

LUNAR EXPLORATION EFFORTS
By ISRO
Chandrayaan-1 and Beyond



LEAG-ILEWG-SRR
28TH OCTOBER 2008

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Deviprasad Karnik

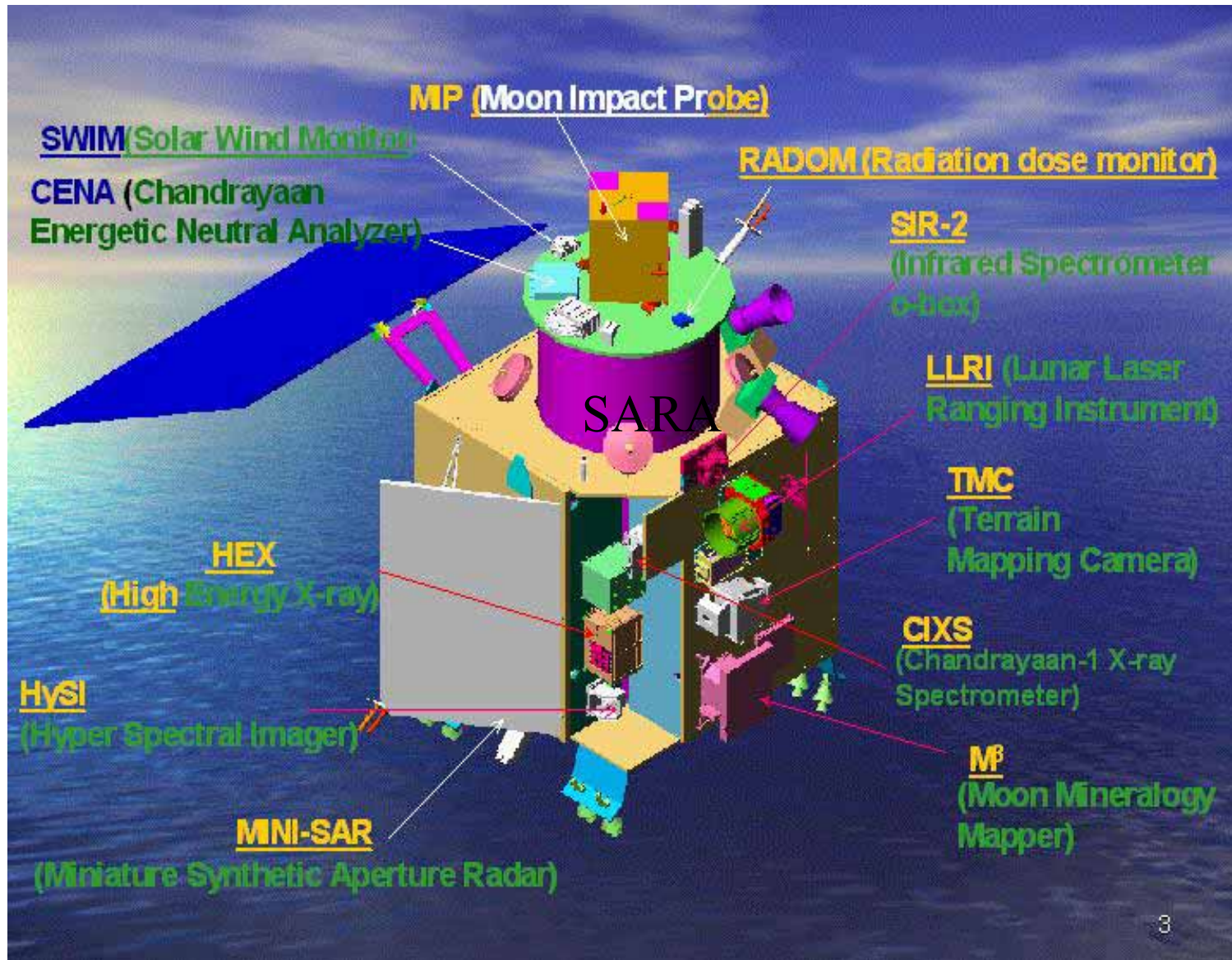
Indian Space Research Organisation



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.

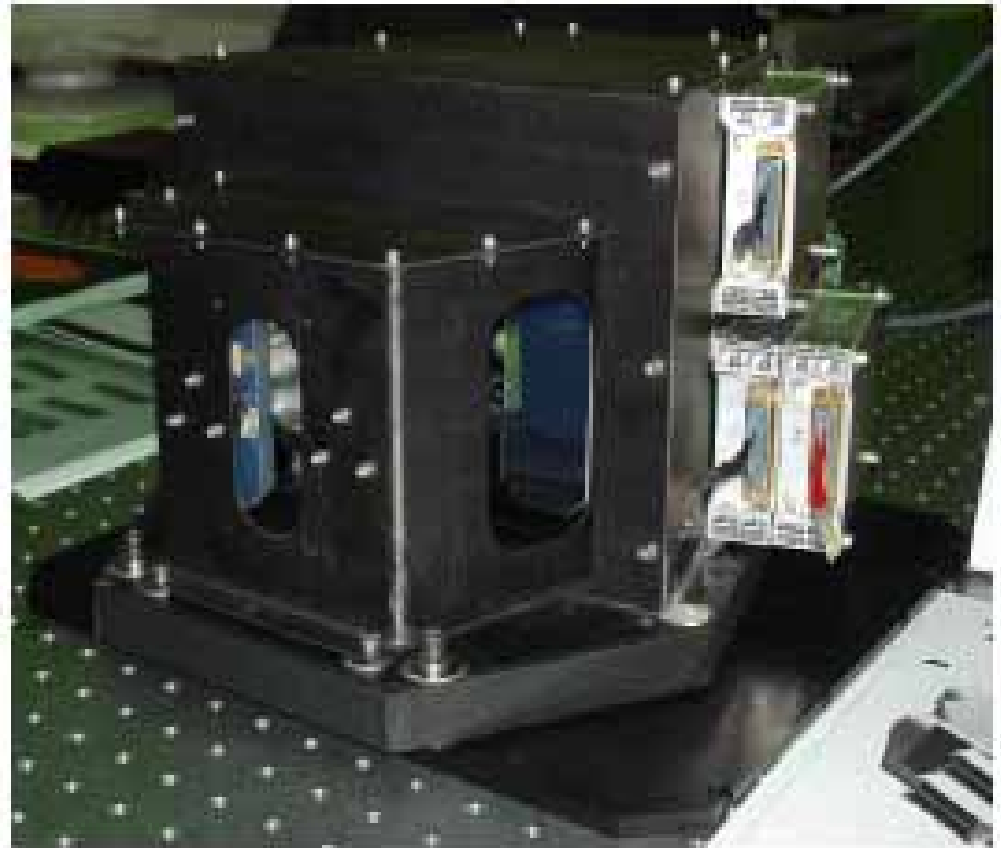
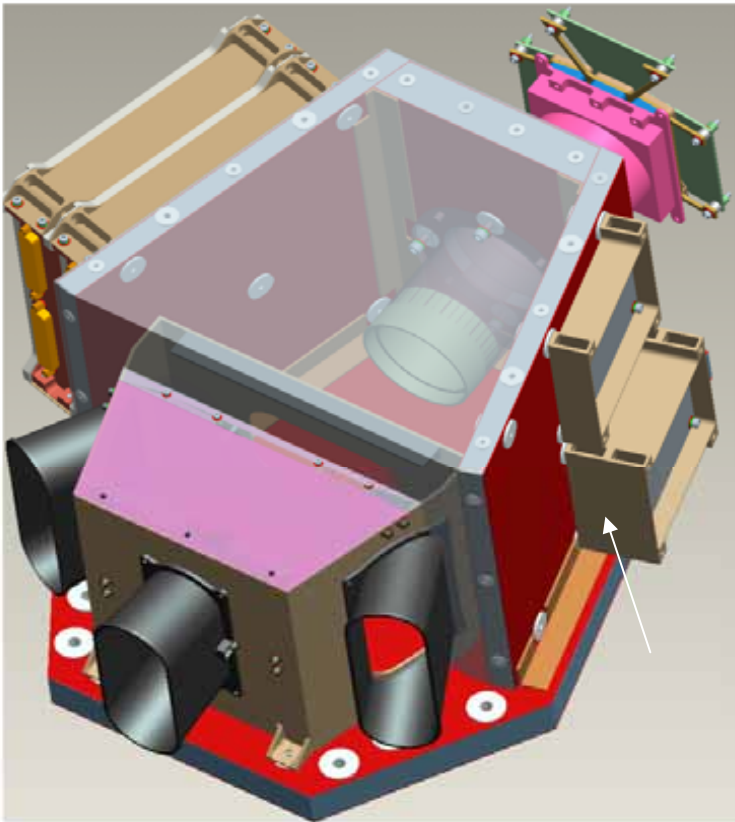
Chandrayaan-1, Payloads



Terrain Mapping Camera (TMC)- From ISRO

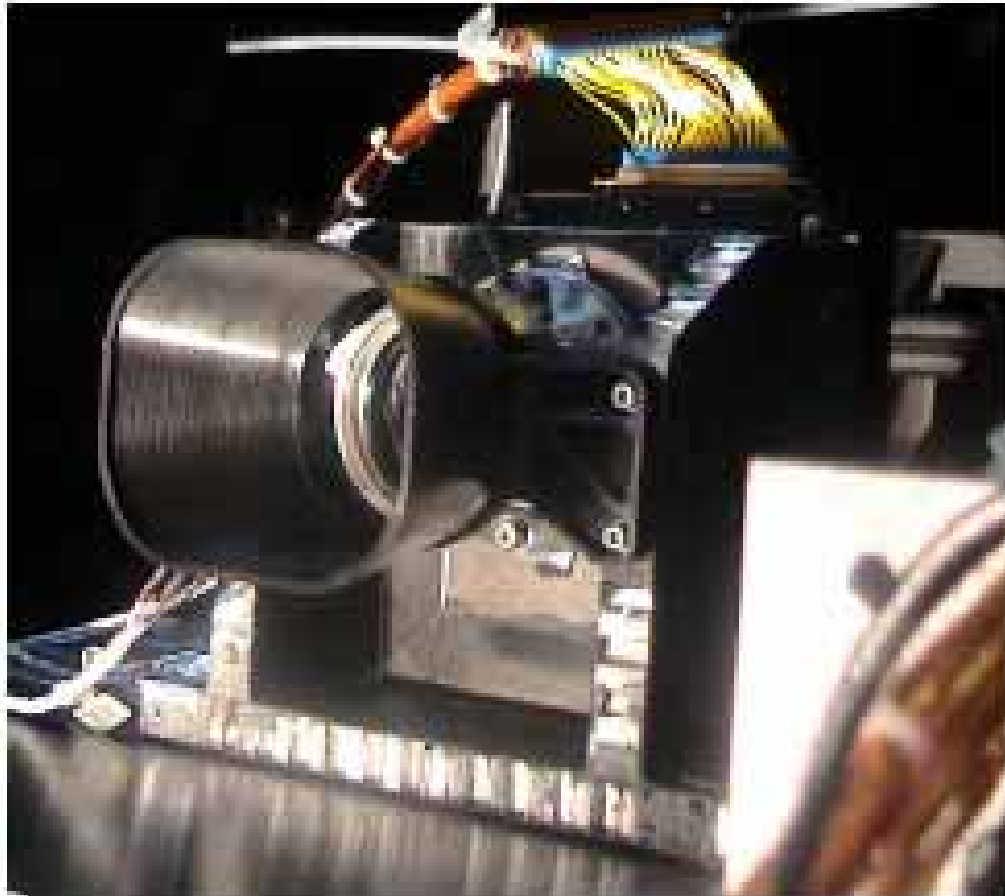
➤ (produce a high-resolution map of the Moon.)

SMG/ SEDA



- To prepare a 3-dimensional atlas with high spatial and altitude resolution
- Swath 20km and Resolution 5m Spectral Range 0.5 to 0.6 μm range

Hyper Spectral Imager (HySI) – From SAC/ISRO



- perform mineralogical mapping
- Spectral range 0.4 to 0.95 μm range ; 64 Bands
- 80m resolution
- 40km Swath

Lunar Laser Ranging Instrument (LLRI) from LEOS/ISRO

Determine Global Topographic Field of Moon (Surface topography)

- Supplement TMC and HySI
- Improved model of lunar gravity field

ATTITUDE & POSITION

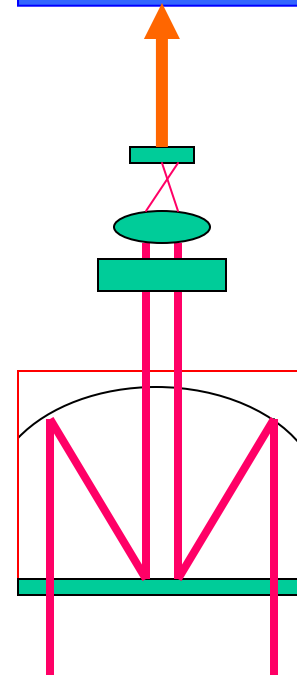
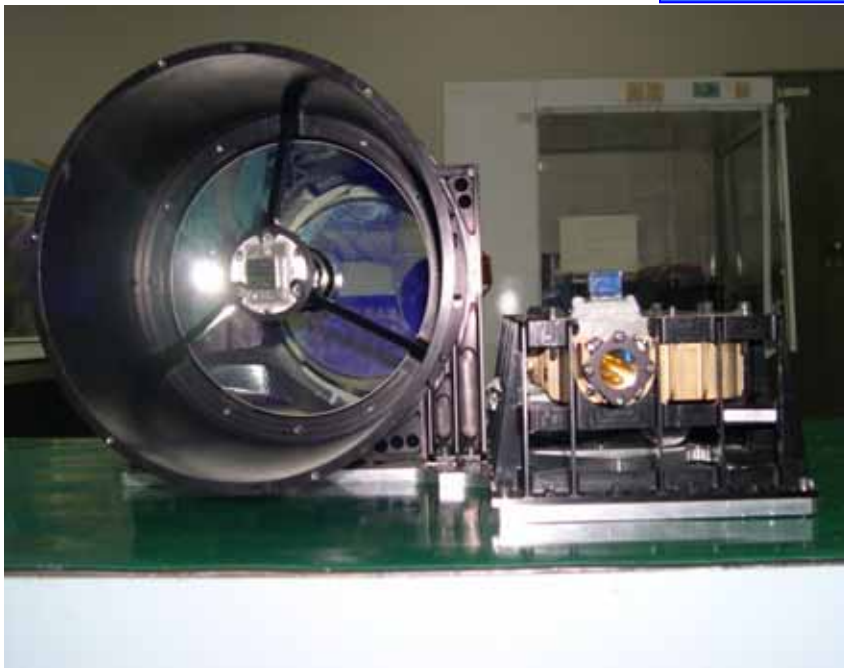
RANGE RECEIVER & DATA ACQUISITION

POWER SUPPLY & THERMAL INTERFACE

Nd YAG LASER

BEAM EXPANDER

LASER BEAM
10Hz 10mJ



High Energy X- γ Ray Spectrometer (HEX) PAYLOAD – ISAC/ISRO

- Volatile Transport on Moon through detection of 46.5 keV line from Pb-210
 - Th and U map of Polar and U-Th-rich regions



Basic Features

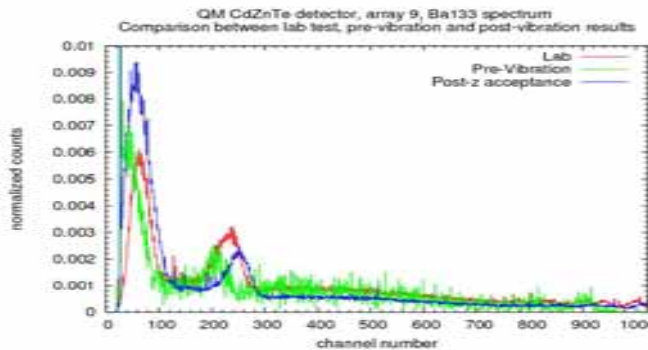
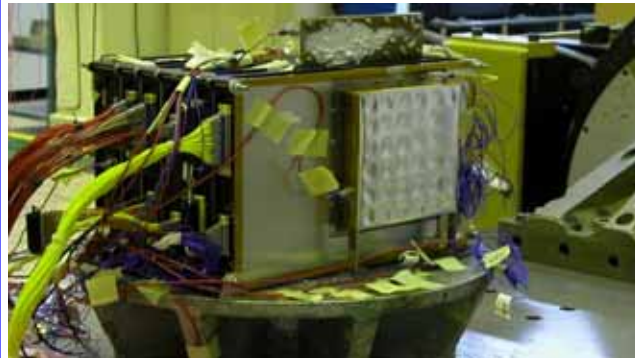
Detector: Cd-Zn-Te Array

Energy Range: 20-250 keV

Energy Resolution:
 $\leq 6\%$ @60keV

FOV: 40km x 40km

Active Anticoincidence
Shielding: CsI(Tl)+PMT



X-ray fluorescence spectrometer (C1XS)

(collaboration between Rutherford Appleton laboratory, U.K, ESA and ISRO)

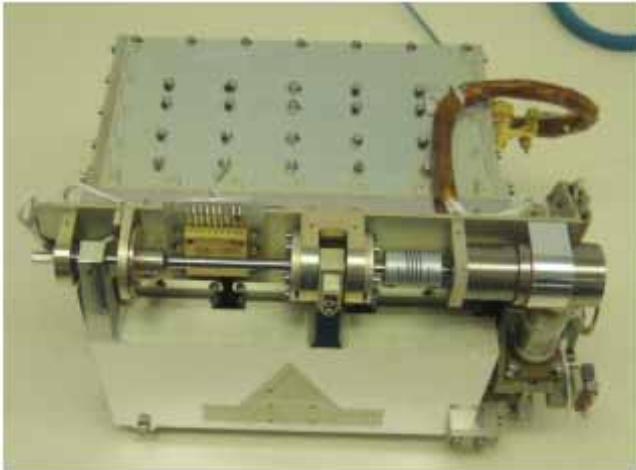
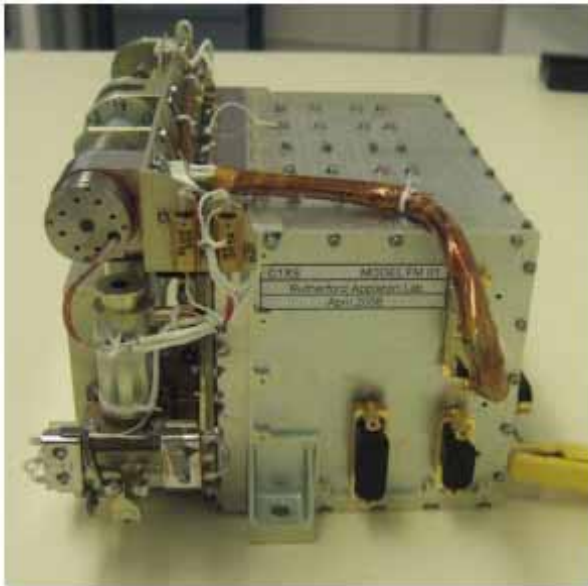


Figure 5: Plan view of C1XS instrument



Objective : Chemical mapping
map the abundance of **Mg**, **Al**, **Si**, **Ca**, **Ti**,
& **Fe** at the surface,
and will monitor the **solar flux**

Energy range :1 – 10keV

Used in conjunction with
Solar X-ray monitor

Moon Impact probe (MIP)

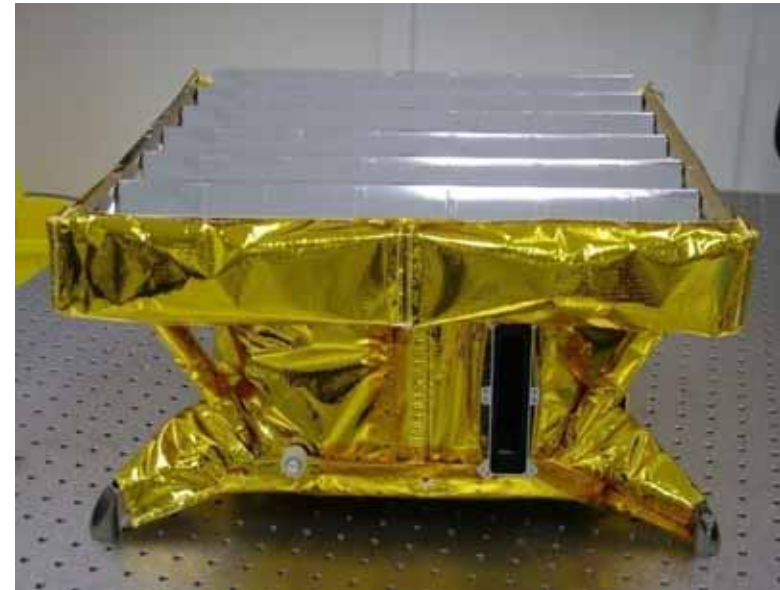
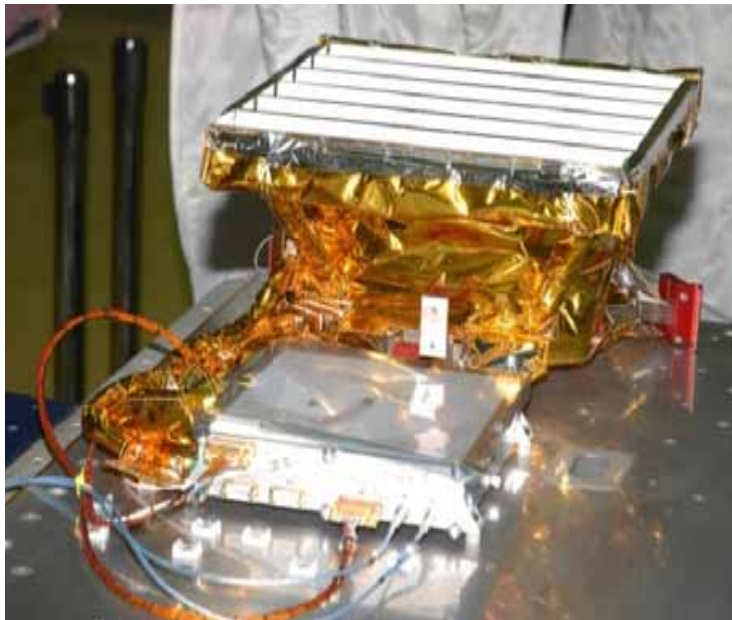
developed by ISRO

will be ejected once it reaches 100 km orbit around moon, to impact on the moon. **MIP** carries three more instruments namely, a high resolution mass spectrometer, an S-Band altimeter and a video camera.



Moon Mineralogy Mapper – M3 (From JPL/NASA)

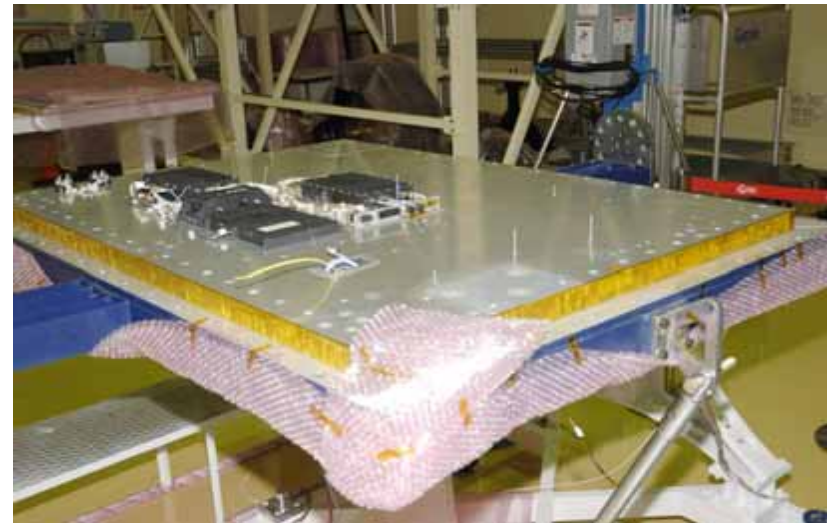
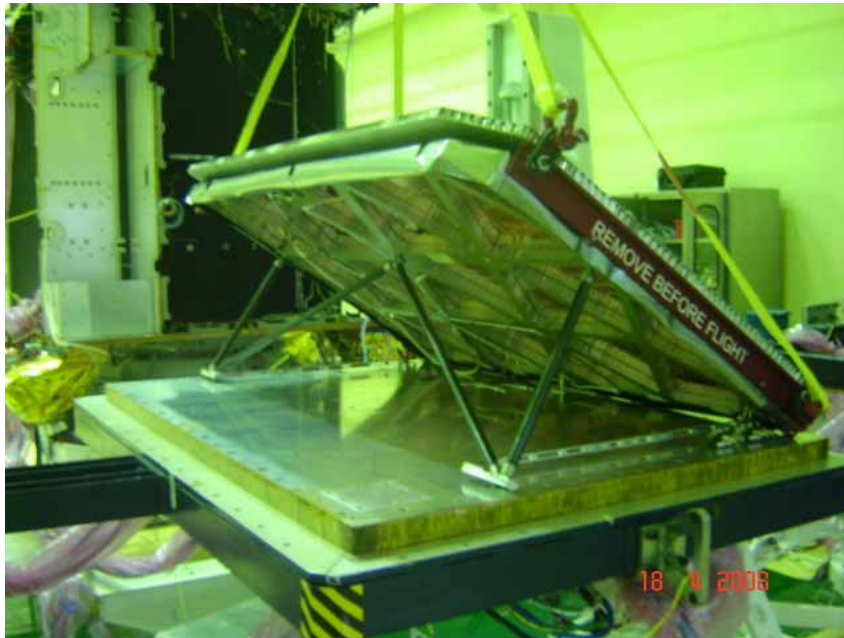
- imaging spectrometer operating in 0.4 to 3.0 μm range
- 256 bands of 10nm resolutions
- Objective :surface mineral composition.



MiniSAR

(From APL/NASA)

- To detect Lunar polar water Ice
- S-Band synthetic Aperture Radar
- 75m resolution in SAR mode
- 500m resolution in Scatterometer mode





CENA - Chandrayaan Energetic Neutral Analyzer **Jointly From Sweden, Norway, Japan and India)**

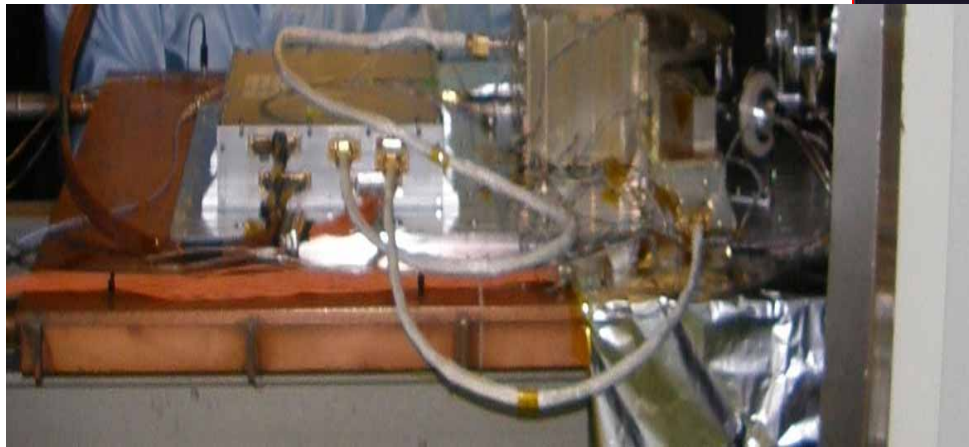
**To image the Moon surface using
low energy neutral atoms in the
range 10eV-2keV**

- **To study Moon's surface composition**
- **To map lunar magnetic anomalies and**
- **To study Space Weathering**

SWIM-Solar Wind Monitor

(From Sweden /Japan/Norway/INDIA)

To image Solar wind – Lunar Surface Interaction

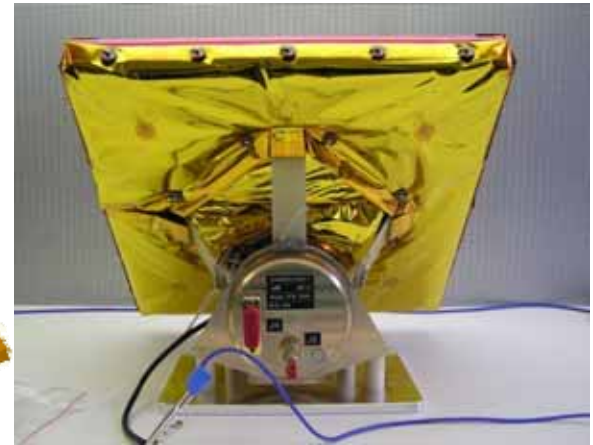
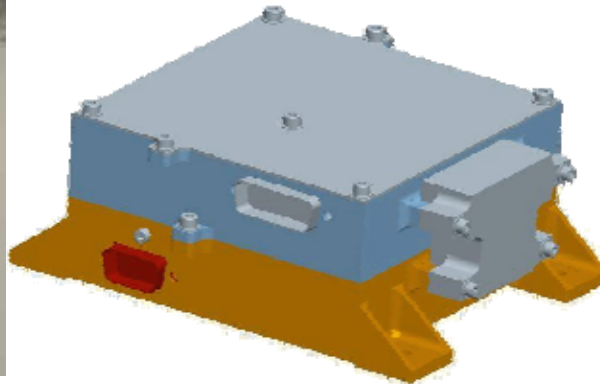
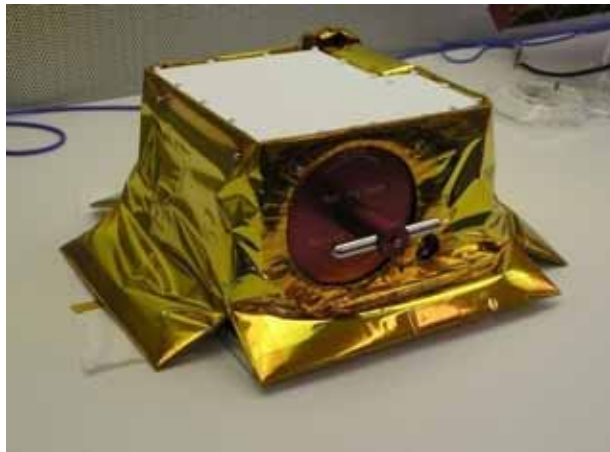




near infrared spectrometer (SIR-2)

from ESA Max Planck Institute for Solar System Research, Polish Academy of Science and University of Bergen

Objective: Mineral Mapping
Spectral range 0.9 to 2.7 μm



❖ map the mineral composition using an infrared grating spectrometer.

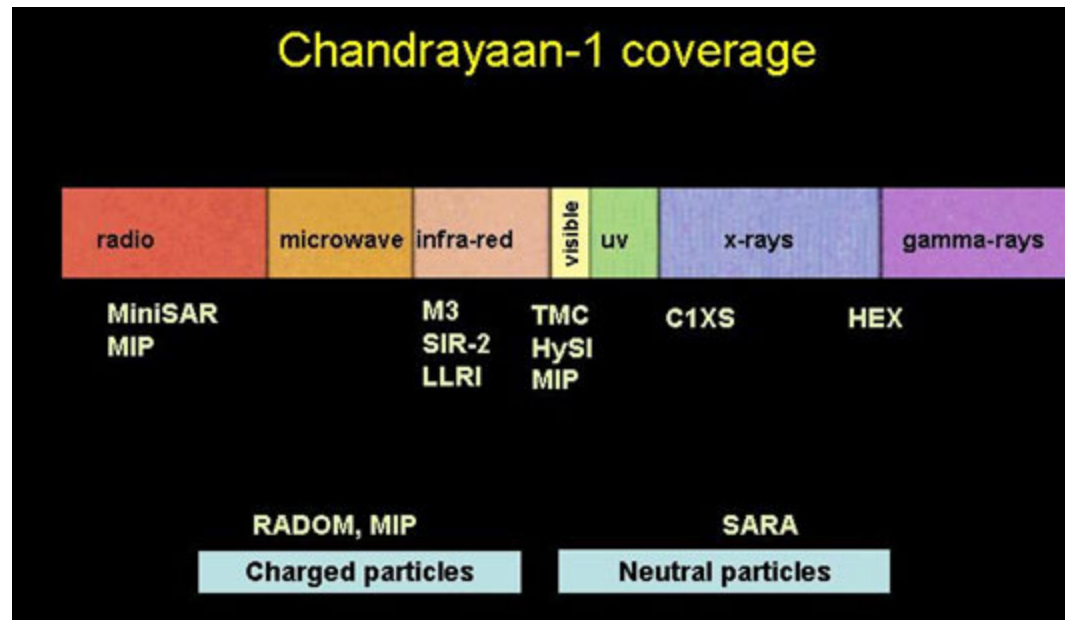
RADOM-Radiation Dose Monitor (From Bulgaria)



To measure Radiation Environment both in Lunar Orbit and Enroute to the moon

Attractive mass and power:
180gm and 200mW

Summary of Chandrayaan-1 Wavelength range coverage



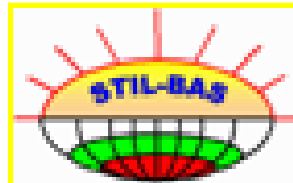
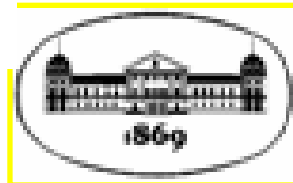
Chandrayaan-1 : International Participation



BROWN

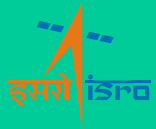


Science & Technology Facilities Council
Rutherford Appleton Laboratory

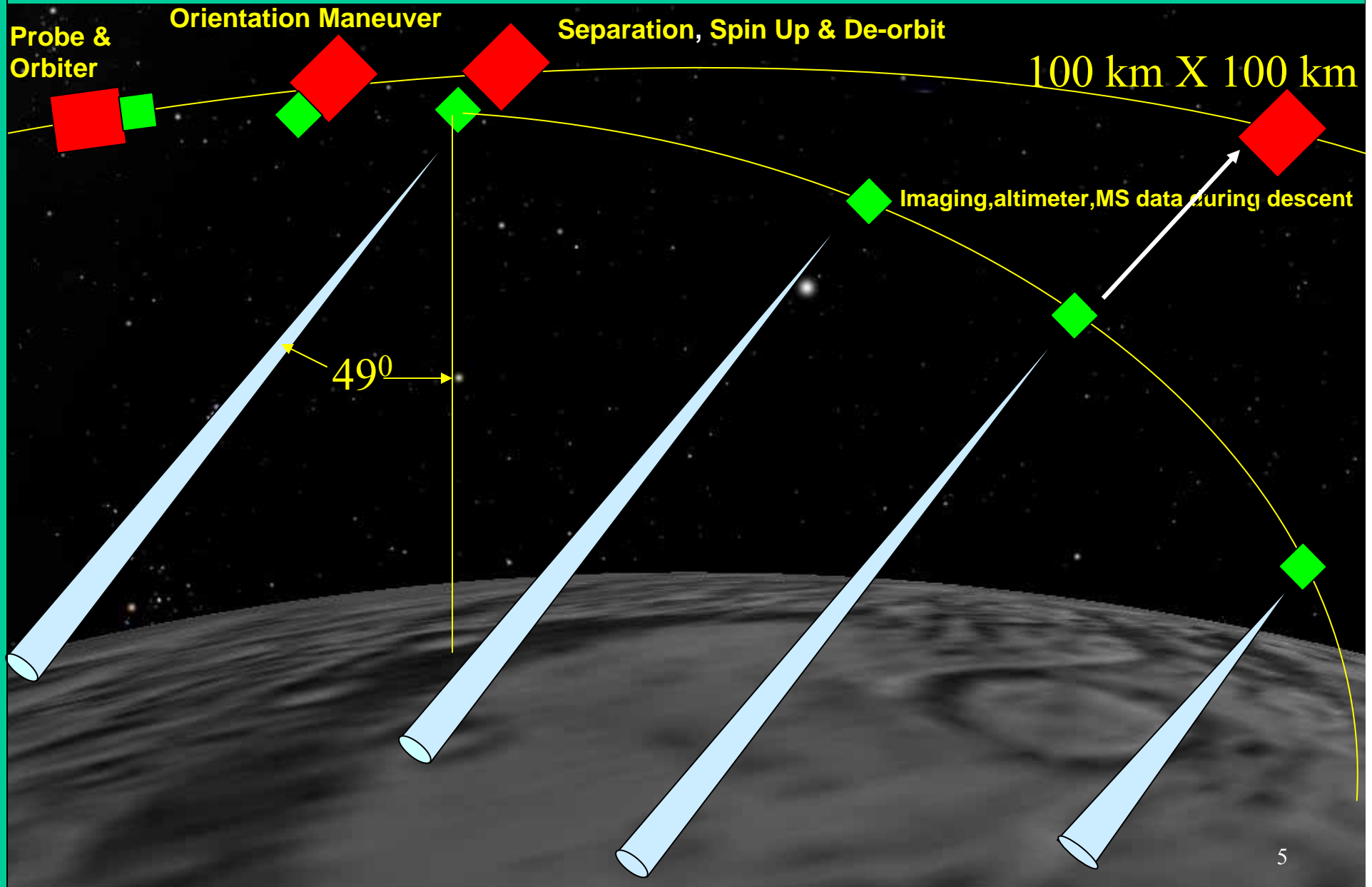


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UNIVERSITÄT
BERN



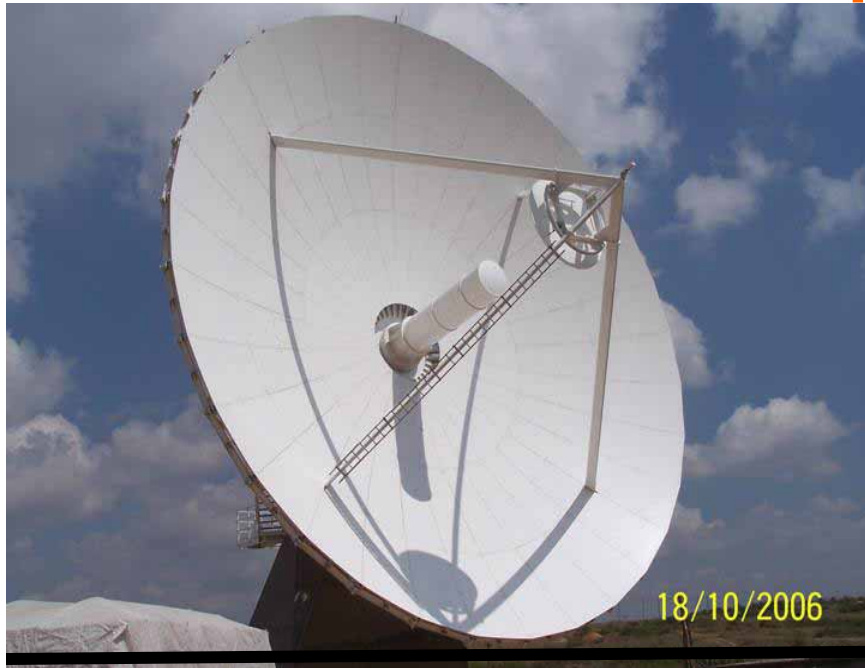
Impact Probe Mission Profile



Indian Deep Space Network(IDSN)



Indian Deep Space Network (IDSN), Mission Operations Complex (MOX) and Indian Space Science Data Centre (ISSDC).



18m Terminal
Adequate for Chandrayaan-1



32m Terminal
Cater to future interplanetary
Missions beyond Moon

Both are Co-located near Bangalore

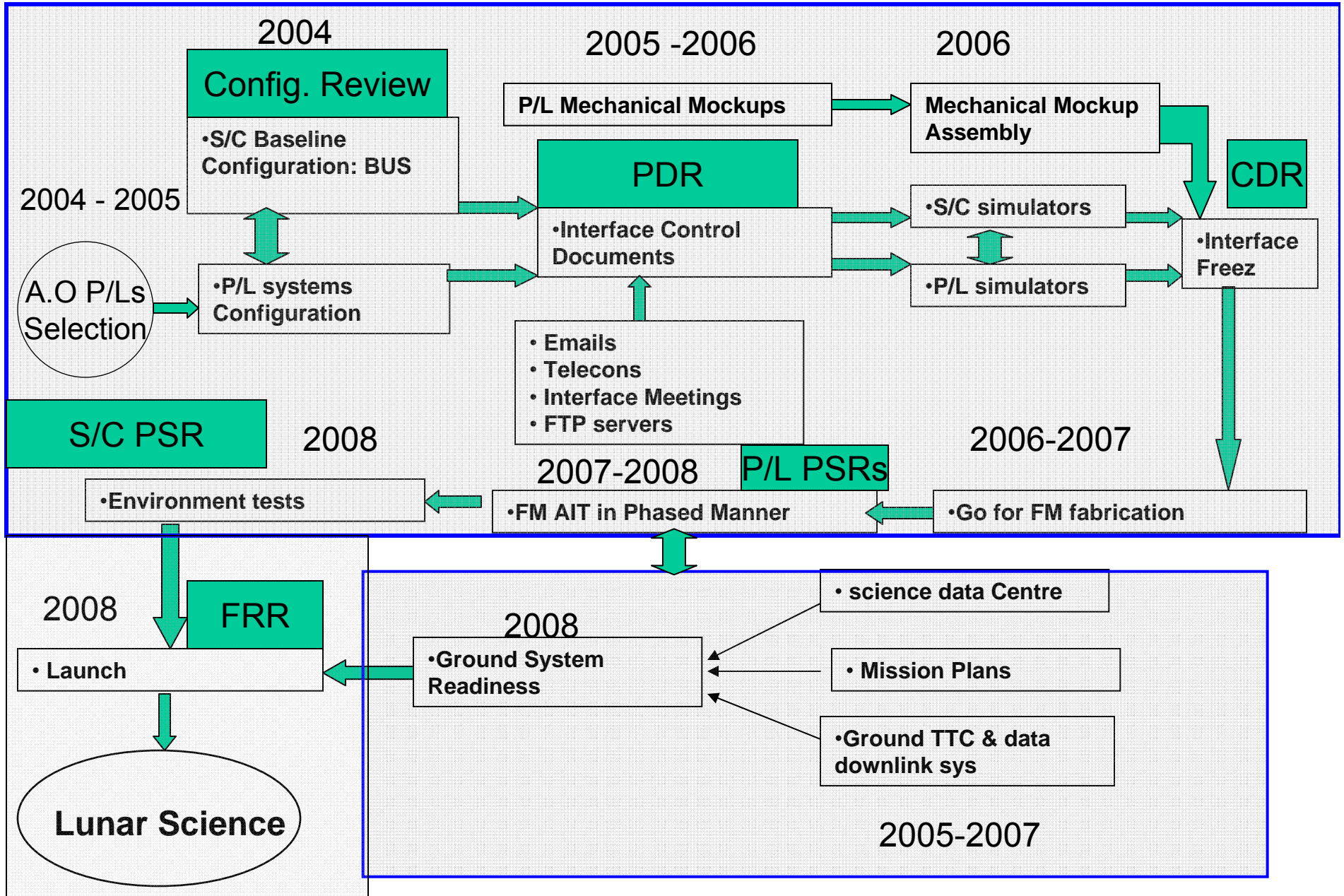


Challenges in Interfacing Science Instruments

- 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



Project : Interface Controls to Facilitate 2008 - Launch





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**















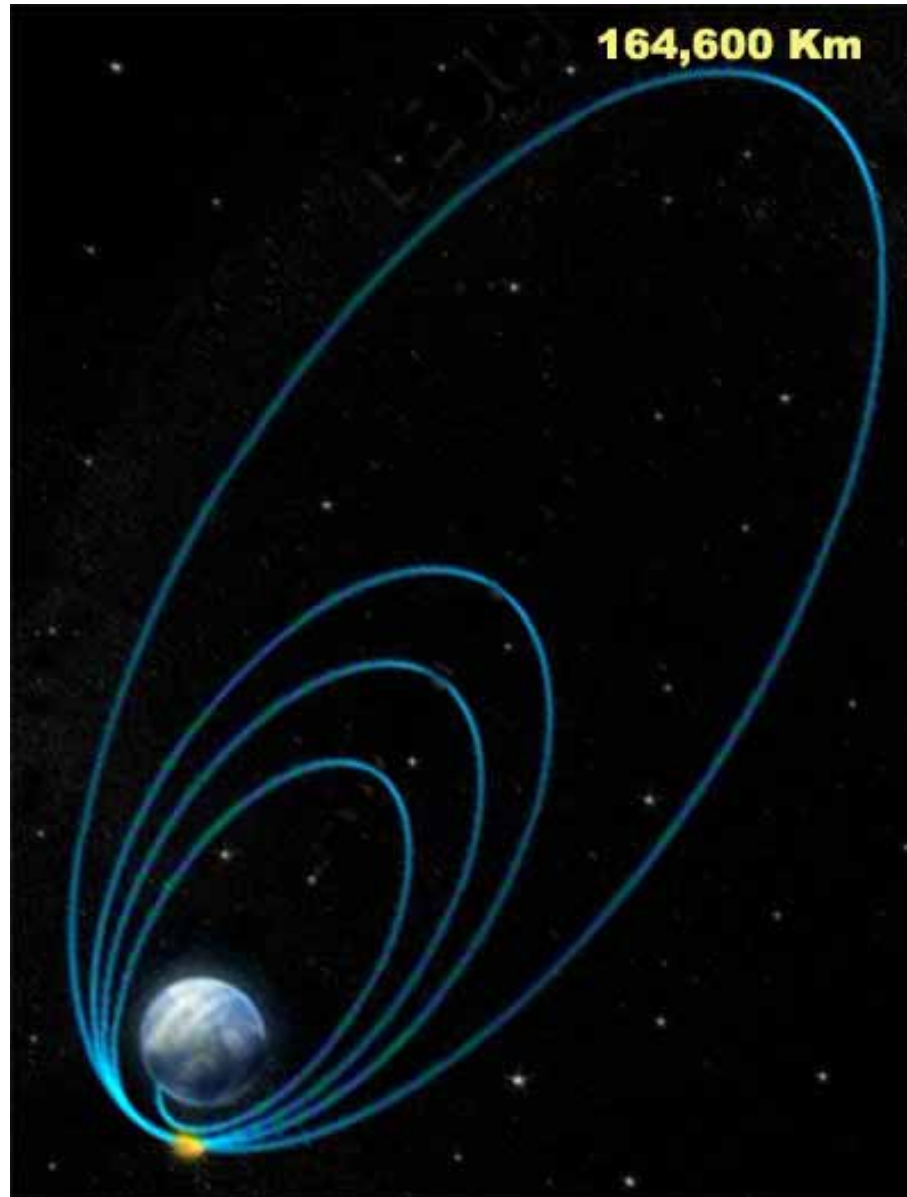








Chandrayaan-1 Orbit raising maneuver (26th Oct)





LUNAR EXPLORATION EFFORTS

Beyond Chandrayaan-1

***Future Planetary Missions by ISRO:
A Thinking -***



CHANDRAYAAN-2

(Lunar Orbiter, Lander, Rover, Robotics)

Mission Objective

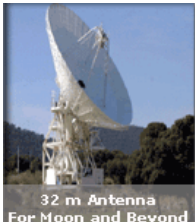
- To design, realize and deploy a lunar Lander-rover capable of soft landing on a specified lunar site for in-situ studies.
- Carry payloads in the orbiter that will enhance and add to the scientific objectives of Chandrayaan-1.
- Develop & demonstrate newer technologies, including those that will be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



GSLV

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



32 m Antenna
For Moon and Beyond

Chandrayaan-1

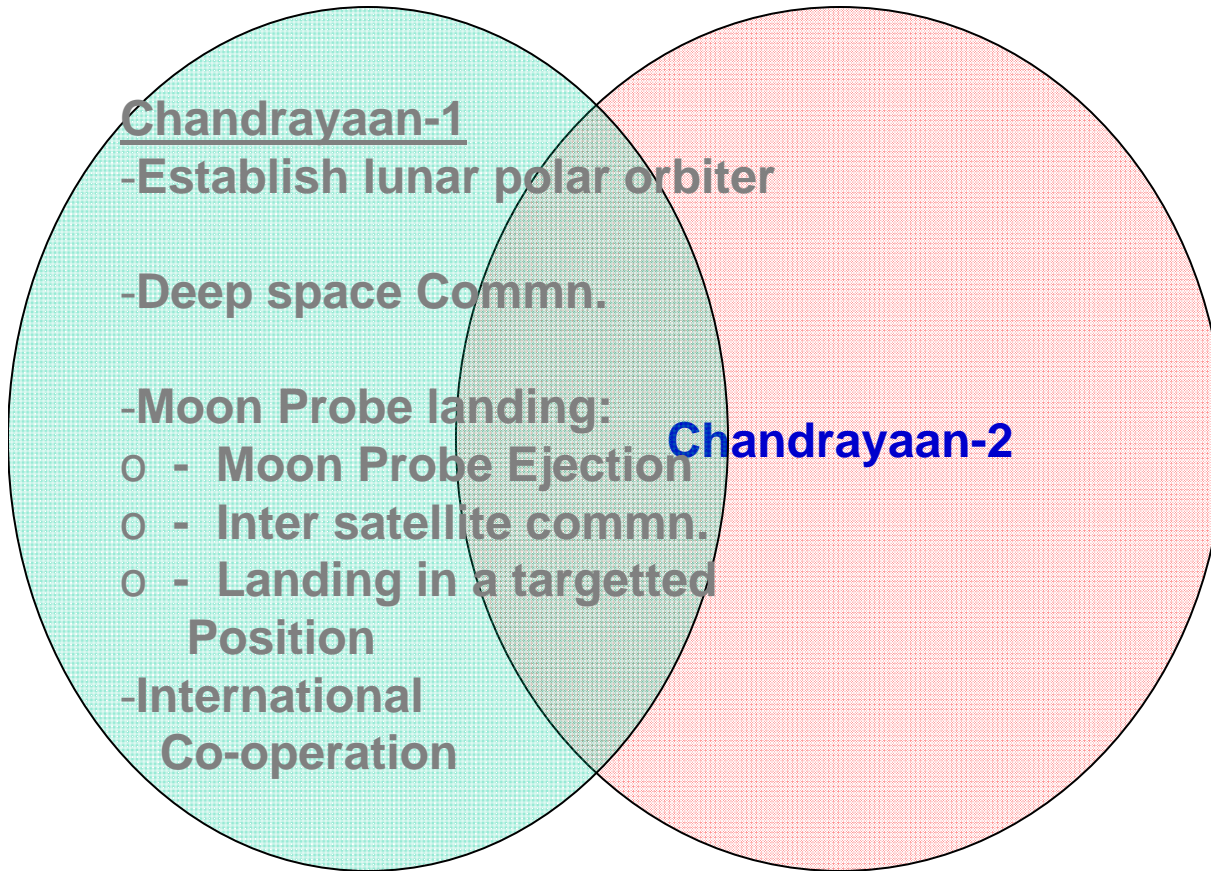
-Establish lunar polar orbiter

-Deep space Commn.

-Moon Probe landing:

- Moon Probe Ejection
- Inter satellite commn.
- Landing in a targetted Position

-International
Co-operation

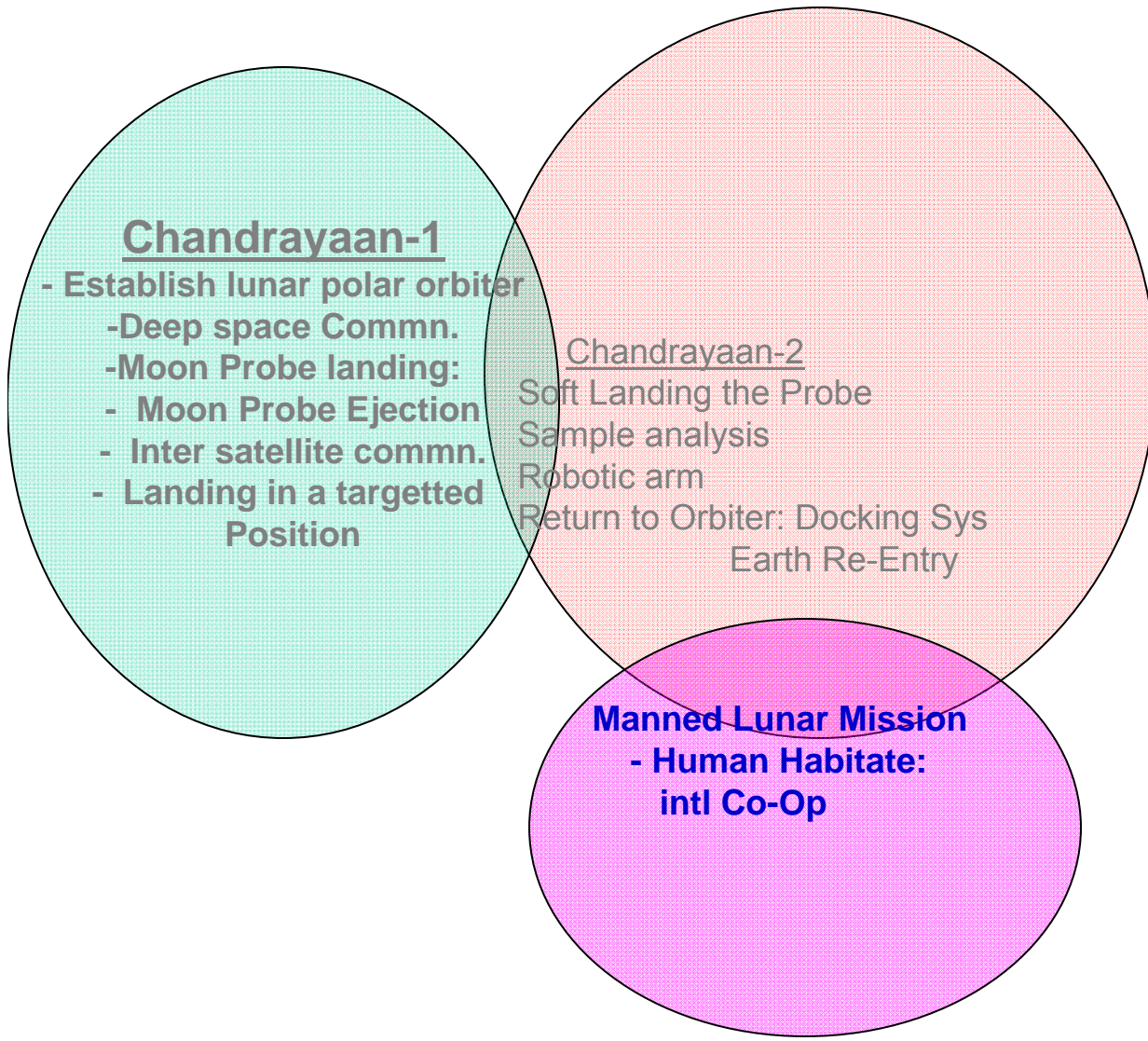


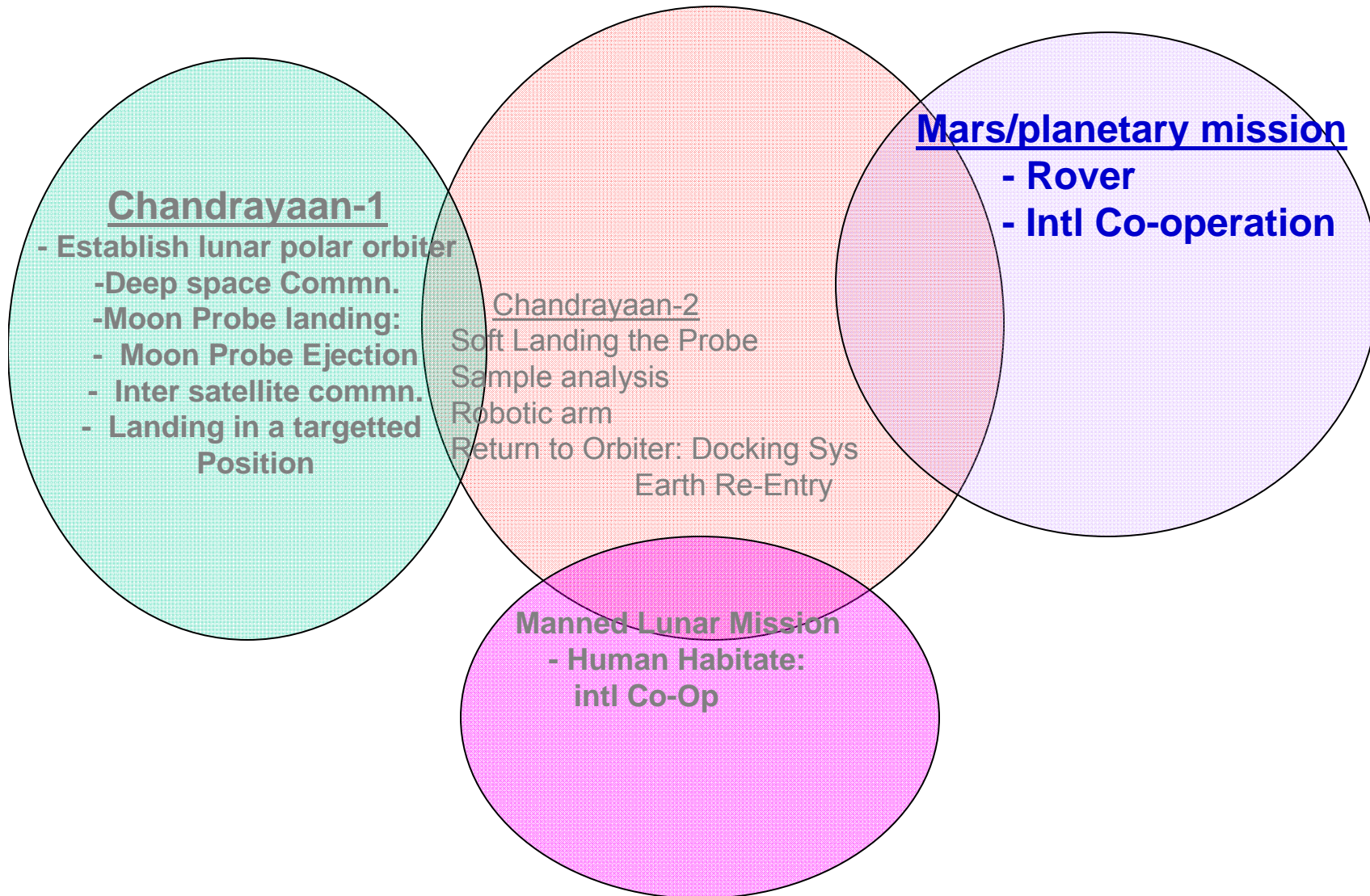
Chandrayaan-1

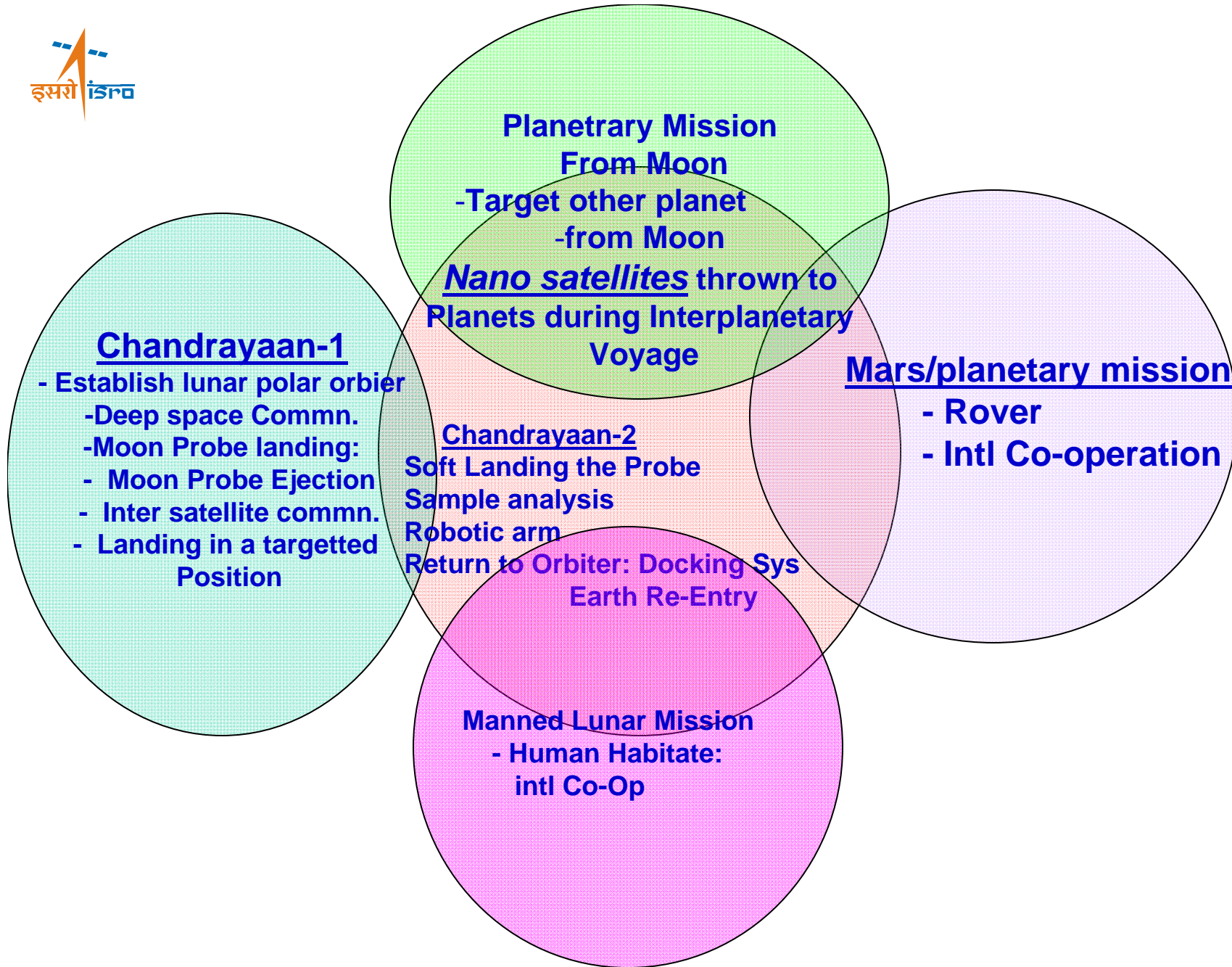
- Establish lunar polar orbiter
- Deep space Commn.
- Moon Probe landing:
 - Moon Probe Ejection
 - Inter satellite commn.
 - Landing in a targetted Position
- International Co-operation

Chandrayaan-2

- Soft Landing the Probe
- Sample analysis
- Robotic arm
- Return to Orbiter: Docking Sys
- Earth Re-Entry









Summary

- Chandrayaan-1 has 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