Chandrayaan-2 Orbiter Mission

Chandrayaan-2 is the second lunar exploration mission developed by the Indian Space Research Organization (ISRO) after Chandrayaan-1. Chandrayaan-2 was configured as a two module system comprising of an Orbiter Craft (OC) and a Vikram (Lander), with a six wheel Pragyan accommodated inside Vikram. The Orbiter and Vikram modules were interfaced mechanically by an inter module adapter.

Orbiter Mission objectives

- Expanding the technologies inherited from Chandrayaan-1 spacecraft and Develop & Demonstrate newer technologies that will be useful for future planetary missions.
- To carry payloads in the Orbiter craft that will enhance the scientific objectives of Chandrayaan-1 with improved resolution.

Launch

GSLV-M3 injected Chandrayaan-2 integrated module in an Elliptic Parking Orbit (EPO) of size 170 x 45475 km on 22-July-2019 at 09:30:35UTC. Subsequently, through a series of Earth Burns (EBN), apogee height was increased to bring the CH2 composite close to the Moon. On 13-Aug-2019, a Trans Lunar Injection (TLI) maneuvre followed by Lunar Orbit Insertion (LOI) maneuver on 20-Aug-2019 were carried out. The Composite Module entered Moon's orbit of 117 X 18072 Km. After insertion in lunar orbit, a series of six maneuver was carried out for orbiter to achieve 100 X 100 orbit around Moon on 24-Sep-2019.

Orbit Characteristics

The present orbit is near circular polar orbit specified as follows:

Orbit : 100 Km Polar orbit
Inclination : 91.7 deg.
Orbit Period : 118 Minutes
Revolutions per day : ~12
Altitude maintained within +/- 25 Km from the mean altitude of 100 Km.

The final lunar orbit achieved is a non-sun synchronous and the sun-aspect angle i.e. angle between orbit-plane and Sun varies in full range (0 to 360°). This result two extreme cases of illumination, defined as Dawn-Dusk (DD Season) orbit, where the sun vector is perpendicular to the spacecraft orbit plane and Noon-Midnight (NM Season) Orbit, where the sun vector is parallel to the spacecraft orbit plane.

Orbit Maintenance

CH2-Orbiter in 100 km circular polar orbit, and has an orbital life time of about ~180 days without any maneouvers. Periodic orbit maintenance maneuvers (OM) are required to keep the altitude within the mission specifications. At present, orbit is maintained within ±25 km over mean altitude 100 km. To maintain above orbit specification, a pair of Orbit Maneuver (OM) is being carried out periodically. Generally, first OM in any cycle is to increase perilune followed by second OM to decrease in apolune. On average, frequency of OM is approximately 35 to 45 days.

Orbiter Payloads

The Orbiter Craft (OC) has eight payloads such as Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS), X-Ray Solar Monitor (XSM), Synthetic Aperture Radar (SAR), Imaging IR Spectrometer (IIRS), Chandrayaan-2 Altitudinal Composition Explorer (CHACE-2), and Terrain Mapping Camera (TMC-2), Orbiter High Resolution Camera (OHRC), Dual Frequency Radio occultation Science experiment (DFRS). CLASS maps the abundance of the major rock forming elements Mg, Al, Si, Ca, Ti and Fe on the lunar surface using the technique of X-ray Fluorescence. XSM observe the X-rays emitted from the sun and Sun corona and supports the CLASS payload observation. SAR observes the scattering characteristics of lunar surface and subsurface features aid to map lunar craters and other features especially in the Polar Regions. IIRS Images the moon surface to investigate & identify minerals and detection of signatures of hydroxyl (OH) and water (H2O) molecules in polar region. CHACE-2 is a Neutral Mass Spectrometer which will carry out a detailed study of the lunar exosphere.

At present CH-2 orbiter mission is engaged with its prime objective of mapping the Moon with its eight most advanced and sophisticated payloads. The polar orbit exhibits few distinct characteristics when compared to Low Earth remote sensing (LEO) Orbits: due to Earth's motion around the sun and also due to its inertial fixed nature.

Payload Operation based on Season

The three month period around Noon-Midnight (NM) orbit geometry is been defined as Prime Imaging season. In this period illumination dependent payload, TMC and IIRS are operated to image near and far side of moon. The remaining period is defined as secondary Imaging season and this comprises of three months centered on Dawn-Dusk (DD) orbit. The payload which are not illumination dependent (DF-SAR), is getting operated during that season. Other payloads CLASS, CHACE-2, XSM and DFRS is operated in both (DD and NM) the season. OHRC operation is planned based on demand.

Attitude Definition

Two different attitudes namely AD#1 and AD#2 is defined for DD and NM seasons respectively to ensure optimum power and to meet other S/C constraints.

Satellite Operations at ISTRAC

The CH2 orbiter operations are carried out in round the clock shift operations from ISTRAC, Bangalore. CH2 is tracked by IDSN stations and Telemetry, Tracking and Commanding operations are carried out regularly. The CH2 orbiter is visible over IDSN for nearly 12 hours and there is a visibility gap for the next 12 hours. During the visibility gap, support is taken for nearly 5 to 6 hours from external ground station at Hawaii belonging to Swedish Space Corporation. Hawaii station supports TM and Payload data download operations. The TM data down linked is processed and displayed in real time and the spacecraft health parameters are continuously monitored to ensure the parameters are as expected and within the mission specified values. Commanding operations are carried out over IDSN stations for routine maintenance, payload operations and special operations. Ranging is carried out to collect the tracking data using which Orbit determination is done on regular basis. The payload data collected by the ground stations are transferred to ISSDC for processing, dissemination and archival. The payload data is released for public as per the policy.

The TTC operations are carried out in S band whereas payload data download is done through X band. All the data including payload and housekeeping data are recorded onboard and downloaded during the ground station visibilities.

Orbiter spacecraft subsystem configuration

Power	• Single Array solar panels • Power Generation:1kW (Normal Incidence) • 28 – 42V Battery Tied • Battery : Li Ion 50.4 AH capacity
Mass	• Launch pad Mass: Orbiter : 2379Kg • Present Mass: 888 Kg (dry mass 680 kg)

RF systems	**S-Band for TTC**
	Downlink
	• Downlink Frequency (MHz) : 2217.120, 2230.800
	  • TM : 0.5/1/2/4 Kbps – With coding
	  • Modulation : PCM/PSK/PM
	  • Polarisation: Circular (LCP and RCP)
	Uplink
	  • Uplink Frequencies (MHz): 2041.598, 2054.195
	  • TC : 125 bps & CCSDS Standard
	  • Modulation: PCM/PSK/PM
	  • Polarisation: Circular (LCP and RCP)
	X-Band for P/L data
	  • Downlink Frequency (MHz) : 8483.968
	  • Polarisation :LCP
	  • Modulation: QPSK

	• Data rate: 4.2/8.4 Mbps - With coding
Propulsion Systems	**Bi propellant system (MON3 + MMH)** • 2 x 780 L propellant Tanks, • 2 x 67 L Pressurant tank. • Attitude Thrusters 8 x 22N • 1 Liquid Engine 440 N

Collision Avoidance Plan

ISRO & JPL have coordination towards Conjunction analysis for Earth-orbiting, Interplanetary and Lunar orbiting S/C. As a part of cross support, ISTRAC- ISRO provides CH2- Spice Trajectory (BSP file) to JPL-MADCAP, through DSSAM-ISRO HQ, on weekly basis. JPL-MADCAP performs Conjunction analysis for all S/C in lunar-orbit.

- Based on Conjunction Data limits, additional Maneuvers are planned
- During Orbit Maintenance maneuver, ISRO gets the clearance form JPL-MADCAP

End of Mission life

- The present 100 x 100 Km orbit can be maintained for the next 4 to 5 years approximately.
- At the end of operational life, it is planned to raise the orbit to extend the orbital life.

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