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FIRST VOICE. LAST WORD.

AN ISRO SUNRISE

ADITYA-L1

Isro's launch vehicle PSLV-C57 rocket carrying India's first solar mission, Aditya-L1, lifts off from the Satish Dhawan Space Centre in Sriharikota on Saturday. PTI

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NEW DELHI: India's space programme got another roaring boost on Saturday when a PSLV-C57 blasted off and successfully deposited the Aditya-L1 solar probe into an orbit from where the latter will set off on a four-month voyage towards the Sun, stamping the credo of the country as a major space power 10 days after Chandrayaan-3's successful Moon landing.

The rocket left a trail of smoke as scientists clapped and crowds gathered at viewing galleries near the launch site cheered, before a tense 63-minute period as the rocket, in its four stages, took the spacecraft to an orbit outside of the Earth's atmosphere. Here, the Aditya-L1 will gather momentum before catapulting itself to a spot 1.5 million kilometres away.

"PSLV-C57/Aditya-L1 Mission: The launch of Aditya-L1 by PSLV-C57 is accomplished successfully. The vehicle has placed the satellite precisely into its intended orbit. India's first solar observatory has begun its journey to the destination of Sun-Earth L1 point," the Indian Space Research Organisation (Isro) said in a statement after the 11.50am launch.

The L1 point mentioned in the statement refers to Lagrange Point 1, a region 1.5 million km from Earth towards the Sun, where gravitational forces of celestial objects work in such a way that the spacecraft can be parked in what is known as a halo orbit — an oval that shifts on three axes.

For now, the spacecraft has been injected in an elliptical orbit of 235kmX19,500km as intended, and it will on Sunday switch on its rocket once more precisely at 11.45am in order to gain more velocity, the agency said. It will keep raising its orbit near Earth for 16 more days before it gathers enough momentum to be launched into

continued on →7

TRACKING ADITYA'S JOURNEY →P2

Moon mission will go to 'sleep' after lunar sunset

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NEW DELHI: The Indian Space Research Organisation (Isro) began putting the Chandrayaan-3's lander, Vikram, and rover, Pragyan, to sleep on Saturday, confirming that the primary objectives of the lunar mission were successfully completed.

The agency did not rule out the possibility of the robot and the scientific instruments being revived when the Sun rises again on the Moon around September 22, a period before which the devices will be in complete darkness and severely cold temperatures that are expected to be punishing for the batteries.

"We have achieved all our primary mission objectives. From September 3, before the lunar sunset, the instruments will be turned off. The collected data will now be analysed," Isro chairman S Somanath said. →P2

ADITYA-L1

its 1.5 million km journey, which is about 1% of the way to the star at the centre of the solar system.

"The mission approach was very different today [compared to regular PSLV mission]. From here, Aditya-L1 will take on its journey to the L1 point, after some Earth manoeuvres. It is a long journey for about 125 days. We wish all the best to Aditya for its onward journey," said S Somanath, Isro chairman, after the launch.

It was on August 23 that Chandrayaan-3, India's lunar exploration project, made a historic landing near the south pole of the Moon — hitherto unexplored by any other country's probe.

In the last fortnight, Isro has now pulled off two significant achievements that cement its place among the world's foremost space programmes, especially due to the cheap costs involved.

Union minister for science and technology and space Jitendra Singh said that Saturday's was a "sunshine moment" for India.

"While the whole world watched this with bated breath, it is indeed a sunshine moment for India... Coming close on the heels of successful Chandrayaan-3 landing, the successful launch of Aditya-L1 is also a testimony to the 'whole of science and the whole of nation' approach in which we have sought to adopt in our world culture," the minister said.

Prime Minister Narendra Modi congratulated all the scientists associated with the mission and said that India's findings will be the success of the entire scientific community around the world.

"After the success of Chandrayaan-3, India continues its space journey. Congratulations to our scientists and engineers at Isro for the successful launch of India's first Solar Mission, Aditya-L1. Our tireless scientific efforts will continue in order to develop better understanding of the Universe for the welfare of entire humanity," Modi tweeted.

The spacecraft is equipped with seven payloads to study the Sun's corona, chromosphere, photosphere and solar wind, Isro said. From L1, the spacecraft will be able to see how particles and radiation from heightened solar activity has an effect, while also studying the outer surface of the star in close detail — something that is normally not possible from the Earth, or even its orbit.

Scientists said that after 125 days, the seven scientific instruments will draw readings and the first of the data is expected in February or March next year. While the mission is designed to provide data for the next five years, experts said that there is a possibility of it going on till 10 or even 15 years.

Nigar Shaji, the project director of the Aditya-L1 mission, said that the successful launch on Saturday was a "dream come true" for all the scientists who have worked on the mission.

"Aditya (L1) has started its 125-day journey. The mission has been planned to study all the major solar events. We have seven payloads that will be studying aspects including coronal mass ejections (CME), solar flares, solar winds etc. We will try to understand these major events and its impacts on space weather," she said.

THE MISSION IS DESIGNED TO PROVIDE DATA FOR THE NEXT FIVE YEARS, BUT MAY EVEN GO ON FOR 10 OR 15 YEARS

SPOTLIGHT | SPACE MISSIONS

Aditya-L1 begins its long solar voyage

On Sunday, Isro will perform the first Earth-bound firing to raise the orbit of the Aditya-L1 craft

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NEW DELHI: India's first solar mission took off on Saturday, embarking on a 125-day journey before it is placed in a halo orbit around Lagrange Point 1 (L1), a spot between the Sun and the Earth about 1.5 million kilometres from us.

Insertion in L1 will enable the solar observatory Aditya-L1 to monitor the Sun with a "constant, uninterrupted view". But the process for its final placement is long, and requires a series of intricate manoeuvres, the first of which will be performed on Sunday, as the craft uses Earth's gravity to gather momentum.

At 11.45am on Sunday, the Indian Space Research Organisation (Isro) will perform the first Earth-bound firing to raise the orbit of the Aditya-L1 craft and ensure that the craft gains the necessary velocity for its journey. "Aditya-L1 will stay Earth-bound for 16 days, during which it will undergo five manoeuvres to gain the necessary velocity for its journey," a senior Isro scientist explained.

The Earth-bound manoeuvres will involve the rockets firing and some adjustments to angles, as required. How this will work can perhaps be understood by taking the example of when a person is on a swing — to make the swing go higher, a pressure (by shifting body weight) is applied when in the phase when the swing is coming down towards the ground. In Aditya-L1's case, once it gains enough velocity, it will slingshot around to its intended path towards L1.

"This will mark the beginning of its 110-day trajectory to the destination around the L1 Lagrange point," the scientist said.

Once the spacecraft arrives at the L1 point — the position in space where the gravitational forces of a two-body system (the Earth-Sun system here) produce enhanced regions of attraction and repulsion — another manoeuvre will be performed to bind the Aditya-L1 craft to the orbit, the space agency said.

"The satellite spends its whole mission life orbiting around L1 in an irregularly shaped orbit in a plane roughly perpendicular to the line joining the Earth and the Sun," an Isro document read.

The strategic placement will ensure that Aditya-L1 can continuously monitor the Sun.

"The strategic placement at the L1 Lagrange point ensures that Aditya-L1 can maintain a constant, uninterrupted view of the Sun. This location also allows the satellite to access solar radiation and magnetic storms before they are influenced by Earth's magnetic field and atmosphere," the document said.

The gravitational stability at this point will also minimise the need for frequent orbital maintenance, it said. "Additionally, the L1 point's gravitational stability minimises the need for frequent orbital maintenance efforts, optimizing the satellite's operational efficiency."

Explaining the similarity between Chandrayaan-3's route and the route that Aditya-L1 will take, Annapurni Subramaniam, director, Indian Institute of Astrophysics (IIA), said, "It will go on a circular orbit first, then it will slingshot and make it into an elliptical orbit and after four such orbit enhancements, it will go on a cruise phase. It will take over 120 days to reach the L1 point."

The IIA has designed the primary payload of the mission — Visible Emission Line Coronagraph (VELC).

On Saturday, after a successful lift off from the Satish Dhawan Space Centre in Sriharikota, the spacecraft was placed in an elliptical orbit of 235X19,500kms. This means that the Perigee (the point in a satellite's orbit at which it is nearest to the Earth) was 235kms, and the Apogee (the point in the orbit at which the satellite is farthest from the Earth) was 19500kms.

With Aditya-L1, which was launched on Isro's most-trusted PSLV-XL, scientists performed a unique flight sequence, where the upper stage of the rocket took two burn sequences for injecting the primary satellite.

Explaining the reason for this, a second Isro official said that a specific angle of Perigee (AOP) — the angle between the ascending node and perigee directions, measured along the orbital plane — was required for the mission.

"The final stage of PSLV was fired for about 30 seconds and then we waited for the AOP to reach the required range, and then it was fired again. The separation took place after that. The entire process took over an hour, which in a lighter mission would take around 25 minutes," a senior Isro official said.

Following the successful launch, project director for Aditya-L1 Nigar Shaji said that it was a "dream come true" for the scientist.

"Aditya (L1) has started its 125-day journey. The mission has been planned to study all the major solar events. We have seven payloads that will be studying aspects including coronal mass ejections (CME), solar flares, solar winds etc. We will try to understand these major events and its impacts on space weather," she said.

Scientists from IIA said that after 125 days, a few tests will be conducted, and the first set of data from the instruments on board is expected from February or March next year.

While the mission is designed to provide data for the next five years, experts said that there is a possibility of it going on till 10 or even 15 years.

Tracking Aditya's journey

India's first solar mission set off on a spectacular journey to the L1 point, a spot between the Sun and the Earth, 1.5 million kms from us. A look at the mission

The launch

Aditya-L1 took off at the scheduled time of 11.50am from the Satish Dhawan Space Centre in Sriharikota amid loud applause from thousands of spectators

The spacecraft was launched on board Isro's most trusted launch vehicle, the Polar Satellite Launch Vehicle-XL with the rocket completing its longest flight of 63 minutes

PSLV-XL is the heavy cargo carrying version of Isro's workhorse PSLV rocket which can carry up to 1800kg into space

A seamless flight sequence

After the lift-off, scientists placed the spacecraft at the Low Earth Orbit following a complex series of manoeuvres

Flight time | Altitude | Estimated velocity

- PS2 ignition: 109.6sec | 55.663km | 2406.8m/s
- PS2 separation: 262.38sec | 130.372km | 5400.7m/s
- CLG Initiation: 114.60sec | 59.745km | 2435m/s
- HPS3 separation: 581.42sec | 192.868km | 7728.3m/s
- 1st ignition of PS4: 1493.52sec | 313.067km | 7587.5m/s
- 1st cut-off of PS4: 1523.38sec | 313.07km | 7677.8m/s
- 2nd ignition of PS4: 3127.52sec | 217.614km | 7793.6m/s
- 2nd cut-off of PS4: 3599.52sec | 342.65km | 9695m/s
- Satellite separation: 3799.52sec | 648.781km | 9429.2m/s
- PS1 separation: 109.4sec | 55.496km | 2407.3m/s
- PS1 Ignition: 0 sec | 0.025km | 451.9 m/s

The 125-day journey

1 SEPT 2, 12.54PM: The spacecraft was placed in an orbit of 235kmX19,500km

2 SEPT 3, 11.45AM: The space agency will begin manoeuvres to place the spacecraft into a more elliptical orbit. Five such manoeuvres are planned

SEPT 17-18: Aditya-L1 will undergo a trans-Lagrangian 1 insertion manoeuvre using on-board propulsion so it exits the Earth's gravitational Sphere of Influence and cruises towards the L1

JAN 4-5: It will be injected into a large Halo Orbit around L1 point near the Sun

FEB/MARCH, 2024: First set of data from the on-board instruments is expected

What the mission entails

The objective of the mission is to observe the solar atmosphere — the chromosphere and the corona, the two outermost layers of the star. The major scientific objectives include:

- Understanding the coronal heating and solar wind acceleration
- Mapping the initiation of coronal mass ejection, flares and near-Earth space weather
- To understand coupling and dynamics of solar atmosphere
- To understand solar wind distribution and temperature anisotropy

Seven payloads on board Aditya-L1

VELC: Visible Emission Line Coronagraph to study the solar corona and dynamics of Coronal Mass Ejections (CME)

SUIT: Solar Ultraviolet Imaging Telescope to images the Solar photosphere and Chromosphere in near Ultraviolet and measure the solar irradiance variations

ASPEX and PAPA: The Aditya Solar Wind Particle Experiment and Plasma Analyser Package for Aditya payloads to study the solar wind, energetic ions and the energy distribution

SoLEXS and HEL1OS: The Solar Low Energy X-ray Spectrometer and the High Energy L1 Orbiting X-ray Spectrometer (HEL1OS) to study X-ray flares from Sun

Magnetometer: The payload will measure interplanetary magnetic fields at the L1 point

"The mission approach was very different today. From here, Aditya-L1 will take on its journey to the L1 point, after some earth manoeuvres. It is a long journey, for about 125 days. We wish all the best to Aditya for its onward journey."

— S Somanath, ISRO CHIEF

Women who helmed mission's success

HT Correspondent
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Nigar Shaji and Annapurni Subramaniam

NEW DELHI: The successful launch of Aditya-L1 is a "dream come true", said 59-year-old Nigar Shaji, the project director whose name shines the brightest among the brilliant omen behind India's first solar mission.

"This is like a dream come true. I am extremely excited that PSLV (Polar Satellite Launch Vehicle) was able to place Aditya-L1 in the intended orbit. Once Aditya L-1 is commissioned, it will be an asset to the country and the global scientific fraternity," said Shaji, a resident of Tenkasi district of Tamil Nadu who comes from a family of farmers.

She completed her engineering in electronics and communication from the Tirunelveli Government Engineering College and later pursued her Master's in electronics and communications from Birla Institute of Technology (BITS), Ranchi. After her Master's, she joined the Satish Dhawan Space Centre in 1987 and later went on to be a part of the team at the UR Rao Satellite Centre.

An expert in communications and interplanetary satellite programmes, Shaji has also made significant contributions to the space agency's remote sensing programme. She was also the associate project director of "Resourcesat-2A" — the Indian Remote Sensing Satellite for National Resource Monitoring and management.

While Shaji took the lead in the launch activities of the mission, another woman scientist, Annapurni Subramaniam, ensured that India's maiden mission to study the Sun goes smoothly.

Subramaniam is the director of the Indian Institute of Astrophysics — an autonomous institute under the department of science and technology that developed the primary instrument on-board Aditya-L1 spacecraft.

Resident of a village in the Palakkad district of Kerala, Subramaniam comes from a family of musicians. She has completed her PhD in Physics from IIA, where she now heads, and specialises in the areas of star clusters (open and globular), star formations and pre-main sequence star, galactic structures, Magellanic clouds and stellar population.

"We have designed the primary instrument that is being carried on Aditya-L1. It (VELC) is basically a coronograph, which will see the Sun in a total solar eclipse all the time. This mission will for the first time help us see the inner most part of the Sun," she said.

THEY SAY

Our tireless scientific efforts will continue in order to develop better understanding of the universe for the welfare of entire humanity.

NARENDRA MODI, Prime Minister

We are indebted to our scientists, space engineers, researchers and our hard-working personnel at @ISRO... Together, we celebrate their success...

MALLIKARJUN KHARGE, Congress president

The launch of Aditya-L1, India's first solar mission, is a landmark achievement that takes India's indigenous space programme to a new trajectory.

DROUPADI MURMU, President

{ 'PRIMARY MISSION OBJECTIVES ACHIEVED' }

Chandrayaan devices to be put to 'sleep' today

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NEW DELHI: The Indian Space Research Organisation (Isro) began putting the Chandrayaan-3's lander, Vikram, and rover, Pragyan, to sleep on Saturday, confirming that the primary objectives of the country's third lunar mission were successfully completed.

And the agency hoped that the robot and the scientific instruments can be revived when the Sun rises again on the Moon around September 22, a period before which the devices will be in complete darkness and severely cold temperatures that are expected to be punishing for the batteries that store power for the devices.

"We have achieved all our primary mission objectives. From September 3, before the lunar sunset, the instruments will be turned off. The collected data will now be analysed by our teams," Isro chairman S Somanath told HT.

Hours later, Isro confirmed in a tweet that Pragyan had been "safely parked and set into sleep mode".

"Currently, the battery is fully charged. The solar panel is oriented to receive the light at the next sunrise expected on September 22, 2023. The receiver is kept on," it added, after mentioning that two of Pragyan's instruments had been turned off and data from them were being transmitted via Vikram to Earth.

The Chandrayaan-3 mission was launched on July 14 from the Sriharikota spaceport. PTI

"Hoping for a successful awakening for another set of assignments! Else, it will forever stay there as India's lunar ambassador," Isro added.

The Chandrayaan-3 mission was launched on July 14 from the Sriharikota spaceport. On August 23, at 6.03pm, Vikram made a successful soft-landing near the lunar south pole, making India the first country to achieve the feat. On August 24, the rover rolled out of Vikram's belly.

The equipment, all of which is solar powered, spent a day charging batteries, and the experiments commenced late on August 24, giving the mission around nine days for collecting data.

While the lunar sunset is expected around September 6, scientists explained that the visibility in the area where the lander is parked has started reducing, necessitating a phased initiation of putting the equipment to sleep.

Speaking to HT, Anil Bhardwaj, director of the Physical Research Laboratory (PRL), said: "We do not have a set timeline for when which instrument will be put to sleep, but the process will start from tomorrow (September 3). The problem is that the light around the area has started getting dimmer."

Isro's PRL is closely involved in the mission and designed some of the instruments on-board the modules.

According to National Aeronautics and Space Administration's (Nasa) Moon Tracker, the lunar sunset will commence from September 4 — starting from the area where Chandrayaan-3's lander is parked —and go on till September 6.

The next lunar sunrise is scheduled for September 20, according to the Nasa tracker, but at the south pole, that could come slightly later.

Bhardwaj, however, reiterated that the Indian space agency has successfully completed its mission targets.

"We are still getting data and we are extremely happy with the quality and the quantity of it," he said.

Bhardwaj said that there is a possibility of the instruments recharging after 20 days if they are able to withstand the low temperatures during the long lunar night.

"The lunar surface experiences major temperature variations and during lunar nights, the temperatures tend to drop to below 200 degrees Celsius. If instruments are able to withstand such temperatures, there is a possibility that it will recharge itself once the sun's rays hit their solar panels again after a fortnight or so. That will be bonus data for us," he said.

So far, Isro has revealed some crucial findings from the lunar experiments including recording the first seismic readings on the Moon, confirming the presence of sulphur, oxygen and other elements on the lunar surface, and recording the thermal variations beneath the surface.

The rover, which according to Isro scientists was supposed to have traversed a distance of around 200metres throughout its mission life, has successfully charted a distance of over 100metres from the landing point of Vikram.

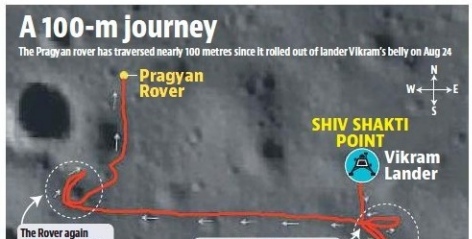
The scientists attributed this gap in distance to the maneuvers the rover had to undertake to avoid craters.

A follow-up mission to the 2019 Chandrayaan-2, the latest Moon programme had three objectives – to demonstrate a safe and soft landing on the moon surface, to demonstrate rover roving abilities on the moon surface, and to conduct in-situ scientific experiments.

With the successful landing on August 23, India became the fourth country to land on the surface of Moon after the US, the former USSR, and China.

A 100-m journey

The Pragyan rover has traversed nearly 100 metres since it rolled out of lander Vikram's belly on Aug 24



Pragyan rover traverses over 100 metres on lunar surface

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NEW DELHI: The Chandrayaan-3 mission achieved another milestone in lunar exploration on Saturday, after the Pragyan rover successfully traversed 100 metres on the Moon's surface, as the instruments aboard it continued to record crucial data, the Indian Space Research Organisation (Isro) said on Saturday.

"Pragyan:100 not out. Meanwhile, over the Moon, Pragyan Rover has traversed over 100 metres and continuing," Isro posted on X (formerly Twitter).

The 100m distance was shorter than the 200m initially estimated it would travel, but scientists said the reduction was due to the detours it had to take to avoid craters.

By covering over 100 metres, the objective of demonstrating the rover's abilities has been achieved "perfectly", the space agency said.

A senior scientist from the Chandrayaan-3 team, who spoke on the condition of anonymity, explained that while the Pragyan rover is designed to avoid obstacles that come in its path, its movements on the Moon are driven by a set of commands from Isro's ground stations.

"The rover majorly relies on commands given to it for movement on the lunar surface. Through the navigation cameras, our teams monitor the rover's movement and give commands to it for movement. If there is an obstacle, such as the crater that we encountered, we retract the path," the scientist said.