Science and Technology Class 02

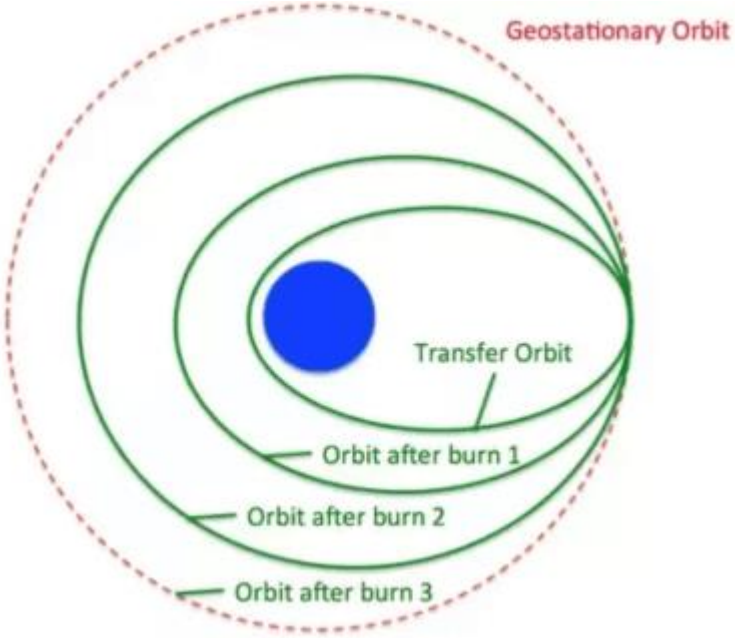
8th July, 2023 at 9:00 AM

REVISION OF THE PREVIOUS CLASS(9:13 AM):

- An orbit is a curved path of one celestial object around another celestial object/artificial object because of gravitational attraction.
- These orbits can be categorized based on different criteria such as shape, height, and inclination.
- If the satellite's rotation is synchronized with the earth's rotation on its axis, i.e. the satellite completes one revolution in one sidereal day(23 hours,56 minutes 4 seconds).
- Such orbits are called **Geosynchronous orbits.**
- **Geostationary orbit** is a special case of geosynchronous orbit.

Geotransfer orbit:

- Before achieving the desired geosynchronous or geostationary orbit, satellites are first placed in a highly elliptical orbit with an apogee in the range of 36000 km.
- When the satellite reaches its apogee (even at perigee), a boost (**apogee motor firing)** is given to change its orbit.
- All the temporary orbits before we can reach the desirable orbit are called geo-transfer orbits.

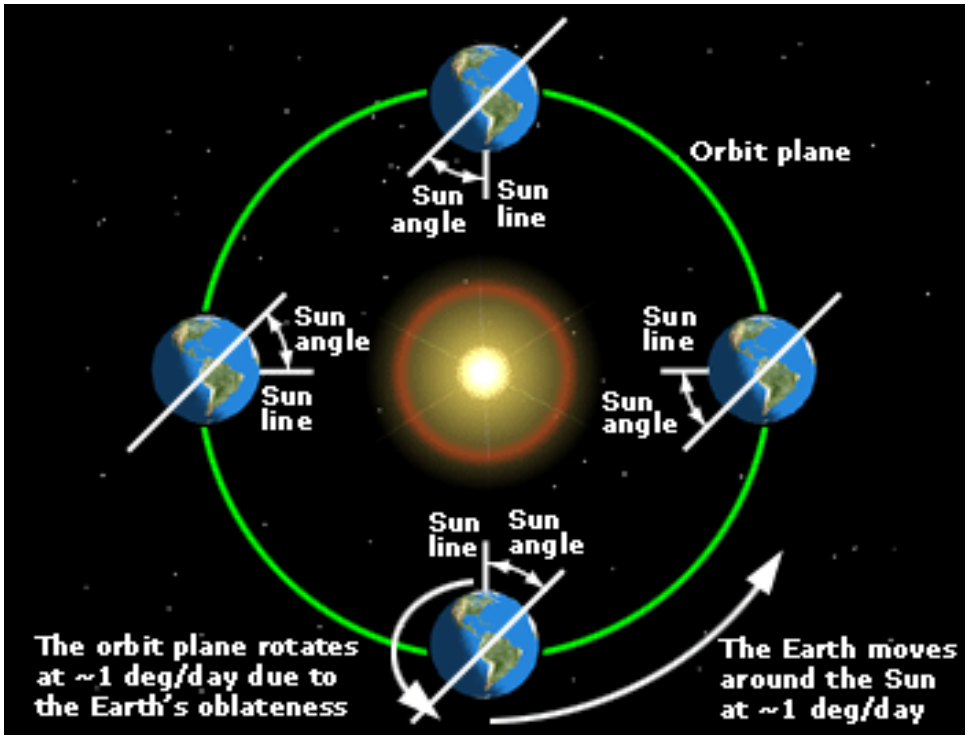


Sun-synchronous orbit :

- In these orbits, the satellite’s orientation is fixed relative to the sun throughout the year.
- Whenever a satellite observes a given ground location/crosses a point on the Earth, the sun is around the same location in the sky.
- Thus, the satellite passes through a given point on the planet's surface at the same **local solar time.**
- This **consistent lighting** is a very useful characteristic for a satellite that images the earth’s surface.
- Scientists can compare images of a particular point on Earth across several years without worrying about extreme changes in lighting and shadow.
- Often, the satellites are placed into an orbit of 600-800 km at an inclination of 94-98 degrees.
- Because of this, it is also called the **polar sun-synchronous orbit.**

HOW TO ACHIEVE A SUN-SYNCHRONOUS ORBIT? (9:35 AM):

- The earth is not a perfect sphere as it has bulged on the equator and is flat on the poles.
- Because of this mass asymmetry, often the orbits do not remain fixed and the orbits themselves rotate.
- Such a type of motion is called **Precessional motion**.

- Generally, orbital precession is not desirable and it is a challenge for space agencies.
- However, in the case of the sun-synchronous orbit, we use this challenge as an opportunity.
- In these orbits, the daily precession cancels out the change in the position of the sun because of the earth's revolution around it.
- We know that the sun's position with respect to the Earth also changes due to the Earth's revolution around it.
- Per-day change is approximately 1 degree (360 degrees/365 days).
- If we can have orbital precession of the same magnitude in a way that cancels the sun's daily changes in position because of the earth's revolution, we will get a sun-synchronous orbit.
- 

- Thus, the satellite's orbit's position remains the same with respect to the sun.
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TYPES OF SATELLITES (10:00 AM):
Various types of satellites are:

- Communication Satellite.
- Earth Observation Satellite.
- Navigational Satellites.
- Space Sciences Satellites.
- Experimental satellite.
- Small satellite.
- University/Academic Institution satellite

Communication Satellites:

- They create a communication channel between a source transmitter and receiver in different locations on the earth.
- These are generally placed in geosynchronous orbits.
- **ISRO's** communication program **INSAT**- Indian National Satellite is one of the largest communication programs in the Asia-Pacific Region.
- Some recent examples include CMS 01, GSAT 30, GSAT 31, etc are the latest communication satellites of ISRO.
- Here CMS means Communication Satellite and GSAT refers to Geosynchronous Satellite.
- CMS 02 launch got failed, and future launches will be named CMS 03 onwards.

Applications of communication satellites:

Television & Radio:

- It involves using satellites for broadcasting various radio and television channels.
- We can even use the **ionosphere** for such communication, but it will have limitations of frequency band and quality.

Tele-education:

- It involves using satellite channels for education.
- It got much more popular during Covid-lockdown
- The **Edusat Program** of ISRO provides many free channels to students across the world.
- Even online classes can be considered under it.

Telemedicine:

- It involves connecting remote and rural medical colleges and hospitals to major specialty hospitals in the city via satellites.
- **For example** the **Practo App.**
- Connecting medical colleges and hospitals in rural parts with the major specialty hospitals in cities with the help of satellites.

VSAT (Very Small Aperture Terminal):

- These are small satellite earth stations that receive and transmit data via satellite.
- Their antenna size is very small(1m -4m), and hence they are called very small aperture terminals.

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- It can be used for accessing the internet in places where setting up mobile towers is not feasible.
- This method gave less speed and high latency.
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Latency:

The time /time lag which is taken by any system to respond to the user request.

The usual video buffering is an issue of speed and is not related to latency.

- It is now used by major stock markets like BSE, ATM operations of banks, Train -ticketing systems, Oil companies, etc.
- Satellite phones can also use VSAT.

Village Resource Center:

- It is a program of ISRO where with the help of satellites, some panchayats are supported in Panchayat planning, skill development programs, weather information, etc.

Difference between VSAT and the proposed Starlink of Tesla:

- Starlink will not need ground stations for operations and the devices will be directly connected to the satellites.
- Starlink will launch satellites(around 40,000) into low earth orbit(500-600 km) to reduce latency and increase speed.
- The Starlink antennae would both have signal receiving and transmission facilities.

COSPAS- SARSAT:

- It is an intergovernmental program with the objective of satellite-aided search and rescue.
- India is a member of the program through ISRO.
- It is used by aircraft, ships, and people engaged in recreational activities in remote areas.

Satellite Collission:

We see very few such collisions.

Space is very huge to be congested with human action of launching satellites.

We can also predict/ monitor the paths of other satellites and many other objects.

Yet there can be some collisions due to human error or technical fault.

The golden foil on launch vehicles & satellites:

It is called Multi-Layer Insulation (MLI).

It protects against large temperature variations.

It is made of polyester with layers of aluminum.

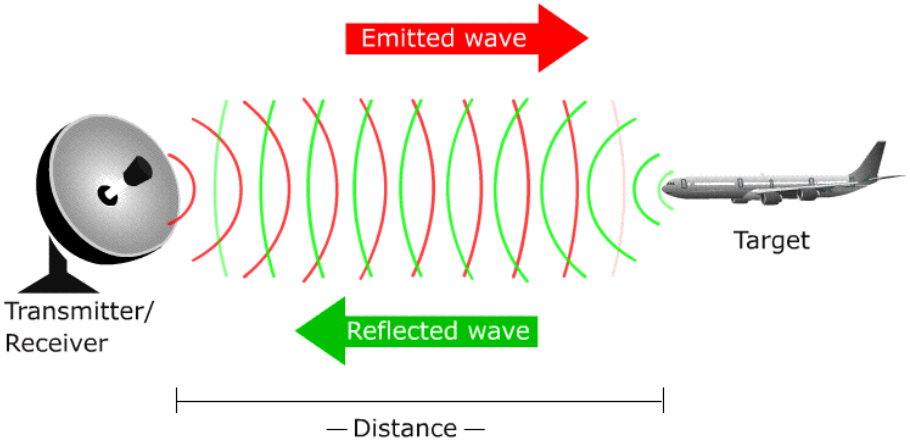
Earth Observation Satellites:

- They are also called **Remote Sensing Satellites.**
- Their purpose is to collect data about a particular location on the earth.
- Such data can help us in determining the physical, chemical, and even biological properties of a particular location.
- They use many sophisticated techniques such as LIDAR(Light Detection & Ranging), RADAR imaging, Hyper Spectral imaging, Spectroscopic analysis, etc

RADAR:

RADAR stands for Radio Detection and Ranging System.

It works by radiating energy into space and monitoring the echo or reflected signal from the objects.



LiDAR:

LiDAR stands for Light Detection and Ranging System.

It uses a pulsed laser to calculate an object's variable distances from the point where the LiDAR is placed.

These light pulses can be used to generate accurate 3D information about the earth's surface and the target object.

Along with magnetism and artificial intelligence(computer vision), Lidar is another important technology behind self-driven cars.

Hyperspectral imaging:

It is a technique that analyzes a wide spectrum of light instead of just assigning primary colors (red, green, blue) to each pixel.

The images will not get blurred when zoomed in/out.

Spectroscopy:

Just like all organisms have unique genetic makeup, all types of objects (living and non-living) have a unique signature of interacting with the light.

Spectroscopy is the study of the absorption and emission of light and other radiation by matter.

It has been used to determine things like the hydrogen composition of the sun, the presence of water vapor on faraway planets, etc.

- These satellites are designed to observe the Earth from an orbit.
- The different technologies are necessary because the human brain can only process and make images of visible light.
- We see such applications of differential interactions all around us:
- **X-rays** can pass through flesh, but not through bones.
- So tracing the path of X-rays and getting their imprint over a sheet will give us an internal map of our body.
- **Microwaves** can warm up food but not ceramic jars.
- The interaction between microwaves and metal can damage our equipment, and this is why metallic jars are not put in microwaves.

SOLAR CORONA (10:40 AM):

- The Sun’s corona is the outermost part of the Sun’s atmosphere.
- The corona is usually hidden and it is only visible during solar eclipse.
- Its temperatures can reach up to millions of degrees Celsius, while the sun's core temperature lies in the range of 6000 degrees Celsius.

- **Nasa's Parker probe** entered and it is still working and sending data without melting.

Why did Parker not melt?

- For that, we must be clear about the difference between **temperature and heat.**
- Heat is the exchange of "thermal" energy due to a temperature difference.
- Temperature is essentially the measure of the average kinetic energy of one molecule and determines the direction of heat transfer- always from high to low.
- Even if some particles have a very high energy content, until and unless they can transfer that energy to another body, that other body would not "feel " the heat as such.
- **For example-** The **Parker** probe of NASA has entered the Solar Corona which has temperatures of more than one million degrees Celsius.
- We have not yet found/created materials that could withstand temperatures over 1500-1600 degrees centigrade.
- Yet the Parker is not expected to melt anytime soon because the particles in the solar corona, despite having a much higher temperature, lie in the corona which has very less particle density.
- This will reduce the transfer of energy to Parker and its temperature is not expected to go beyond around 1000 degree centigrade.
- Parker will not even survive for 5 seconds in the Photosphere of the sun which has a lesser temperature but higher particle density than the corona.

APPLICATIONS OF EARTH OBSERVATION/REMOTE SENSING SATELLITES (11:05 AM):

- Soil monitoring in agriculture.
- Environmental monitoring -like change in forest cover.
- Renewable energy capacity.
- Geology, geomorphology.
- Ocean sciences.
- Mineral exploration.
- Disaster Management
- It can be also used for governance, like monitoring the progress of Housing schemes, Clean Ganga, MGNREGAetc.
- They are generally placed in the lower earth orbit (LEO), polar sun-synchronous orbit, and sometimes also in geosynchronous orbits.
- RISAT, Oeansatand Cartosat 3 are some of the latest earth observation satellites of ISRO.
- Isro has adopted the nomenclature EOS for such satellites.
- These orbits are placed in Lower Earth Orbits, Polar sun-synchronous orbits, Geosynchronous orbits, etc.

Recent events in Indian Space Sector:

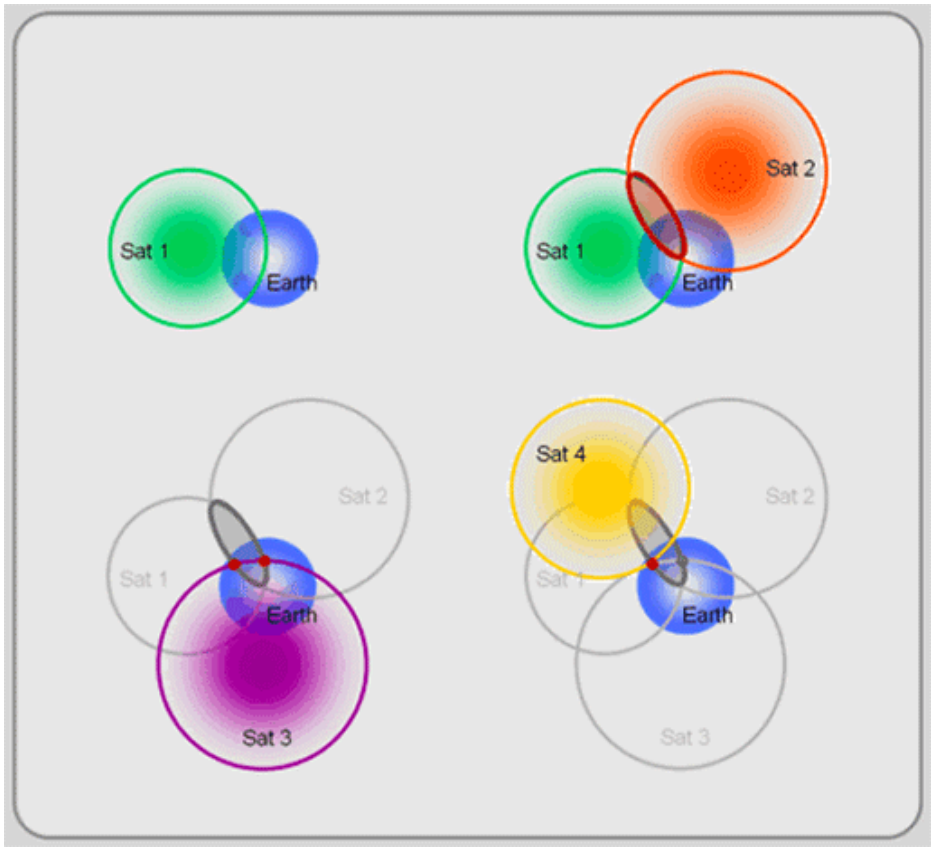
- ISRO has achieved spectacular success despite much lesser resources than space agencies of other developed nations.
- But despite the progress, Indian contribution to the global space market is less than 3 %.
- We are seeing an increase in private participation in the space tech field.
- This is a very good development and will foster innovation.
- But private participants in the space sector have to face bureaucratic hassles to access the data collected by ISRO systems.
- Steps have been taken to make ISRO data public.

NAVIGATIONAL SATELLITES (11:30 AM):

- Their purpose is to determine the precise location-latitude, longitude, and altitude of a particular point on Earth.
- An electronic receiver requires data from a minimum of four satellites to determine its precise location.
- These satellites are used to provide geo-spatial positioning.
- **For example:**
- GPS- USA.
- GLONASS- Russia.
- Galileo- Europe.
- Beidou- China.
- The above are Global Navigational Satellite Systems (GNSS).
- There are also local satellite systems such as:
- I. NAVIC- India.
- II. Quasi-Zenith Satellite System(QZSS)- Japan in collaboration with GPS.
- **Such systems provide two types of services:**
- I. Standard Positioning System(SPS)/Standard Services- civilian use.
- II. Protection Positioning System(PPS)- restricted services for military uses available only to selected military personnel and intelligence officials.
- Proper authentication is needed to access PPS.

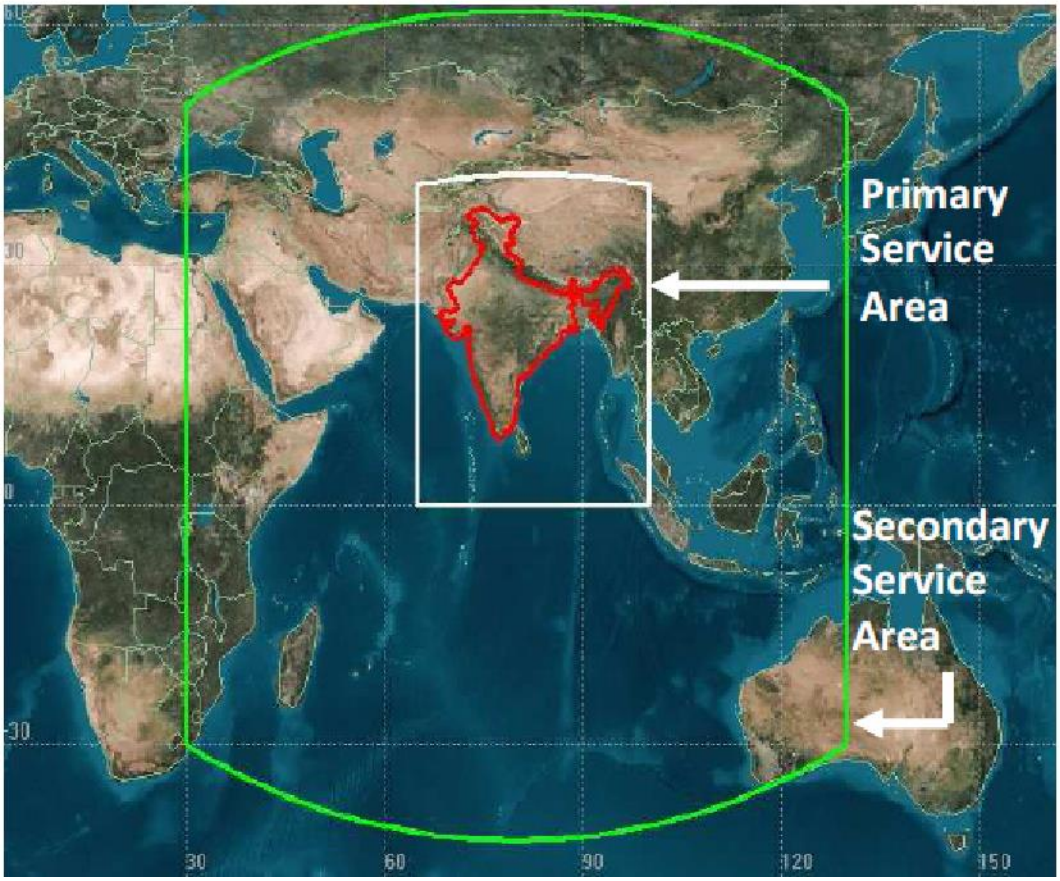
Why do we need a minimum of 4 satellites for navigation?:

- The first satellite locates you somewhere on a sphere (top left of Figure).
- The second satellite narrows your location to a circle created by the intersection of the two satellite spheres (top right).
- The third satellite reduces the choice to two possible points (bottom left).
- Finally, the fourth satellite helps calculate a timing and location correction.

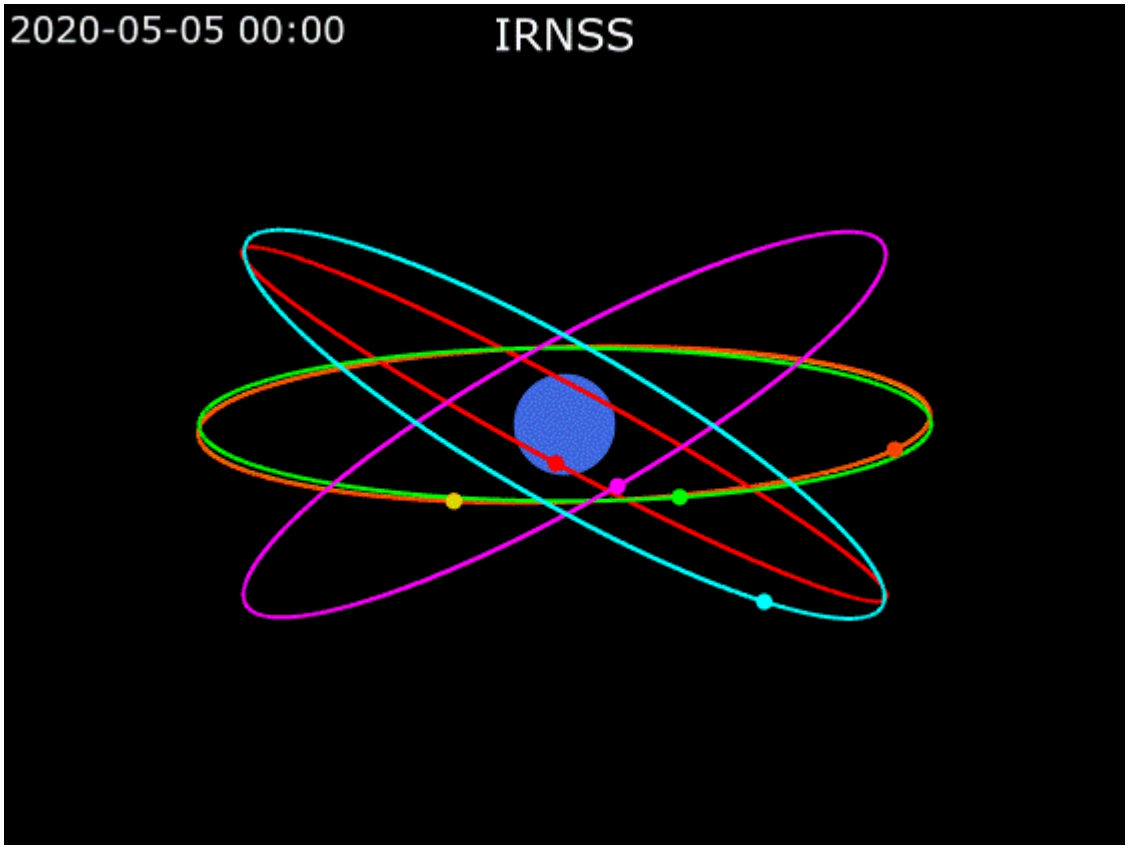
- 

Navigation Of the Indian Constellation (NAVIC):

- It is an autonomous regional navigation satellite system developed by India.
- The main objective is to provide reliable position, navigation, and timing services over India and its neighborhood.
- It will provide navigational services in India and about 1500km beyond borders.

- 

- Like other navigational satellite systems, it will provide two types of services:
- (1)Standard services for civilian use.
- (2)Restricted services for military applications which is available only to authorized users.
- The need for such a system was felt after the USA's refusal to share sensitive data during the **Kargil conflict in 1999.**
- It consists of seven satellites- four in geosynchronous and three in geostationary orbits.
- The initial seven satellites were called **IRNSS- Indian Regional Navigational Satellite System.**
- After one of the satellites recently has been replaced with **NVS01 (**Navigational Satellite 1)
- For the precise location of any point, it must be in the line of sight of at least four satellites.
- ISRO plans to make the system global in the future.

- 

NAVIC v/s GPS :

NAVIC	GPS
Regional	Global
It has 7 satellites	It has 32 satellites
It is in the Geosynchronous orbit (35,786 km)	It is in the Medium Earth Orbit (around 20,000 km)
Low cost	Higher cost(estimated)

Navigational satellites have **many applications such as:**

- Terrestrial, aerial, and marine navigation.
- Integration with mobile phones.
- Vehicle tracking.
- Integration with mobile phones.
- Precise timing.
- Disaster management.

GAGAN -GPS Aided Geo Augmented Navigation:

- ISRO and the Airports Authority of India (AAI) (Ministry of Civil Aviation)have implemented the GAGAN for navigation requirements of civil aviation in the Indian airspace.
- ISRO lies under the Department of Space which lies directly under the Prime Minister's Office, just like the Department of Atomic Energy.
- It utilizes the communication satellites of ISRO, GPS satellites, and ground stations to provide accurate information on civilian aircraft movement.
- It is now also used for railways, deep-sea explorations, fisheries, etc.

The topics for the next class are rockets of ISRO,ISRO missions such as Gaganyaan, Chandrayaan, etc.