Science Payloads Onboard Chandrayaan-1 Mission

Chandrayaan-1 had five indigenously developed core payload/ experiments: TMC, HySI, LLRI and HEX and a Moon Impact Probe (MIP) to impact on a predetermined location on the lunar surface.

- Terrain Mapping stereo Camera (TMC) in the panchromatic band, having 5 m spatial resolution and 20 km swath.

- Hyper Spectral Imaging camera (HySI) operating in 400-950 nm band with a spectral resolution of 15 nm and spatial resolution of 80 m with a swath of 20 km.

- Lunar Laser Ranging Instrument (LLRI) with height resolution of less than 5 m

- High Energy X-ray spectrometer (HEX) using Cadmium-Zinc-Telluride (CdZnTe) detector in the 30-270 keV energy region with spatial resolution of 33 km.

- Moon Impact Probe (MIP) as piggyback payload on the main orbiter of the Chandrayaan-1 spacecraft, which will impact on the surface of the Moon.

Apart from the above indigenous payloads/experiments, ISRO solicited proposals through an Announcement of Opportunity (AO) from International and Indian Scientific Community for participating in the mission by providing suitable scientific payloads, complementing the overall Chandrayaan-1 scientific objectives. Out of the proposals received, six experiments were selected for inclusion in Chandrayaan-1 mission; two of the AO payloads, C1XS and SARA are developed by ESA jointly with ISRO.

- Chandrayaan-1 X-ray Spectrometer (C1XS) through ESA - collaboration between Rutherford Appleton Laboratory, UK and ISRO Satellite Centre, ISRO. Part of this payload is redesigned by ISRO to suit Chandrayaan-1 scientific objectives.

- Near Infra-Red spectrometer (SIR-2) from Max Plank Institute, Lindau, Germany through ESA.

- Sub keV Atom Reflecting Analyser (SARA) through ESA, collaboration between Swedish Institute of Space Physics, Sweden and Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO. The Data Processing Unit of this payload/ experiment is designed and developed by ISRO, while Swedish Institute of Space Physics has developed the payload sensor.

- Radiation Dose Monitor Experiment (RADOM) from Bulgarian Academy of Sciences.

- Miniature Synthetic Aperture Radar (Mini-SAR) from Applied Physics Laboratory, Johns Hopkins University and Naval Air Warfare Centre, USA through NASA.

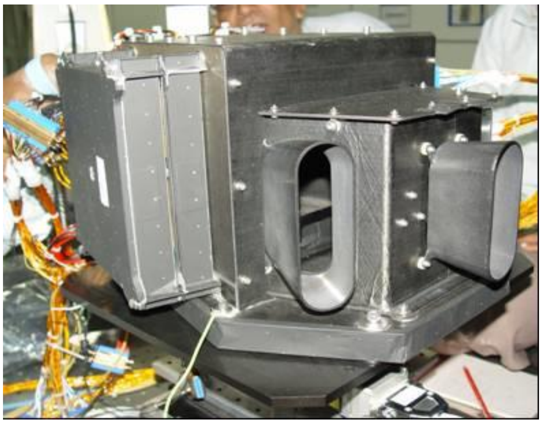
- Moon Mineralogy Mapper (M3) from Brown University and Jet Propulsion Laboratory, USA through NASA.

Provided below is the summary of the prime objectives of the eleven payloads carried onboard Chandrayaan-1 mission

Prime Objectives	Payload
Search for water-ice	MiniSAR, HEX, SARA
Chemical Mapping	C1XS, HEX
Mineralogical Mapping	HySI, SIR-2, M3
Topography Mapping	LLRI,TMC
Radiation Environment	RADOM, HEX, C1XS
Magnetic Field Mapping	SARA
Volatile Transport	HEX
Lunar Atmospheric constituent	MIP

DETAILS OF INDIAN PAYLOADS

i. Terrain Mapping Camera (TMC)



Scientific Objective

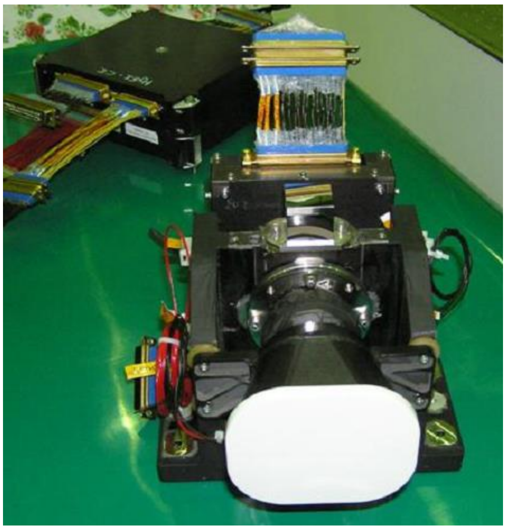
The aim of TMC is to map topography of both near and far side of the Moon and prepare a 3-dimensional atlas with high spatial and elevation resolution of 5 m. Such high resolution mapping of complete lunar surface will help to understand the evolution processes and allow detailed study of regions of scientific interests. The digital elevation model available from TMC along with the Lunar Laser Ranging Instrument (LLRI) on Chandrayaan-1 could improve upon the existing knowledge of Lunar Topography.

Payload Configuration Details

The TMC will image in the panchromatic spectral region of 0.5 to 0.85 µm, with a spatial/ ground resolution of 5 m and swath coverage of 20 km. The camera is configured for imaging in the pushbroom mode, with three linear 4k element detectors in the image plane for fore, nadir and aft views, along the ground track of the satellite. The fore and aft view angles are ±25º respectively w.r.t. Nadir. TMC will measure the solar radiation reflected / scattered from the Moon's surface. The dynamic range of the reflected signal is quite large, represented by the two extreme targets – fresh crust rocks and mature mare soil.

TMC uses Linear Active Pixel Sensor (APS) detector with in-built digitizer. Single refractive optics will cover the total field of view for the three detectors. The output of the detector will be in digitized form. The optics is designed as a single unit catering to the wide field of view (FOV) requirement in the direction along the ground track. The incident beams from the fore (+25°) and aft (-25°) directions are directed on to the focusing optics, using mirrors. Modular camera electronics for each detector is custom designed for the system requirements using FPGA / ASIC. The expected data rate is of the order of 50 Mbps. The dimension of TMC payload is 370 mm x 220 mm x 414 mm and mass is 6.3 kg.

ii. Hyper Spectral Imager (HySI)



Scientific Objective

The main aim is to obtain spectroscopic data for mineralogical mapping of the lunar surface. The data from this instrument will help in improving the available information on mineral composition of the surface of Moon. Also, the study of data in deep crater regions/central peaks, which represents lower crust or upper mantle material, will help in understanding the mineralogical composition of Moon's interior.

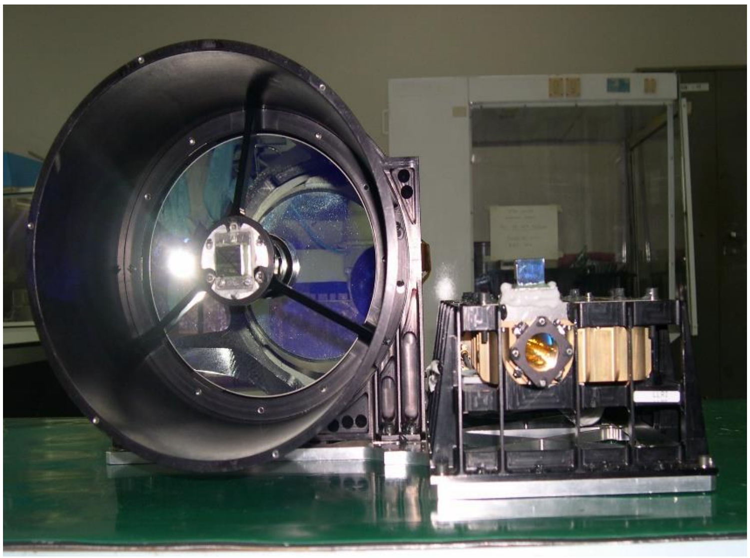
Payload Configuration Details

The uniqueness of the HySI is in its capability of mapping the lunar surface in 64 contiguous bands in the VNIR, the spectral range of 0.4-0.95 µm region with a spectral resolution of better than 15 nm and spatial resolution of 80 m, with swath coverage of 20 km. HySI will collect the Sun's reflected light from the Moon's surface through a tele-centric refractive optics and focus on to an APS area detector for this purpose.

The dispersion is achieved by using a wedge filter so as to reduce the weight and compactness of the system compared to using a prism / grating. The wedge filter is an interference filter with varying thickness along one dimension so that the transmitted spectral range varies in that direction. The wedge filter will be placed in close proximity to an area detector. Thus, different pixels in a row of the detector will be receiving irradiance from the same spectral region but different spatial regions in the across track direction. In the column direction of the detector, different rows will receive irradiance of different spectral as well as spatial regions in the along track direction. The full spectrum of a target is obtained by acquiring image data in push broom mode, as the satellite moves along the column direction of the detector. An Active Pixel Sensor (APS) area array detector with built-in digitizer would map the spectral bands. The payload mass is 2.5 kg and its size is 275 mm x 255 mm x 205 mm.

iii. Lunar Laser Ranging Instrument (LLRI)

The elevation map of the Moon prepared using the laser ranging instrument carried onboard Chandrayaan-1 spacecraft will help in studying the morphology of large basins and other lunar features, study stress, strain and flexural properties of the lithosphere and when coupled with gravity studies, would be able to find the density distribution of the crust.



Scientific Objective

To provide ranging data for determining the accurate altitude of the spacecraft above the lunar surface, determine the global topographical field of the Moon, determine an improved model for the lunar gravity field and supplement the terrain mapping camera and hyper-spectral imager payloads.

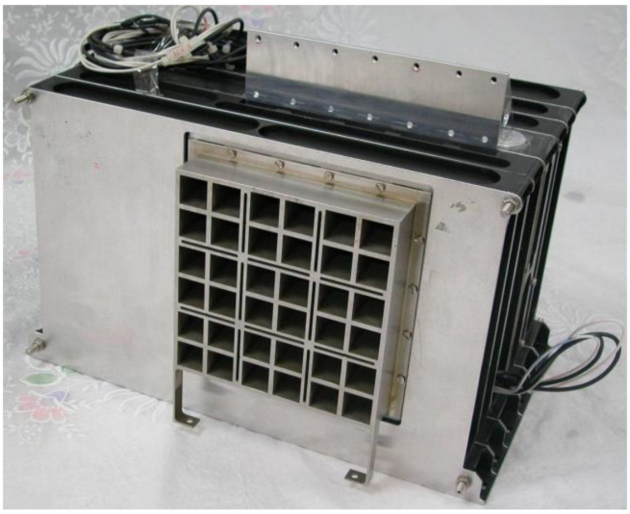
Payload Configuration Details

LLRI works on the time-Of-Flight (TOF) principle. In this method, a coherent pulse of light from a high power laser is directed towards the target whose range is to be measured. A fraction of the light is scattered back in the direction of the laser source where an optical receiver collects it and focuses it on to a photoelectric detector. By accurately measuring the roundtrip travel time of the laser pulse, highly accurate range/spot elevation measurements can be made.

LLRI consists of a 10 mJ Nd:YAG laser with 1064nm wave source operating at 10 Hz pulse repetition mode. The reflected laser pulse from the lunar surface is collected by a 200 mm Ritchey-Chrétien Optical receiver and focused on to a Silicon Avalanche Photodetector. The output of the detector is amplified and threshold detected for generating range information to an accuracy <5m.Four constant fraction discriminators provide the slope information in addition to range information. The different modes of operation of LLRI and the range computations from the detector output are controlled and computed by a FPGA based electronics. The processed outputs of LLRI will be used for generating high accuracy lunar topography. The payload mass is 11.37 kg with base plate.

iv. High Energy X-ray Spectrometer (HEX)

The High-Energy X-ray spectrometer covers the hard X-ray region from 30 keV to 270 keV. This is the first experiment to carry out spectral studies of planetary surface at hard X-ray energies using good energy resolution detectors.



The High Energy X-ray (HEX) experiment is designed primarily to study the emission of low energy (30-270 keV) natural gamma-rays from the lunar surface due to ^{238}U and ^{232}Th and their decay chain nuclides.

Scientific Objectives

The scientific goal of the HEX instrument is as follows:

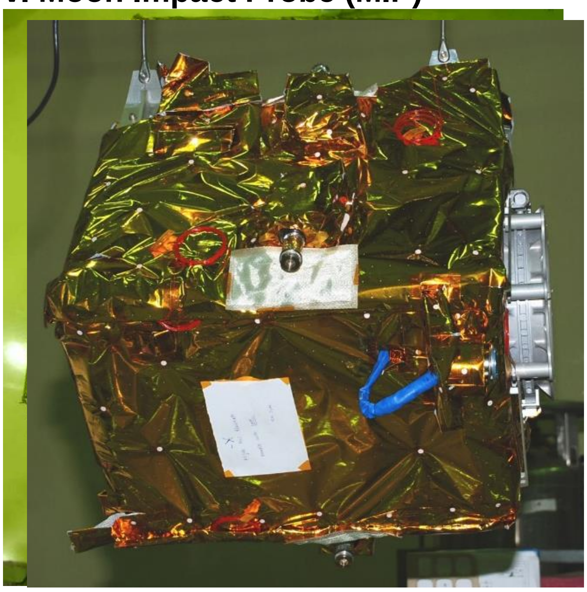
- To identify excess ^{210}Pb in lunar polar regions deposited there as a result of transport of gaseous ^{222}Rn, a decay product of ^{238}U from other regions of the Moon. This will enable us to understand transport of other volatiles such as water to the polar regions.
- To detect other radioactive emissions, to characterise various lunar terrains for their chemical and radioactive composition on the basis of specific/integrated signal in the 30-270 keV region.
- To explore the possibility of identifying polar regions covered by thick water-ice deposit from a study of the continuum background.

Payload Configuration Details

The geometric detector area of 144 cm^2 is realized by nine Cadmium Zinc Telluride (CZT) arrays, each 4 cm x 4 cm (5 mm thick), composed of 256 (16x16) pixels (size: 2.5 mm x 2.5 mm). Each CZT array is readout using two closely mounted Application Specific Integrated Circuits (ASICs), which provides self-triggering capability. The detector will be biased at the cathode with –550 V and the electronic charge signals are collected at the anode. A Cesium Iodide (CsI (Tl)) scintillator crystal coupled to photomultiplier tubes (PMT), will be used as the anticoincidence system (ACS). The ACS is used to reduce the detector background.

A specially designed collimator provides a field of view (FOV) of 33 km X 33 km at the lunar surface from a 100 km orbit. The spatial resolution of HEX is 33 km and the mass is 14.4 kg.

v. Moon Impact Probe (MIP)



The impact probe of 35 kg mass will be attached at the top deck of the main orbiter and will be released during the final 100 km x 100 km orbit at a predetermined time to impact at a pre-selected location. During the descent phase, it is spin-stabilized. The total flying time from release to impact on Moon is around 25 minutes.

The primary objective is to demonstrate the technologies required for landing the probe at a desired location on the Moon and to qualify some of the technologies related to future soft landing missions.

Main Objectives

- Design, development and demonstration of technologies required for impacting a probe at the desired location on the Moon.
- Qualify technologies required for future soft landing missions.
- Scientific exploration of the Moon from close range.

Payload Configuration Details

There will be three instruments on the Moon Impact Probe

- Radar Altimeter – for measurement of altitude of the Moon Impact Probe and for qualifying technologies for future landing missions. The operating frequency band is 4.3 GHz ± 100 MHz.
- Video Imaging System – for acquiring images of the surface of the Moon during the descent at a close range. The video imaging system consists of analog CCD camera.
- Mass Spectrometer – for measuring the constituents of tenuous lunar atmosphere during descent. This instrument will be based on a state-of-the-art, commercially available Quadrupole mass spectrometer with a mass resolution of 0.5 amu and sensitivities to partial pressure of the order of 10^{-14} torr.

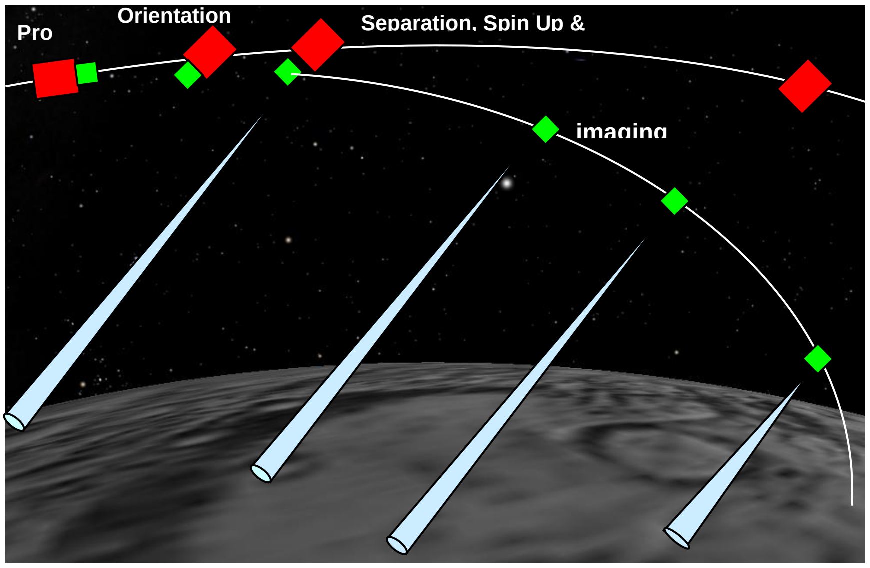
The dimension of the impact probe is 375 mm x 375 mm x 470 mm

MIP System configuration

The Moon Impact Probe (MIP) essentially consists of honeycomb structure, which houses all the subsystems and instruments. In addition to the instruments, the separation system, the de-boost spin and de-spin motors, it comprises of the avionics system and thermal control system. The avionics system supports the payloads and provides communication link between MIP and the main orbiter, from separation to impact and provides a database useful for future soft landing.

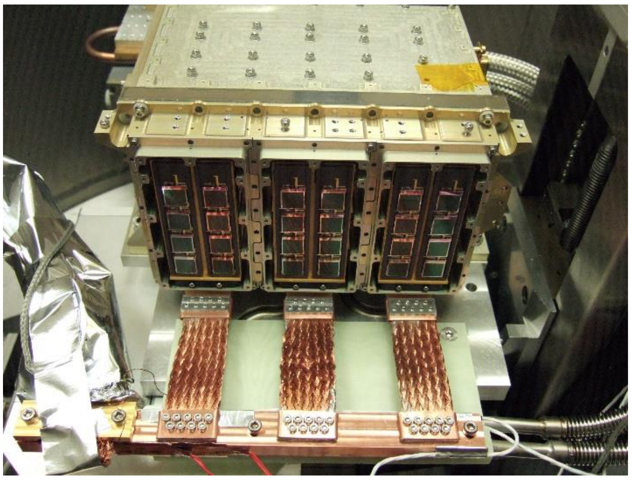
The mission envisages collecting all the instrument data during descent and transmits to main orbiter, which in turn will transmit them to the ground station during visible phases.

Impact Probe Mission Profile



DETAILS OF ANNOUNCEMENT OF OPPORTUNITY PAYLOADS

i. Chandrayaan-1 X-ray Spectrometer (C1XS)



Scientific Objective

The primary goal of the C1XS instrument is to carry out high quality X-ray spectroscopic mapping of the Moon, in order to constrain solutions to key questions on the origin and evolution of the Moon. C1XS will use X-ray fluorescence spectrometry (1.0-10 keV) to measure the elemental abundance, and map the distribution, of the three main rock forming elements: Mg, Al and Si. During periods of enhanced solar activity (solar flares) events, it may be possible to determine the abundance of minor elements such as Ca, Ti and Fe on the surface of the Moon.

Background

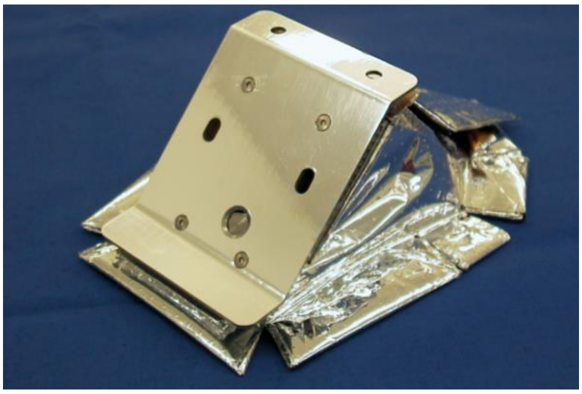
When a primary X-ray beam strikes a sample, the X-rays can either be absorbed or scattered by the atom. Upon absorption the X-ray, transfers all its energy to an innermost electron. If the primary X-ray has sufficient energy, electrons are ejected from the inner shells creating vacancies, causing an unstable condition for the atom. As the atom returns to its stable condition, electrons from the outer shells are transferred to the inner shells and in the process they radiate an X-ray photon at a characteristic energy. Each element has a unique set of energy levels, and produces X-rays at a unique set of energies, allowing it to be identified by measurement and thereby to derive the elemental composition of a sample. The process of emission of characteristic X-rays is called 'X-ray Fluorescence' or XRF and is widely used to measure the elemental composition of materials.

Solar X-rays excites fluorescent emission from the lunar surface. It is possible to map the absolute elemental abundances of the main rock-forming elements on the Moon by simultaneous measurement of this emission, and by monitoring of the incident Solar X-ray flux. In addition, during bright flares, localized concentration levels of key minor elements can also be detected.

Payload Configuration Details

The instrument utilises technologically innovative Swept Charge Device (SCD) X-ray sensors, which are mounted behind low profile gold/copper collimators and aluminium/polycarbonate thin film filters. The system has the virtue of providing superior X-ray detection, spectroscopic and spatial measurement capabilities, while also operating at near room temperature. A deployable proton shield protects the SCDs during passages through the Earth's radiation belts, and from major particle events in the lunar orbit. In order to record the incident solar X-ray flux at the Moon, which is needed to derive absolute lunar elemental surface abundances, C1XS also includes an X-ray Solar Monitor.

The X-ray Solar Monitor (XSM) is provided through collaboration between Rutherford Appleton Laboratory (RAL) and University of Helsinki. With its wide field-of-view of ± 52 degrees, XSM provides observation of the solar X-ray spectrum from 1-20 keV with good energy resolution (< 250 keV@5.9 keV) and fast spectral sampling at 16 s intervals.

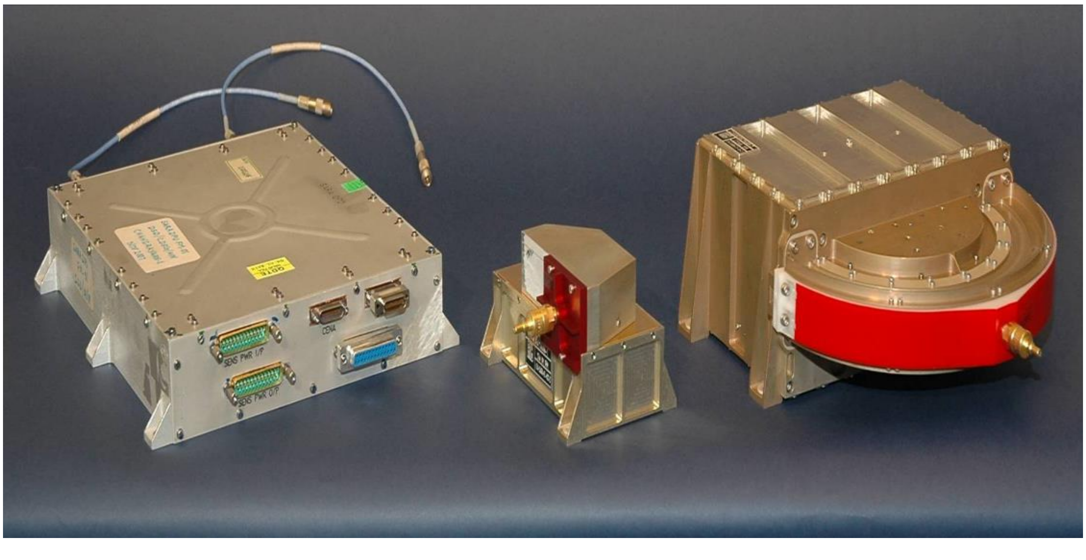


Throughout the normal solar conditions, C1XS will be able to detect abundance of Mg, Al and Si in the lunar surface. During solar flare events, it may additionally be possible to detect other elements such as Ca, Ti and Fe. The onboard solar monitor acting in real time will greatly enhance the capability of C1XS to determine absolute elemental abundances as well as their ratios. The total mass of C1XS and XSM is 5.2 kg.

C1XS will be able to map the highland, mare regions, impact basins and large craters on the Moon. The observation may be able to shed some light on the existence and scale of pre-mare volcanism, help to refine estimates of the bulk composition of the Moon and improve the evolutionary models.

Heritage: The primary C1XS instrument is based on the D-CIXS instrument on the ESA SMART-1 mission, which is redesigned to suit Chandrayaan-1 scientific objectives.

ii. Sub keV Atom Reflecting Analyser (SARA)



Scientific Objectives

SARA will image the Moon surface using low energy neutral atoms as diagnostics in the energy range 10 eV - 3.2 keV to address the following scientific objectives:

- Imaging the Moon's surface composition including the permanently shadowed areas and volatile rich areas
- Imaging the solar wind-surface interaction
- Imaging the lunar surface magnetic anomalies
- Studies of space weathering

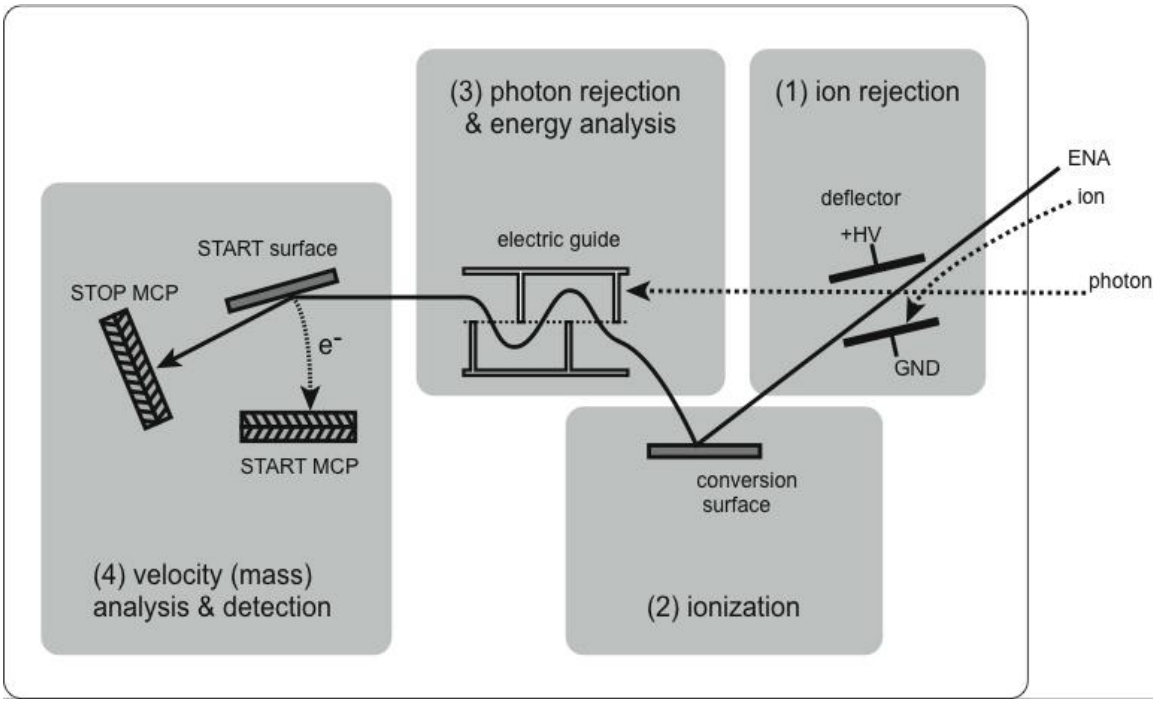
Background

The Moon does not possess a magnetosphere and atmosphere. Therefore, the solar wind ions directly impinge on the lunar surface, resulting in sputtering and backscattering. The kick-off and neutralized solar wind particles leave the surface mostly as neutral atoms. The notable part of the atoms has energy exceeding the escape energy and thus, such atoms propagate along ballistic trajectories. The SARA instrument is designed to detect such atoms with sufficient angular and mass resolution to address the above scientific objectives. SARA is the first-ever energetic neutral atom imaging mass spectrometer.

Payload Configuration Details

The SARA instrument consists of neutral atom sensor CENA (Chandrayaan-1 Energetic Neutrals Analyzer), solar wind monitor SWIM and DPU (Data Processing Unit). CENA and SWIM interface with DPU, which in turn interfaces with the spacecraft. The masses of CENA, SWIM and DPU are 2 kg, 0.5 kg and 2 kg respectively, totaling the SARA mass as 4.5 kg.

The functional blocks of CENA are shown below: Low-energy neutral atoms enter through an electrostatic charged particle deflector (1), which sweeps away ambient charged particles by a static electric field. The incoming low energy neutral atoms are converted to positive ions on an ionization surface (2), and then passed through an electrostatic analyzer of a specific ("wave") shape that provides energy analysis and effectively blocks photons (3). Particles finally enter the detection section (4) where they are reflected at grazing incidence from a start surface towards one of several stop micro channel plate (MCP) detectors. Secondary electrons generated at the start surface and the stop pulses from the stop MCP detectors preserve the direction and the velocity of the incident particle.

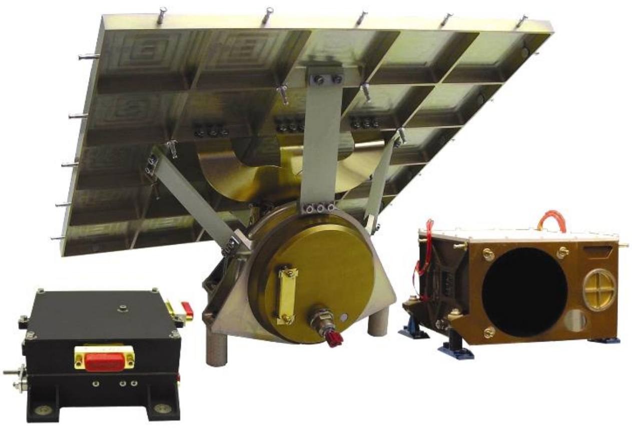


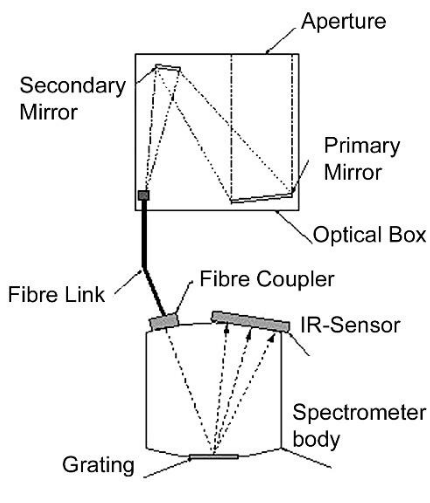
CENA main components

SWIM is an ion mass analyzer, optimized to provide monitoring of the precipitating ions. Ions first enter the deflector, which provides selection on the azimuth angle, following a cylindrical electrostatic analyzer. Exiting the analyzer the ions are post-accelerated up to 1 keV and enter the time-of-flight cell, where their velocity is determined by the same principle (surface reflection), as in the CENA instrument.

iii. Near-IR Spectrometer (SIR-2)

Scientific Objectives





SIR-2 will address the surface-related aspects of lunar science in the following broad categories:

- Analyse the lunar surface in various geological/mineralogical and topographical units;
- Study the vertical variation in composition of crust;
- Investigate the process of basin, maria and crater formation on the Moon;
- Explore "Space Weathering" processes of the lunar surface;
- Survey mineral lunar resources for future landing sites and exploration.

Background

The determination of the chemical composition of a planet's crust and mantle is one of the important goals of planetary research. Diagnostic absorption bands of various minerals and ices, which are expected to be found on the surfaces of planetary bodies, are located in the near-IR range, thus making near-infrared measurements of rocks, particularly, suitable for identifying minerals.

Payload Configuration Details

SIR-2 is a grating NIR point spectrometer working in the 0.93-2.4 microns wavelength range with 6 nm spectral resolution. It collects the Sun's light reflected by the Moon with the help of a main and a secondary mirror.

This light is fed through an optical fiber to the instrument's sensor head, where it is reflected off a dispersion grating. The dispersed light reaches a detector, which consists of a row of photosensitive pixels that measure the intensity as a function of wavelength and produces an electronic signal, which is read out and processed by the experiment's electronics.

The mass of the instrument is 3.3 kg and the instrument unit dimension is 260 mm x 171 mm x 143 mm.

iv. Radiation Dose Monitor Experiment (RADOM)

Scientific Objectives

RADOM will qualitatively and quantitatively characterize the radiation environment in near lunar space, in terms of particle flux, dose rate and deposited energy spectrum. The specific objectives are

- Measure the particle flux, deposited energy spectrum, accumulated radiation dose rates in Lunar orbit;
- Provide an estimate of the radiation dose around the Moon at different altitudes and latitudes;
- Study the radiation hazards during the Moon exploration. Data obtained will be used for the evaluation of the radiation environment and the radiation shielding requirements of future manned Moon missions.

Background

The dominant radiation components outside the earth's magnetosphere are the Galactic Cosmic Rays (GCR), modulated by the magnetic fields associated with the low energy charged particles (the solar wind), which are continuously emitted from the Sun and the Solar energetic Particle Events (SPE) emitted during solar flares, sudden sporadic eruptions of the chromosphere of the Sun.

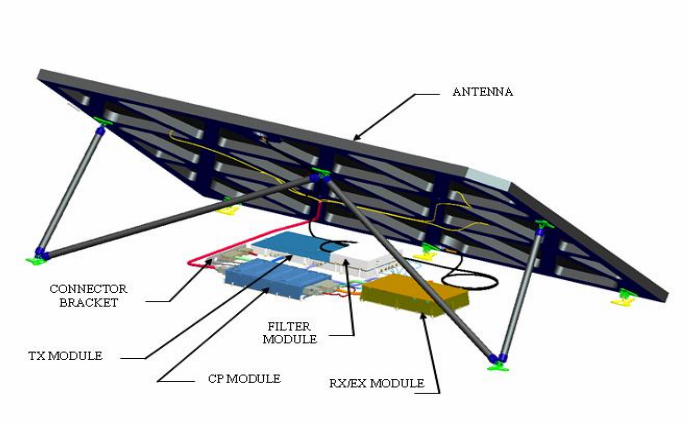
Radiation exposure of crewmembers on future manned space flight had been recognised as an important factor for the planning and designing of such missions. Indeed, the effects of ionising radiation on crew health, performance and life expectancy are a limitation to the duration of man's sojourn in space. Predicting the effects of radiation on humans during a long-duration space mission requires i) accurate knowledge and modelling of the space radiation environment, ii) calculation of primary and secondary particle transport through shielding materials and through the human body, and iii) assessment of the biological effects of the dose.

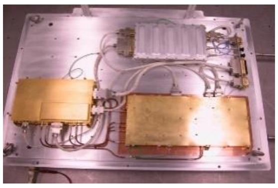
The general purpose of RADOM is to study the radiation hazards during the Moon exploration. Data obtained will be used for the evaluation of radiation environment and radiation shielding requirements for future manned lunar missions.

Payload Configuration Details

RADOM is a miniature spectrometer-dosimeter containing one semiconductor detector of 0.3 mm thickness, one charge-sensitive preamplifier and two micro controllers. The detector weighs 139.8 mg. Pulse analysis technique is used for obtaining the deposited energy spectrum, which is further converted to the deposited dose and flux in the silicon detector. The exposure time for one spectrum is fixed at 30 s. The RADOM spectrometer will measure the spectrum of the deposited energy from primary and secondary particles in 256 channels. RADOM mass is 160 g.

v. Miniature Synthetic Aperture Radar (Mini-SAR)





Scientific Objective

To detect water ice in the permanently shadowed regions on the Lunar poles, upto a depth of a few meters.

Background

Although returned lunar samples show the Moon to be extremely dry, recent research suggest that water-ice may exist in the polar regions. Because its axis of rotation is perpendicular to the ecliptic plane, the poles of the Moon contain areas that never receive light and are permanently dark. This results in the creation of “cold traps”, zones that, because they are never illuminated by the sun, may be as cold as 50–70° K. Cometary debris and meteorites containing water-bearing minerals constantly bombard the Moon. Most of this water is lost to space, but, if a water molecule finds its way into a cold trap, it remains there forever – no physical process is known that can remove it. Over geological time, significant quantities of water could accumulate.

In 1994, the Clementine polar-orbiting spacecraft used its radio transmitter to “illuminate” these dark, cold trap areas; echoes were recorded by the radio antennas of the Earth-based Deep Space Network. Analysis of one series of data indicated that at least some of the dark regions near the South Pole had reflections that mimicked the radio-scattering behavior of ice. Subsequently, the orbiting Lunar Prospector spacecraft found large quantities of hydrogen in the polar regions, corresponding closely with large areas of permanent shadow, consistent with the presence of water ice. The controversy over lunar polar ice continues to this day.

An onboard SAR at suitable incidence would allow viewing of all permanently shadowed areas on the Moon, regardless of whether sunlight is available or the angle is not satisfactory. The radar would observe these areas at incidence angle near 45 degrees, recording echoes in both orthogonal senses of received polarization, allowing ice to be optimally distinguished from dry lunar surface.

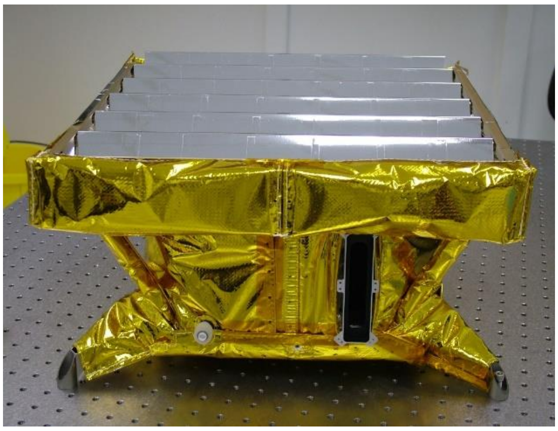
The Mini-SAR radar system can operate as an altimeter/scatterometer, radiometer, and as a synthetic aperture radar imager.

Payload Configuration Details

The Mini-SAR system will transmit Right Circular Polarization (RCP) and receive, both Left Circular polarization (LCP) and RCP. In scatterometer mode, the system will measure the RCP and LCP response in the altimetry footprint, along the nadir ground track. In radiometer mode, the system will measure the surface RF emissivity, allowing determination of the near normal incidence Fresnel reflectivity. Meter-scale surface roughness and circular polarization ratio (CPR) will also be determined for this footprint. This allows the characterization of the radar and physical properties of the lunar surface (e.g., dielectric constant, porosity) for a network of points. When directed off nadir, the radar system will image a swath parallel to the orbital track by delay/Doppler methods (SAR mode) in both RCP and LCP.

The synthetic aperture radar system works at a frequency 2.38 GHz, with a resolution of 75 m per pixel from 100km orbit and its mass is 8.77 kg.

vi. Moon Mineralogy Mapper (M3)



M3 with high-resolution compositional maps will improve the understanding of the early evolution of a differentiated planetary body and provide a high-resolution assessment of lunar resources.

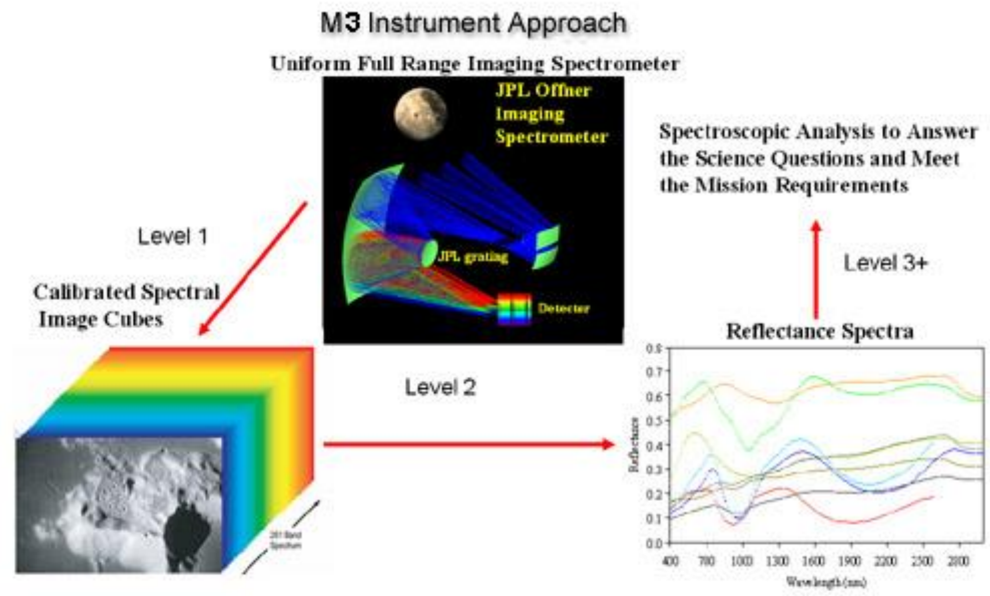
Scientific Objectives

The primary Science goal of M3 is to characterize and map lunar surface mineralogy in the context of lunar geologic evolution. This translates into several sub-topics relating to understanding the highland crust, basaltic volcanism, impact craters, and potential volatiles.

The primary *exploration* goal is to assess and map lunar mineral resources at high spatial resolution to support planning for future, targeted missions. These M3 goals translate directly into the following requirements:

- Accurate measurement of diagnostic absorption features of rocks and minerals;
- High spectral resolution for deconvolution into mineral components;
- High spatial resolution for assessment geologic context and active processes;

M3 Measurements



M3 Optical Configuration

M3 measurements are obtained for 640 cross track spatial elements and 261 spectral elements. This translates to 70 m/pixel spatial resolution and 10 nm spectral resolution (continuous) from a nominal 100 km polar orbit for Chandrayaan-1. The M3 FOV is 40 km in order to allow contiguous orbit-to-orbit measurements at the equator that will minimize lighting condition variations.

Payload Configuration Details

The M3 scientific instrument is a high throughput pushbroom imaging spectrometer, operating in 0.7 to 3.0 μm range. It measures solar reflected energy, using a two-dimensional HgCdTe detector array.

Sampling : 10 nanometers
Spatial resolution: 70 m/pixel [from 100 km orbit]
Field of View: 40 km [from 100 km orbit]
Mass: 8.2 kg

The spectral range 0.7 to 2.6 μm captures the absorption bands for the most important lunar minerals. In addition, the spectral range 2.5 to 3.0 μm is critical for detection of possible volatiles near the lunar poles. The presence of small amounts of OH or H_2O can be unambiguously identified from fundamental absorptions that occur near 3000 nm.