# INDIA'S LUNAR PROGRAMMES

## PRESENT & FUTURE

## Chandrayaan-1 and Beyond


**2ND GLOBAL SPACE DEVELOPMENTAL SUMMIT**

**12TH NOVEMBER 2009**

Deviprasad Karnik

(Indian Space Research Organization)

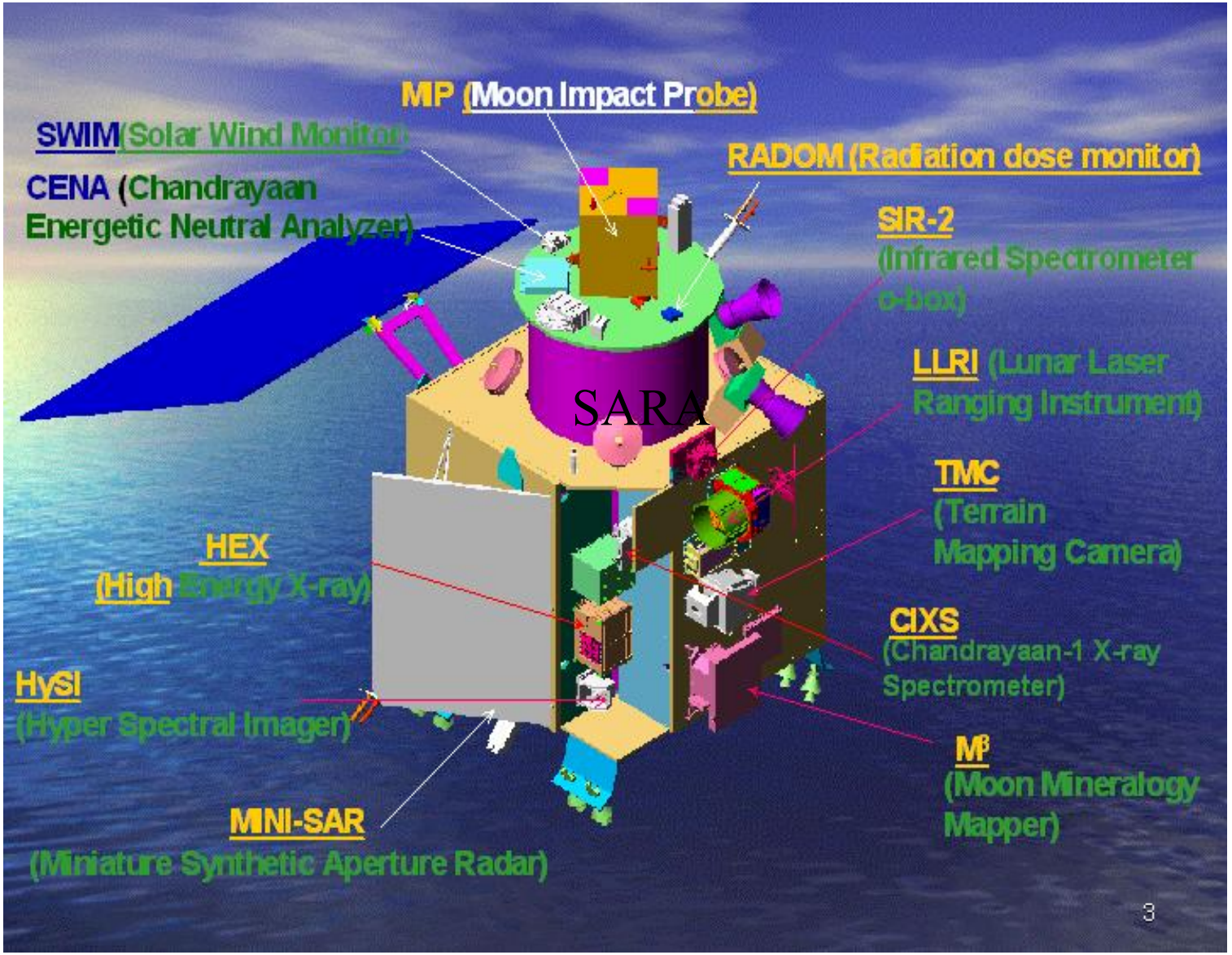
**COUNSELLOR (SPACE) EMBASSY OF INDIA**

**WASHINGTON DC**

# Chandrayaan-1:Mission Objective

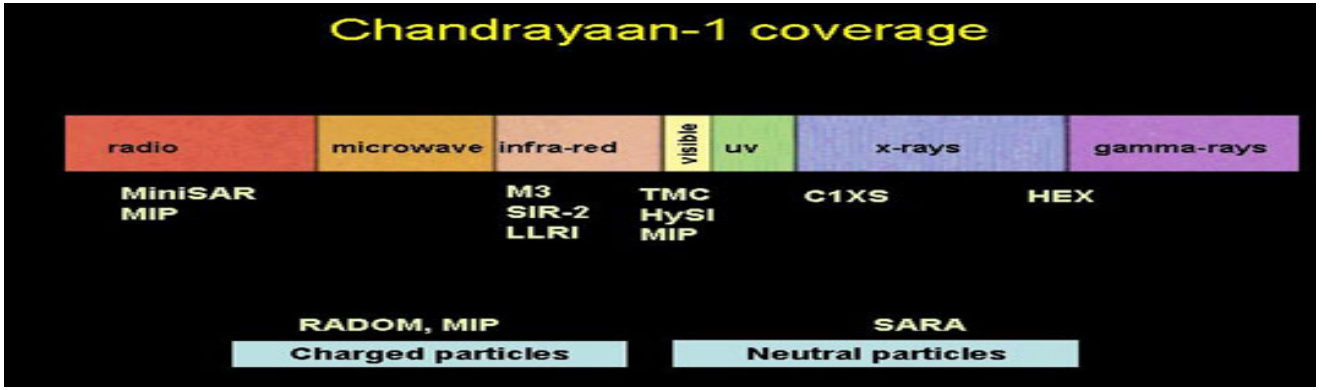
- Design, develop and launch a spacecraft in a lunar polar orbit.
- Develop expertise for planning and execution of mission and ground systems for future planetary exploration missions.
- Chemical and mineralogical mapping of lunar surface to understand the origin and evolution of the moon.
- Systematic topographic mapping of the whole surface of the moon.
- To establish capability of planetary data analysis and also data archival and dissemination.
- To enhance India's image in the international scene by being part of a select group having capability for Planetary Missions.

# Chandrayaan-1, Payloads



# Summary of Chandrayaan-1
## Wavelength range coverage

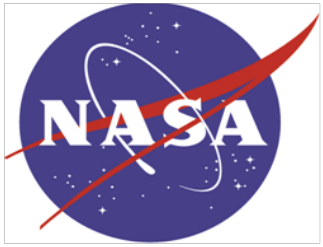
| Prime Objectives | Payload |
|---|---|
| •• Search for water-ice | MiniSAR, HEX, SARA |
| •• Chemical Mapping | C1XS, HEX |
| •• Mineralogical Mapping | HySI, SIR-2, M3 |
| •• Topography Mapping | LLRI,TMC |
| •• Radiation Environment | RADOM, HEX, C1XS |
| •• Magnetic Field Mapping | SARA |
| •• Volatile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



# Chandrayaan-1 : International Participation



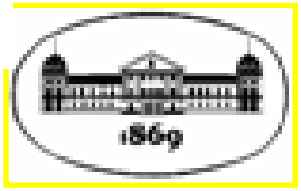


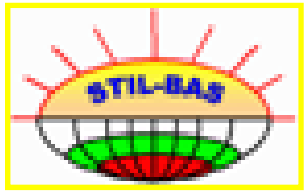











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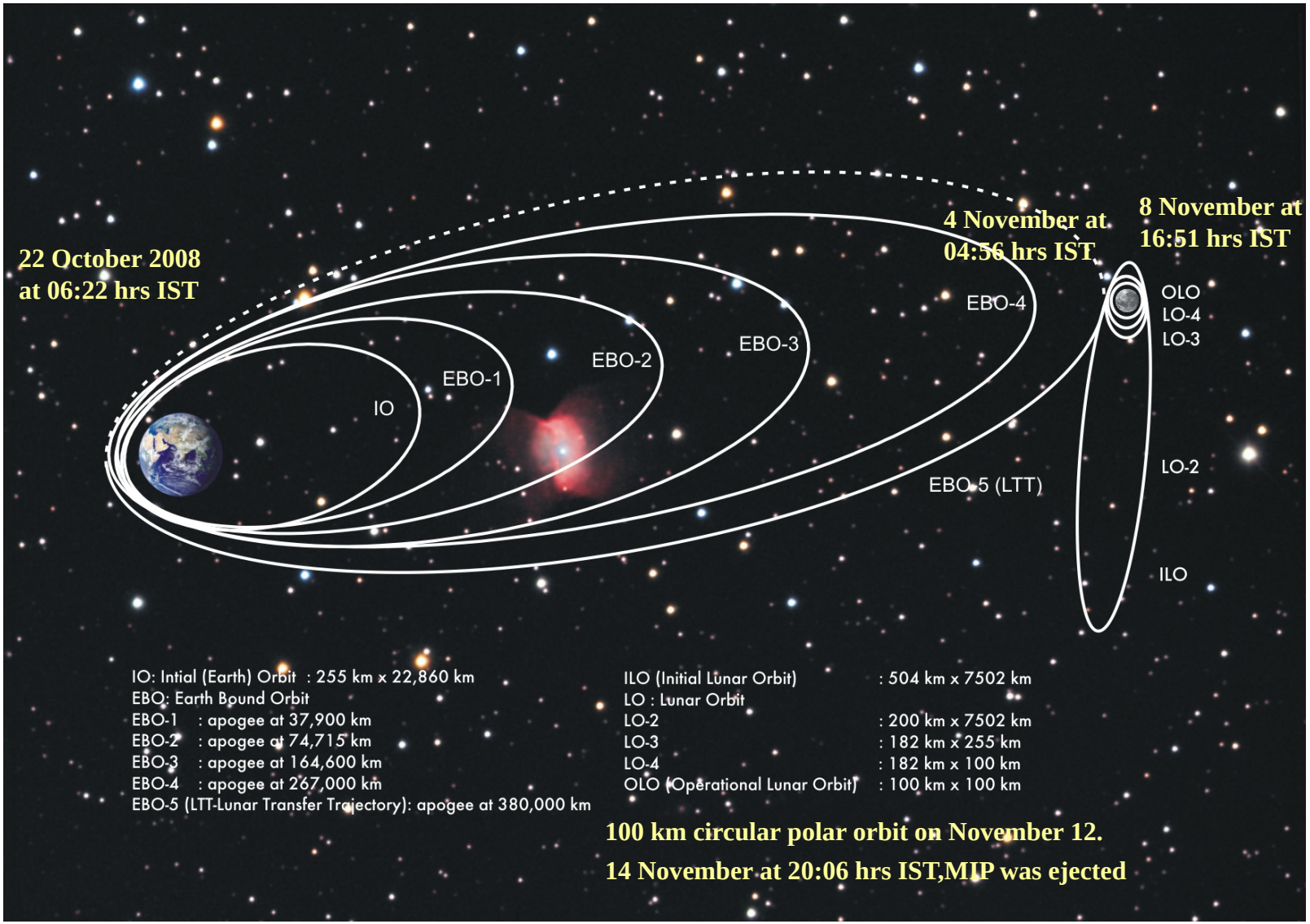
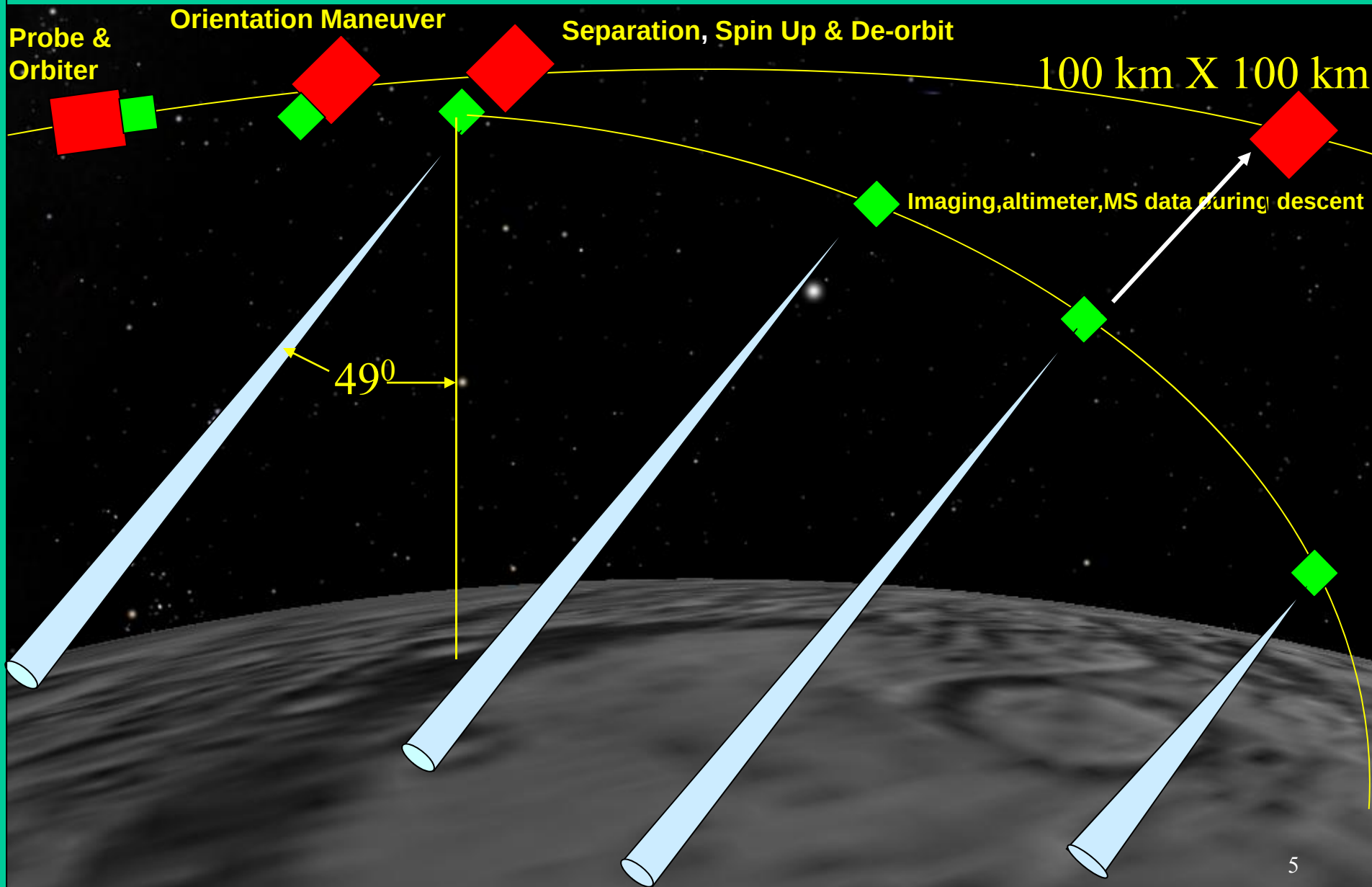
# Chandrayaan-1 Mission Sequence



# Impact Probe Mission Profile



# Polar Satellite Launch Vehicle

**Lift Off Mass: 319 tons**
**Payload Lift off capability**
**SSPO : 1750kgs**
**GTO : 1140kgs**
**EPO : 1320kgs**
**(260km X 22860km)**

PSLV has four stages, using solid and liquid propulsion systems alternately. Six strap-on motors augment the first stage thrust. PSLV-XL is the upgraded version of PSLV. In PSLV-XL, the six strap-on motors carry 4 tonne more propellant compared to PSLV; There is also an increase in the length of each strap-on.

# Challenges in Interfacing Science Instruments

- Technical , Managerial and logistic :
  - Trade off Studies, Alternatives, Schedule management
- Geographic Locations of Instrument teams: Time Difference
- Work culture: NASA, ESA, JAXA,BSA and Scientists
- Varying I/F requirements
  - Engineering units
  - Drawing Conventions and Formats
  - Mechanical : Mass , Volume , FOV , Access and Thermal
  - Electrical : TM,TC ,Power and data
    - Varying Standards : RS232/ RS-422/CAN-Bus /1553/ Customised Interface
  - Data rate and volume
  - Handling Constraints
  - Cleanliness requirements
  - Safety issues
- Transportation
- Post launch Data processing and Deriving science

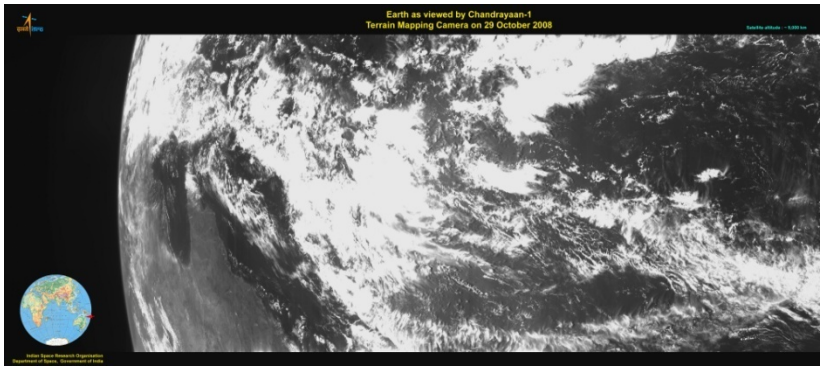
# A of O Enabled Co-operations

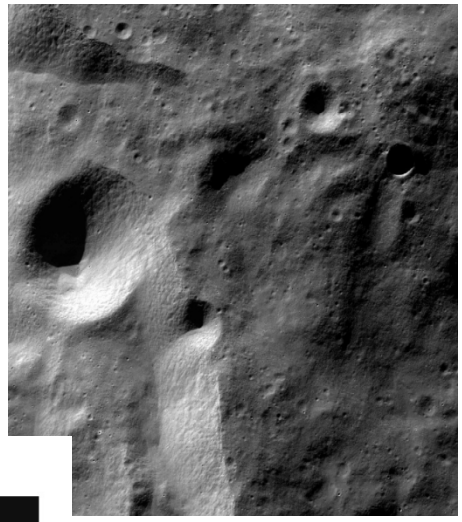
- PDS training for Chandrayaan-1 science and data processing team by ESA team
- SMART-1 tracking and orbit determination comparison exercise between ESOC and ISRO
- SPICE training for Chandrayaan-1 Mission and Science teams by JPL/NASA team
- APL 18m and NASA DSN support agreement
- NAV support discussions with NASA and ESA teams
- Thermal and calibration Support for CIXS hardware
- Calibration and Thermal support for SIR-2 and RADOM
- MLI support for SARA and RADOM

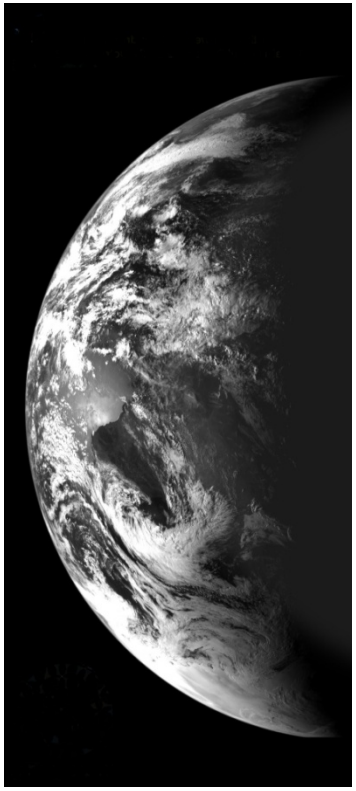

SWL: 10.000 KG.


PSLV CH
INDIA

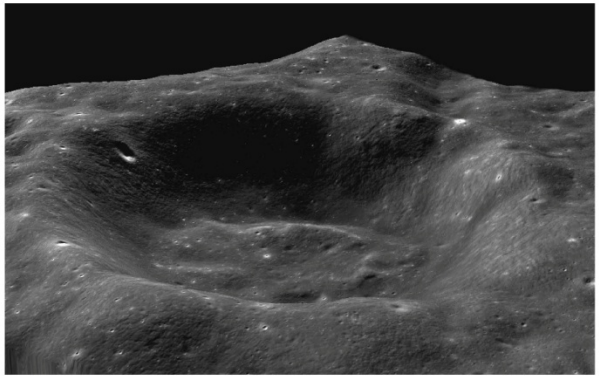

INDIA

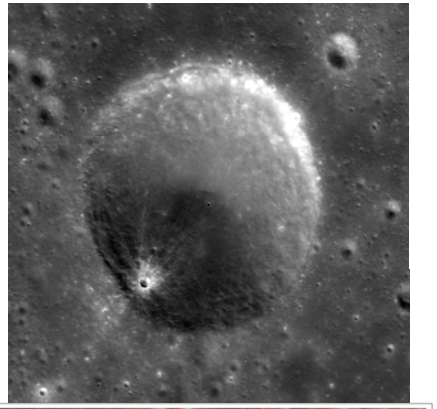


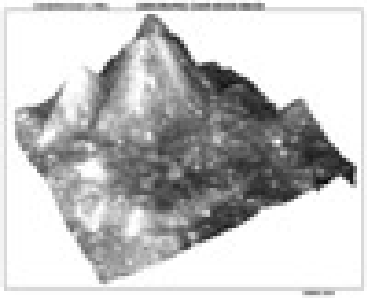





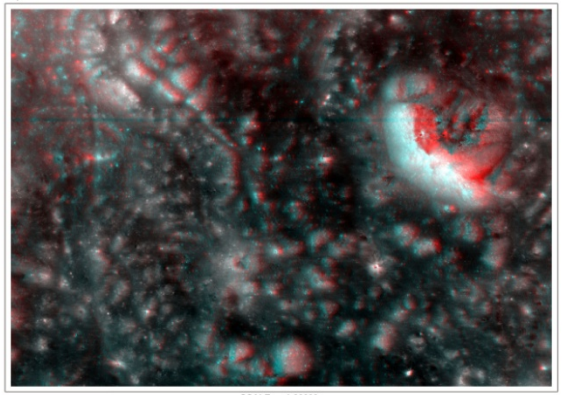

2.5D Visualisation (Coulomb C Crater)







MOON ANAGLYPH



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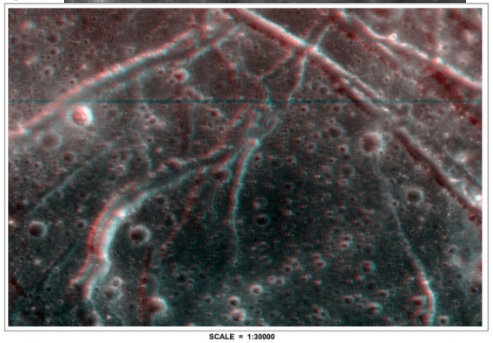

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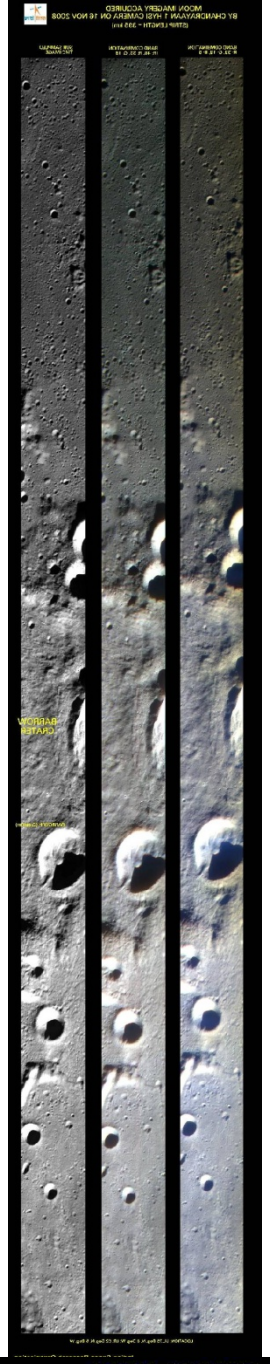
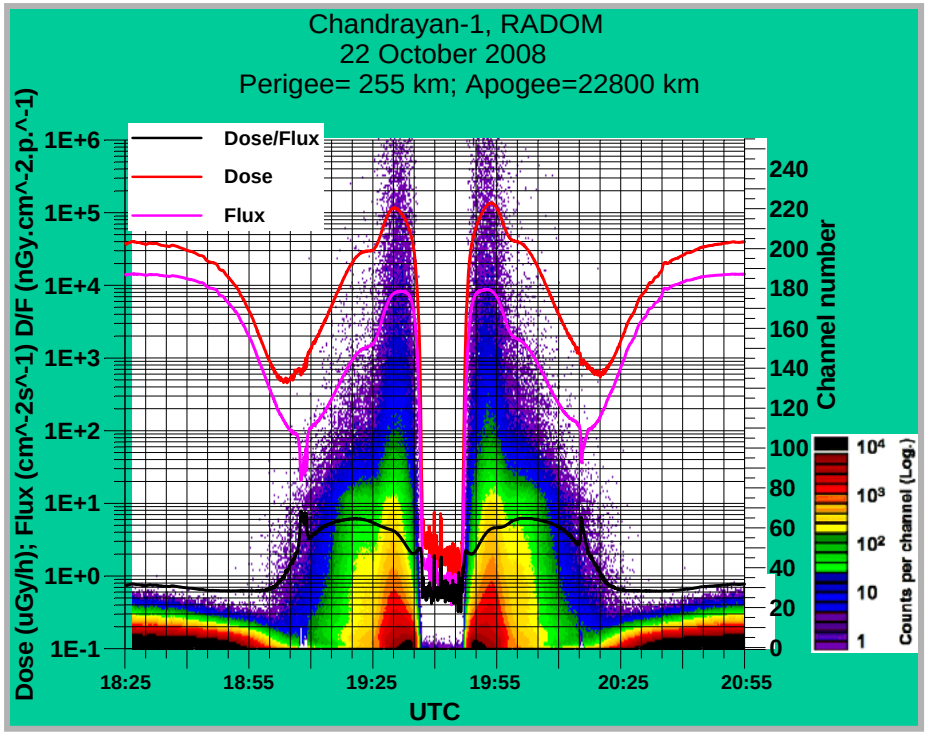
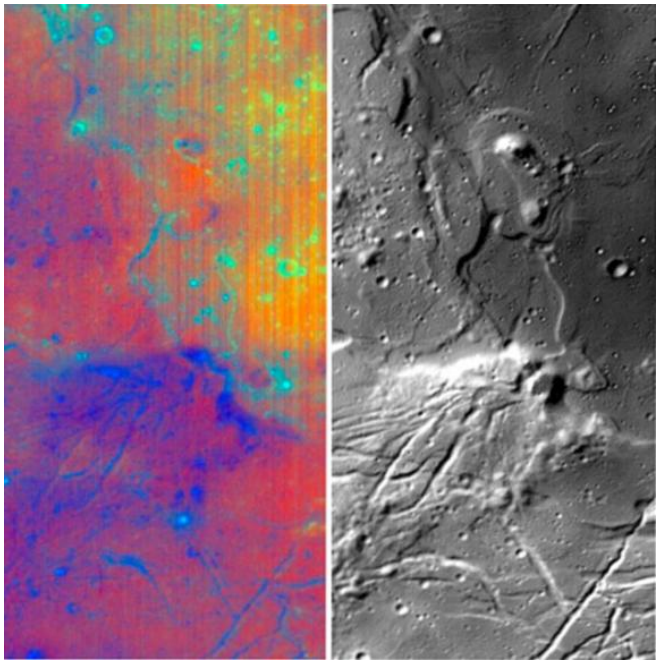
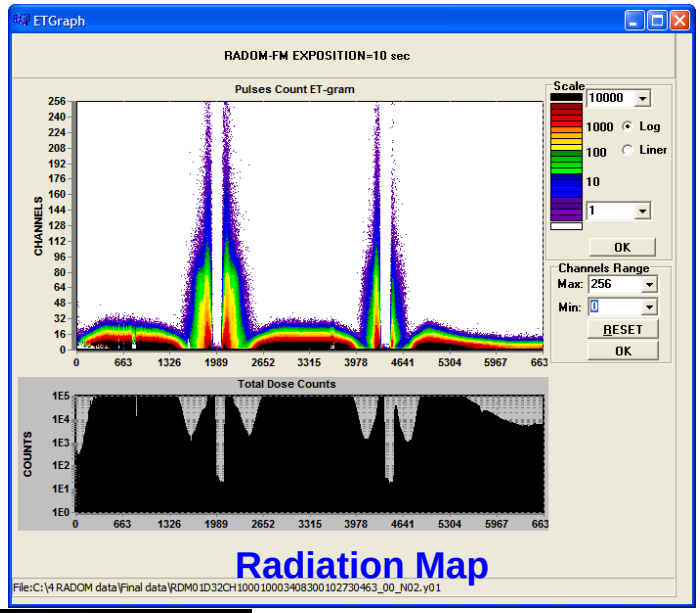
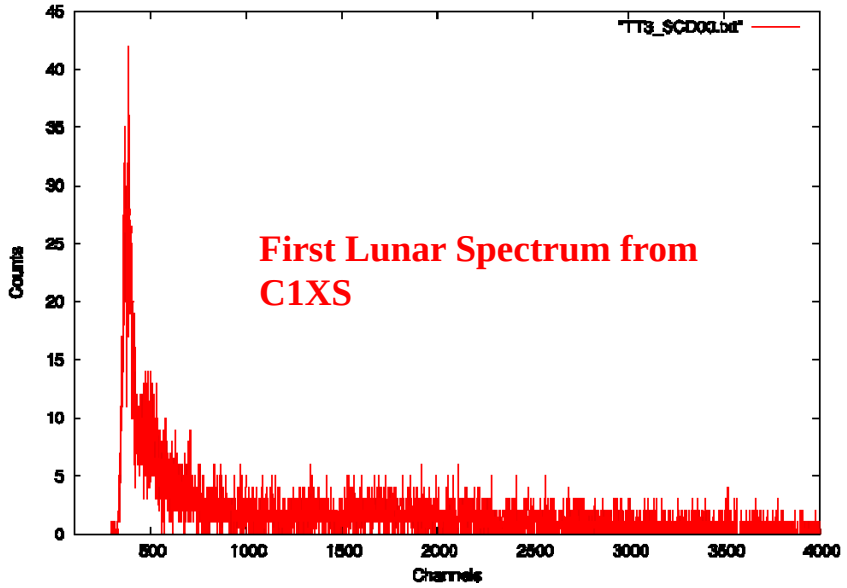


M3 composite image of the *Orientale* region.



# Chandrayaan-2

## Objectives

**Maximal use of Chandrayaan-1 derived data to explore the moon in a more detailed way.**

**Extend the technologies inherited from Chandrayaan-1**

**Develop and demonstrate the newer technologies that will be of use for the future planetary missions.**

# Chandrayaan-2

- **To design, realize and deploy a lunar Lander-rover capable of soft landing on a specified lunar site to enable in situ detection of chemicals, maximally using the data gathered during Chandrayaan-1 mission.**

- **Carry payloads in the orbiter that will enhance the scientific objective of Chandrayaan-1 and further our understanding of the Moon.**

# Mass Budget

| No | Element | Mass (kg) |
|---|---|---|
| 1 | Orbiter+ Lander-rover/rover | 2457 |
| 2 | Inter module adopter | 40 |
| 3 | Orbiter with Propellant at liftoff | 1317 |
| 4 | - Orbiter dry mass | 487 (50kgs payload) |
| 5 | - Propellant for orbiter | 830 |
| 6 | Lander-rover+ rover module in LTT with Propellant | 1100 |
| 7 | Lander-rover+ rover module on lunar surface | 420 |

# Payload Location and Purpose

| | | |
|---|---|---|
| **Payload** | Orbiter | Solarwind-magneto-tail interaction |
| **Payload** | Orbiter | Detection of low energy charge particle in lunar environment |
| **Payload** | Orbiter | Terrain and mineral mapping |
| **Payload** | Orbiter | Chemical mapping |
| **Payload** | Orbiter | Mapping of Radon and other alpha emitter; volatile transport |
| **Payload** | Orbiter | Thermal mapping |
| **Payload** | Lander-rover | Seismic study |
| **Payload** | Lander-rover | Lunar atmospheric abundance study |
| **Payload** | Orbiter | Sub surface analysis |

| Payload | Location | Purpose |
|---|---|---|
| Regolith Evolved Gas Analyser (REGA)+ Mass Spectrometer | Lander-rover | Incineration and composition |
| Sample Analysis and Transfer Mechanisms. | Lander-rover | Drilling for sample acquisition |
| Tunable Diode Laser | Lander-rover | $H_2O$ detection in polar shadowed region |
| Laser Induced ion Mass Spectrometer | Lander-rover | same as above |

# CHANDRAYAAN-2

## (Lunar Orbiter, Lander, Rover, Robotics)

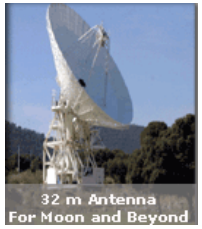
GSLV

### Mission Objective

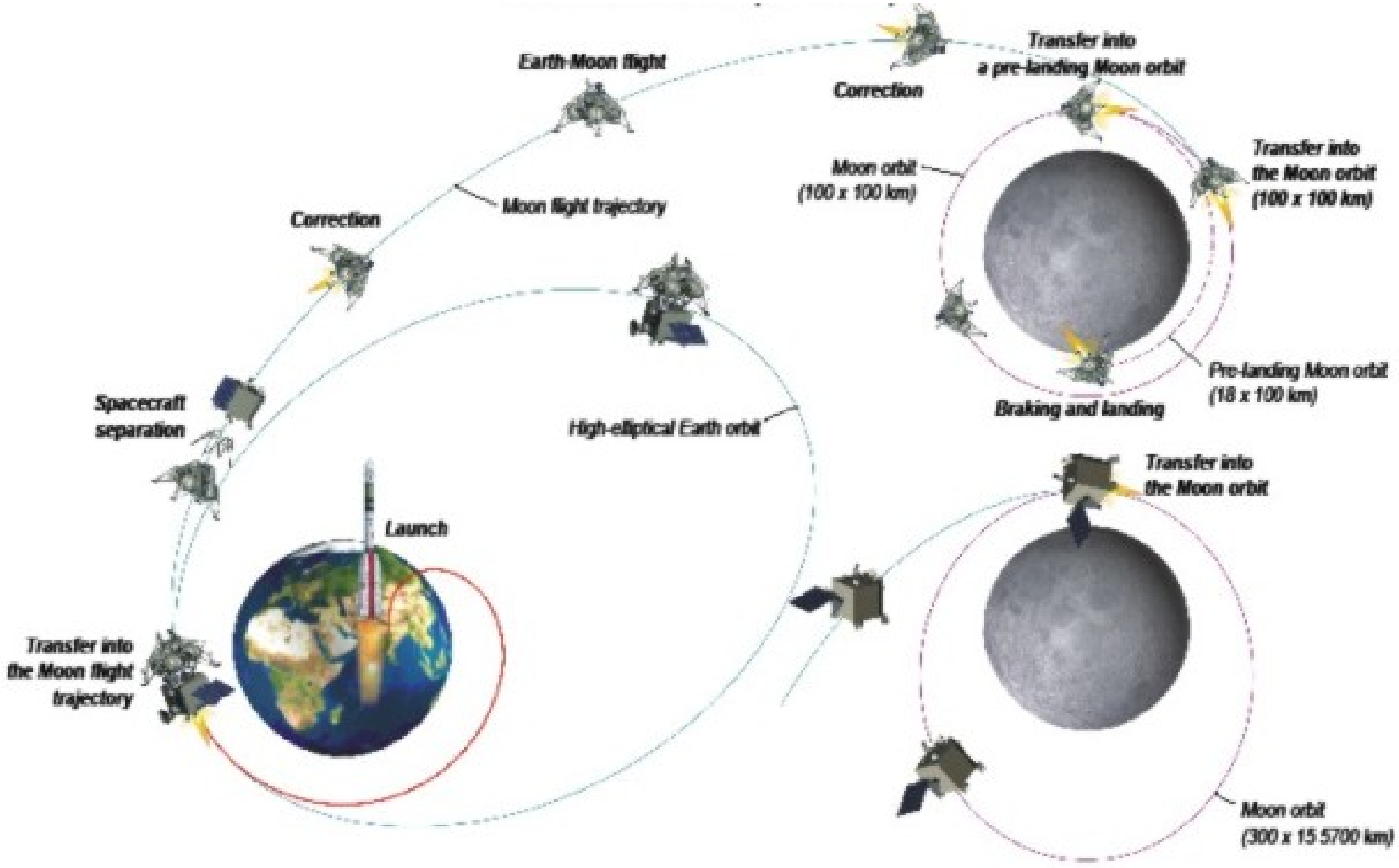
- To design, realize and deploy a lunar Lander-rover capable of soft landing on a specified lunar site for in-situ studies.
- Carry payloads in the orbiter that will enhance and add to the scientific objectives of Chandrayaan-1.
- Develop & demonstrate newer technologies, including those that will be useful for future planetary missions (e.g. Sample return).

### *Technological Challenges:*

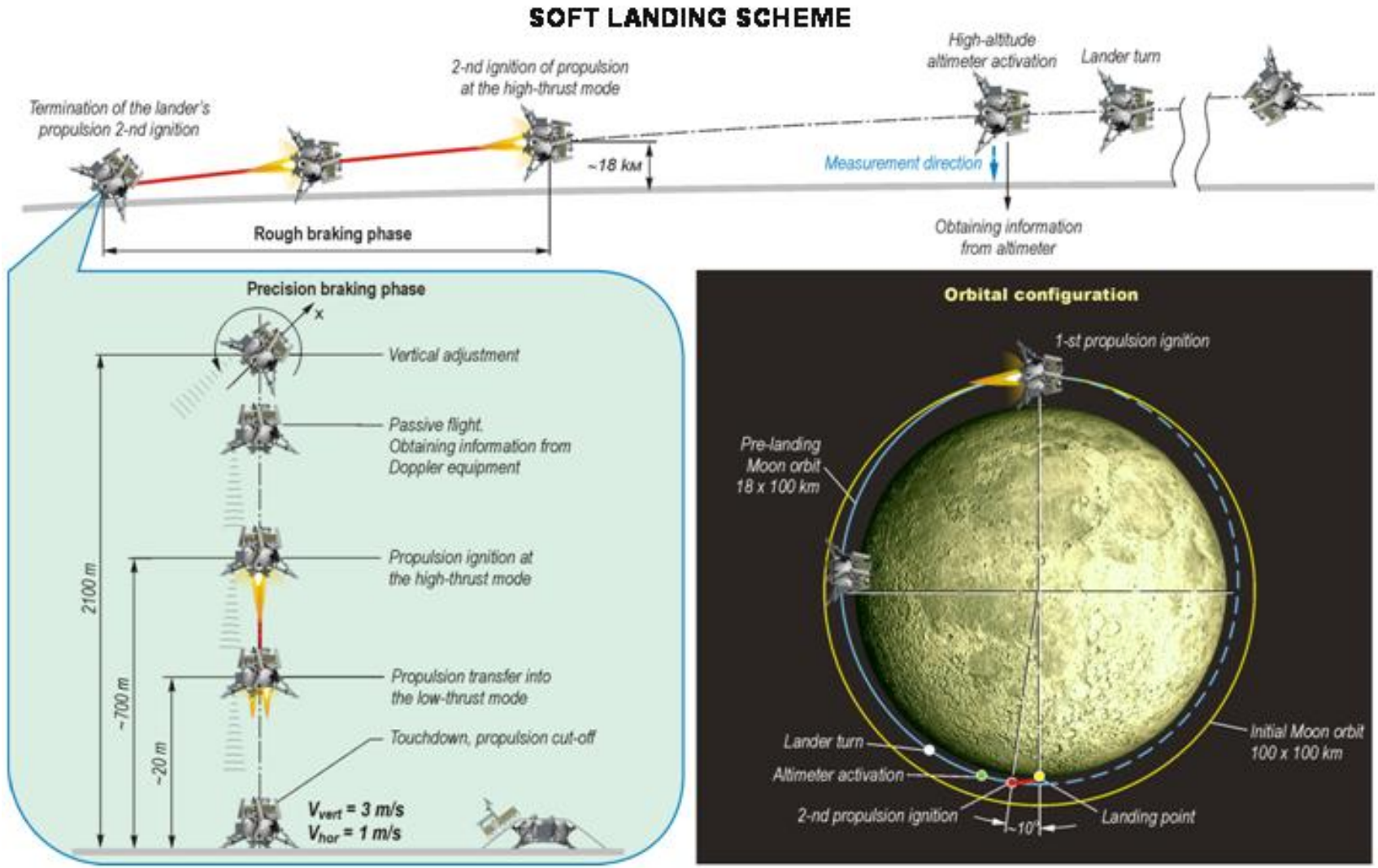
*Orbit management, Intelligent auto-navigation; Realization of Lander, Robotics and Rover; Energy Resources, Communication, sampling and in-situ analysis, Environment (thermal, vacuum …) compatibility*



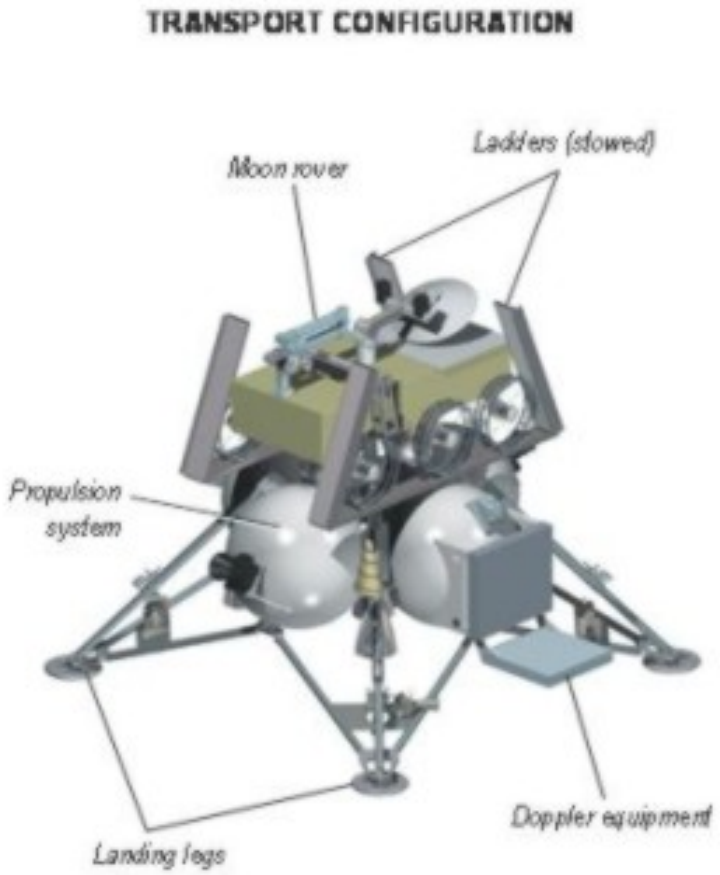
# Mission Profile

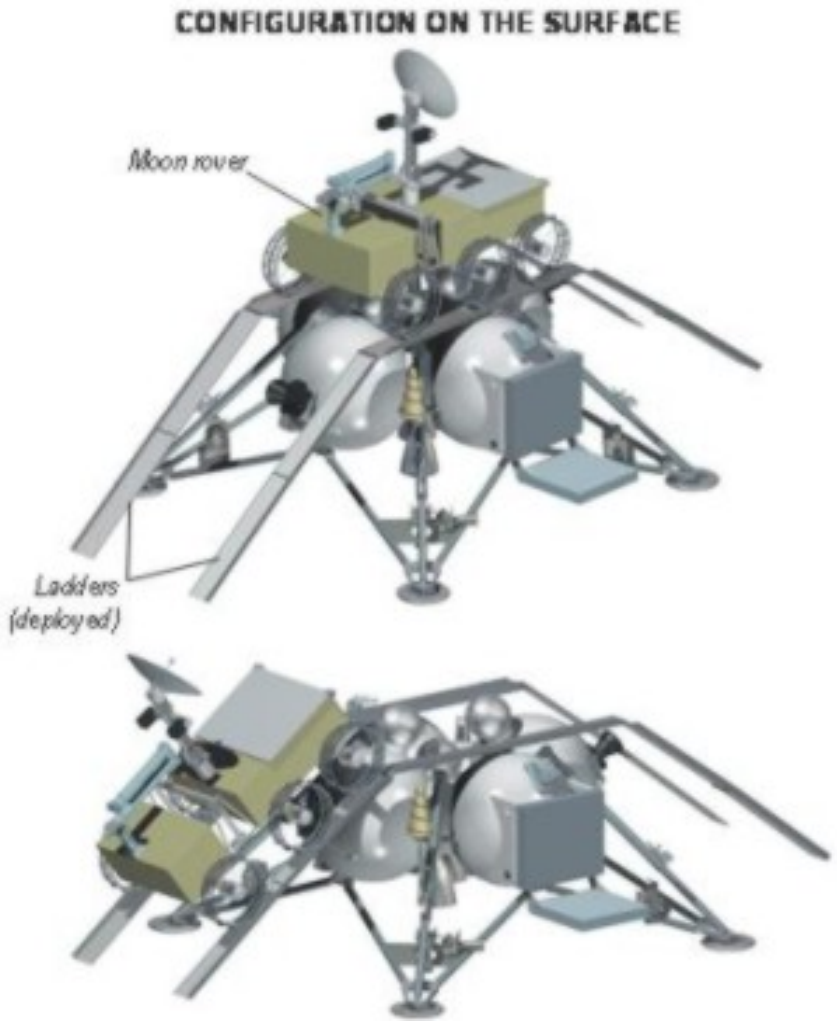


# Lander-rover Configuration

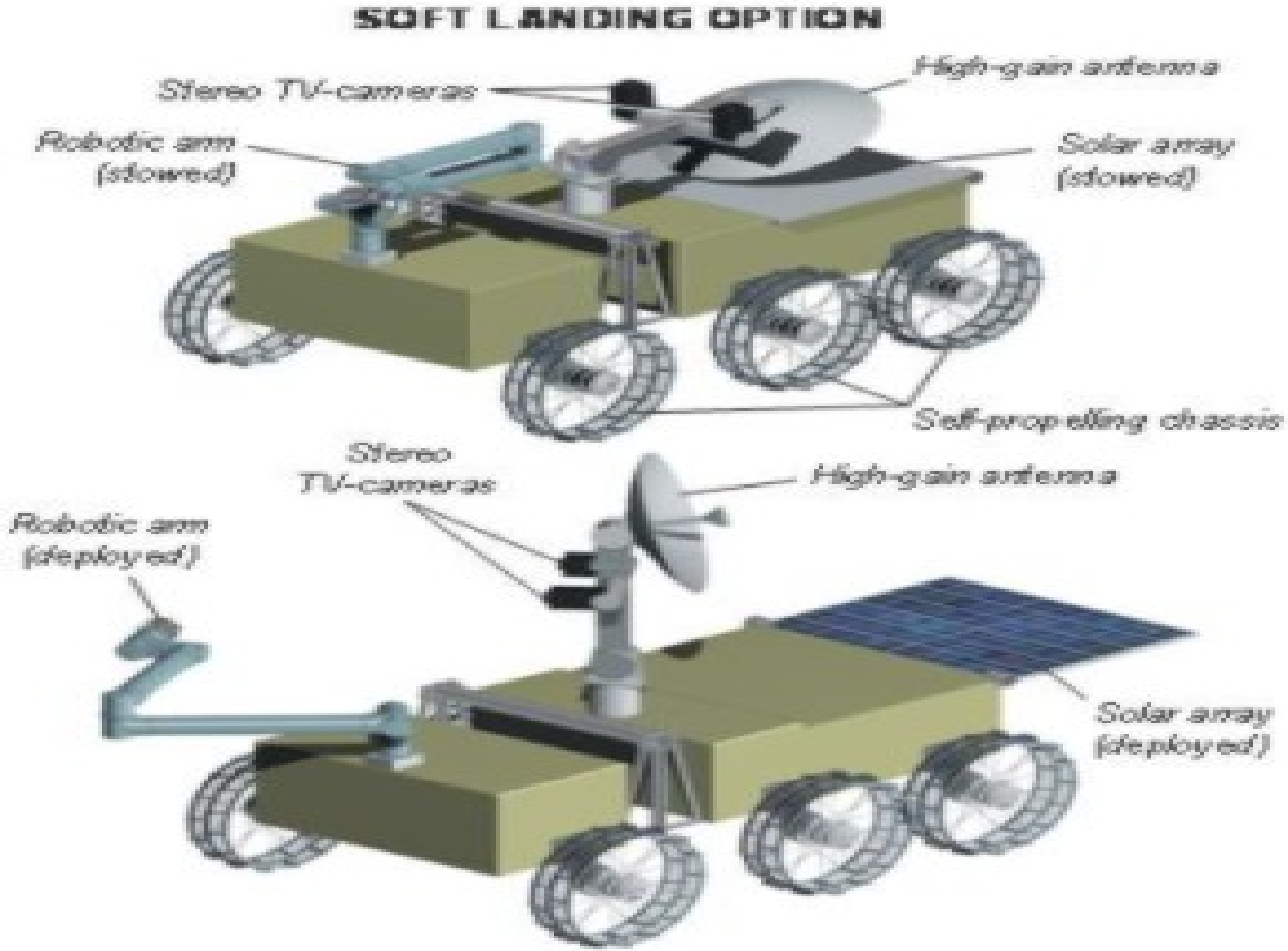


# Lander-rover Configuration



# Rover configuration



# International Participation

- A provision of about 20 Kg (10kg in the orbiter and 10kg in the rover) is proposed to be provided for Announcement of Opportunity (AO) payloads from Russia or other international space agencies/ laboratories/universities.

- Several space agencies like European Space Agency (ESA), Canadian Space Agency (CSA), German Space Agency (DLR) and NASA have expressed their interest to participate in Chandrayaan-2 mission. Depending upon the scientific value besides their utility in complementing / supplementing Chandrayaan-2 mission objective, their involvement will be considered.

# Summary

- Chandrayaan-1 had a purpose.
  - Science, Technical and managerial
- Demonstrates International co-operation with India playing leading role
  - Meeting targeted science, technical, Budget and schedule challenges
- Provides Logical extension for Chandrayaan-2 – Lunar Lander with Rover and Future Planetary Missions
  - Chandrayaan-2 has been already approved by Govt. of India with the budget allocation of 4.26billion Indian rupees ($ 100m)
- Provides an opportunity for India to work in future planetary missions while working with International partners.


THANK YOU