India’s Science Missions:
CHANDRAYAAN-3 & ADITYA-L1

Presentation to
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Evolution of Indian Lunar Exploration Programme

**CHANDRAYAAN 1**
(2008)
Reaching the moon
Impacting with probe
Scientific Experiments

**CHANDRAYAAN 2**
(2019)
Full fledged Orbiter
Lander & Rover
Scientific Experiments

Prime focus: Soft Landing
Lander & Rover
Scientific Experiments

(2023)
Chandrayaan-1: Reaching the moon

Total Satellite Mass: 1380 kg
Designed Life: 2 Year

Payloads
- India: 5
- Europe + India: 2
- Europe: 2
- USA: 2

Launch: 22 October 2008
End of mission: 30 August 2009

High resolution imaging of the Moon; Mineralogical & Chemical mapping of the lunar surface

- Presence of Hydroxyl & water molecules on lunar surface (M3)
- Detection of Mg, Al, Si, Ca on lunar surface
- Detection of Argon-40 in the lunar exosphere
**Chandrayaan-2: Landing attempt**

- **Total Spacecraft Mass:** 3877 kg
- **Designed Life:** 1 Year
- **Expected Life:** 7.5 Years

- **Lift off mass:** 641 T
- **GTO payload:** 4.0 T

- **Launched on 22nd July 2019**
- **Inserted into lunar orbit on 20th August 2019**
- **Achieved 100km orbit on 2nd September 2019.**

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Chandrayaan-2 Orbiter Images of Moon

L-Band Synthetic Aperture Radar reveals craters hidden below the surface (1,2) and disturbed regions (3,4) hidden by lunar regolith

Sharpest images ever from a lunar orbiter platform

Crater Centre location:
24.742 N, 21.00 E

Diameter of Crater~8 km
Depth of Crater~1.7 km

Sarabhai crater on the Moon imaged by TMC-2
Chandrayaan-3: Safe & Soft Landing

Lander Module
- Mass: 1750 kg
- Power: 738W
- Payloads: 3

Rover
- Mass: 26 kg
- Power: 50 W
- Payloads: 2

Propulsion Module
- Mass: 2145 kg
- Power: 758W
- Payload: 1

On Orbit Testing & Evaluation
- To demonstrate Safe and Soft Landing
- To demonstrate Rover roving on the moon
- To conduct in-situ scientific experiments

Ground Tests & Simulations

Robustness built in Lander
- CH-2 On orbit experience addressed

Chandrayaan-2 heritage

Safe and Soft Landing
**Special tests & Simulations**

- Autonomous 6 DoF Simulation
- Software In Loop Simulation
- Hardware in Loop Simulation

To validate the performance of sensors and navigation, under different test configuration and flight profile.
1. 5th August, 2023
   Lunar Orbit Insertion

2. 17th August, 2023
   Lander Separation

3. 23rd August, 2023
   Landing on the Moon

14th July, 2023
LVM3-M4 Lift-off

5 EBNs

5 LBNs

JPL, NASA

ESA

BENGALURU

SDSC SHAR

CHANDRAYAAN

Lunar Transfer Trajectory
The Lunar Landing

- **Powered Decent Start**
  - Altitude: 30 km
  - $V_H = 1.68 \text{ [km/s]}$
  - $V_V = 0 \text{ [m/s]}$

- **Rough Braking Phase**
  - Altitude: 7.4 km
  - $V_H = 358 \text{ [m/s]}$
  - $V_V = -61 \text{ [m/s]}$

- **Attitude Hold Phase**
  - Altitude: 6.8 km
  - $V_H = 336 \text{ [m/s]}$
  - $V_V = -59 \text{ [m/s]}$

- **Fine Braking Phase**
  - Altitude: 7.4 km
  - $V_H = 0 \text{ [m/s]}$
  - $V_V = 0 \text{ [m/s]}$

- **Terminal Descent Phase**
  - Downrange travelled: 745.5 km
  - Time: 690 s

- **Downrange Travelled**
  - 745.5 km
  - 713.5 km
  - 32 km
  - 28.52 km
  - 150 m

- **Time**
  - 12 s
  - 131 s
  - 22 s
  - 52 s
  - 76 s
  - 38 s
  - 9 s
Achieved soft landing on the Moon on 23 August, 2023 at 18:04 IST

- ShivShakti Point
- 69.3 S, 32.3 E

- India became the 4th country to have soft-landed on the Moon
- The 1st country to have soft-landed in higher lunar latitude
1. First-ever detection of Sulphur on the lunar regolith, along with trace constituents Aluminum, Calcium, Iron, Chromium, & Titanium on the lunar surface (LIBS Payload)

2. First-ever temperature profiling of the lunar regolith up to ~ 10 cm depth, results show good thermal insulating properties of the lunar soil (ChaSTE payload)

3. A few events of ground vibrations of the lunar surface are recorded (ILSA payload)

4. First-ever characterization of the near-surface lunar plasma at higher lunar latitude; indicate that only a few tens to hundreds of electrons per cc; dependence on local time (RAMBHA-LP payload)
Aditya-L1: First Indian dedicated Mission to study the Sun

- Halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system (at a distance of about 1.5 million km from the Earth).
- Major advantage: continuously viewing the Sun without any occultation/eclipses.
- Payload Verification (PV) phase is going on.

Launched on 2\textsuperscript{nd} Sep 2023
Halo Orbit Insertion on 6\textsuperscript{th} Jan 2024

Sun’s Radius : 0.7 M km
Distance from Earth: 150 M Km
Aditya-L1 Mission: Challenges in realization

- **First Indian Mission to L1 - Trajectory Optimization:**
  - Launch vehicle capacity, launch window constraints & fuel minimization during Earth-bound manoeuvres, in cruise as well as orbit maintenance.

- **Stringent pointing accuracy and stability:**
  - 15 arc-second pointing accuracy and spacecraft stability within $5 \times 10^{-5}$ deg/s.

- **Magnetic cleaning & sub-system magnetic field requirements:**
  - New harness routing developed to magnetically clean the spacecraft.

- **Stringent contamination control requirements:**
  - Stringent contamination control for payloads & spacecraft. For VELC & SUIT payloads it is Class 100 requirements.
Capturing the recent solar fury.

(a) Sun image in Mg II k line using SUIT / AdityaL1

(b) VELC observations made on May 14, 2024, at 5303 Angstrom. AR 13664 location is marked in this raster image as a box.
Capturing the recent solar fury....

SoLEXS: Low energy X-ray (1 – 22keV)

HEL1OS: High energy X-ray (8 – 200keV)

Disturbance of the IMF: MAG/Aditya-L1

Proton (lower) and alpha (upper) lines: ASPEX/Aditya-L1
Sample Return from Moon ....... Under Configuration

1. 1st module launch by LVM3

2. 2nd module launch by LVM3

Technology elements
- Lunar Sampler (Robotic Arm)
- Ascender module
- Docking in Lunar / Earth Orbits
- Sample transfer
- Return & re-entry

Target: 2027

Thank You ...