Science and Technology

Syllabus

- Science and Technology- developments and their applications and effects in everyday life
- Achievements of Indians in science & technology
- Indigenization of technology and developing new technology
- Awareness in the fields of
  - IT
  - Space
  - Computers
  - Robotics
  - Nano-technology
  - Bio-technology
  - Issues relating to intellectual property rights.

Past Year Questions - Mains

Space technology

1. What is the main task of India's third moon mission which could not be achieved in its earlier mission? List the countries that have achieved this task. Introduce the system in the spacecraft launched and explain the role of the 'Virtual Launch Control Centre' at the Vikram Sarabhai Space Centre which contributed to the successful launch from Sriharikota. (Answer in 250 words) 15. 2023
2. Launched on 25th December, 2021, James Webb Space Telescope has been much in the news since then. What are its unique features which make it superior to its predecessor Space Telescopes ? What are the key goals of this mission ? What potential benefits does it hold for the human race? (Answer in 250 words) 15 2023
3. What is India's plan to have its own space station and how will it benefit our space programme? 2019
4. Why is Indian Regional Satellite Navigation System needed? How does it help in navigation. (Paper 1 2018) 150 words 10 marks
5. How doe Juno mission of NASA help to understand the origin and evolution of Earth. (Paper 1 2017) 150 words 10 marks
6. India has achieved remarkable successes in unmanned space missions including the Chandrayaan and Mars Orbitter Mission, but has not ventured into manned space mission, both in terms of technology and logistics? Explain critically. 2017
7. Discuss India's achievements in the field of Space Science and Technology. How the application of this technology has helped India in its socio-economic development? 2016
8. What do you understand by 'Standard Positioning Systems' and 'Protection Positioning Systems' in the GPS era? Discuss the advantages India perceives from its ambitious IRNSS programme employing just seven satellites. 2015

Past Year Questions - Mains

Biotechnology

1. Discuss several ways in which microorganisms can help in meeting the current fuel shortage. (Answer in 150 words) 2023
2. What is the basic principle behind vaccine development? How do vaccines work? What approaches were adopted by the Indian vaccine manufacturers to produce COVID-19 vaccines ? (Answer in 250 words) 15
3. What are the research and developmental achievements in applied biotechnology/? How will these achievements help to uplift the poorer sections of the society? (Answer in 250 words) 2022
4. How can biotechnology improve the living standards of farmers? 2019
5. Why is there so much activity in the field of biotechnology in our country? How has this activity benefitted the field of biopharmacy? 2018
6. Stem cell therapy is gaining popularity in India to treat a wide variety of medical conditions including Leukaemia, Thalassemia, damaged cornea and several burns. Describe briefly what stem cell therapy is and what advantages it has over other treatments. 2017

Past Year Questions - Mains

- **Nanotechnology**
  - What do you understand by nanotechnology and how is it helping in health sector? 2020
  - Why is nanotechnology one of the key technologies of the 21st century? Describe the salient features of Indian Government's Mission on Nanoscience and Technology and the scope of its application in the development process of the country. 2016
- **IPR Related Issues**
  - How is the government of India protecting traditional knowledge of medicine from patenting by pharmaceutical companies? 2019
  - India's Traditional Knowledge Digital Library (TKDL) which has a database containing formatted information on more than 2 million medicinal formulations is proving a powerful weapon in the country's fight against erroneous patents. Discuss the pros and cons making this database publicly available under open-source licensing. 2015
  - In a globalised world, intellectual property rights assume significance and are a source of litigation. Broadly distinguish between the terms – copyrights, patents and trade secrets. 2014

Past Year Questions - Mains

- **Nuclear Technology**
  - With growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy. 2018
  - Give an account of the growth and development of nuclear science and technology in India. What is the advantage of fast breeder reactor programme in India? 2017
- **Contributions of India in Science and Technology**
  - How was India benefited from the contributions of Sir M. Visvesvaraya and Dr. M. S. Swaminathan in the fields of water engineering and agricultural science respectively? 2019
  - Discuss the work of 'Bose-Einstein Statistics' done by Prof. Satyendra Nath Bose and show how it revolutionized the field of Physics. 2018
- **Robotics**
  - What are the areas of prohibitive labour that can be sustainably managed by robots? Discuss the initiatives that can propel research in premier research institutes for substantive and gainful innovation. 2015

Past Year Questions - Mains

- **ICT**
  - Introduce the concept of Artificial Intelligence (AI). How does Al help clinical diagnosis? Do you perceive any threat to privacy of the individual in the use of Al in healthcare? (Answer in 150 words) 2023
- **Defence**
  - How is S-400 air defence system technically superior to any other system presently available in the world? (Answer in 150 words) 2022

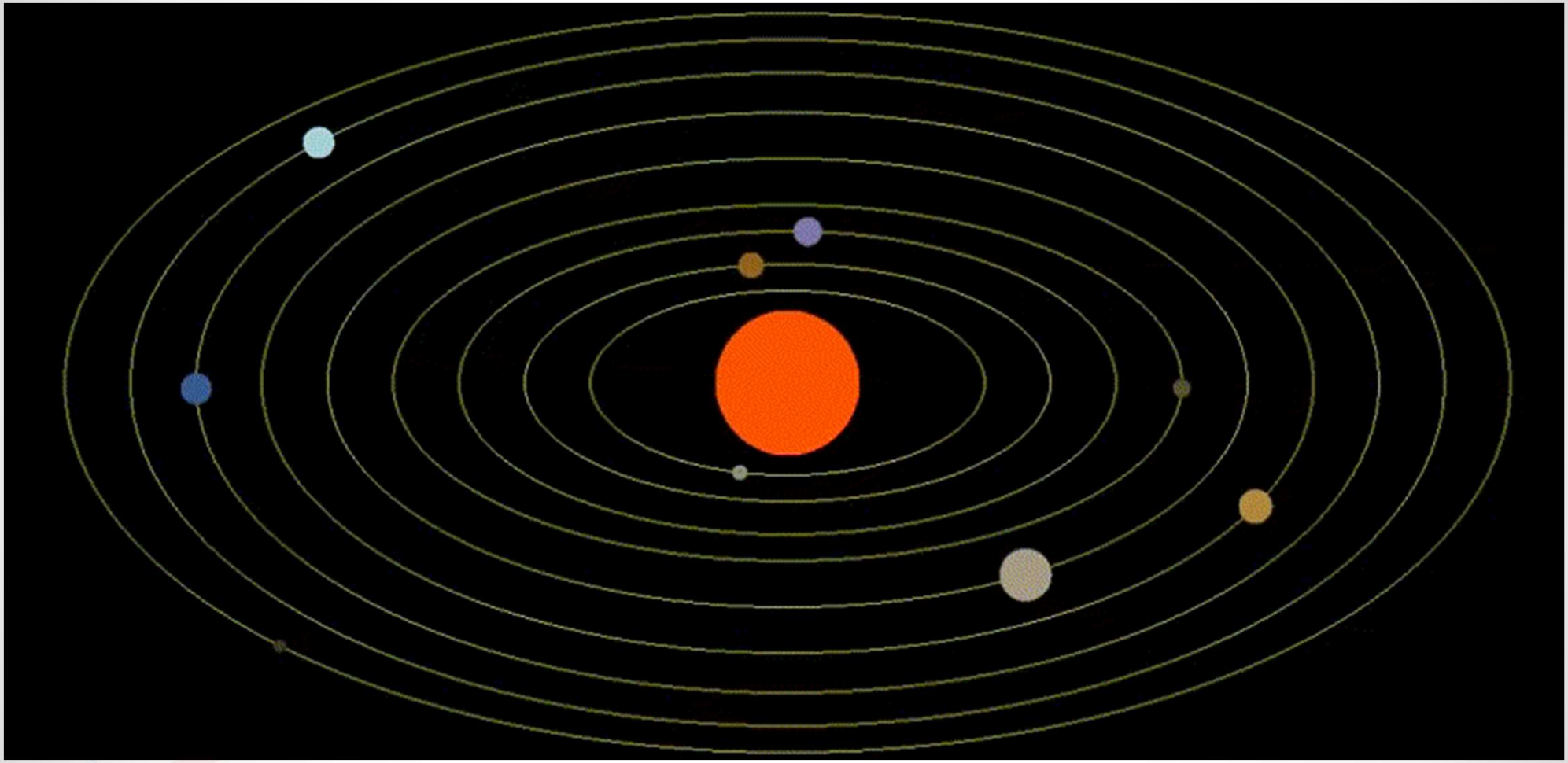
Past Year Questions - Mains

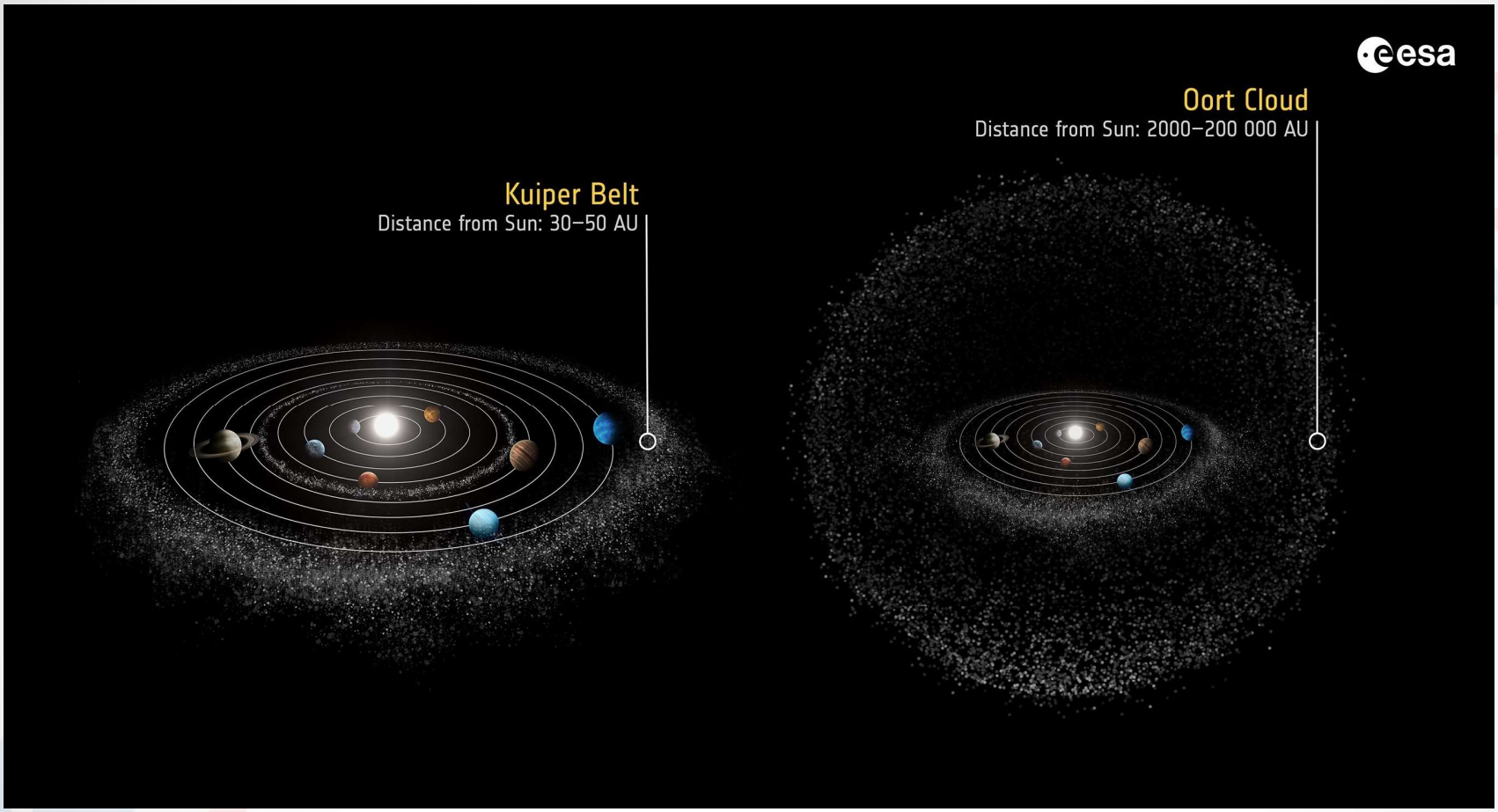
- **Science and Technology – Developments and Applications**
  - The adoption of electric vehicles is rapidly growing worldwide. How do electric vehicles contribute to reducing carbon emissions and what are the key benefits they offer compared to traditional combustion engine vehicles? (Answer in 250 words) 2023
  - The Nobel Prize in Physics of 2014 was jointly awarded to Akasaki, Amano and Nakamura for the invention of Blue LEDs in 1990s. How has this invention impacted the everyday life of human beings ? (Answer in 250 words) 2022
  - COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management of the pandemic. 2020
  - How is science interwoven deeply with our lives? What are the striking changes in agriculture triggered off by the science-based technologies? 2020
  - Scientific research in Indian universities is declining, because a career in science is not as attractive as our business operations, engineering or administration, and the universities are becoming consumer oriented. Critically comment. 2014
  - Can overuse and the availability of antibiotics without doctor's prescription, the contributors to the emergence of drug-resistant diseases in India? What are the available mechanisms for monitoring and control? Critically discuss the various issues involved. 2014

Space Technology

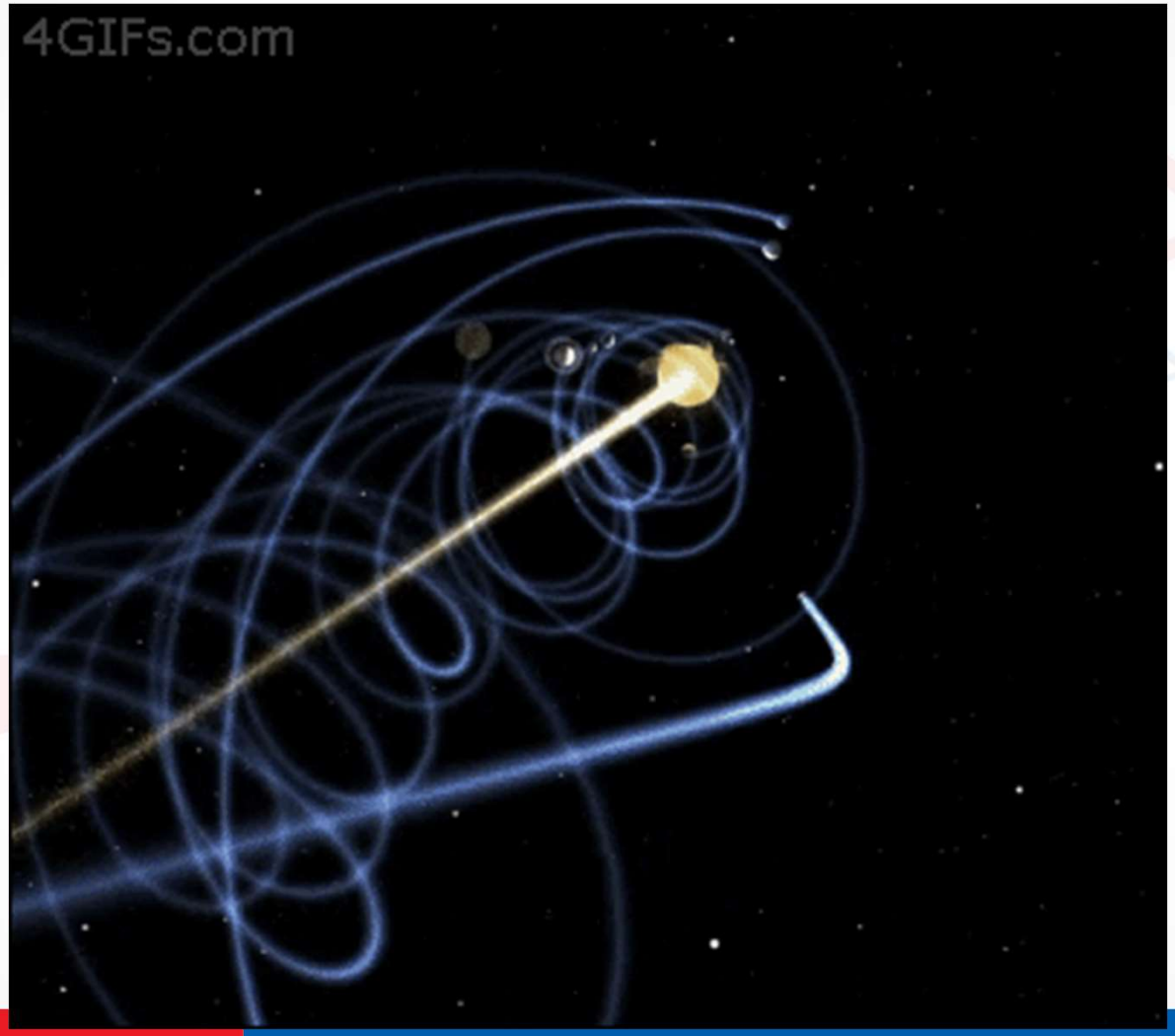
Topics to Be covered

- Scope of Space Technology
- Why Satellites revolve and why Rockets go upwards? – Newton's laws of motion
- Orbit of Planets around sun – Keppler's laws
- Types of orbits around Earth
- Types of Satellites and their applications
- Launch Vehicles of ISRO
- Significant missions of ISRO
- Emerging trends in Space Technology

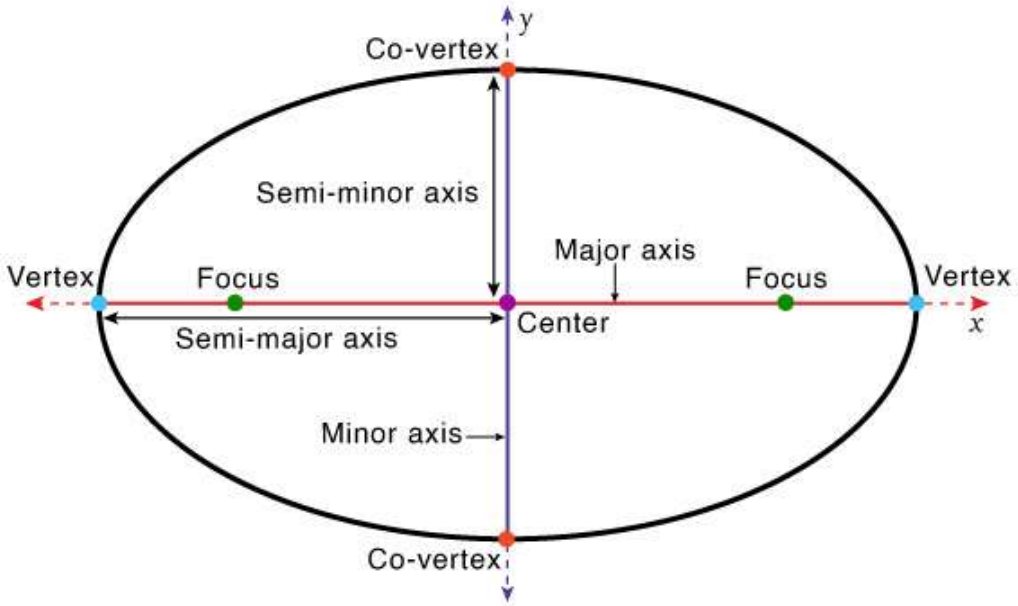


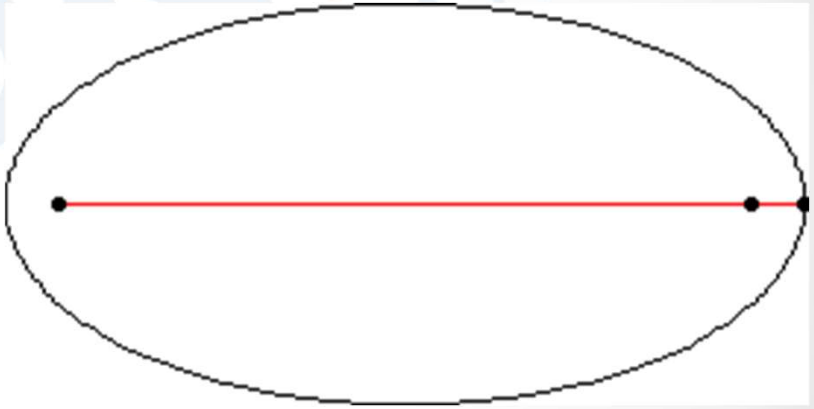


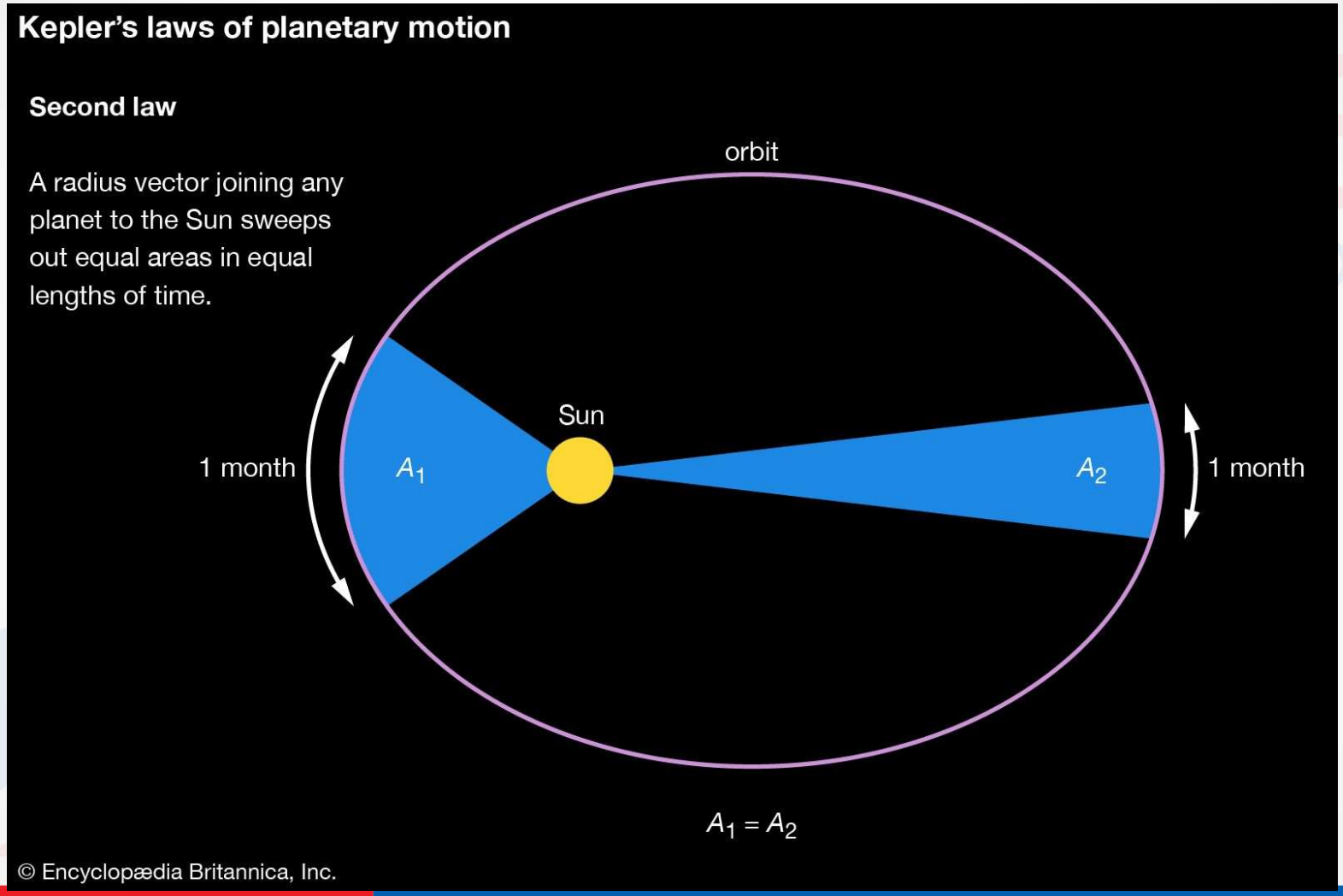
Kuiper Belt and Oort Cloud

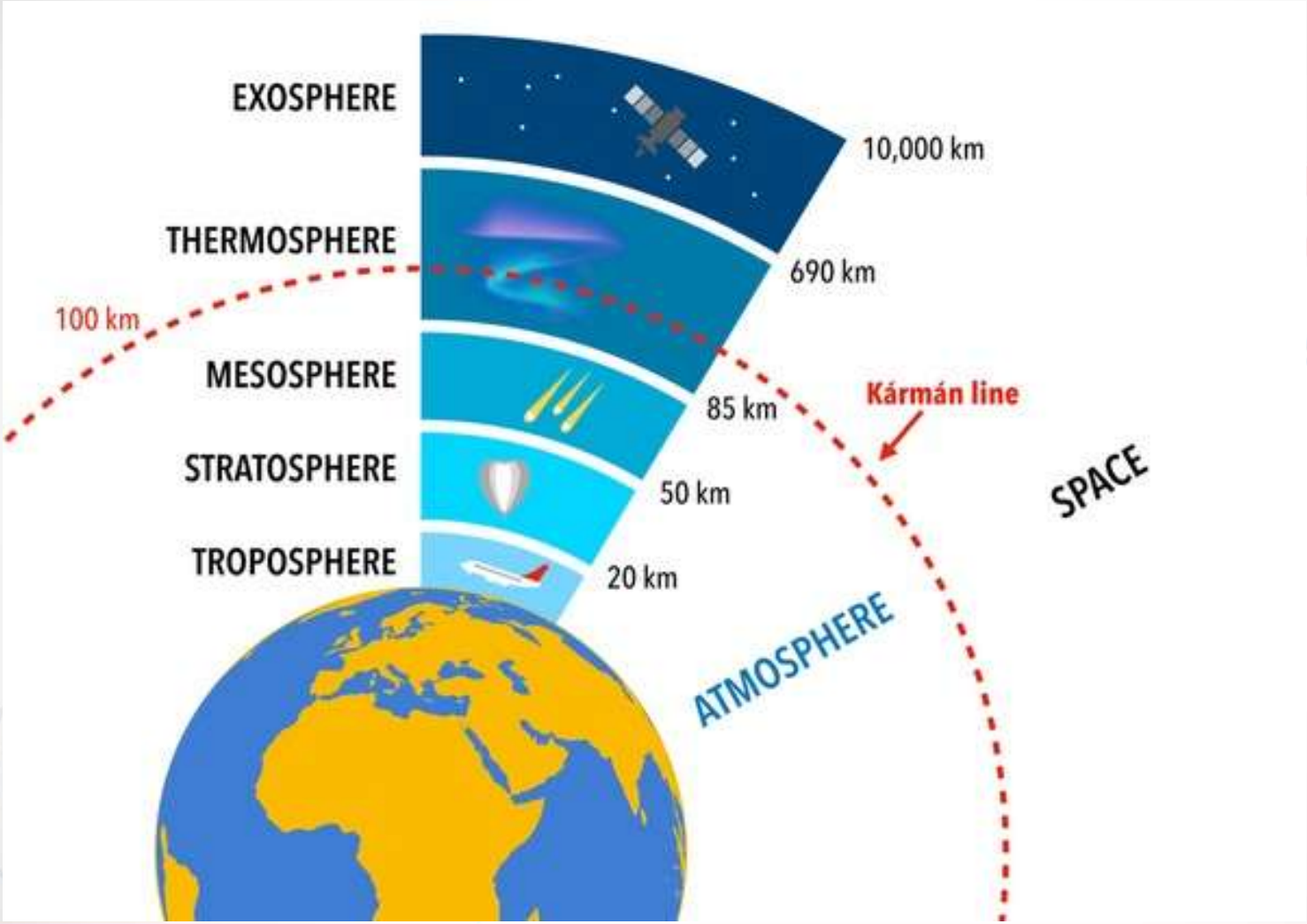


Parts of an Ellipse



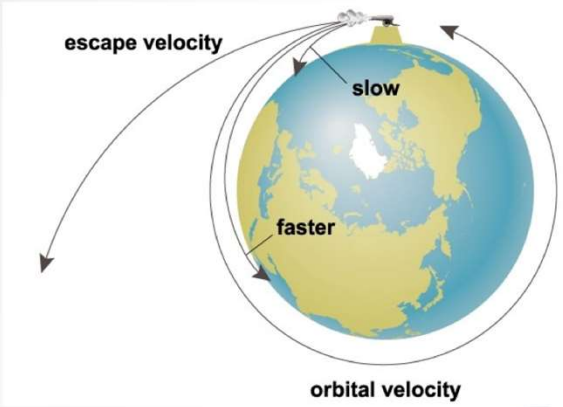


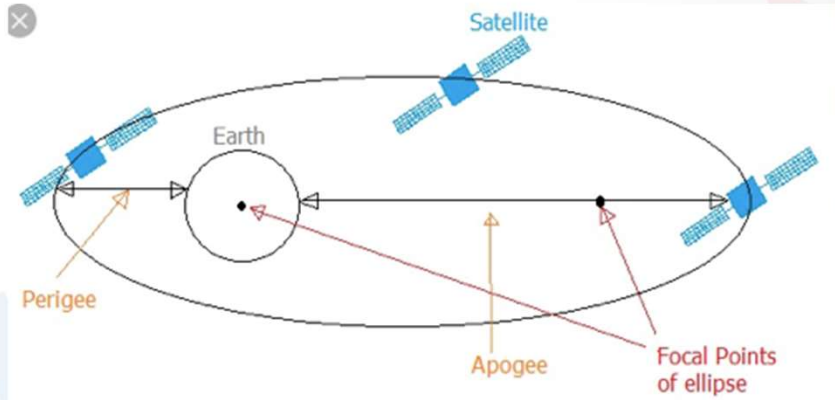




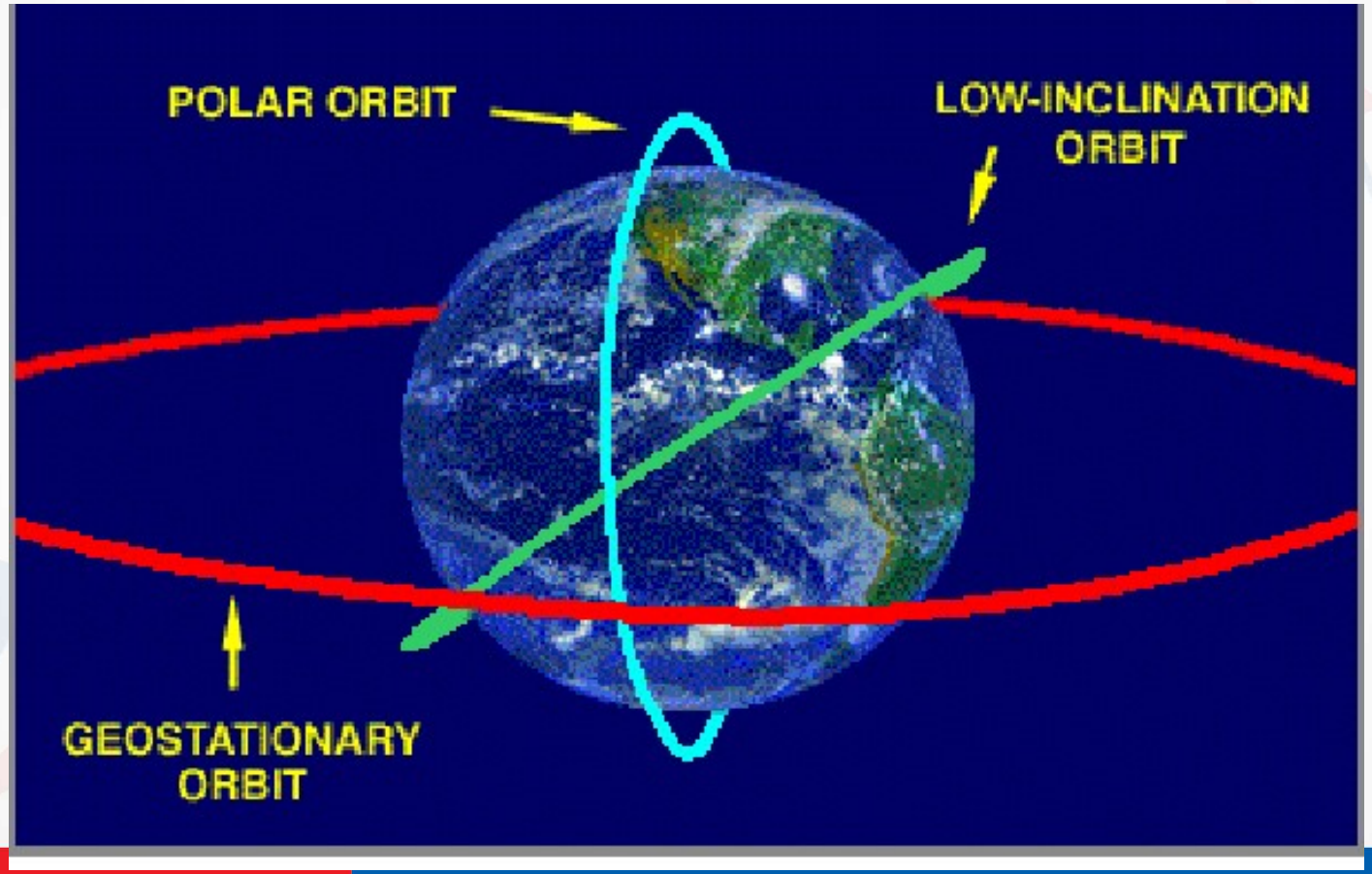
Karman Line

Orbits around Earth

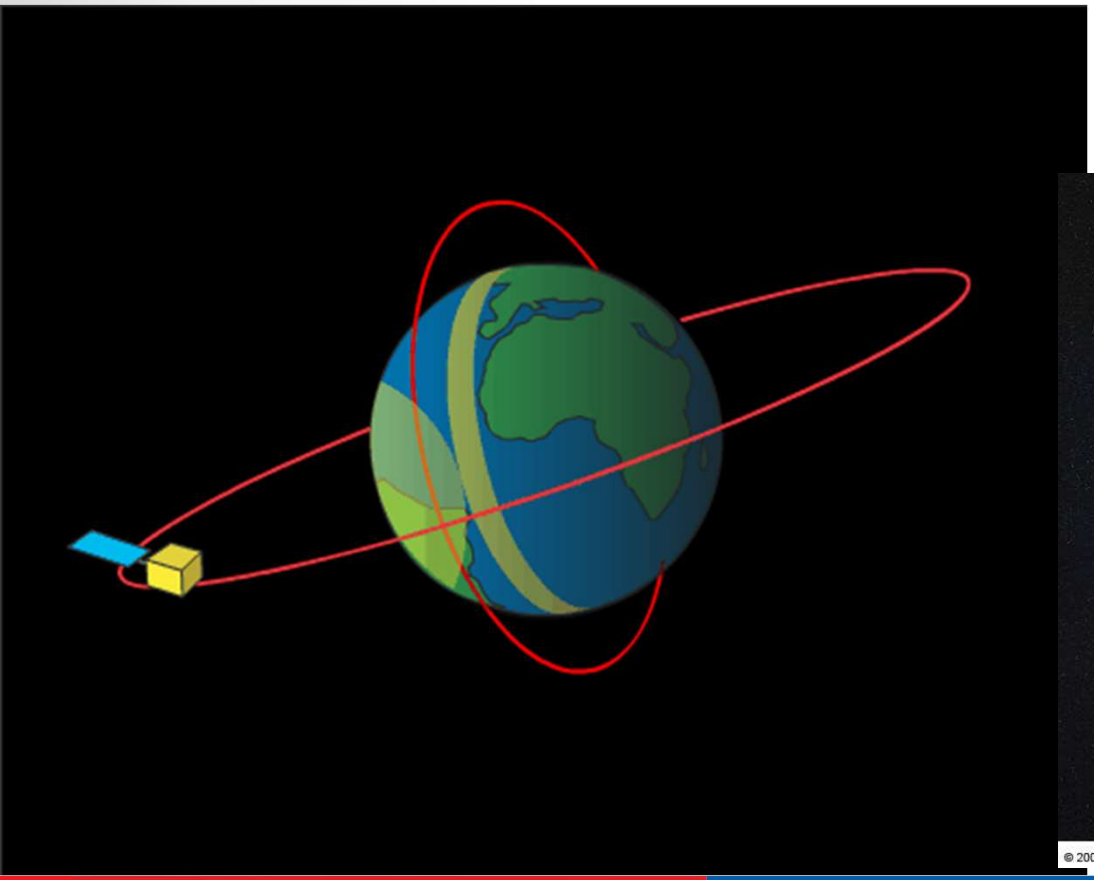


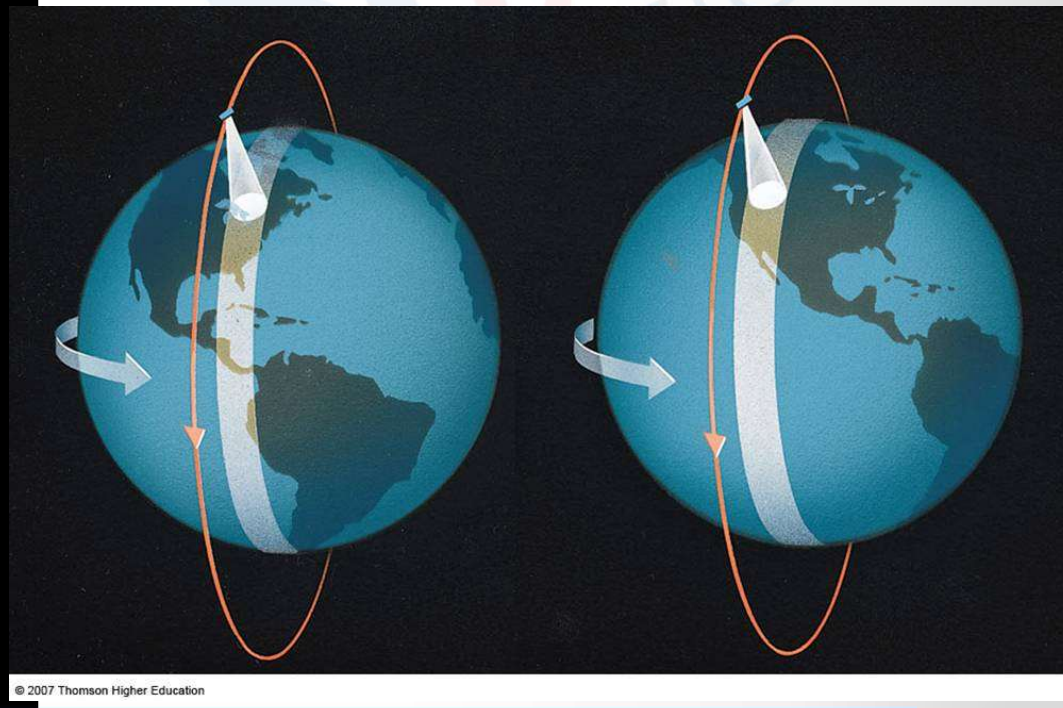


Inclination of Orbits

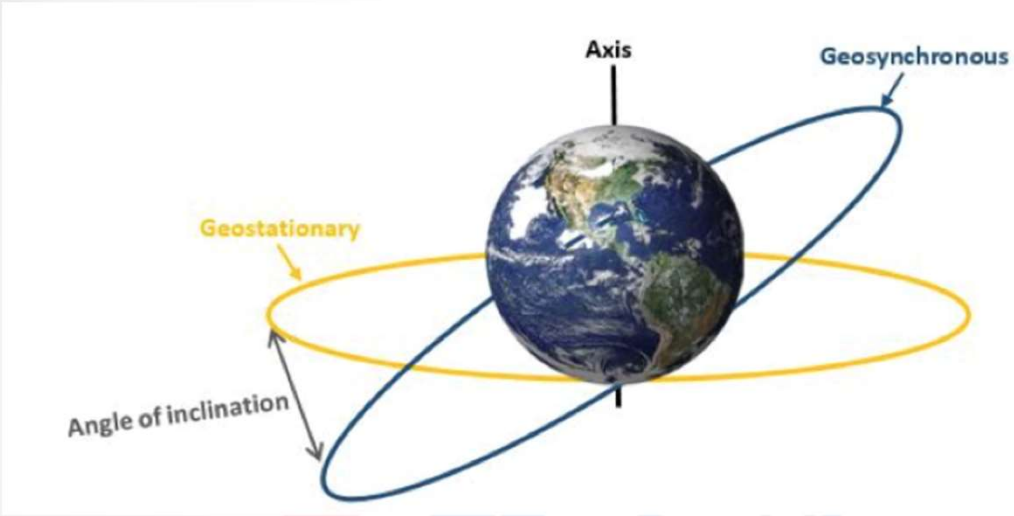


Polar Orbits





Geosynchronous, Geostationary and Geo Transfer orbit

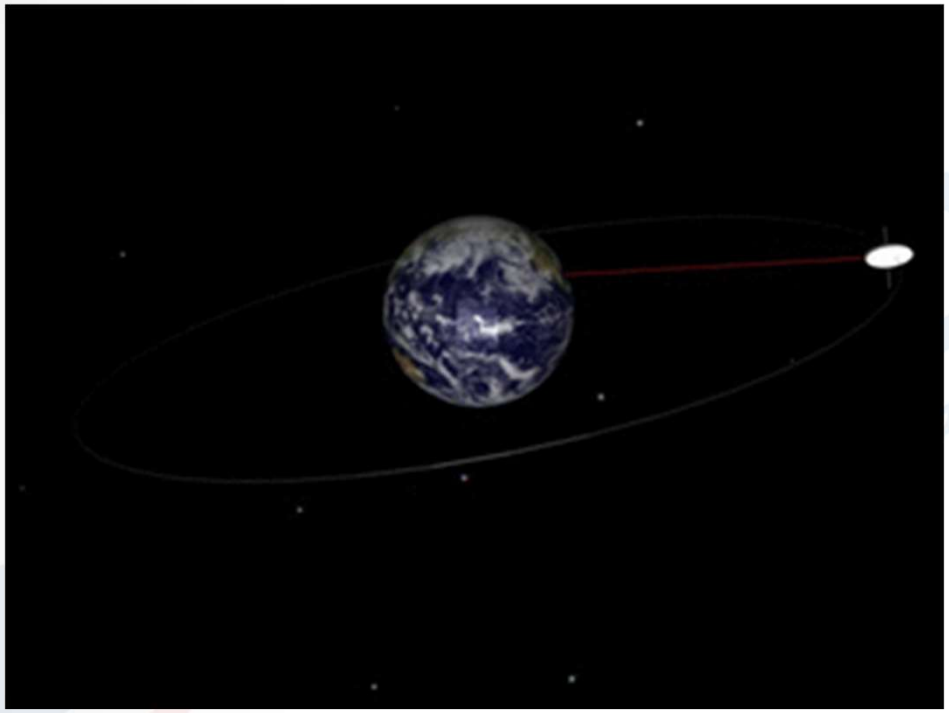


https://www.youtube.com/watch?v=6dISKhVdX7g&list=PLbwlDcoxvJYf0iV288yJTVIwpGEydfqFr&index=12&t=1s

Geosynchronous orbit

- satellite completes one orbit around the earth in one sidereal day (23 hours 59 minutes, 4.091 seconds)
- an altitude of about 35,786 km
- Communications and surveillance satellites

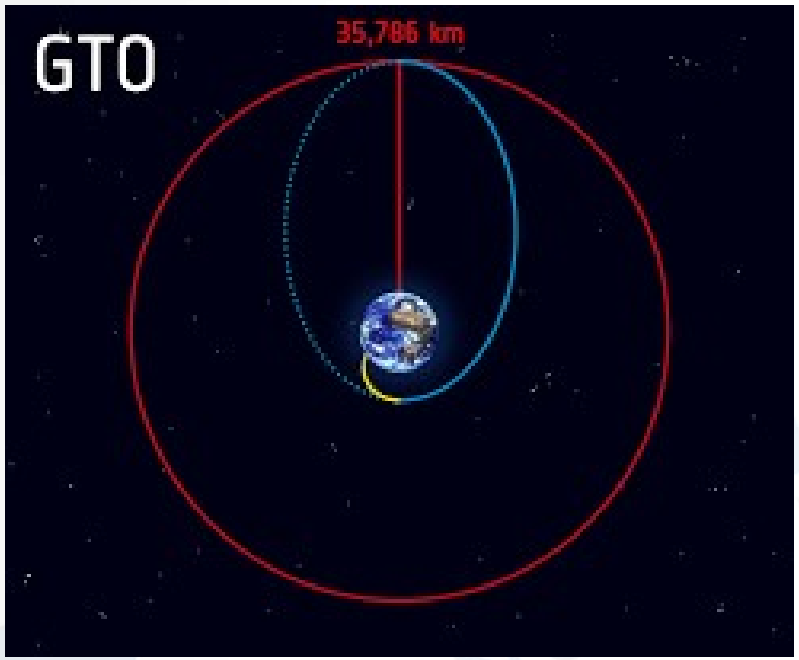
Geosynchronous, Geostationary and Geo Transfer orbit



Geostationary orbit

- Circular Orbit
- a special case of a geosynchronous orbit
- stay over the same point of the earth's equator
- Orbit lies in Equatorial plane

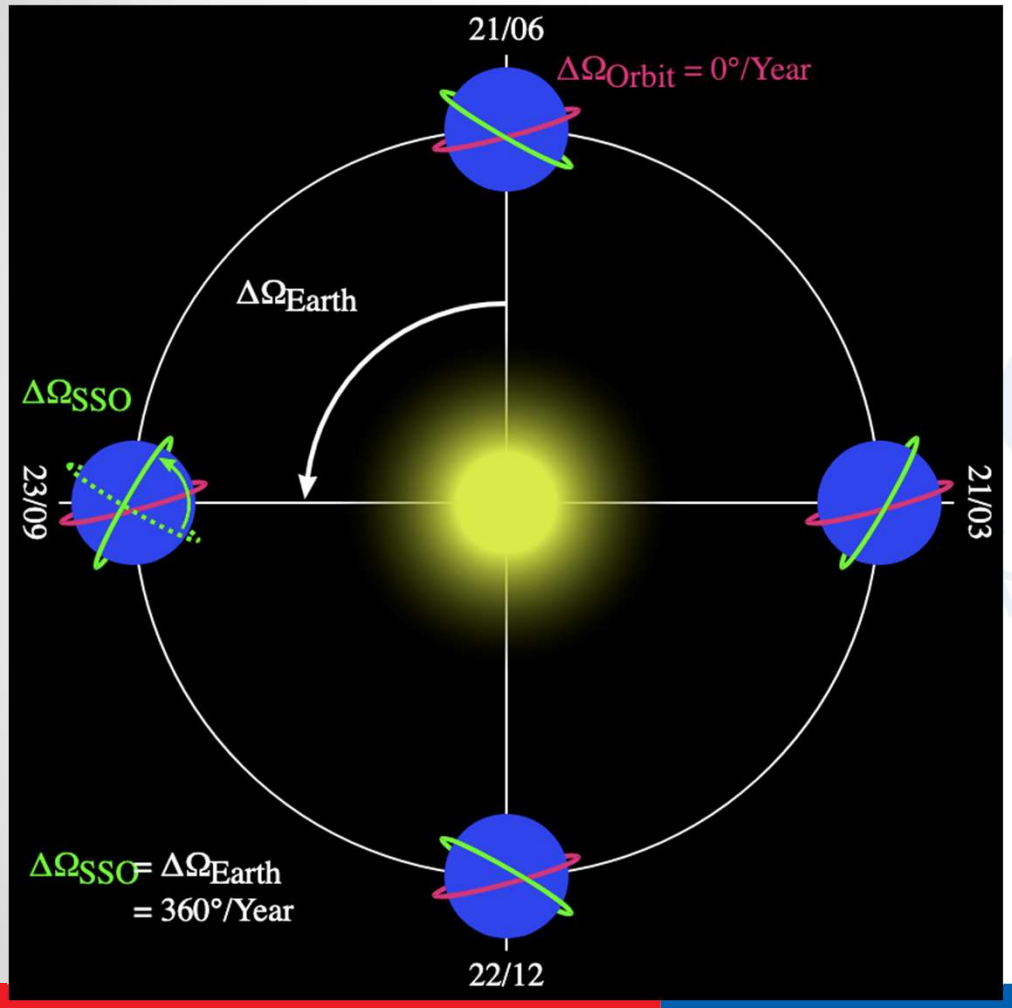
Geosynchronous, Geostationary and Geo Transfer orbit



Geo Transfer orbit

- an elliptical orbit used to transfer a spacecraft from a low altitude orbit or flight trajectory to geostationary/geosynchronous orbit.
- Apogee – 35,786 km

Polar Sun synchronous orbit (PSSO)

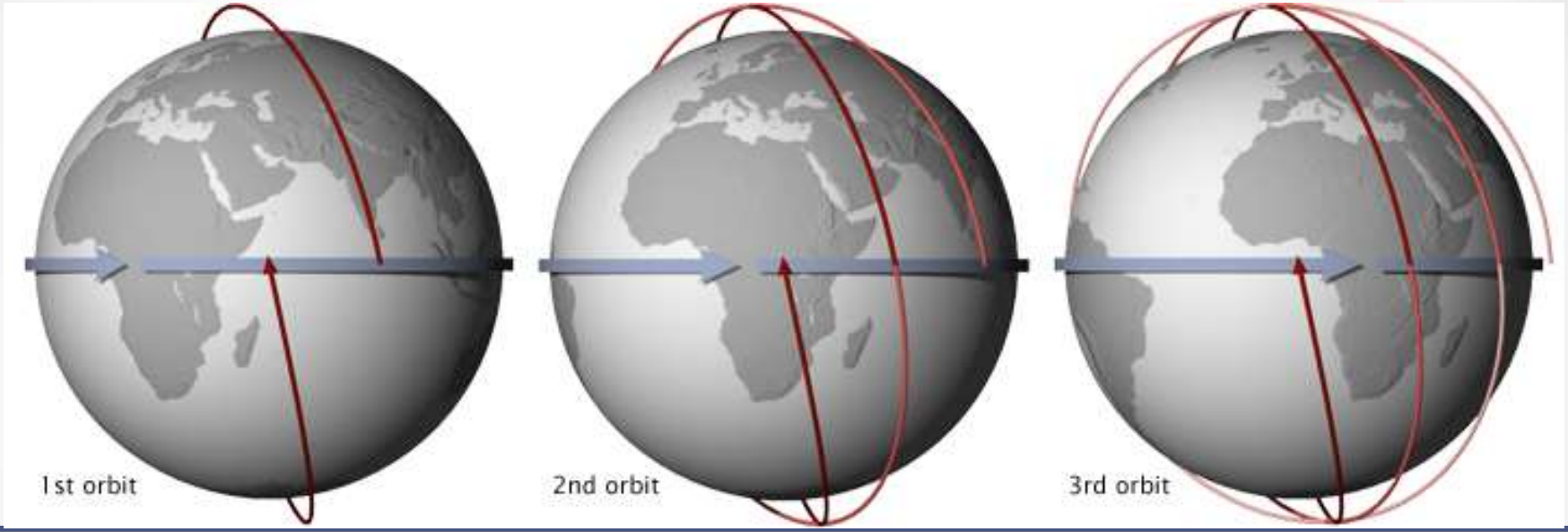


Polar Sun synchronous orbit

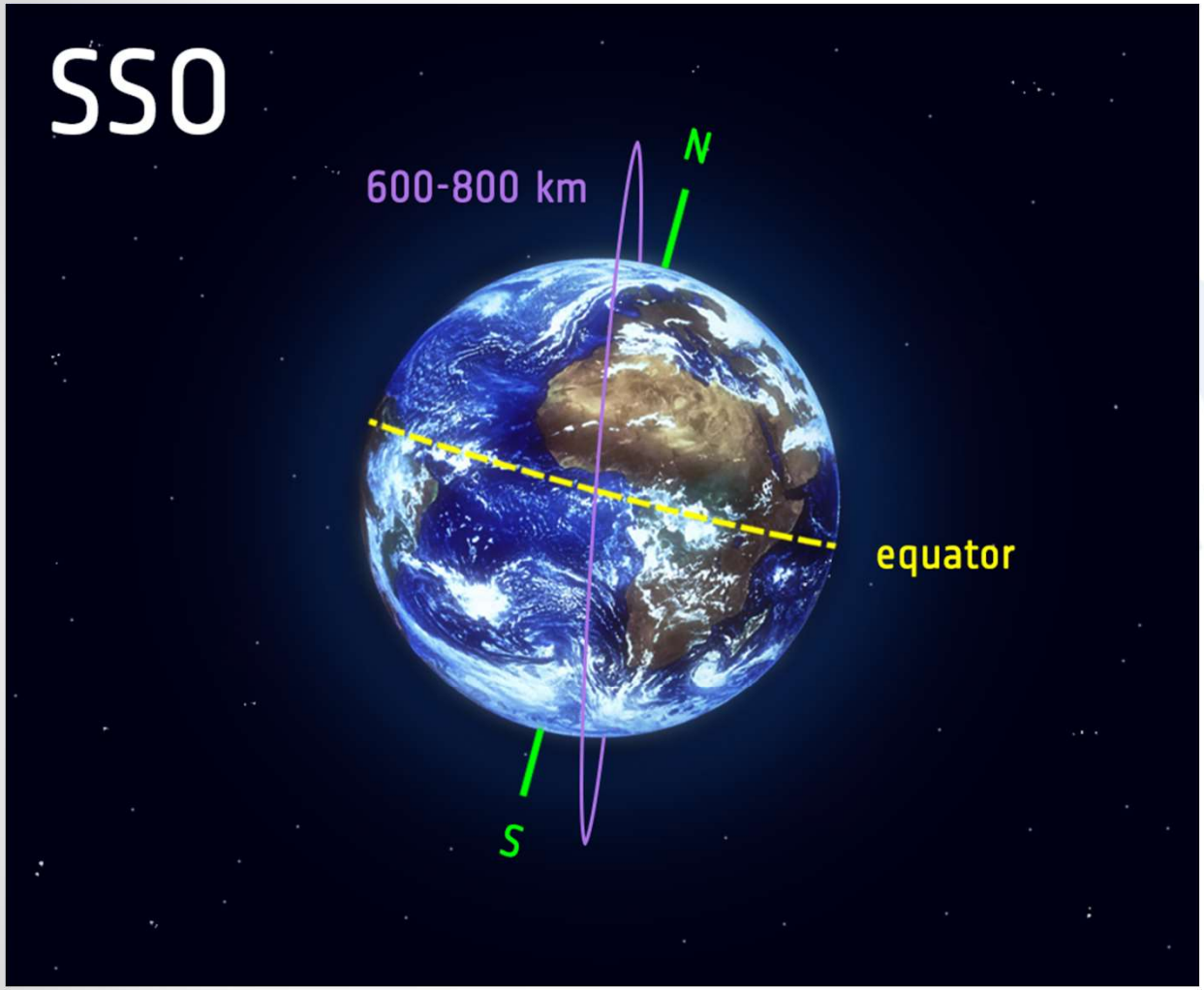
- satellite's orientation is fixed relative to the Sun throughout the year
- whenever the satellite observes a given ground location, the Sun is always in the same location in the sky.
- satellite passes over any given point of the planet's surface at the same local solar time.

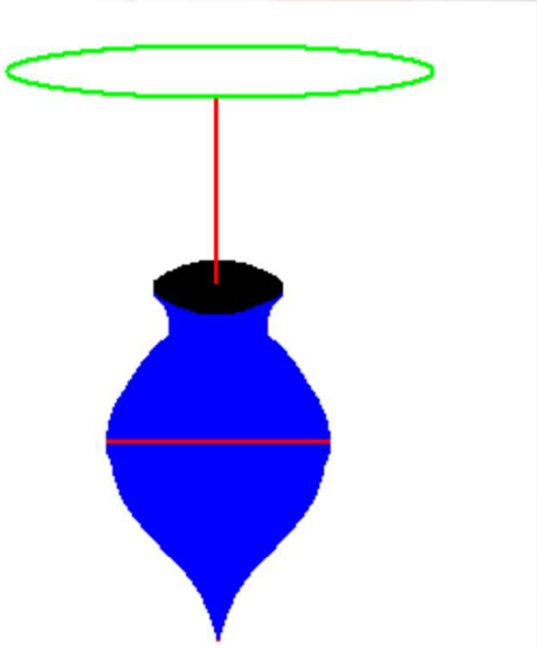
https://www.youtube.com/watch?v=tOp1UYbmp0Y

Polar Sun synchronous orbit (PSSO)



- This consistent lighting is a useful characteristic for satellites that image the Earth's surface
- can compare images from the same season over several years
- very useful thing for a weather or Earth Observation/Remote Sensing satellite
- precession of the orbital plane around the Earth due to gravitational irregularities keeps the plane at a constant angle with respect to a line between the Earth and Sun throughout the year.
- 96–98°, LEO


SSO
600-800 km
N
equator
S



UPSC Prelims Questions

An artificial satellite orbiting around the Earth does not fall down. This is so because the attraction of Earth.

(a) Does not exist at such distance

(b) Is neutralized by the attraction of the moon

(c) Provides the necessary speed for its steady motion

(d) Provides the necessary acceleration for its motion

Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when

1. The orbit is geosynchronous.

2. The orbit is circular.

3. The orbit lies in the plane of the Earth's equator.

4. The orbit is at an altitude of 22,236 km.

Select the correct answer using the codes given below:

(a) 1,2 and 3 only

(b) 1, 3 and 4 only

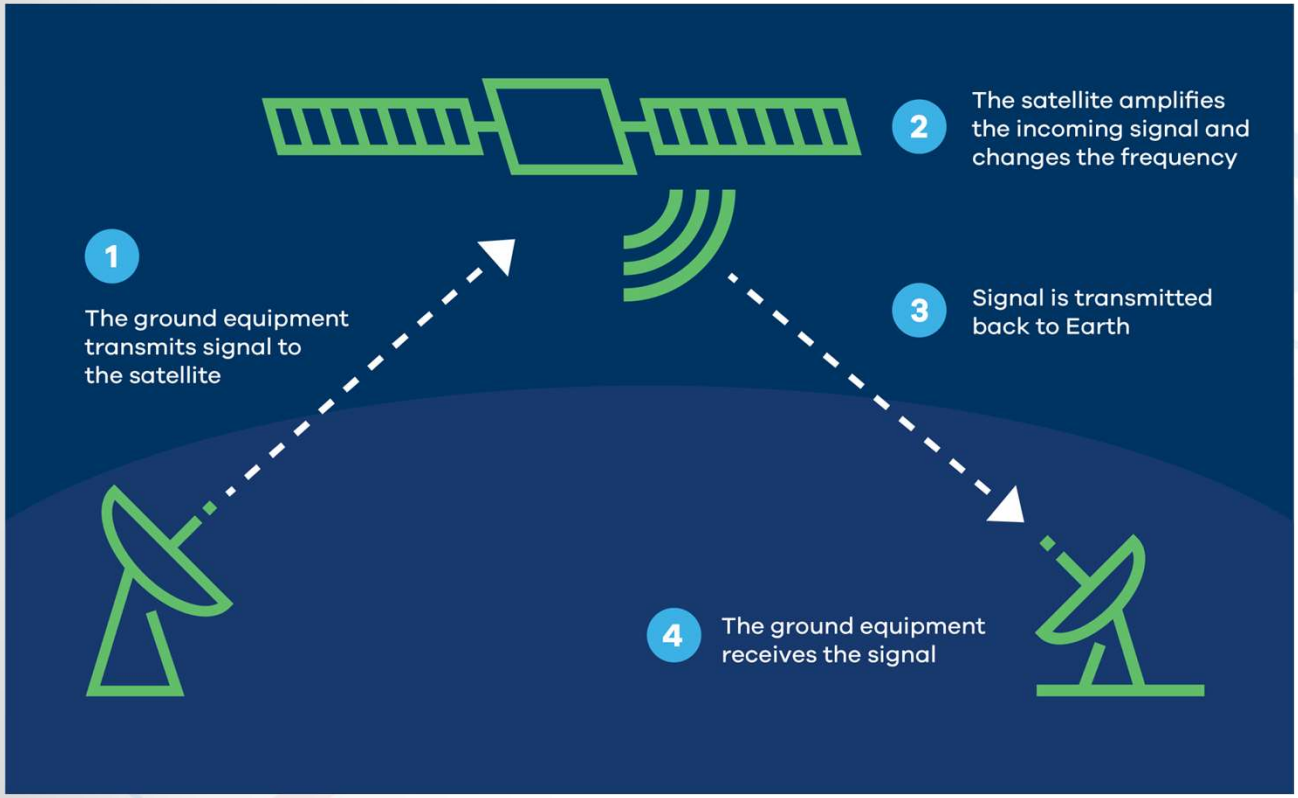
(c) 2 and 4 only

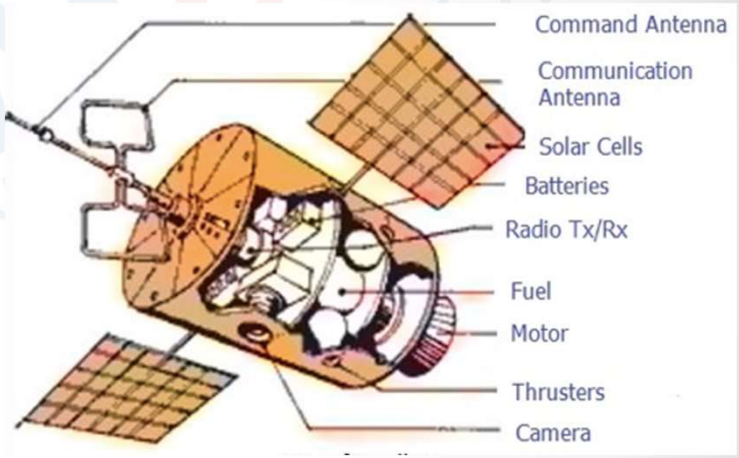
(d) 1, 2, 3 and 4

ISRO Classification of Satellites

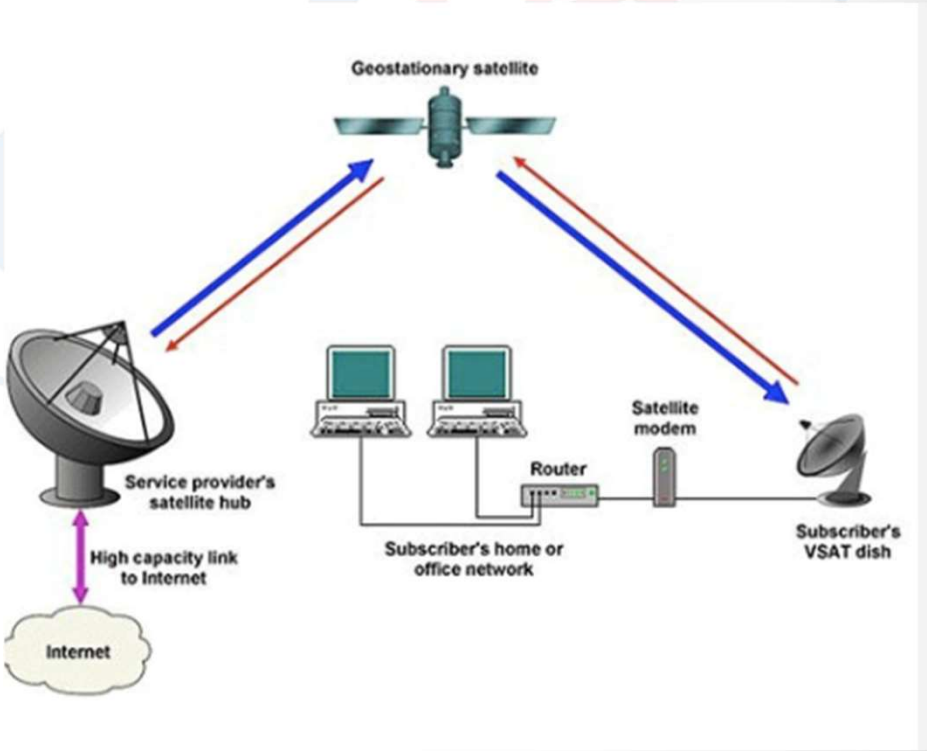
- Communication
- Earth Observations
- Navigation
- Space Science
- Experimental
- Small Satellite
- University / Academic Institute Satellites

Communication Satellites

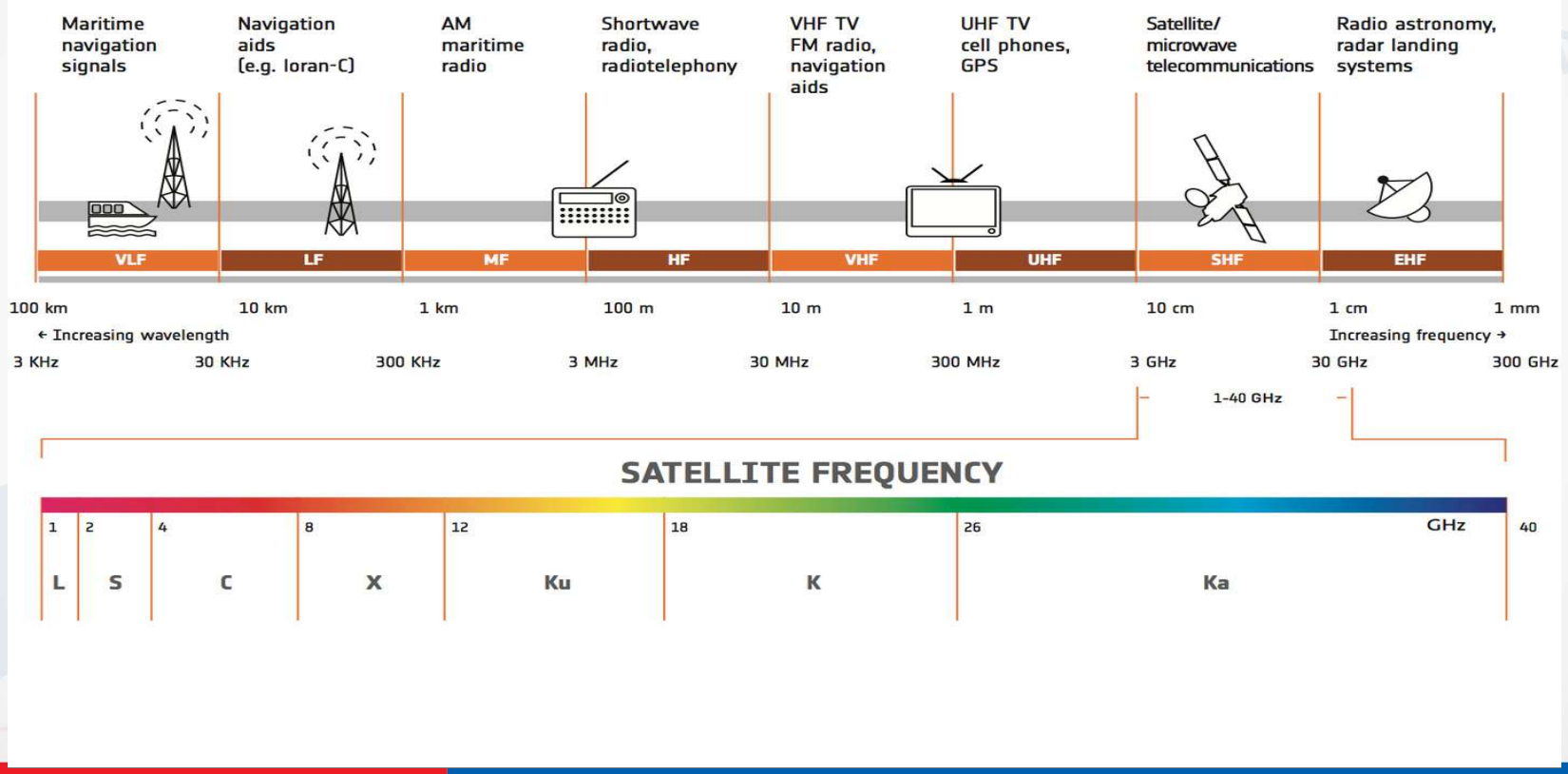




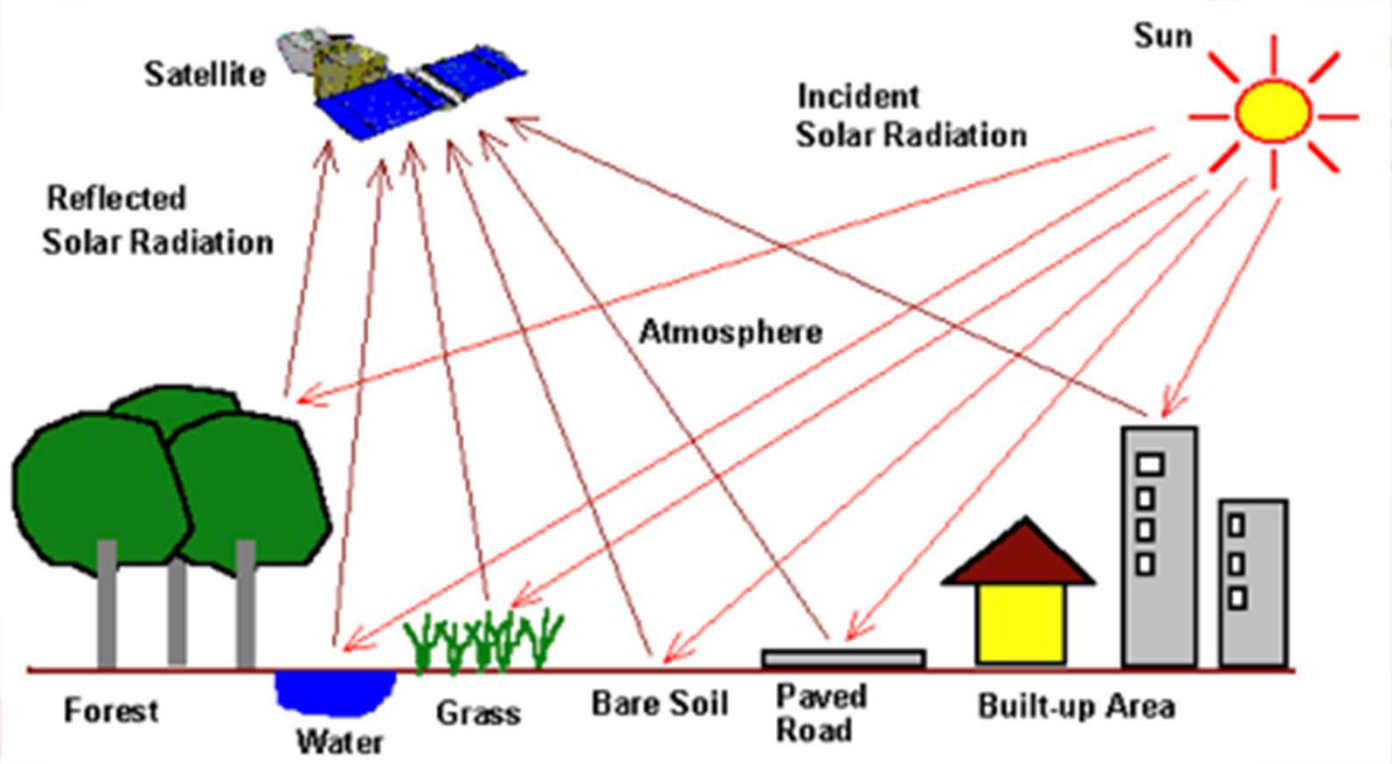
VSAT

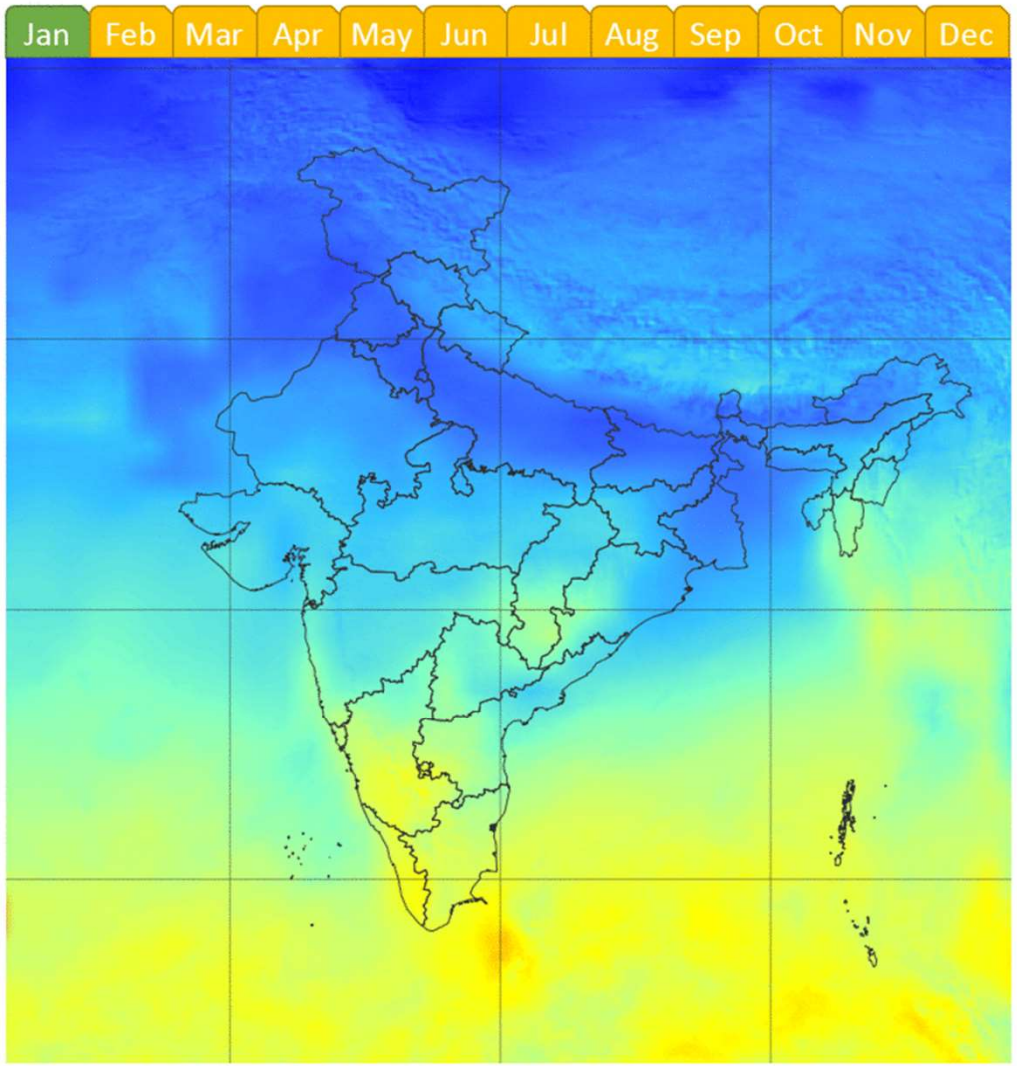


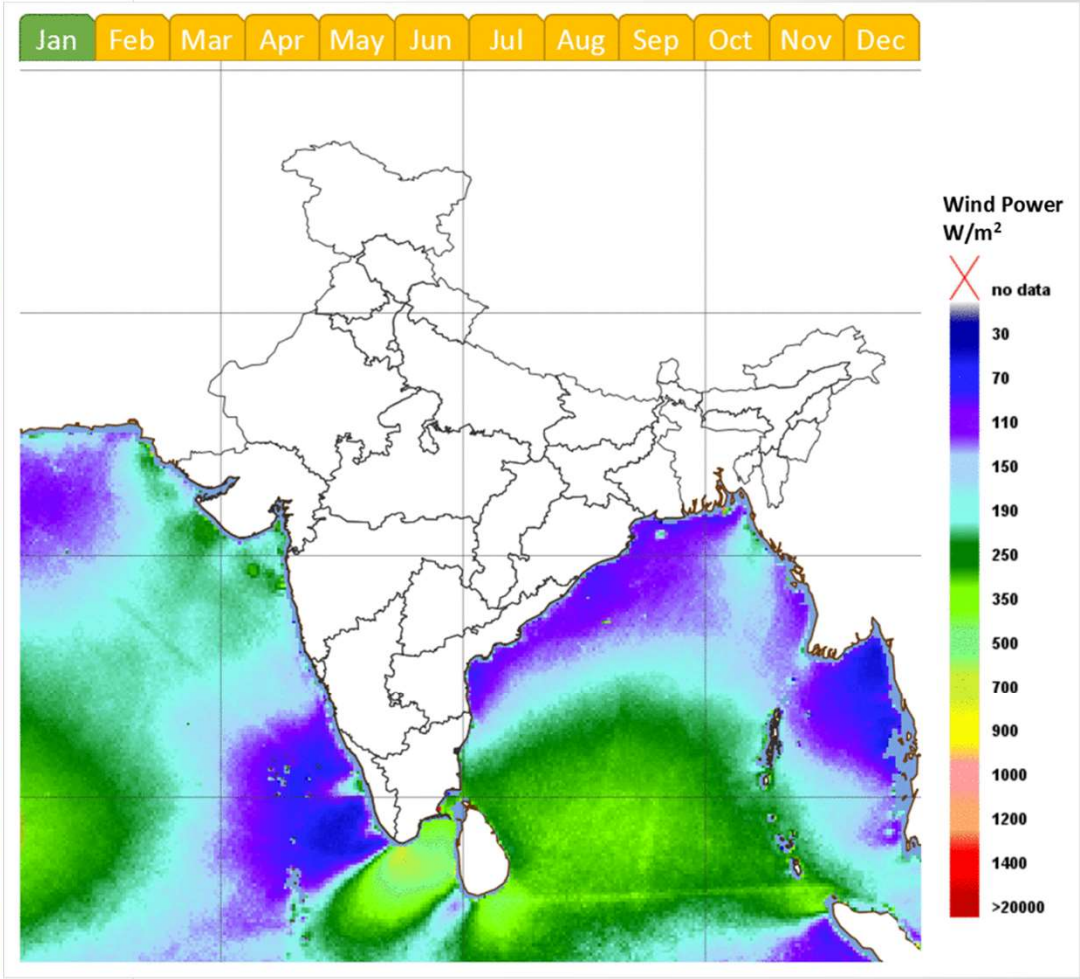
Satellite frequency

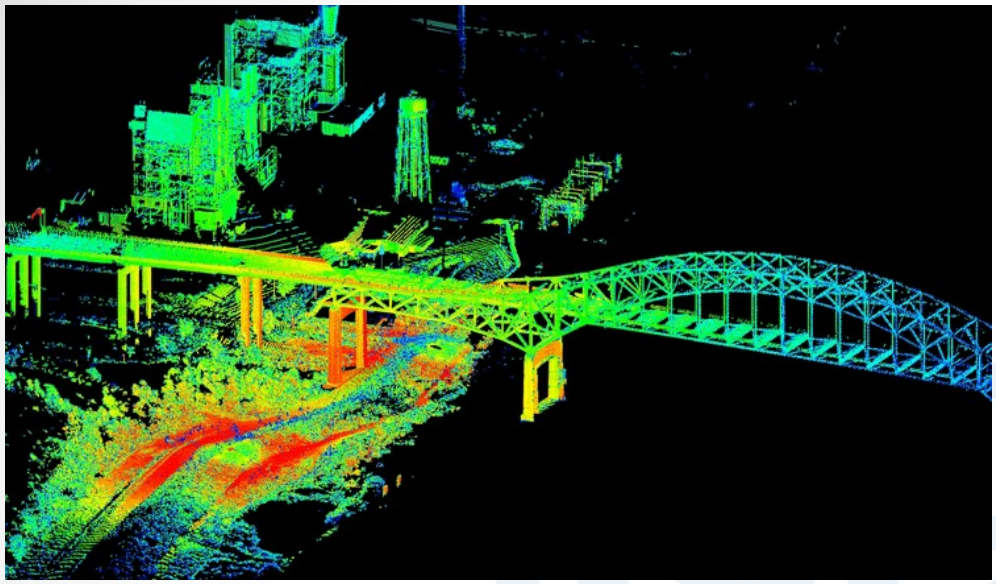


Remote sensing satellite

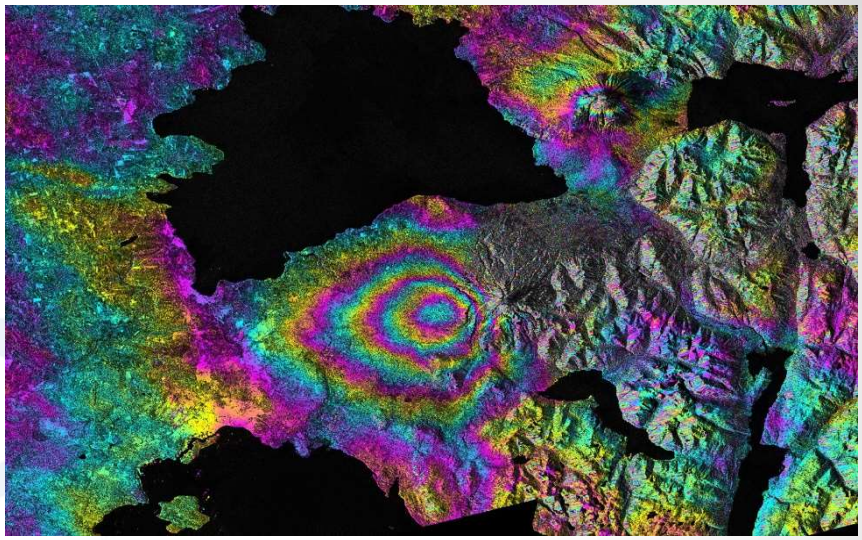




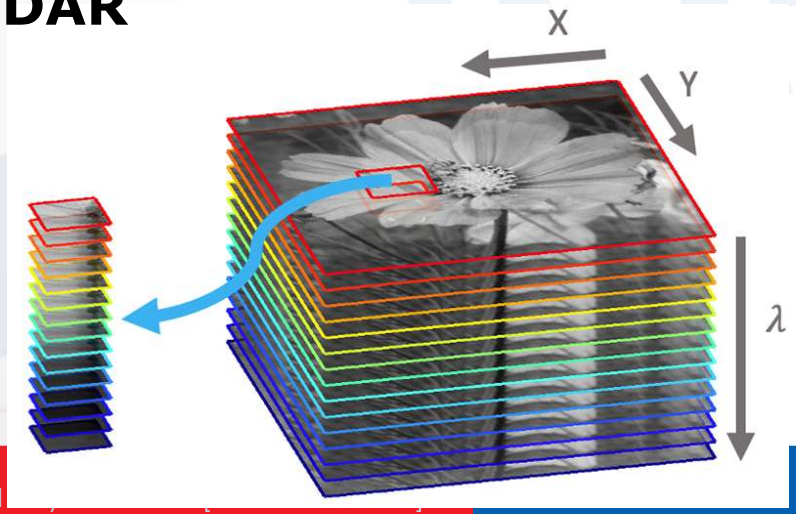




LIDAR



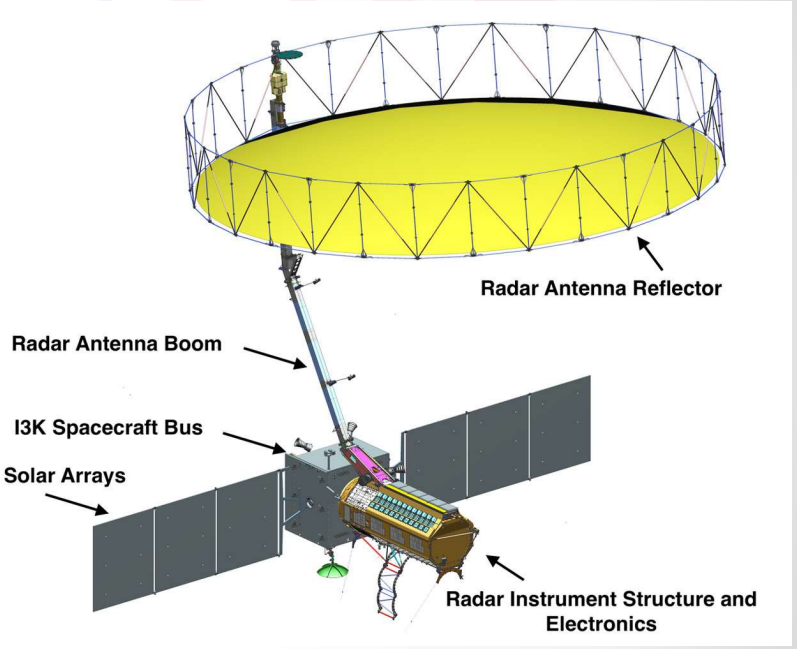
Synthetic Aperture Radar



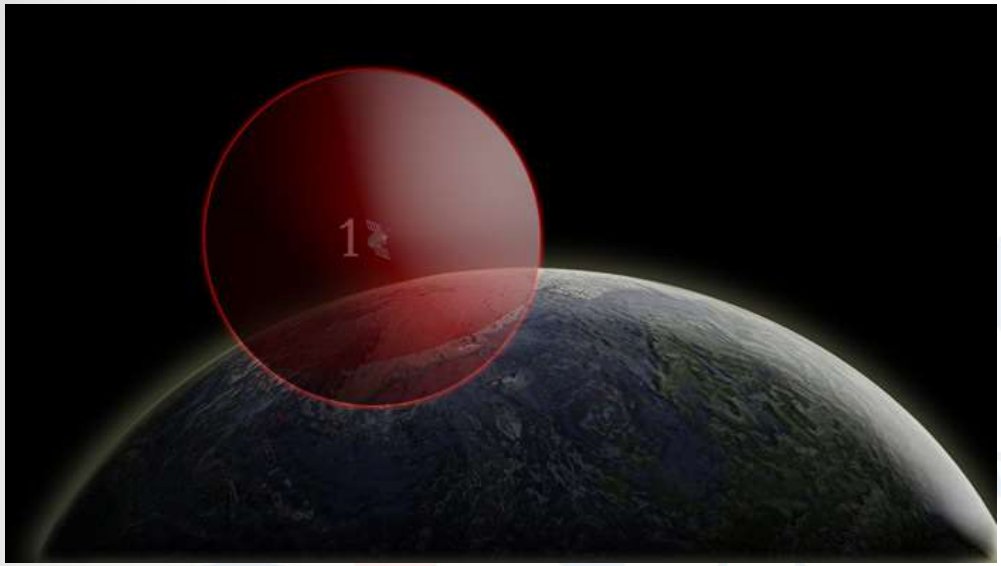
Hyperspectral Imaging

NISAR Mission

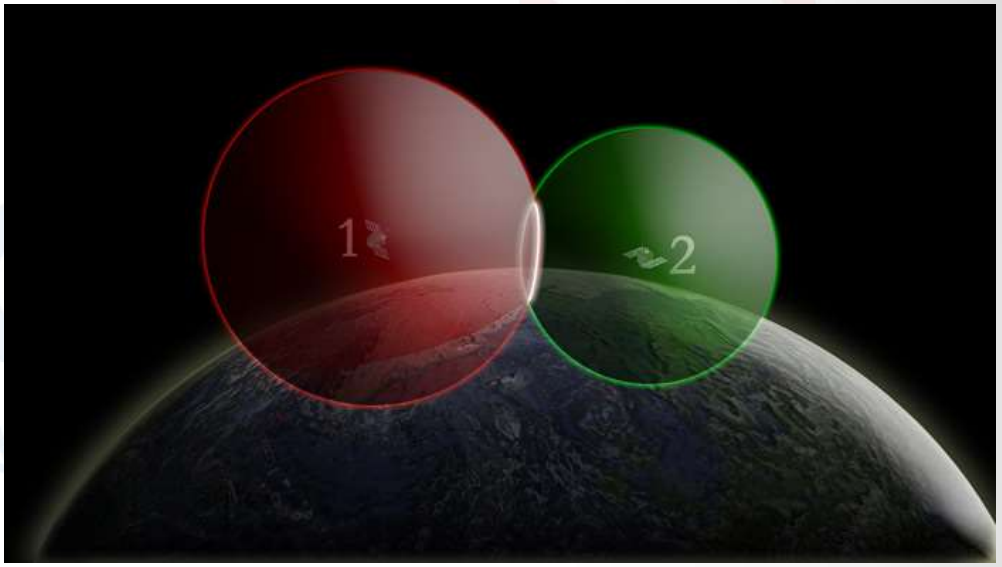
- NASA-ISRO Synthetic Aperture Radar
  - a technique for producing fine-resolution images
  - It requires that the radar be moving either on an airplane or orbiting in space.
- **dual frequency L-band and S- band radar mission**
- map Earth every 12 days from two directions.
- **studying hazards and global environmental change**
  - ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides



Satellite Navigation

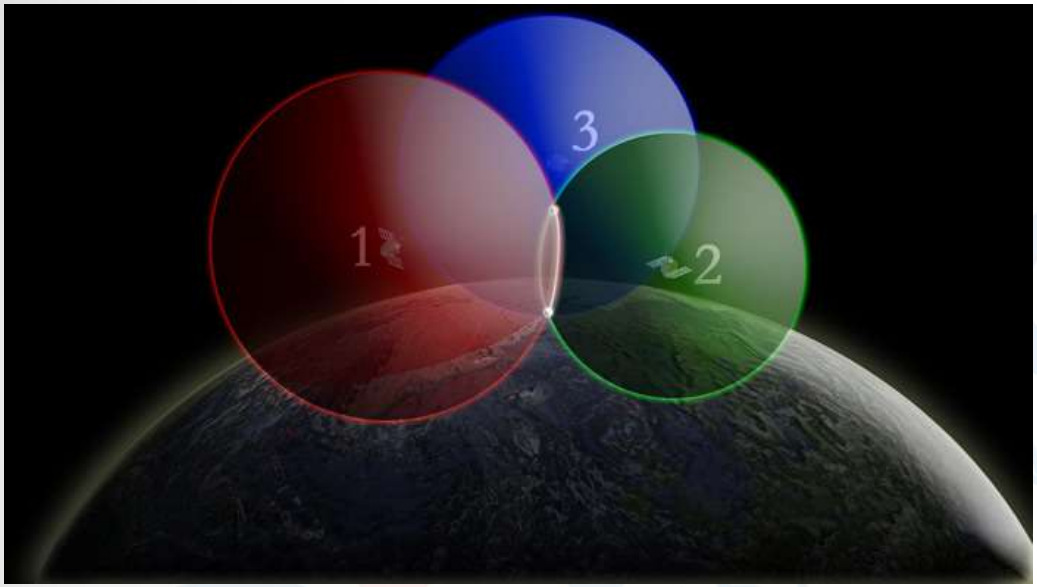


- It takes four GPS satellites to calculate a precise location
- three to determine a position on the Earth, and one to adjust for the error in the receiver's clock

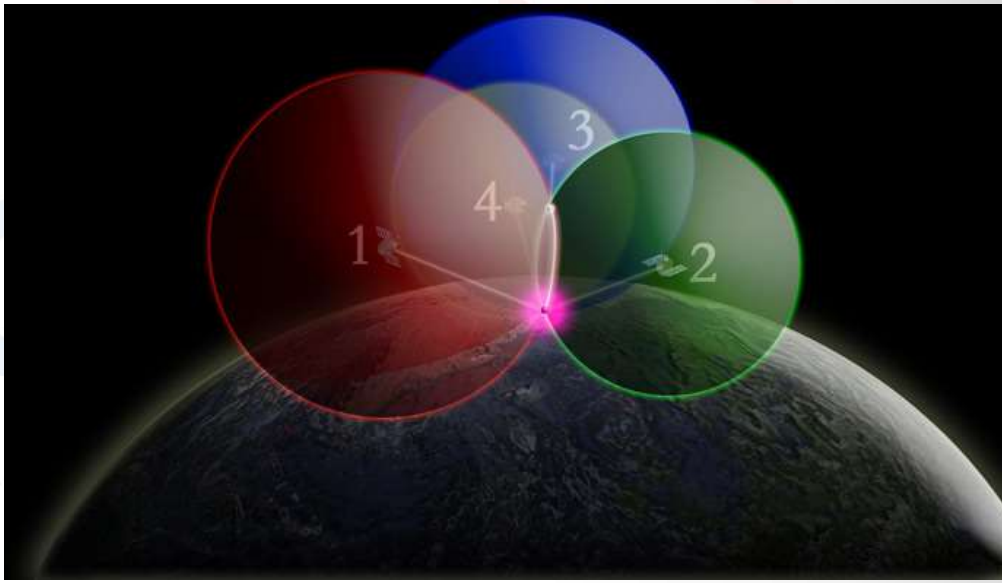


- With one satellite you could be anywhere on an imaginary red sphere.
- Add a second satellite (green sphere), you can only be where these two imaginary spheres intersect

Satellite Navigation



- Add a third satellite (blue sphere) and In this situation, there are only two points (the two white points) where you could possibly be



- To correct for the GPS receiver's clock error and find your precise position, a fourth satellite (yellow sphere) must be used.

IRNSS

Indian Regional Navigation Satellite System

IRNSS (NavIC) is designed to provide accurate real-time positioning and timing services to users in India as well as region extending up to 1,500 km from its boundary

NAVIGATION CONSTELLATION CONSISTS OF SEVEN SATELLITES

3 in geostationary earth orbit (GEO) and **4** in geosynchronous orbit (GSO) inclined at 29 degrees to equator

Each sat has three rubidium atomic clocks, which provide accurate locational data

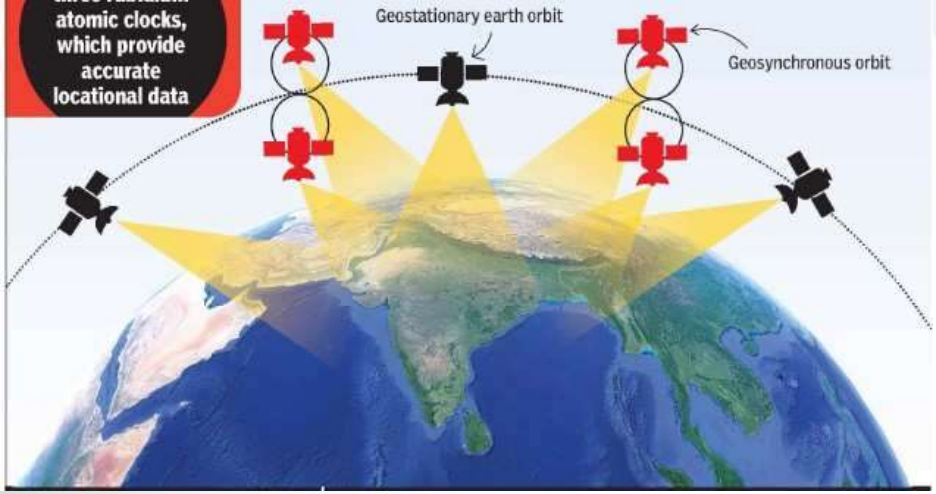
IT WILL PROVIDE TWO TYPES OF SERVICES

1 **Standard positioning service** | Meant for all users

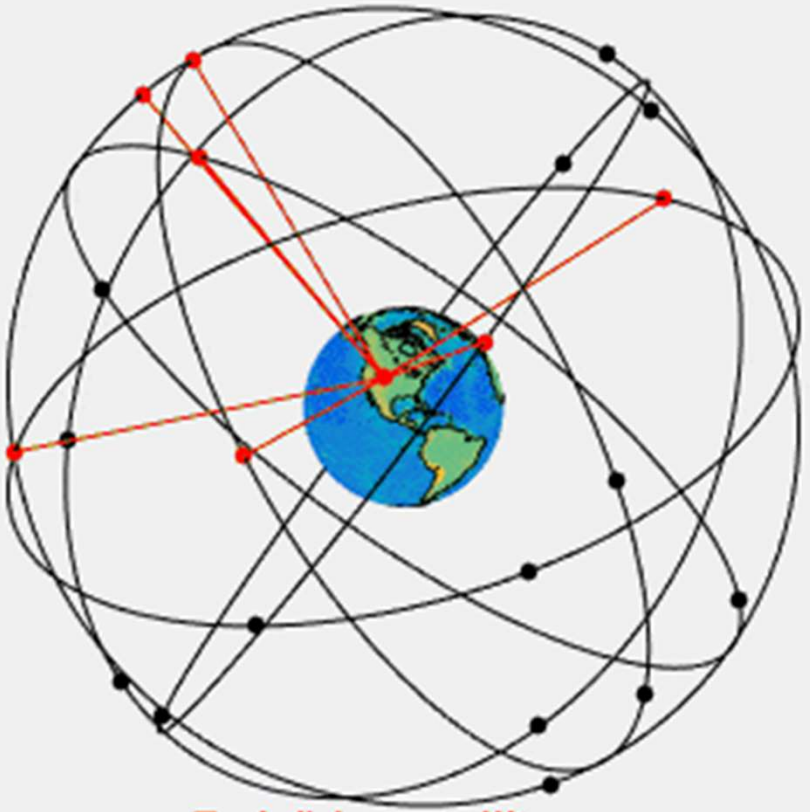
2 **Restricted service** | Encrypted service provided only to authorised users (military and security agencies)

Applications of IRNSS are: Terrestrial, aerial and marine navigation; disaster management; vehicle tracking and fleet management; precise timing mapping and geodetic data capture; terrestrial navigation aid for hikers and travellers; visual and voice navigation for drivers

While **American GPS** has **24 satellites** in orbit, the number of sats visible to ground receiver is limited. In **IRNSS, four satellites** are always in geosynchronous orbits, hence always visible to a receiver in a region **1,500 km** around India



GPS



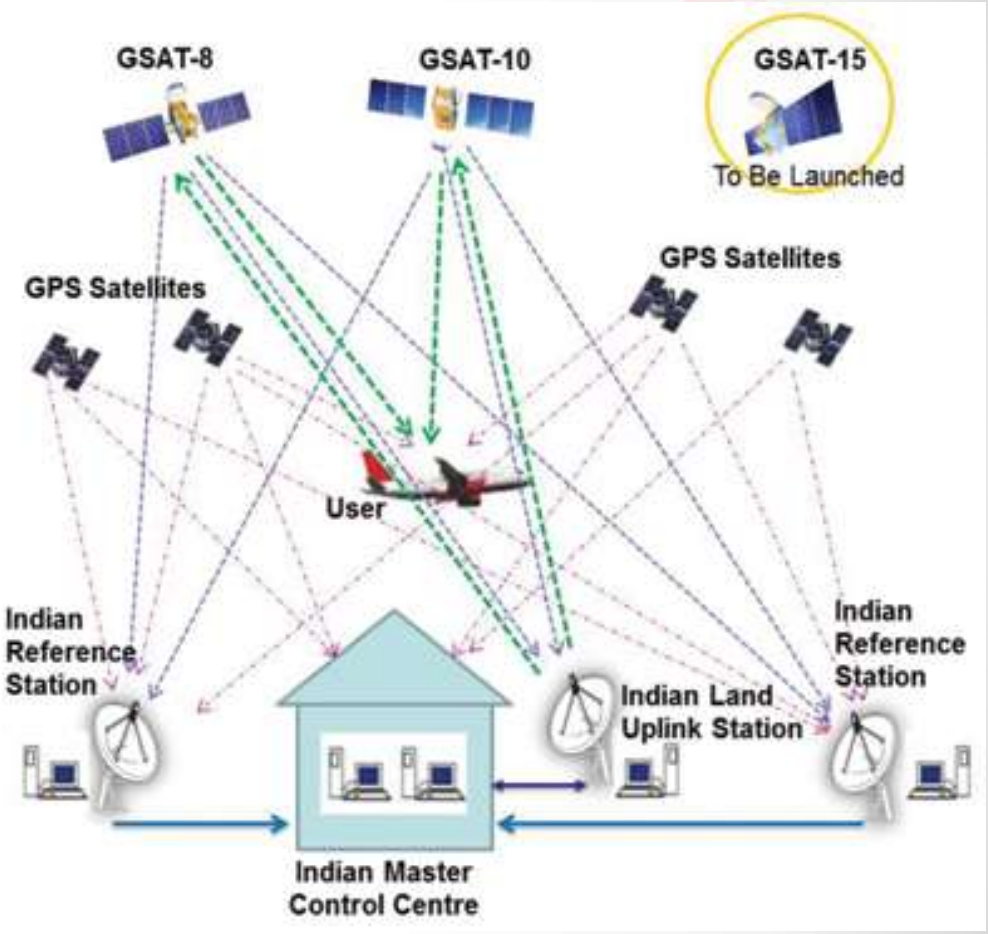
7 visible satellites

NAVIC

- an independent regional navigation satellite system being developed by India
- to provide Reliable **Position, Navigation and Timing** services over India and its neighbourhood
- **1500 km beyond border**
- consists of the IRNSS constellation of seven satellites
- 3 satellites in the geostationary orbit and the remaining 4 in geosynchronous orbits
- **Standard Positioning and Restricted Services**

GAGAN

- Airports Authority of India (AAI) and ISRO
- to provide Satellite-based Navigation services for civil aviation applications
- to provide better Air Traffic Management over Indian Airspace



EVOLUTION OF THE INDIAN LAUNCH VEHICLE

Satellite Launch Vehicle (SLV-3):

Height: 22m

Fuel: Four solid stages

Weight: 17 tonnes

Capability: Placing 40kg class payloads in low earth orbit

Augmented Satellite Launch Vehicle

Height: 23.8m

Weight: 40 tonnes, 23.8 m tall

Fuel: Five stage, all-solid propellant

Capability: Orbiting 150kg class satellites into 400km circular orbits

Polar Satellite Launch Vehicle

Height: 44.4m

Weight: 295 tonnes

Capability: 1600kg satellites in 620km sun-synchronous polar orbit and 1,050kg satellite in geo-synchronous transfer orbit (GTO)

Fuel: Four stages using solid and liquid propulsion systems alternately

GSLV Mark I and II

Height: 49 m

Weight: 414 tonne

Capability: Placing INSAT-II class of satellites (2000 – 2,500kg) into GTO

Fuel: Three stages, S125 solid booster with four liquid (L40) strap-ons, GS2 liquid engine and GS3 cryogenic stage

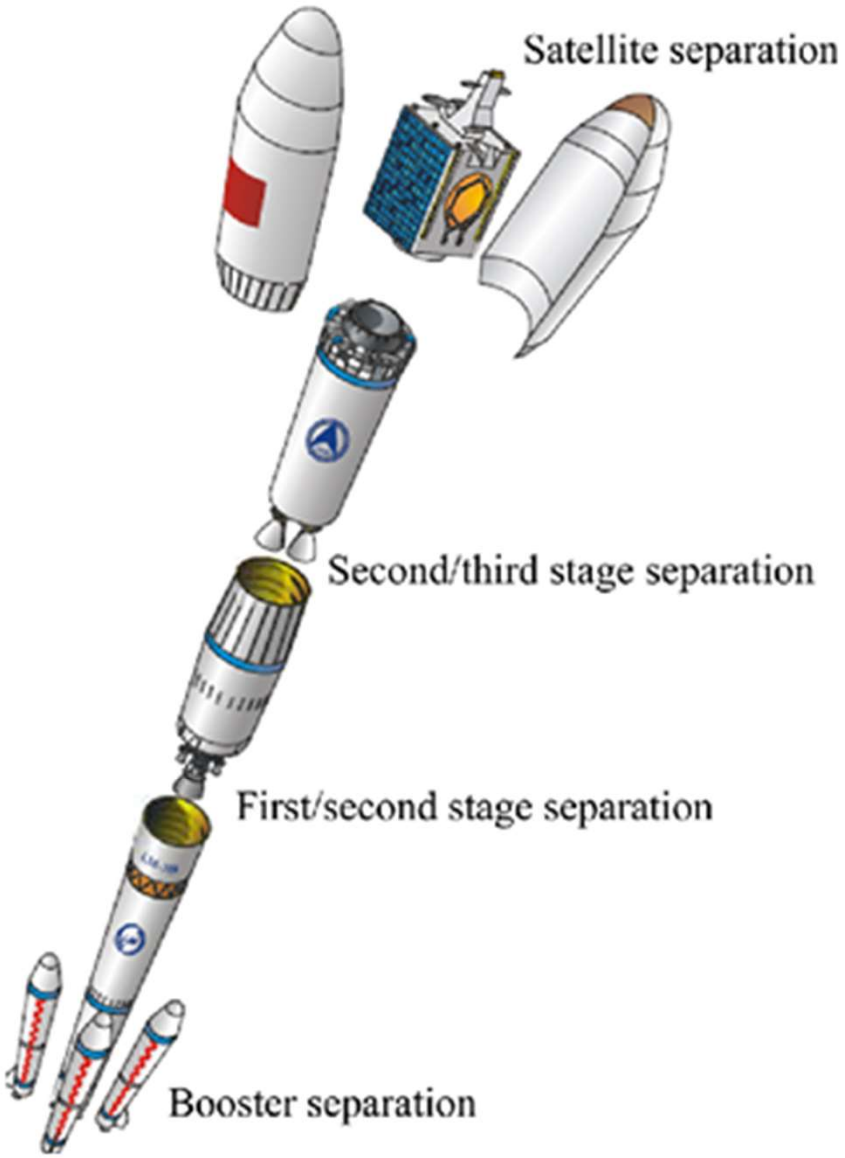
GSLV Mark III

Height: 42.4m

Weight: 630 tonnes

Fuel: Three stage; two identical S200 Large Solid Booster (LSB) with 200 tonne solid propellant, the L110 re-startable liquid stage, the cryogenic stage

Capability: Placing communication satellites of INSAT-4 class, weighing 4,500-5,000kg in GTO, LEO, polar and intermediate circular orbits



Stages of a Launch vehicle

https://www.youtube.com/watch?v=n0HnrG6xafU&t=3525s

33:47 T-10
33:57 LIFTOFF
35:50 STAGE 2 SEPERATION
36:55 FAIRING SEPERATION
38:17 STAGE 3 SEPERATION
40:27 ENGINE CUTOFF
43:44 STAGE 4 SEPERATION
48:48 STAGE IGNITION
50:59 ENGINE CUTOFR
51:57 SATTELITE SEPERATION 1
53:16 SATTELITE SEPERATION 2

PSLV

- 1750 kg payload to 600 km
- 1425 kg to GTO
- 4 statge: S-L-S-L
- For LEO

GSLV MK II

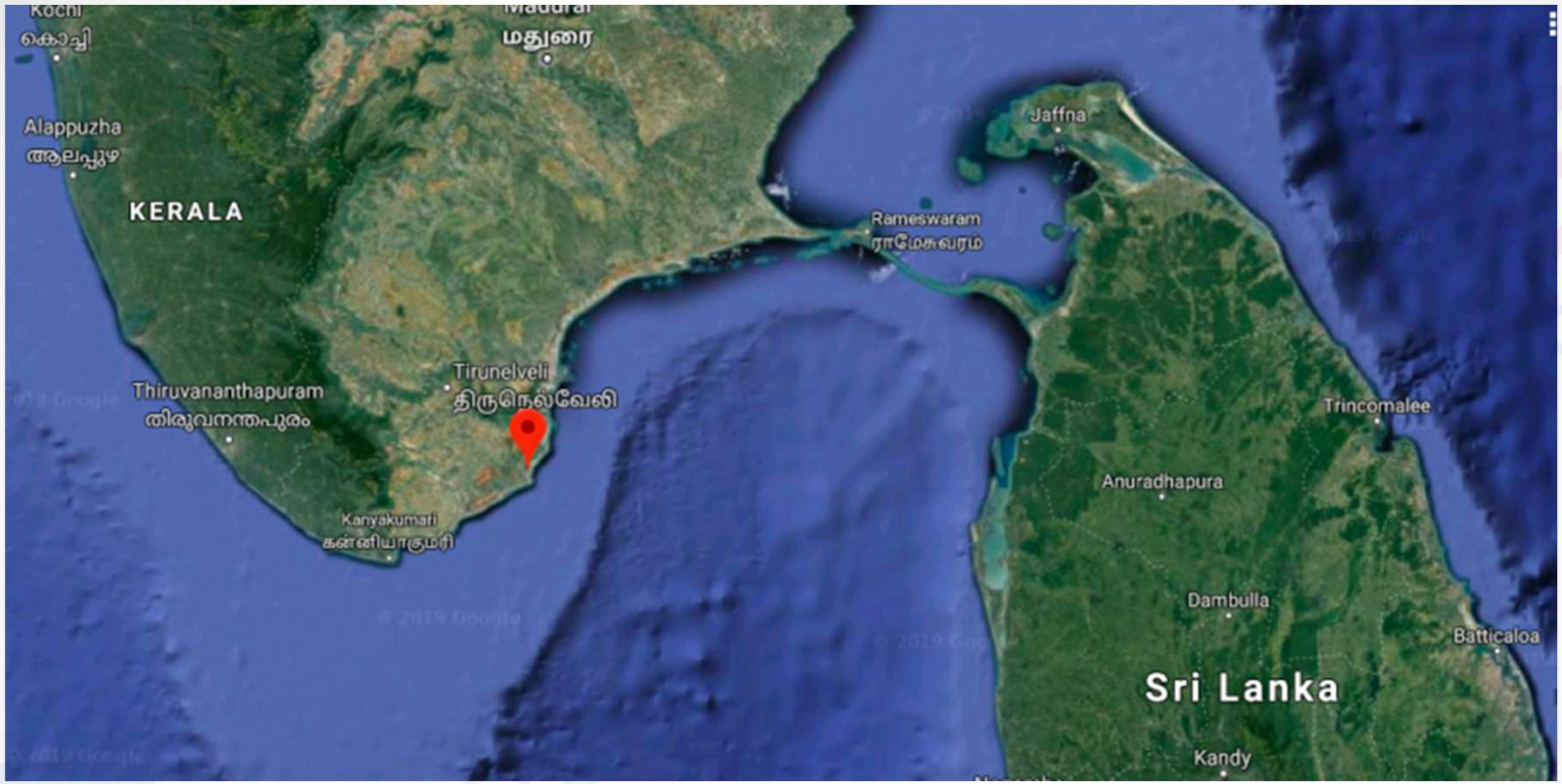
- 6000 kg payload to LEO
- 2,250 kg to GTO
- S-L-C

LVM 3 (GSLV MK III)

- 8000 kg payload to 600 km
- 4000 kg to GTO
- 3 stage: S-L-C

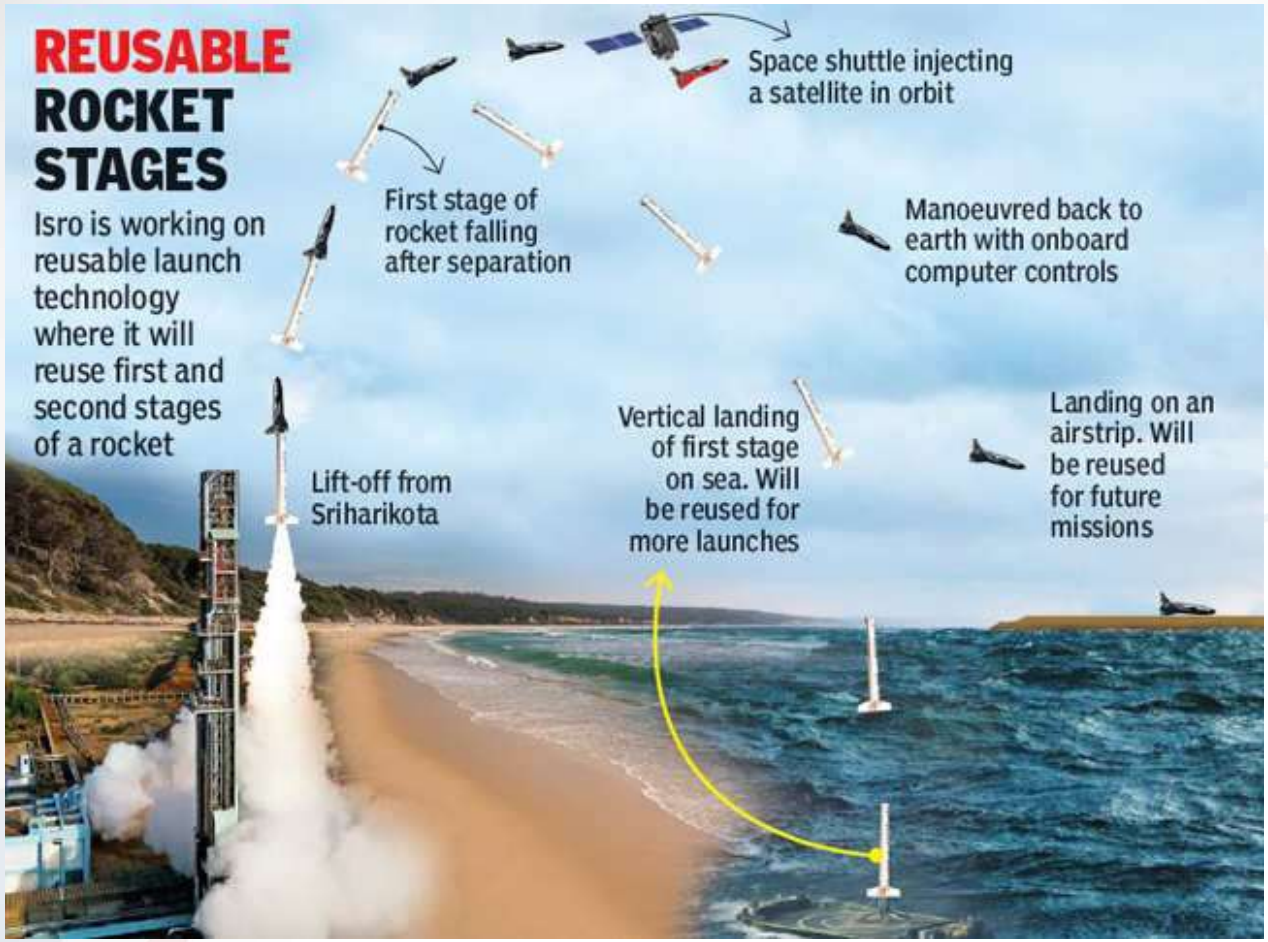
Small Satellite Launch Vehicle (SSLV)

- Cost effective launcher, launch on demand
- 500kg in 500km orbit
- 3 solid propulsion stages and Liquid Velocity Trimming module as terminal stage



Kulasekarapattinam Spaceport

- New rocket launching station for SSLV
- Thoothukudi district of Tamil Nadu



https://www.youtube.com/watch?v=Tk338VXcb24&t=98s – Falcon 9 Animation

Reusable Launch Technology Demonstration

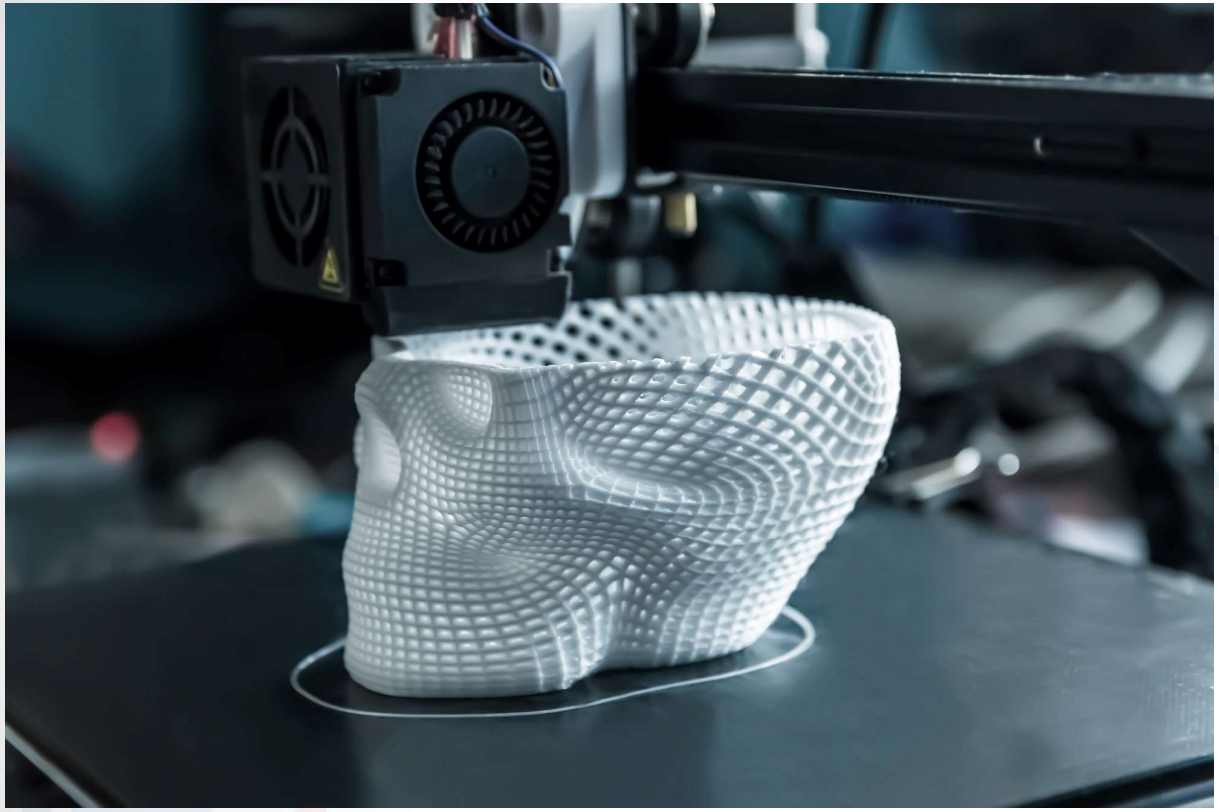
MAX PAYLOAD	HEIGHT	DIAMETER	LIFT OFF MASS
100 kg to 700 km LEO	18 m	1.3 m	14000 kg

Agnibaan Rocket made by Agnikul

815 kg to 500 km Low Inclination Orbit

560 kg to 500 km SSPO

Vikram Series of Rocket made by Skyroot Aerospace



3d Printing

Q. In which of the following activities are Indian Remote Sensing Satellites used?

1. Assessment of crop productivity
2. Locating groundwater resources
3. Mineral Exploration
4. Telecommunications
5. Traffic studies

Select the correct answers using the code given below.

(a) 1, 2 and 3 only

(b) 4 and 5 only

(c) 1 and 2 only

(d) 1, 2, 3, 4 and 5

Q. For the measurement/estimation of which of the following are satellite images/remote sensing data used?

1. Chlorophyll content in the vegetation of a specific location

2. Greenhouse gas emissions from rice paddies of a specific location

3. Land surface temperatures of a specific location

Select the correct answer using the code given below.

(a) 1 only

(b) 2 and 3 only

(c) 3 only

(d) 1, 2 and 3

Q. In which of the following areas can GPS technology be used?

1. Mobile phone operations
2. Banking operations
3. Controlling the power grids

Select the correct answer using the code given below:

(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Q. With reference to the Indian Regional Navigation Satellite System (IRNSS), consider the following statements:

1. IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.

2. IRNSS covers entire India and about 5500 sq. km beyond its borders.

3. India will have its own satellite navigation system with full global coverage by the middle of 2019.

Which of the statements given above is/are correct?

(a) 1 only

(b) 1 and 2 only

(c) 2 and 3 only

(d) None

Q. With reference to India's satellite launch vehicles, consider the following statements:

1. PSLVs launch the satellite useful for Earth resources monitoring whereas GSLVs are designed mainly to launch communication satellites.

2. Satellites launched by PSLV appear to remain permanently fixed in the same position in the sky, as viewed from a particular location in Earth.

3. GSLV Mk III is a fourstaged launch vehicle with the first and third stages using solid rocket motors; and the second and fourth stages using liquid rocket engines.

Which of the statements given above is/are correct?

(a) 1 only
(b) 2 and 3
(c) 1 and 2
(d) 3 only

57. Which one of the following countries has its own Satellite Navigation System?

(a) Australia

(b) Canada

(c) Israel

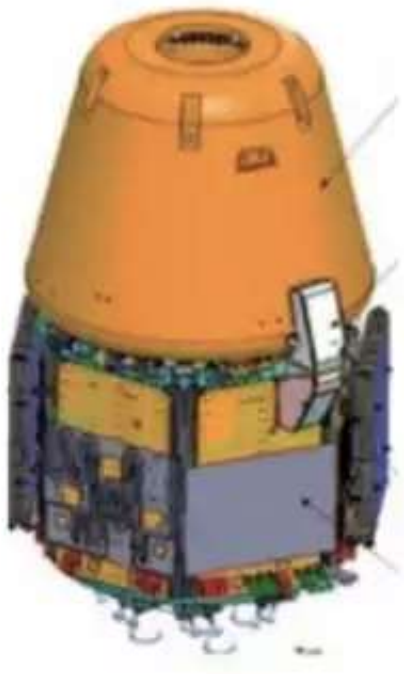
(d) Japan

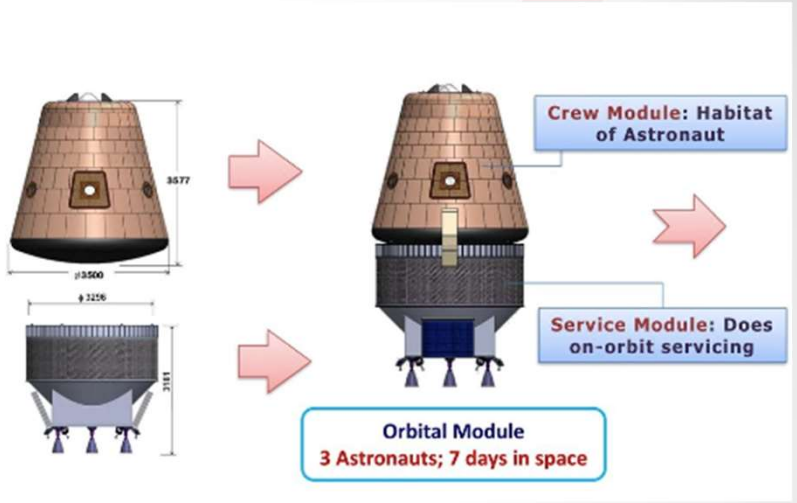
GAGANYAAN

- Precursor missions to Gaganyaan
  - **Space Capsule Recovery Experiment (SRE-2007)**
  - **Crew module Atmospheric Reentry Experiment (CARE-2014)**
  - **GSLV Mk-III (2014)**
  - **Crew Escape System and Pad Abort Test**
- Help from France and Russia
- 3 people (or maybe only 1) for 4-5 days, LEO (300-400 km), collaboration with IAF
- If successful – India will be 4th country after USSR, USA and China

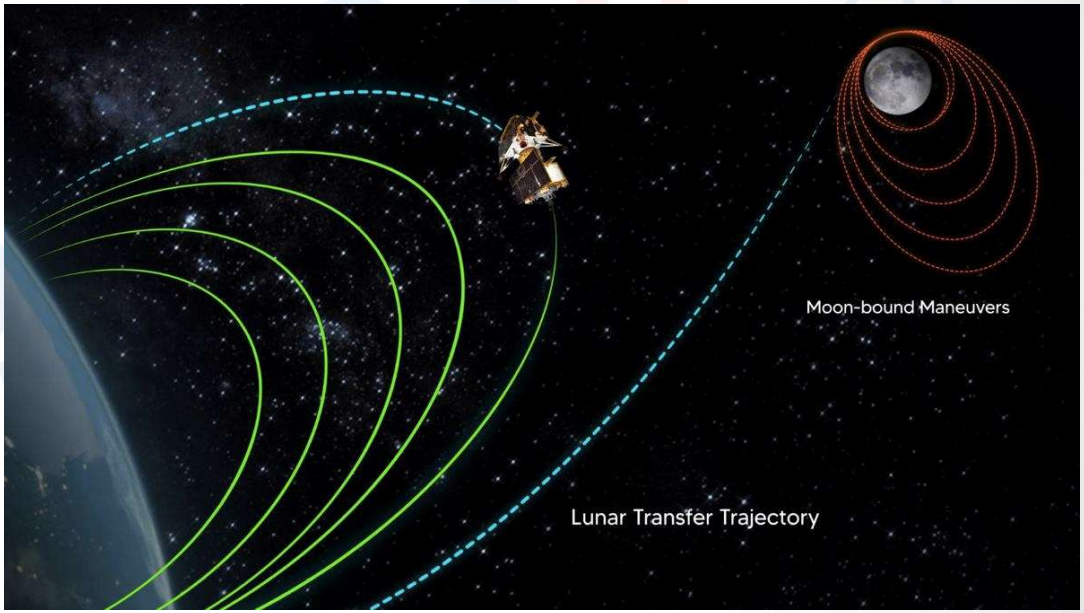
Vyom Mitra: half humanoid, AI based robotic system for Unmanned mission before Gaganyaan, developed by ISRO and IISc

GAGANYAAN




Crew Module: Habitat of Astronaut
Service Module: Does on-orbit servicing
Orbital Module
3 Astronauts; 7 days in space

Chandrayaan 3



	CHANDRAYAAN 1 (2009)	CHANDRAYAAN 2 (2019)
 Objective	To **prepare a three-dimensional atlas** of both near and far side of the moon and chemical, **mineralogical and photo-geological mapping of moon**	To **demonstrate the ability to soft-land** on the lunar surface and operate a robotic rover on the surface.
 Modules	Contained **only Orbiter,** which was **successfully placed at 100kms** from Lunar surface.	Contained **Orbiter, Lander (VIKRAM)** and **Rover (PRAGYAN)**, the orbiter was successfully placed, but the lander lost connection while landing.
 Findings	• The **detection of Water (H2O) and Hydroxyl (OH)** on the surface of the moon. • It **confirmed the Ocean Magma Hypothesis** i.e. the moon was once completely in molten state. • **Detection of new spinel-rich rock** type on lunar surface. • **It confirmed the presence of magnesium, aluminium, silicon and calcium on lunar surface,** through x-ray signals.	• Identified the **presence of variable Argon-40** at the middle and higher latitudes of the Moon. • Detected the **presence of Chromium and Manganese** on the lunar surface. • Detected **signatures of the sub-surface water-ice,** and achieved high resolution mapping of the **lunar morphological features** in the polar regions. • **Micro solar flares, were observed outside the active region of the sun for the first time,** which will help to understand the mechanism behind heating of the solar corona.

Chandryaan 3 Payloads

Lander Module

- **Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA):** To measure the near surface plasma density and its changes with time.
- **Chandra's Surface Thermo physical Experiment (ChaSTE):** To measure thermal properties of lunar surface in polar region.
- **Instrument for Lunar Seismic Activity (ILSA):** To measure seismicity and determine lunar crust and mantle.
- **LASER Retroreflector Array (LRA):** To understand dynamics of moon system.

Rover Module

- **LASER Induced Breakdown Spectroscope (LIBS):** To derive the chemical Composition and infer mineralogical composition of Lunar-surface.
- **Alpha Particle X-ray Spectrometer (APXS):** To determine composition of lunar soil and rocksat the landing site.

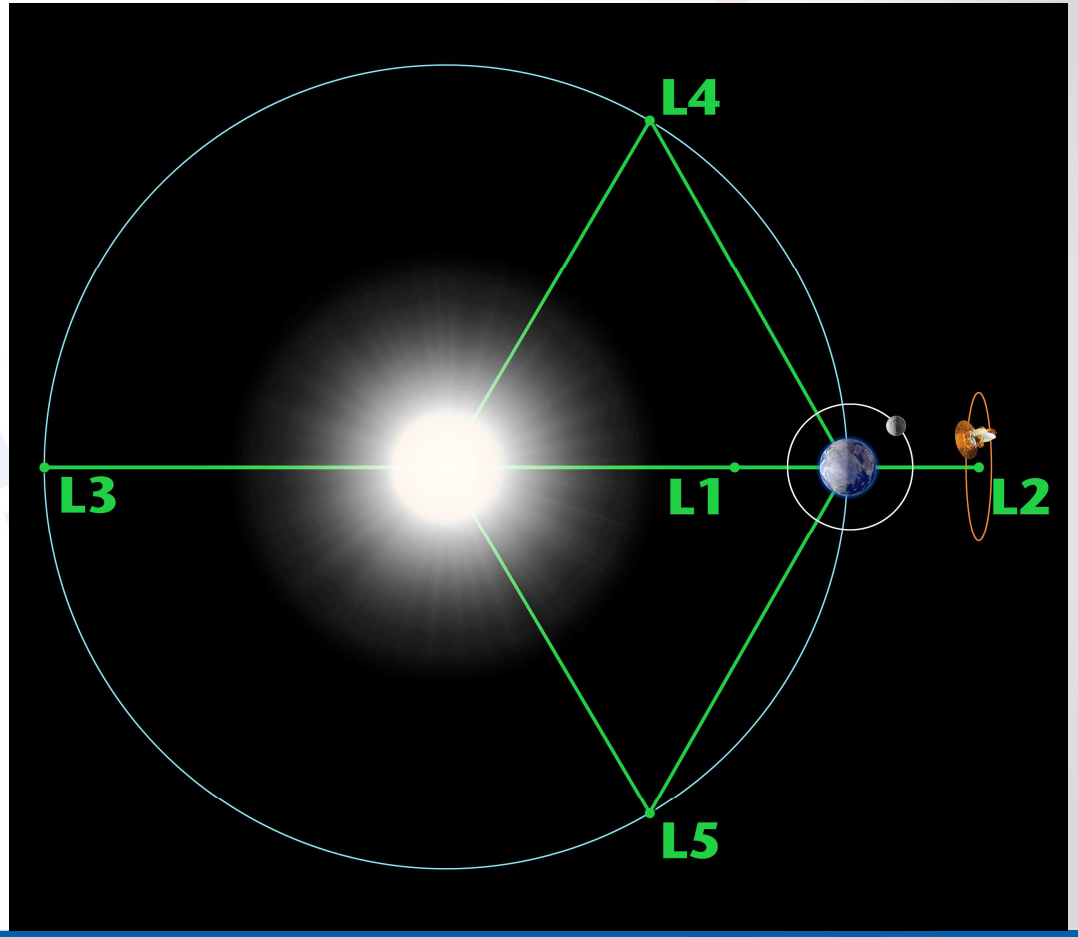
Propulsion Module

- **Spectro-polarimetry of HAbitable Planet Earth (SHAPE):** To probe into Exo-planets which would qualify for habitability in future.

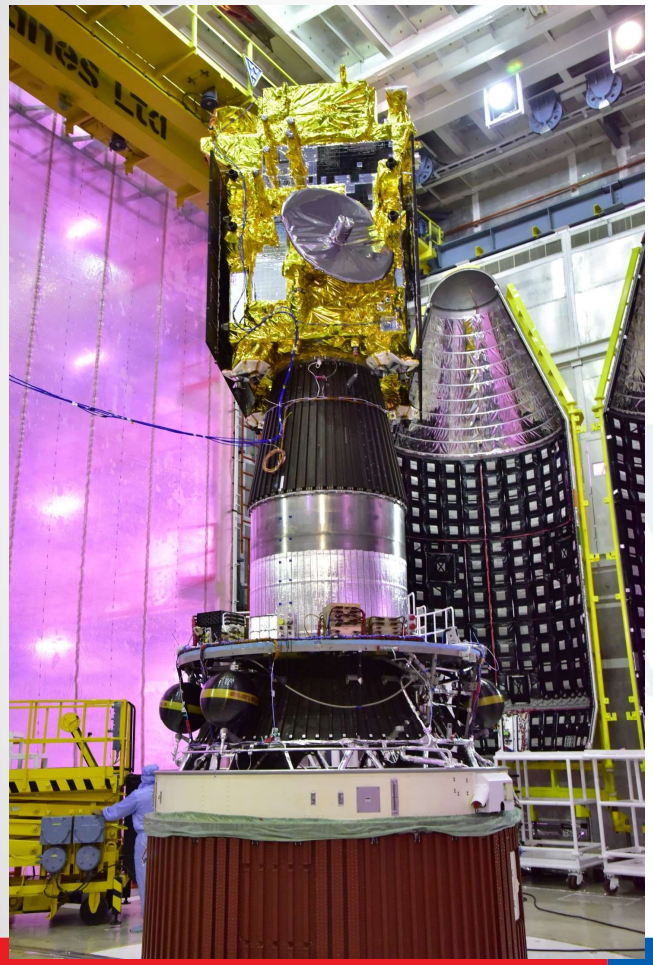
Aditya L1 mission

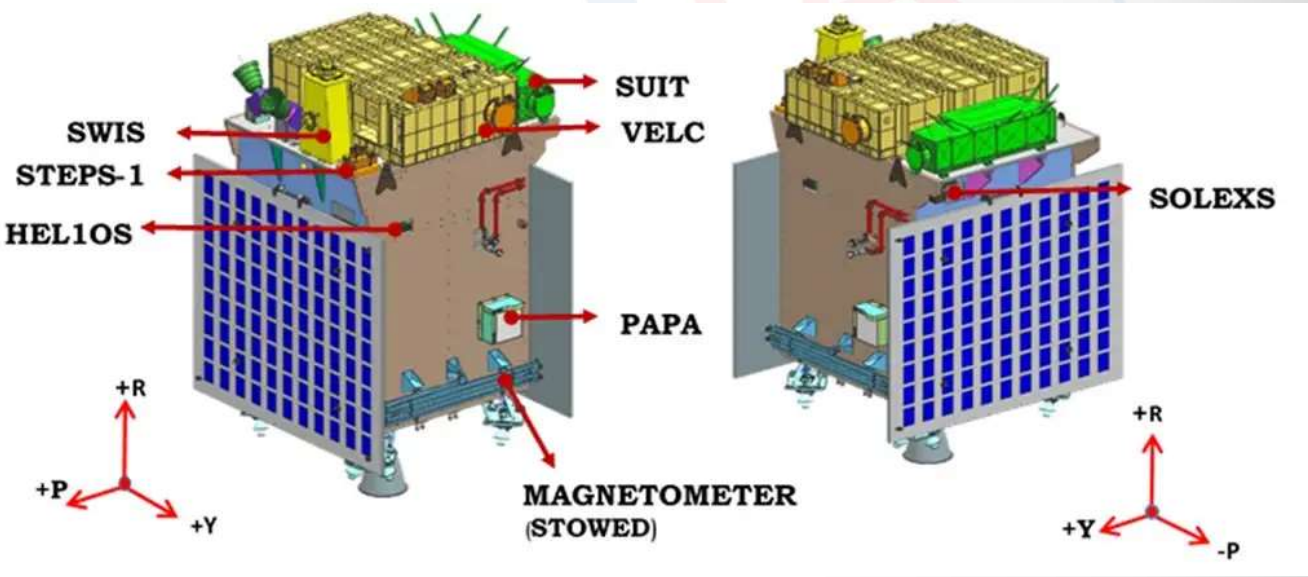
- halo orbit around the **Sun-Earth Lagrangian point (L1)**,
- about 1.5 million km from the Earth.
- ISRO's first scientific expedition to study Sun
- 400 kg-class satellite
- **7 payloads on board** to study Sun's corona, solar emissions, solar winds and flares, and Coronal Mass Ejections, and will carry out round-the-clock imaging of Sun.

https://www.youtube.com/watch?v=6cUe4oMk69E&list=TLGG8tIphgpDAHkyNzAxMjAyMg&t=1s

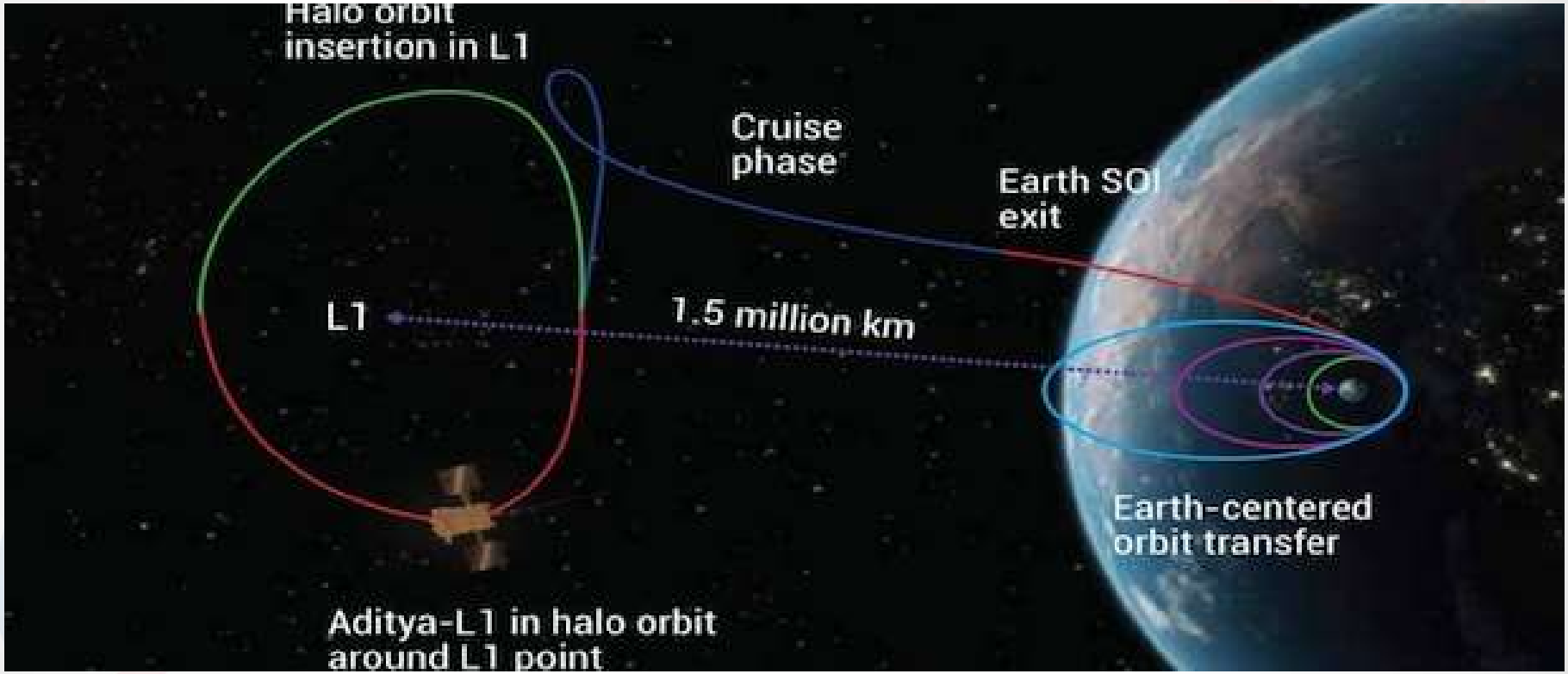


Aditya L1 mission



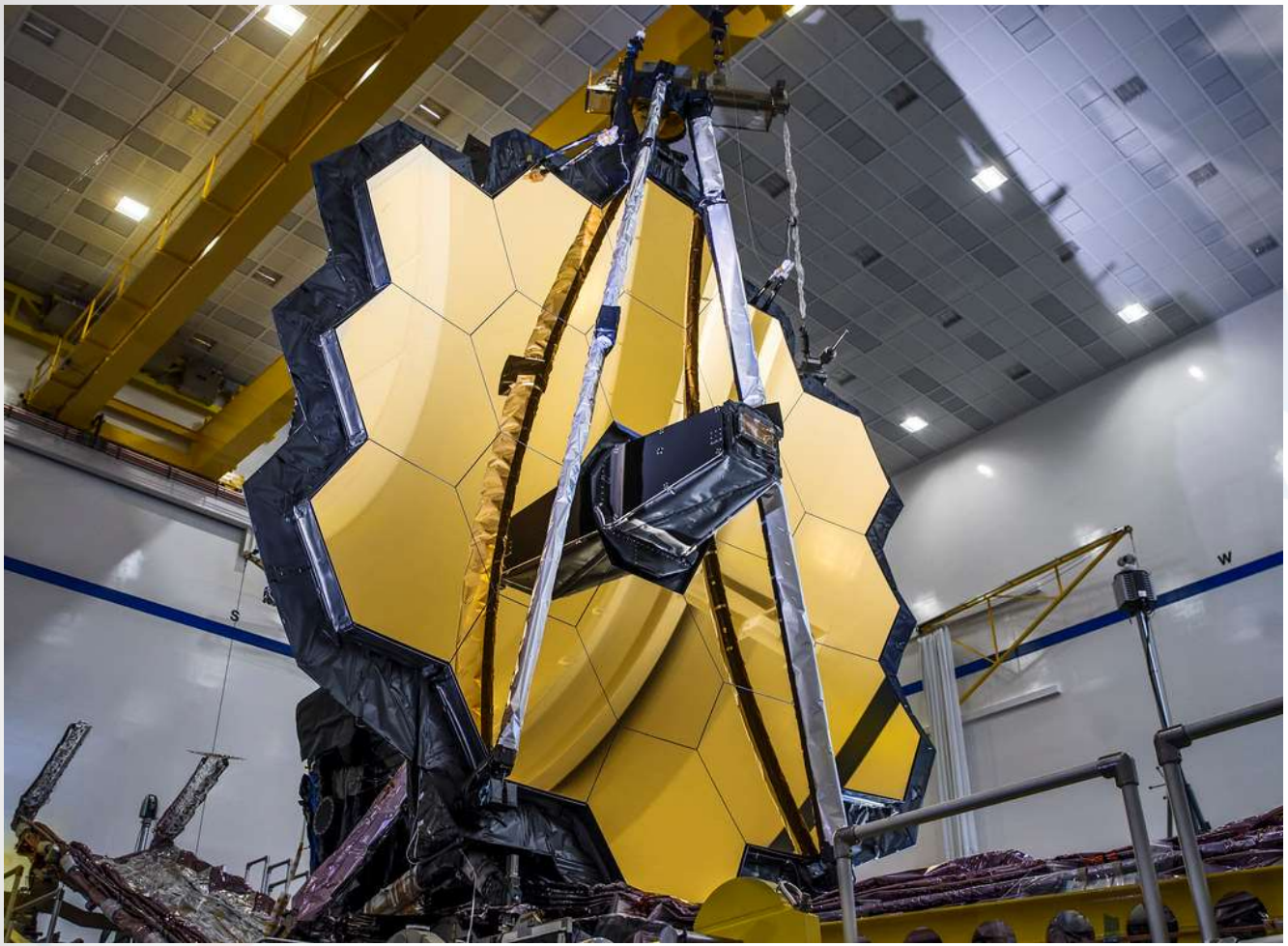


Aditya L1 mission

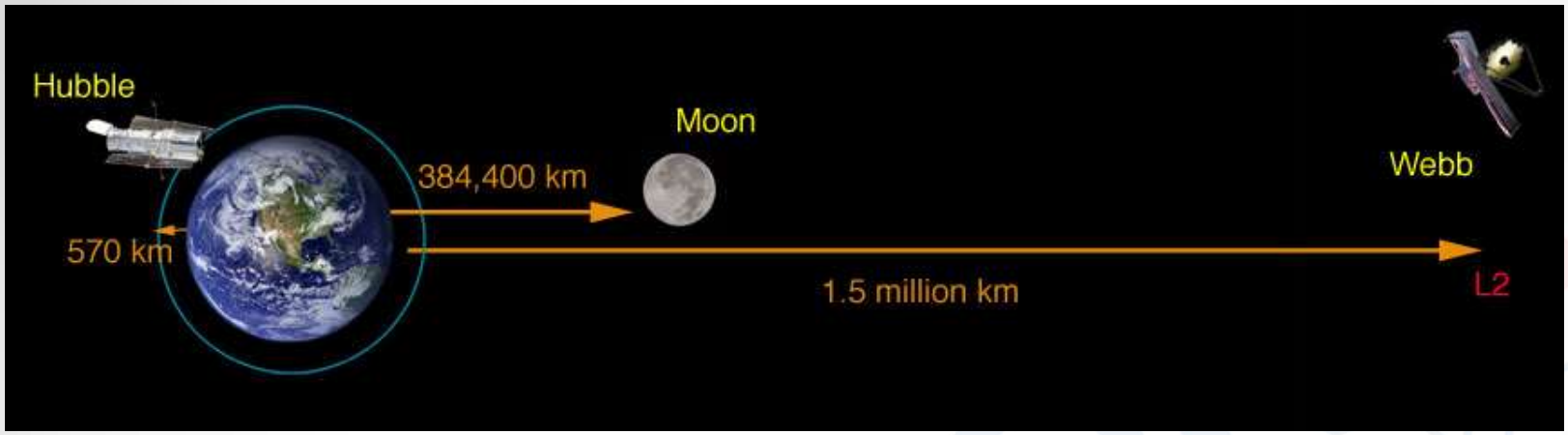


Lagrange Points and Halo Orbit

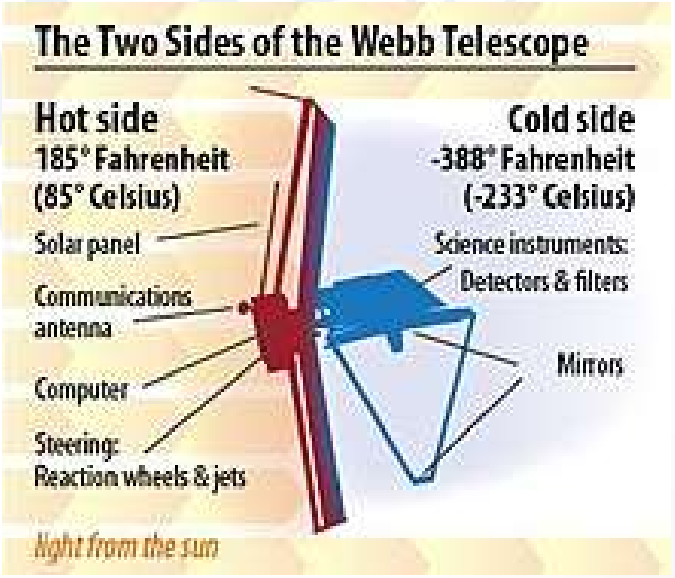
- 5 special points where a small mass can orbit in a constant pattern with two larger masses.
- gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.
- **The orbits around the Lagrangian point is called Halo Orbit.**
- **The L1 point** of the Earth-Sun system affords an uninterrupted view of the sun and is currently home to the **Solar and Heliospheric Observatory Satellite SOHO.**
- **L2 is ideal for astronomy** because a spacecraft is close enough to readily communicate with Earth, can keep Sun, Earth and Moon behind the spacecraft for solar power and provides a clear view of deep space for our telescopes.



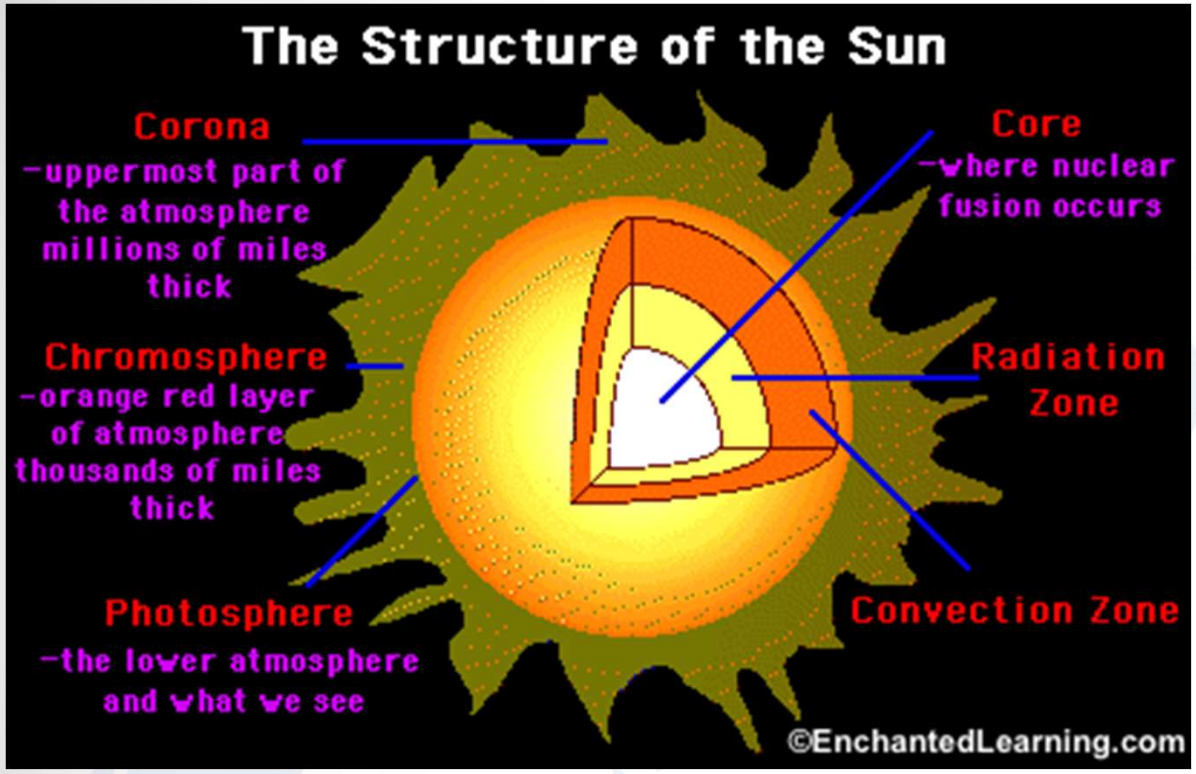
James Webb Space Limited

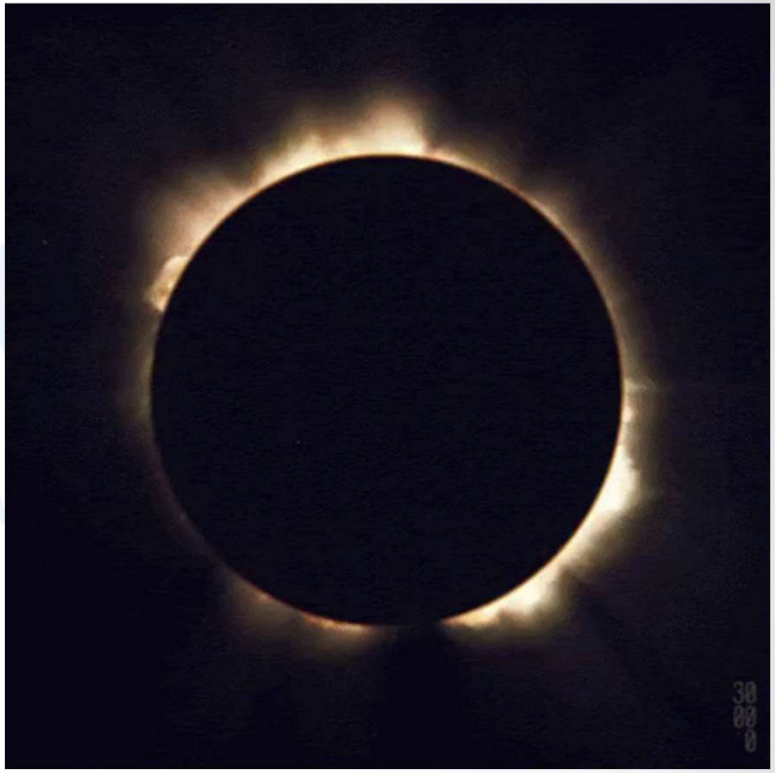


At L2 point



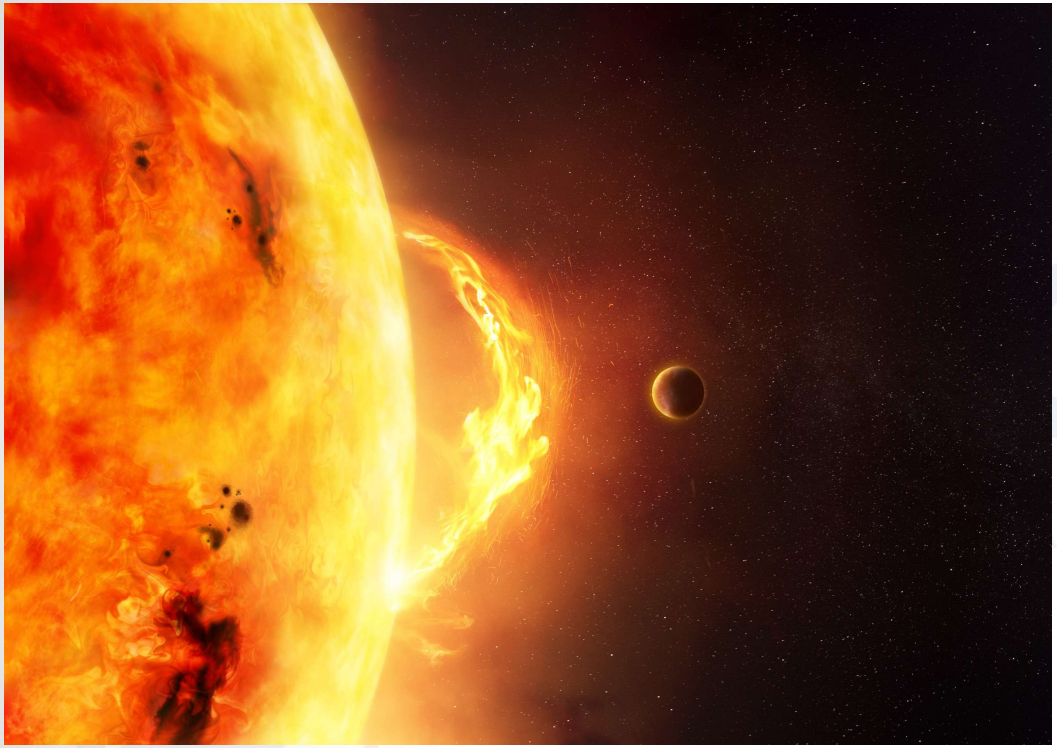
Sunshield

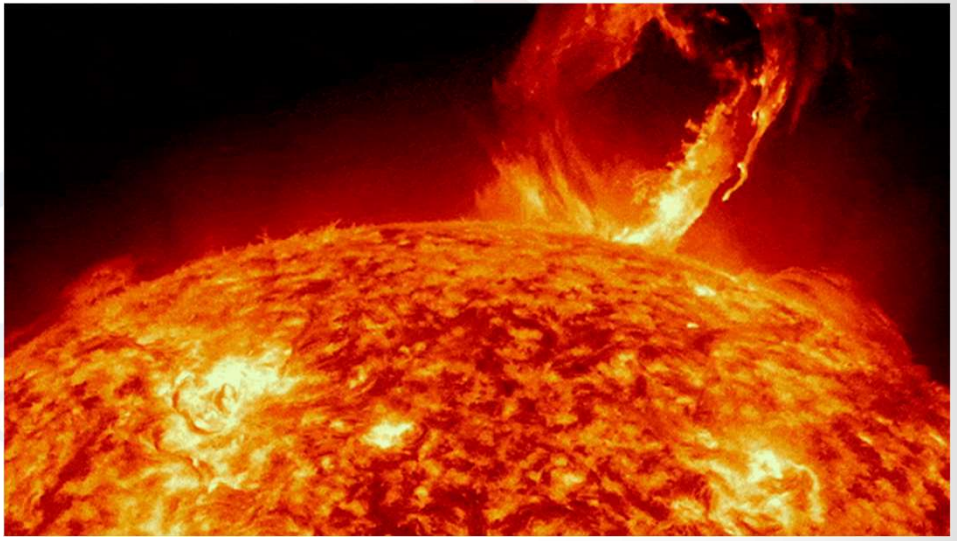




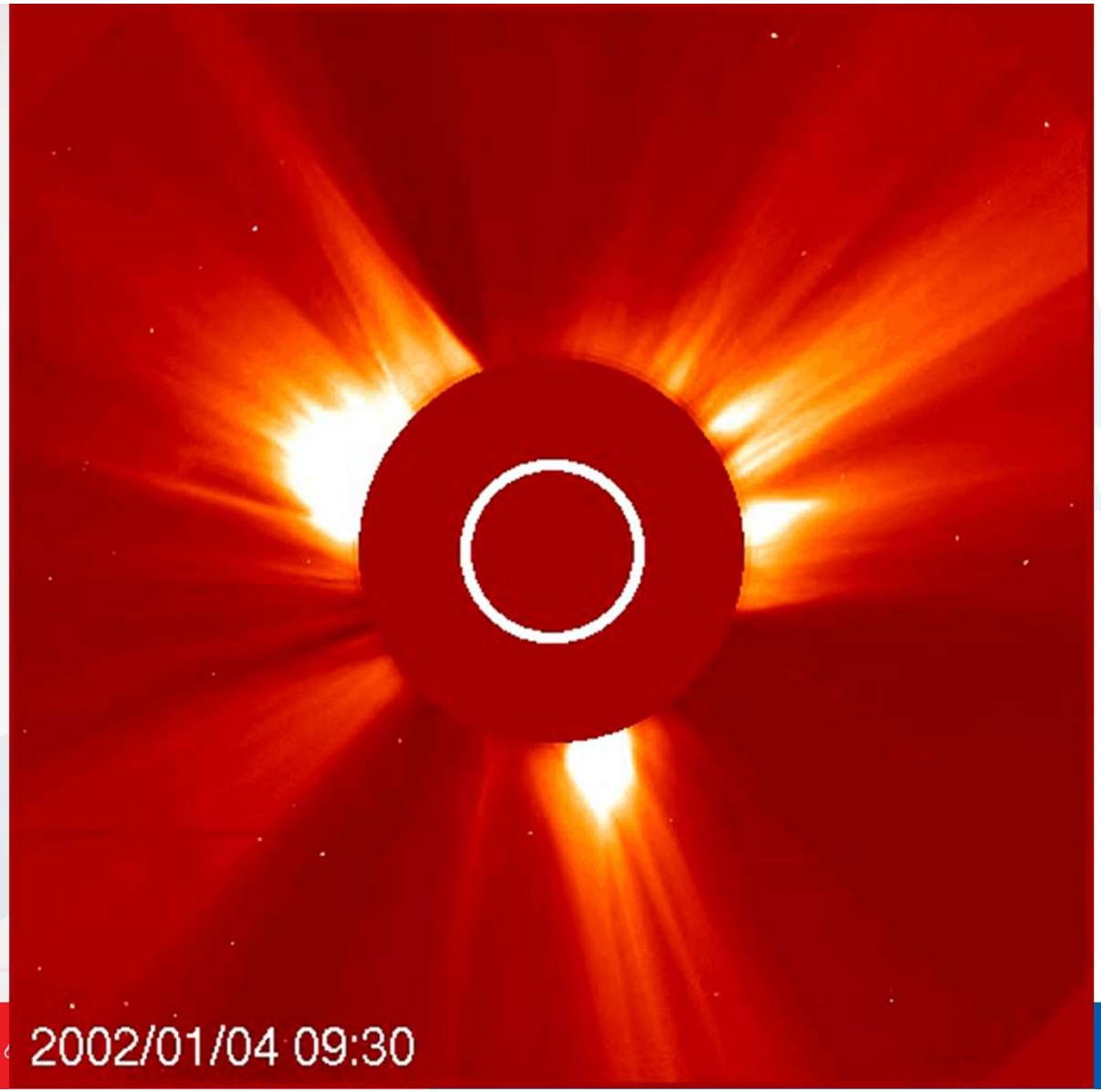
Solar Corona

Solar Wind

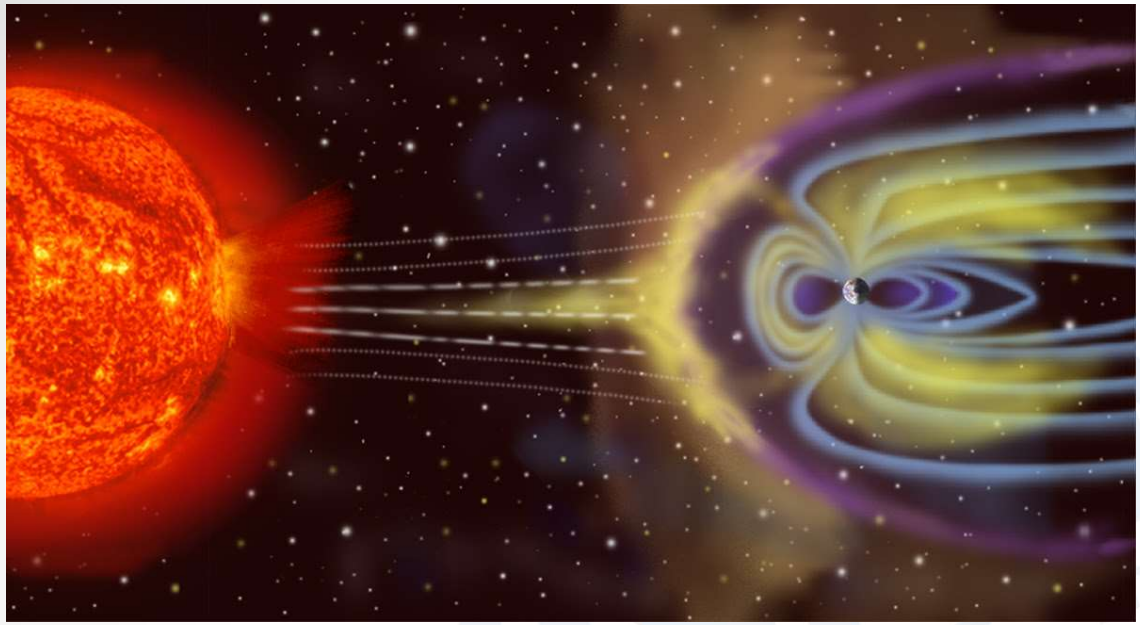




Solar Flare



Coronal Mass Ejection

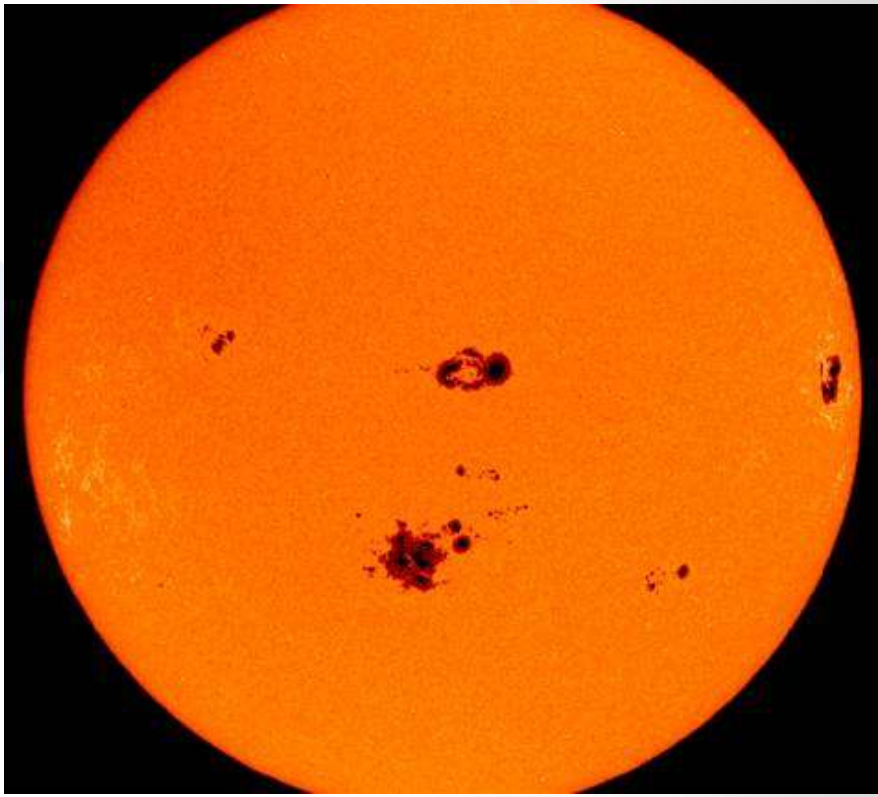


Geomagnetic Storm

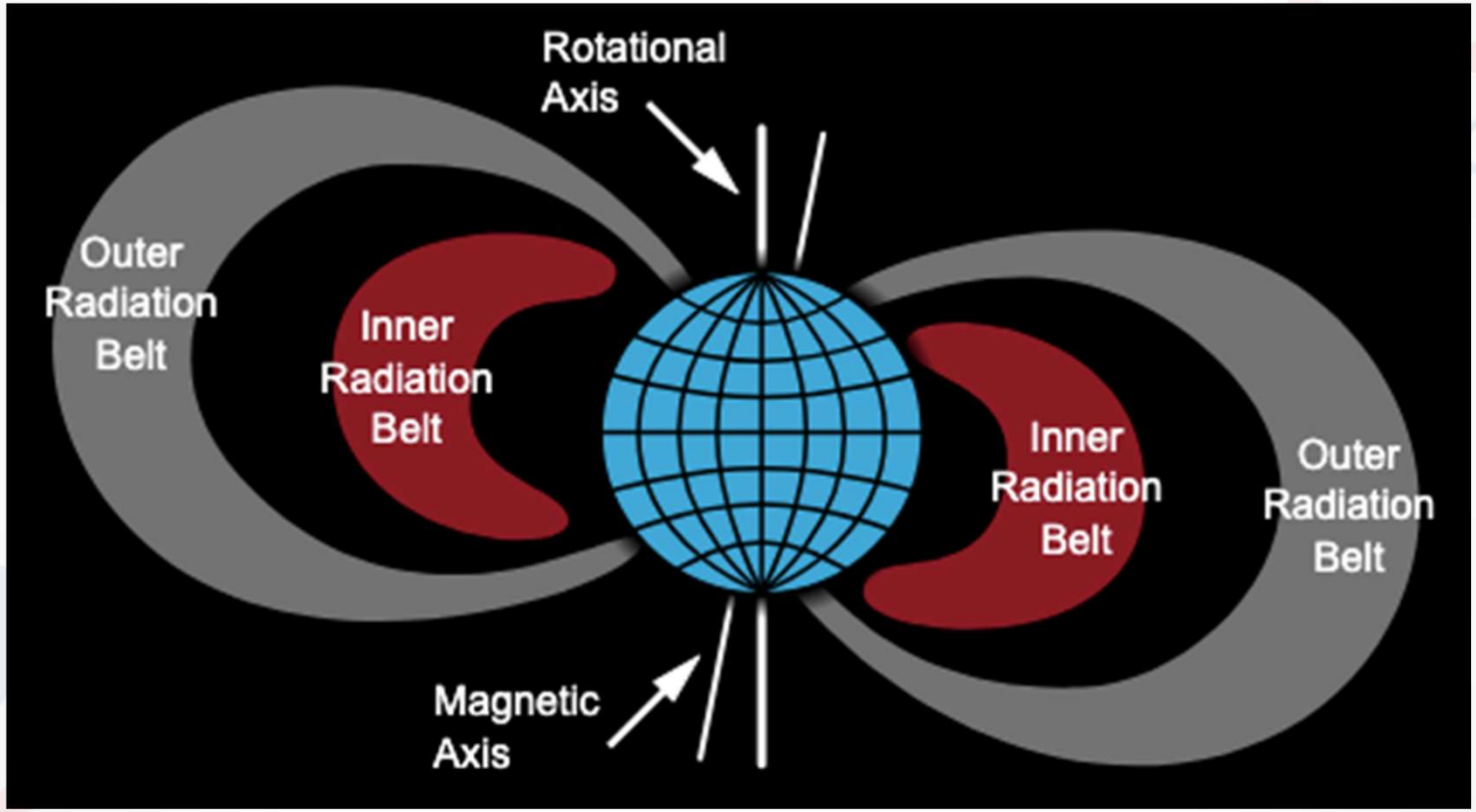
Aurora

Sun Spot Cycle

- Sunspots are areas that appear dark on the surface of the Sun
- cooler than other parts of the Sun's surface.
- **Strong magnetic fields**: they some of the heat within the Sun from reaching the surfa
- **Sun Spot Cycle**: the recurring increase and decrease in the number of sunspots over a period averaging about eleven years.
- Solar Maximum and Solar Minimum
- https://www.youtube.com/watch?v=1DXHE4kt3Fw
- Solar Wind, Solar Flare and Coronal Mass Ejection



Van Allen Radiation Belt



If a major solar storm (solar flare) reaches the Earth, which of the following are the possible effects on the Earth ?

1. GPS and navigation systems could fail.
2. Tsunamis could occur at equatorial regions.
3. Power grids could be damaged.
4. Intense auroras could occur over much of the Earth.
5. Forest fires could take place over much of the planet.
6. Orbits of the satellites could be disturbed.
7. Shortwave radio communication of the aircraft flying over polar regions could be interrupted.

Select the correct answer using the code given below :

(a) 1, 2, 4 and 5 only

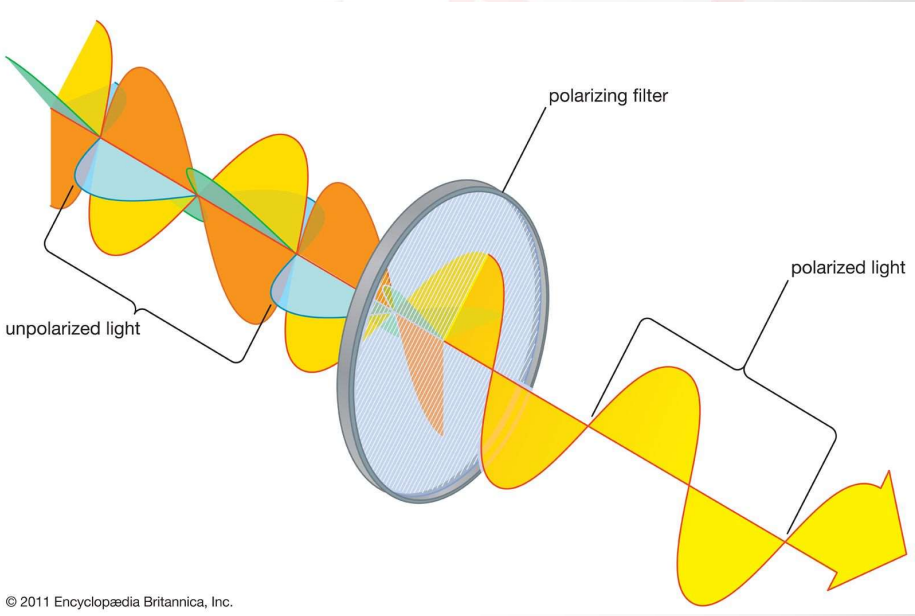
(b) 2, 3, 5, 6 and 7 only

(c) 1, 3, 4, 6 and 7 only

(d) 1, 2, 3, 4, 5, 6 and 7

2022

XPoSat



Polarized and Unpolarized light

International Space Station:

- a collaboration of five space agencies
  - NASA (United States)
  - Roscosmos (Russia)
  - JAXA (Japan)
  - ESA (Europe)
  - CSA (Canada)
- Heaviest man made object in space
- Orbit: 418 km

Space Debris

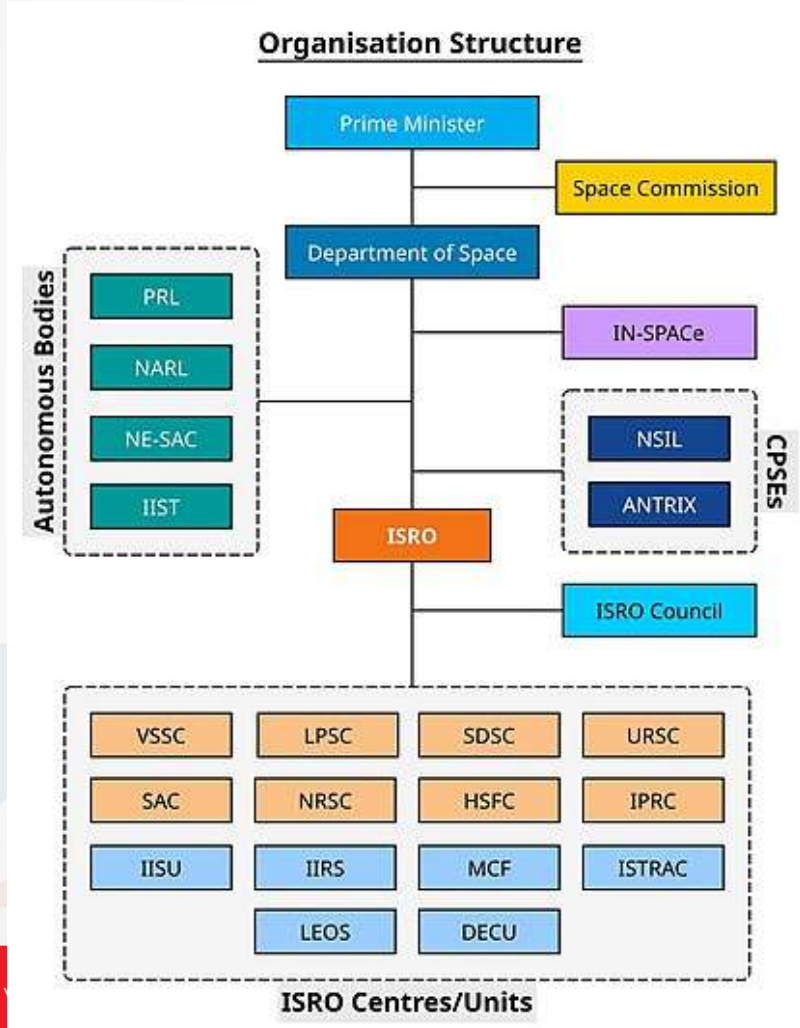
- Sources:
  - Fragmentation of spacecraft and rocket bodies
  - Discarded rocket stages:
  - Defunct or outdated satellites
  - Human-made objects: Other human-made objects, such as tools, cameras
  - Natural sources: Even natural events, such as micrometeoroid impacts
- Way Forward:
  - Space situational awareness
  - Minimizing creation of debris
  - Active removal of debris

Space Tourism

	Suborbital tourism	Orbital tourism
		
Altitude	**About 100 km**	**Over 400 km**
Feature	Experiencing **a few minutes in a low gravity environment,** see the earth from space and the curvature of the earth.	Spacecraft is placed on a trajectory where it could remain in space for **at least one orbit.**

Weaponization of Space

Organizational Structure of DoS



List of Abbreviations/Acronyms

ANTRIX: Antrix Corporation Limited
DECU: Development and Educational Communication Unit
HSFC: Human Space Flight Centre
IIRS: Indian Institute of Remote Sensing
IISU: ISRO Inertial Systems Unit
IIST: Indian Institute of Space Science and Technology
IN-SPACe: Indian National Space Promotion and Authorization Centre
IPRC: ISRO Propulsion Complex
ISTRAC: ISRO Telemetry Tracking and Command Network
LEOS: Laboratory for Electro-Optical Systems
LPSC: Liquid Propulsions System Centre
MCF: Master Control Facility
NARL: National Atmospheric Research Laboratory
NE-SAC: North Eastern Space Applications Centre
NRSC: National Remote Sensing Centre
NSIL: NewSpace India Limited
PRL: Physical Research Laboratory
SAC: Space Applications Centre
SDSC: Shatish Dhawan Space Centre
URSC: U R Rao Satellite Centre
VSSC: Vikram Sarabhai Space Centre