अन्तरिक्ष भारत

SPACE INDIA

भारतीय अन्तरिक्ष अनुसंधान संगठन

Indian Space Research Organisation

अक्तूबर-दिसंबर **2008** October-December

The Indian Space Programme

The space activities in the country were initiated with the setting up of Indian National Committee for Space Research (INCOSPAR) in 1962. In the same year, the work on Thumba Equatorial Rocket Launching Station, (TERLS) near Thiruvananthapuram was also started. The Indian space programme was institutionalized in November 1969 with the formation of Indian Space Research Organisation (ISRO). The Government of India constituted the Space Commission and established the Department of Space (DOS) in June 1972 and brought ISRO under DOS in September 1972.

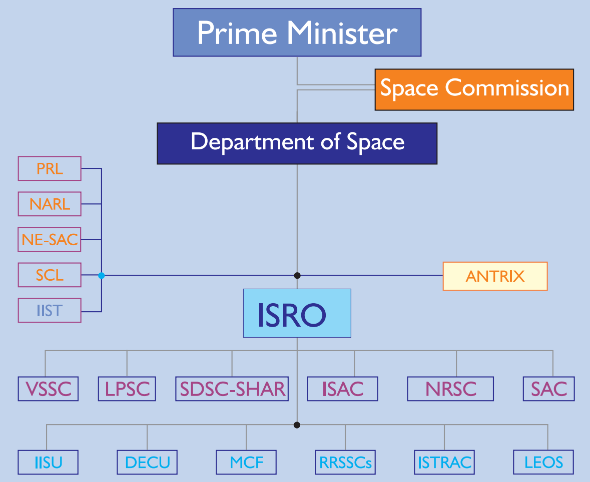
Department of Space (DOS) has the primary responsibility of promoting development of space science, technology and applications towards achieving self reliance and assisting in all round development of the nation. Towards this, DOS has evolved the following programmes:

- Indian National Satellite (INSAT) programme for telecommunications, TV broadcasting, meteorology, developmental education, etc.
- Remote Sensing programme for application of satellite imagery for various developmental purposes.
- Indigenous capability for design and development of spacecraft and associated technologies for communications, resources survey and space sciences.
- Design and development of launch vehicles with indigenous technology for access to space and orbiting INSAT, IRS spacecraft and space science missions.
- Research and development in space sciences and technologies as well as application programme for national development.

The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country. DOS implements these programmes through, mainly, Indian Space Research Organisation (ISRO), Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL). The Antrix Corporation, established in 1992 as a government owned company, markets the space products and services.

Both the DOS and ISRO Headquarters are located at Bangalore. The development activities are carried out at the Centres and Units spread over the country.

So far, 51 Indian Satellite Missions, and 27 Launches from Sriharikota have been conducted.



NRSC: National Remote Sensing Centre, **PRL:** Physical Research Laboratory, **NARL:** National Atmospheric Research Laboratory, **NE-SAC:** North Eastern Space Applications Centre, **SCL:** Semi-Conductor Laboratory, **ISRO:** Indian Space Research Organisation, **Antrix:** Antrix Corporation Limited, **VSSC:** Vikram Sarabhai Space Centre, **LPSC:** Liquid Propulsion Systems Centre, **SDSC:** Satish Dhawan Space Centre, **ISAC:** ISRO Satellite Centre, **SAC:** Space Applications Centre, **IISU:** ISRO Inertial Systems Unit, **DECU:** Development and Educational Communication Unit, **MCF:** Master Control Facility, **RRSSCs:** Regional Remote Sensing Service Centres, **ISTRAC:** ISRO Telemetry, Tracking and Command Network, **LEOS:** Laboratory for Electro-optic Systems, **IIST:** Indian Institute of Space Science and Technology

The centres of Indian Space Programme

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Earth... Moon... and Beyond

Background

The technical capabilities acquired by India and the enthusiasm of modern Indian scientists in exploring the Moon, prompted ISRO to undertake – Chandrayaan – 1, India's first mission to the Moon. The primary objectives of the mission are to expand knowledge about the origin and evolution of the Moon, further upgrade India's technological capabilities and provide challenging opportunities to the young scientists working in planetary sciences.

The idea of an Indian mission to the Moon was initially mooted in a meeting of the Indian Academy of Sciences in 1999 that was followed up by discussions in the Astronautical Society of India in 2000. Based on the recommendations made by these forums, a National Lunar Missions Task Force was constituted by the Indian Space Research Organisation (ISRO) with leading scientists and technologists from all over the country for considering and making an assessment of the possible configuration and feasibility of taking up an Indian Mission to the Moon.

A peer group of more than hundred eminent Indian scientists representing various fields of planetary and space sciences, earth sciences, physics, chemistry, astronomy, astrophysics, engineering and communication sciences deliberated on the Study

Report of the Task Team in 2003 and unanimously recommended that India should undertake the Mission to the Moon, particularly, in view of the renewed international interest with several exciting lunar missions planned for the new millennium. In addition, such a mission will provide the needed thrust to basic science and engineering research in the country, including new challenges to ISRO to go beyond the geostationary orbit.

Government of India approved ISRO's proposal for the Indian Moon Mission, called Chandrayaan – I, in November 2003.

Approach to Realisation of Chandrayaan-I

PSLV-C11, chosen to launch Chandrayaan-I spacecraft, was an uprated version of ISRO's Polar Satellite Launch Vehicle standard configuration. PSLV-C11 would place the Chandrayaan-I spacecraft into a highly elliptical Transfer Orbit (TO) around the earth. Later, through a series of highly complex manoeuvres, the desired trajectories will be achieved. After circling the Earth in its Transfer Orbit, Chandrayaan-I spacecraft will be taken into more elliptical 'Extended Transfer Orbits' by repeatedly firing its Liquid Apogee Motor (LAM) in a pr-determined sequence. Subsequently, the LAM is again fired to make the spacecraft to travel to the vicinity of the moon.

When it reaches the vicinity of the Moon and passes at a few hundred kilometers from it, its LAM is 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 is reduced in steps. After a careful and detailed observation of the orbit perturbations there, the orbital height of Chandrayaan-I will be finally lowered to its intended 100 km height from the lunar surface. Moon Impact Probe will be ejected from Chandrayaan-I spacecraft at the earliest opportunity to hit the lunar surface in a chosen area.

Later, cameras and other scientific instruments are turned ON and thoroughly tested. This leads to the operational phase of the mission. This phase lasts for about two years during which Chandrayaan-I spacecraft explores the lunar surface with its array of instruments that includes cameras, spectrometers and SAR.

Objectives

The primary objectives of Chandrayaan-I are:

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

Chandrayaan-I aims to achieve these well-defined objectives through high-resolution remote sensing of moon in the visible, near infrared, microwave and X-ray regions of the electromagnetic spectrum. With this, preparation of a 3-dimensional atlas of the lunar surface and chemical and mineralogical mapping of entire lunar surface is envisaged.

Payloads

There are 11 payloads (scientific instruments) through which Chandrayaan-I intends to achieve its scientific objectives.

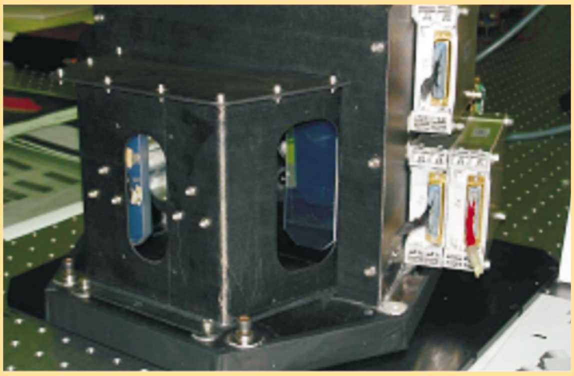
They include five instruments designed and developed in India, three instruments from European Space Agency (one of which is developed jointly with

India and the other with Indian contribution), one from Bulgaria and two from the United States.

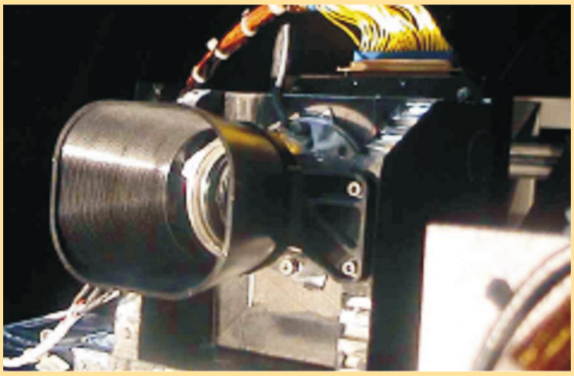
Payload Commissioning Dates	
Payload	**Date of Commissioning**
Radiation Dose Monitor	22.10.08
Terrain Mapping Camera (TMC)	29.10.08
Moon Impact Probe (MIP)	14.11.08
Lunar Laser Ranging Instrument (LLRI)	16.11.08
Hyper Spectral Imaging Camera (HYSI)	16.11.08
Mini SAR	17.11.08
Moon Mineralogy Mapper (M3)	18.11.08
InfraRed Spectrometer (SIR-2)	19.11.08
Chandrayaan-1 X-ray Spectrometer (C1XS)	20.11.08
High Energy X-ray (HEX)	05.12.08
Sub keV Atomic Reflecting Analyser (SARA)	08.12.08

a) Indian payloads

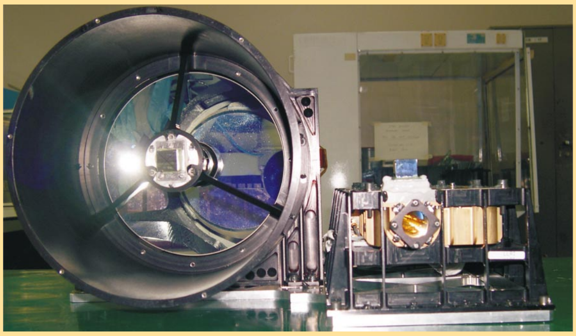
Terrain Mapping Camera (TMC), a CCD camera that maps the topography of the moon, which helps in better understanding of the lunar evolution process.



Hyperspectral Imager (HySI), another CCD camera, is designed for mapping of the minerals on the lunar surface as well as for understanding the mineralogical composition of Moon's interior.



Lunar Laser Ranging Instrument (LLRI) provides necessary data for accurately determining the height of lunar surface features.

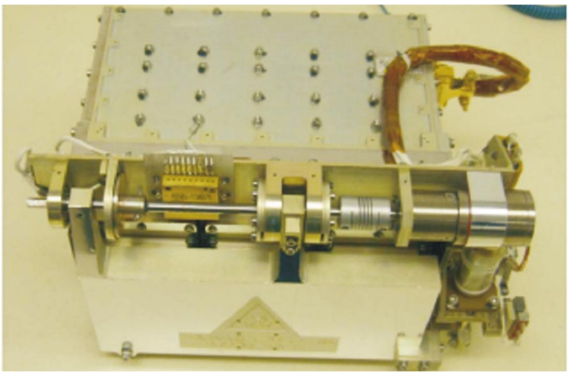


High Energy X-ray Spectrometer (HEX) is designed to help explore the possibility of identifying Polar Regions covered by thick water-ice deposits as well as in identifying regions of high Uranium and Thorium concentrations.

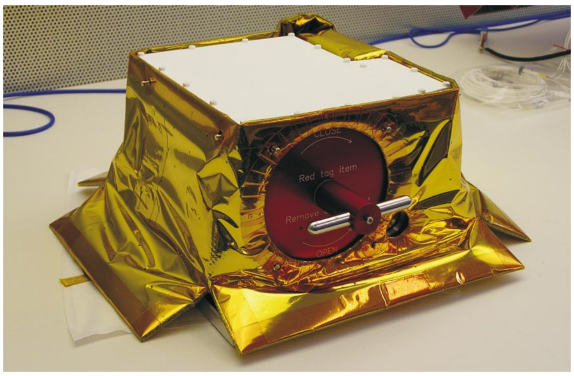
Moon Impact Probe (MIP) demonstrates the technologies required for landing a probe at the desired location on the moon. It is also intended to qualify some of the technologies related to future soft landing missions.

b) International payloads

Chandrayaan-1 Imaging X ray Spectrometer (C1XS), an ESA payload and jointly developed by Rutherford Appleton Laboratory of England and ISRO Satellite Centre, Bangalore, intends is to carry out high quality mapping of the moon using X-ray fluorescence technique for finding the presence of Magnesium, Aluminium, Silicon, Iron and Titanium distributed over the surface of the Moon.



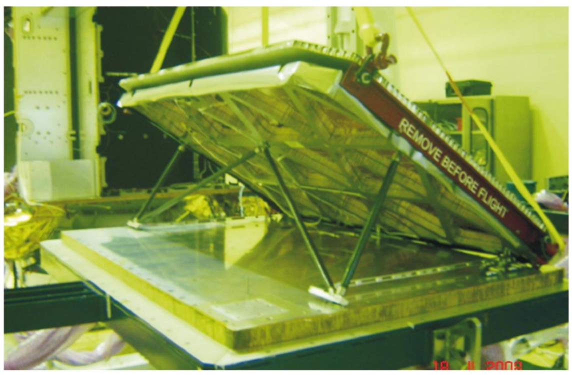
Smart Near Infrared Spectrometer (SIR-2), another ESA payload, developed by Max Plank Institute of Germany, aims to study the lunar surface to explore the mineral resources and the formation of its surface features.



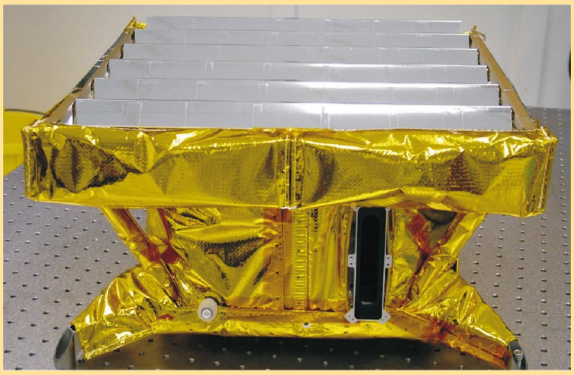
Sub kiloelectronvolt Atom Reflecting Analyser (SAR), the third payload from ESA, is built by Swedish Institute of Space Physics and Space Physics Laboratory of Vikram Sarabhai Space Centre, Tiruvananthapuram. The aim of this instrument is to study the surface composition of the moon and the magnetic anomalies associated with the surface of the moon.

Radiation Dose Monitor (RADOM), a payload developed by Bulgarian Academy of Sciences, aims to characterise the radiation environment in a region of space surrounding the moon.

Mini Synthetic Aperture Radar (MiniSAR) is one of the two scientific instruments from the USA and is from Johns Hopkins University's Applied Physics Laboratory and Naval Air Warfare Centre, USA through NASA. MiniSAR is mainly intended for detecting water ice in the permanently shadowed regions of the lunar poles up to a depth of a few meters.

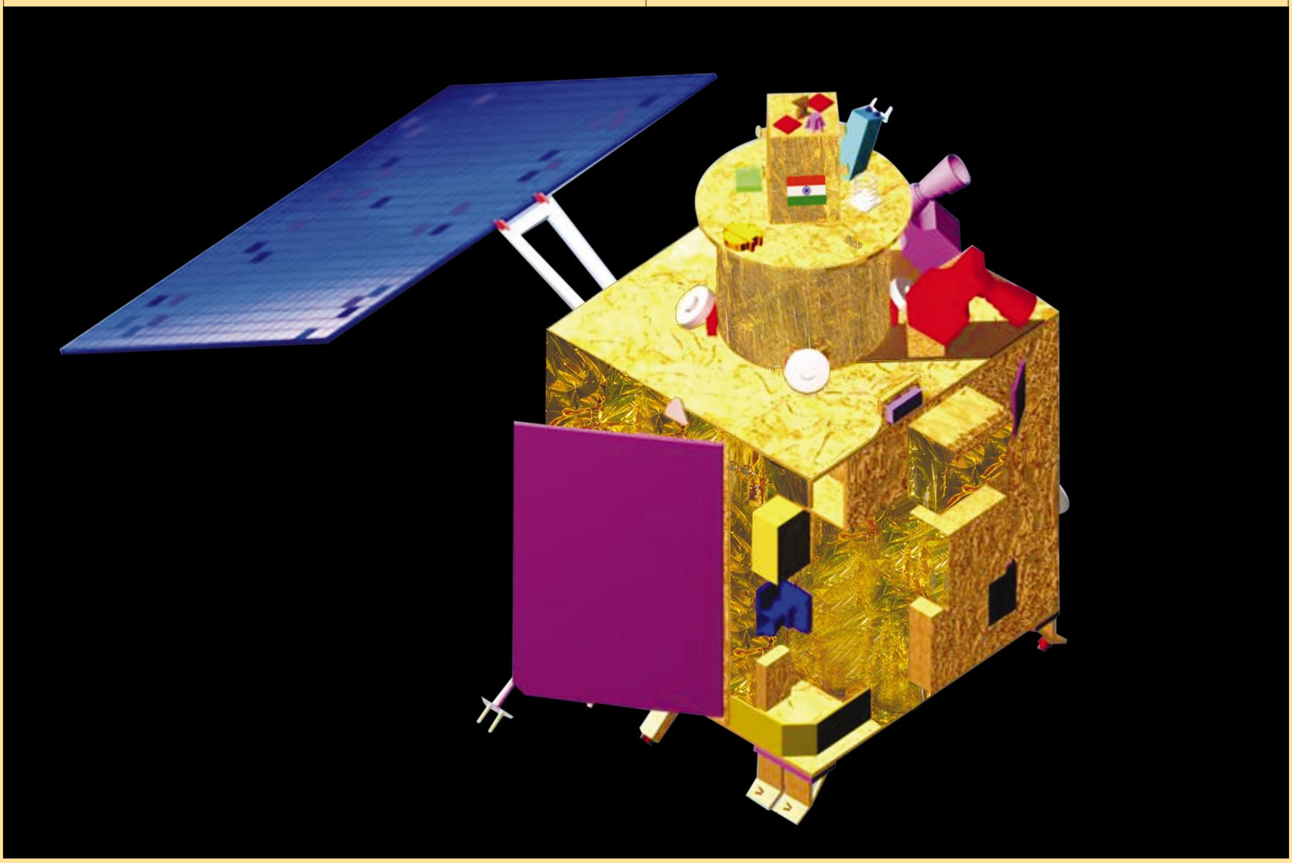


Moon Mineralogy Mapper (M3) is an imaging spectrometer from Brown University and Jet Propulsion Laboratory of the US through NASA is intended to assess and map lunar mineral resources at high spatial and spectral resolution.



Spacecraft

Chandrayaan-1 spacecraft weighed about 1380 kg at the time of its launch and is a 1.5 m cuboid with a solar panel projecting from one of its sides. 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 Chandrayaan-1



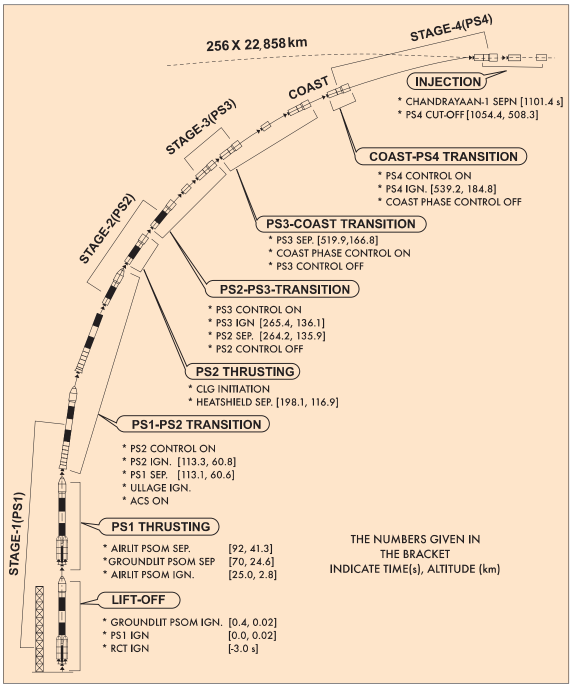
spacecraft to travel towards the Moon, its Liquid Apogee Motor (LAM) is used. Liquid propellants needed for LAM as well as thrusters are stored onboard the spacecraft. Chandrayaan-1 spacecraft's Dual Gimballed Antenna transmits the scientific data gathered by its eleven scientific instruments to Earth.

Chandrayaan-1 spacecraft was built at ISRO Satellite Centre, Bangalore with contributions from Vikram Sarabhai Space Centre (VSSC), Liquid Propulsion Systems Centre (LPSC) and ISRO Inertial Systems Unit (IISU) at Tiruvananthapuram, Space Applications Centre (SAC) and Physical Research Laboratory (PRL), Ahmedabad and Laboratory for Electro-optic Systems (LEOS), Bangalore.

Launch Vehicle

PSLV-C11 is the uprated version of ISRO's Polar Satellite Launch Vehicle in its standard configuration.

Weighing 320 tonnes at lift-off, the vehicle uses larger strap-on motors (PSOM-XL) to achieve 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. During



PSLV-C11 Nominal Flight Profile

1993-2008 period, PSLV had fourteen launches of which thirteen (including today's launch) are consecutively successful. PSLV has repeatedly proved its reliability and versatility by launching 30 spacecraft (14 Indian and 16 for international customers) into a variety of orbits so far.

Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, designed and developed PSLV. ISRO Inertial Systems Unit (IISU) at Thiruvananthapuram developed the inertial systems. The Liquid Propulsion Systems Centre (LPSC), also at Thiruvananthapuram, developed the liquid propulsion stages for the second and fourth stages of PSLV as well as reaction control systems. SDSC SHAR processed the solid propellant motors and carried out launch operations. ISRO Telemetry, Tracking and Command Network (ISTRAC) provided telemetry, tracking and command support.

The Ground Segment

The Ground facilities of Chandrayaan-1 perform the important task of receiving the health information as well as the scientific data from the spacecraft. It also transmits the radio commands to be sent to the spacecraft during all the phases of its mission. Besides, it processes and stores the scientific data sent by Chandrayaan-1 spacecraft.

ISRO Telemetry, Tracking and Command Network (ISTRAC) had a lead role in establishing the Ground Segment of Chandrayaan-1 with contributions from

ISAC and SAC. The Ground Segment of Chandrayaan-1 consists of:

1. Indian Deep Space Network (IDSN)
2. Spacecraft Control Centre (SCC)
3. Indian Space Science Data Centre (ISSDC)

a) Indian Deep Space Network receives the data sent by the Chandrayaan-1 spacecraft. Besides, it sends commands to the spacecraft at a power level of upto 20 kilowatts. IDSN consists of two large parabolic antennas – one with 18 m diameter and the other 32 m diameter – at Byalalu, situated at a distance of about 35 km from Bangalore. Of these 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 32m antenna can support spacecraft missions well beyond Moon.

b) Spacecraft Control Centre located near the ISTRAC campus at Peenya, North of Bangalore, is the focal point of all the operational activities of Chandrayaan-1 during all the phases of the mission.

C) Indian Space Science Data Centre forms the third element of Chandrayaan-1 ground segment. Also located at Byalalu, ISSDC receives data from IDSN as well as other external stations that support Chandrayaan-1, stores, processes, archives, retrieves and distributes scientific data sent by Chandrayaan-1 payloads to the user agencies.

Sequence Of Operations

India joined a select band of countries who have undertaken lunar missions by launching the first un-manned mission to Moon-Chandrayaan-1. In a historic flight conducted from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota on October 22, 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 deg to the equator. Chandrayaan-1 spacecraft began its journey from Earth onboard India's Polar Satellite Launch Vehicle (PSLV-C11) and first reached a highly elliptical Initial Orbit (IO).

Sequence of operations as appeared in the ISRO's Press Release are listed chronologically in the next few paragraphs.

Launch on October 22, 2008

In its fourteenth flight conducted from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota on

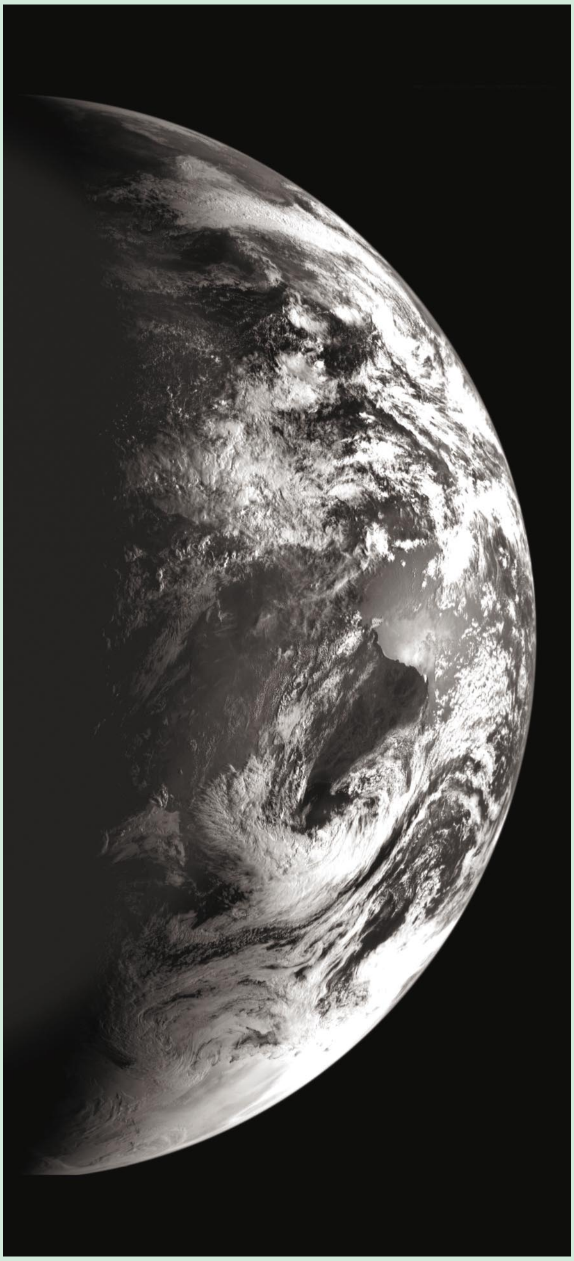
October 22, 2008, the Indian Space Research Organisation's (ISRO's) Polar Satellite Launch Vehicle, PSLV-C11, successfully launched the 1380 kg Chandrayaan-1 spacecraft into a transfer orbit with a perigee (nearest point to Earth) of 255 km and an apogee (farthest point to Earth) of 22,860 km, inclined at an angle of 17.9 deg to the equator.

After a 52 hour count down, PSLV-C11 lifted off from the Second Launch Pad at SDSC SHAR at 06:22 Hrs Indian Standard Time (IST) with the ignition of the core first stage. The important flight events included the separation of the first stage, ignition of the second stage, separation of the payload fairing at about 116 km altitude after the vehicle had cleared the dense atmosphere, second stage separation, third stage ignition, third stage separation, fourth stage ignition and fourth stage cut-off.

Camera Tested on October 31, 2008

The Terrain Mapping camera (TMC) on board Chandrayaan-1 spacecraft was successfully operated on October 29, 2008 through a series of commands issued from the Spacecraft Control Centre of ISRO Telemetry, Tracking and Command Network (ISTRAC) at Bangalore. Analysis of the first imagery received by the Indian Deep Space Network (IDSN) at Byalalu and later processed by Indian Space Science Data Centre (ISSDC) confirms excellent performance of the camera. The first imagery (image 1) taken at 8:00 am IST from a height of 9,000 km shows the Northern coast of Australia while the other (image 2) taken at 12:30 pm from a height of 70,000 km shows Australia's Southern Coast.

TMC is one of the eleven scientific instruments (payloads) of Chandrayaan-1. The camera can take

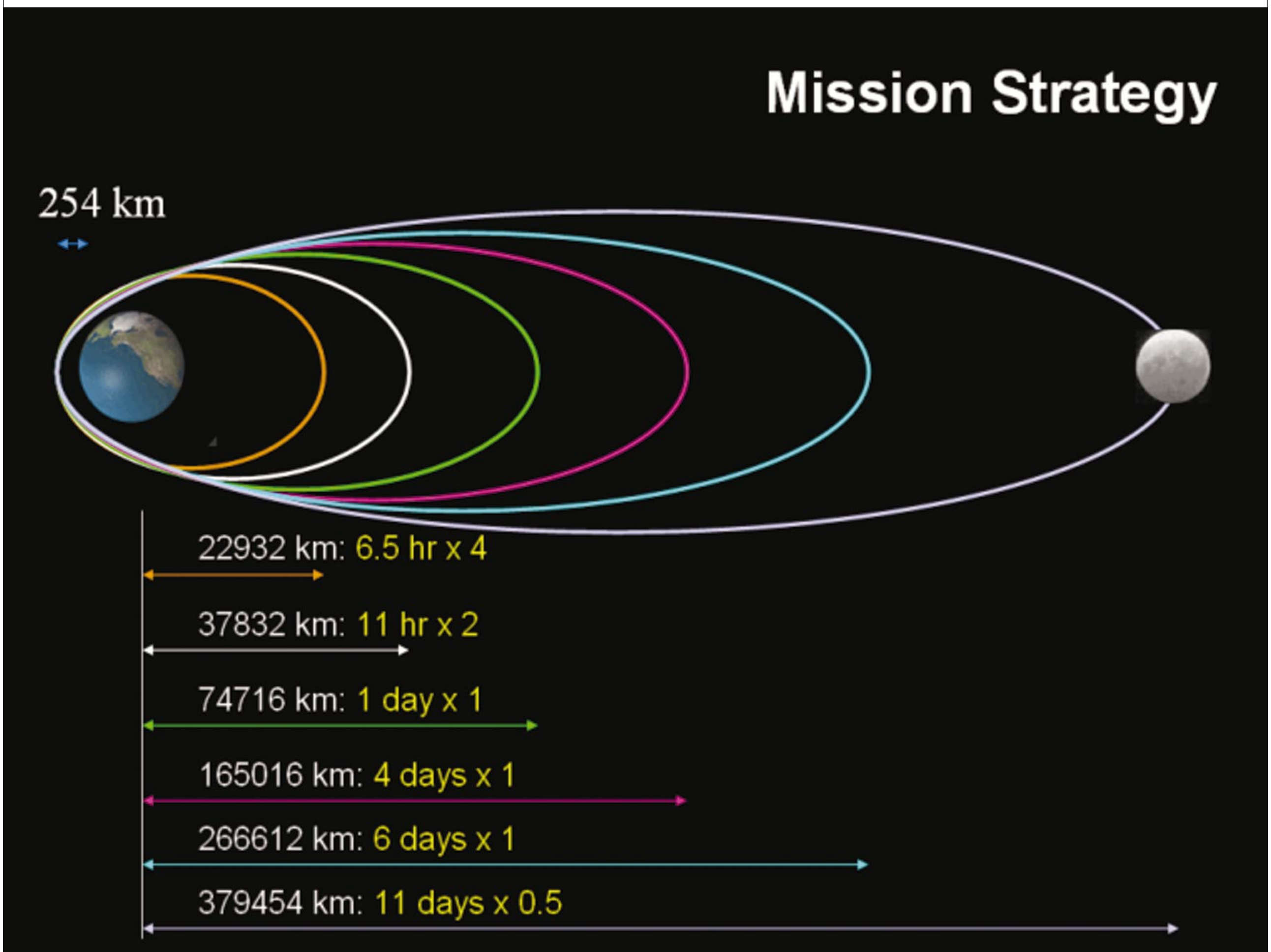


black and white pictures of an object by recording the visible light reflected from it. The instrument has a resolution of about 5 metres.

Besides TMC, the other four Indian payloads of Chandrayaan-1 are the Hyper spectral Imager (HySI), Lunar Laser Ranging Instrument (LLRI), High Energy X-ray Spectrometer (HEX) and the Moon Impact Probe (MIP). The other six payloads of Chandrayaan-1 are from abroad.

Earth Bound Maneuvers (22 Oct – 8 Nov 2008 17.5 days)

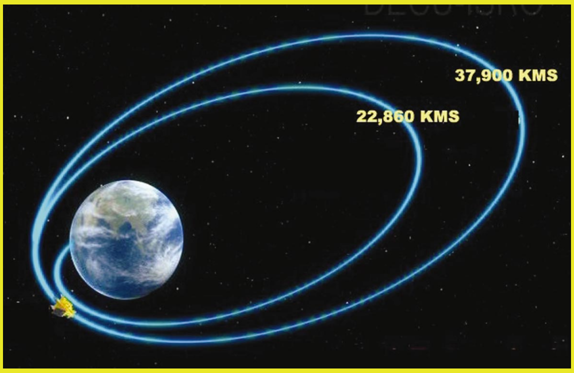
OM	Date & Burn Start	Duration (s)	delta-V (m/s) Planned	delta-V (m/s) Realized	Prop consumed (kg)	Apogee (km)
EBN #1	Oct 23, 08 03:34:33	1064.6	339.02	343.19	143.42	37831.8
EBN #2	Oct 25, 08 00:18:17	921.36	328.92	328.92	125.46	74715.9
EBN #3	Oct 26, 08 01:38:42	567.74	220.19	221.19	76.99	165016
EBN #4	Oct 29,08 02:08:22	192.18	77.29	77.38	25.86	266612
EBN #5	Nov 03, 08 23:26:12	147.69	60.64	60.65	19.70	379454
TCM #1	Nov 05, 08 11:59:57	5.59	0.87	0.87	0.43	-



Orbit Raising Manoeuvre

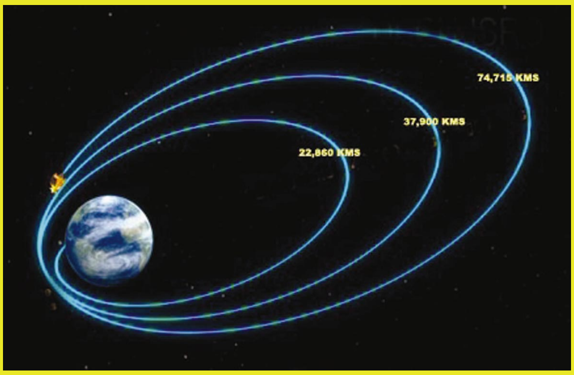
a) Chandrayaan-1 Spacecraft's Orbit Raised on October 23, 2008

The first orbit-raising manoeuvre of Chandrayaan-1 spacecraft was performed at 09:00 hrs Indian Standard Time (IST) on October 23, 2008, when the spacecraft's 440 Newton Liquid Engine was fired for about 18 minutes by commanding the spacecraft from Spacecraft Control Centre (SCC) at ISRO Telemetry, Tracking and Command Network (ISTRAC) at Peenya, Bangalore. With this engine firing, Chandrayaan-1's apogee has been raised to 37,900 km, while its perigee has been raised a little, to 305 km. In this orbit, Chandrayaan-1 spacecraft takes about 11 hours to go round the Earth once.



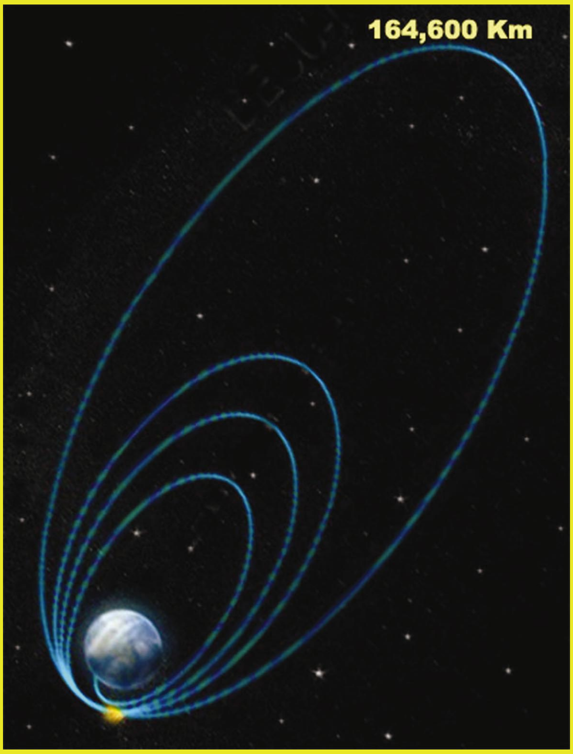
b) Chandrayaan-1 Spacecraft's Orbit Raised Further on October 25, 2008

The second orbit-raising manoeuvre of Chandrayaan-1 spacecraft was carried out at 05:48 hrs IST this morning (October 25, 2008) when the spacecraft's 440 Newton Liquid Engine was fired for about 16 minutes by commanding the spacecraft from Spacecraft Control Centre (SCC) at ISRO Telemetry, Tracking and Command Network (ISTRAC) at Peenya, Bangalore. With this engine firing, Chandrayaan-1's apogee has been further raised to 74,715 km, while its perigee has been raised to 336 km. In this orbit, Chandrayaan-1 spacecraft takes about twenty-five and a half hours to go round the Earth once. This is the first time an Indian spacecraft has gone beyond the 36,000 km high geostationary orbit and reached an altitude more than twice that height.



c) Chandrayaan-1 enters Deep Space on October 26, 2008

Chandrayaan-1 spacecraft has entered deep space after crossing the 150,000 km (one and a half lakh km) distance mark from the Earth. This happened after the successful completion of the spacecraft's



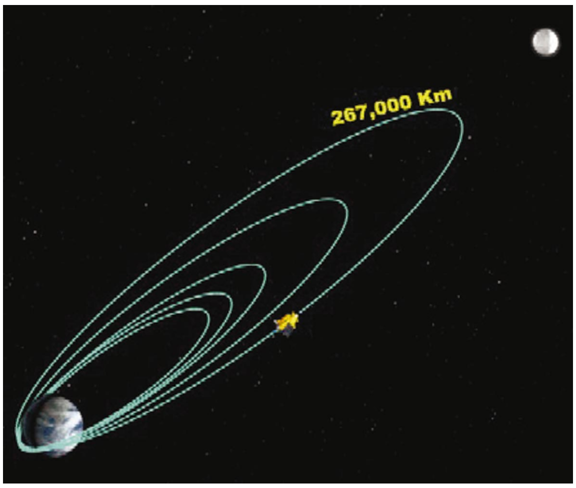
third orbit raising manoeuvre on October 26, 2008 morning.

During this manoeuvre which was initiated at 07:08 IST, the spacecraft's 440 Newton liquid engine was fired for about nine and a half minutes. With this, Chandrayaan-1 entered a much higher elliptical orbit around the Earth. The apogee (farthest point to Earth) of this orbit lies at 164,600 km while the perigee (nearest point to Earth) is at 348 km. In this orbit, Chandrayaan-1 takes about 73 hours to go round the Earth once.

The antennas of the Indian Deep Space Network at Byalalu are playing a crucial role in tracking and communicating with Chandrayaan-1 spacecraft in such a high orbit. The spacecraft performance is normal. More orbit raising manoeuvres are planned in the coming few days to take Chandrayaan-1 towards the Moon.

d) Chandrayaan-1's Orbit Closer to Moon on October 29, 2008

The fourth orbit raising manoeuvre of Chandrayaan-1 spacecraft was carried out on October 29, 2008 morning at 07:38 am IST. During this manoeuvre, the spacecraft's 440 Newton liquid engine was fired for about three minutes. With this, Chandrayaan-1 entered into a more elliptical orbit whose apogee (farthest point to Earth) lies at 267,000 km (two lakh sixty seven thousand km) while the perigee (nearest point to Earth) lies at 465 km. Thus, Chandrayaan-1 spacecraft's present orbit extends more than half the way to moon. In this orbit, the spacecraft takes about six days to go round the Earth once.



e) Chandrayaan-1 Camera Tested on October 31, 2008

The fifth and final orbit raising manoeuvre of Chandrayaan-1 spacecraft was successfully carried out on November 4, 2008 morning at 04:56 am IST. During this manoeuvre, the spacecraft's 440 Newton liquid engine was fired for about two and a half minutes. With this, Chandrayaan-1 entered the Lunar Transfer Trajectory with an apogee (farthest point to Earth) of about 380,000 km (three lakh eighty thousand km).

f) Chandrayaan-1 enters Lunar Transfer Trajectory on November 8, 2008

Chandrayaan-1, India's first unmanned spacecraft mission to moon, entered lunar orbit on November 8, 2008. This is the first time that an Indian built spacecraft has broken away from the Earth's gravitational field and reached the moon. This historic event occurred following the firing of Chandrayaan-1 spacecraft's liquid engine at 16:51 IST for a duration of 817 seconds. The highly complex 'lunar orbit insertion manoeuvre' was performed from Chandrayaan-1 Spacecraft Control Centre of ISRO Telemetry, Tracking and Command Network at Bangalore.

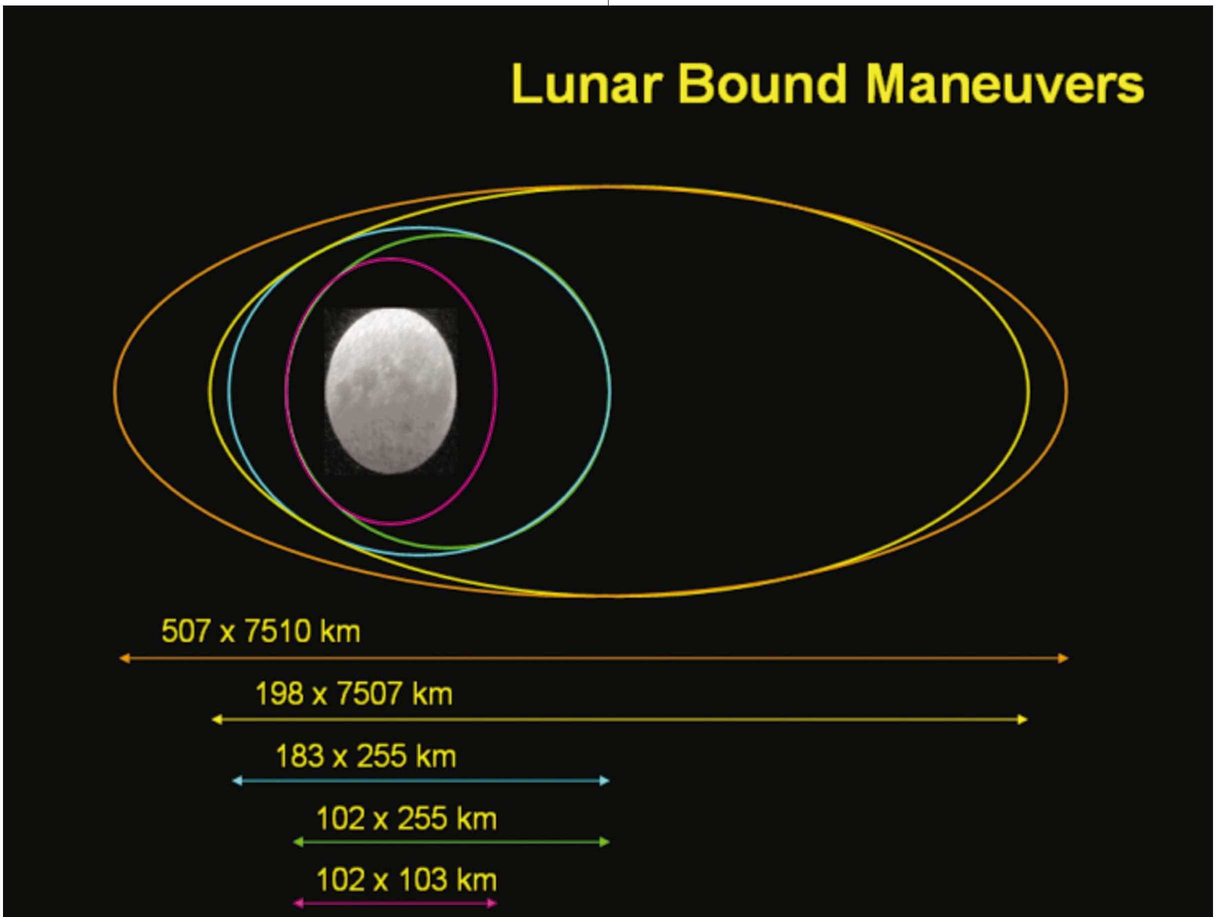
Lunar Orbit Reduction Manoeuvre

a) First Lunar Orbit Reduction Manoeuvre of Chandrayaan-I Successfully Carried Out on November 10, 2008

The first orbit reduction manoeuvre of Chandrayaan-I spacecraft orbiting the moon, was successfully performed on November 9, 2008 night. As part of that manoeuvre which began at 20:03 IST, the 440 Newton liquid engine of the spacecraft was fired for about 57 seconds. With this, the nearest point of Chandrayaan-I's orbit (periselene) from the moon's surface was reduced from 504 km to 200 km while the farthest point (aposelene) remained unchanged at 7,502 km. In this elliptical orbit, Chandrayaan-I takes about ten and a half hours to circle the moon once.

Lunar Bound Maneuvers (8 Nov – 12 Nov 2008 4 days)

Mission event	Start Time	Duration	Delta-V	Peri-Selene (KM)	Apo-Selene (KM)	Inclination
LOI	08.11.08 11-20-58	817.07	366.80	507	7510	90.02
LBN # 1	09.11.08 14-48-46	56.95	26.44	197.8	7507	90.02
LBN # 2	10.11.08 16-28-04	868.01	448.08	183.0	255.2	90.16
LBN # 3	11.11.08 13-00-44	31.38	17.031	101.8	255.0	90.18
LBN # 4	12.11.08 13-00-44	58.63	32.14	101.9	102.8	90.51



b) Chandrayaan-1 Successfully Reaches its Operational Lunar Orbit on November 12, 2008

Chandrayaan-1 spacecraft has successfully reached its intended operational orbit at a height of about 100 km from the lunar surface. This followed a series of three orbit reduction manoeuvres conducted during the past three days by repeatedly firing the spacecraft's 440 Newton Liquid Engine. As part of these manoeuvres, the engine was fired for a cumulative duration of about sixteen minutes. As a result of these manoeuvres, the farthest point of Chandrayaan-1's orbit (aposelene) from the moon's surface was first reduced from 7,502 km to 255 km and finally to 100 km while the nearest point (periselene) was reduced from 200 km to 182 km and finally to 100 km.

With this, the carefully planned complex sequence of operations to carry Chandrayaan-1 from its initial Earth orbit to its intended operational lunar orbit with the use of its liquid engine has been successfully completed. During these operations, Chandrayaan-1's liquid engine built by Liquid Propulsion Systems Centre (LPSC), Thiruvananthapuram, has been fired a total of ten times successfully. In its present operational orbit, Chandrayaan-1 spacecraft takes about two hours to go round the moon once.

From this operational circular orbit of about 100 km height passing over the polar regions of the moon, it is intended to conduct chemical, mineralogical and photo geological mapping of the moon with Chandrayaan-1's 11 scientific instruments (payloads). Two of those 11 payloads – Terrain Mapping Camera (TMC) and Radiation Dose Monitor (RADOM) –

have already been successfully switched ON. TMC has successfully taken the pictures of Earth and moon.

c) Indian Tricolour Placed on the Moon on Pandit Jawaharlal Nehru's Birthday

In a historic event, the Indian space programme achieved a unique feat on November 14, 2008 with the placing of Indian tricolour on the Moon's surface on Pandit Jawaharlal Nehru's birthday. The Indian flag was painted on the sides of Moon Impact Probe (MIP), one of the 11 payloads of Chandrayaan-1 spacecraft, that successfully hit the lunar surface today

at 20:31 hrs (8:31 pm) IST. This is the first Indian built object to reach the surface of the moon. The point of MIP's impact was near the Moon's South Polar Region. It may be recalled that the modern Indian space programme was initiated in 1962 when Pandit Jawaharlal Nehru was the Prime Minister of India.

Weighing 34 kg at the time of its launch onboard Chandrayaan-1, the box shaped MIP carried three instruments – a video imaging system, a radar altimeter and a mass spectrometer. The video imaging system was intended to take the pictures of the moon's surface as MIP approached it. The radar altimeter was included to measure the rate of descent of the probe to the lunar surface. Such instruments are necessary for future lunar soft landing missions. And, the mass spectrometer was for studying the extremely thin lunar atmosphere.

MIP's 25 minute journey to the lunar surface began with its separation from Chandrayaan-1 spacecraft

Abdul Kalam at control centre

at 20:06 hrs (8:06 pm) IST. This was followed by a series of automatic operations that began with the firing of its spin up rockets after achieving a safe distance of separation from Chandrayaan-1. Later, the probe slowed down with the firing of its retro rocket and started its rapid descent towards the moon's surface. Information from the its instruments was radioed to Chandrayaan-1 by MIP. The spacecraft recorded this in its onboard memory for later readout. Finally, the probe had a hard landing on the lunar surface that terminated its functioning.

Thus, India's very first attempt to send a probe to the moon's surface from its spacecraft orbiting the moon has been successfully concluded.

With the switching ON of two of Chandrayaan-1's payloads – Terrain Mapping Camera (TMC) and Radiation Dose Monitor (RADOM) – on its journey to moon and with MIP's successful impact on the

lunar surface today, it is planned to switch ON and test the remaining eight payloads of the spacecraft in the coming few days.

d) LASER Ranging Instrument on Chandrayaan-1 Successfully Turned "ON" on November 16, 2008

Lunar Laser Ranging Instrument (LLRI), one of the 11 scientific instruments (payloads) carried by Chandrayaan-1 spacecraft, has successfully been turned ON today (November 16, 2008). The instrument was switched ON when the spacecraft was passing over western part of the moon's visible hemisphere. Preliminary assessment of the data from LLRI by ISRO scientists indicates that the instrument's performance is normal. LLRI sends pulses of infrared laser light towards a strip of lunar surface and detects the reflected portion of that light. With this, the instrument can very accurately measure the height of moon's surface features. LLRI will be continuously kept ON and takes 10 measurements per second on both day and night sides of the moon. It provides topographical details of both polar and equatorial regions of the moon. Detailed analysis of the data sent by LLRI helps in understanding the internal structure of the moon as well as the way that celestial body evolved.

e) NASA's Moon Mineralogy Mapper (M3), a guest instrument of Chandrayaan-1 Inaugurates 3-D Moon Imaging on ....

Conclusions

All the payloads have been switched on and all are working satisfactorily. Excellent quality pictures of the lunar surface of both nearside and far side have been obtained specifically by Terrain Mapping Camera (TMC) and Hyper-Spectral Imager (HySI) cameras. Chandrayaan-1 has successfully demonstrated the country's capability and expertise in accomplishing highly complex space missions. The success of Chnadrayaan – 1 has paved way for undertaking missions to moon and beyond.