



# Hindustan Times

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## All eyes on Chandrayaan-3: It's D-day for moon mission

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**NEW DELHI:** A nail-biting countdown for the descent of Chandrayaan-3's lander began on Tuesday with India aiming to become the fourth country in the world to successfully land on the moon, and the first on the lunar south pole.

Senior scientists said they were confident of a successful landing of the Chandrayaan-3 lander module, Vikram, and the Indian Space Research Organisation (ISRO) was performing the final checks for a successful touchdown as soon as the sun rises on the moon a little after 6pm IST on Wednesday.

**Chandrayaan-3 Mission:** The mission is on schedule. Systems are undergoing regular checks. Smooth sailing is continuing. The Mission Operations Complex (MOX) is buzzed with energy & excitement," the space agency said in a post on X on Tuesday.

Since India's second lunar mission, Chandrayaan-2, crashed on the surface of moon on September 7, 2019, scientists at ISRO have spent the last four years analysing each contingency and rectifying the errors of the last mission, strengthening

continued on > 31

### The crucial final minutes

#### The descent

Lander Vikram will identify its landing site in an area of 4kmx2.5km

Thrusters will start controlled descent at around 5:45pm

Closer to the lunar surface, Vikram's speed will reduce enough for it to hover over landing area

Vikram's legs will extend out and the craft will make a landing at around 6:04pm

After successful touchdown, rover Pragyaan will roll out to the surface

#### 'SMOOTH SAILING'

"The mission is on schedule. Systems are undergoing regular checks. Smooth sailing is continuing. Mission Operations Complex is buzzed with energy & excitement!" — ISRO

#### In case of a miss

• ISRO will attempt a second landing on Aug 24

• And the last window for a landing will open in mid-September at the time of the next lunar sunrise

• In the meantime, the craft will hover in its current orbit of 25km x 134km

### TOMY TO BE ISRO CONSULTANT FOR SAFE RECOVERY OF GAGANYAAN CREW

Rahul Singh

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**NEW DELHI:** Champion sailor Commander Abhilash Tomy (ret'd) will serve as a consultant to the Indian Space Research Organisation (ISRO) for the safe recovery of astronauts from sea after their return from India's first crewed spaceflight, Gaganyaan, next year, people aware of the development said on Tuesday.

ISRO's Gaganyaan project envisages demonstration of human spaceflight capability by launching a crew of three to an orbit of 400km for a three-day mission and bringing them back safely to earth, by landing in seas close to India. The astronauts are hand-picked fighter pilots from the Indian Air Force.

"I will be advising ISRO on risk mitigation and ensuring the wellbeing of the astronauts after the module's splashdown. I will formulate the strategy by drawing on my own experiences of surviving extreme conditions at sea," Tomy said.

## We even prepared backup plans for our backups, says ISRO chief

**NEW DELHI:** The Indian Space Research Organisation (ISRO) chairman S Somanath on Tuesday said the agency was confident that India's third lunar spacecraft will land on the surface of the moon as planned because of the work that had gone behind ensuring the mission's success.

"We are extremely confident that it is going to be a successful mission," Somanath told HT ahead of the landing scheduled at 6:04pm IST on August 23. "And I want to clarify that this confidence is coming from the work that our teams have put in to ensure the success of the mission. In fact, we

have prepared backups of our backup plans as well." Till late last night, "everything has gone as per our plan and there have been no contingencies," Somanath said, adding that the agency was prepared to handle the situation if something goes wrong.

### MOON MISSION

the hardware and software of the craft, and have prepared for worst-case scenarios via simulations.

"We have accounted for all scenarios that can go wrong and have prepared a backup plan for that. Till now, all stages of the mission have gone as per plan, and we are confident that our lander Vikram will successfully land on the moon tomorrow," ISRO chairman S Somanath said.

Prime Minister Narendra Modi, who is in South Africa for the 15th BRICS Summit, could join the landing virtually, reports said citing officials.

Union minister for science and technology Jitendra Singh is scheduled to attend the landing virtually from Delhi.

After all final checks on Wednesday, Chandrayaan-3's lander will identify its landing site which has been increased to an area of 4km x 2.5km from the 500m x 500m spot that was planned for its predecessor.

Thrusters will then start a controlled descent of the spacecraft around 5:45pm. Once the lander module reaches closer to the lunar surface, its speed will gradually reduce, its legs — which have also been engineered to be stronger compared to the Chandrayaan-2 lander — will extend out, and the craft will make a landing at around 6:04pm.

Following a successful touchdown, the lander's flaps will open to reveal a ramp for the rover, Pragyaan, to roll out.

Once the rover is placed on the moon, it will click pictures of the lunar surface. The lander and rover will also take pictures of each other to ensure that there is communication between the two, and ISRO's base station to monitor the mission progress.

The indigenous lander module, propulsion module and rover on Chandrayaan-3 have the objective of developing and demonstrating new technologies for interplanetary missions.

The propulsion module separated from the craft to carry out independent experiments in the lunar orbit.

The lander, meanwhile, has the capability to "soft land" and deploy the rover which will carry out in-situ chemical analysis of the lunar surface during the course of its mobility. Both the lander and the rover are equipped with scientific payloads to carry out experiments.

The lander is carrying the Chandrayaan-3 Surface Thermophys-

ical 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 the National Aeronautics and Space Administration (NASA) is also accommodated for lunar laser ranging studies.

The rover, on the other hand, has the payload of the Alpha Particle X-ray Spectrometer (APXS) and Laser Induced Breakdown Spectroscope (LIBS) for deriving the elemental composition in the vicinity of landing site.

While according to the initial plan, the experiments are expected to go on for 14 Earth days — one lunar day — the ISRO chief on Monday told HT that there is a scope for an extended life of the solar-powered equipment if it gets recharged after the next lunar sunrise.

#### Changes from Chandrayaan-2

While Chandrayaan-2 could not make a soft landing on the moon, officials said the mission was a "part failure", as the orbiter has continued to orbit the moon, providing critical data that has helped ISRO prepare for the latest mission.

Ahead of the Chandrayaan-3 launch on July 14, an ISRO official said, "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."

A failure analysis report of the mission, prepared by ISRO after the partial failure of Chandrayaan-2, highlighted that the five engines (these have been downgraded to four for the latest mission) used for the reduction of velocity developed a higher thrust than was intended.

The plan was for the lander to lose most of its velocity at a distance of 400m from the lunar surface and start hovering above the landing spot to ensure a soft vertical descent. The high velocity, however, led to the crash.

For Chandrayaan-3, ISRO has built a sturdier spacecraft with a higher fuel capacity to reduce the possibility of failure and to give the craft more flexibility to manoeuvre possible errors during landing.

#### Backup landing plans

While the best-case scenario that the agency has prepared for is a landing on Wednesday evening, scientists said that they have prepared for contingency plans in case the lander module is unable to reach the lunar surface.

The ISRO chief said that the agency has a backup plan that will be explored for landing, in case it missed the first opportunity in the evening of August 23.

"The aim is to land in the initial period after the lunar sunrise so that the mission gets enough days to complete its experiments," Somanath told HT. "The availability of sunlight is crucial to power the equipment."

All modules on the craft are solar powered. The agency has, thus, planned the mission in a way that the craft lands at the time of lunar sunrise to allow 14 Earth days (one lunar day) for experiments.

"If it doesn't land tomorrow owing to whatever factor, whether the health of the lander or a break in communication, we will attempt the landing again within 24-50 hours. Meanwhile, alternate landing sites will also be considered," Somanath said.

If the descent is deemed risky, the landing could be deferred for a month till the next lunar sunrise, he added.

In that case, the craft will hover in its current orbit of 25km x 134km till next lunar sunrise, the scientist said.

Officials did not reveal details of ISRO's backup plan citing security reasons.

# Our systems are better tested, our craft is sturdier... We are ready

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**NEW DELHI:** Somanath is the man of the hour. He is also very busy. As he waits for the evening of August 23, when India's third lunar spacecraft is scheduled to land on the surface of the moon after falling to do so four years ago, the chairperson of the Indian Space Research Organisation (ISRO) is ensuring that all safety checks of the lander are happening, receiving regular reports from the ISRO Telemetry, Tracking and Command Network (ISTRAC) — the main centre from where the craft is being tracked — and scrambling to find time for interviews, such as this one in which he assured HT that his team is confident of a successful descent on the lunar south pole region on Wednesday. **Edited excerpts**



Somanath

## pared to avoid those mistakes now?

Chandrayaan-2 went till the final phase, but we could not land because of a soft landing. We landed with a higher velocity. During Chandrayaan-2, one of our mistakes was that we kept the landing spot to a limited area of 500m x 500m, this did not leave much room for error. We had also accumulated some of the errors the craft was facing and did not rectify as it was descending. This time we are better prepared. We have learnt from our past mistakes and have rectified those mistakes and have also left room for any other error that could occur. Overall, our systems are better tested, our craft is sturdier and can tolerate unfavourable conditions and our teams are also better prepared. We are ready.

How are the preparations coming along for the landing on Wednesday? We are extremely confident that this mission will be a success. We are confident and I want to clarify that this confidence is coming from the work that our teams have put in to ensure the success of the mission over the last four years. After Chandrayaan-2, make a hard landing in 2019, so, this is not overconfidence. Four years is not a short period [of time], and we have utilised every bit of it bettering our mission, to map all contingencies and prepare backup plans. In fact, we have prepared backups of our backup plans as well.

So far, during the course of this mission, everything has gone as per our plan and there have been no major anomalies. In fact, we also got some surprising results — we had initially planned for our propulsion module with six months, but because we had six extra months, the propulsion module can now stay in orbit for several years.

We have prepared for the landing by conducting multiple levels of verifications of the system and the health of the lander is perfectly fine. Chandrayaan-2 had also successfully completed all these stages, but the mission failed in the final stage. Are you better pre-

## MISSIONS | MORE TO COME

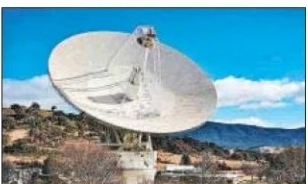
### Isro has a packed schedule even after Chandrayaan-3



**A mission to study the Sun, launching a climate observation satellite, a test vehicle as part of Gaganyaan human space flight programme and an Indo-US synthetic aperture radar — Isro has a packed schedule ahead. In addition, XPoSat (X-ray Polarimeter Satellite), India's first dedicated polarimetry mission to study various dynamics of bright astronomical X-ray sources in extreme conditions, is also ready for launch. ISRO officials said on Tuesday. Aditya-L1, the first space-based Indian observatory to study the Sun, is getting ready for the launch, most likely in the first week of September. It has also lined up the launch of a climate observation satellite INSAT-3DS. The launch of a test vehicle mission, for the validation of the crew escape system for Gaganyaan, is also expected. "There we have to launch NSAR, the India-US built Synthetic Aperture Radar," Somanath said in his Independence Day address at ISRO headquarters on August 15. "So, our hands are full." PT**

## COLLABORATION | COMMUNICATION HELP

### How Nasa, ESA are working to ensure success of Isro



**While Indians are rooting for the success of Chandrayaan-3, two international agencies will also be providing support to the Indian space body for uninterrupted communication between the ground stations and lander module. US's Nasa and the European Space Agency (ESA) have earmarked stations that will provide tracking support to Chandrayaan-3. "Our New Nordic deep space antenna has just finished a 90-minute session tracking the Chandrayaan-3 lander module," ESA said on Tuesday, adding that it has turned an ESA station for keeping track of the Chandrayaan-3 mission. Nasa's deep space network, on the other hand, is also providing telemetry and tracking coverage during the powered descent phase from Deep Space Station (DSS) 65 and DSS-34 at Canberra Deep Space Communications Complex followed by DSS-65 at Madrid Deep Space Communications Complex. HT**

## LANDING MANIA | #ALLTHEBESTCHANDRAYAAN

### Excitement across country, schools to telecast landing



**With less than 12 hours to go for the scheduled landing of India's third lunar spacecraft, people from all walks of life related their wishes to the Indian Space Research Organisation (ISRO) for a successful landing. On Tuesday, #AllTheBestChandrayaan was one of the trending hashtags on X (formerly known as Twitter). People from different cities, especially children, posted their photos and video messages wishing the success of Chandrayaan-3 mission. After the space agency's requests to schools to allow the live streaming of the landing, states such as Uttar Pradesh and Maharashtra announced that government schools will broadcast the landing for students. "On August 23, the Chandrayaan-3 moon landing process will be telecast live on ISRO website, YouTube and DO National. Arrangements should be made for live telecast by organising special meetings in schools and educational institutions from 5:15 to 6:15 pm," directions to UP government schools read. HT**

## LUNAR DREAMS | WHAT IS SCHEDULED TODAY

# The landing and its challenges

The lander of India's ambitious third mission to the Moon - Chandrayaan-3 - is scheduled to touch down on the lunar surface in the evening today, which if successful, will make India the first country in the world to reach the uncharted south pole of Earth's only natural satellite. A look at what is planned for today, and why such a mission is filled with challenges

**THE MOON, AS VISIBLE FROM THE EARTH**

**5.20pm IST** Sequence to begin

**6.04pm IST** Sequence to end

**WHERE IT WILL LAND**  
 The landing plans for Chandrayaan-3 are similar, yet different in some crucial aspects, compared to the plan ISRO had devised for Chandrayaan-2

**THE SIMILARITY WHERE IT'S LANDING**  
**WHERE: 68.7°N, 31.33°W**  
 The area that ISRO has picked for the landing is on a patch of lunar highland smooth plains located between crater of Manzinus P (aka 'Smilelet' of Manzinus crater) and Boguslawsky M (aka 'Smilelet' of Manzinus crater) craters.

**THE DIFFERENCE SIZE OF 'LANDING ZONE'**  
 A key difference between the previous landing plan and the current one is that ISRO has significantly reduced the size of the zone that it is targeting to land in.

**ALTERNATIVE LANDING PLANS**  
 ISRO has said that it is open to the idea of postponing this touchdown and moving the location, if required.

**OPTION 1: Postpone landing to a day later - August 27**

**OPTION 2: Postpone landing to a full lunar day (14 days) later**

**AND LANDING SPOT?** ISRO has picked a spot between Simplus and Manzinus craters as a backup spot

**THE COMPLICATED LANDING MANOEUVRE**  
 At 5:20pm today, ISRO will start the process of descent of the spacecraft. It will consist of the following steps:  
 - The lander will first be flipped from a horizontal orientation to a vertical one using thrusters that also reduce its velocity  
 - A final set of thrusters will ensure that the craft's speed gradually reduces to zero  
 - The legs of the lander pull out and it will make a soft landing

**15 MINUTES OF TERROR!**  
 In 7:10, ISRO managed all but the final phase of Chandrayaan-2. ISRO has identified challenges in the final 15 minutes of landing. Braking commands have to be precisely timed to ensure the lander is secured in a controlled manner and velocity is adequately dropped

**What went wrong the last time**  
 The five minutes when we used the production velocity in Chandrayaan-2, developed higher thrust than intended. This made the craft start making very fast turns, spinning it out of control. Since the craft was approaching the surface fast, it had to build sudden thrusters in order to bring it to a halt. But since it was lagging a small landing spot, it had very limited 'scope of error' to manoeuvre in, and find the final landing spot

**GROUND STATIONS MUST UNINTERRUPTED CONTACT WITH THE LANDER MODULE TO KEEP TRACK OF THE PROGRESS OF THE DESCENT AND MAKE ANY CORRECTIONS**

## SCIENCE, MYTH, AND MYSTERY |

# How the Moon has fascinated humanity

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**NEW DELHI:** Vikram the lander's scheduled touchdown on the Moon's south pole, part of ISRO's Chandrayaan-3 mission, will likely be just one of many firsts, for the Moon offers many more mysteries for humans to solve. Beyond its unexplored territory, there remains the question about how the Moon formed in the first place, even though one among various theories is widely accepted today. Beyond its origin, again, the Moon continues to fascinate modern humans as much as it did our ancestors, partly for science, partly with awe.

The Moon was not just worshipped as a deity but also held responsible (it still is) for diverse events on today, the myth persists that a full moon influences people into making irrational decisions, an idea with no scientific basis. Wolves were thought to howl at the moon, giving rise to the myth about werewolves, humans who supposedly turn into wolves when the moon is full.

That said, the Moon does influence life on Earth. It is responsible for the tides in the oceans, dictates the migration of birds, and influences the reproduction cycles of some animals. And Earth's natural satellite has not only revealed some of its mysteries but also inspired science.

**What Moon has told us**  
 Ancient humans used the Moon as a calendar system, secure in the knowledge that it follows a regular orbit around our planet. As knowledge of geometry evolved, scientists began to measure the Moon's distance from Earth based on the shadow cast during a lunar eclipse.

In the 17th century, Galileo's telescopes revealed, for the first time, mountains and craters on the lunar surface. Since the 1950s, manned and unmanned lunar missions have revealed more. Among these discoveries were views of the far side of the Moon, which is hidden from Earth as its axis always looks the same from Earth, presenting a face with features that we identify as "the man in the Moon". The Moon and Earth are also rotationally locked in a way that the Moon takes the same amount of time to rotate about its axis as it takes to make one orbit around Earth. This rotation causes the same side of the Moon to always face Earth.

As a result, the far side of the Moon was a mystery until the USSR released clearer and clearer images. In December 1968, astronauts on NASA's Apollo 8 mission, became the first humans to see and photograph the far side, although they did not land on the Moon. Most recently, China's robotic spacecraft Chang'e-4 in 2019 became the first mission to land on the far side.

All these missions have enabled scientists to identify and name several craters and other features on the far side of the moon. But one mystery endures: How was the Moon and Earth should have nearly the same composition.

To come back to the giant impact theory, first proposed in the 1970s, it can explain the composition of the Moon to a far greater extent than the other theories. Those who are not convinced, however, raise various questions. If there was indeed a giant impact, a magma ocean would have formed on Earth's surface, but there is no evidence that Earth should have had a magma ocean. Scientists note that the ratios between various elements on the Moon are not explained by the giant impact theory. Also, if Earth were impacted, why wasn't Venus struck by a similar object, which should have resulted in Venus having its own Moon?

**Hunt for an answer**  
 The book *Assimil's New Guide to Science* discusses the fusion, capture and condensation theories and notes how certain aspects remain unresolved. Moon rocks brought back to Earth should have resolved the mystery, but Isaac Asimov dwells on how their composition raises questions about each of the theories.

Scientists have even heard to mutter that if the evidence for the Moon's origin is carefully considered, then the only possible conclusion is that the Moon is not really out there — a conclusion, however, that just means we must continue the search for additional evidence," Asimov writes.

"There is an answer, and I will be found."



The Moon rises over a hill in Syria's Aleppo on July 31. AFP

**soni** championed this idea. What he proposed was thought to be possible during his time, but scientists today discount it. Among the grey areas, the theory does not explain how materials on the Moon were baked more than those on Earth.

■ The capture theory, on the other hand, proposes the Moon was formed independently of Earth, and was later captured into Earth's orbit. For such a capture, there would need to have been some event that slowed the Moon down by just the right amount at just the right time. Such "fine tuning" is believed improbable.

■ The condensation theory proposes that the same dust cloud that led to the formation of Earth also created the Moon. The Moon has received ever since, but was never part of Earth. While the Moon indeed continues to nucleate from Earth, ever so slowly, the condensation theory would require that

## Gaganyaan: Ace sailor to help in safe recovery of astronauts

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**NEW DELHI:** Champion sailor (retired) Commander Abhishek Tomiy (ret'd) will serve as a consultant to the Indian Space Research Organisation (ISRO) for the safe recovery of astronauts from sea after they return to Earth following their spaceflight, Gaganyaan, next year, people aware of the development said on Tuesday.

ISRO's Gaganyaan project envisages demonstration of human spaceflight capability by launching a crew of three to an orbit of 400km for a three-day mission and bringing them back by landing in seas close to India. The astronauts are hand-picked fighter pilots from the Indian Air Force who have undergone training in Russia.

"I will be advising ISRO on risk mitigation and ensuring the well-being of the astronauts after the module's splashdown. I will formulate the strategy by drawing on my experiences of surviving extreme conditions at sea," he said.

April 28 other sailing for 28 days in his boat named Bayanat.

Two locations have been identified for the landing of the crew module in the sea with the deployment of a series of parachutes, the officials said, asking not to be with the recovery conditions? How to keep your sanity till help arrives? And what to do and what not to do during that period? Then there's something as basic as where should the medical kit be kept for easy access in case the crew is indisposed or injured," said Tomiy, who has met the astronauts.

ISRO successfully completed the sequence for the Gaganyaan crew module's deacceleration system consists of 10 parachutes, they said.

The first batch of the crew recovery team of the Gaganyaan mission completed the first phase of training at Indian Navy's Water Survival Training Facility at Kochi in Tamil Nadu in July.

"A crucial component of this mission is the deployment of drogue parachutes, which play a pivotal role in stabilising the crew module and reducing its velocity to a safe level during re-entry. Drogue parachutes, packed within the Gaganyaan crew module, are ingeniously designed to eject the parachutes into the air upon command," ISRO said. These parachutes ensure a smooth and controlled descent.

However, in a contingency, the astronauts will have to survive in the module for as long as 48 hours to reach and retrieve them, said Tomiy, who suffered a spinal injury on September 22, 2018, during the 20th GCR, after rolling over in the southern Indian Ocean, one of the remotest spots on Earth, crippled his yacht, SV Thurya.

"What if the module is damaged during the splashdown? There are so many aspects to it. How to deal



Abhishek Tomiy