CHANDRAYAAN-1: INDIAN MISSION TO MOON. J. N. Goswami[1], K. Thyagarajan[2] and M. Annadurai[2], [1]Physical Research Laboratory, Ahmedabad – 380009, India (goswami@prl.res.in), [2]ISRO Satellite Center, Bangalore - 560017, India..

The Indian Space Research Organisation (ISRO) has started a new initiative to launch dedicated scientific satellites earmarked for planetary exploration, astronomical observation and space and atmospheric sciences. The Chandrayaan-1 mission to Moon is the first planetary exploration mission of this new initiative. The primary scientific objective of the Chandrayaan-1 mission, scheduled for launch in late 2007, is to further our understanding of the origin and evolution of the Moon based on high resolution selenological and chemical mapping of the Moon.

A suite of baseline payloads, identified to meet this scientific objective, include a Terrain Mapping Camera (TMC), a Hyper-Spectral Imager (HySI), a Low Energy X-ray Spectrometer (LEX), a High Energy X-γ ray Spectrometer (HEX) and a Lunar Laser Ranging Instrument (LLRI). These payloads will provide simultaneous mineralogical, chemical and photo-geological mapping of the lunar surface at resolutions better than previous and currently planned lunar missions. They will allow (i) direct estimation of lunar surface concentration of the elements Mg, Al, Si, Ca, Ti and Fe with high spatial resolution (≤20 km), (ii) High resolution (~100m) UV-VIS-NIR mapping of the lunar surface to identify abundances of various lunar minerals, (iii) High resolution 3D mapping of the lunar surface, and (iv) nature of volatile transport on moon, particularly to colder lunar polar regions.

ISRO also offered opportunity to the international scientific community to participate in Chandrayaan-1 mission and several payloads that complement the basic objectives of the Chandrayaan-1 mission have been selected for inclusion in this mission. These are: a miniature imaging radar instrument (Mini-SAR) to explore the polar regions of the moon to look for possible presence of water ice, two infrared spectrometers (SIR-2 and Moon Mineral Mapper: MMM) for extending the range beyond that of the hyper spectral imager, a low-energy X-ray Spectrometer (CIXS) for high resolution chemical mapping, a sub-keV atom reflecting analyzer (SARA) for detection of solar wind sputtered low energy neutral atoms as well as studies of lunar surface magnetic anomalies and a radiation dose monitor (RADOM) for monitoring energetic particle flux in the lunar environment. Three of the payloads, SIR-2, CIXS and SARA, developed at the Max-Planck Institute, Lindau, Rutherford Appleton Laboratory (RAL), UK and Swedish Institute of Space Physics, respectively, will be provided by the European Space Agency (ESA). NASA will provide Mini-SAR, developed by JHU/APL and NAWC, and MMM, developed by Brown University and JPL. RADOM will be provided by the Bulgarian Academy of Sciences. There will be significant technical participation of ISRO in realizing two of the payloads, CIXS and SARA. There will be active scientific collaboration between ISRO scientists and investigators associated with each of the AO payloads. The basic characteristics of the baseline payloads are described here; description of the AO payloads may be found in companion abstracts (see also Spudis et al., 36th LPSC, 1153.pdf).

The terrain mapping stereo camera (TMC) in the 500-850 nm band will have three linear array detectors for nadir, fore and aft viewing and will have a swath of 20 km. It will be capable of providing 3D image of the lunar surface with a ground resolution of 5m with base to height ratio of one. The hyper spectral imager for mineralogical mapping will be operating in the 400-950 nm band employing a wedge filter coupled to an area array detector. It will have 64 continuous channels with a spectral resolution better than 15nm and a spatial (pixel) resolution of 80m with a swath of 20 km. Two options were considered for detection of low energy (1-10keV) fluorescence X-rays from the lunar surface; use of a thermoelectrically cooled X-ray CCD (LEX) or of a swept-charge X-ray detector (SCD) array. The final choice was SCD and CIXS (Chandrayaan Imaging X-ray Spectrometer), a modified version of D-CIXS instrument on board SMART-1, proposed by RAL, UK, and supported by ESA was selected in place of LEX. This collimated low energy X-ray spectrometer will have a field of view of 20 km and provide detail chemical mapping of the lunar surface for the elements, Mg, Al, Si and also for Ca, Ti and Fe during flare times. The high-energy X-γ ray (20-250keV) spectrometer (HEX) will employ CdZnTe solid-state detectors and will have suitable collimator providing an effective spatial resolution of 40 km in the low energy region (<60 keV). It will employ a CsI anticoincidence system for reducing background and is primarily intended for the study of volatile transport on Moon using the 46.5 keV γ ray line from ^{210}Pb decay as tracer. ^{210}Pb is a decay product of volatile ^{222}Rn and both belong to the ^{238}U decay series. Attempt will be made to infer compositional characteristics of lunar terrain from a study of the continuum background in this energy range as well as low resolution Th and U mapping of terrains enriched in these elements (e.g. KREEP). The laser ranging instrument (LLRI) will employ a Nd-Yag laser with energy 10mJ and employ a 20 cm optics receiver coupled to a Si-APD. It will be operating at 10Hz (5ns pulse) and can provide a vertical resolution better than 5m. The LLRI and TMC will provide complementary data for generating a topographic map of the Moon and the LLRI, in particular, will provide the first such data set for the polar region.

In addition to the primary scientific payloads, an impactor carrying a high sensitive mass spectrometer, a video camera and a radar altimeter will also be a part of the overall payload system. The impactor will be released at the beginning of the mission and attempt will be made to land it in a predetermined location on the lunar surface. Apart from the video imaging of the landing site, the onboard mass spectrometer will try to detect possible presence of trace gases in the lunar exosphere.

The spacecraft design is adopted from flight proven Indian Remote Sensing Satellite bus coupled with suitable modifications specific to the lunar mission. Apart from the solar array, TTC and data transmission, that are specific to the lunar mission, other aspects of system design have flight heritage.

The Chandrayaan-1 mission will be implemented using an advanced version of the indigenous Polar Satellite Launching Vehicle (PSLV-XL). The PSLV will place the 1 ton class lunar-craft into an elliptical transfer orbit and subsequently into a lunar transfer trajectory. Lunar orbit insertion maneuver will be carried out to place the spacecraft into an eccentric orbit around the moon initially that will be trimmed to achieve 100 km circular polar orbit. The planned lifetime of the mission is two years.

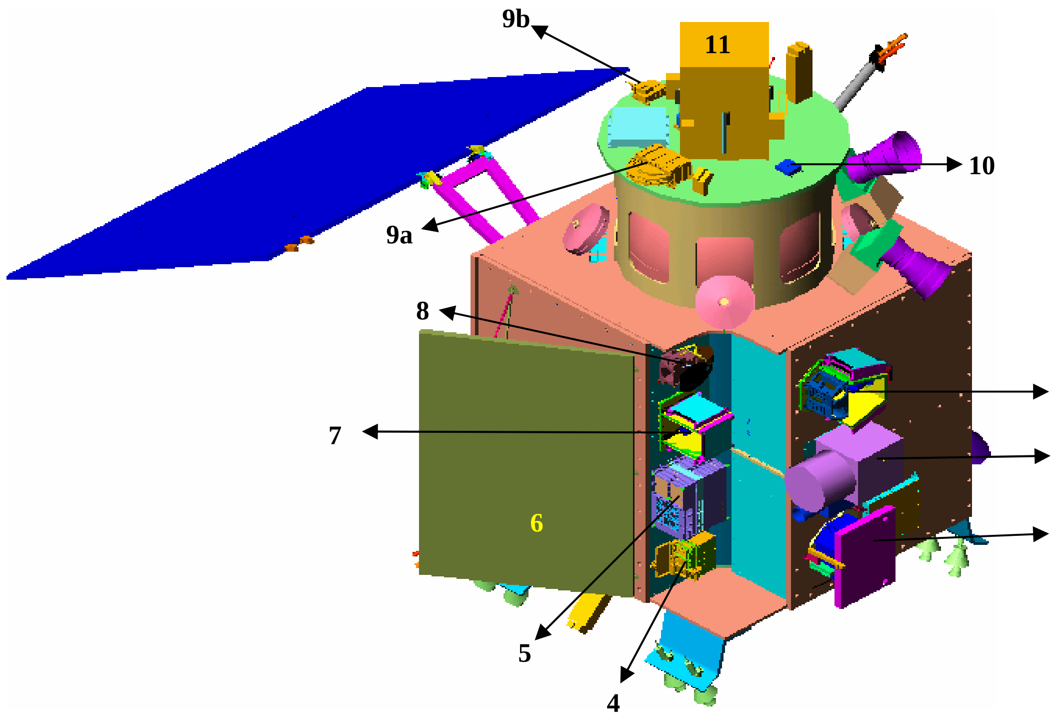

Fig. 1 A view of the Chandrayaan-1 spacecraft showing the placement of the various payloads: 1. Terrain mapping camera (TMC); 2. Lunar laser ranging instrument (LLRI). 3. Moon mineral mapper (MMM); 4. Chandrayaan Imaging X-ray Spectrometer (CIXS); 5. High energy X-ray spectrometer (HEX); 6. Miniature synthetic aperture radar (mini-SAR) antenna; 7. Hyper spectral imager (HySI); 8. Infrared Spectrometer (SIR-2); 9. Sub-keV atom reflecting analyzer [SARA: (a) energetic neutral analyzer (b) solar wind monitor]; 10. Radiation dose monitor (RADOM); 11. Impact probe. The blue panel is the canted solar array.