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SPACE TECHNOLOGY

Chandrayaan (1)

Chandrayaan-1, India's first mission to Moon, was launched successfully on October 22, 2008 from Sriharikota. The spacecraft was orbiting around the Moon at a height of 100 km from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon.

Launch Vehicle used:It was launched using using the Polar Satellite Launch Vehicle (PSLV-C11).

Objectives:

1. **To design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch-vehicle**.
2. To conduct scientific experiments using instruments on the spacecraft which would yield data.
   a) for the preparation of a three-dimensional atlas of both the near and far sides of the Moon
   b) for chemical and mineralogical mapping of the entire lunar surface at high spatial resolution, mapping particularly the chemical elements magnesium, aluminium, silicon, calcium, iron, titanium, radon, uranium, and thorium.
3. To increase scientific knowledge
4. **To test the impact of a sub-satellite (Moon Impact Probe – MIP) on the surface of the Moon as a fore-runner for future soft-landing missions**.

Goals:

In **order to reach its objective, the mission defined these goals:**

1. High-resolution mineralogical and chemical imaging of the permanently shadowed north- and south-polar regions.
2. To search for surface or sub-surface lunar water-ice, especially at the lunar poles.
3. Identification of chemicals in lunar highland rocks
4. Chemical stratigraphy of the lunar crust by remote sensing of the central uplands of large lunar craters, and of the South Pole Aitken Region (SPAR)
5. Mapping the height variation of features of the lunar surface
6. Providing new insights in understanding the Moon's origin and evolution.

Findings of Chandrayaan 1:

1. Chandrayaan has confirmed the magma ocean hypothesis, meaning that the Moon was once completely molten.
2. Data from the Mineralogy Mapper (M3), one of the instruments on Chandrayaan-1, indicates the presence of hematite at the lunar poles.
   Hematite (Fe_2O_3) is a mineral which is a form of iron oxide, or rust, produced when iron is exposed to oxygen and water.
3. The major discovery of the Chandrayaan-1 mission is the detection of water (H2O) and hydroxyl (OH) on the lunar surface. The data also revealed their enhanced abundance towards the polar region.
4. **Chandrayaan-1 detected titanium, confirmed the presence of calcium, and gathered the most accurate measurements yet of magnesium, aluminium and iron on the lunar** surface.
5. **The Terrain mapping camera on board Chandrayaan-1, besides producing more than 70,000 three dimensional images, has recorded images of the landing site of US spacecraft** Apollo 15.
6. **Chandrayaan-1 imaging X-ray Spectrometer (C1XS) - detected more than two dozen weak solar flares during the mission duration**.
7. **Evidence of lunar caves** formed by an ancient lunar lava flow.

Chandrayaan 2

Chandrayaan-2 is India's second unmanned lunar mission. It is the 1st Indian expedition to attempt a soft landing on moon with indigenous technology.

Launch vehicle :Chandrayaan-2 was launched aboard a GSLV Mark III rocket touted as the most powerful rocket built by ISRO.

Components :

1. Lander (Vikram) will remain stationary after touching down, will mainly study the moon's atmosphere. It will also look out for seismic activity.It had a mission life of 14 days.
2. Rover (Pragyan): Once on the Moon, the Rover, a six-wheeled solar-powered vehicle, will detach itself and slowly crawl on the surface, making observations and collecting data. It will study the composition of the surface near the lunar landing site, and determine the abundance of various elements.It had a mission life of 14 days.
3. Orbiter:The Orbiter will orbit from 100 km away. It will study the mineral composition on the moon and the lunar atmosphere, and also to assess the abundance of water.It had a mission life of 7 years.

Primary objective of Chandrayaan 2: To demonstrate the ability to soft-land on the lunar surface and operate a robotic rover on the surface.

Mission Objectives

1. Try and build on the evidence of water molecules shown by Chandrayaan-I and study the extent and distribution of water on the Moon.
2. **Study topography, seismography, composition of lunar surface and the lunar atmosphere.**
3. **The study of ancient rocks and craters can offer indications of origin and evolution of the Moon**.
4. The South Pole region of the Moon also contains clues to the fossil records of early solar system. Thus, it will improve our understanding of the early solar system as well.
5. **Map the lunar surface and prepare 3D maps of** it.

Significance of the Mission.

1. The moon offers a pristine environment to study. It is also closer than other celestial bodies. Understanding how it formed and evolved can help us better understand the solar system and even earth itself.
2. **With space travel taking shape and exoplanets being discovered everyday, learning more about earth's celestial neighbour can help in advanced missions**.
3. **India would be the 4th nation to reach the Moon. It boosts national pride in the citizens of India**.
4. It will boost the morale of scientists and research academicians. Also, it can motivate the youth to develop scientific temper and undertake real-life applications of science and technology.
5. **High precision components used in the mission require high standards of manufacturing procedures. It is critical for imbibing the spirit of innovation in Indian manufacturing industry**.
6. ISRO initially partnered with a startup-TeamIndus for the launch, which however could not materialize. Still, it gave a boost to the Indian startup industry in space sector thereby promoting entrepreneurship. Chandrayaan-2 offers similar possibilities.
7. For Chandrayaan-2 mission, two women - Ritu Kridhal and M Vanitha are leading as project and mission directors respectively. Thus, it is a symbol of women empowerment and an icon of women taking leadership roles in the country's biggest projects.

Mission Challenges

1. Successfully performing the launch of its heaviest rocket GSLV-Mark III.
2. **Ensuring trajectory accuracy while travelling such a long distance. It will perform successive orbital manoeuvres to raise the module into higher orbits** until it reaches the "Earth to Moon" transfer orbit.
3. **Landing on safe hazard free zone: ISRO had never performed soft landing on any space object. The lunar surface is covered with** craters, rocks, dust, hot gases and faces extreme surface temperature variations. Thus, it is an extremely hostile environment for lander and rover operations.
4. **Further, the South Pole region of the Moon receives less sunlight compared to equatorial region, which is required by solar-powered instruments**.

Key information gathered from Chandrayaan-2:

1. **Presence of water molecules on moon which is the most precise information about water till date**.
2. **Presence of Minor elements: Chromium, manganese and Sodium have been detected for the first time through remote sensing.**
3. **Information about solar flares: A large number of microflares outside the active region have been observed for the first time. It shall help in understanding** the mechanism behind heating of the solar corona.
4. **Sodium:Chandrayaan-2 orbiter mapped an abundance of sodium on the moon for the first time**.
5. On October 14, 2019, Chandrayaan-2 detected the presence of Argon-40 in the lunar exosphere.
1. **On July 30th, 2020 Chandrayaan-2 imaged the Sarabhai Crater located on the north-east quadrant** of the moon

What happened to Chandrayaan-2.

1. **Chandrayaan-2, India's second mission to the Moon, had failed to make a soft-landing on the lunar surface**.
2. The lander and rover malfunctioned in the final moments and crash-landed, getting destroyed in the process.

Chandrayaan 3

Chandrayaan-3 is a lunar exploration mission by the Indian Space Research Organisation (ISRO). It is the third mission in the Chandrayaan series, following Chandrayaan-1 and Chandrayaan-2. Chandrayaan-3 is a follow-on mission to Chandrayaan-2 to demonstrate end-to-end capability in safe landing and roving on the lunar surface.

Launch Vehicle:Chandrayaan-3 Mission was launched using the LVM3 rocket system.

Components :

Propulsion Module

1. Carries the **lander-rover to a 100 km** lunar orbit.
2. Features a **solar panel and mounting** structure for the lander.

Lander (Vikram)

1. Executes the soft landing on the Moon.
2. It had four landing legs and four landing thrusters capable of producing 800 newtons of thrust each
3. Accommodates the rover and scientific instruments.

Rover (Pragyan)

1. A six-wheeled, 26 kg vehicle.
2. Conducts diverse measurements, contributing to lunar research.
3. **Investigates lunar surface composition, presence of water ice, lunar impact history, and atmosphere evolution**.

Mission objectives:

1. To demonstrate Safe and Soft Landing on Lunar Surface
2. To demonstrate Rover roving on the moon and
3. To conduct in-situ scientific experiments.

Study objectives of the mission:

1. **Discovery of Water:The southern polar region of the Moon, characterized by deep craters in permanent darkness, is believed to contain water ice. Previously, Chandrayaan-1 instruments discovered water and hydroxyl (OH)** molecules in the Moon's thin atmosphere and on the lunar surface.
2. **Buried Lava Tubes:Chandrayaan-1's terrain mapping camera and hyperspectral imager found evidence of underground lava tubes. These structures offer a potentially safe habitat for humans in the future, shielding against radiation, meteoric impacts, extreme temperatures**, and dust storms on the lunar surface.
3. **Magma Ocean Thesis:The Moon's formation from an impact that led to surface melting, called the magma ocean hypothesis, was studied by Chandrayaan-1's M3 payload. This will be further studied by this** mission.
4. **Dynamic Moon:Contrary to the belief of lunar dormancy, Chandrayaan-1 revealed the Moon's dynamic nature interacting with the exosphere. Terrain mapping camera identified volcanic vents, lava ponds, and channels as recent as 100 million** years old, indicating recent volcanic activity.
5. Solar Flares:Chandrayaan-2's Solar X-Ray Monitor observed solar microflares beyond the active region, analyzing elemental abundance from the solar corona.
6. Mapping of Minerals:The new mission will further explore abundant oxygen in mineral oxides on the Moon, potentially exploitable as fuel for future space missions.

Significance of the Mission:

Future lunar exploration:

1. The Mission can play a vital role in India's quest to establish a human presence on the moon.
2. The collaboration with JAXA (Japan Aerospace Exploration Agency) for their Lunar Polar Exploration mission (LUPEX) or Chandrayaan-4, etc., will be benefited by the success of this Mission.

Advancing space education:

1. **The Mission will work towards advancing space education** and scientific temper in India.
2. It can serve as an inspiration for the scientific community as well as future generations of space enthusiasts.

Lunar Surface Exploration:

1. Chandrayaan-3's lander and rover are studying rocks and soil to understand moon history, possibly revealing asteroid impacts that caused surface changes.
2. Focusing on the moon's south pole, Chandrayaan-3 aims to find minerals, underground features, and water, promising fresh insights into moon geology and resources.

Scientific Discoveries:

1. **-Chandrayaan-3 carries tools to study moonquakes and underground heat. Seismometers on its surface** show the moon's interior and thermal probes uncover crust movements, aiding our knowledge of the moon.
2. It will strengthen India's grasp of lunar geology, resources, and surroundings, deepening insights about celestial bodies.

Boosting private investment:

1. India's field-tech sector is on investors' radars with historic growth of private rocket launches and satellite deployments by 2022.
2. **The accomplishment of the Chandrayaan trio should drive investor confidence higher and** attract more private investment in aerospace technology projects.

Job creation:

1. India's booming aerospace technology sector has already created hundreds of jobs.
1. **Successful lunar missions and subsequent programs** are poised to create additional high-tech business opportunities, both directly and indirectly.

Nurturing startups:

1. The success of Chandrayaan-3 could be a technology showcase, boosting India's goodwill in the global space community.
2. **This could attract joint ventures and business opportunities for Indian companies and** startups to develop and develop space systems for the global market.

Strengthening international reputation:

1. **Successful completion of Chandrayaan-3 will make India the fourth country to land on the moon, earn global recognition and lead to the cost-effective adoption of spacecraft** manufactured by Indian companies and proof of its reliability.
2. This achievement could lead to useful international cooperation.

Strategic Positioning:

1. **The success of Chandrayaan-3 could position India as an important player in the international space race, potentially matching China's influence. With Russia facing economic sanctions, it is an opportunity for India to** strengthen its position.
2. Together with Artemis Accords, it will enhance India's ever-increasing space footprints.

Findings :

1. **Lunar temperature: Chandrayaan 3 measured the soil temperature of the moon and revealed some interesting findings. The temperature ranges from minus10 degree-celsius to around 70 degree-celsius**. While minus 10-degree was recorded at 80 mm under the ground, 60-degree was above the ground -- around 20 mm.
2. **List of elements Chandrayaan 3 found on the moon: Aluminum (Al), sulphur (S), calcium (Ca), iron (Fe), chromium (Cr), titanium (Ti), manganese (Mn), silicon (Si), and oxygen (O). The** findings are significant because if Chandrayaan 3 finds the hydrogen that it is searching for, then it will be a step further in the search for water on the moon.
3. **4-meter diameter crater on Moon's surface: On 27 August, while plying on the Moon's surface, Chandrayaan-3 Rover faced an obstacle as it came across a 4-meter diameter** crater. In an update from ISRO, it said the crater was positioned 3 meters ahead of its location.

Why South Pole of Moon is attracting countries.

1. Moon's South Pole, also known as the lunar south pole is of special interest to scientists because of the occurrence of water ice in permanently shadowed areas around it.
2. The lunar south pole has craters on its surface that are unique in their own way, as sunlight is not able to reach their interiors.
3. NASA even claims that some craters in the moon's south pole have not received sunlight for billions of years and the temperatures here could dip as low as -203 degrees Celsius.
4. These craters are cold traps that contain a fossil record of hydrogen, water ice, and other volatiles dating from the early Solar System. Considering these cold temperatures, the matter trapped in the southern lunar region wouldn't have witnessed much change over the years and could thereby hold clues to early life.
5. In addition to water ice, the moon's south pole may also contain other volatiles, such as methane and ammonia.These volatiles could also be used as resources for future human exploration.
6. Studying the South Pole-Aitken basin could provide insights into the Moon's formation and evolution.
7. The moon's south pole is also a good location for astronomical observations.The permanently shadowed craters at the south pole are shielded from the Sun's radiation, which makes them ideal for observing radio waves and other forms of radiation that are blocked by the Earth's atmosphere.

Gaganyaan

Gaganyaan is an Indian crewed orbital spacecraft that is intended to send 3 astronauts to space for a minimum of seven days by 2023, as part of the Indian Human Spaceflight Programme.

Mission objectives:

Primary objective:The Gaganyaan Mission's principal goal is to demonstrate the technology. The program will rely on Indian companies for 60-70 percent of its components and value-added services.

Other objectives:

1. To Boost the Science and Technology and scientific temper of the country.
2. Other Institutes, academia, and industry will also be involved in these national programs.
3. Encourage the youth to take on challenges in the field of science and technology.
4. Developed technology for the betterment of society.
5. Further Human Resource Development.
6. Make a path to international collaboration and policies.

Launch Vehicle:

GSLV Mk-lll (Geosynchronous Satellite Launch Vehicle) the three-stage heavy-lift launch vehicle will be used for carrying the orbital module.

Components/Payloads:**Consists of a service module and a crew module, collectively known as an Orbital Module**.

a) Crew module: Spacecraft carrying human beings

b) Service module: Powered by two liquid propellant engines.

Flights under Gaganyaan:Three flights will be sent into orbit.There will be two unmanned flights and one human spaceflight.

Vyom Mitra:

1. **ISRO has also developed a female half humanoid robot named Vyommitra which will be sent on the first unmanned Gaganyaan** flight.
2. **Vyommitra will help in simulating human functions in space and will also interact with the environment** control life support system.
3. **Vyommitra has been designed to speak in Hindi and English, can act as a companion to the astronauts, converse with them**, and also respond to their queries.

Placement:

1. The spacecraft will be placed in a low earth orbit of 300-400 km.
2. **The human spaceflight will take 16 minutes to reach the orbit where it will stay for five to seven days**.
3. **The capsule will rotate around the Earth every 90 minutes, and astronauts will be able to witness sunrise and sunset. The three astronauts will be able to see India from space every 24 hours, while they conduct experiments on micro-gravity**.

Timeline of the Project:

1. The first trial (uncrewed flight) for Gaganyaan is being planned for the end of 2023 or early 2024.
2. It will be followed by sending Vyom Mitra– a humanoid, and then with the crew onboard.
3. The crewed mission is expected to be launched by December 2024. If successful, India would be the 4th country to send a manned mission after Russia, the USA, and China.

Significance of the Mission:

1. If the maiden human spaceflight Gaganyaan mission is a success, **India will become the fourth country to have conducted human spaceflights after** the US, Russia, and China.
2. The programme would spur research and development within the country in niche science and technology.
3. **ISRO has developed some critical technologies like re-entry mission capability, crew escape system, crew module configuration, thermal protection system, deceleration** and flotation system, sub-systems of life support system required for Mission Gaganyaan.
4. **The human spaceflight programme will provide a unique micro-gravity platform in space for conducting experiments and a test bed for future** technologies.
5. It **has potential for technology spinoffs in several areas such as medicine, agriculture, industrial safety, pollution, waste management, water** and food resource management through this programme.
6. **The maiden spaceflight is also aiming to achieve economic activities such as employment generation, human resource development**, and enhanced industrial capabilities.

Challenges in the mission:

1. **Environmental Hazards: Hostile space environment with a lack of gravity and atmosphere and danger of radiation**.
2. Astronauts may have medical issues due to:

   Microgravity: Transition from one gravity field to another affects hand-eye and head-eye coordination leading to orientation-loss, vision, muscle strength, aerobic capacity, etc.

   Isolation: They may encounter depression, cabin fever, fatigue, sleep disorder and other psychiatric disorders.
3. Artificial Atmosphere: A pure or concentrated oxygen atmosphere is toxic and has fire risk, especially in ground operations.
4. **Aerospace Technology Challenges:. Travelling in a rocket is like sitting on an exploding bomb with a speed increasing from 0 to over 25,000 km per hour in a few minutes. Anything may go wrong during the launch and pre and post phases, including the explosion** of the rocket.

Way forward:

1. **A well-developed Environmental Control and Life Support System (ECLSS) is needed to supply the essentials**, maintain the acceptable environment and deal with the management of waste products.
2. **Ground testing will have to be followed by tests in the space orbit while simulating zero gravity and deep vacuum**.
3. Launch escape system safety features have to be built to minimize the loss and warning of anything

abnormal.

4. The crew and mission control team require extensive training to prepare. They also need to familiarize themselves with man-machine interfaces within the crew module and various safety drills.

Astrosat

AstroSat is the first dedicated Indian astronomy mission aimed at studying celestial sources in X-ray, optical and UV spectral bands simultaneously.

Scientific objectives:

1. To understand high energy processes in binary star systems containing neutron stars and black holes.
2. Estimate magnetic fields of neutron stars.
3. Study star birth regions and high energy processes in star systems lying beyond our galaxy.
4. Detect new briefly bright X-ray sources in the sky.
5. Perform a limited deep field survey of the Universe in the Ultraviolet region.

Features of Astrosat:

1. It is a multi-wavelength astronomy mission on an IRS-class (Indian Remote Sensing-Class) satellite in a 650-km, near-equatorial orbit.
2. It was launched by the Indian launch vehicle PSLV from Satish Dhawan Space Centre, Sriharikota on September 28, 2015 by ISRO.
3. It is the first dedicated Indian astronomy mission aimed at studying celestial sources in X-ray, optical and UV spectral bands simultaneously with its five unique X-ray and ultraviolet telescopes working in tandem.
4. One of the unique features of AstroSat mission is that it enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.

Findings of Astrosat:

1. A **team of Scientists from the Inter University Centre for Astronomy and Astrophysics (IUCAA) has discovered one of the earliest galaxies called AUDFs01 using AstroSat.**
2. The galaxy is located in the Hubble Extreme Deep field, 9.3 billion light-years away from Earth.
3. **The team comprises scientists from India, Switzerland, France, USA, Japan and Netherlands**.

Navic(Navigation with Indian Constellation)/IRNSS(Indian Regional Navigation Satellite System (IRNSS)

Navigation with Indian Constellation (NavIC) is an independent regional navigation satellite system designed to provide position information in the Indian region and 1500 km around the Indian mainland.

Main objective of IRNSS:(a)**The main objective is to provide reliable position, navigation and timing services over India and its neighbourhood.**

Important features of IRNSS:

a) **RNSS is India's own GPS-like system, much like the American GPS system. The difference between both is that while the IRNSS is** a regional satellite navigation system, the American GPS is a global satellite navigation system

b) However, compared to GPS (24 satellites) which has a position accuracy of 20-30 metres, the NavIC is able to pinpoint location to an estimated accuracy of under 20 metres.

Space Segment of IRNSS:

1. It is a **constellation of total 7 satellite launched in space and a ground facility on land to receive signals from** space satellites.
2. **3 of its satellite Located in Geostationary orbit and 4** are inclined to geosynchronous orbit.
3. **However full NAVIC system has 9 satellite, 2** on ground in standby mode.

Areas it will cover:

1. **Primary Service Area: To provide accurate position information service to users in India as well as the region extending up to 1500 km** from its boundary, which is its primary service area.
2. **Extended Service Area: It lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude** 30 deg East to 130 deg East.

Services provided:IRNSS would provide two types of services, namely

1. **Standard Positioning Services available to all users** and
2. **Restricted Services provided to authorised** users. (Encrypted)

Applications of IRNSS:

1. Terrestrial, Aerial and Marine Navigation.
2. Disaster Management.
3. Vehicle tracking and fleet management.
4. Integration with mobile phones.
5. Precise Timing.
6. Mapping and Geodetic data capture.
7. Terrestrial navigation aid for hikers and travelers.
8. Visual and voice navigation for drivers

Significance:

1. **India became one of the 5 countries having their own navigation system like GPS of USA, GLONASS of Russia, Galileo of Europe and** BeiDu of China. So India dependence on other countries for navigation purposes reduces.
2. It **give real time information for 2 services i.e standard positioning service open for civilian use and Restricted service which may be encrypted** for authorised user like for military. Currently we uses GPS system of USA for navigation.
3. It **will help to mitigate the disaster effects by providing information of disaster timing, safe location and also help the disaster relief management to make earlier plans and save** the lives of people in India as well as up to 1500 km around it.
4. It **will help the mariners for far navigation and fisherman for get information about the valuable fisheries location and any disturbance** in Sea.
5. It **will help to make friendly relations with others countries by providing real time information during any calamity or disaster for mitigate its after** effect and for making early plans.
6. In **April 2019, the government made NavIC-based vehicle trackers mandatory for all commercial vehicles in the country in accordance** with the **Nirbhaya case verdict**.
7. **NavIC can majorly cut our dependence on navigation systems operated by other countries, which can be critical during emergencies**, natural calamities or war.
8. **The Ministry of Road Transport and Highways has mandated that all national-permit vehicles must have such tracking devices.** As a pilot, many fishing boats have been fitted with these devices that have a unique texting facility.

Recent development with Navic:

1. **The newly launched Apple iPhone 15 Pro and iPhone 15 Pro Max will** support India's own GPS system-- commonly known as NavIC. **This is the first batch of Made in India iPhones** which will see support for the indigenous GPS system
2. **The leading semiconductor manufacturer Qualcomm Technologies Inc. developed and tested** NavIC-friendly chipsets.
3. **This will help NAVIC support upcoming Automotive, Mobile and IoT (Internet of things) applications and platforms**.
4. **The collaboration will enable superior location-based services to India's industries and technology** ecosystem.

Mission Aditya

The Aditya-L1 mission, developed by the Indian Space Research Organisation (ISRO), represents India's first space-based observatory dedicated to studying the Sun.

Positioning of Aditya:

Positioned at the Lagrange point 1 (L1), located about 1.5 million km from Earth, this pioneering mission aims to unravel the mysteries of the Sun's behavior, magnetic fields, and space weather impacts.

Objective: The major objectives of Aditya-L1 mission are:

1. Study of Solar upper atmospheric (chromosphere and corona) dynamics.
2. **Study of chromospheric and coronal heating, physics of the partially ionized plasma, initiation of the coronal mass ejections, and** flares.
3. Observe the in-situ particle and plasma environment providing data for the study of particle dynamics from the Sun.
4. Physics of solar corona and its heating mechanism.
5. **Diagnostics of the coronal and coronal loops plasma: Temperature, velocity and density.**
6. **Identify the sequence of processes that occur at multiple layers (chromosphere, base and extended corona) which eventually leads** to solar eruptive events.
7. **Magnetic field topology and magnetic field measurements** in the solar corona.
8. **Drivers for space weather (origin, composition and dynamics** of solar wind.

Launch vehicle: It will be launched using PSLV(Polar Satellite launch Vehicle.

Significance of Aditya Mission:

1. **Understanding of the evolution of Earth due to Sun's Impact – All planets and exoplanets including the earth evolve around the parent star (Sun). Changes in the Sun affect the evolution pattern of the planets. Aditya L-1 will help in understanding these evolution** patterns.
2. **Understanding of the changes of weather on Earth due to the Sun-The solar weather and environment which is determined by the processes taking place inside and around the sun affects the weather on Earth. Aditya L-1 will provide knowledge about solar events**, which will be key to understanding space weather.
3. **Tracking of Earth Directed Solar Storms – Every Solar storm that emerges from the Sun and heads towards Earth passes through Lagrange Point L1.**

Since Aditya L-1 is placed at Lagrange Point L1 of the Sun-Earth system, it has the major advantage of continuously tracking these Earth Directed Solar Storms.

4. **Solving the mystery of 'Coronal Heating Problem'-. Observations by Aditya-L1 of the magnetic fields bubbling out of the photosphere into the corona will help solve the mystery** of 'coronal heating problem'.
5. **First UV imaging of Sun – UV rays of the wavelengths from 200-400 nanometers are prevented from entering the earth by the ozone layer. Since these wavelengths are stopped, we are not able to ascertain the intensity of these UV rays. Ozone depletion can lead to this radiation filtering through to lower levels where it can have harmful effects. Aditya L-1 mission will record the intensity of these** waves which will help in preventing mankind from harmful effect of these UV rays in future.
6. **Safe upkeeping of satellites in space – Variations in solar weather can change the orbits of satellites or shorten their lives. They can also damage onboard electronics of satellites** and cause power blackouts. Aditya L-1 can provide information about the variations in solar weather which will be helpful in the safe upkeeping of satellites and International Space Station.

Challenges associated :

1. **Huge Distance between Sun and Earth – The L1 point where Aditya L-1 will be placed is about 1.5 million km from Earth. Aditya L-1 has to travel approximately 5 times the distance travelled** by Chandrayaan- 3. Safe placement of Aditya L-1 at this point is a challenging task.
2. **Exposition to heat of the Sun – Aditya L-1 mission will be exposed to high coronal heat which can interfere with the function of the instruments** onboard.
3. **Solar flares:Withstanding solar flares is a challenge that Aditya L-1 faces. SOHO, which was the first mission by NASA to study the sun from L-1 point, suffered damage and could not** fulfill its entire mission objectives.
4. **Presence of Moving components –Aditya L-1 has moving components like polished mirrors on the telescope and multiple operations of the front window of the telescope. Ensuring proper functioning of these moving payloads**/components is a challenging task.
5. **Shorter Duration – The duration of Aditya L-1 which is expected to last for 5 years has a very short time span for observation of solar cycles which take more than 10** years.

Way forward:

1. **Various solar phenomena are multi-directional, and hence, it is necessary to go** beyond the L1 point to study the multi-directional distribution of energy erupting out of the sun.
2. **As the study of the sun's magnetic fields and polar dynamics is very important to know more about the various solar processes, there should be missions to study the sun's polar regions also, despite the technological challenges** of the spacecraft.
3. **Future Missions should be directed towards the L5 for studying the Earth-directed events and assessing the space weather more accurately**.

Langrange Points

Lagrange Points are positions in space where the gravitational forces of a two-body system like the Sun and the Earth balance out, allowing a spacecraft to remain in position with reduced fuel consumption.

Types of Langrange Points:

1. L1**:The first Lagrange point is located between the Earth and the Sun, giving satellites at this point a constant view of the Sun.Aditya** will be placed in L1
2. L2:**The second Lagrange point is about the same distance from the Earth but is located behind the Earth. Earth is always between the second Lagrange point and the Sun.It is a good location for space telescopes, including the future James Webb Space Telescope**.
3. L3:**The third Lagrange point is opposite the Earth on the other side of the Sun so that the Sun is always between it and Earth.A satellite in this position would not be able to communicate with Earth.It offers the potential to observe** the far side of the Sun.
4. **L4 and L5:L4 and L5 points are resistant to gravitational perturbations.Because of this stability, they are used to study objects such as dust and asteroids .**

Significance of Langrange Points:

1. Stable remote orbits:Langrange Points provide a sollution by offering orbits stability ,even when they are millions of Kilometers away.
2. Gravitational balance:These points are the specific points where gravitational forces of both earth and sun work harmoniously.
3. Anchoring spacecraft:Spacecraft positioned at Langrange Points remain stable and can be effectively anchored relative to earth.
4. Minimized effort for positioning:Spacecraft

at Langrange Points stay fixed with minimal effort,ensuring proximity to Earth without entering different orbits.

5. Reduced fuel consumption:These can be used by spacecraft to reduce fuel consumption needed to remain in position.

NISAR(NASA-ISRO Synthetic Aperture Radar).

NISAR is a joint Earth-observing mission between NASA and the Indian Space Research Organization (ISRO) with the goal to make global measurements of the causes and consequences of land surface changes using advanced radar imaging.

Features:

1. NISAR is a Low Earth Orbit (LEO) observatory jointly developed by NASA and ISRO. NISAR will map the entire globe in 12 days.
2. It is an SUV-size satellite weighing 2,800 kilograms.
3. It **consists of both L-band and S-band synthetic aperture radar (SAR) instruments, which makes it a dual-frequency imaging radar satellite.**
4. NISAR will be the first satellite mission to use two different radar frequencies (L-band and S-band) to measure changes in our planet's surface.
5. SAR is capable of penetrating clouds and can collect data day and night regardless of the weather conditions.
6. NASA has provided the L-band radar, GPS, a high-capacity solid-state recorder to store data, and a payload data subsystem. ISRO has provided the S-band radar, the GSLV launch system, and spacecraft.
7. It **also consists of a large 39-foot stationary antenna reflector made of a gold-plated wire mesh which will be used to focus "the radar signals emitted and received by the upward-facing feed on the instrument structure**.

Launch of the Mission

1. The satellite will be launched from India aboard a GSLV in Q1 of 2024.
2. The orbit will be a Sun-synchronous, dawn-to-dusk type. The planned mission life is three years.

Objectives of the Mission

1. **NISAR will observe subtle changes in Earth's surfaces, helping researchers better understand the causes and consequences of such phenomena.**
2. It will spot warning signs of natural disasters, such as volcanic eruptions, earthquakes and landslides.
3. **The satellite will also measure groundwater levels, track flow rates of glaciers and ice sheets, and monitor the planet's forest and agricultural regions, which can improve our understanding of carbon exchange**.
4. ISRO will use NISAR for a variety of purposes including agricultural mapping, and monitoring of glaciers in the Himalayas, landslide-prone areas and changes in the coastline.
5. **By using synthetic aperture radar (SAR), NISAR will produce high-resolution images.**
6. **SAR is capable of penetrating clouds and can collect data day and night regardless of the weather conditions**.

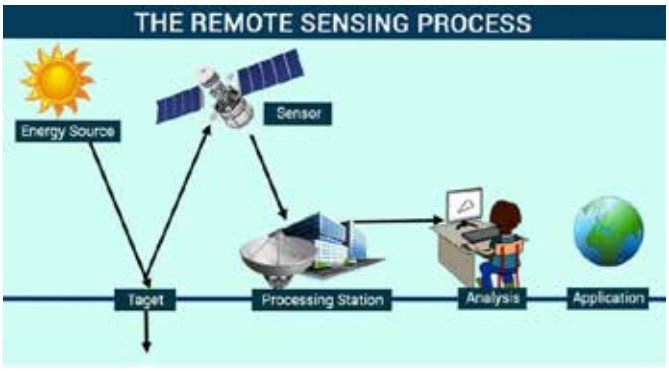
Significance of Nisar:

1. **Earth Science: NISAR will provide a wealth of data and information about the Earth's surface changes, natural hazards, and ecosystem disturbances, helping to advance our understanding of Earth** system processes and climate change.
2. **Disaster Management:** The mission will provide critical information to help manage natural disasters such as earthquakes, tsunamis, and volcanic eruptions, enabling faster response times and better risk assessments.
3. **Agriculture:** NISAR data will be used to improve agriculture management and food security by providing information about crop growth, soil moisture, and land-use changes.
4. **Infrastructure Monitoring:** The mission will provide data for infrastructure monitoring and management, such as monitoring of oil spills, urbanization, and deforestation.
1. **Climate Change:** NISAR will help to monitor and understand the impacts of climate change on the Earth's land surface, including melting glaciers, sea-level rise, and changes in carbon storage.

Remote Sensing Satellites

Remote sensing is the method of detecting and monitoring the physical characteristics of a region by measuring its reflected and emitted radiation at a distance from a satellite or aircraft.

Remote Sensing process:



Remote Sensing Satellites of India:

India's Recent IRS satellites

1. **2012: Radar Imaging Satellite-1 (RISAT-1)** imaging of the surface features during both day and night under all weather conditions.
2. **2011: Megha-Tropiques,** for studying the water cycle and energy exchanges in the tropics.
3. **2011: RESOURCESAT-2** to continue the remote sensing data services to global users provided by RESOURCESAT-1, and to provide data with enhanced multispectral and spatial coverage as well.
4. **2010: Cartosat-2B** to provide multiple spot scene imageries. It is capable of imaging a swath (geographical strip) of 9.6 km with a resolution of better than 1 metre.
5. 2009: Oceansat-2 is to provide continuity of Oceansat (IRS-P4) with enhanced application potential.
6. **2009: Radar Imaging Satellite (RISAT-2)** is capable of taking earth images in all weather.
7. **2008: IMS-1,** previously referred to as TWSat (Third World Satellite), is a low-cost microsatellite imaging mission of ISRO.
8. **2008: CARTOSAT – 2A** is the thirteenth satellite in the Indian Remote Sensing Satellite series (IRS).
9. **2007: CARTOSAT-2**, launched by PSLV-C7 on January 10, 2007, is the twelfth in the Indian Remote Sensing.
10. **2005: CARTOSAT – 1** is the first Indian Remote Sensing Satellite capable of providing in-orbit stereo images.
11. **2003: RESOURCESAT-1** is the tenth satellite of ISRO in IRS series.

1. **Application of Remote Sensing Satellites:**
   - ❖ Applications in Agriculture and Soil
   - ❖ Cropping pattern mapping;
   - ❖ Pre- harvest crop area, production and yield estimation;
   - ❖ Compliance monitoring (farming practices) e.g. crop stubble burning;
   - ❖ Identification of suitable sites for different agricultural practices;
   - ❖ Mapping of soil characteristics;
   - ❖ Mapping of soil management practices;
   - ❖ Mapping of saline soils and monitoring of land reclamation;
   - ❖ Inventorying and categorization of wastelands; and
   - ❖ dentification of fishery prospects.
2. **Applications in Bio-resources and Environment**
   - ❖ Mapping of forest cover, types, density and species inventory;
   - ❖ Measurement of biophysical conditions of forest strands;
   - ❖ Social forestry and agroforestry mapping;
   - ❖ Biomass estimation;
   - ❖ Afforestation and deforestation assessment;
   - ❖ Forest fire surveillance;
   - ❖ Forest health and vigor monitoring;
   - ❖ Detailed survey and inventory of the existing bio-resources;
   - ❖ Environmental impact assessment including pollution (land, water and air);
   - ❖ Mapping and monitoring of tiger reserves, elephant corridors, biosphere reserves, mangroves and coral reefs;
   - ❖ Assessment of fuel wood and timber resources; and
   - ❖ Environmental hazard related studies like zonation and damage assessment (floods, drought, cyclone, landslide, volcano, earthquake etc.)
3. **Applications in Geology and Mineral Resources**
   - ❖ Mapping of surfacial deposits and bedrock;
   - ❖ Geo - hazard mapping, monitoring and zonation.
4. **Applications in Oceanography**
   - ❖ Identification of potential fishery zones;
   - ❖ Phytoplankton abundance and habitat assessment;
   - ➢ Observation of marine pollution and sedimentation and its impact; and
   - ❖ Assessment of sediment dynamics, tidal fluctuations, sea level changes and coastal circulations.
5. **Applications in Water Resources**
   - ❖ Mapping of surface water bodies;
   - ❖ ঘdentification of potential ground water resources;
   - ❖ Wetland mapping and monitoring;
   - ❖ Snow pack and glacial monitoring;
   - ❖ Ice thickness measurements;
   - ❖ Rivers, watersheds and ice lake monitoring and modelling;
   - ❖ Flood mapping and monitoring;
   - ❖ Monitoring reservoir extends over seasons and irrigation scheduling and flood management;
6. **Applications in Urban Sector**
   - ❖ Identification of illegal encroachment, and constructions;

- ❖ Property tax assessment and estimations;
- ❖ Transport and urban planning;
- ❖ Population estimation;
- ❖ Slum detection and monitoring;

Communication Satellites

A communications satellite is an artificial satellite that relays and amplifies radio telecommunications signals through a transponder.

Communication Satellites of India: - INSAT, GSAT, EDUSAT, and HAMSAT etc.

Application of Satellite Communication

1. **Television**

   INSAT has been a major catalyst for the expansion of television coverage in India. **DOS has made available the required transponders through INSAT/GSAT satellites and through leased** capacity to cater to the needs of television service.

2. **Radio Networking**

   Radio Networking (RN) through INSAT provides a reliable high-fidelity programme channels for National as well as Regional Networking.

3. **Telecommunications:**

   Satellite links are the primary means of connectivity to remote and far flung regions of the country and they are the backup links for large number of terrestrial connectivity in the mainland.

4. **Telemedicine:**Telemedicine is assisting rural health services by bringing Super-Specialty doctor services to outlying areas.

5. **Tele-education:**
   - ❖ **EDUSAT had manifold objectives - to supplement the curriculum-based teaching, imparting effective teacher training, providing access to quality resource persons and new technologies, thus finally resulting in taking education to every nook and** corner of India.
   - ❖ **EDUSAT provided connectivity to schools, colleges and higher levels of education and also supported non-formal education including development communication**.

6. **Satellite Meteorology:**

   At present, INSAT/GSAT satellites carrying meteorological payloads are supporting weather forecasting services.

7. **Satellite Aided Search and Rescue (SAS&R):**

   India is a member of the international COSPAS-SARSAT programme for providing distress alert and position location service through LEOSAR (Low Earth Orbit Search And Rescue) satellite system.

8. International cooperation in DMS:During 2015, satellite data support (28 scenes) were provided for 10 emergency requests from Vietnam, Pakistan, Indonesia, Bangladesh, Japan, Myanmar, Nepal and Taiwan for floods, oil spill, landslides and Typhoon disasters.

Benefits of Satellite Communication for India

1. **Can reach inaccessible areas: An estimated 20-25% of India's population lives in areas that are difficult to reach by terrestrial telecom and lack mobile and internet access. These areas are easily accessible via** satellite.
2. **Lesser Cost of reaching difficult terrain areas: Terrestrial telecom rollout in difficult terrain can cost up to** 15 times more than in more accessible areas.

   Furthermore, such areas are frequently under-populated, with low average revenue per user.

   Satcom has the potential to significantly improve backhaul for mobile service providers in these areas.
3. **Enhanced dependability and quality: Only about 35% of mobile base stations are connected to fibre. Satellite connectivity outperforms microwave technology and is more practical in difficult terrain than fibre**.

   As a result, Satcom could improve the dependability and quality of existing mobile networks.
4. **Rural Economy:Satellite communication has the potential to transform the rural economy by enabling village connectivity, education and skill development** programmes, healthcare and telemedicine, warehousing, public distribution systems, and a variety of other applications in far-flung and remote locations.
5. **Security purposes:Satellite communication is also essential in military operations, coastal security, border surveillance, disaster management, and other mission-critical operations and strategic applications**.

Thus Satellite communications is emerging as an important component of India's plans to expand access to high-quality internet across the country. Satellite communications is crucial to the digital economy and India's growing clout in the global technology landscape. As a result, satellites and space will play an important role in the overall mission to ensure internet delivery and the goal of connecting people to the digital economy.

GAGAN(GPS Aided GEO Augmented Navigation)

Gagan is a Space Based Augmentation System (SBAS) jointly developed by ISRO (Indian Space Research Organisation) and AAI to provide the best possible navigational services over Indian FIR (Flight Information Region) with the capability of expanding to neighboring FIRs.

Objective of Gagan: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

Background

1. GPS (Global Positioning System) signals are not always pin-point accurate.
2. GPS is susceptible to factors and disturbances such as ionospheric interference, the location of the moving vehicle, and even the functioning of the GPS satellite, signal availability,
3. Many advanced countries have their own localised solutions to such problems and systems to perform this corrective action. Example: US-WAAS, European EGNOS, and Japanese MSAS etc.

GAGAN Technology

1. **Using a technology known as the Satellite-Based Augmentation System (SBAS), GAGAN correct the errors in GPS signals and** feed the corrected signals to the moving vehicle (GPS user), thus enabling precise navigation.
2. Thus, GAGAN is a system of satellites and ground stations that provide GPS signal corrections, giving better position accuracy.
3. The system is inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc.
4. **The GAGAN Signal-In-Space (SIS) is available through GSAT-8** and GSAT-10.

Services Offered

Aviation, Forest management, Railways signalling, Scientific Research for Atmospheric Studies, Natural Resource and Land Management, Location based services, Mobile, Tourism.

Gagan applications

1. Smaller airports will benefit: Once fully rolled out, it will make several smaller airports such as those in the North-East capable of having compliant aircraft land in low-visibility scenarios.
2. Poor weather and low visibility: This new technology provides a substantial operational benefit in poor weather and low visibility conditions.
3. **Safety: Aircraft can derive maximum benefit in terms of improved safety during landing, reduction in fuel consumption, reduction in delays, diversions and cancellations** etc
4. **Tool to alert before natural disaster**: AAI in coordination with Indian National **Centre for Ocean Information Services (INCOIS) has implemented GAGAN Message Service (GMS) through which alert messages to fishermen**, farmers, and disaster affected people will be sent on the occurrence of natural disasters, calamities, such as flood, earthquake etc.
5. **Non-aviation field: The additional capabilities of GAGAN are also being explored to utilise it in non-aviation fields such as railways, surveying**, agriculture, power sector, mining etc.
6. **Other benefits: While GAGAN** is primarily meant for aviation, it will provide benefits to several other segments such as intelligent transportation, maritime, highways, railways, security agencies, telecom, etc.

GIS (Geographical information system)

According to Environmental Systems Research Institute (ESRI)Geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth._

Applications of GIS:

Agriculture:

1. **Drought management**: GIS helps manage droughts by identifying areas or lands that are experiencing a lack of water. It helps prevent damage to plant seeds, human efforts, and expensive fertilizers.
2. **Pest control**: It is also used for pest control by predicting attacks from pests like locusts and rodents by analyzing spatial data of specific agricultural lands. It allows the government and farmers to plan how to deal with these pests.
3. **Land and soil analysis**: By studying previous data sets, satellite images, or even analyzing the field directly, field workers can gather information about the land and soil conditions.
4. **Planning of future food demand**: By considering the population's needs, the government and farmers can plan and produce enough crops to meet the demand.

Example:A software named "Image Processing and Analysis Software (ENVI) program uses GIS to create layers of agricultural land and allows farmers to decide what parts are best for rice production.

Applications of GIS in Environment:

1. Quality of Life: It helps monitor the air and water quality to analyze real-life habitat conditions.
2. **Planning: It simplifies the process of selecting the proper location for new infrastructure plans by checking the project's impact** on the environment
3. Resource management: Governments can locate areas with natural resources like water bodies, forests, and agricultural lands.
4. **Climate change: They can analyze climate data to assess the risks associated with climate change**.

Example:Parivesh is an online system in India where people can submit construction proposals for approval. Using GIS, the software checks if the project can harm the environment, which lets the government decide whether to accept or reject these proposals.

Urban Planning and Transportation:

1. **Growth Forecast: It's useful in developing models to predict and plan for the future expansion** of cities.
2. **Planning Land Usage: It lets infrastructure experts analyze and allocate land for various purposes like residential, commercial, and industrial** use in urban areas.
3. **Transportation network: Countries can improve transportation systems, including roads, public transit, and pedestrian infrastructure, to ensure** smooth movement within cities.
4. **Infrastructure management: Cities can efficiently manage urban infrastructure, such as bridges and public** facilities, to support sustainable development.

Example:Dubai's Roads and Transport Authority uses GIS to manage its transportation system by improving the use of traffic signals as well as checking the flow of traffic.

Applications of GIS in Disaster Management:

1. Risk-Prone Locations: It helps in identifying risk-prone locations such as hospitals.
2. **Isolation** Centers: It assists in establishing isolation centers near high-risk zones.
3. Calamity Records: Government officials can use them to maintain records of past calamities in an area.
4. Previous Impact: GIS helps analyze the impact of previous disasters to plan for future contingencies.

Example:FEMA is a US agency that helps the US government prepare for natural disasters, mainly earthquakes. They have a GIS system called HAZUS that predicts how disasters will affect specific areas. This information helps FEMA create safety plans, such as strengthening buildings and establishing emergency recovery programs in high-risk locations

Applications of GIS in Business Management:

1. Target Markets: It lets businesses understand customer demographics and behavior patterns to find target locations for new business ventures.
2. Choosing Advertising Sites: It can help companies find suitable places for billboards or other advertising mediums.
3. Managing Product Distribution: Businesses can select the best transport routes to save money and make their distribution process more efficient.

Example: Starbucks uses GIS to find ideal locations for new stores.

Applications of GIS in Health and Human Services:

1. Identifying High-Risk Zones: By mapping the distribution of diseases in a specific location, authorities can find areas at high health risk.
2. **Educating about Health: GIS can assist the government in raising awareness about health-related issues, promoting healthy behaviors, and** achieving other objectives.
3. **Emergency Response: GIS helps coordinate emergency responses by mapping healthcare** facilities, emergency services, evacuation routes, and more.

Example: Cowin used GIS data to provide information about infected persons during Covid-19

Education:

GIS technology is useful in education for making subjects like geography and environmental studies easier to understand. It can also help decide where to build schools to provide education to students who don't have many opportunities.

Examples:Esri UK, an England-Based software company, created a program called "Teach with GIS" to help teachers in their classrooms. This program offers different resources such as lesson plans, videos, interactive maps, and dashboards.

Crime & Defence:The Centre of Excellence on Satellite & Unmanned Remote Vehicle Initiative (CoE-SURVEI) in India uses GIS-based software. This software uses satellite images to find any suspicious activities in the country's defense lands. It can also find authorized or unauthorized constructions, helping to prevent illegal activities.

Oil and Gas:Niti Aayog and ISRO collaborated to create a system that uses GIS to find all the places in India that have energy (oil and gas) reserves.

Challenges and Limitations of GIS:

1. **Costs: It can be difficult for some organizations to buy and use, as GIS technology can** be very costly.
2. **Huge Data: GIS deals with a large amount of data, which can take a lot of time and require powerful hardware and efficient software**.
3. **Technical Expertise: Using the GIS system effectively requires specific knowledge and technological** expertise.
4. Integration Problem: Combining data from many sources can be challenging and time-consuming.
5. **Privacy and Security: A major concern is keeping private and confidential** data safe from unauthorized access.

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