Chandrayaan-3

Why in News?

At 2.35 p.m. Indian Standard Time on July 14, the Indian Space Research Organisation (ISRO) plans to launch the Chandrayaan-3 mission to the moon onboard a Launch Vehicle Mark 3 from Sriharikota.

Key Highlights

- Chandrayaan-3 is largely a replica of its predecessor Chandrayaan-2, that was launched in July 2019 in the form of an orbiter and a lander ('Vikram') bearing a rover ('Pragyan'). While the orbiter entered into orbit around the moon, the surface mission failed in September when the lander crashed instead of executing a slow descent.
- In Chandrayaan-3, the rocket will place the payload in an elliptical orbit around the earth, where a propulsion module will take over and pilot the lander to a circular orbit around the moon.
- Finally, the lander will detach and begin a series of manoeuvres culminating in a gradual landing (on August 23-24 this year) over the surface.
- To improve the chances of success at this stage, ISRO has strengthened the lander's legs, lowered its minimum thrust, enhanced the availability of power, and upgraded the landing sequence.

This will be India's second attempt to soft-land a lander and rover on the lunar surface, and demonstrate end-to-end capability in the relevant technologies.

- Soft-landing on the moon is a complicated exercise and the possibility of failure exists, even if it may be lower — yet there is good reason to focus on the consequences of a complete success.
- The success of Chandrayaan-3 will also make it the surface mission closest to the lunar south pole to date, a region of the moon that has been found to be **geologically unique** and host to spots in permanent shadow.
    - To study these and other features, the mission has **six scientific payloads**. A seventh instrument, on the **propulsion module**, will profile the signs of life on earth to help scientists look for similar signs on planets beyond the solar system

The mission will play out with India's decision to join the **Artemis Accords** in the backdrop; in this group, if the mission succeeds, the country will be just the second to have soft-landed a rover on the moon.

Second moonshot

Chandrayaan-3 speaks to moon's rising importance in scientific, political milieus

At 2.35 p.m. Indian Standard Time on July 14, the Indian Space Research Organisation (ISRO) plans to launch the Chandrayaan-3 mission to the moon onboard a Launch Vehicle Mark 3 from Sriharikota. Chandrayaan-3 is largely a replica of its predecessor, Chandrayaan-2, that was launched in July 2019 in the form of an orbiter and a lander ('Vikram') bearing a rover ('Pragyan'). While the orbiter entered into orbit around the moon, the surface mission failed in September when the lander crashed instead of executing a slow descent. ISRO later identified a problem in the guidance software and unexpected dispersion in the propulsion system during certain phases of the descent. In Chandrayaan-3, the rocket will place the payload in an elliptical orbit around the earth, where a propulsion module will take over and pilot the lander to a circular orbit around the moon. Finally, the lander will detach and begin a series of manoeuvres culminating in a gradual landing (on August 23-24 this year) over the surface. To improve the chances of success at this stage, ISRO has strengthened the lander's legs, lowered its minimum thrust, enhanced the availability of power, and upgraded the landing sequence.

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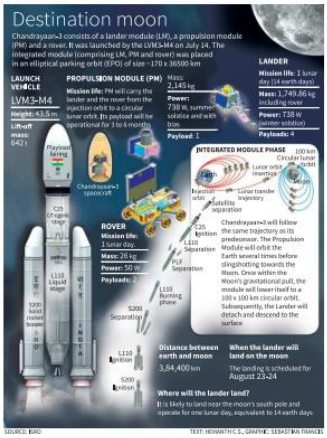
Success of Chandrayaan launch vehicle gives Gaganyaan a leg-up

Gaganyaan is expected to demonstrate India's manned spaceflight capability; LVM project director Mohan Kumar said the human-rated S200 [solid strap-on motors] have been used again, and the L110 Vikas engine has also become human-rated

The Hindu Bureau
SRIHARIKOTA



SOURCE: ISRO TEXT: HEMANTHIS S., GRAPHIC: SEBASTIAN PAMEDU

With a human-rated Launch Vehicle Mark (LVM) to be used for the upcoming Gaganyaan mission, the LVM-3's successful launch of the Chandrayaan-3 on Friday gained significance, as it has further enhanced the reliability of the launch vehicle.

Following the launch, LVM project director Mohan Kumar said that the rocket used for the Chandrayaan-3 mission used multiple systems that were rated for humans. "The human-rated S200 [solid strap-on motors] that were used earlier were again used, and the L110 Vikas engine has also completely become human-rated today," he said.

ISRO's Gaganyaan project is expected to demonstrate India's human spaceflight capability by launching three astronauts to an orbit of 400 km for a three-day mission, and then bringing them safely back to earth, landing them in Indian seas.

The success of the Chandrayaan-3 launch was celebrated by several public and private sector units all over the country that played an active role in the mission. For instance, Mishra Dhatu Nigam Limited (MIDHANI), the defence PSU, had developed and supplied various critical and strategic materials for the three-stage heavy lift launch vehicle.

It supplied cobalt base alloys, nickel base alloys, titanium alloys and special steels for liquid engine, nozzles for liquid stages, gas bottles, thrusters, cryogenic upper stage components, rocket motor casing, propellant tanks and investment castings of nickel alloys, stainless steel for exhaust unit, etc., said an official release.

Kerala government undertaking Keltron in Thiruvananthapuram, Kerala Minerals and Metals (KMML) in Kollam, and long-time industry partners of the Indian Space Research Organisation (ISRO) such as Ananth Technologies Ltd (ATL) and Kortas Industries Pvt Ltd supplied many components. Keltron supplied 41 electronics modules and various power modules. Many of the critical components on the mission used alloys from titanium sponge produced by the KKML. KMML has a 500-tonne capacity titanium sponge plant at Chavara, Kollam, a joint venture with the Vikram Sarabhai Space Centre (VSSC) and the Defence Metallurgical Research Laboratory (DMRL). A Kerala-based rubber products firm supplied the a crucial flex seal. Vajra Rubber Products in Thrissur supplied S-200 thrust vector control flex seal for the vehicle.

The Hyderabad-headquartered Ananth Technologies Ltd (ATL), which has exclusive facilities in Thiruvananthapuram and Bengaluru for supporting ISRO's space programmes, contributed to the avionics packages for the LVM-3 mission, including on board computers on the launch vehicle, navigation system, control electronics, telemetry, power systems and various vehicle interface units.

In Bhubaneswar, technicians and students of the Central Tool Room and Training Centre are eagerly waiting to see the successful soft landing of the vehicle on the moon's surface. The CTTC has also supplied critical components. The Bhubaneswar-based central PSU has manufactured several flow control valves used in the LVM-3. It also supplied gyroscopes, propellant walls and parts, and sensors. The CTTC also manufactured some links and components of the wheel mechanism of the moon lander.

(With inputs from Kerala, Telangana and Karnataka bureaus and PTI)

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- The importance of this feat cannot be overstated: a slew of public and private moon-landing missions is in the works worldwide as the establishment of permanent bases on the natural satellite has emerged as a major geopolitical goal.
- The **Accords define** the U.S.-led axis while China and Russia are working on an 'International Lunar Research Station'.

Taken together, Chandrayaan-3 offers opportunities for India to lead the world's response to the moon's growing importance in the scientific and the political milieus.

Artemis Accords

The Artemis Accords are a non-binding set of principles designed to guide civil space exploration and use in the 21st century. These principles will help to ensure the maintenance of a safe and predictable outer space environment.

NASA, in coordination with the U.S. Department of State, established the Artemis Accords in 2020, together with seven other founding member nations.

Artemis Accords signatories as of May 30, 2023: Australia, Bahrain, Brazil, Canada, Colombia, Czech Republic, France, Israel, Italy, Japan, Luxembourg, Mexico, New Zealand, Nigeria, Poland, the Republic of Korea, Romania, Rwanda, Saudi Arabia, Singapore, Spain, Ukraine, the United Arab Emirates, the United Kingdom, and the United States.

Principles of Artemis Accord: Peaceful Purposes, Transparency, Interoperability, Emergency Assistance, Registration of Space Objects, Release of Scientific Data, Protecting Heritage, Space Resources, Deconfliction of Activities, Orbital Debris and Spacecraft Disposal.

Mission Objectives

Chandrayaan-3, with its Lander and Rover configuration, is driven by several key objectives that aim to advance our understanding of the Moon and demonstrate India's capabilities in lunar exploration. The mission objectives of Chandrayaan-3 are as follows:

Demonstrate Safe and Soft Landing on Lunar Surface

- Showcase the ability to achieve a precise and controlled soft landing on the lunar surface.
- Establish India's competence in executing safe landings on extra-terrestrial bodies and enhance the success rate of lunar missions.
- Develop crucial technologies and techniques required for future missions, including crewed lunar landings and robotic exploration.

Demonstrate Rover Roving on the Moon

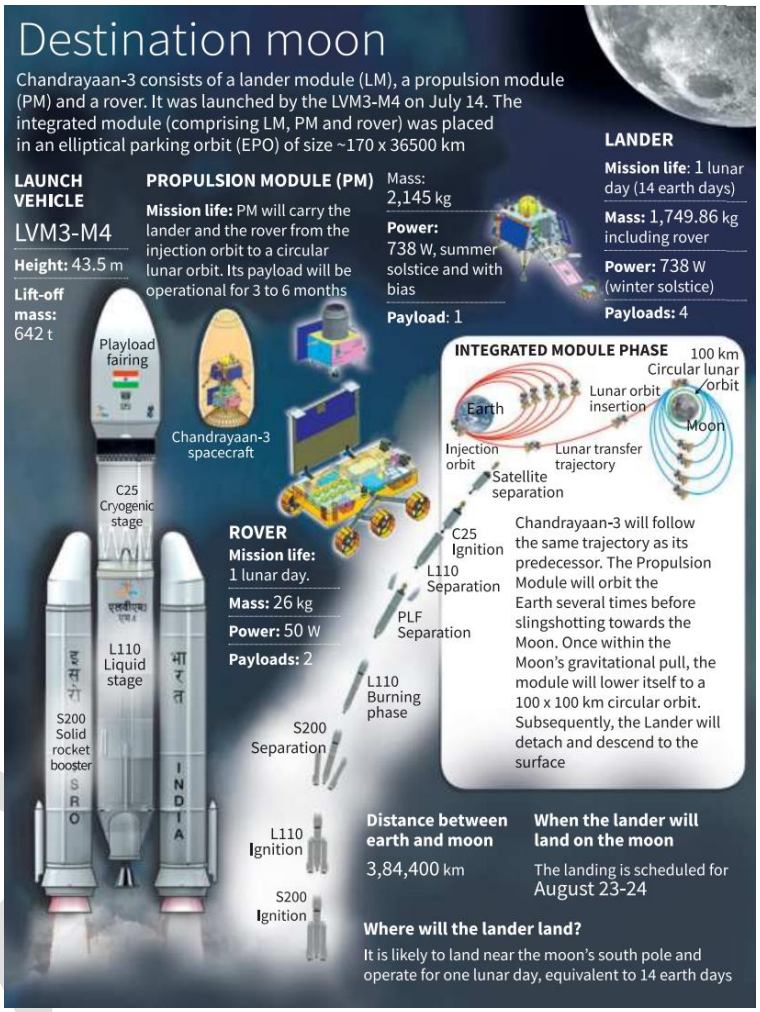
- Showcase the mobility and operational capabilities of the Rover module on the lunar surface.
- Validate the rover's ability to traverse the lunar terrain, withstand the harsh lunar environment, and perform scientific investigations.
- Lay the foundation for future rover missions, enabling extensive exploration, sample collection, and scientific analysis across the lunar surface.

Conduct In-situ Scientific Experiments

- Carry out scientific experiments to study the lunar surface and its environment.
- Gather data on the Moon's geological properties, composition, regolith characteristics, and potential resources.
- Enhance our understanding of the Moon's formation, evolution, and the processes that have shaped its surface. Provide valuable insights for future lunar missions, resource utilization, and potential human exploration.

Development and Timeline

Chandrayaan-3, the lunar mission by the Indian Space Research Organisation (ISRO), underwent a comprehensive development phase to ensure its success. The timeline of the mission showcases the efforts made to overcome challenges and prepare for its launch. Here are the key details:



- **Announcement and Design Phase: January 2020:** Chandrayaan-3 mission was first announced, outlining the objective of developing and demonstrating new technologies for interplanetary missions.
  Scientists and engineers initiated the design and assembly process for the spacecraft, including the Lander module with enhanced impact legs.
- **Impact of COVID-19 Pandemic:** The development and assembly process of Chandrayaan-3 faced delays due to the COVID-19 pandemic, which impacted manufacturing and testing schedules.
  The pandemic's first and second waves caused additional setbacks, despite the propulsion systems being nearly ready by May 2021.
- **Launch Preparation: July 14, 2023:** The much-anticipated launch of Chandrayaan-3 took place at 2.35 p.m. IST from the Satish Dhawan Space Centre, Sriharikota.
  - The launch vehicle used was the GSLV-Mk3, capable of delivering the integrated module to space.
- **Journey and Lunar Orbit:** After liftoff, the integrated module embarked on a journey of approximately one month to reach the Moon.
  - The propulsion module accompanied the Lander and Rover configuration until they reached a lunar orbit of 100 kilometers in a circular path.
- **Landing: August 23-24, 2023:** The landing of the Lander module is scheduled in the Moon's South Polar Region.
  - The descent is expected to be a crucial and nerve-wracking phase, often referred to as the "15 minutes of terror."
- **Operation Duration:** The Rover module, named 'Pragyan,' will operate on the lunar surface for approximately one lunar day, equivalent to 14 Earth days.
  - During this time, the Rover will carry out in-situ chemical analysis and scientific experiments, enhancing our understanding of the lunar environment.

Components of Chandrayaan-3: Lander and Rover Configuration

Chandrayaan-3 consists of two vital components: The Lander and Rover configuration. These components work to facilitate safe landing on the lunar surface and enable extensive exploration.

Lander Payloads

The Lander module of Chandrayaan-3 is equipped with a range of scientific payloads designed to carry out experiments and collect valuable data on the lunar surface. These payloads enable researchers to gain insights into various aspects of the Moon's environment and composition. Here are the details of the payloads:

Chandra's Surface Thermophysical Experiment (ChaSTE)

- **Objective:** Measure the thermal conductivity and temperature of the lunar surface.
- **Significance:** Provides valuable insights into the thermal properties of the Moon's regolith, helping understand heat distribution and effects of solar radiation.
    - Contributes to studying the Moon's geological processes, surface features, and geophysical characteristics.

Instrument for Lunar Seismic Activity (ILSA)

- **Objective:** Measure and analyze seismic activity around the landing site.
- **Significance:** Provides crucial information about the Moon's internal structure, subsurface composition, and tectonic activity.
    - Enhances our understanding of the Moon's geology, seismicity, and potential geological hazards.

Langmuir Probe (LP)

- **Objective:** Estimate plasma density and its variations in the lunar environment.
- **Significance:** Provides insights into the presence and behavior of plasma in the Moon's exosphere.
    - Contributes to the study of the Moon's interaction with the solar wind and its impact on the lunar surface.

Passive Laser Retroreflector Array

- **Objective:** Accommodated from NASA, used for lunar laser ranging studies.
- **Significance:** Allows for precise distance measurements between Earth and the Moon, aiding in the study of lunar dynamics and geodesy.
    - Supports ongoing scientific research and enhances our understanding of the Moon's orbit and gravitational interactions.

Advanced Technologies in Lander

These advanced technologies incorporated in the Lander module of Chandrayaan-3 enhance its capabilities and ensure precise landing, navigation, and control during the mission.

Technology	Description
Altimeters	Laser and RF-based altimeters used for precise measurement of altitude during descent.
Velocimeters	Laser Doppler Velocimeter and Lander Horizontal Velocity Camera to monitor landing velocity.
Inertial Measurement	Laser gyro-based Inertial referencing and Accelerometer package for precise navigation and control.

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Technology	Description
Propulsion System	Throttleable Liquid Engines (800N), attitude thrusters (58N), and Throttleable Engine Control Electronics.
Navigation, Guidance & Control	Powered Descent Trajectory design and associated software elements for precise control during descent.
Hazard Detection and Avoidance	Lander Hazard Detection & Avoidance Camera and Processing Algorithm to detect and avoid potential hazards.
Landing Leg Mechanism	Mechanism for the safe deployment and landing of the Lander module.

Rover Payloads

The Rover module of Chandrayaan-3 is equipped with advanced scientific payloads that enable in-situ analysis and examination of the lunar surface. These payloads provide valuable data on the elemental and chemical composition of the vicinity of the landing site. Here are the details of the rover payloads:

Alpha Particle X-ray Spectrometer (APXS)

- **Objective:** Determine the elemental composition of the lunar surface.
- **Significance:** Enables the identification and quantification of various elements present in the vicinity of the landing site.
    - Contributes to our understanding of the Moon's geological history, surface processes, and the distribution of different elements.

Laser Induced Breakdown Spectroscope (LIBS)

- **Objective:** Derive the chemical composition of the lunar surface through laser-induced plasma spectroscopy.
- **Significance:** Provides detailed information about the chemical makeup of the lunar regolith.
    - Helps in identifying specific minerals, analyzing geological processes, and assessing the potential resources available on the Moon.

Significance of Chandrayaan-3

Advancing Lunar Exploration → **Technological Advancements** → **Scientific Discoveries** → **Global Collaborations**

- **Advancing Lunar Exploration:** Chandrayaan-3 demonstrates India's commitment to furthering lunar exploration and expanding our knowledge of the Moon.
- **Technological Advancements:** The mission allows for the development and demonstration of new technologies required for interplanetary missions, including safe landing and roving capabilities.
- **Scientific Discoveries:** Chandrayaan-3's payloads enable the study of the Moon's surface, composition, thermal properties, seismic activity, and potential resources, contributing to our understanding of lunar geology and evolution.
- **Global Collaborations:** Collaborations with international partners, such as NASA and Indo-Japan initiatives, facilitate knowledge sharing, data exchange, and collective efforts in lunar research.

Future Plans

Resource Utilization	Lunar South Pole Exploration	Human Lunar Missions	Enhanced Scientific Missions	International Collaborations	Deep Space Missions

- **Resource Utilization:** Chandrayaan-3 and subsequent missions aim to explore the Moon's resources, such as water ice, which could potentially support future human missions and sustainable space exploration.
- **Lunar South Pole Exploration:** Chandrayaan-3's focus on the lunar South Pole region, with its permanently shadowed craters, holds promise for discovering water molecules and preserved records of the Moon's history.
- **Human Lunar Missions:** Chandrayaan-3's technological advancements lay the foundation for future crewed missions to the Moon, facilitating safe landings and providing crucial knowledge for human exploration and habitation.
- **Enhanced Scientific Missions:** ISRO plans to conduct more lunar missions, with advanced scientific payloads to explore different regions of the Moon and study its diverse geological features.
- **International Collaborations:** Collaborative efforts with international partners, space agencies, and scientific communities will foster knowledge sharing, joint missions, and comprehensive lunar research.
- **Deep Space Missions:** ISRO envisions undertaking deep space missions, including Mars exploration and planetary missions to expand our understanding of the solar system and beyond.

ISRO's vision extends beyond Chandrayaan-3, with plans to expand lunar research and exploration. The agency aims to build upon the mission's success and continue to contribute to scientific discoveries and technological advancements.

Conclusion

Chandrayaan-3, India's ambitious lunar mission, marks a significant milestone in the country's space exploration endeavours. With its focus on safe landing, roving capabilities, and in-situ scientific experiments, the mission showcases India's commitment to advancing lunar research, technological innovations, and international collaborations.

Chandrayaan-3 represents a significant achievement for India's space program, serving as a testament to the nation's scientific prowess and its quest to unravel the mysteries of the Moon. With its ambitious objectives, advanced technologies, and future plans, Chandrayaan-3 propels India forward in its pursuit of knowledge and exploration beyond Earth's boundaries.