphere.
The maximum frequency that a layer of ionosphere can reflect back is called its Critical frequency.

Reason for reflection of em waves from the ionosphere.

The **ionosphere** extends from 65 km to 400 km above earth surface.

Ionizations occur due to absorption of UV and other high energy radiations coming from sun by air molecules.

The **degree of ionization varies with the height**. The top layers and bottom layers of ionosphere have low density of ions. It is because as we go up above the earth's surface, the density of atmosphere decreases means there are fewer air molecules as we go up.

In top most layers of ionosphere, the ionizing radiation of sun is quite strong but the air molecules to be ionized are small in number, hence low density of ions in top most layers.

In bottom most layers, the number of air molecules are quite large but the ionizing radiation of sun is weak. So, only small number of molecules can be ionized, hence low density of ions in bottom layers of ionosphere.

The ion density is quite large in the middle of ionosphere.

The reflection phenomenon from layers of ionosphere is similar to total internal reflection of light in optics.

c) SPACE WAVE PROPAGATION

For space waves length of antenna is quite small.

Have you ever **wondered that your cell phone has no visible antenna? It is because are operated in Ultra high frequency (UHF) range which extends from 300MHz to 3000MHz.**

Due to straight line nature of space waves, these waves are sometimes blocked by earth's curvature as shown in fig.

To overcome such problem height of both transmitting antenna and receiving antenna should be raised.

7. SATELLITE COMMUNICATION

In this mode of communication, the receiver antenna receives signals from transmitting antenna through satellite.

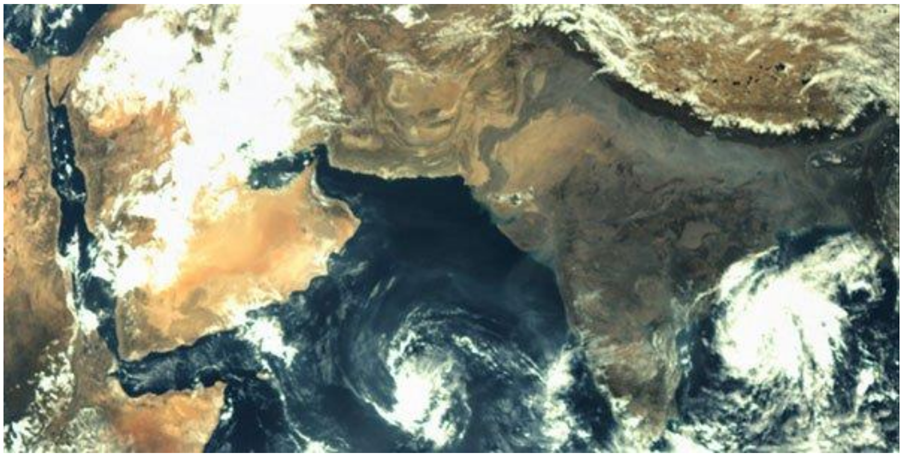
The transmitter located on earth sends signal to the satellite, this process is called **Uplink**.

The satellite processes the signal and sends it to receiving station located on earth. This process of sending the signal to receiving station is called **Downlink**.

The uplink and downlink frequencies are different.

Uplink frequencies are 5.925 – 6.425 GHz and downlink frequencies are 3.7 – 4.2 GHz. It is so to avoid *Interference* between uplink and downlink waves. Interference is a phenomenon in which there occurs redistribution of energy of two waves meeting at a place.

A communication satellite can be polar or a geo-stationary satellite.



Indian sub-continent as seen by Mars Orbiter Mission spacecraft during its geocentric phase

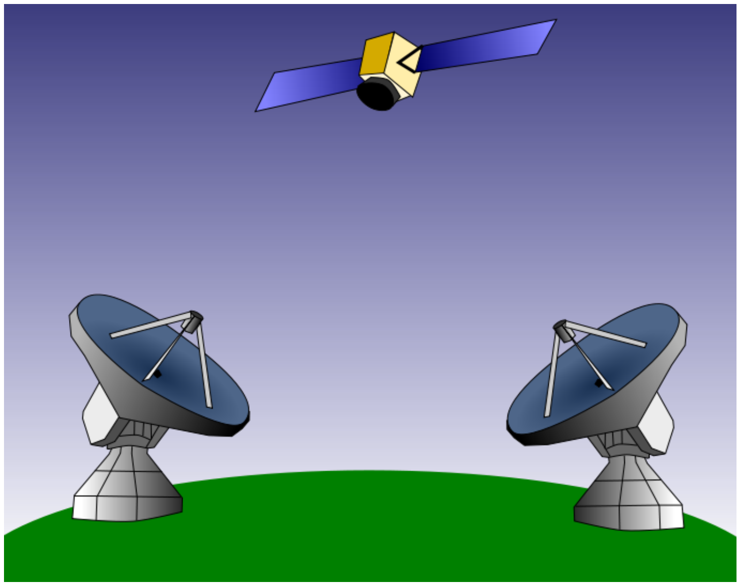
A geo-stationary satellite is the one which has same time period as that of earth i.e. 24 hours and also has the same sense of revolution as that of earth.

This makes satellite stationary with respect to a particular place on earth. Thus the satellite can easily be located. Now you can understand why your dish of TV, points in a particular direction.

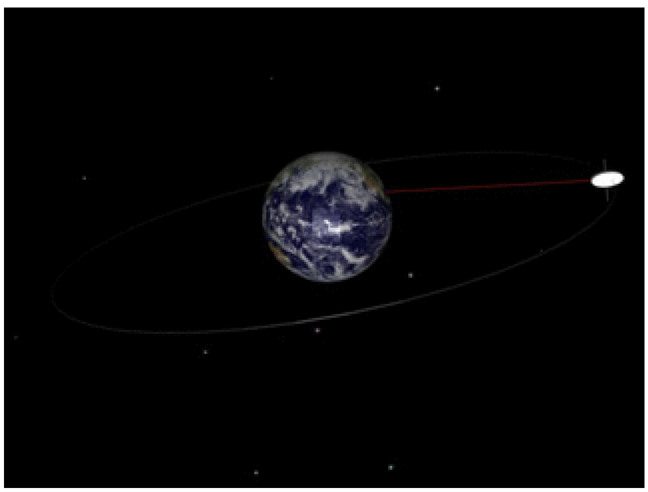
https://hi.m.wikipedia.org/wiki/%E0%A4%9A%E0%A4%BF%E0%A4%A4%E0%A5%8D%E0%A4%B0:Tata_Sky.JPG

A single satellite cannot cover the whole earth. It is because earth is a sphere.

A satellite can cover only the area falling in front of it, it cannot detect the areas away from its sight.



https://upload.wikimedia.org/wikipedia/commons/thumb/1/18/Satellite_Communication_Scetch.svg/684px-Satellite_Communication_Scetch.svg.png



https://commons.wikimedia.org/wiki/Category:Satellites#/media/File:Geosynchronous_orbit.gi

This is the same as some part of earth has day while remaining part has night. The parts of earth falling in front of the sun have day time while other parts have night.

The manufacturing and launching cost of satellite is quite high but operational cost is very low. Considering large no. of people being benefitted, in the long run satellite communication proves to be much cheaper than any other means of communication.

The geo-stationary satellites are located 36000 km above equator of earth. Signal has to travel large distance (2 × 36000 Km) in going and coming back.

This causes a small time delay between transmission and reception of signal.

You must have observed this fact in a live debate on a news channel.

The question asked by reporter is answered after a small time delay by the person present in the video conference.

8. INDIAN SATELLITE PROGRAM

About ISRO

India decided to go to space when **Indian National Committee for Space Research** (INCOSPAR) was set up by the Government of India in **1962**. With the visionary

Dr Vikram Sarabhai at its helm, INCOSPAR set up the Thumba Equatorial Rocket Launching Station (TERLS) in Thiruvananthapuram for upper atmospheric research.

Indian Space Research Organisation, formed in 1969, superseded the erstwhile INCOSPAR. Vikram Sarabhai, having identified the role and importance of space technology in a Nation's development, provided ISRO the necessary direction to function as an agent of development. ISRO then embarked on its mission to provide the Nation space based services and to develop the technologies to achieve the same independently.

Throughout the years, ISRO has upheld its mission of bringing space to the service of the common man, to the service of the Nation.

In the process, it has become **one of the six largest space agencies in the world.** ISRO maintains one of the largest fleet of **communication satellites (INSAT) and remote sensing (IRS)** satellites, that cater to the ever growing demand for fast and reliable communication and earth observation respectively.

ISRO develops and delivers application specific satellite products and tools to the Nation**:**

- **broadcasts,**
- **communications,**
- **weather forecasts,**
- **disaster management tools,**
- **Geographic Information Systems,**
- **cartography,**
- **navigation,**
- **telemedicine,**
- **Dedicated distance education satellites** being some of them.

To achieve complete self-reliance in terms of these applications, it was essential to develop cost efficient and reliable launch systems, which took shape in the form of the **Polar Satellite Launch Vehicle (PSLV)**. The famed PSLV went on to become a favoured carrier for satellites of various countries due to its reliability and cost efficiency, promoting unprecedented international collaboration. The **Geosynchronous Satellite Launch Vehicle (GSLV)** was developed keeping in mind the heavier and more demanding geosynchronous communication satellites.

Apart from technological capability, ISRO has also contributed to science and science education in the country.

Various dedicated research centres and autonomous institutions for **remote sensing, astronomy and astrophysics, atmospheric sciences and space sciences** in general function under the aegis of Department of Space. ISRO's own **Lunar and interplanetary missions** along with other scientific projects encourage and promote science education, apart from providing valuable data to the scientific community which in turn enriches science.

Future readiness is the key to maintaining an edge in technology and ISRO endeavours to optimise and enhance its technologies as the needs and ambitions of the country evolve. Thus, ISRO is moving forward with the development of heavy lift launchers, human spaceflight projects, reusable launch vehicles, semi-cryogenic engines, single and two stage to orbit (SSTO and TSTO) vehicles, development and use of composite materials for space applications etc.

OUR SATELLITES

Communication Satellites

Supports telecommunication, television broadcasting, satellite news gathering, societal applications, weather forecasting, disaster warning and Search and Rescue operation services.

The Indian National Satellite (INSAT) system is one of the largest domestic communication satellite systems in Asia-Pacific region with nine operational communication satellites placed in Geo-stationary orbit. Established in 1983 with commissioning of INSAT-1B, it initiated a major revolution in India's communications sector and sustained the same later. GSAT-17 joins the constellation of INSAT System consisting 15 operational satellites, namely - INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-6, 7, 8, 9, 10, 12, 14, 15, 16 and 18.

The INSAT system with more than 200 transponders in the C, Extended C and Ku-bands provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.

Earth Observation Satellites

The largest civilian remote sensing satellite constellation in the world - thematic series of satellites supporting multitude of applications in the areas of land and water resources; cartography; and ocean & atmosphere.

Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites. Today, India has one of the largest constellations of remote sensing satellites in operation. Currently, *thirteen* operational satellites are in Sun-synchronous orbit – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1, and *four* in Geostationary orbit- INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR. Varieties of instruments have been flown on board these satellites to provide necessary data in a diversified spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage. The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.

Satellite Navigation

Satellites for navigation services to meet the emerging demands of the Civil Aviation requirements and to meet the user requirements of the positioning, navigation and timing based on the independent satellite navigation system.

Satellite Navigation service is an emerging satellite based system with commercial and strategic applications. ISRO is committed to provide the satellite based Navigation services to meet the emerging demands of the Civil Aviation requirements and to meet the user requirements of the positioning, navigation and timing based on the independent satellite navigation system. To meet the Civil Aviation requirements, ISRO is working jointly with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (GAGAN) system. To meet the user requirements of the positioning, navigation and timing services based on the indigenous system, ISRO is establishing a regional satellite navigation system called Indian Regional Navigation Satellite System (IRNSS).

GPS Aided GEO Augmented Navigation (GAGAN):

This is a Satellite Based Augmentation System (SBAS) implemented jointly with Airport Authority of India (AAI). The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace. The system will be interoperable with other international SBAS systems and provide seamless navigation across regional boundaries. The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10.

His is an independent Indian Satellite based positioning system for critical National applications. The main objective is to provide Reliable Position, Navigation and Timing services over India and its neighbourhood, to provide fairly good accuracy to the user. The IRNSS will provide basically two types of services

1. Standard Positioning Service (SPS)
2. Restricted Service (RS)

To date, ISRO has built a total of nine satellites in the IRNSS series; of which eight are currently in orbit Three of these satellites are in geostationary orbit (GEO) while the remaining in geosynchronous orbits (GSO) that maintain an inclination of 29° to the equatorial plane. The IRNSS constellation was named as “NavIC” (Navigation with Indian Constellation) by the Honourable Prime Minister, Mr. Narendra Modi and dedicated to the nation on the occasion of the successful launch of the IRNSS-1G satellite. The eight operational satellites in the IRNSS series, namely IRNSS-1A, 1B, 1C, 1D, 1E, 1F, 1G and 1I were launched on Jul 02, 2013; Apr 04, 2014; Oct 16, 2014; Mar 28, 2015; Jan 20, 2016; Mar 10, 2016, Apr 28, 2016; and Apr 12, 2018 respectively. The PSLV-39 / IRNSS-1H being unsuccessful; the satellite could not reach orbit.

Experimental satellites

A host of small satellites mainly for the experimental purposes. These experiments include Remote Sensing, Atmospheric Studies, Payload Development, Orbit Controls, recovery technology etc.

Sub 500 kg class satellites - a platform for stand-alone payloads for earth imaging and science missions within a quick turnaround time.

Scientific research

Spacecraft for research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics.

ISRO's Student Satellite programme is envisaged to encourage various Universities and Institutions for the development of Nano/Pico Satellites.

9. SUMMARY

- **Role of atmosphere on propagation of em waves:**

Earth's atmosphere allows em waves of visible range to pass through it that is why sunlight reaches earth.

The atmosphere's ozone layer blocks UV radiations.

The clouds block infra-red radiation that is why it is warmer in cloudy night.

EM waves up to 40 MHz are reflected back by different layers of ionosphere.

EM waves above 40MHz penetrate through the ionosphere and travel in a straight line. These are used in satellite communication.

EM waves of few KHz to 3MHz glides near the earth surface.

- **EM waves travel in in three modes:**

i) Ground wave propagation
ii) Sky wave propagation and
iii) Space wave propagation

Ground wave propagation:

Ground wave or surface wave propagation is a mode of propagation in which the wave moves close to earth's surface. It is suitable for low frequencies few KHz to 3MHz.Due to attenuation and diffraction, this mode of propagation is suitable for local broadcast like **AM broadcast** of **medium wave band** of frequency range 530KHz to 1710Khz.This attenuation increases rapidly with increase in frequency of wave and with increase in distance. This mode of communication is used at airports, marine, trade fairs, shopping malls or local mela.

Sky wave propagation:

It is the mode of wave propagation in which the waves reach receiver antenna after reflection from ionosphere. This mode of propagation is suitable for frequency range 3MHz to 40MHz. Due to reflection from ionosphere; this mode of propagation is useful for long distance communication. So, it is used for **short wave broadcast** services.

Different frequencies are reflected by different layers of ionosphere. The maximum frequency that a layer of ionosphere can reflect back is called its Critical frequency.

The ionosphere extends from 65Km to 400Km above earth surface. Ionization occur due to absorption of UV and other high energy radiations coming from sun by air molecules.

The degree of ionization varies with the height. The top layers and bottom layers of ionosphere have low density of ions.

In top most layers of ionosphere, the ionizing radiation of sun is quite strong but the air molecules to be ionized are small in number, hence low density of ions in top most layers. In bottom most layers, the no. of air molecules are quite large but the ionizing radiation of sun is weak. So, only small number of molecules can be ionized, hence low density of ions in bottom layers of ionosphere. The reflection phenomenon from layers of ionosphere is similar to total internal reflection of light in optics.

Space wave communication:

It is the mode of propagation in which wave travels in a straight line from transmitting antenna to receiving antenna through space. This mode of communication is suitable for frequencies above 40MHz.

Since the waves travel in a straight line from transmitting antenna to receiving antenna, these space waves are used for **line of sight (LOS)** communication.

Space waves are used for television broadcast, microwave links, cell phones and satellite communication.

Due to straight line nature of space waves, these waves are sometimes blocked by earth's curvature. To overcome such problem height of both transmitting antenna and receiving antenna should be raised.

Satellite communication:

In this mode of communication, the receiver antenna receives signals from transmitting antenna through satellite.

The transmitter located on earth sends signal to the satellite, this process is called **Uplink**. The satellite sends the signal to receiving station located on earth. This process of sending the signal to receiving station is called **Downlink**.

The uplink and downlink frequencies are different. Uplink frequencies are 5.925 – 6.425 GHz and downlink frequencies are 3.7 – 4.2 GHz. It is so to avoid *Interference* between uplink and downlink waves. Interference is a phenomenon in which there occurs redistribution of energy of two waves meeting at a place.