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# Science Reporter

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## ISRO'S GAGANYAAN MISSION

Exploring India's Space Goals

### Features

- Origin of Life in the Universe
- Revolutionising Aerospace
- Future of the Fuel Cells: From Earth to Mars

- The Power and Potential of Biomanufacturing
- Q&A, Fiction, Science Cartoons & much more

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COVER STORY

# ISRO'S GAGANYAAN MISSION

## Exploring India's Space Goals

Neha Tripathi



**G**ET ready as India gears up for an exciting milestone, “Gaganyaan Mission”, the first-ever manned space mission with the Gaganyaan spacecraft. This historic journey will showcase India's space prowess and determination on a global scale.

By sending Indian astronauts into space for the first time, India is set to join the elite league of nations with human spaceflight capabilities. The Gaganyaan mission has already captured the world's attention and is expected to raise India's profile in the space community.

The Gaganyaan project is a massive undertaking demonstrating India's ability to send four crew into space for a three-day mission before they safely return to Earth. This project combines the expertise of Indian scientists, engineers, industry, academia, and international technologies. Also, key technologies like a human-rated launch vehicle, life support systems, emergency escape plans, and crew management strategies are being developed to ensure the mission's success.

The mission will launch from the Satish Dhawan Space Centre (SDSC) in Sriharikota, Andhra Pradesh, India's primary spaceport. This carefully chosen location offers the necessary infrastructure and facilities for a mission of this magnitude, including multiple launch pads, tracking stations, and a range safety system. The SDSC's eastern coastal position also provides favourable launch trajectories for missions heading eastward. To prepare for the mission, ISRO has been conducting unmanned test flights to validate technologies and systems.

The dream of sending Indians to space has simmered for decades. Indian Space Research Organisation (ISRO) laid the groundwork with crucial technological advancements. The story of the Gaganyaan programme started in 2006 with plans to send astronauts to space and was revived in 2014. ISRO has been testing technologies for human spaceflight, and in 2018, the project was officially approved.

In 2018, Prime Minister Narendra Modi announced the Gaganyaan mission to the nation, igniting a fire of excitement. This ambitious project aimed to be a historic leap for India.



Hon'ble PM with Astronauts

Since then, the team of scientists at ISRO have been on their toes to make the mission a success. In 2021, five science experiments were selected to be conducted on Gaganyaan by various Indian research institutes, which will study biological and physical phenomena in space.

VSSC and DRDO test drogue parachutes for Gaganyaan mission, confirming readiness for Test Vehicle-D1. Parachutes stabilise crew module during re-entry, showcasing progress in mission development. The sequence includes ten parachutes for safe landing.

## The Orbital Module

The Orbital Module (OM) is a crucial spacecraft component that will orbit Earth. The OM is equipped with state-of-the-art avionics systems and redundancy measures to prioritise the safety and wellbeing of the crew during the mission. It is made of the following two main sections:

### 1. Crew Module (CM)

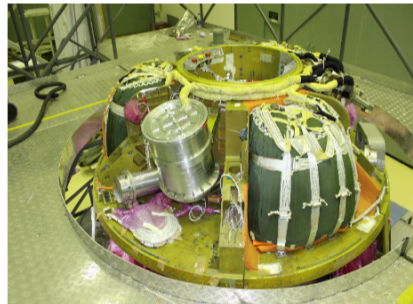
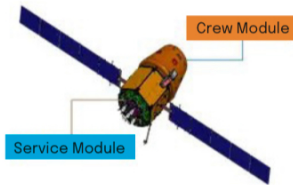
- Crew Module (CM) is the living space for the crew in space, designed for safety and comfort.
- It carries a 4-member crew and has a double wall for protection.
- The Inner Structure is pressurised metallic, while the External Structure has a Thermal Protection System (TPS).
- Systems within the CM support the crew, including interfaces, life support, avionics, and deceleration for re-entry.

### 2. Service Module (SM)

- SM supports CM in orbit with essential systems.
- Unpressurised structure houses thermal control, propulsion, power, avionics.
- Systems work together to ensure CM functions safely in space.

“Sare Jahan Se Accha”... these were the words of Wing Commander Rakesh Sharma, the first Indian to travel to space when our then Prime Minister Indira Gandhi asked him — “How India looked from outer space?”

On 3 April 1984, Squander Leader Rakesh Sharma became the first Indian to orbit in space. He was on board Soyuz T-11, launched from Kazakh Soviet Socialist Republic's Baikonur Cosmodrome. He carried out all the scientific experiments planned for the joint Indo-Soviet Space Mission and other tasks assigned to him with great facility and excellence.



First Crew Module for Gaganyaan test flight takes shape

### The Launch Vehicle

The Human Rated LVM3 (HLVM3) is a specialised version of the LVM3 rocket created by ISRO for the Gaganyaan mission. This heavy lift launcher incorporates solid, liquid, and cryogenic stages to meet safety requirements for carrying human crew members into space. One standout feature is the inclusion of a Crew Escape System (CES) powered by high burn rate solid motors, designed to move the Crew Module and occupants to safety in case of emergencies during launch pad operations or the ascent phase.

HLVM3 is a reliable and proven launcher capable of delivering the Orbital Module to a Low Earth Orbit of 400 km. Its advanced technology and safety features make it well-equipped to support the successful execution of the mission and safeguard the astronauts on board.

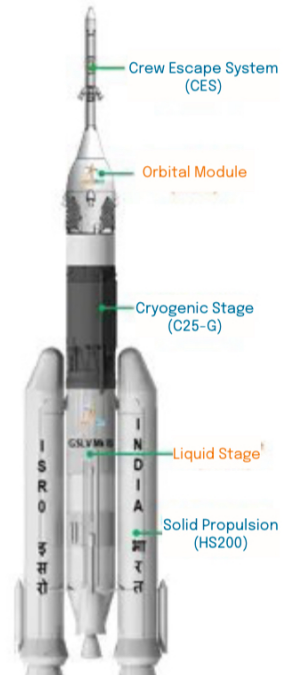
### Necessary Technologies

In order to ensure the safety and success of the Gaganyaan mission, several advanced technologies have been developed and implemented. These technologies cover many aspects, from the man-rating of the launch vehicle to crew recovery and materials used in the spacecraft. ISRO helped us list down a few.

- Development of man-rating technology for launch vehicle to meet safety standards for carrying human passengers.
- Crew abort and escape systems for emergencies.
- Crew recovery technologies for safe return to Earth.
- Environmental Control and Life Support System (ECLSS) for astronaut comfort and survival in space.
- Crew quarantine measures to ensure astronaut health before the mission.
- Selection and testing of materials for spacecraft durability in space.

- Sensors and tracking technologies to monitor spacecraft health and performance.

In the last few months, ISRO Chairman Mr S Somnath reiterated on various platforms that the organisation's dedication is towards indigenous development and harnessing local industries across various platforms. Emphasising the pursuit of human space flight capabilities, Mr Somnath highlighted ISRO's commitment to pioneering new technologies for astronaut safety and mission success. Despite challenges faced in the Gaganyaan programme, including a lack of expertise in ECLSS development, ISRO decided to engineer the system to ensure self-reliance independently. Stressing the importance of skill-building and design enhancement for successful human space travel, Mr Somnath emphasised



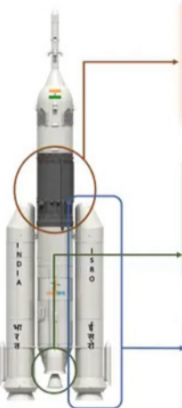
Launch Vehicle



Test vehicle for characterisation of Crew Escape System ready at SDSC

#### Major collaborating partners for Gaganyaan mission include:

- Indian Armed Forces
- Defence Research and Development Organisation (DRDO)
- Indian maritime agencies – Indian Navy, Indian Coast Guard, Shipping Corporation of India, National Institute of Oceanography, National Institute of Ocean Technology.
- Indian Meteorological Department (IMD)
- CSIR Labs
- Academic institutes
- Industry partners



#### Cryo Stage (C25) - Engine qualification tests



#### Liquid Stage (L110) – Engine (VIKAS) qualification tests



#### Solid booster (HS200) – Static test



the need to protect astronauts from failures. ISRO is currently focusing on incorporating intelligent systems in rockets to address failures and proactively ensure astronaut safety during missions.

#### Fortunate Indian Astronauts and their Training

The fortunate Indian astronauts who will embark on this groundbreaking mission have been carefully selected and trained for years to prepare them for the challenges of space travel. They have undergone rigorous physical and psychological testing to ensure they can handle space exploration demands.

1. With his extensive experience in flying various aircraft and conducting flight test operations, Group Captain Prashanth Nair brings a wealth of knowledge to the team.
2. Group Captain Angad Pratap, known for his exceptional skills in handling complex flight scenarios, is a valuable asset to the mission.
3. With his aerospace engineering and flight testing expertise, Group Captain Ajit Krishnan adds a strong technical aspect to the team.
4. Wing Commander Shubhanshu Shukla, known for his precision in flight test operations, rounds out the elite test pilots.

The selection of these four highly skilled individuals for the Gaganyaan mission is a testament to their dedication, expertise, and professionalism. The astronauts, who are test pilots from the Indian armed forces, initially underwent training at the Yuri Gagarin Cosmonaut Training Center in Russia. This training involved various aspects of spaceflight, including simulations, physical conditioning, and familiarisation with the spacecraft systems. ISRO confirms that currently, the astronauts are undergoing functional training in various subsystems that are crucial for the success of the Gaganyaan mission. This includes training in spacecraft systems, emergency procedures, navigation, communication, and scientific experiments they will conduct during their time in space.

These astronauts will be privileged to represent their country internationally and will be pioneers in India's space exploration efforts. As they embark on this historic journey to become India's first astronauts, they carry with them the hopes and aspirations of the nation. Their selection represents a significant milestone in India's space exploration efforts and paves the way for future missions to explore the depth of space. Their bravery and dedication to the mission will inspire future Indian space explorers and scientists.

Former ISRO Chairman Dr K Sivan also proudly shared, "The four astronauts went through 11 months of training in Russia, which was extended to 15 months. The training was impacted by the corona pandemic, which was resumed and



completed. Now module-specific training is being carried out at various places in India.”

ISRO has also been collaborating with international space agencies and organisations to ensure that the astronauts receive the best possible training and preparation for their mission.

### What is Zero Gravity Training?

Zero gravity training, also known as zero-G training, is one of the most crucial parts of the training. It is a form of training that simulates the microgravity environment experienced by astronauts in space. It involves using special aircraft, such as a reduced gravity aircraft or a parabolic flight aircraft, to create brief periods of weightlessness by flying in parabolic arcs. This type of training is used to prepare astronauts for the physical and psychological challenges of working in space and to conduct research in a weightless environment.

Rakesh Sharma shared the details based on his experiences with zero gravity training. He explains training test pilots for zero gravity for space travel involves a combination of classroom instruction, simulation training, and actual parabolic flights. Here is an overview of how test pilots are trained for zero gravity for space travel:

1. **Classroom instruction:** test pilots are first taught the principles of microgravity and how it affects the human body. They learn about the physiological changes that occur in space, such as fluid shifts, bone density loss, and

Following the successful completion of the Gaganyaan programme soon, the next goal will be to develop the capability for maintaining a continuous human presence in space.

muscle atrophy. They also learn about the challenges of working in a weightless environment, such as orientation and coordination issues.

2. **Simulation training:** test pilots undergo simulation training in specialised facilities that can recreate the feeling of weightlessness. They practice moving and working in a simulated zero-gravity environment to familiarise themselves with the sensations and learn how to adapt to the lack of gravity.
3. **Parabolic flights:** test pilots then participate in parabolic flights, also known as “zero gravity flights,” where an aircraft follows a parabolic trajectory to create periods of weightlessness. During these flights, test pilots experience actual zero gravity conditions and practice performing tasks in a weightless environment.

Rakesh Sharma remembers, “The process of zero gravity training, which involves attaching sponges to the sides of the ship to simulate the volume of the room. The ship first dives, then pulls up and slows down, causing the nose to bend and create a curve with a pilot. During this process, gravity inside the universe becomes zero for twenty-five seconds. The astronauts experience what the atmosphere will be like in space during this time. After the training, which lasts one and a half to two hours, the astronauts must evacuate the ship as it heads towards the ground”.

4. **Specialised training equipment:** test pilots may also use specialised equipment, such as harnesses, bungee cords, and training platforms, to simulate the conditions of space travel. They practice using these tools to maintain balance, stability, and coordination in a weightless environment.
5. **Continuous practice and evaluation:** test pilots undergo regular training sessions and evaluations to monitor their

The ground uniforms for the Gaganyaan mission were designed by a team from the National Institute of Fashion Technology (NIFT), Bengaluru. The team, which included three students and two professors, worked on creating a functional and ergonomic uniform that would suit the needs of the astronaut-designates. After considering seventy possibilities, the final design featured an asymmetrical two-coloured style line, drawing inspiration from various space agency uniforms.

### SAKHI

- A software called SAKHI (Space-borne Assistant and Knowledge Hub for Crew Interaction) developed by the Vikram Sarabhai Space Centre will assist astronauts during the Gaganyaan mission.
- SAKHI will monitor their health, provide vital data on their physical state, maintain communication with ground-based stations, and serve as a reminder for their daily tasks.
- The engineering model of the smart device with SAKHI has been successfully tested with plans to create a production-ready model for use on the mission.

progress and ensure they are prepared for the challenges of space travel. They receive feedback from instructors and experts to improve their skills and adaptability in zero gravity.

### How will ISRO Ensure Astronauts' Safety on the Gaganyaan Mission?

Former ISRO Chairman AS Kiran Kumar stresses the importance of perfect pre-mission preparations. He highlights the need to ensure everything is working well before sending humans into space. Therefore, preparatory mission activities are underway to meet all the established requirements and standards for a human space mission.

ISRO is diligent about this mission aspect. When queried about it, ISRO provided extensive details in response. It has provided us with a comprehensive list of measures put in place to ensure the mission's and astronauts' safety.

"Safety is ensured through abort and escape systems during the launching phase and recovery systems during the descent phase. ECLS system is being developed to take care of crew safety in the orbit," as per ISRO.

Abort and escape systems are designed to safely remove the astronauts from the spacecraft in the event of an emergency during launch. They provide a way for the crew to quickly evacuate the spacecraft and return to Earth in case of technical difficulties or malfunctions. ISRO has developed recovery systems for the descent phase of the mission. These systems ensure a safe landing for the astronauts once they return to Earth. By carefully planning and implementing these systems, ISRO is working to minimise any risks associated with the mission and prioritise the crew's safety.

### Factors potentially impact the timeline for the Gaganyaan mission

Formerly Dr K Sivan provided an update on the Gaganyaan mission progress, mentioning ground and in-flight tests are underway. Final touches are being made to the mission's configuration, including astronauts and a robot. Two flights will be conducted with a robot, Vyommitra, scheduled to travel on one of the missions. Everything is proceeding as planned.

However, the timeline for this ambitious mission launch depends on several factors that could potentially impact the schedule. ISRO explains that "there are various series of

tests planned to qualify various subsystems. The schedules are prepared based on the assumption that all the tests will qualify the systems in the first attempt. These tests are crucial to ensure that all systems function properly and are ready for the mission. If any anomalies are detected during these tests, additional time may be required to address and rectify them".

External factors such as weather conditions and logistical challenges could also impact the timeline for the launch of the Gaganyaan mission. Launching a manned mission into space requires careful planning and coordination, and unforeseen obstacles could delay the mission.

### Potential benefits and scientific outcomes

ISRO has high hopes for the future of the space sector and is confident that the Gaganyaan mission will bring great value. ISRO helped us make a list highlighting the potential benefits and expected scientific results of the Gaganyaan mission:

1. One of the key areas of focus for the Gaganyaan mission is deep technology applications. The mission will involve using cutting-edge technology and techniques with the potential for a wide range of spin-off applications. These technologies could have applications in areas such as communication, navigation, and remote sensing and could benefit industries and sectors.
2. Another area of exploration during the Gaganyaan mission will be microgravity experiments in biology and agriculture. Microgravity environments offer unique opportunities for studying biological processes and plant growth in ways that are not possible on Earth. By conducting experiments in these conditions, scientists hope to understand better how plants and animals respond to zero gravity, which could have implications for future space missions and agriculture here on Earth.
3. The Gaganyaan mission will also involve the use of high-end sensors for life-saving purposes. The mission will involve monitoring the health and wellbeing of the astronauts in real-time, using a range of sensors to track their vital signs and ensure their safety throughout the mission. These sensors could have potential applications in healthcare and emergency response areas, where real-time monitoring of patients' vital signs could be crucial for saving lives.

The successful completion of the Gaganyaan mission will mark a historic moment for India and showcase the country's capabilities in space technology and exploration. The Gaganyaan mission will inspire a new generation of scientists, engineers, and innovators in India, fostering a culture of scientific curiosity and technological innovation. It will fuel the aspirations and dreams of young Indians to explore the cosmos and contribute to the country's space programme.

This will be a transformative moment for India in the space sector, showcasing the country's potential and opening up new horizons for advancement and collaboration. As India embarks on this historic journey to send its astronauts into space, the world will witness its rise as a formidable player in space exploration, shaping the future of space travel and discovery.

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