CHANDRAYAAN-2 MISSION

ORBITER PAYLOADS

Terrain Mapping Camera-2 (TMC-2)

Terrain Mapping Camera-2 (TMC-2) is in continuation of the TMC of Chandrayaan-1 mission for topographic coverage of the moon. TMC-2 will measure the solar radiation reflected / scattered from the Moon's surface.

The primary objectives of TMC-2 are:

- To map the lunar surface with high spatial and vertical resolution in continuation to TMC-1;
- To address the evolution of the Lunar surface through systematic morphometric (height/depth, length, breadth etc.) mapping of various landforms (Domes, Cones, rilles etc) and chronological studies.

Parameter	**Value**
Spectral band	0.5-0.8 µm; pushbroom mode
Spatial resolution	5 m
Swath	20 km @ 100 km altitude
View angles (fore and aft)	±25º
Expected higher level data product	10 m DEM

View of TMC-2

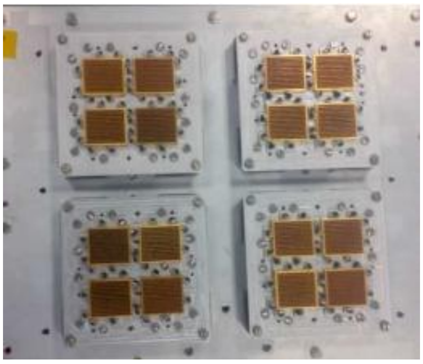
Chandrayaan-2 Large Area Soft X ray spectrometer (CLASS)

CLASS aims to measure the X-ray Fluorescence (XRF) spectra for deriving the elemental abundance on the lunar surface. This is an indigenous version of Chandrayaan-1 X-ray Spectrometer (C1XS) payload with a larger collection area.

The primary objectives of CLASS are:

- To map the abundance of major elements (Mg, Al, Si, Ca, Ti, Fe, Na) at tens of km scales on the lunar surface.
- To search for Particle Induced X-ray Emission (PIXE) during the passage of Orbiter through the geotail, once a month around full moon.

The payload consists of sixteen Swept Charge Devices (SCDs) of a total area 64 cm^2 arranged in four quadrants. Gold coated copper collimators define the field of view (FOV).



CLASS flight model

16 detectors with collimators arranged in four quadrants

Parameter	Value
Spatial resolution	12.5 x 12.5 km @ 100 km altitude
Spectral resolution	165 eV @ 5.9 keV
Energy range	0.8 -20 keV
Expected higher level data product	Maps of Mg, Al,Si, Ca and Fe (and any element with > 1 wt% abundance)

Solar X-ray Monitor (XSM)

Solar X-ray Monitor (XSM) is a companion payload to CLASS to measure the intensity of solar radiation in X-rays.

The primary objectives of this payload is

- To provide Solar X-ray spectrum in the energy range of 1-15 keV.

The solar flares are classified into five different classes known as A, B, C, M and X class according to the GOES peak flux, with A being the faintest and X being the highest intensity flare.

View of XSM

XSM is designed to measure Solar X-ray spectrum in the energy range of 1-15 keV. This is achieved using the X-ray Silicon Drift Detector (SDD), which provide high energy resolution as well as high count rate capability. XSM will provide high energy resolution (better than 250 eV @ 5.9 keV) and high cadence (full spectrum every second) measurements of solar X-ray spectra as input for analysis of data from CLASS.

Parameter	**Value**
FOV	45 x 45 deg
Spectral resolution	< 250 eV @ 5.9 keV
Energy range	1 -15 keV
Expected higher level data product	Solar spectrum with response matrices

Imaging IR Spectrometer (IIRS)

Moon Mineralogy Mapper (M3), an international AO payload on Chandrayaan-1 mission with the wavelength range 0.7-3 micron discovered the presence of Hydroxyl and water-ice molecules on the high latitude lunar regions. IIRS aims to confirm OH, H_2O and water-ice signatures by extending the wavelength range to 5 micron.

The primary objectives are:

- Global mineralogical and volatile mapping of the Moon in the spectral range of ~0.8-5.0 µm for the first time at high resolution of ~20 nm.
- Complete characterization of water/hydroxyl feature near 3.0 µm for the first time at high spatial and spectral resolution

IIRS will measure the solar radiation reflected from the lunar surface in 256 contiguous spectral bands from 100 km lunar orbit.

View of IIRS payload

Parameter	**Value**
Spatial resolution	80 m
No:of spectral bands	256
Spectral resolution	20 nm
Spectral band	0.8-5 μm
Expected higher level data product	Calibrated and radiometrically corrected reflectance spectra

Dual Frequency Synthetic Aperture Radar (SAR)

The Dual-frequency (L and S) SAR is aimed at providing enhanced capabilities compared to the Chandrayaan-1 S-band MiniSAR such as

a) L-band for greater depth of penetration (~5-10m i.e twice that of S-band)

b) Circular and full polarimetry with range of resolution options (2m – 75m) and incident angles (9° - 35°) for understanding scattering properties of permanently shadowed regions.

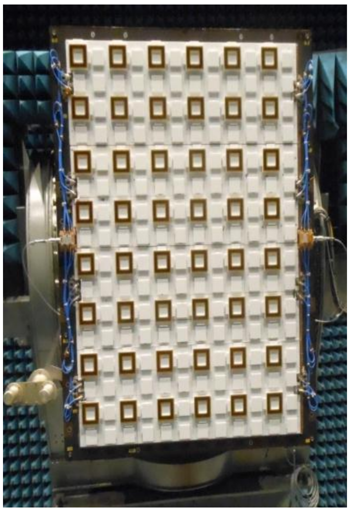
c) L and S band operation in stand-alone and simultaneous mode to validate Mini-SAR observations.

The scientific objectives of this payload are:

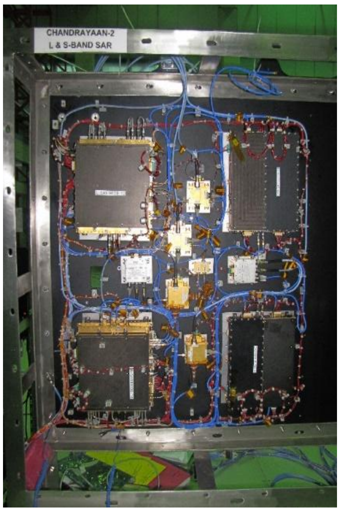
i) High resolution lunar mapping in the polar regions.

ii) Quantitative estimation of water-ice in the polar regions

iii) Estimation of Regolith Thickness and its distribution



Dual Frequency SAR



Dual Frequency SAR

In the Circular polarization mode, transmit signal is circularly polarized and reception is by dual-linearly polarized channels. After reception, appropriate signal processing will be done to extract polarimetric information by decomposition of image data. In the full (linear) polarization mode, transmit polarization is switched between V & H for consecutive pulses and reception is by simultaneous dual-linearly polarized channels, for each of the transmit polarization.

Parameter	**Value**
Band	L and S
Spatial resolution	2- 75 m
Primary observations	Polar and specific areas of interest
Expected higher level data product	Calibrated SAR images …

Chandrayaan-2 Atmospheric Compositional Explorer-2 (CHACE-2)

Chandra's Altitudinal Composition Explorer (CHACE) experiment aboard the Moon Impact Probe (MIP) in Chandrayaan-1, in the mass range of 1 to 100 amu yielded interesting scientific results on lunar Ar, Ne, He and H2, as well as a few heavier species (mass>50 amu).

The CHACE-2 experiment is a sequel to the CHACE experiment. The primary objective of CHACE-2 is:

- In-situ study of the composition and distribution of the lunar neutral exosphere and its variability.

View of CHACE-2

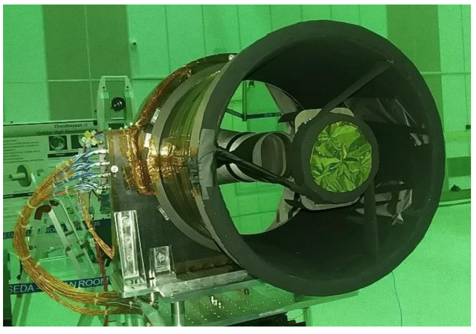
It is a quadrupole mass spectrometer (QMA) capable of scanning the lunar neutral exosphere in the mass range of 1 to 300 amu with the mass resolution of ~0.5 amu. The instrument is equipped with an electron impact ionizer that ionizes the ambient neutrals, Bayard Alpert Gauge to measure the total pressure and a combination of Faraday cup and Channel Electron Multiplier (CEM) detectors.

Parameter	Value
Mass range	1-300 amu
Resolution	0.5 amu

Orbiter High Resolution Camera (OHRC)

This payload is included in Orbiter for imaging the landing site prior to lander separation to ensure safe landing. The images taken in two different look angles will be used for generating DEM of the landing site. Subsequent to lander separation, this payload will be used as science payload.

The primary objective of this payload is to provide high-resolution images of lunar regions of interest.



OHRC is a panchromatic high resolution camera with a ground sampling of 0.32 m. OHRC images of 12 km x 3 km area, obtained in 2 orbits, will be used for safe landing area selection. In addition to detection of craters and boulders, Digital Elevation Model (DEM) generation is also planned. The binary image consisting of edges of craters and other features with topology of entire area will be uploaded to Lander-Craft as reference datasets in appropriate formats.

Parameter	**Value**
Spatial resolution	0.32 m
Spectral band	Panchromatic
Swath	12 km x 3 km
Expected higher level data product	DEM for selected regions

Dual Frequency Radio Science (DFRS) experiment

The Radio Science experiment relies on the principle that the phase of a radio signal, propagating from a satellite to the ground station, gets perturbed when it crosses through the planetary/ Lunar atmosphere or ionosphere.

The primary objectives of this payload are:

i) To study the variations in the ionosphere/ atmosphere at Moon
ii) To explore if the Ionosphere at Moon is omnipresent or has episodic appearances (electron density ~ 100-1000 cm^{-3})
iii) To study the temporal variations, if any, in the ionospheric plasma density (TEC ~ 10^{14} electrons / m^2) with lander experiment

Coherent radio signals at X and S band radio frequencies and highly stable radio source with the frequency stability of the order of 10^{-11} is provided for this payload.

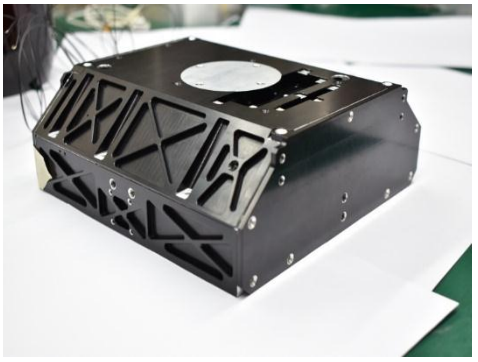
LANDER PAYLOADS

Instrument for Lunar Seismic Activity (ILSA)

Seismology is the best geophysical tool to determine the internal structure of any planetary body. A total of 12,000 moon quakes have been recorded by lunar seismometers deployed during the Apollo missions. After the Apollo missions, there have been no missions to Moon for conducting further studies in this field.

The Moon's seismic signals are however characterized by very low frequency and moon quakes are of very low amplitude. In order to conduct seismic studies, a very sensitive instrument (sub-micro gravity level) which can pick up ground displacement or velocity or acceleration is developed.

- The primary objective of this payload is to characterise the seismicity around the landing site.



ILSA will be kept ON during the entire mission life, of 1 lunar day, and it can sense artificial seismic activities such as the Rover movement from the ramp, drilling of thermal probe etc.

ILSA is a three axis MEMS-based seismometer that can measure ground acceleration due to lunar quakes. The instrument is designed to resolve acceleration as low as 100 ng /µHz with a dynamic range of± 0.5 g and a bandwidth of 40 Hz. To meet the dynamic range, two sensors are used: Coarse range sensor (± 160 µg to ± 0.5 g) and fine range sensor (± 0.7 µg to ± 400 µg). The output data will be in the form of ground acceleration which can be further processed to represent in terms of velocity or displacement.

Chandra's Surface Thermo-physical Experiment (ChASTE)

Knowledge of thermal properties and temperature distribution in lunar surface is important for its geophysical characterisation. Lunar thermal models indicate a two layer approach: The top 2-3 cm is a fluffy layer with low density and low thermal conductivity. It is followed by a layer that is more compact and of higher thermal conductivity. Due to this, a sharp change in temperature is expected in the top few cm of the lunar surface.

The primary objective of ChASTE is:

- To measure the vertical temperature gradient and the thermal conductivity of the lunar surface.

The instrument consists of a thermal probe (consisting of a series of temperature sensors spaced at different distances and a heater) which is inserted into the lunar regolith down to a depth of ~10 cm.

The payload operation has two modes: (i) Passive mode operation in which continuous in situ measurements of temperature at different depths will be carried out, (ii) Active mode operation in which the heater is switched ON for a specific time duration. The variation of temperature due to heater ON is monitored as a function of time and the thermal conductivity of the regolith under contact is estimated.

Langmuir Probe (LP)

The lunar ionosphere is a highly dynamic plasma environment. Tenuous and thin as it may be, the lunar atmosphere contains valuable information on the near surface volatiles and serves as a reservoir of gases released from the interior.

The Langmuir Probe has proved to be a important tool for plasma diagnostics and is of great value in probing plasma in the space.

The primary objectives of this payload are:

1) To measure the ambient electron density/temperature near the lunar surface
2) To measure the temporal evolution of the Lunar plasma density for the first time near the surface under varying solar conditions

The Chandrayaan-2 LP consists of a metal (conducting) sphere, which is inserted into plasma and electrically biased with respect to a reference electrode to collect electron and/or positive ion currents. The spherical probe of 5 cm diameter is made of Ti alloy material coated with Titanium Nitride. The metallic sphere is mounted on a CFRP boom of 1m length so that the probe is well immersed in the lunar plasma. The observation method consists of obtaining Current-Voltage characteristic of the probe as the applied bias voltage is swept from a negative to a positive potential (-14 to +14 V).

ROVER PAYLOADS

Alpha Particle X-ray Spectrometer (APXS)

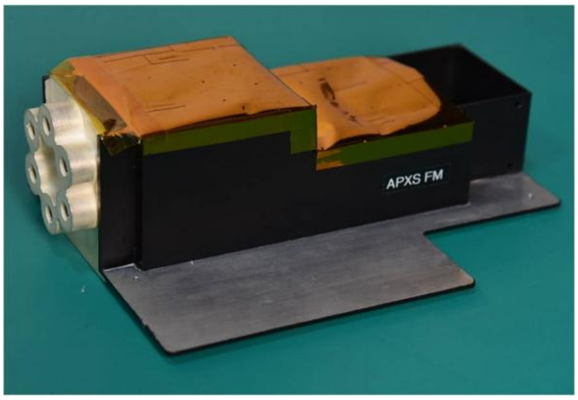
Alpha Particle X-ray Spectrometer (APXS) is a well proven instrument for in situ quantitative elemental analysis of planetary surfaces.

The primary scientific objective of APXS is

- To determine the elemental composition of the lunar surface in the regions surrounding the landing site.

The technique is of X-ray fluorescence spectroscopy using in-situ excitation of surface by an X-ray or alpha particle source. For this purpose, APXS uses ^{244}Cm radio-active sources emitting both alpha particles having energy of 5.8 MeV energy and X-rays having energy of 14.3 and 18.3 keV, which excites the elemental characteristic X-rays by the processes of particle induced X-ray emission (PIXE) and X-ray fluorescence spectroscopy (XRF).

The characteristic X-rays are detected by the 'state-of-the-art' X-ray detector known as Silicon Drift Detector (SDD), which provides high energy resolution as well as high efficiency in the energy range of 1 to 25 keV. This enables APXS to detect all major rock forming elements like Na, Mg, Al, Si, Ca, Ti, Fe etc. (except O) and some trace elements such as Sr, Y, Zr which are found in the lunar surface.



Laser Induced Breakdown Spectroscope (LIBS)

Laser Induced Breakdown Spectroscopy (LIBS) is a technique by which the planetary surface is bombarded by a laser source which generates a plasma of the elements at the surface whose characteristic lines of emission are studied by spectroscopy.

The primary objective of this payload is

- To identify and determine the abundance of elements near the landing site.

LIBS instrument will be housed on Chandrayaan-2 Rover facing the lunar surface. The collection lens to surface distance is 205 mm. LIBS instrument conducts the investigation site on lunar surface by firing a series of high peak power laser pulses which generates the so called laser induced plasma. The plasma during its decay will emit the radiation which is collected by the LIBS instrument as a spectrum and analyzed further for elemental presence and abundance.

Passive Experiment

Laser Retroreflector Array (LRA)

LRA will help us understand the dynamics of Earth's moon system and also derive clues about the lunar interior.