

A decorative border of various botanical illustrations surrounds the central text. It includes green ferns, yellow flowers, green leaves, a red leaf, and purple flowers.

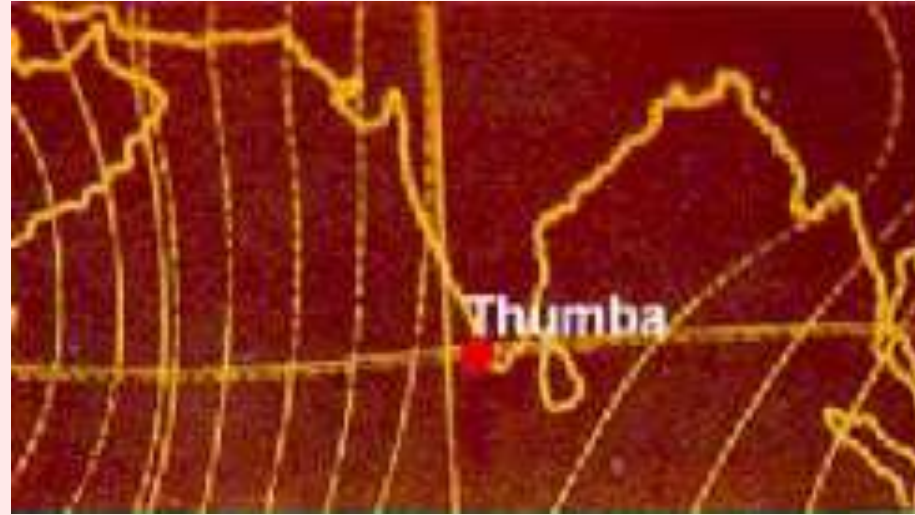
Space missions and its Applications

B N Ramakrishna
Director, ISTRAC
ISRO, Bangalore

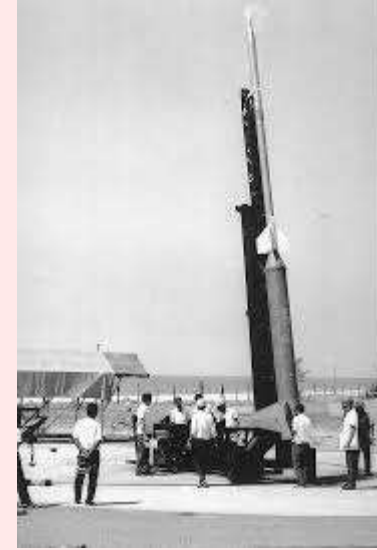


Dr. Vikram A. Sarabhai

Founder of Indian Space Programme







Concepts derived from societal problems



Use of accessible technology



Demonstration of solutions (SITE/STEP)
1975



Right use of enabling technology

Innovative concepts using existing technology



Leap-frogging (IRS-1C)



Using Space Technology As Tool

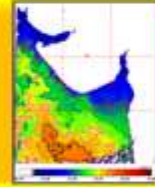
NAVIC - Not GPS



Fishermen's problems



PFZ/NAVIC - Solution to Fishermen





Space Centres in India



Space Technology Applications

Remote Sensing

AN EYE IN THE SKY - REMOTE SENSING SATELLITES

Indian Remote Sensing (IRS) satellite system was commissioned with the launch of IRS-1A in 1988. IRS is the largest civilian Remote Sensing Satellite Constellation in the world





Land Use / Land Cover

- Watershed Mapping
- Urban Sprawl Studies
- Growth Centre Analysis
- Monitoring Water Logged Areas, Salt affected Areas, Eroded Lands, Shifting Cultivation etc.



Agriculture

- Crop Acreage and Production Estimation
- Crop Condition Assessment



Water Resources

- Surface Water Mapping
- Run off Forecasting
- Reservoir Sedimentation and Discharge
- Conjuction Studies
- Groundwater Potential Zone Mapping



Ocean Applications

- Potential Fishing Zone (PTZ) Mapping
- Monitoring of Non-pollution Chemicals
- Coastal Zone Mapping
- Coastal Reef Mapping



Soil

- Soil Mapping
- Land Capability and Irrigability Assessment
- Soil Moisture Estimation



Urban Planning

- Smart City Project
- Gas Pipe Line
- NTFC



Disaster Warning & Management

- Flood Damage Assessment
- Flood Risk Zone Mapping
- Monitoring of Seismic, Earthquake and Underground Coal Fire
- Forest Fire and Risk Mapping



Geosciences

- Geological Mapping
- Geomorphological Mapping
- Mineral Targeting



Forests

- Forest Cover Mapping and Monitoring
- Forest Management Plan
- Biodiversity Conservation
- Environmental Impact Studies
- Grassland Productivity



Environment

- Air Quality, Greenhouse and Aerosols
- Land-Atmosphere Interaction
- High Climate Data
- Weathering

Communication

INDIAN COMMUNICATION SATELLITES - EXCEEDED THE EXPECTATIONS

18 Operational Satellites in Geostationary Orbit at 36,000 km. Support Telecommunication, Weather Forecasting & Cyclone Warning, DTH & TV Broadcasting, Banking and ATM, Radio Broadcasting, Disaster Warning and Search & Rescue Services.



Radio Broadcasting



Telemedicine



News Broadcasting



Banking & ATM



Tele-education



TV Broadcasting



Search & Rescue



Weather Forecast & Cyclone Warning Service

Navigation

Aviation



Railways



Roadways



Maritime



Navigation



Survey



Space Science

X-ray Astronomy
Aeronomy &
Solar Physics

Multi-wavelength studies of stars and galaxies in UV and X-rays

Terrestrial upper atmosphere & space weather

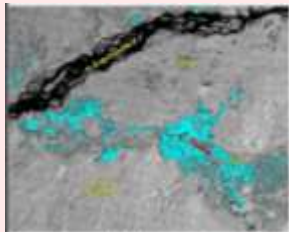
Topography, Elemental & mineral, abundance, water/ice

surface features, morphology, mineralogy and Atmosphere

Space Technology Applications



- ✓ Communication Infrastructure
- ✓ Data connectivity
- ✓ Broadcasting, Education



- ✓ Monitor Natural resources
- ✓ Meteorological Observations
- ✓ Discern Environment, Climate



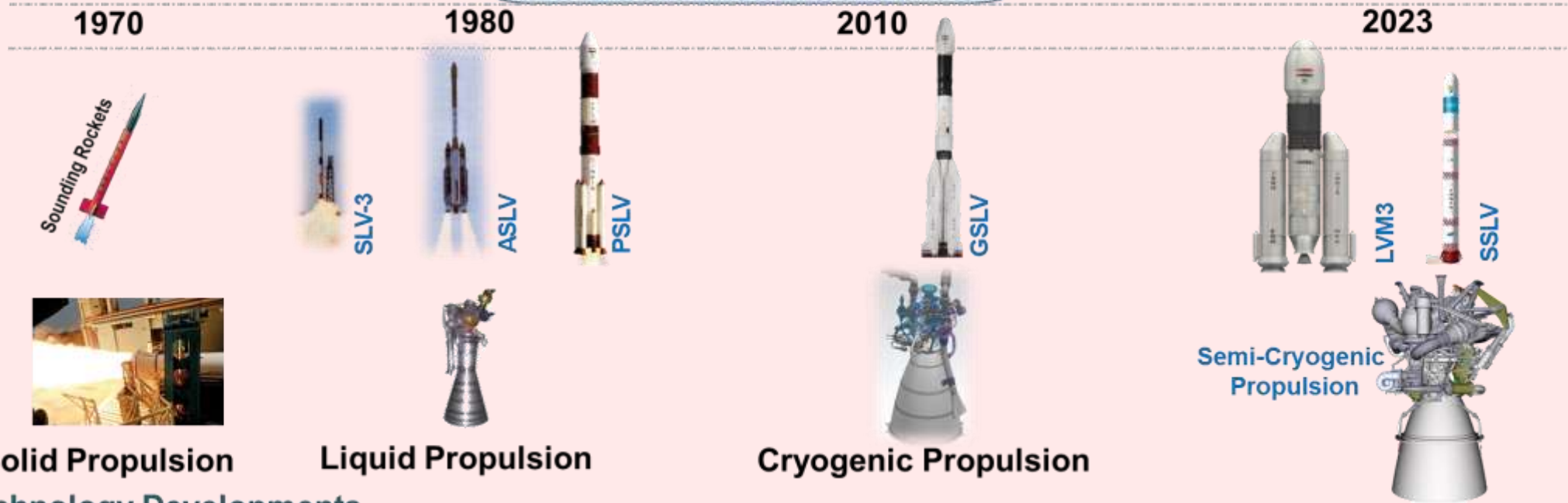
- ✓ Strategic Services
- ✓ Assured Navigation Signals
- ✓ Location-based services



- ✓ Geospatial Services
- ✓ Sustainable Development Plan
- ✓ Disaster Management Support

Technology Evolution: Launch Vehicle

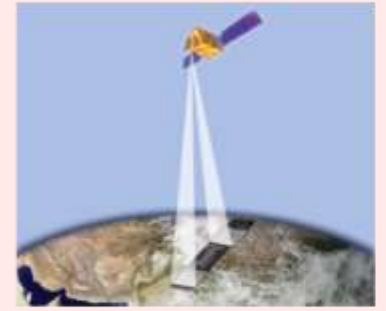
Payload Capacity 30 kg (120 km) → 4200 kg (GTO)



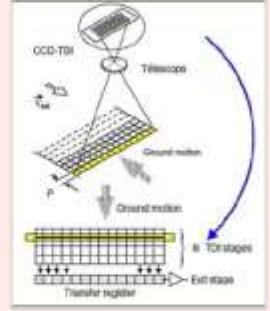
Technology Developments

 Aerodynamics	 Fabrication	 Composites	 Mission simulation	 Avionics	 Pyros
 Mechanisms	 Materials	 System reliability	 Structural engg.	 Payload integration	 Advanced propulsions

Indian EO Satellites: Evolution



Stereo imaging



TDI Imaging



Stereo imaging

TDI Imaging



Cartosat 2 Series (2016)
0.6 m, 11 bits

Altimeter (2013)

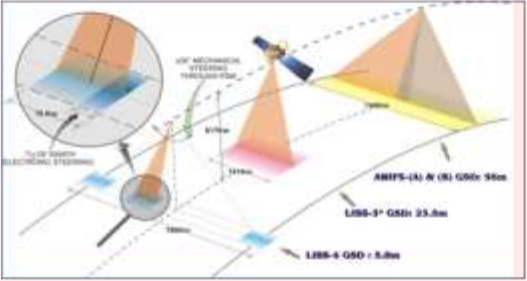
Microwave (2012)

Scatterometer (2009)

Cartosat 1 (2005)
2.5 m, 10 bits,

TES (2001)
~1 m, 10 bits

Step-and-Stare



3 tier imaging



3 tier imaging

Resourcemat 1/2/2A (2003/ 11/ 16)
6 to 56 m, 7-14 bits, 5 / 24 days



IRS IC/ID (1995/ 1997)

6 to 188 m , 7 bits
5 / 24 days



Bhaskara-1/2 (1979/ 81)
1 Km resolution



2 tier imaging

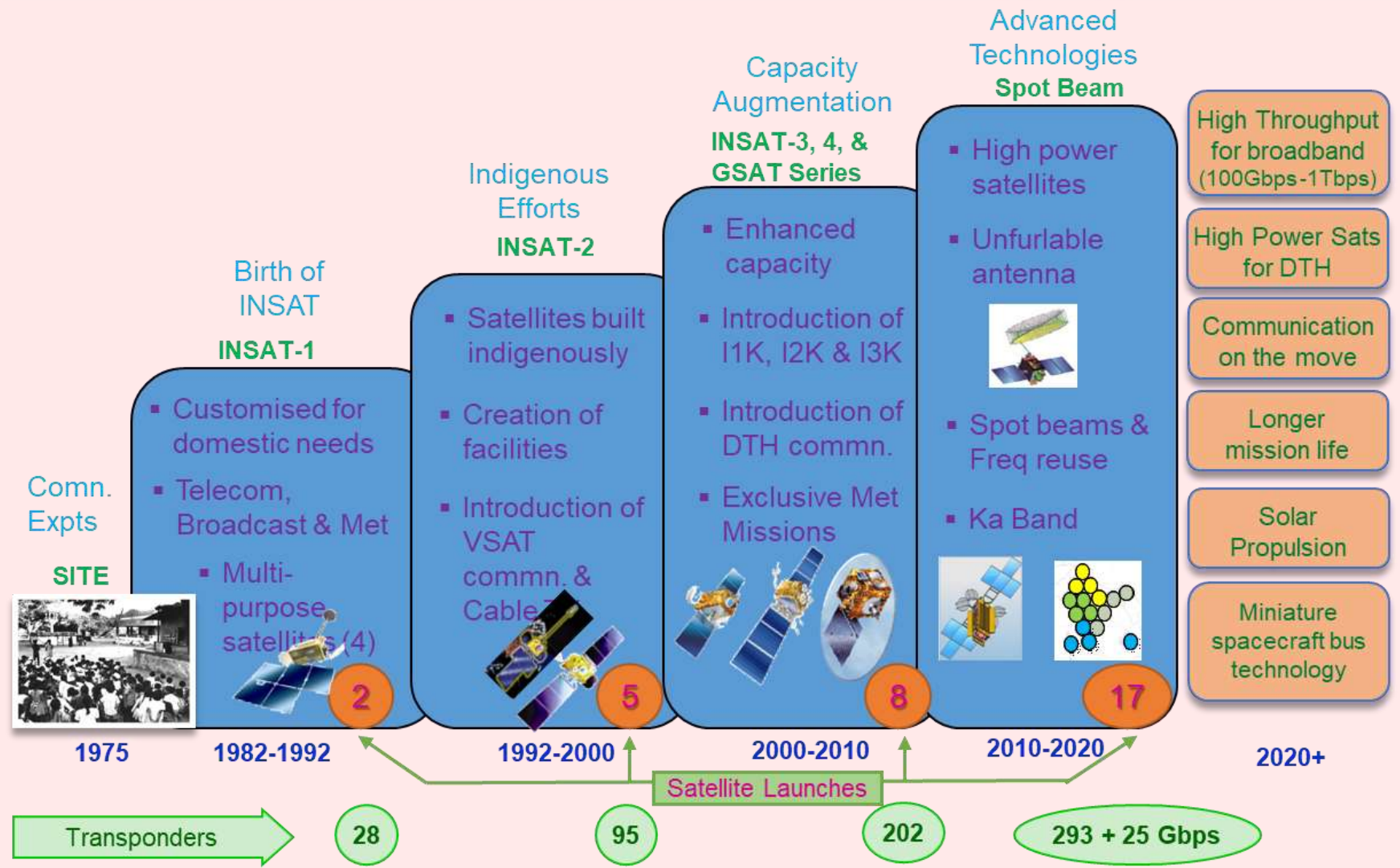
IRS 1A/1B (1988/ 91)
36/72 m, 7 bits, 22 days

Spatial Resolution
1 Km → 0.6 m

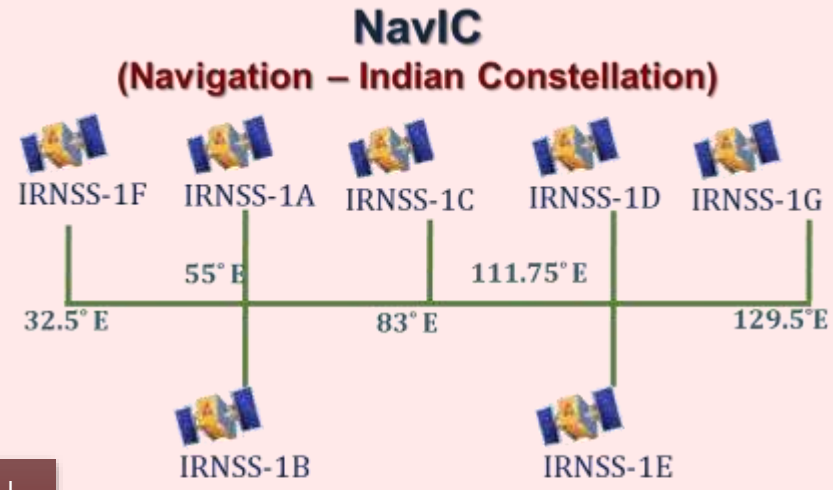
Temporal Resolution
24 days → 2.5 days

Spectral Resolution
7 bits → 14 bits

Growth path of satellite communication in India



Evolution of Navigation Satellites



GAGAN (GPS Aided Geo Augmented Navigation)



Navigation Program started in 1996 with GAGAN program

IRNSS program in 2006

- Vehicle Tracking and Fleet Management
- Maritime Services & Port Operations
- Railway operations
- Civil aviation
- Disaster Management Support
- Geo-tagging/ Geo-fencing
- Location based services
- Survey Applications
- Infrastructure Planning
- Power Grid Synchronization
- Forest and Mining
- Precise Timing
- Mapping and Geodetic data capture
- Earth and Atmospheric Studies
- Search & Rescue



Space Science Experiments

X-ray Astronomy
Aeronomy &
Solar Physics



1975
Aryabhata

GRB & RPA
experiments
Publ: 24



1992 & 1994
SROSS series

X-ray
spectrometer
Publ:10



2003
SOXS on GSAT-2

Terrestrial
upper
atmosphere
& space



2011
Youthsat

Multi-wavelength
studies of stars
and galaxies in
UV and X-rays



2015
ASTROSAT

1985
Spacelab/ Anuradha



Cosmic Ray
Experiment

1996
IXAE on IRS-P3



Bright X-ray
binaries
Publ:31,
Ph.D:4

2008
Chandrayaan-1



2013
**Mars Orbiter
Mission**



Martian surface
features, morphology,
mineralogy and
Martian atmosphere

Topography, Elemental &
mineral, abundance,
water/ice
Publ: 150+

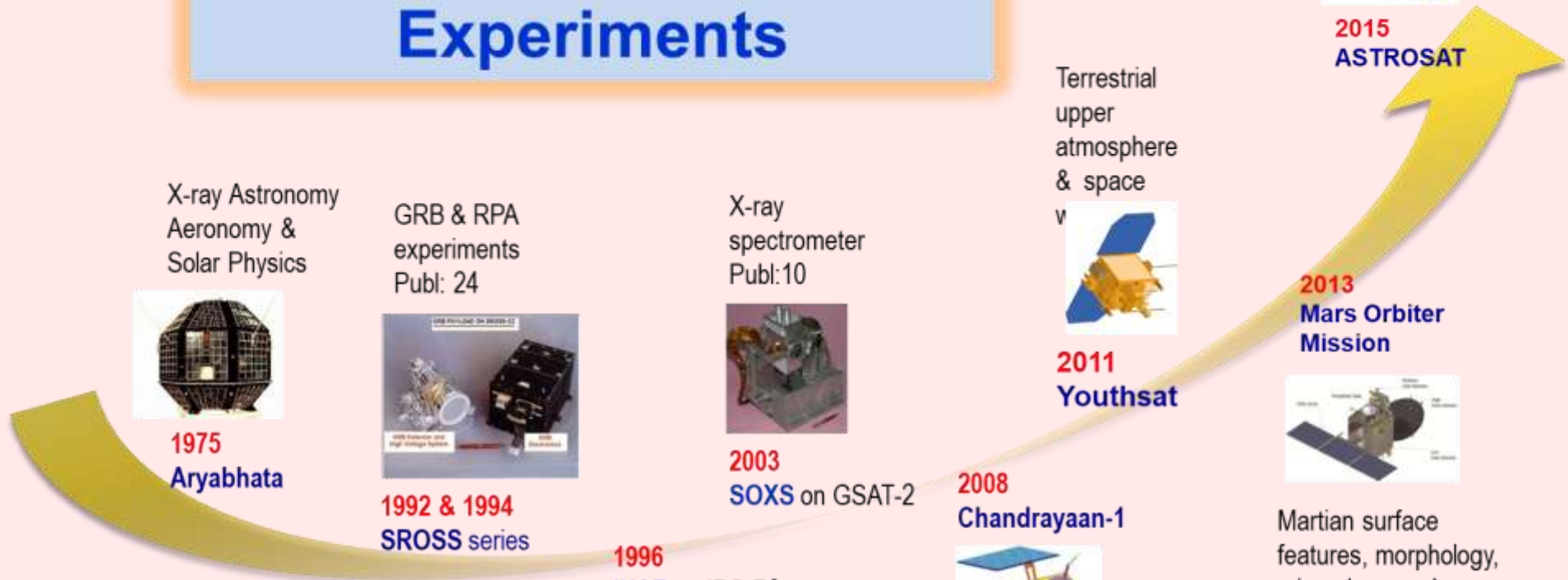
Chandrayaan-2 & 3

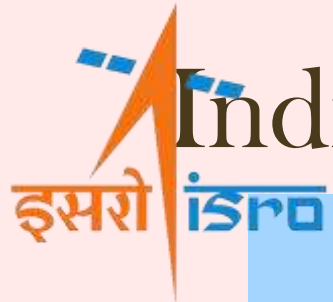


XpoSat



Aditya-L1





Indian Space Programme - at a Glance



94
Launches

125
Spacecraft

217



6 Technology Demonstrations



431 Satellites of **34** countries



15 Student satellite missions

**\$1.6B Budget; HR: 17,000;
40 entities in 22 locations**



Indian Space Ecosystem & ISRO's Verticals



INDUSTRY

450+
MSME

50+
Large companies

START-UPS

100+
Start-ups



ACADEMIA

5 RAC-S

6 STIC

9 STC

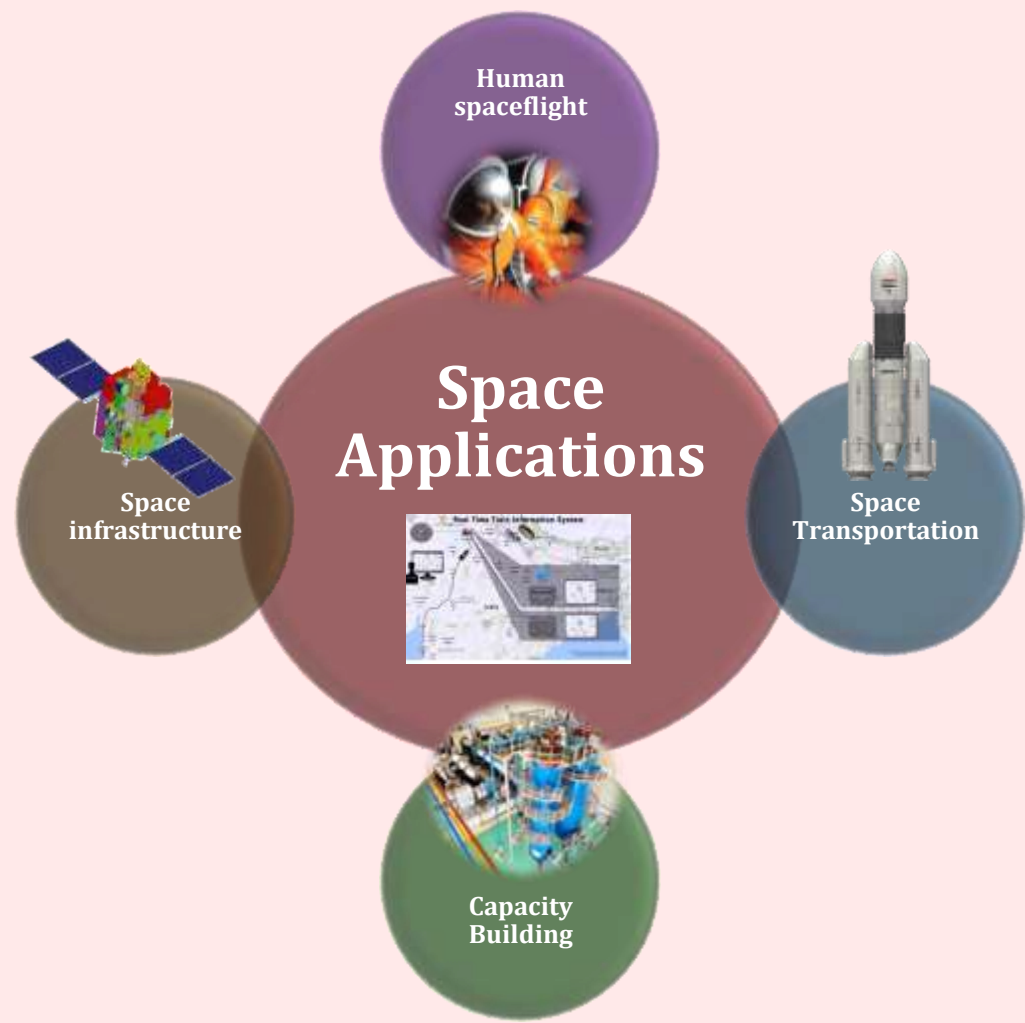
300 Sponsored Research

PARTNERS

Govt. Ministries

State Government

Departments





Recent Missions

Commercial

Scientific

User funded

Development Flight

Test Vehicle for Gaganyaan



OneWeb India-1/
NSIL



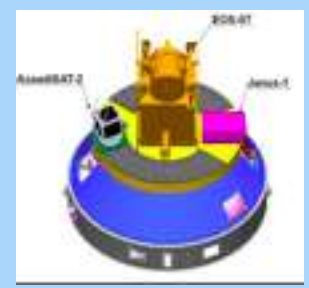
Chandrayaan-3



EOS-06 / OceanSat



SSLV-D2/ EOS-07,
Janus-1 & AzaadiSAT-2



Gaganyaan-TV-
D1

International Capacity Building

Downstream Applications

Indian Institute of Remote Sensing (IIRS) at Dehradun

- Offers 8-weeks course on RS & GIS under Indian Technical Economic Cooperation (ITEC) sponsored by MEA



UN affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), Dehra Dun (Nov 1, 1995)

- Offers short-term training courses and 9-months PG Diploma for officials from this region on space technology applications
- 5 Themes: RS & GIS; SATCOM, SATMET, Space Science & GNSS
- Uses facility & expertise of IIRS, SAC, PRL



More than **3900** officials from **109** Countries are offered training by IIRS & CSSTEAP On-line training on DMS 6870 participants from 102 countries

UNNATI (UNISpace Nanosatellite Assembly & Training by ISRO)

Batch 1: Jan-March 2019



29 Participants from 17 Countries

Algeria, Argentina, Azerbaijan, Bhutan, Brazil, Chile, Egypt, Indonesia, Kazakhstan, Malaysia, Mexico, Mongolia, Morocco, Myanmar, Oman, Panama & Portugal

Batch 2: Oct-Dec 2019



30 Participants from 16 Countries

Bahrain, Bangladesh, Belarus, Bolivia, Brunei, Colombia, Kenya, Mauritius, Nepal, Nigeria, Peru, South Korea, Sri Lanka, Thailand, Tunisia & Vietnam



30 Participants from 21 Countries

Argentina, Armenia, Bhutan, Chile, Dominican Republic, Ecuador, El Salvador, Ethiopia, Fiji, Mexico, Namibia, Nicaragua, Panama, Papua New Guinea, Philippines, Sao Tome and Principe, Singapore, Slovakia, Sudan, UAE & Uzbekistan

Upstream Technology



Main SELM: July 6-7, Bengaluru
Space Agency Heads and senior representatives from space agencies of 18 G20 countries, 8 invited countries, and 1 international organization (ITU)
Additionally, 32 space industries from abroad and 53 Indian space industries actively participated.





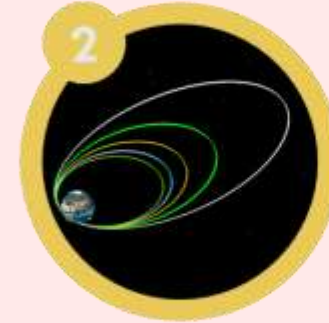
Recent Programs

चंद्रयान-3 MISSION CHANDRAYAAN-3



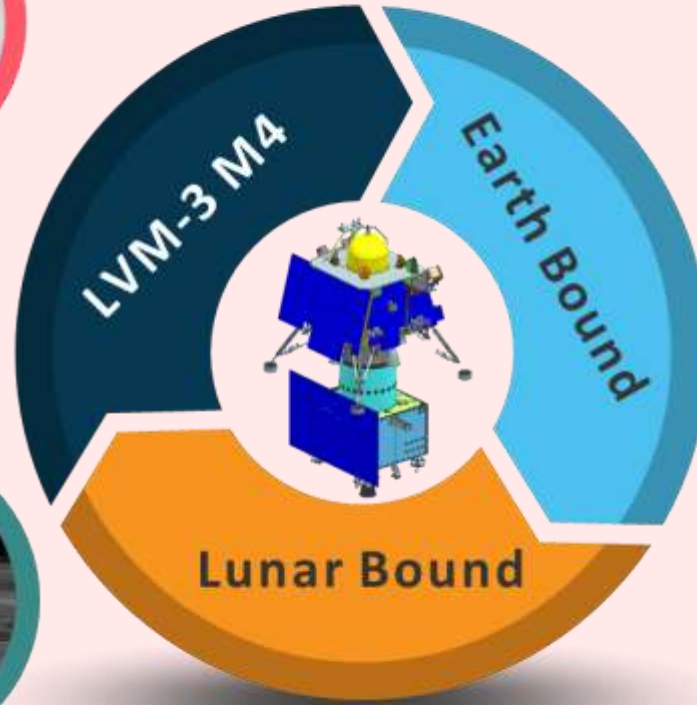
LVM-3 M4

Elliptical Parking Orbit
(170 x 36501 km,
21.29°)



Series Of EBNs

Total Planned Maneuvers : 6
(4 Perigee, 1 Apogee and TLI)



Landing

Power Descent



Series Of LBNs

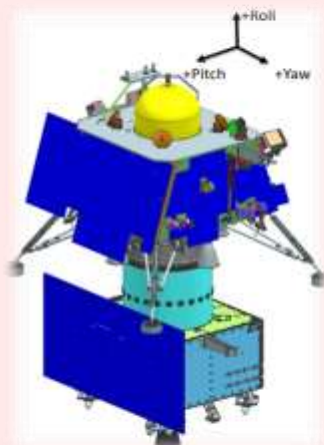
Total Maneuvers: 5 (Including LOI)
followed by 2 De-boost maneuvers



Rover Movement

1 Lunar day

INDIA
भारत



Chandrayaan-3
Science Instruments



Lander Payloads



RAMBHA-LP
Langmuir Probe
To measure the near surface plasma (ions and electrons) density and its changes with time.



ChaSTE
Chandra's Surface Thermo-physical Experiment
To carry out the measurements of thermal properties of lunar surface near polar region.



ILSA
Instrument for Lunar Seismic Activity
To measure seismicity around the landing site and delineating the structure of the lunar crust and mantle.

Rover Payloads



APXS
Alpha Particle X-Ray Spectrometer
To derive the chemical composition and infer mineralogical composition to further enhance our understanding of lunar surface.



LIBS
Laser Induced Breakdown Spectroscopy
To determine the elemental composition (Mg, Al, Si, K, Ca, Ti, Fe) of lunar soil and rocks around the lunar landing site.

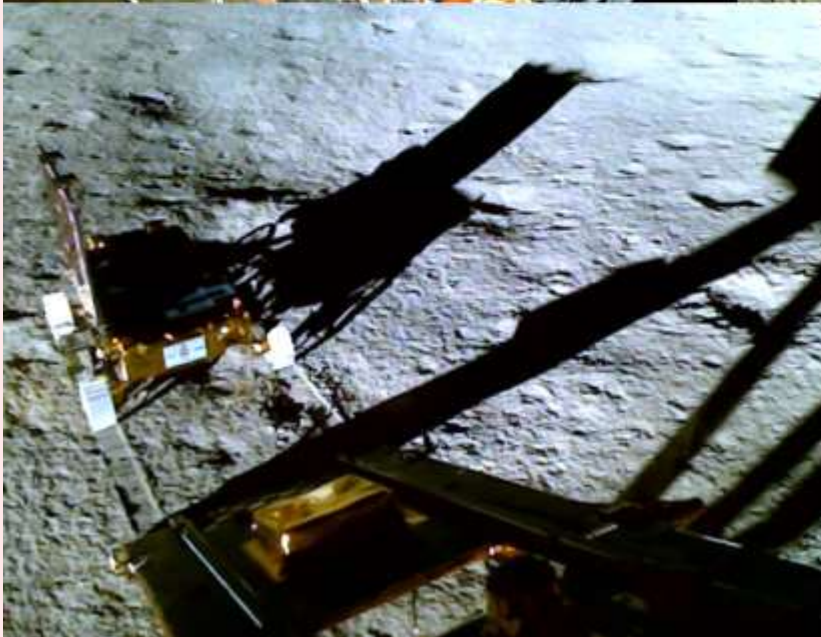
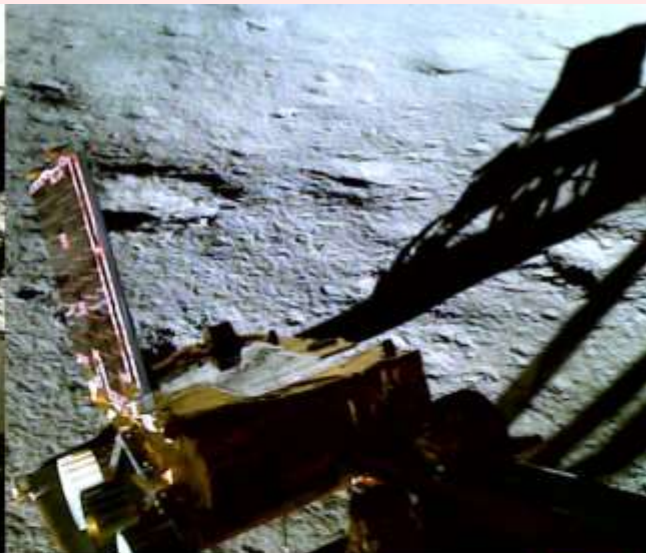
Propulsion Module Payload





SHAPE
Spectro-polarimetry of Habitable Planet Earth
An experimental payload to study the spectro-polarimetric signatures of the habitable planet Earth in the near-infrared (NIR) wavelength range (1-1.7 μm).








CHANDRAYAAN-3 PARAMETERS DISPLAY  

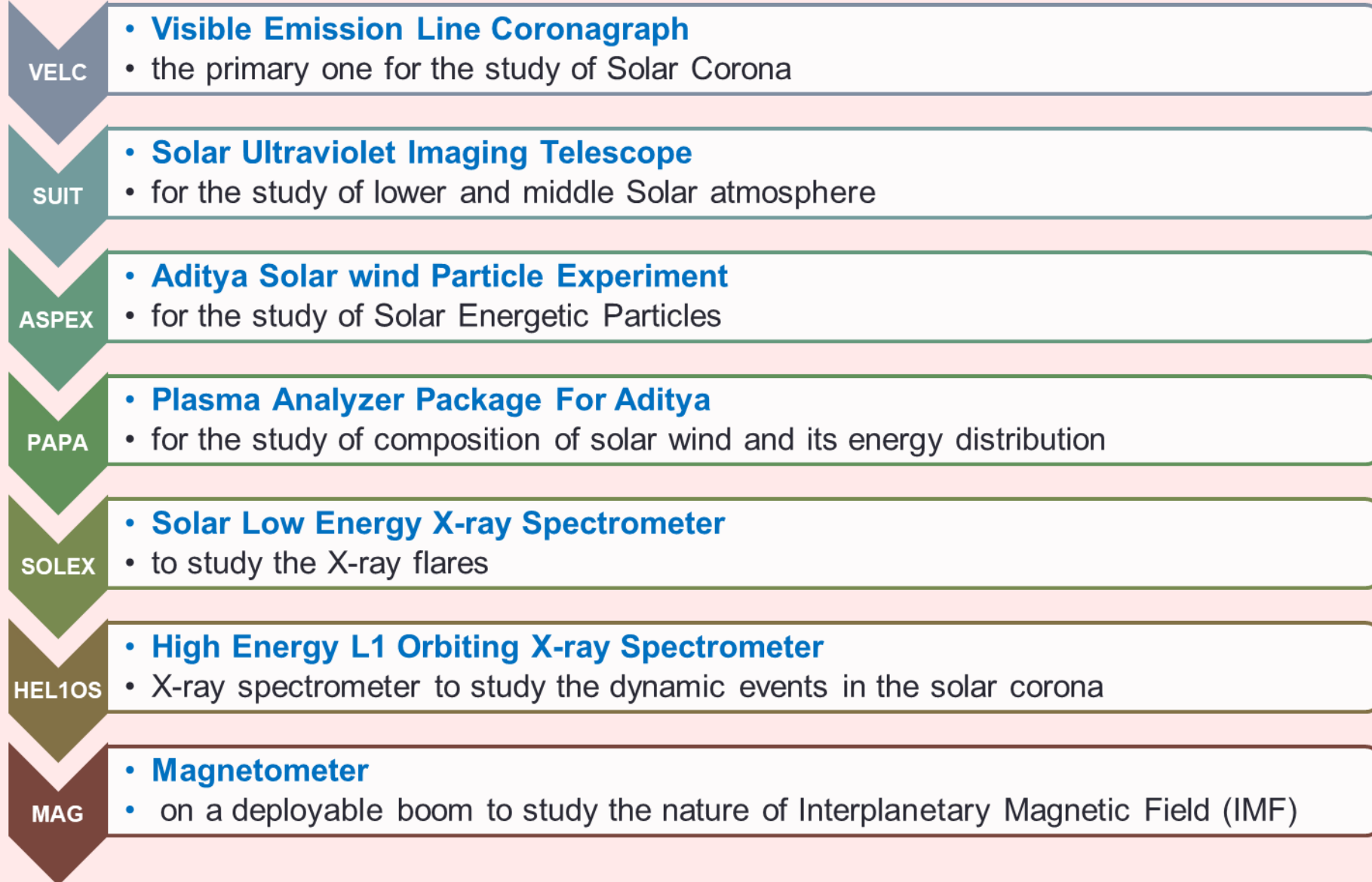
COUNTDOWN FROM DESCENT START : + 00:32:17

0.000 HORZ. VELOCITY	0.000 VERT. VELOCITY 	0.000 ALTITUDE
LANDED LOCAL NAV ALL ENGINE OFF SEQUENCER STATE	SAFELY LCL NAV OVER TOUCH DOWN SEQUENCER SUB STATE	

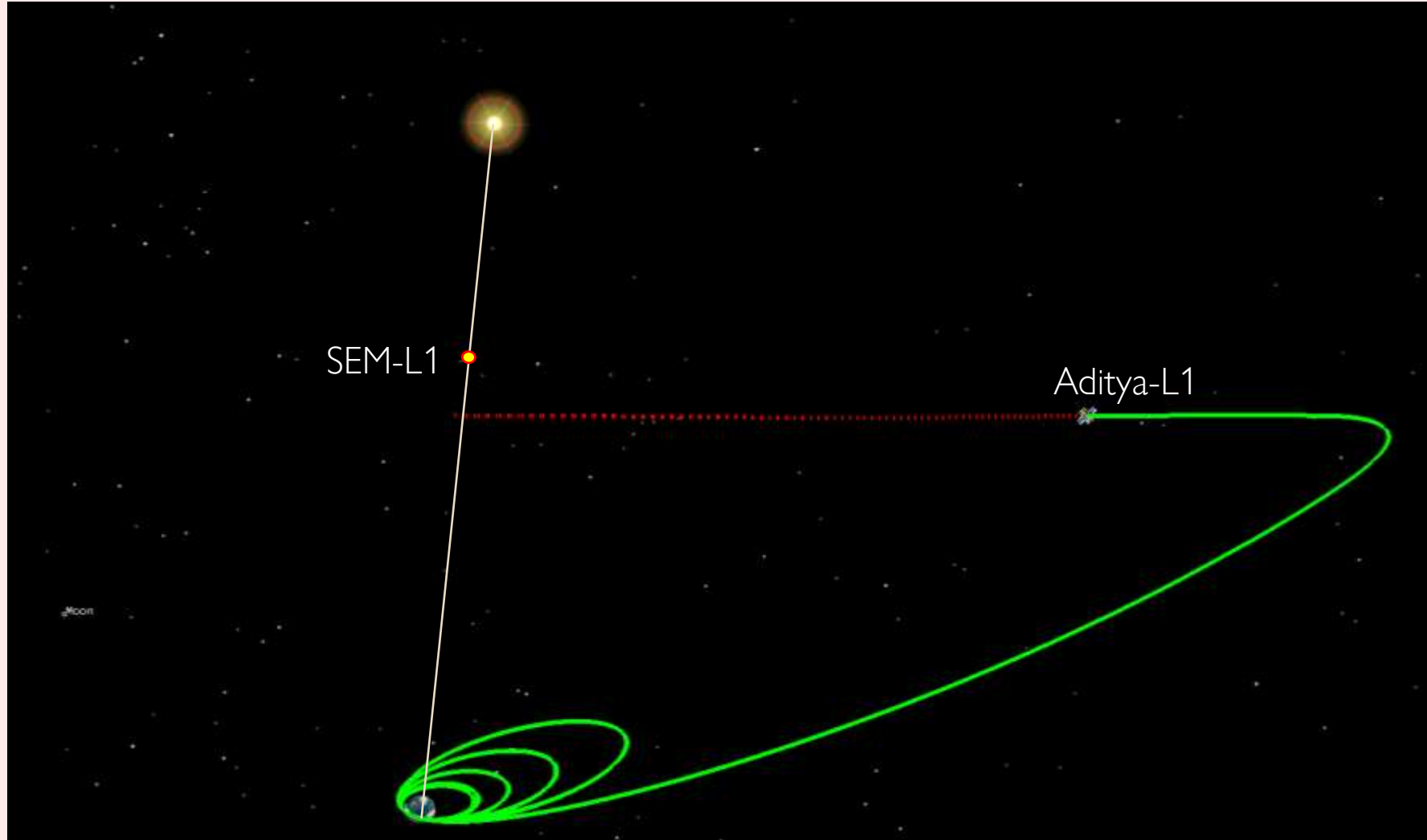
SERVER-1 SERVER-2



Aditya-L1



Aditya-L1





Way Forward

- Indian Space Sector is open for end-to-end Private Sector Activities
- Focus on developing key technologies, Outer Space Exploration
 - Reusable/ Re-entry vehicles | Low cost constellation | On-orbit servicing | Flexible payloads | Electric propulsion | Quantum Communication | AI & ML | etc.
- Develop critical; long-lead; time-& capital-intensive infrastructure
- Promote & Practice Long Term Sustainability of Outer Space
- Play proactive role in Regional & International cooperation in Space Sector
- Joint Missions, Global Collaborative Constellations, Virtual RS Constellations for Data sharing,.....

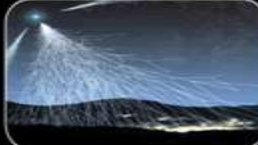




Space Situational Awareness (SSA)




ISRO System for Safe and Sustainable Space Operations Management (IS⁴OM)

Space Situational Awareness




Outer Space Environment






Objectives

Network for space object TRacking & Analysis (NETRA)



Prime Responsibilities


- Integration and analysis of observational data
- Space debris mitigation and compliance evaluation for long term sustainability
- Research and development related to SSA and Space Traffic Management (STM)
- Data exchanges, coordination and collaboration with ISAC centers and external entities

ISRO System for Safe and Sustainable Space Operations Management (IS⁴OM)

Near Earth Objects and Planetary Defence


Near Earth Asteroid (NEA)

Asteroids in vicinity of the Earth (with perihelion distance less than 1.3 au, 1 au = 1.5 million km)



Potentially Hazardous Asteroid (PHA)

- Bigger NEAs (size > 140 m) with orbits within 7.5 million km of Earth's orbit
- Impact can wreak havoc like extinction of several species
- Postulated to have caused dinosaur extinction




Asteroid Apophis


- 340 m sized Asteroid 99942 identified as the most hazardous asteroid
- Possibility of impact ruled out within next 100 years based on subsequent monitoring and analysis

Notable impacts

Date	Impacting Object	Place of impact	Consequence
05/02/2013	Chelyabinsk meteor 20 m asteroid	Chelyabinsk Oblast, Russia	~1500 Injured ~7200 buildings damaged
30/06/1908	30 m Asteroid	Tunguska, Russia	Destroyed 8 crores Trees
6.5 crore years ago	10-15 km asteroid	Mexico	Killed 70% of all species





Artist's impression of a PHA impact on a planet





Lonar lake impact crater in Maharashtra, India


Key: Detect any asteroid or comet potentially impacting Earth, either prevent or mitigate the risk


Detection


Tracking and Monitoring



Characterization


Risk assessment



Mitigation

Impulsive Deflection

Deflection achieved by high velocity projectiles



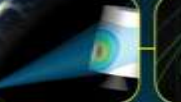
Kinetic Impactors
Deflection caused by impulsive transfer of momentum




Nuclear Impactors
Nuclear explosives to mitigate impact when warning time is short

Low Thrust Deflection

Deflection achieved by a low but continuous thrust



Ion Beam Shepherd
Push asteroid by continuous hitting of high speed beams of ions.



Gravity tractor
Contact less deflection method: spacecraft used to create gravitational attraction and change the trajectory

GAGANYAAN EXPLORING FRONTIERS

India's First Human Spaceflight

Vision: To implement a sustained and affordable human and robotic programme to explore the Solar system and beyond. To extend human presence across the solar system, starting with human spaceflight to low earth orbit and return.

- No. of Crew: 3
- Orbit: 400 km Circular
- Recovery : Arabian Sea / Bay of Bengal

Human Rated
GSLV MkIII



Orbital Module -
Crew Module &
Service Module

Crew
Escape
System



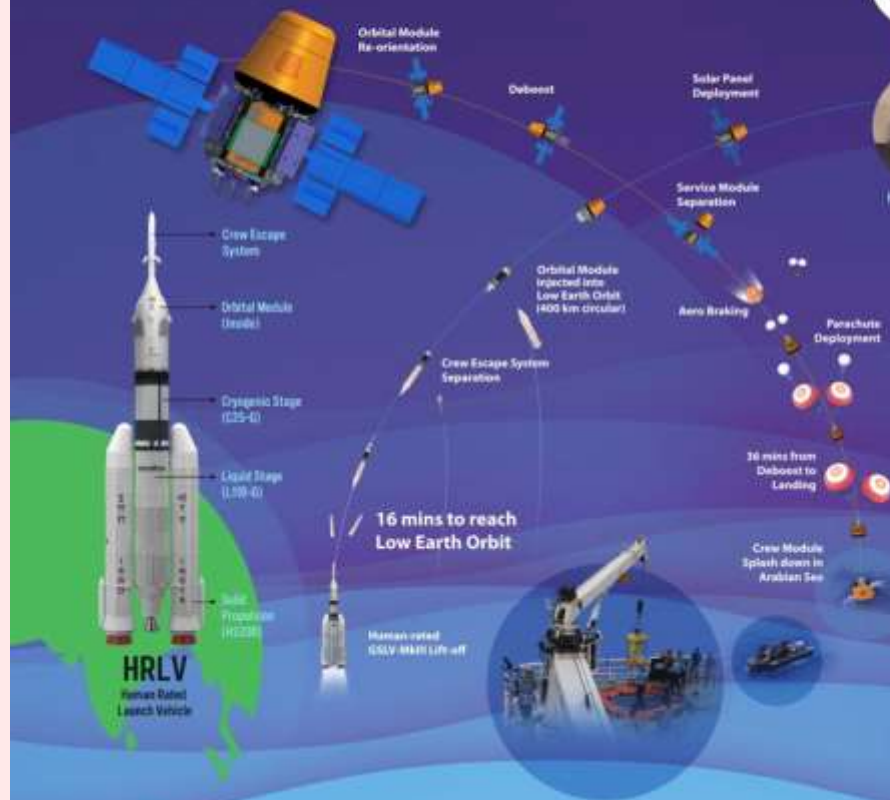
ECLSS

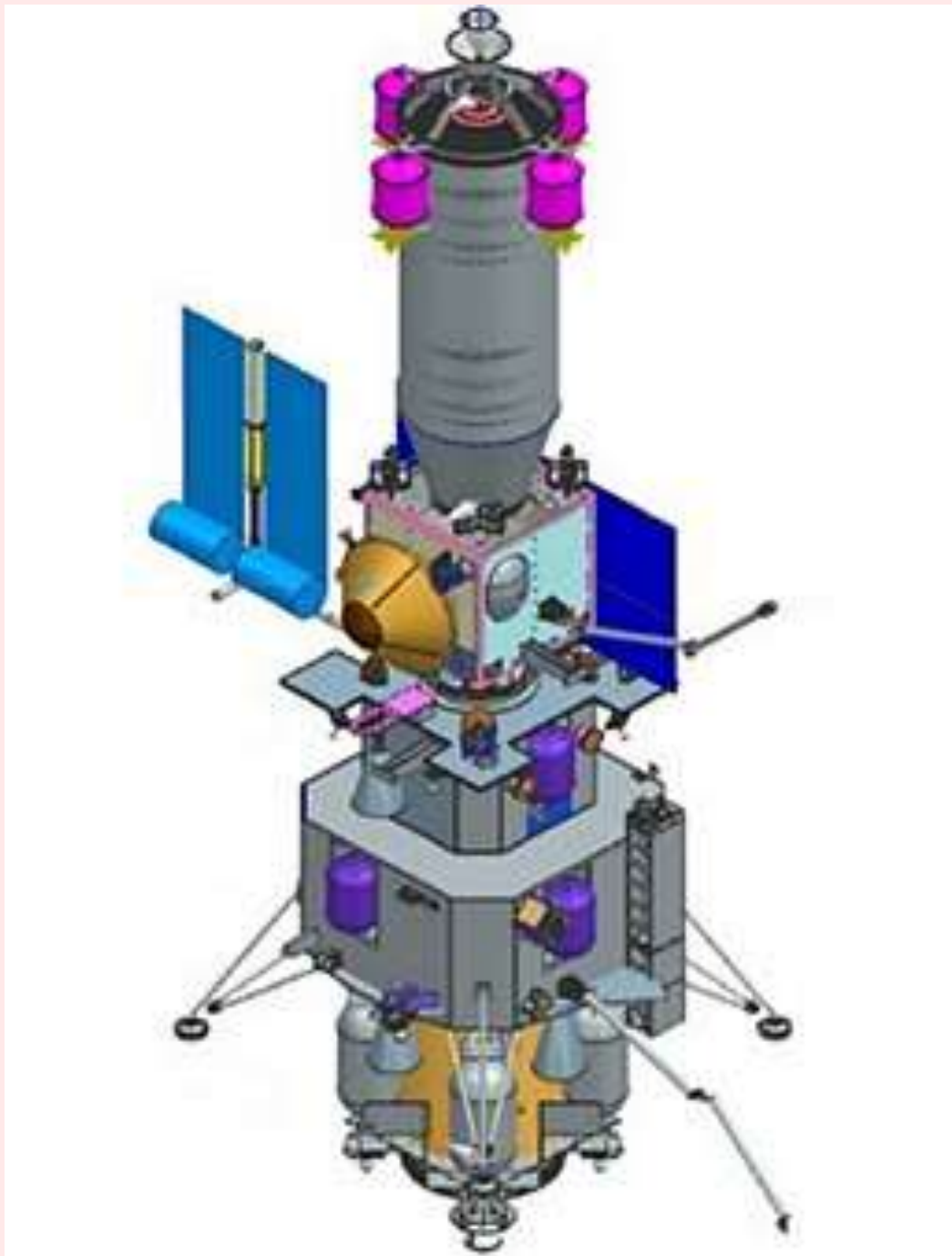


Space
Suit

Space Food
and Medicine

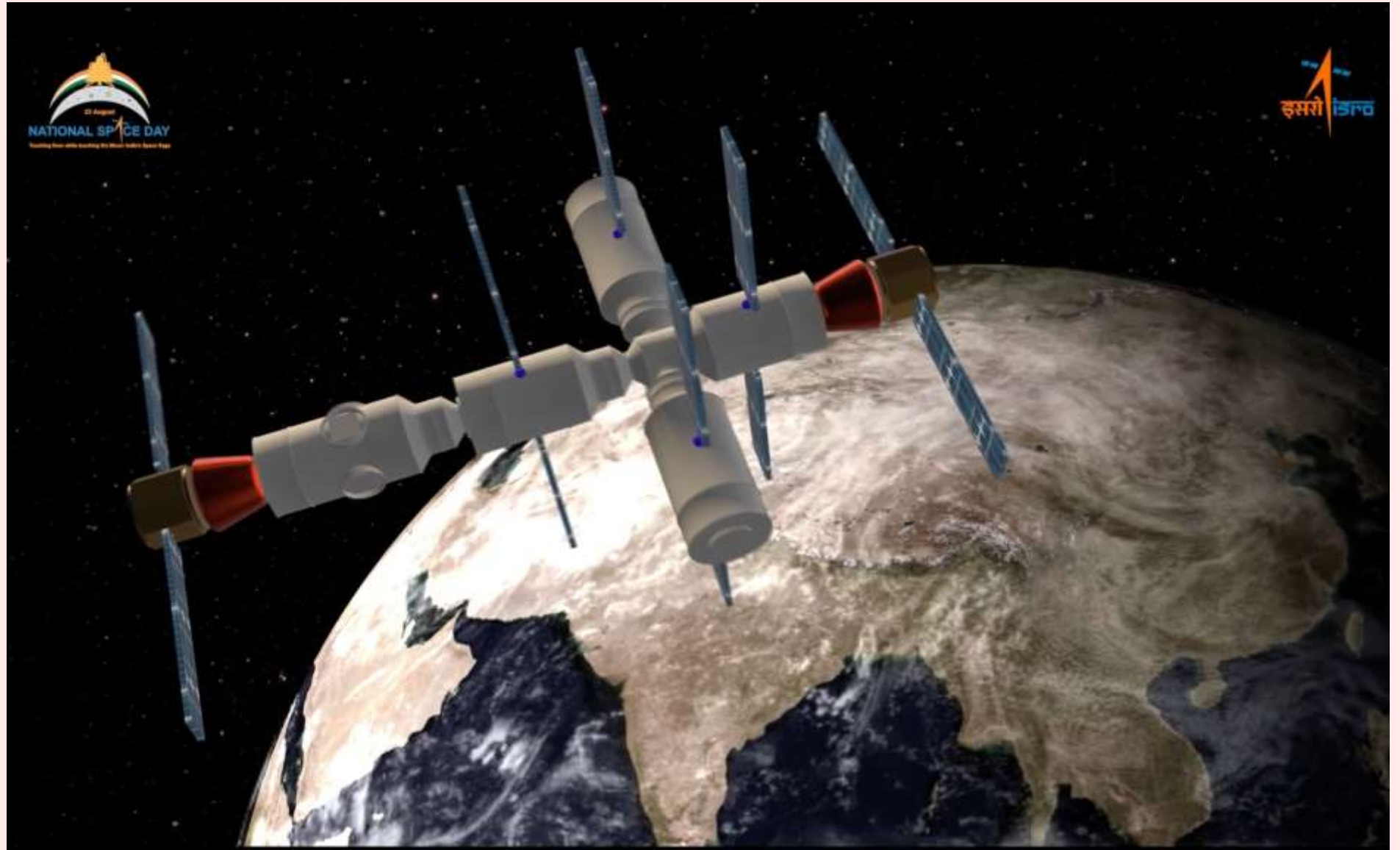
Ground
Control
System





Chandrayaan-4

Bharatiya Anthariksha Station



Next Generation Launch Vehicle



