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India's Chandrayaan Missions: Crawling Steps for Global Space Dominance

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***Abstract*:** ISRO's Chandrayaan-3 Mission and the nack of Indian scientists to succeed unprecedented tasks have made every Indian Proud. This paper discusses the technical aspects of Chandrayaan 3, comparison of all the three Chandrayaan missions of India.

Keywords: *Chandrayaan 3, ISRO, Chandrayaan missions of India.*

I. INTRODUCTION

Since ancient times humans are attracted to know about space. Motion of the celestial objects has been a wonder. Human race has continuously been trying to predict the placements and reaction of Sun, Moon, Earth, and Stars. The Moon is the closest celestial body and offers the best connection to Earth's prehistoric past and early civilization. It is also the closest body at which space exploration may be performed and recorded. In addition, the Moon is easily available test site for showcasing the technology needed for journeys to deep space. Exploring the Moon will improve our comprehension of the celestial body, spur technological development, foster international cooperation, and incite new generations of scientists and explorers.

From the time of its formation to the narrative of its evolution, the gigantic rock hanging in the darkness of the sky has endured millions of bombardments from other space rocks. It all started with Chandrayaan-1, when ISRO launched the first Moon mission, which eventually resulted in the finding of water on the Moon. Moving on with the sequel, Chandrayaan-3 was there to study the far side of the Moon and make an effort to soft land on the lunar surface. On Wednesday, August 23, 2023, India created history with the successful soft landing of Chandrayaan 3 on the south Pole of the Moon. Prime Minister Narendra Modi remarked that Chandrayaan-3's triumph mirrors the aspirations and capabilities of 140 crore Indians [2].

II DETAILS ABOUT CHANDRAYAAN 3

Chandrayaan 3, a follow-on mission to Chandrayaan-2, comprises a lander and a rover similar to Chandrayaan-2, but would not have an orbiter and a propulsion module. Its propulsion module was working like a communications relay satellite. [3]

The propulsion module carried the lander and rover from injection orbit to 100 km lunar orbit. The propulsion module, in addition to the lander, carried a payload called Spectro-polarimetry of Habitable Planet Earth (SHAPE) to study the spectral and polarimetric measurements of Earth from the lunar orbit. [Fig. 2]

Pragyan Rover: The rover is a rectangular chassis mounted on a six-wheel rocker-vehicle. It has navigation cameras and a solar panel that can generate 50 W and it communicates directly with the lander.

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Fig 1. Vikram Lander and Pragyan Rover

Vikram Lander: The lander is also generally box-shaped, with four landing legs and four landing thrusters. It has a mass of 1752 kg, including 26 kg for the rover, and can generate 738 W using side-mounted solar panels.

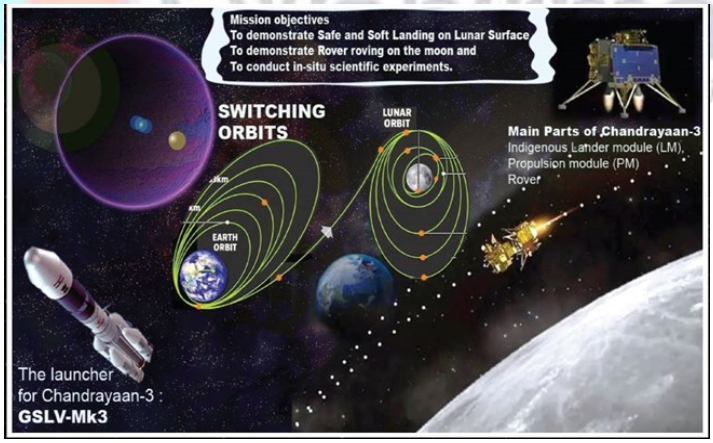

Fig 2. Chandrayaan 3 Modules and Objectives [4]

The Lander and the Rover have scientific payloads to carry out experiments on the lunar surface. The main function of the PM is to carry the LM from launch vehicle injection to final lunar 100 km circular polar orbit and separate the LM from the PM. Apart from this, the Propulsion Module also has one scientific payload as a value addition which will operate post-separation of the Lander Module.

Lander payloads: Chandra's Surface Thermophysical Experiment (ChaSTE) to measure the thermal conductivity and temperature; Instrument for Lunar Seismic Activity (ILSA) for measuring the seismicity around the landing site; Langmuir Probe (LP) to estimate the plasma density and its variations. A passive Laser Retroreflector Array from NASA is accommodated for lunar laser ranging studies.

Rover payloads: Alpha Particle X-ray Spectrometer (APXS) and Laser Induced Breakdown Spectroscope (LIBS) for deriving the elemental composition in the vicinity of the landing site.

III MISSION CHANDRAYAAN-3 TIMELINE AS PER ISRO'S UPDATES

- ***July 14, 2023*** LVM3 M4 vehicle successfully launched Chandrayaan-3 on a Geosynchronous Satellite Launch Vehicle GSLV Mark 3 (LVM 3) heavy-lift launch vehicle from Satish Dhawan Space Center in Sriharikota, Andhra Pradesh, into an approximately 170 x 36,500 km elliptic parking orbit. into orbit. Chandrayaan-3, in its precise orbit, has begun its journey to the Moon.

- ***July 15, 2023*** The first orbit-raising manoeuvre (Earthbound firing-1) successfully performed at ISTRAC/ISRO, Bengaluru. Spacecraft now in 41762 km x 173 km orbit.

- ***July 17, 2023*** The second orbit-raising manoeuvre performed. The spacecraft now in 41603 km x 226 km orbit.

- ***July 22, 2023*** The fourth orbit-raising manoeuvre (Earth-bound perigee firing) completed. The spacecraft placed in a 71351 km x 233 km orbit.

- ***July 25, 2023*** Orbit-raising manoeuvre performed on July 25, 2023. The next firing (Trans Lunar Injection), planned for August 1, 2023.

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• ***August 01, 2023*** The spacecraft inserted into the translunar orbit. The orbit achieved was 288 km x 369328 km. Lunar-Orbit Insertion (LOI) was planned for Aug 5, 2023.

• ***August 05, 2023*** Chandrayaan-3 was successfully inserted into the lunar orbit. The orbit achieved 164 km x 18074 km, as intended.

• ***August 06, 2023*** Second Lunar Bound Phase (LBN#2) successfully completed. The spacecraft placed in 170 km x 4313 km orbit around the moon.

• ***August 09, 2023*** Chandrayaan-3's orbit reduced to 174 km x 1437 km following a manoeuvre performed on August 9, 2023.

• ***August 14, 2023*** The mission was in the orbit circularisation phase. The spacecraft was in 151 km x 179 km orbit.

• ***August 16, 2023*** The moon, as seen by Lander Imager Camera 4 on August 20, 2023. The spacecraft is in an orbit of 153 km x 163 km after the firing on August 16, 2023.

• ***August 17, 2023*** Lander Module was successfully separated from the Propulsion Module. Deboosting planned for August 18, 2023.

• ***August 20, 2023*** The Lander Module was in 25 km x 134 km orbit. Powered descent was expected to commence on August 23, 2023, around 1745 Hrs. IST

• ***August 19, 2023*** The Lander Module was in 113 km x 157 km orbit around the moon. The second de-boosting was planned for August 20, 2023.

• ***August 23, 2023*** Chandrayaan-3 successfully soft-lands on the moon. Touchdown velocity had been planned to be less than 2 m/s vertical and 0.5 m/s horizontal. The propulsion module/communications relay satellite will remain in lunar orbit to enable communications with Earth. Chandrayaan 2 was also used as a backup relay. The lander and rover are designed to operate for one lunar daylight period (about 14 Earth days).

• ***August 24, 2023*** **Chandrayaan-3 ROVER:** Made in India. Made for the MOON! The Ch-3 Rover ramped down from the Lander and India took a walk on the moon!

IV COMPARISON OF CHANDRAYAAN MISSIONS OF INDIA

	Chandrayaan1	Chandrayaan2	Chandrayaan3
	India's First Lunar Mission	Follow up mission to Chandrayaan1 , ISRO's 1St inter-Planetary mission to land rover on any celestial body	Third lunar exploration mission by ISRO
Launch Year	October 2008	July 2019	July 2023
Launch Vehicle	PSLV[C11, Light Lift Vehicle]	GSLV MKIII [Far more powerful]	LVM3 M4
Spacecraft Size	1380 Kg	3850 Kg	3900 Kg
Mission and Life	Orbiter 1 Year [Failed 4 months prematurely]	Orbiter 1 Year, Lander and Rover 14 earth days	Vikram lander: ≤ 14 Earth days (planned); Pragyan rover: ≤ 14 Earth days (planned)
Cost	Rs. 540 Crore	Rs. 978 Crore	Rs. 615 Crore
Payloads	11, Indian & International	14 Indian (Many same as CY1) 1 from NASA 8 on Orbiter 4 on Lander 2 on Rover	Lander: 3 Rover: 2 Propulsion Module: 1
Speciality	Crashed the tri-coloured moon impact probe near the southern Lunar hemisphere	Orbiter: 100Km from lunar surface still existing Vikram Lander: failed to soft-land near south pole Pragyan Rover: got in pieces after 15 days. (Couldn't do Insitu experiments)	Consists of a lander and a rover similar to Chandrayaan-2, but would not have an orbiter. Its propulsion module will behave like a communication relay satellite.

Fig 3 comparison of Chandrayaan missions of India

V SCIENTISTS TAKE ON CHANDRAYAAN 3

While addressing Students Padmashree Mr. Pramod Kale, Ex-Director, ISRO (SAC), Ahmadabad, said Chandrayaan mission objective was "The first objective was to go to the moon, land on the moon's surface, and roll out the rover so that the scientists could make the measurements on the surface and additionally deploy the experiments. Going to a particular point with minimum energy was also a challenge. Chandrayaan 1 proved there is water in the soil of the moon; if so, it should be near the South Pole, as sun rays don't reach there. If Chandrayaan-3 could land near the south pole of the moon, then it should be able to actually detect the presence of frozen water in some of the small craters, so the maximum probability of finding water in that particular area exists."

Also Padmashree Pramod Kale said the emerging technologies played a crucial role in the mission,

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with a standout being our innovative use of Chandrayaan-2 orbiter photographs. These images were loaded into the lander's memory and compared with real-time camera feed, enabling precise landing. This achievement marks a significant breakthrough. ISRO also employed laser and radio frequency altimeters, but the camera tech was the game-changer. During the lunar orbit phase, Chandrayaan 3 had to reduce its speed from 1.6 kilometers per second to under a meter per second in just 10 to 12 minutes for a successful landing. This technology opens doors for future applications, such as for landing our helicopters or taking it up to the next level of our vehicles, like the reusable vehicle, which is now being developed. Similar to SpaceX's Falcon 9, which has already demonstrated this capability. Our Chandrayaan technology holds promise for such endeavors.

Chandrayaan-3's mission objectives, to demonstrate a soft landing on the lunar surface and a rover roving on the moon as well as to conduct in-situ scientific experiments, conquer both the technical challenges and the exploration opportunities. The lunar South Pole holds promise for studying water and ice, crucial for future lunar missions. Its technical accomplishments, contributions to science, and impact on the Indian economy are impressive, but its influence on inspiring humanity is equally noteworthy.

VI CONCLUSION

The Chandrayaan mission has kindled passion for space, imparted knowledge, and served as a model for exploration, especially for youth. ISRO's approach, building on previous missions, reflects a blend of resilience and readiness. India's achievement solidifies the idea that space is accessible to all and today's youngsters can take this as their initial point and go head to explore many more in the field of astronomy and also in science.

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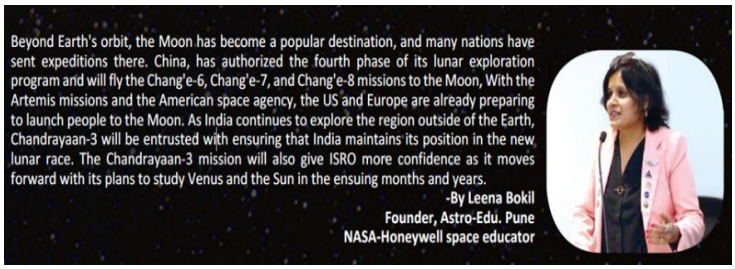

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