

Chandrayaan-1: India's first mission to moon launched

India joined a select band of countries who have undertaken lunar missions by launching the first un-manned mission to the moon – Chandrayaan-1. In a historic flight conducted from the Satish Dhawan Space Centre (SDSC), Sriharikota on 22 October 2008, the Polar Satellite Launch Vehicle, PSLV-C11 successfully launched the 1380 kg Chandrayaan-1 spacecraft into a transfer orbit with a perigee of 255 km and an apogee of 22,860 km, inclined at an angle of 17.9° to the equator (Figure 1).

PSLV-C11 is the uprated version of its standard configuration. Weighing 316 tonnes at lift-off, the vehicle used larger strap-on motors (PSOM-XL) to achieve required higher payload capability. PSOM-XL uses 12 tonnes of solid propellants instead of 9 tonnes used in the earlier configuration of PSLV. PSLV is a four-stage launch vehicle employing both solid and liquid propulsion stages. PSLV is the trusted workhorse launch vehicle of ISRO with 13 consecutively successful flights.

Chandrayaan-1 is India's first spacecraft mission beyond the earth's orbit. It aims to further expand our knowledge about the earth's only natural satellite – the moon. With well-defined objectives, the Chandrayaan-1 mission intends to put an unmanned spacecraft into orbit around the moon and to perform remote sensing

of our nearest celestial neighbour for about two years using 11 scientific instruments built in India and five in other countries.

The primary objectives of Chandrayaan-1 are:

- To upgrade the technological base in the country.
- To place an unmanned spacecraft in an orbit around the moon.
- To conduct mineralogical and chemical mapping of the lunar surface.

Chandrayaan-1 aims to achieve these objectives through high-resolution remote sensing of the moon in the visible, near-infrared, microwave and X-ray regions of the electromagnetic spectrum. A three-dimensional atlas of the lunar surface and chemical and mineralogical mapping of the entire lunar surface will be prepared.

The spacecraft: The Chandrayaan-1 spacecraft weighed 1380 kg at the time of its launch and is a 1.5 m cuboid. The spacecraft is powered by a single solar panel generating electrical power of 700 W. A lithium ion battery supplies power when the solar panel is not illuminated by the sun. To make the Chandrayaan-1 spacecraft travel towards the moon, its liquid engine is used. Liquid

propellants needed for the engine as well as thrusters are stored on-board the spacecraft. The dual gimbaled antenna of the spacecraft transmits the scientific data.

The payloads: There are 11 payloads (scientific instruments) using which Chandrayaan-1 intends to achieve its scientific objectives. These include five instruments designed and developed in India, three from the European Space Agency (one of which was developed jointly with India and the other with Indian contribution), two from the United States and one from Bulgaria.

The Indian payloads of Chandrayaan-1 are:

(i) Terrain mapping camera: A CCD camera that maps the topography of the moon, which helps in better understanding of the lunar evolution process.

(ii) Hyperspectral imager: Another CCD camera designed for mapping of minerals on the lunar surface as well as for understanding the mineralogical composition of the moon's interior.

(iii) Lunar laser ranging instrument: This provides the necessary data for accurately determining the height of lunar surface features.

(iv) High energy X-ray spectrometer: This is designed to help explore the pos-

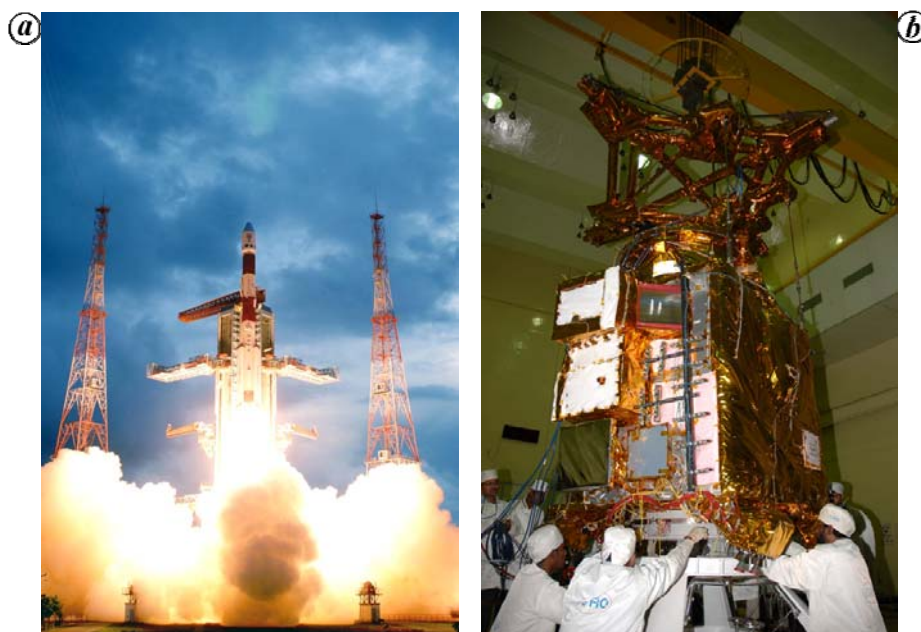


Figure 1. a, PSLV-C11 lift-off, and b, Chandrayaan-1 spacecraft.

sibility of identifying polar regions covered by thick water-ice deposits as well as in identifying regions of high uranium and thorium concentrations.

(v) Moon impact probe (MIP): It demonstrates the technologies required for landing a probe at the desired location on the moon. It is also intended to qualify some of the technologies related to future soft-landing missions.

The six international payloads of Chandrayaan-1 are:

(i) Chandrayaan-1 imaging X-ray spectrometer: An ESA payload, jointly developed by Rutherford Appleton Laboratory, England and ISRO Satellite Centre, Bangalore. This intends to carry out high-quality mapping of the moon using X-ray fluorescence technique to find magnesium, aluminium, silicon, iron and titanium distributed over the surface of the moon.

(ii) Smart near infrared spectrometer: Another ESA payload, developed by Max Plank Institute, Germany to study the lunar surface and explore the mineral resources, and formation of its surface features.

(iii) Sub kiloelectronvolt atom reflecting analyser: The third payload from ESA, built by Swedish Institute of Space Physics and Space Physics Laboratory of Vikram Sarabhai Space Centre, Thiruvananthapuram. The aim of this instrument is to study the surface composition of the moon and the magnetic anomalies associated with the surface of the moon.

(iv) Radiation dose monitor: A payload developed by Bulgarian Academy of Sciences, to characterize the radiation environment in a region of space surrounding the moon.

(v) Mini synthetic aperture radar (MiniSAR): This instrument from the

Applied Physics Laboratory, Johns Hopkins University and Naval Air Warfare Centre, USA through NASA. This is mainly intended to detect water-ice in the permanently shadowed regions of the lunar poles up to a depth of a few metres.

(vi) Moon mineralogy mapper: This is an imaging spectrometer from Brown University and Jet Propulsion Laboratory, USA through NASA, is intended to assess and map lunar mineral resources at high spatial and spectral resolution.

The journey: First, Chandrayaan-1 spacecraft was launched from SDSC by the PSLV into a highly elliptical transfer orbit (TO) around the earth.

After circling the earth in its TO, Chandrayaan-1 spacecraft will travel in elliptical 'extended transfer orbits' by repeatedly firing its liquid engine in a pre-determined sequence. Subsequently, the liquid engine will be again fired to make the spacecraft travel to the vicinity of the moon by following a 'lunar transfer trajectory'.

When the spacecraft reaches the vicinity of the moon and passes at a few hundred kilometers from it, the liquid engine will be fired again so that the spacecraft slows down sufficiently to enable the gravity of the moon to capture it into an elliptical orbit.

Following this, the height of the spacecraft's orbit around the moon will be reduced in steps. After a careful and detailed observation of the orbit perturbations, the orbital height of Chandrayaan-1 will be finally lowered to its intended 100 km height from the lunar surface. MIP will be ejected from Chandrayaan-1 spacecraft at the earliest opportunity to hit the lunar surface in the chosen area.

Later, cameras and other scientific instruments will be turned on and tested. This will lead to the operational phase of the mission. This phase will last for about two years during which the Chandrayaan-1 spacecraft will explore the lunar surface with its array of instruments that include cameras, spectrometers and SAR.

The ground segment: ISRO Telemetry, Tracking and Command Network (ISTRAC) has established the ground segment of Chandrayaan-1, which consists of the following:

(i) The Indian Deep Space Network (IDSN) which will receive the data sent by the Chandrayaan-1 spacecraft. Besides, it will send commands to the spacecraft at a power level of up to 20 kW. IDSN consists of two large parabolic antennae – one with 18 m diameter and the other 32 m diameter – at Byalalu, about 35 km from Bangalore. The 32 m antenna with its 'seven mirror beam waveguide system', was indigenously designed, developed, built, installed, tested and qualified. The 18 m antenna can support Chandrayaan-1 mission, but the 32 m antenna can support spacecraft missions well beyond the moon.

(ii) The Spacecraft Control Centre, located near the ISTRAC campus, north of Bangalore, is the focal point of all the operational activities of Chandrayaan-1 during all phases of the mission.

(iii) The Indian Space Science Data Centre forms the third element of ground segment. Also located at Byalalu, the Centre will receive data from IDSN as well as other external stations that support Chandrayaan-1, store, process, archive, retrieve and distribute scientific data sent by Chandrayaan-1 payloads to the user agencies.