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

Introduction: The first Indian planetary mission to moon, Chandrayaan-1 [1], launched on 22nd October, 2008, with a suite of Indian and International payloads on board, collected very significant data over its mission duration of close to one year. Important new findings from this mission include, discovery of hydroxyl and water molecule in sunlit lunar surface region around the poles [2], exposure of large anorthositic blocks confirming the global lunar magma hypothesis [3], signature of sub surface ice layers in permanently shadowed regions near the lunar north pole [4], evidence for a new refractory rock type [5], mapping of reflected lunar neutral atoms and identification of mini-magnetosphere [6], possible signature of water molecule in lunar exosphere [7], preserved lava tube that may provide site for future human habitation [8] and radiation dose en-route and around the moon [9].

The success of Chandrayaan-1 orbiter mission provided the impetus to implement the second approved Indian mission to moon, Chandrayaan-2, with an Orbiter-Lander-Rover configuration. The enhanced capabilities will enable addressing some of the questions raised by the results obtained from the Chandrayaan-1 and other recent lunar missions and gather new data to further our understanding of the origin and evolution of the moon. The orbiter will carry payloads to probe the morphological, mineralogical and chemical properties of the lunar surface and regolith material through remote sensing observations in x-ray, visible, infra-red and microwave regions. The Lander-Rover system will enable in-depth studies of a specific lunar location and probe various physical properties of the moon. The Chandrayaan-2 mission will be a collaboration between Indian Space Research Organization (ISRO) and the Federal Space Agency of Russia. ISRO will be responsible for the Launch Vehicle, the Orbiter and the Rover while the Lander will be provided by Russia. Initial work to realize the different elements of the mission is currently in progress in both countries.

Mission Elements: On board segment of Chandrayaan-2 mission consists of a lunar Orbiter and a lunar Lander-Rover. The orbiter for Chandrayaan-2 mission is similar to that of Chandrayaan-1 from structural and propulsion aspects. Based on a study of various mission management and trajectory options, such as, separation of the Lander-Rover module in geo-transfer-orbit (GTO) or in lunar transfer trajectory (LTT) or in lunar polar orbit (LPO), the option of separating this module at LTT, after required mid-course corrections, was selected as this offers an optimum mass and overall mission management advantage. The orbiter propulsion system will be used to transfer Orbiter-Lander-Rover composite from GTO to LTT. The Lander-Rover and Orbiter modules are configured with individual propulsion and house keeping systems.

The indigenously developed Geostationary Satellite Launch Vehicle GSLV(Mk-II) will be used for this mission. The most critical aspect of its feasibility was an accurate evaluation of the scope for taking a 2660 kg lift off mass into GTO. A Lander-Rover mass of 1260kg (including the propellant for soft landing) will provide sufficient margin for such a lift off within the capability of this flight proven launch vehicle.

Mission Scenario: The GSLV(Mk-II) will launch the Lunar Orbiter coupled to the lunar Lander-Rover into GTO (180km×36,000km), following which the Orbiter will boost the orbit from GTO to LTT where the two modules will be separated. Both of them will make their independent journey towards moon and reach lunar polar orbit independently. The orbiter module will be initially placed in an elliptical (5000km×200km) polar orbit following which the Lander-Rover module descends to the lunar surface.

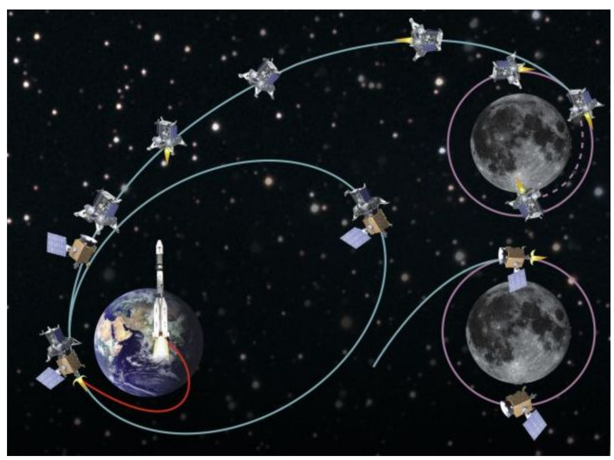

Fig. 1. The Mission Profile of Chandrayaan-2

After landing, a motorized rover with robotic arm and scientific instruments would be released on to the lunar surface. Althouh the exact landing location is yet to be finalized, a high latitude location is preferred from scientific interest. Multiple communication links involving Rover-Lander-Orbiter-Earth, direct Lander-Earth and Rover-Orbiter will be implemented. Following the initiation of operations of the Rover-Lander modules, the orbiter will be placed in a 200 km circular orbit and the instruments on board will have a close up view of the moon.

Scientific Payloads: The scientific payloads on the orbiter include a Terrain Mapping Camera (TMC-2), an Imaging Infra-red Spectrometer (IIRS), a Synthetic Aperture Radar (SAR), a Collimated Large Area Soft x-ray Spectrometer (CLASS), and a Neutral Mass Spectrometer (ChASE-2). TMC with two cameras will provide 3D imaging and DEM, while the IIRS will cover the 0.8-5 micron region at high spectral resolution using a grating spectrograph coupled to an active cooler based MCT array detector. It will provide information on lunar mineral composition, detect OH and H_2O on lunar surface and also measure thermal emission from the moon.

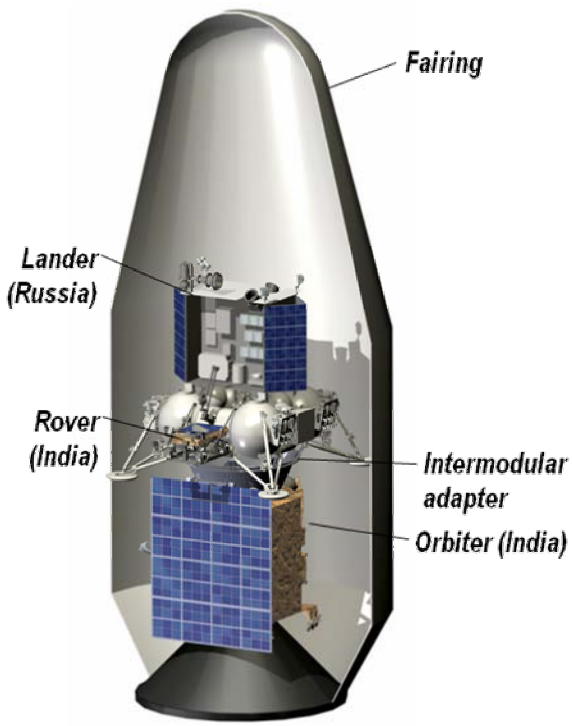

Fig. 2. The Orbiter, Lander & Rover Configuration

CLASS is an improved version of C1XS flown on Chandrayaan-1 and will employ swept charge detector (SCD) for detection of X-rays from lunar surface during solar flares. ChASE-2 is a modified version of ChASE, one of the instruments on the Moon Impact Probe (MIP) that provided hints for the presence of water molecule in the lunar exosphere. The Synthetic Aperture Radar will include both L (1.25 GHz) and S (2-2.2 GHz) bands with selectable resolution of up to a few meters. A radiating patch arrangement is designed for the integrated L-band and S-band antenna.

There will be two payloads on the Rover: an Alpha Particle induced X-ray Spectrometer (APXS) and a Laser Induced Breakdown Spectroscopy (LIBS) for studies of chemical composition and volatiles present in lunar surface material within a km of the landing site.

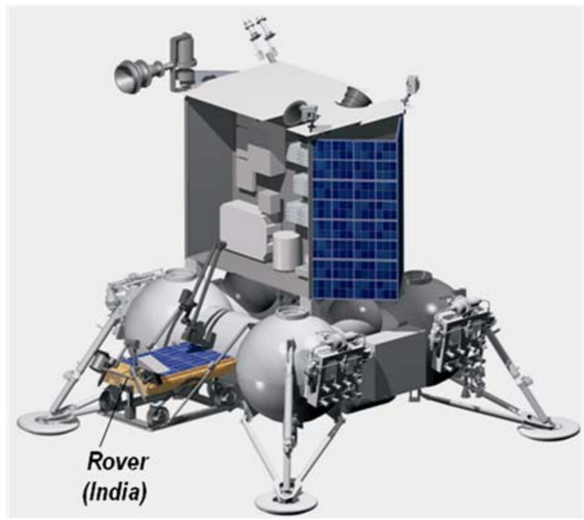

Fig. 3. The Landing Station and Rover

The Landing Station will have a suite of instruments to study both physical and chemical properties of the landing site. It will have direct communication link to Earth Stations as well as via Orbiter. The Lander will also act as the hub for communication with the Rover. The design and development of the various mission elements as well as of the scientific payloads are currently in progress in India and Russia. Preliminary Design Reviews of several mission elements are already completed.

References: [1] Goswami J. N. & Annadurai M. (2009) *Current Science 96*, 486-491. [2] Pieters C. M. et al. (2009) *Science*, 326, 568-572. [3] Pieters C. M. et al. (2009) *LPS 40*, #2052. [4] Spudis P. D. et al. (2010) *Geophys. Res. Lett. 37,* L06204. [5] Pieters et al. (2010) *JGR (submitted)*. [6] Wieser M. et al. (2010) *Geophys. Res. Lett. 37*, L05103. [7] Sridharan R. et al. (2010)) *Planet. Sp. Sci. 58,* 947-950. [8] Arya A. S. (2010) *LPS40*, #1484. [9] Vadawale V. S. et al. [2010] *Adv. Geosci*. (in Press).