



Hindustan Times

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Chandrayaan-3 was launched from the Satish Dhawan Space Centre in Sriharikota on Friday, on board the LVM-3 rocket. ISRO

Chandrayaan-3 sets off on journey to the Moon

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NEW DELHI: India's third moon craft successfully blasted off on Friday afternoon from Andhra Pradesh's Sriharikota spaceport, marking the first stage of a complicated 40-day mission that aims to vault the country into an elite club of nations that have successfully landed on the lunar surface.

Built at a cost of nearly ₹600 crore by the Indian Space

Research Organisation (Isro), Chandrayaan 3 was launched at 2:25pm from the Satish Dhawan Space Centre using a Launch Vehicle Mark-3, formerly known as the Geosynchronous Satellite Launch Vehicle Mk-III. The craft carried a rover (Pragyan) and a lander (Vikram) that will aim to become the first to land on the south pole of the moon, which has generated tremendous scientific interest in recent years due to the presence of water ice. "We are expecting it (Chan-

drayaan-3) to enter into lunar orbit by August 1 and two-three weeks from then, separation of the propulsion module and lander module will happen on August 17. The final descent is currently planned for August 23, at 5:47pm. That is the plan if it goes as per the schedule," said ISRO chief S Somanath.

Scientists inside the mission control centre (MCC) waited with bated breath to see Chandrayaan-3 separate from the rocket about 16 minutes after lift-

off even as thousands of spectators broke into loud cheers as the rocket lifted off in plumes of golden and white smoke.

If Chandrayaan-3 lands on the moon — something its predecessor was unable to do when it veered off course in the final moments before the descent on September 6, 2019, and crashed on the lunar surface — it will make India only the fourth country (after the United States, the erstwhile Soviet Union, and

continued on 217

To the moon, and beyond

Chandrayaan 3 is a milestone in India's tryst with space. It marks a firm step forward for the nation and its technological prowess

In a blaze of golden light and white smoke clouds, India's third mooncraft blasted off from Sriharikota on Friday, attempting to etch a successful third chapter in a journey that first began in 2003. That year, then prime minister Atal Bihari Vajpayee announced from the ramparts of the Red Fort that India had decided to go to the moon in an indigenously developed craft, attempting to become the fifth entity — after the United States, the erstwhile Soviet Union, China, Japan and the European Space Agency — to successfully reach the lunar surface. The first phase began with the Chandrayaan 1 launch in October 2008. On board the craft were payloads designed to explore the terrain, topography and atmosphere of the moon. The mission was successful, prompting scientists to set a far more complex and daring objective for the next iteration in 2019: successfully landing a craft on the moon. Chandrayaan 2 performed its other objectives — deploy an orbiter successfully, and study the lunar atmosphere and surface — creditably but its closing moments ended in heartbreak, when the lander veered off course in the final stretch of the descent due to a software glitch and crashed on the lunar surface.

Undaunted, Indian scientists have again taken up the mantle. Indian Space Research Organisation chief S Somanath said the agency gleaned three major missteps in the previous mission — the engines developing higher thrust than what was intended; the craft making turns too fast; and trying to reach a landing spot that was too far by increasing its velocity. This time around, the target landing spot was expanded from a 500m x 500m patch to a 4km x 2.5km area, the fuel capacity was bolstered, and a propulsion module was added.

Though the eyes of the nation will be trained on its rover Pragyan and lander Vikram as it nears the lunar surface on August 23, the scientific equipment on the craft — three payloads on Vikram and two on Pragyan — is no less impressive. One will measure moonquakes, another the plasma distribution, and a third the temperature distribution in the first 10-cm beneath the lunar surface. Two experiments on the rover will determine the elemental and chemical composition of the lunar surface. The data that will be generated will not only significantly bolster understanding of the earth's closest neighbour but also create a new scientific benchmark for India, which hopes to become the first country to land in high-altitude regions of the moon. It will also mark a personal triumph for India's scientists, now renowned around the world for their frugal engineering.

Interplanetary missions mark epochs in a nation's journey. The ripples they create cannot be measured simply by the immediate success of the mission itself, but also by the technological leaps engineered by researchers and the scientific fervour it seeds among a young generation. In a country often starved of larger-than-life figures in science, the potential of creating a new pantheon of heroes for boys and girls, hunched over wooden benches in cramped classrooms, watching plumes of smoke fill their television and igniting their imagination cannot be overstated. India is already looking beyond the moon with missions planned to the sun and a second one to Mars. In this journey across the vastness of the universe, the successful launch of Chandrayaan 3 is a small, but firm, step forward.

CHANDRAYAAN SETS OFF

China) to achieve a soft landing. Prime Minister Narendra Modi hailed the launch of the mission as a "new chapter" in the country's space odyssey. "It scars high, elevating the dreams and ambitions of every Indian. This momentous achievement is a testament to our scientists' relentless dedication. I salute their spirit and ingenuity!" he tweeted.

President Droupadi Murmu congratulated Isro, for which the launch marked yet another triumph of frugal science, a reference to the fact that the agency's missions are funded at a fraction of the cost of western nations.

"Heartiest congratulations to the Isro team and everyone who worked relentlessly to accomplish the feat. It demonstrates the nation's unwavering commitment to advancement in space science and technology," she said.

The spacecraft comprises a lander and rover, which will be carried by a propulsion module till 100km lunar orbit. The scientific equipment on the craft consists of three payloads on Vikram and two on Pragyan. One will measure moonquakes, another the plasma distribution, and a third the temperature distribution in the first 10-cm beneath the lunar surface. Two experiments on the rover will determine the elemental and chemical composition of the lunar surface.

Mission director S Mohana Kumar said the LVM3 rocket once again proved to be the most reli-

able heavy-lift vehicle of Isro. "Today's mission was a penance of many across Isro," he added.

Project director P Veeramuthuvel said all the spacecraft health parameters, including power generation in propulsion module and lander module, were normal. "... This is a moment of glory for us, a moment of glory for India and a moment of destiny for all of us... I must thank Isro for making India proud..." Union minister of state Jitendra Singh said.

Chandrayaan-3 aims to achieve three objectives — to demonstrate safe and soft landing on the moon surface which could not be achieved by Chandrayaan-2; demonstrate rover abilities on the moon surface; and conduct in-situ scientific experiments. If successful, it could pave the way for Isro to take on more challenging missions, including a planned one to the sun and another to send a human being into space.

Scientists explained that the 2019 mission fell at the final hurdle but managed to successfully place its orbiter around the moon, and this provided invaluable information. Somanath said that it was on the basis of the data and pictures from the orbiter that Isro were able to take corrective steps for the make and landing strategies for Chandrayaan-3.

Senior officials from the department of space explained that Chandrayaan-3 consists of an indigenous lander module (LM), propulsion module (PM), and a rover, with an objective of devel-

oping and demonstrating new technologies required for inter-planetary missions. The lander will have the capability to soft land at a specified lunar site and deploy the rover, which will carry out in-situ chemical analysis of the lunar surface during the course of its mobility.

"The lander and the rover have scientific payloads to carry out experiments on the lunar surface. The main function of PM is to carry the LM from launch vehicle injection till final lunar 100 km circular polar orbit and separate the LM from PM. Apart from this, the propulsion module also has one scientific payload as a value addition which will be operated post separation of the lander module," the Chandrayaan-3 mission module read.

After entering the orbit of the moon, Chandrayaan-3 is expected to reach the lunar orbit, nearly a month after its launch, and its lander and rover are expected to land on the moon on August 23.

The landing site for the mission is near the south pole of the moon (around 300km from the pole) at 70 degrees latitude. "We are aiming for all the geo-physical, chemical characteristics on the surface of the moon. Second, study of the south pole has still not been explored. Nobody has conducted the thermal characteristics on the surface of the moon which Isro would be doing in this mission," Somanath said. Before this, all the lunar missions have only managed to make

a landing in the equatorial region of the moon — a few degrees north or south of the lunar equator. Only the Surveyor-7, launched by National Aeronautics and Space Administration (NASA) in 1968 managed to land near 40 degrees south latitude, which is the furthest that any spacecraft has landed from the equator.

Soft landings occur when the craft touches down at a safe, slow and controlled speed. Soft landings are particularly necessary on crewed missions or missions in which the craft is expected to take scientific measurements or perform tests after landing, as is the case with the Chandrayaan 3 mission.

Congratulatory messages poured in from across the globe.

"This is a great milestone that India has achieved today. I congratulate the Indian government, the space agency Isro, and the people of India for the successful launch," said Gennady Kravtsov, president of the Russian Academy of Sciences.

Senator Bill Nelson, Administrator of the US's National Aeronautics and Space Administration (NASA) also congratulated Isro on the launch of Chandrayaan-3.

He tweeted, "Congratulations to ISRO on the Chandrayaan-3 launch, wishing you safe travels to the Moon. We look forward to the scientific results to come from the mission, including NASA's laser retro-reflector array. India is demonstrating leadership on #ArtemisAccords!"

The long journey to the moon

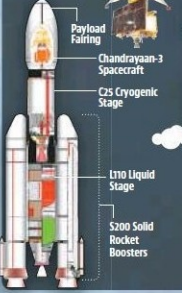
India's third mission to the moon started off in spectacular fashion on Friday, taking off in a fiery blaze in a procedure that went entirely as planned. A look at what lies ahead for Chandrayaan-3 in the coming days.

EXECUTING THE LAUNCH

Chandrayaan-3 took off at the prefixed time of 2.35pm from the second launch pad of the Satish Dhawan Space Centre in Sriharikota amid cheers from thousands who had gathered to watch the launch since early morning.

The mooncraft was sitting atop the Launch Vehicle Mark-3 (LVM-3) rocket. Previously known as Geosynchronous Satellite Launch Vehicle Mk-III, it has six back-to-back successful missions.

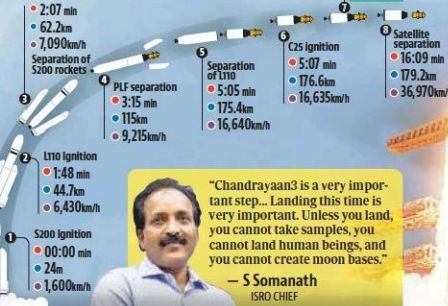
LVM3-M4 VEHICLE



EXECUTION OF A SEAMLESS LAUNCH

The launch process, however, consisted of a complex series of eight manoeuvres during which three sets of boosters would fire one-by-one.

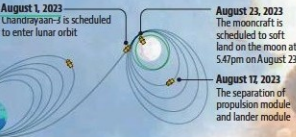
● Flight Time ● Altitude ● Estimated velocity



"Chandrayaan3 is a very important step... Landing this time is very important. Unless you land, you cannot take samples, you cannot land human beings, and you cannot create moon bases."
— Somanath
ISRO CHIEF

THE LONG WAY TO THE MOON

14-31 July, 2023
It will orbit earth 5-6 times in an elliptical cycle with the closest pass being 70km and farthest pass 36,500km



Engine calibration, landing site expansion: Lessons from 2019

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NEW DELHI: At 2.35pm on Friday, the Indian Space Research Organisation (Isro) successfully launched Chandrayaan-3, India's third lunar mission.

On August 23, India hopes to be the fourth country to successfully land on the moon. Isro has worked hard to ensure that the landing goes well; after all, four years ago, the second mission, Chandrayaan-2, was a success till that stage. Isro officials have termed that mission a "part failure" because while the lander and rover of the spacecraft did not complete its scientific objectives, the orbiter was injected into the lunar orbit and continues to provide key data and pictures from the moon.

"We landed with a higher velocity—we call this a crash landing. But if you analyse the mission in its entirety, we have perfected the part of reaching up to the moon in earlier missions," said an Isro official who did not want to be identified. The failure analysis report prepared by Isro after Chandrayaan-2 highlighted that the five engines that were used for the reduction of velocity on the lander, developed a higher thrust than was intended.

The intention was for Vikram lander to lose most of its velocity by the time it was around 400m from the lunar surface and start the process of hovering above the intended landing site to ensure a soft vertical descent.

The high velocity, however, caused it to crash on the moon's surface. "While this higher thrust was being achieved, the errors on the account of this differential started accumulating over a period. This is called the camera costing phase. During this period, the craft is ideally supposed to be steady to take pic-

tures. If there are any errors, corrections can be made while it is happening, but we didn't do that. We started correcting this only towards the end. When all these errors accumulated, which was slightly higher than we expected, the craft started making very fast turns. This hampered the ability of the craft to turn," Isro chief S Somanath told HT in an interview before the launch. Chandrayaan-3 has four engines.

The Chandrayaan-2 lander was to land within a 500m x 500m area. That meant the lander had no flexibility. In the case of Chandrayaan-3 the landing area has been increased to 4km x 2.5km.

Isro has also ensured that the lander is now sturdier, with stronger legs, and a higher fuel capacity, to reduce the possibility of failure.

It has worked to give the craft more flexibility to react to possible errors during the mission, even move around the landing area before landing. The Chandrayaan programme, also known as the Indian lunar exploration programme, is an ongoing series of outer space mission by Isro.

The first moon rocket, Chandrayaan-1, was launched in 2008, and was successfully inserted into lunar orbit. Chandrayaan-2 was successfully launched and inserted into lunar orbit in 2019, but its lander crash-landed on the moon's surface when it deviated from its trajectory while attempting to land on September 6, 2019, due to a software glitch.

It has also factored in the mission, says Isro chief

Chronicling India's tryst with moon

Envisioned in 2003, the moon mission has had three chapters so far

Chandrayaan-1



Oct 22, 2008: Five years after Vajpayee's announcement, Chandrayaan-1 takes off from Satish Dhawan Space Centre at Sriharikota

Nov 8: Spacecraft enters a lunar transfer trajectory, a manoeuvre to set it on a path that will cause it to arrive at the moon

Nov 14: As planned, the Moon Impact Probe ejects and crashes near the lunar South Pole. With this mission, Isro becomes the 5th national space agency to reach the lunar surface

Chandrayaan-2



Sept 18, 2008: The then PM Manmohan Singh-led cabinet approves Chandrayaan-2

Feb 16, 2018: In a press meet, minister Jitendra Singh announces the Chandrayaan-2 mission

July 22, 2019: Chandrayaan-2 lifts off from Satish Dhawan Space Centre, Sriharikota

Sept 2: The lander is separated while orbiting the moon; the orbiter continues to provide data

Sept 6: It makes a 'hard landing' on the moon; the mission partially meets its objective

Chandrayaan-3



Feb 7, 2023: Isro picks possible landing sites for mission

March 16: Space agency successfully conducts key tests for the mission

May 19: Isro starts the assembly process for payloads for Chandrayaan-3

July 14, 2023: The spacecraft lifts off from Satish Dhawan Space Centre

India successfully launches Chandrayaan-3 marking another significant milestone in space exploration.



— Droupadi Murmu, President



— Narendra Modi, Prime Minister

Chandrayaan-3 scripts a new chapter in India's space odyssey. It soars high, elevating the dreams and ambitions of every Indian.