INDIA'S SPACE PROGRAM

(AN OVERVIEW)

(Lecture–1)

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INDIA DECIDES TO GO INTO SPACE

- Background – Ground / Balloon Based Studies,

  Atmospheric Sciences, Cosmic Rays, Astrophysics

- Thumba Equatorial Rocket Launching Station (TERLS) in 1962

  Cooperation with NASA, USSR, CNES AND UK

  Rocket Experiments to Study Equatorial Aeronomy

  Meteorology and Astrophysics

- Population (1.06 Billion), Per capita GDP (550$), Illiteracy (39%),

  Population Below PL (30%)

  India with 16% Population, 2% Land, 1.5% Forest,

  Consumes 2% Energy, has 1.5% Global GDP.

  India Opts Space Technology for Rapid Socio-Economic Development

INDIAN SPACE ENDEAVOUR

There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the Moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally, and in the comity of nations, ***we must be second to none in the applications of advanced technologies to the real problems of man and society***

VIKRAM A. SARABHAI

BUDGET
Rs 3148 Cr/ annum

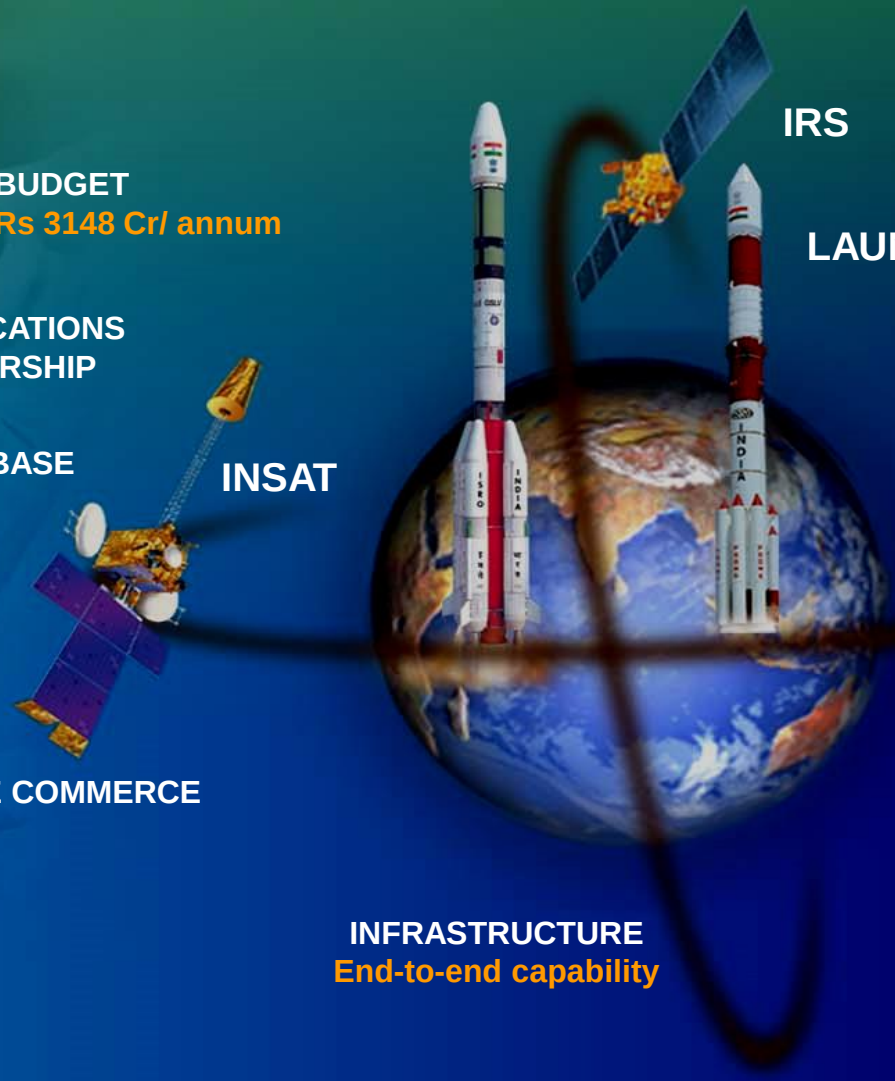
APPLICATIONS
LEADERSHIP

LARGE USER BASE

INSAT

INDUSTRY

SPACE COMMERCE



IRS

LAUNCHER

HUMAN RESOURCES
EXPERTISE
16500 strong

INTERNATIONAL
COOPERATION

SPACE ASSETS
Remote sensing &
Telecom satellite
Constellations

INFRASTRUCTURE
End-to-end capability

STATE OF THE ART
TECHNOLOGY

HUMBLE BEGINNING

- Establishment of Space Science Tech Center, Thumba-1965

  Rocket Technology Development – Centaur – Rohini

- Earth Station at Ahmedabad – 1968 / Space Applications Center 1972

  Landsat Earth Station – Hyderabad – 1978

- Krishi Darshan (80 Village near Delhi) – Remote Sensing Aerial Expts.

- Space Port at Sriharikota – 1970

- Start of SLV-3 Development

  Agreement with Russia for Launching Satellite

  Establishment of Satellite Centre at Bangalore-1972

- SITE Experiment with ATS-6 - 1975-76

  STEP using Symphony - 1976-77

TECHNOLOGY BUILD-UP

- INSAT Studies – PHILCO FORD / GE / MIT-LINCOLN

  Definition of INSAT

- Development of Sounding Rockets
- Successful Launch of Aryabhata – 1975
- Successful Launch of Bhaskara 1 & 2 - (1979, 1981)
- Successful Launch of APPLE – 1981
- Successful Launch of SLV-3 – 1981

START OF OPERATIONAL ERA

- Design of INSAT-1 Series

  Launch of INSAT-1A (1982), INSAT-1B (1983)

- Rapid Development of Communication, Broadcasting,

  Meteorology

- Launch of INSAT-1C (1988) and INSAT-1D (1990) to meet rapidly growing demands

- Launch of Operational IRS-1A (1988) and IRS-1B (1991)

  on VOSTOK

RAPID GROWTH

- Launch of INSAT-2 Series

  2A (1992), 2B (1993), 2C (1995), 2D (1997), 2E (1999)

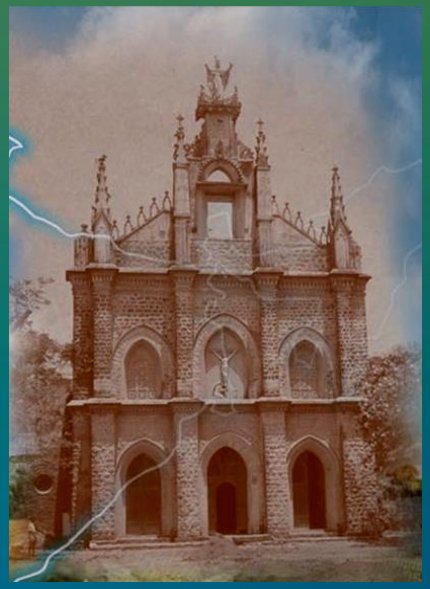
- INSAT-3 Series 3B (2000), 3C (2002), 3A (2003), 3E (2003)
- GSAT-1 (2001), GSAT-2 (2003) on GSLV
- INSAT-4 Series 4A (2005), 4C (2006)
- Launch of State-of-the-art IRS-1C (1995) and 1D (1997)
- Launch of IRS-P2 (1994), IRS-P3 (1996), IRS-P4 (1999), TES (2001) Kalpana (2002), Resourcesat (2003), Cartosat (2005), on PSLV.
- Launch of GSAT (2001, 2003), EDUSAT (2004), INSAT-4C (2006)

  on GSLV

Four Decades of Indian Space Program – 21 Launch Vehicle

Missions – 42 Satellite Missions

Sounding Rockets of ISRO



RH-75

FEATURES	RH- 200	RH-300	RH-300 MKII	RH-560 MKII
No. of stages	2	1	1	2
Length (m)	3.6	4.8	4.9	7.7
LOW (kg)	108	370	510	1350
Payload (kg)	10	60	70	100
Altitude (km)	85	100	150	550
Application	Meteorology	Middle Atm.	Middle Atm.	Ionosphere

SATELLITE EVOLUTION

Remote Sensing Satellites

- High resolution imaging
- Multiple payloads


MeghaTropiques

1700 Watts


RISAT

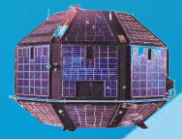

Cartosat – 1/2


Resourcesat - 1


IRS – 1C / 1D

35 Watts

BHASKARA


1979

39 Satellites

3000 Watts

36 Transponders

S, C, Ku Band

Ka Band


INSAT – 3 series


INSAT – 2 series


INSAT – 1 series

1 Transponder


APPLE

1981

C Band

- Multipurpose S/C platform
- Improved S/C Power
- Increased number of transponders

Communication Satellites

ISRO
Launchers

	SLV-3	ASLV	PSLV	GSLV
				
No. of stages	4 (core vehicle)	4 (with 2 Solid strap-on)	4 (with 6 Solid strap-on)	3 (With 4 liquid strap-on)
Propulsion	All Solid	All Solid	Solid & Liquid	Solid, Liquid, Cryogenic
Prop weights (t)	S1- 9, S2- 3.2, S3- 1.1, S4- 0.26	Strap-on: 2x9 S1- 9, S2 - 4.4, S3- 1, S4 - 0.23	Strap-on: 6x9 PS1- 139, PS2- 40, PS3- 7, PS4- 2.5	Strap-on: 4x40 GS1- 139, GS2- 40, CS- 12.5
Control system	SITVC& FTC, RCS, RCS, SPINUP	SITVC/ RCS (Strap-on), SITVC/RCS, RCS, RCS, SPINUP	SITVC(Strap-on), SITVC/RCS, Gimbal, FNC, Gimbal	Gimbal, SITVC, Gimbal, Gimbal/ RCS
Lift-off weight (t) Vehicle Height (m)	17 22	40 23.5	295 44	415 49
P/l Capability (kg)	40 (LEO)	150 (LEO)	1500 (SSO)	2200 (GTO)
No of flights	4 (79- 83)	4 (87- 94)	9 (93- 06)	4 (01- 06)

LAUNCH VEHICLE EVOLUTION

Flex Nozzle &
Gimbal Control
Multiple Satellite
Mission

Beyond 2000

CLG, Onboard RTD,
Strap-on Technology

1990s

Inertial system
Orbital mission

1980s

Solid propulsion
Open loop guidance

1960-1970s

Heavy Cryogenics
Large Boosters

Cryogenic Technology,
GTO Mission

Liquid Propulsion
Maraging Steel
Large Booster &
Upper Stage

Vertical
Integration
Bulbous Heat Shield

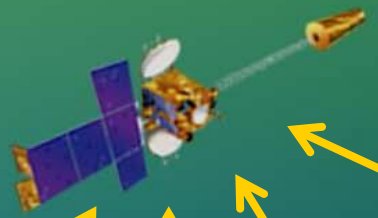
Two Launch Pads

Basics in various Disciplines;
Structures, Aerodynamics,
Avionics, Propellants etc..

INSAT APPLICATIONS

BROADCAST

- Television Broadcasting
- Direct To Home (DTH)
- TV & Radio Networking



COMMUNICATION

- Speech Circuits On Trunk Routes
- VSAT Connectivity

METEOROLOGICAL

- Meteorological Imaging
- Data Collection Platform
- Disaster Warning

OTHERS

- Mobile Satellite Service
- Search and Rescue
- Satellite Navigation

DEVELOPMENTAL

- Tele-health
- Tele-education
- Emergency Communication

EARTH OBSERVATION - APPLICATIONS

AGRICULTURE & SOIL

- Crop Acreage & Production Estimation
- Soil & Land Degradation Mapping
- Watershed Development
- Horticulture Mission for North-East

FOREST, ENVIRONMENT, BIO

- Forest Cover & Type Mapping
- Forest Fire and Risk Mapping
- Biodiversity Characterisation
- Environmental Impact Studies

WATER

- Potential Drinking Water Zones
- Command Area Management
- Reservoir Sedimentation

LAND

- Landuse/Land Cover Mapping
- Wasteland Mapping
- Urban Sprawl Studies
- Large Scale Mapping

WEATHER & CLIMATE

- Extended Range Monsoon Forecasting
- Ocean State Forecasting
- Regional Climate Model

OCEAN

- Potential Fishing Zone (PFZ)
- Coastal Zone Mapping

DISASTER SUPPORT

- Flood Damage Assessment
- Drought Monitoring
- Land Slide Hazard Zonation

INDIA'S SPACE LAUNCHES

No	Launch Date	Spacecraft	Mass (Kg.)	Launcher	Orbit (Perigee/apogee)	Launch Site	Remarks
1.	Apr 19, 1975	Aryabhata	360	Intercosmos	562/620 km	Kapustin Yar, USSR	Mission Completed
2.	June 7, 1979	Bhaskara-I	440	Intercosmos	557/592 km	Kapustin Yar, USSR	Mission Completed
3.	Aug 10, 1979	RTP	35	SLV3-E1	----	SHAR, India	Launch Failure
4.	July 18, 1980	Rohini-RS1	35	SLV3-E2	308/915 km	SHAR, India	Mission Completed
5.	May 31, 1981	Rohini-RS-D1	39	SLV3-D1	183/426 km	SHAR, India	Mission Completed
6.	June 19, 1981	APPLE	670	Ariane-3	GSO 102°E	Kourou, F. Guyana	Mission Completed
7.	Nov 20, 1981	Bhaskara-2	444	Intercosmos	550/590 km	Kapustin Yar, USSR	Mission Completed
8.	Apr 10, 1982	INSAT-1A*	1150	Delta	GSO 74°E	Cape Canaveral	Failed after 5 Months
9.	Apr 17, 1983	Rohini-RS-D2	42	SLV3-D2	388/852 km	SHAR, India	Mission Completed
10.	Aug 30, 1983	INSAT-1B*	1190	Space Shuttle	GSO 74°E	Cape Canaveral	Mission Completed
11.	Mar 24, 1987	SROSS-1	145	ASLV-D1	----	SHAR, India	Launch Failure
12.	Mar 17, 1988	IRS-1A	975	Vostok	904 km, Polar	Baikonur, USSR	Mission Completed
13.	July 13, 1988	SROSS-2	149	ASLV-D2	----	SHAR, India	Launch Failure
14.	July 21, 1988	INSAT-1C*	1190	Ariane-4	GSO 93.5°E	Kourou, F. Guyana	Operated for 15 months

*Satellites procured from outside India, in this case from Ford Aerospace Communication Corporation (FACC), USA

INDIA'S SPACE LAUNCHES

Contd..2

No	Launch Date	Spacecraft	Mass (Kg.)	Launcher	Orbit (Perigee/apogee)	Launch Site	Remarks
15.	June 12, 1990	INSAT-1D*	1292	Delta	GSO 83°E	Cape Canaveral	Mission Completed
16.	Aug 29, 1991	IRS-1B	990	Vostok	904 km, Polar	Baikonur, USSR	Mission Completed
17.	May 20, 1992	SROSS-C	106	ASLV-D3	270/433 km	SHAR, India	Mission Completed
18.	July 10, 1992	INSAT-2A	1905	Ariane-4	GSO 74°E	Kourou, F. Guyana	Now in inclined orbit
19.	July 23, 1993	INSAT-2B	1932	Ariane-4	GSO 93.5°E	Kourou, F. Guyana	In Operation
20.	Sept 20, 1993	IRS-P1	847	PSLV-D1	----	SHAR, India	Launch Failure
21.	May 4, 1994	SROSS-C2	113	PSLV-D4	438/938 km	SHAR, India	Mission Completed
22.	Oct 15, 1994	IRS-P2	804	PSLV-D2	802/874 km, Polar	SHAR, India	Mission Completed
23.	Dec 7, 1995	INSAT-2C	2020	Ariane-4	GSO 93.5°E	Kourou, F. Guyana	Mission Completed
24.	Dec 28, 1995	IRS-1C	1250	Molniya	817 km, Polar	Baikonur, USSR	In Operation
25.	Mar 21, 1996	IRS-P3	922	PSLV-D3	817 km, Polar	SHAR, India	In Operation
26.	June 4, 1997	INSAT-2D	2070	Ariane-4	GSO 74°E	Kourou, F. Guyana	Failed after 4 Months
27.	Sept 29, 1997	IRS-1D	1203	PSLV-C1	727/821 km, Polar	SHAR, India	In Operation
28.	Apr 3, 1999	INSAT-2E	2550	Ariane-4	GSO 83°E	Kourou, F. Guyana	In Operation

*Satellites procured from outside India, in this case from Ford Aerospace Communication Corporation (FACC), USA

INDIA'S SPACE LAUNCHES

Contd..3

No	Launch Date	Spacecraft	Mass (Kg.)	Launcher	Orbit (Perigee/apogee)	Launch Site	Remarks
29.	May 26, 1999	OCEANSAT-1	1282	PSLV-C2	720, Polar	SHAR, India	In Operation
30.	Mar 22, 2000	INSAT-3B	2070	Ariane-4	GSO 83°E	Kourou, F. Guyana	In Operation
31.	April 18, 2001	GSAT-1	1540	GSLV-D1	GSO	SHAR, India	Inclined Orbit
32.	Oct 22, 2001	TES	1108	PSLV-C3	568 km, Polar	SHAR, India	In Operation
33.	Jan 24, 2002	INSAT-3C	2650	Ariane-4	GSO 74°E	Kourou, F. Guyana	In Operation
34.	Sep 12, 2002	KALPANA-1	1060	PSLV-C4	GSO	SHAR, India	In Operation
35.	April 4, 2003	INSAT-3A	2950	Ariane-5	GSO	Kourou, F. Guyana	In Operation
36.	May 5, 2003	GSAT-2	1825	GSLV-D2	GSO	SHAR, India	In Operation
37.	Sep 28, 2003	INSAT-3E	2775	Ariane-5	GSO	Kourou, F. Guyana	In Operation
38.	Oct 17, 2003	RESOURCESAT-1	1360	PSLV-C5	Polar	SHAR, India	In Operation
39.	Sep 20, 2004	EDUSAT	1950	GSLV-F1	GSO	SHAR, India	In Operation
40.	May 5, 2005	CARTOSAT-1	1560	PSLV-C6	618 km, Polar	SHAR, India	In Operation
41.	Dec 22, 2005	INSAT-4A	3086	Ariane-5	GSO	Kourou, F. Guyana	In Operation
42.	July 10, 2006	INSAT-4C		GSLV	GSO	SHAR, India	Launch Failure

*Satellites procured from outside India, in this case from Ford Aerospace Communication Corporation (FACC), USA

Four Decades of Indian Space Programme

20 Launch Vehicle Missions
launched 25 satellites

November 21, 1963

TODAY, 2005

SLV-3 ASLV

Self reliance in launching

42 + 4 Spacecraft Missions

Self reliance in building satellites

PSLV 8 GSLV 3

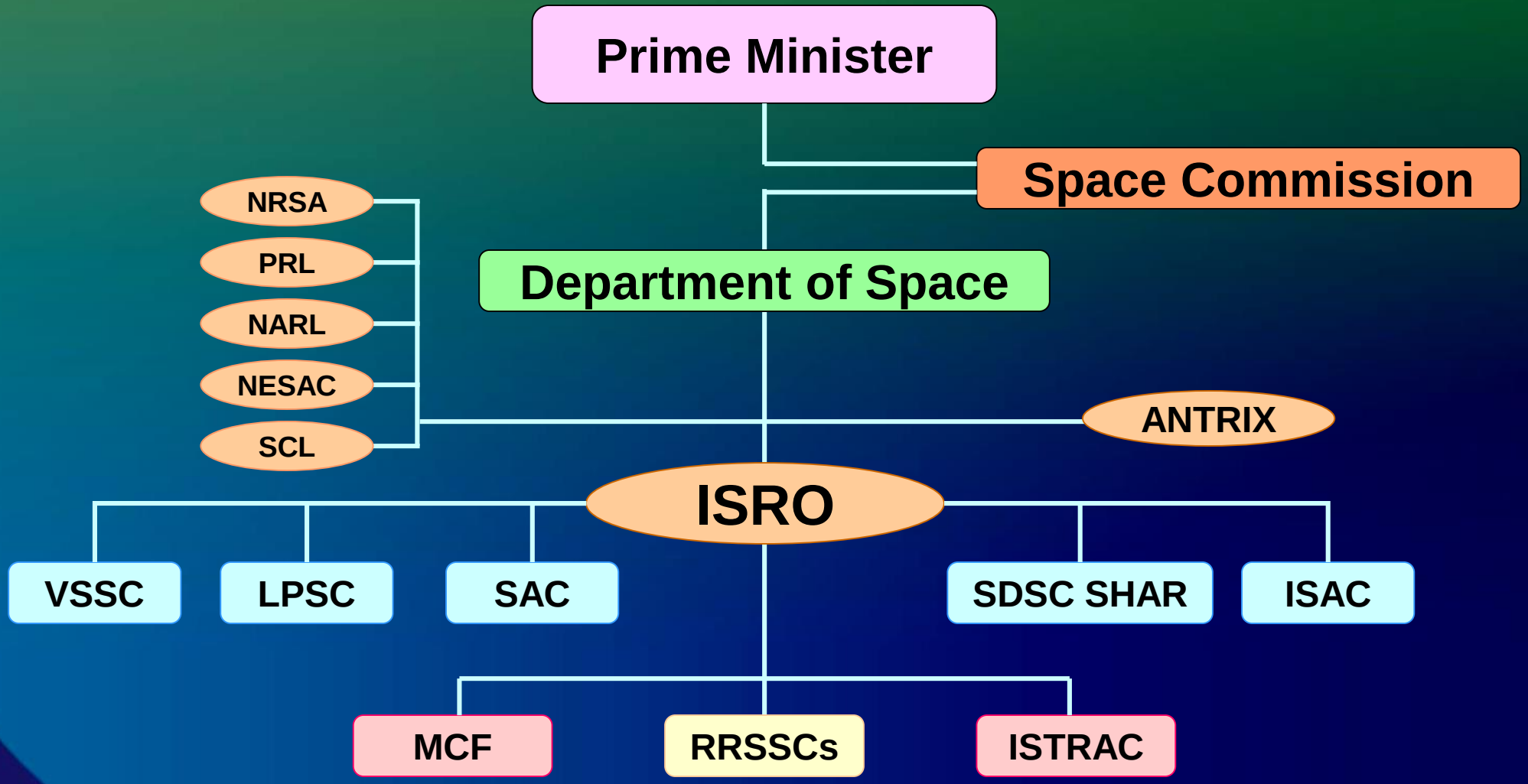
ONE AMONG THE SIX NATIONS

LAUNCH VEHICLE

SATELLITE

APPLICATIONS

Organisation Chart

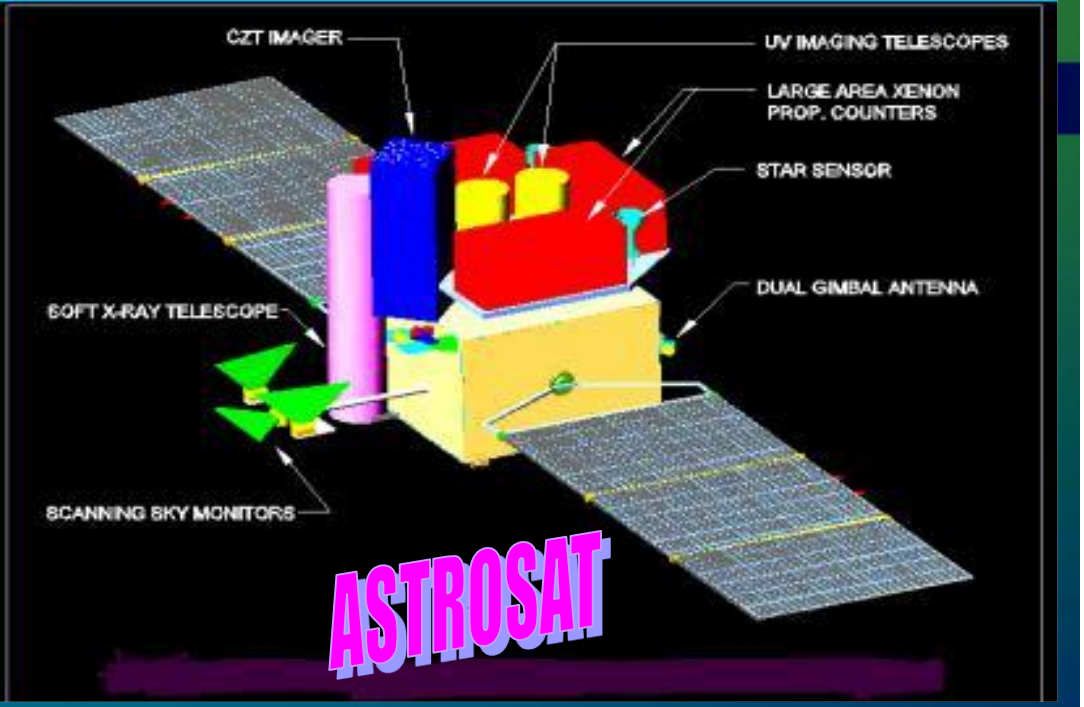


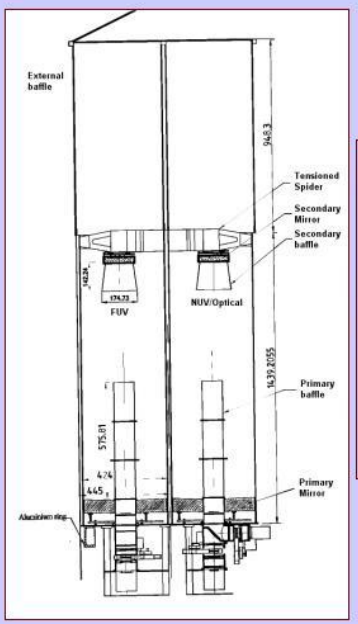
SPACE CENTRES AND UNITS IN INDIA

GLIMPSES OF THE FUTURE

[Expenditure 1963 to date – 250 Billion Rupees or about 9 Billion Dollars]

- Development of Heavy Lift Launchers
- Reusable Launch Vehicle
- Multi-wavelength Astro-Physical Observatory
- Planetary Missions (MARS, Asteroid)
- DTH High Definition TV, Education & Telemedicine Networking
- Very High resolution, High Spectral Imaging in VIS, IR & SAR
- Sustainable Development
- Effective Disaster Management

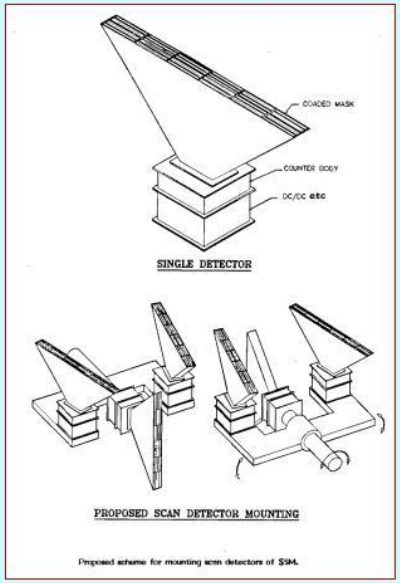




ASTROSAT: Ultra Violet Imaging Telescope (UVIT)

Telescope: Twin telescope of 40cm dia
Wavelength bands:
Channel I: 120-240 nm
Channel II:240-360 nm & 500-600 nm
F-ratio: 12.5
Detector: Photon counting detectors
FOV: 0.5 degree
Absolute pointing: < 30 arcsec
Pointing Accuracy: ~1 arcsec

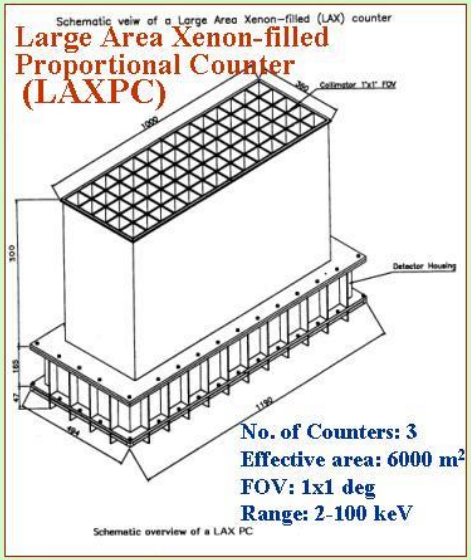
ASTROSAT: SSM PAYLOAD



Scanning X-Ray Sky Monitor (SSM)

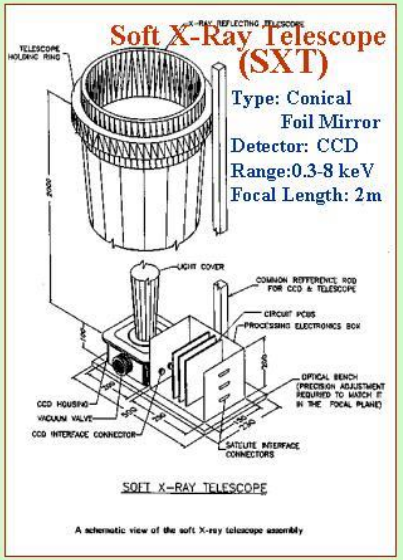
Energy Range: 2-10 keV
Coded Mask Cameras: 3 Nos.
Position Sens. Prop. Counters: 3 Nos.
Effective area (each detector): 60 cm^2
Anode cells (each detector): 8 Nos.
FOV: 90x90 deg in steps of 90x6 deg
Weight: ~50 kg

ASTROSAT: LAXPC AND SXT PAYLOADS



Large Area Xenon-filled Proportional Counter (LAXPC)

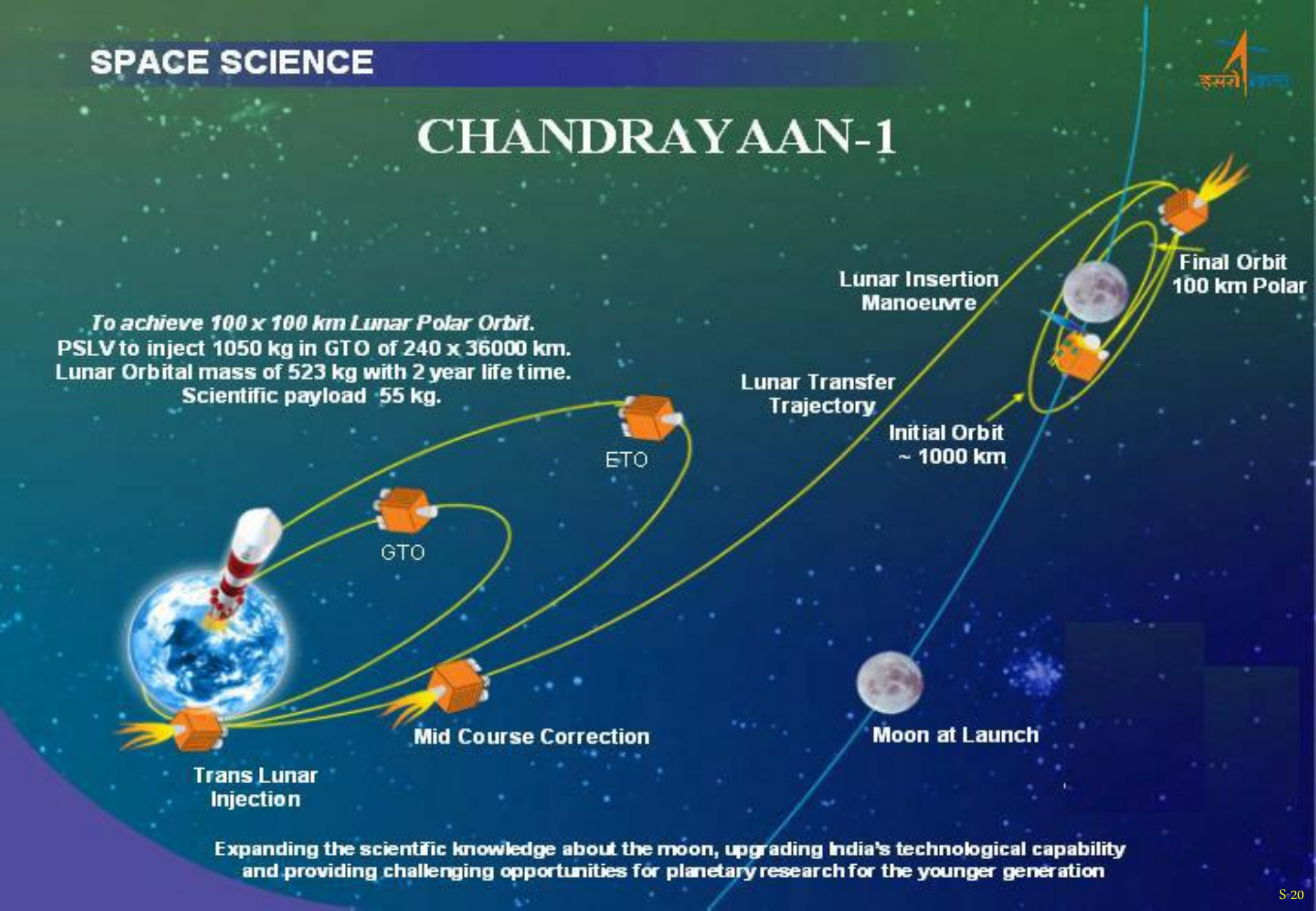
No. of Counters: 3
Effective area: 6000 m^2
FOV: 1x1 deg
Range: 2-100 keV



Soft X-Ray Telescope (SXT)

Type: Conical Foil Mirror
Detector: CCD
Range:0.3-8 keV
Focal Length: 2m

CHANDRAYAAN-1



Expanding the scientific knowledge about the moon, upgrading India's technological capability and providing challenging opportunities for planetary research for the younger generation

Thanks