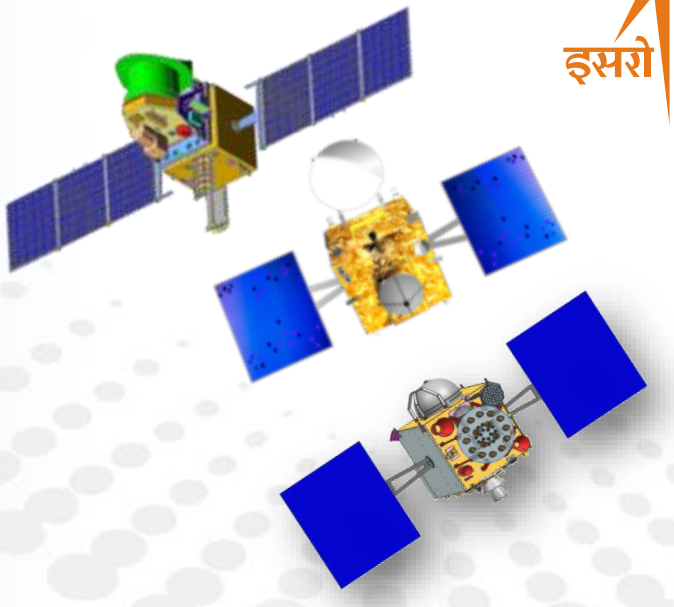
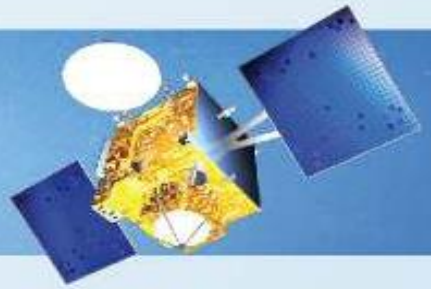


# INDIAN SPACE PROGRAMME

*Dr. SV SHARMA*
GROUP DIRECTOR, PPEG
ISRO SATELLITE CENTRE



# PRESENTATION OVERVIEW

1. INDIAN SPACE PROGRAMME OVERVIEW
2. INTRODUCTION TO SATELLITE TECHNOLOGY
3. COMMUNICATION SATELLITE PROGRAMME
4. NAVIGATION SATELLITE PROGRAMME
5. REMOTE SENSING & SMALL SATELLITE PROGRAMME
6. SPACE SCIENCE SATELLITE PROGRAMME
7. MAKING OF A SATELLITE
8. LAUNCH VEHICLES & LAUNCHERS

# INDIAN SPACE PROGRAMME OVERVIEW

# INDIAN SPACE ENDEAVOUR

VIKRAM A. SARABHAI

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.*


HUMAN RESOURCES
EXPERTISE
16500

INTERNATIONAL
COOPERATION

SPACE ASSETS
Remote sensing
Communication
Met
Navigation
Space science
Lunar

INFRASTRUCTURE
End- to- end capability

BUDGET
Rs 6000-Cr/ annum

SPACE COMMERCE

INDUSTRY
/ACADEMIA

STATE OF THE ART TECHNOLOGY

# NATIONAL SPACE SYSTEMS

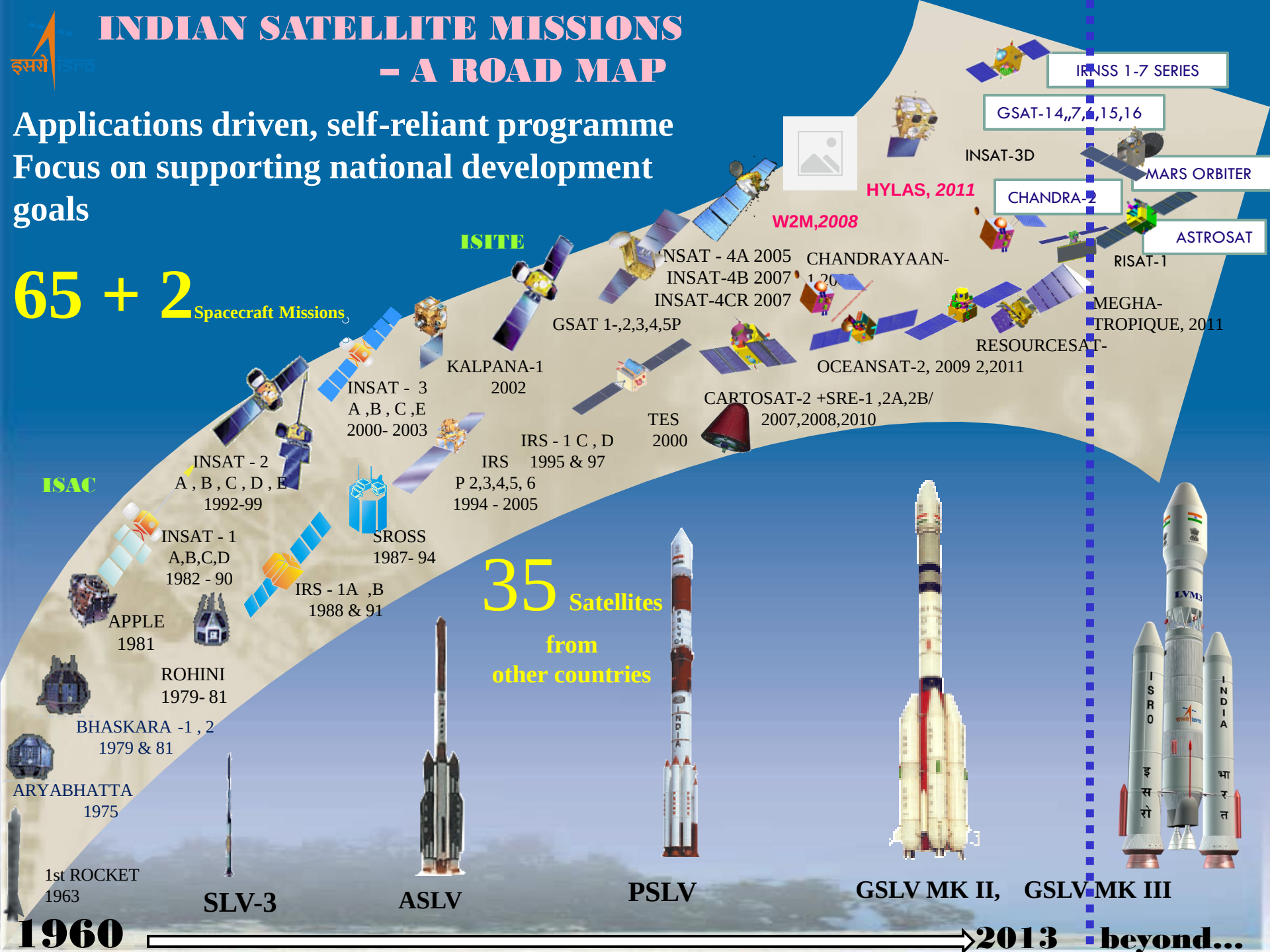
## LAUNCH VEHICLES

## SPACECRAFT MISSIONS

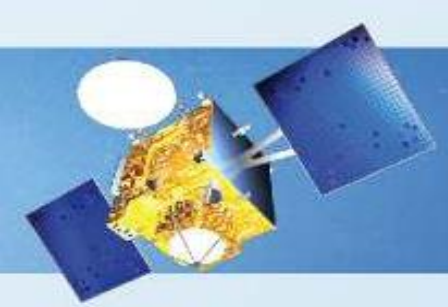
# INDIAN SATELLITE MISSIONS – A ROAD MAP

**Applications driven, self-reliant programme**
**Focus on supporting national development goals**

**65 + 2** Spacecraft Missions



# INTRODUCTION TO SATELLITE TECHNOLOGY



# INTRODUCTION TO SATELLITE TECHNOLOGY

## What is a Satellite?

**A Satellite is basically any object that revolves around a planet in circular or elliptical path.**

## Types of Satellite

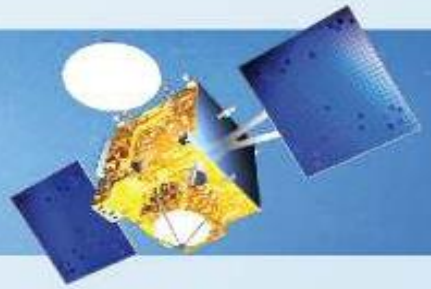
**1.Natural Satellite  For example Moon is earth's natural satellite**
**2. Artificial Satellite  For example man made satellites.**

## What is an Orbit?

**The imaginary path of a satellite is an orbit. In the orbit, the farthest point from Earth is the APOGEE and the nearest point is the PERIGEE.**

**Orbital Velocity: Orbital Velocity is the velocity needed to achieve balance between gravity's pull on the satellite and the inertial of the satellite's motion. – Keeps the satellite's tendency to keep going.**

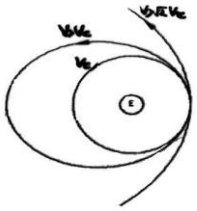
**Earth Orbital Velocity > 7.8 Km / sec ; Earth escape velocity > 11.2 Km / sec**



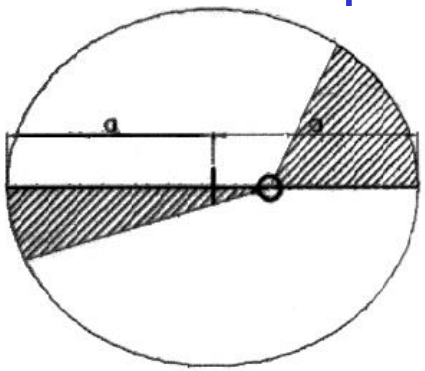
# KEPLER'S LAWS

***- Governing rules of planetary motion in solar system.***

1. The orbit of each planet is an ellipse with sun at one focus



2. The line joining the planet to sun sweeps equal areas in equal times.



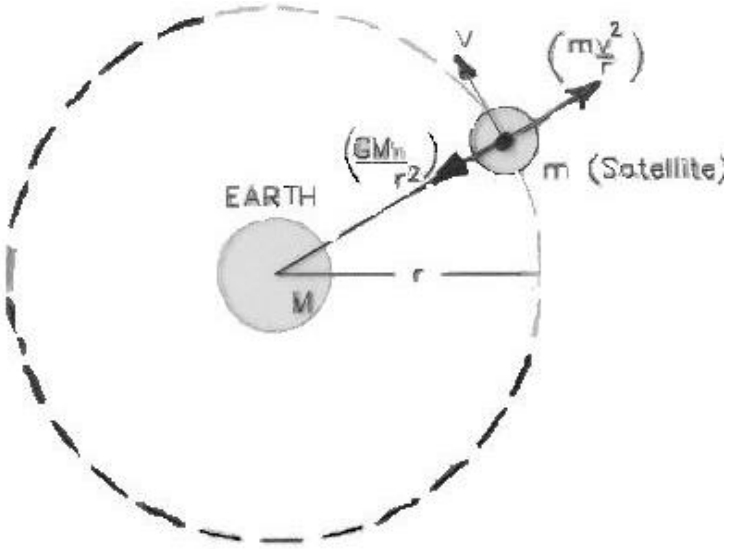
3. Average distance of a planet from the sun uniquely determines the length of time required for the planet to complete one orbital revolution around the sun.

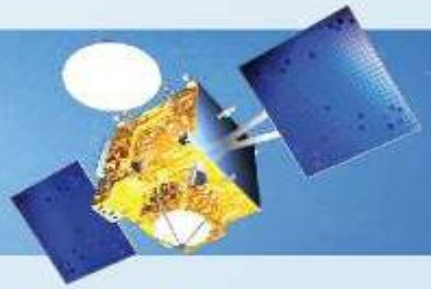
# NEWTON'S LAW OF GRAVITATION

**The Law states that " If two particles of masses 'M 'and 'm' are situated at distance of 'r' apart , each particle attracts the other with a force GMm, where G is an Universal constant.The forces along the line joining the particles is –**

$F = m V^2 / r = G.M.m / r^2$

Where $V_c = GM / r$ =Circular Orbit Velocity



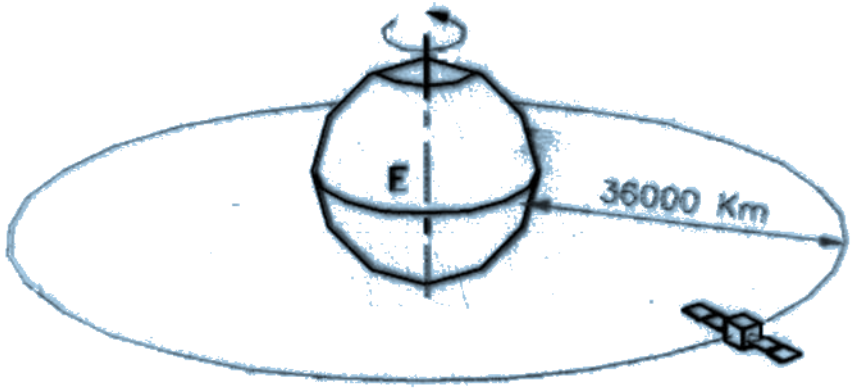


# MOST USEFUL ORBITS

**Equatorial Orbits :**

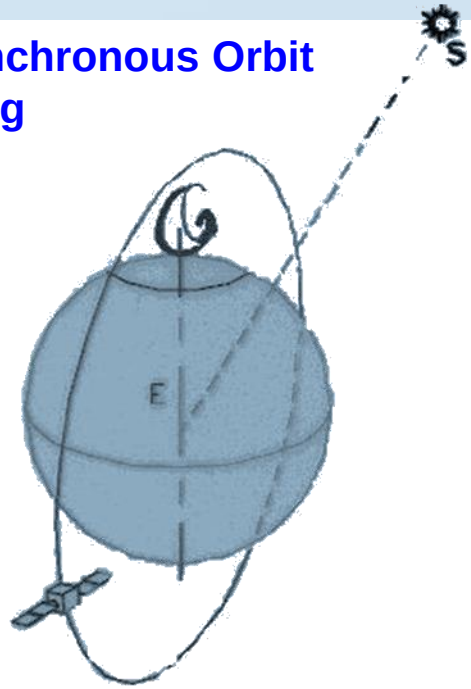
**Geo – Stationary orbit – 24 hour period**

- **for communication application**




**Polar Orbit – Sun Synchronous Orbit**

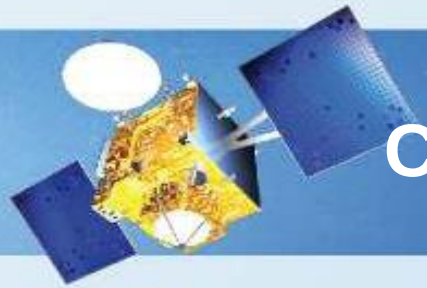
- **for remote sensing**




**The most commonly used orbits for practical applications are :**

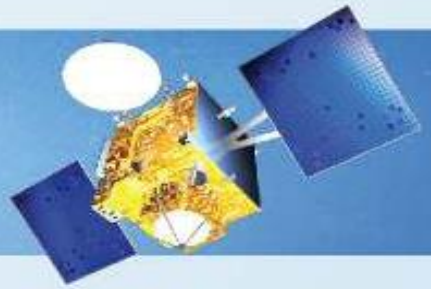
1. **Geo-stationary orbit : at 36000 Km above the equator were the satellite has an orbital period of 24 hrs coinciding with the earth rotation, ideally suited for communication operations for wide area on earth, as satellite appears stationary over the geographic region.**

2. **Polar Sun synchronous Orbit with Sun, Earth centre and the Satellite always in a plane and the satellite goes around the earth over the poles at a distance of 600 to 950 Km height, will cross the equator always at a fixed time, making it suitable for remote sensing surveys under same Sun illumination conditions**



# COMPLEXITY IN SPACECRAFT DESIGN

1. Satellites have to work in hostile space environment for several years
2. All parts/subsystems used in the satellite should have very high reliability along with space quality standards.
3. Selection of parts/components, Extensive qualification of process and fabrication, elaborate testing of various subsystems under different environment conditions are pre-requisites to ensure long life and reliability
4. Time consuming and expensive : requires special expertise and facilities. All the facilities have been established
5. Sophisticated design tools have been developed in the centre for design , analysis and testing of satellites



# SPACECRAFT SYSTEMS

**Spacecraft**

**Mainframe**

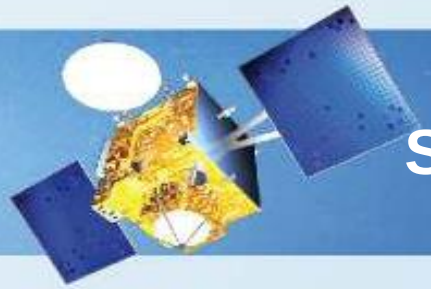
**Payload**

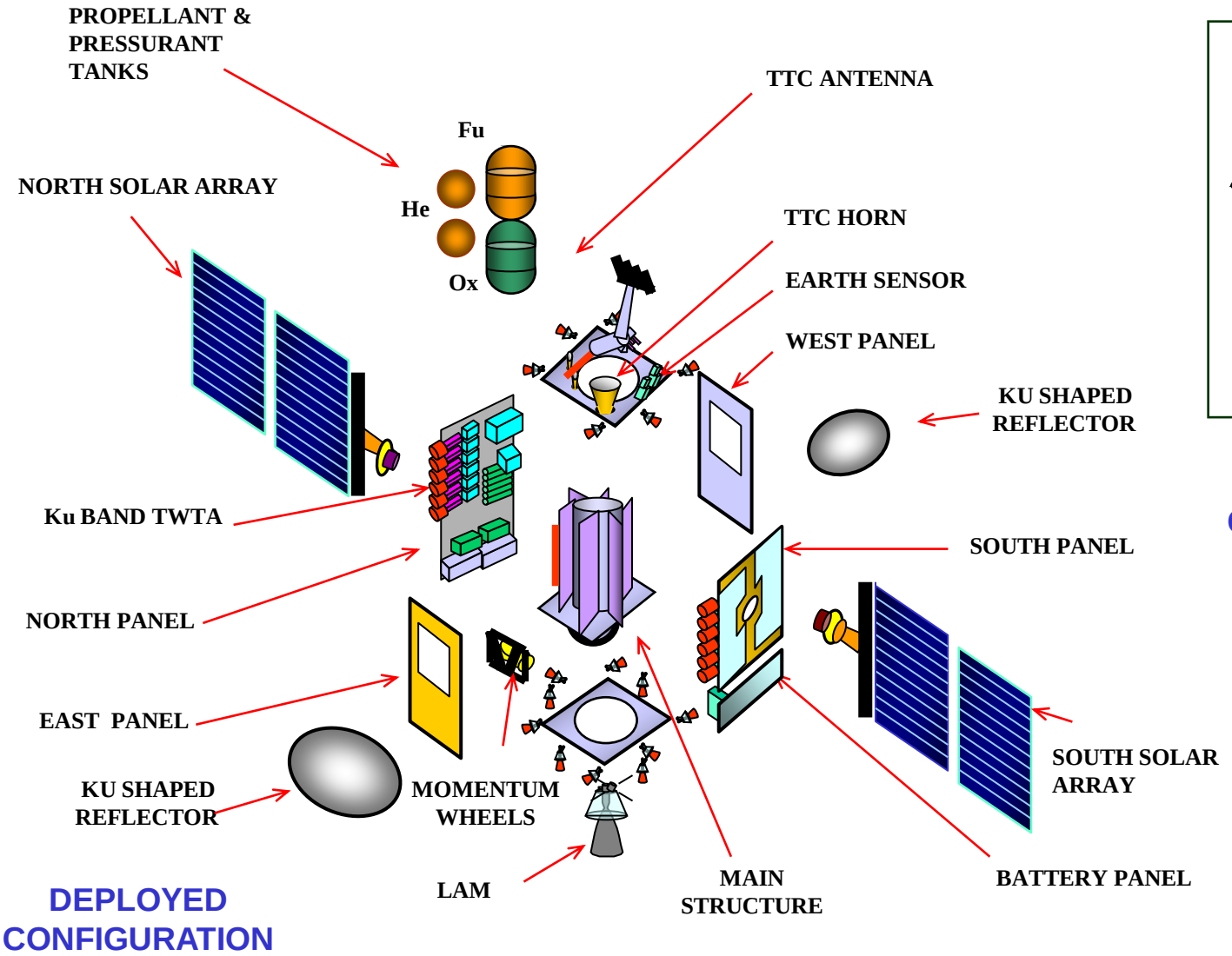
**AIT**
**QA**
**MISSION**

- STRUCTURE
- THERMAL
- MECHANISM
- POWER
- TTC - BB
  TTC - RF
- OBC
- AOCE
- SENSORS
- ACTUATORS
- PROPULSION
- WHEELS / TORQUERS

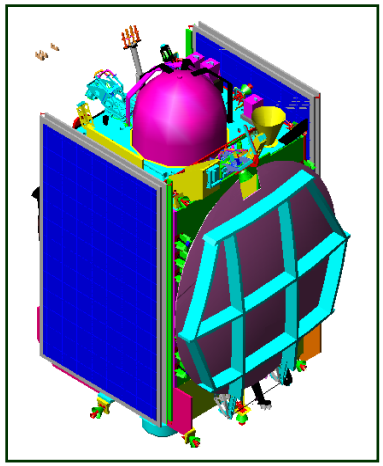
- COMMUNICATION
- REMOTE SENSING
- NAVIGATION
- SCIENTIFIC
- MANNED MISSION

# SPACECRAFT DEPLOYED CONFIGURATION

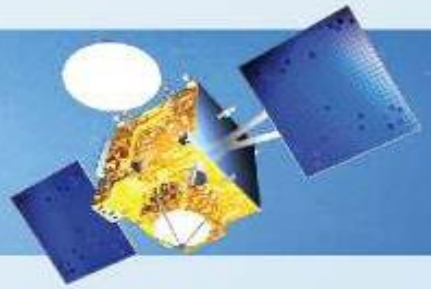





DEPLOYED CONFIGURATION



STOWED CONFIGURATION



# WORK CENTRES

**SAC**
Payloads
(Mission specific)

**LPSC**
Propulsion Elements

**IISU**
IRU elements

**VSSC**
Composite Panels
Reflectors, Pyro
cutters etc

**MCF**
S/C Operations
GEO

**ISTRAC**
S/C Operations
LEO

**ISAC**
Spacecraft Programme
Main Frame + AIT
Project Management

**SDSC**
Launch and support
Services

**NRSC**
Data collection (Images)+
Products

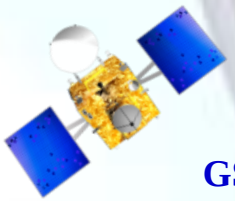
**MISSION LIFE CYCLE**

# COMMUNICATION SATELLITE PROGRAMME

# COMMUNICATION SATELLITE PROGRAMME

*-Uniquely tailored to develop innovative grass root level applications*

## I-1K BUS



**GSAT-12**
*15.07.11*
*12.Ext C*

**Kalpana-1**
12.09.02
VHRR

## I-2K BUS

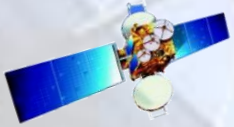
**INSAT-3D**
26-07-13

**HYLAS**
*26.11.11*

**INSAT-4CR**
02.09.07
*12 Ku*

**INSAT-3E**
28..9.03
24 Nor C, 12 Ext C

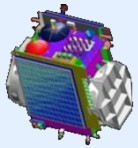
**INSAT-3A**
10.04.03
*I12 C, 6 Xc, 6 Ku,*
*VHRR, DRT, SAR*



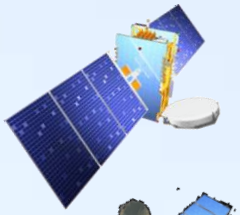
**INSAT-3C**
24.01.02
*12 x C, 3 Ku, 1 MSS*

**INSAT-3B**
22.03.00
*12 x C, 3 Ku, 1 MSS*

## I-3K BUS



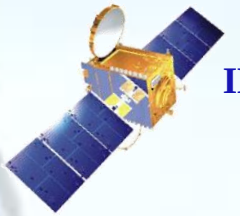
**GSAT-10**
*29.09.12*
12. Ku, 12 Nor-
C,6 Low-Ext C



**GSAT-8**
*21.05.11*
*24 Ku*

**W2M**
*21.12.08*
*32 Ku*

**INSAT-4B**
12.03.07
*12 Ku, 12 C*

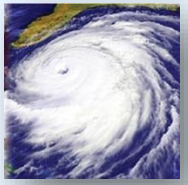


**INSAT-4A**
22.12.05
*12 Ku, 12 C*

## APPLICATIONS

**Telecommunication**

**TV Broadcasting**



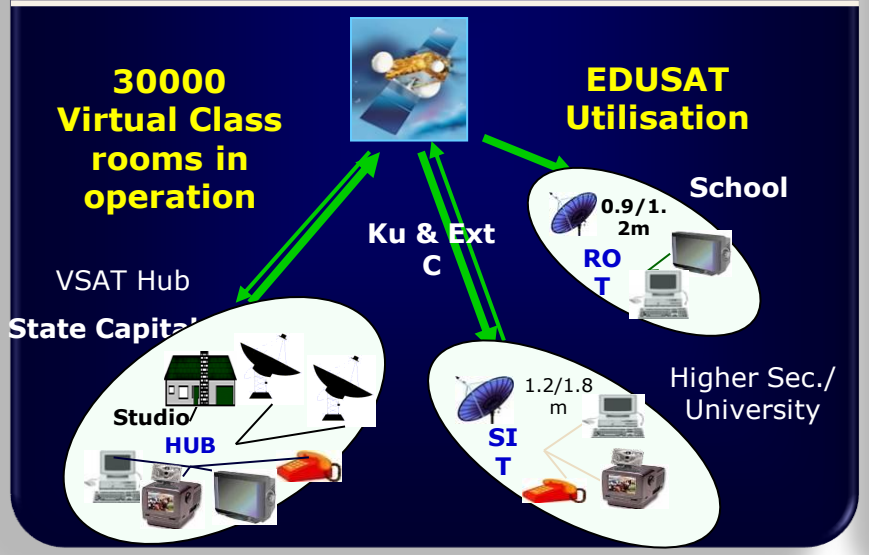
**Meteorology**

- C-band Fixed Satellite Service ; Ku-band Fixed Satellite Services ; Broadcast Satellite Services ; and Mobile Satellite Services
- World's largest domestic satellite communication system (198 transponders & growing)

# INSAT APPLICATIONS

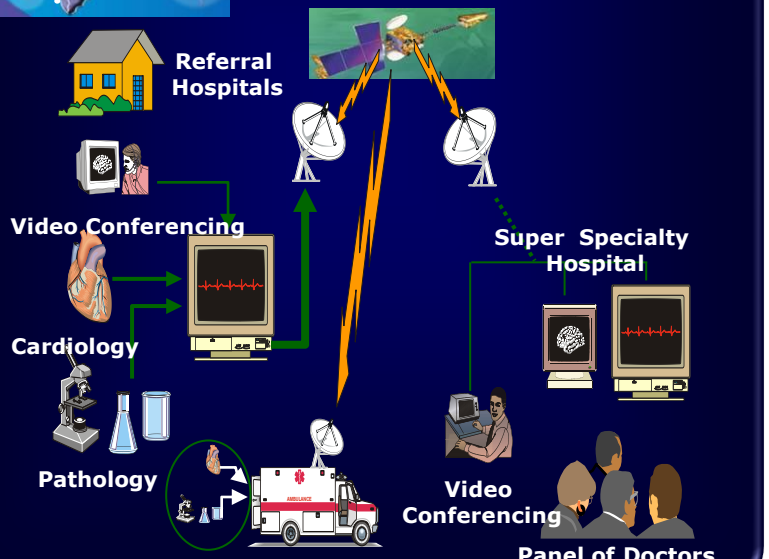
## Tele-Education

- Training & Development Communication Channel (TDCC - 1995)
- Jhabua Development Communications Project (JDCP - 1996)
- GRAMSAT Pilot Project (GPP)




## Tele-Medicine

- >278 Hospitals
- ~235 Dist/ Rural
- > 43 Super Specialty
- 10 Mobile
- *> 3 Lakh patients treated*




### BROADCAST

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

### COMMUNICATION

- Speech Circuits on Trunk Routes
- VSAT Connectivity

### OTHERS

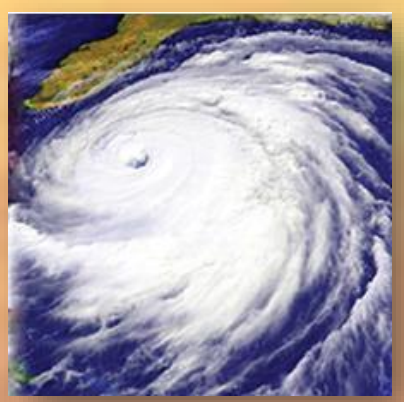
- Mobile Satellite Service
- Search and Rescue
- Satellite Navigation

# INSAT-3D

INSAT-3D Spacecraft is a multipurpose spacecraft with high resolution imager and sounder systems for storm warning and improved atmospheric observations and data dissemination capabilities. It also provides communication services. DRT SAS & R transponders will be providing continuity to some of the INSAT services.

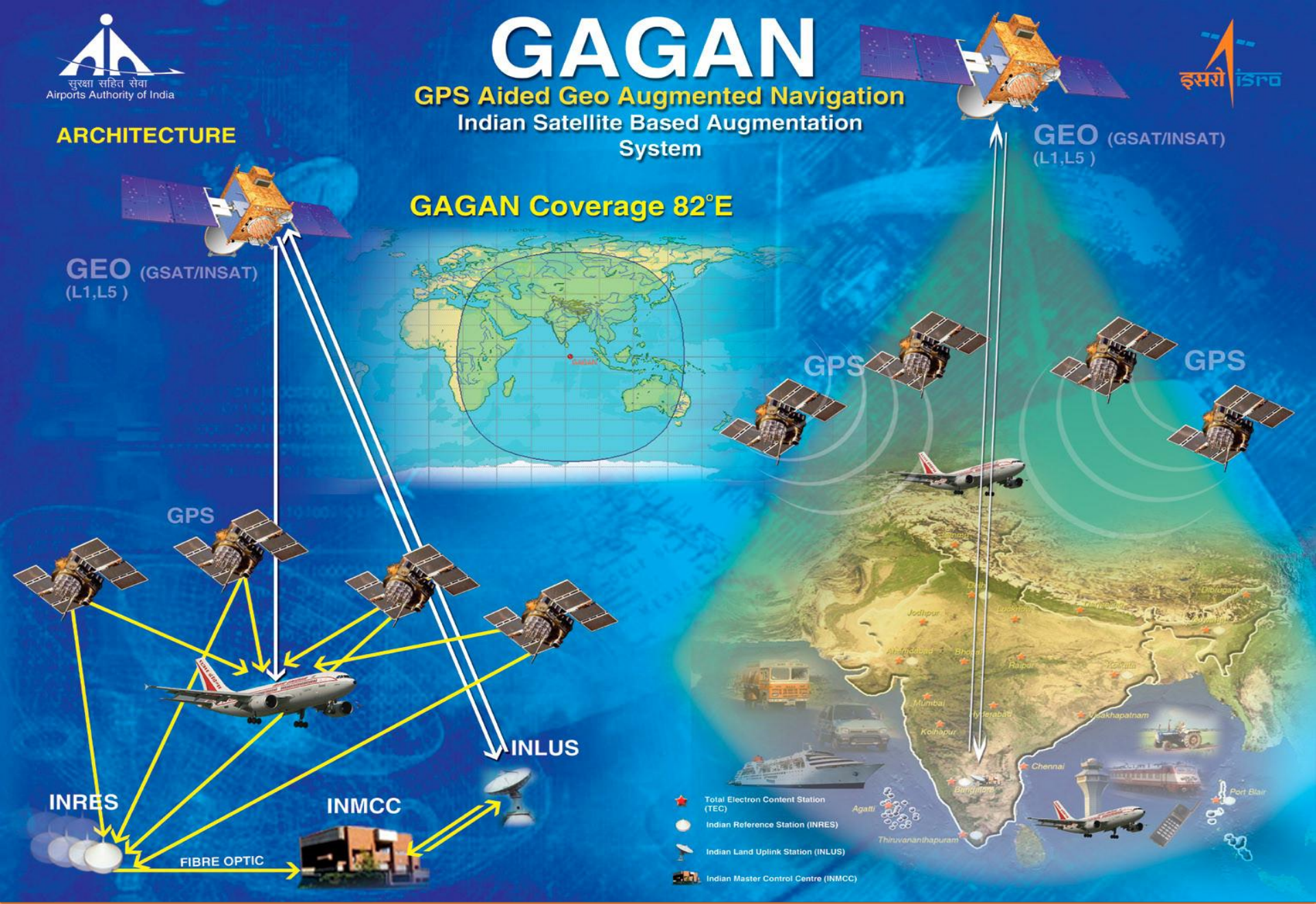
## SPACECRAFT SALIENT FEATURES

| | | |
|---|---|---|
| Orbital Location | : | 82 Deg East |
| Bus | : | I-2K Derived Bus |
| Payload | : | 6 channel Imager, 19 channel Sounder and DRT, SAS&R payloads |
| Power | : | 1100 Watts |
| Spacecraft Mass | : | 2100 Kgs |
| Mission Life | : | 7 Years |

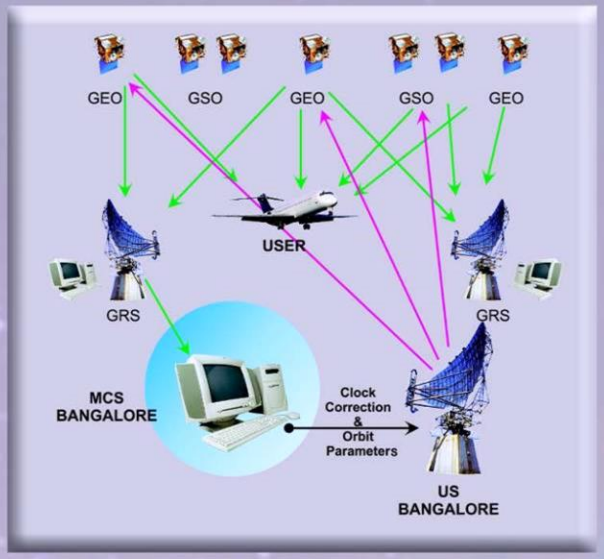


Weather Information

# NAVIGATION SATELLITE PROGRAMME




**Navigation - Air, Sea and Land, Positioning Applications, Survey, Image Correction, GIS, Timing, Surveillance/fleet monitoring**



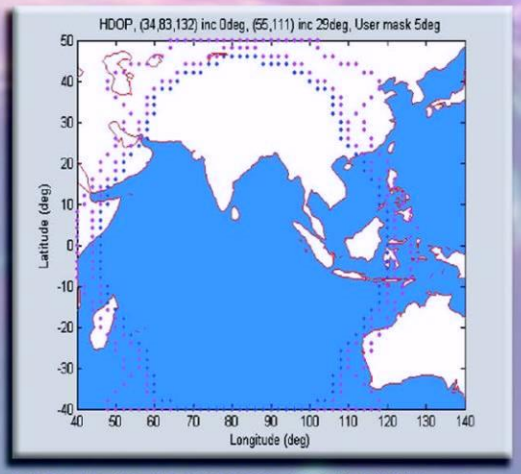
IRNSS SPACE SEGMENT

# IRNSS

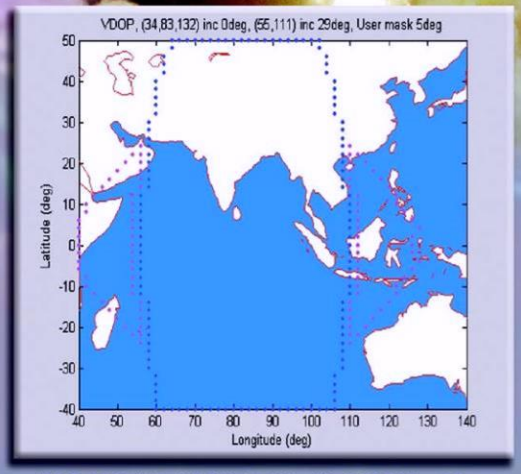
## INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM

### IRNSS CHARACTERISTICS

- A Regional Navigation System for Indian Region
- An independent, self-reliant and civilian system
- 7 Spacecraft (3 GEO + 4 GSO) Constellation
- GSO Longitudes: E 55 deg and E111 deg
- GSO Inclination: 29 deg
- GEO Longitudes: E 34, E 83 and E 132 deg
- 7 Independent Launches of PSLV
- 1304 Kg Satellite Mass at Lift-off
- Dual Frequency downlinks for user
- Position Accuracy = 18.3 m (1-sigma)




PROJECTED ACCURACY – HORIZONTAL <20 m




PROJECTED ACCURACY – VERTICAL <20 m

### IRNSS APPLICATIONS

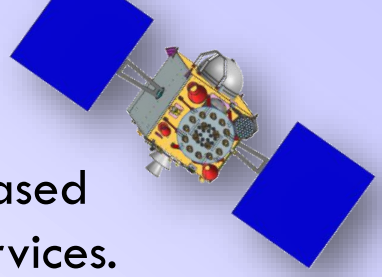
**NAVIGATION**

- Space Craft
- Aircraft
- Ship
- Vehicle
- Fleet Movement
- Routing/Alignment
- Timing

**SCIENTIFIC RESEARCH**

- Atmospheric Studies
- Ionospheric Scintilations

# IRNSS-1A



The objective of the mission is to develop an independent satellite based navigation system capable of providing uninterrupted navigation services. IRNSS-1A is the first navigation satellite built by ISRO for providing Standard positioning service and Restricted Service with encryption. The series of constellation satellites are similar IRNSS-1A configuration & are being realised in the production mode.

## SPACECRAFT SALIENT FEATURES

| | | |
|---|---|---|
| **Orbital Location** | : | Geosynchronous with 29 Deg inclination |
| **Bus** | : | I-1K Bus |
| **Payload** | : | Navigation Payload and Ranging Payload operating in S and L5 bands |
| **Power** | : | 1600 Watts |
| **Spacecraft Mass** | : | 1426.74 Kgs |
| **Mission Life** | : | 10 Years |
| **Application** | : | Regional Navigation application |
| **Launch Date** | : | 01$^{st}$ July 2013 |

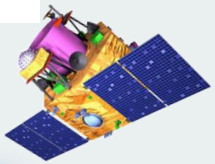
# REMOTE SENSING &

# SMALL SATELLITE PROGRAMME

# REMOTE SENSING SATELLITE PROGRAMME

## Cartography & large scale mapping application

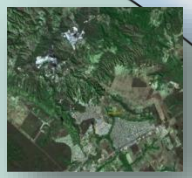
**RISAT-1**
**26.04.2012**
SAR ANTENNA



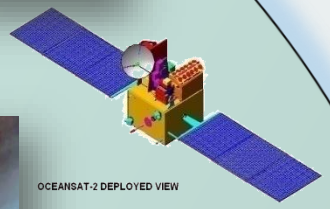
**Cartosat-2B**
**12.07.2010**
PAN CAMERA

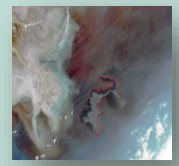
**Cartosat-2A**
**28.04.2008**
PAN CAMERA

**Resourcesat-2**
**20.04.11**
LISS-4, LISS-3, AWIFS



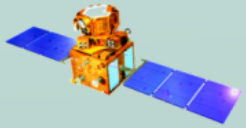
**YOUTHSAT**
**20.04.11**





OCEANSAT-2 DEPLOYED VIEW

**Oceansat-2**
**23.09.09**
OCM, ROSA
Ku Band Scatterometer

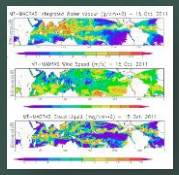


**Resourcesat-1**
**17.10.03**
LISS-4, LISS-3 & AWIFS

## Land & Water Resources Management

## Environmental monitoring & Atmospheric research

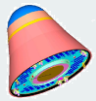
**Meghatropiques**
**12.10.2011**
MADRAS, SAPHIR, SCARAB, ROSA



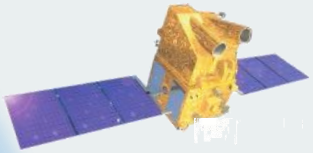
**SARAL**
**25-02-13**
ALTIKA, ARGOS, SCBT

**Cartosat-2**
**10.01.2007**
PAN CAMERA

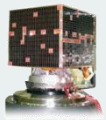
**IMS-1**
**28.04.08**



**SRE-1**
**10.01.07**



**Cartosat-1**
**05.05.2005**
PAN CAMERA



**HAMSAT**
**05.05.05**

**Technology Experiment satellite**

**22.10.01**
PAN CAMERA

**PSLV**

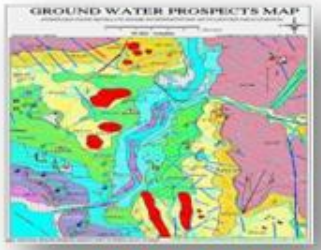
# EARTH OBSERVATION APPLICATIONS *for* Societal Outreach

Agriculture

- National Wheat forecast - 27.25 Mha & 75.90 Mt
- Kharif Rice forecast - 35.66 Mha & 76.82 Mt

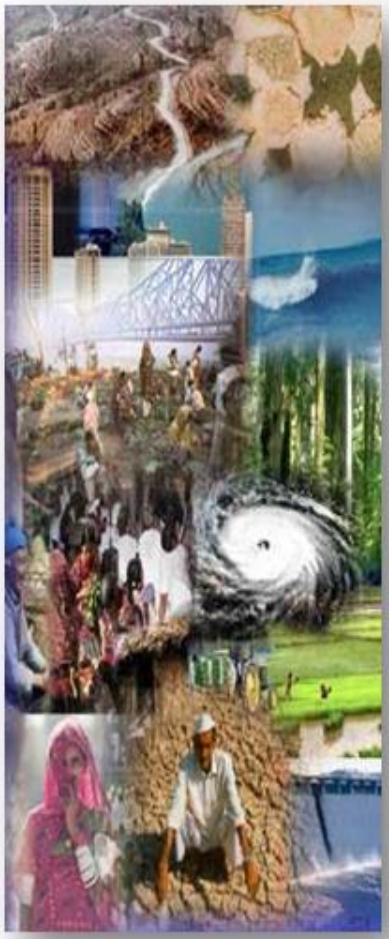
Fisheries

- Potential Fisheries Zone (PFZ) Forecast to > 300 Stations
- ~ 30,000 Users
- Enhanced fish catch with less effort




Drinking Water

- Prospective groundwater zones
- >200,000 wells drilled, with >90% success
- 10 States covered; 17 more taken up




55.27 Mha (17.45%) - 2003 estimates

Desertification & land degradation assessment

Wasteland mapping

- Assessment of irrigation potential created using high-res data
- 5.4 Mha in 18 States

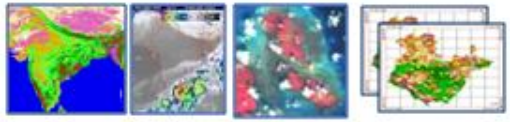
Monitoring Irrigated Commands

- 854 Micro-watersheds in Karnataka
- Support to Rain-fed area development
- World Bank to replicate in Sri Lanka, Africa

Watershed Dev - Sujala

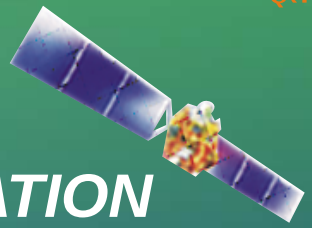
Networking, Early Warning

**Disaster Management Support (DMS) System**

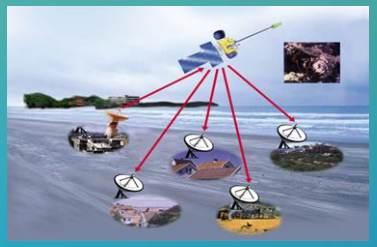


NDEM, Hazard Zonation, Risk Assessment…

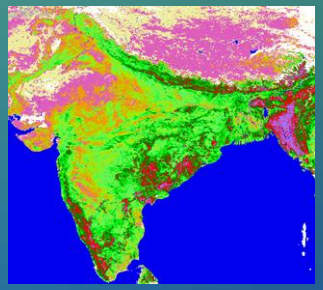
# SPACE & DISASTER MANAGEMENT

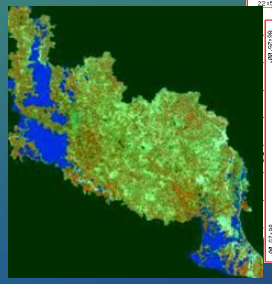


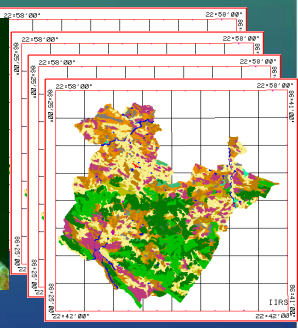
## *SPACE FOR CONNECTIVITY & OBSERVATION*



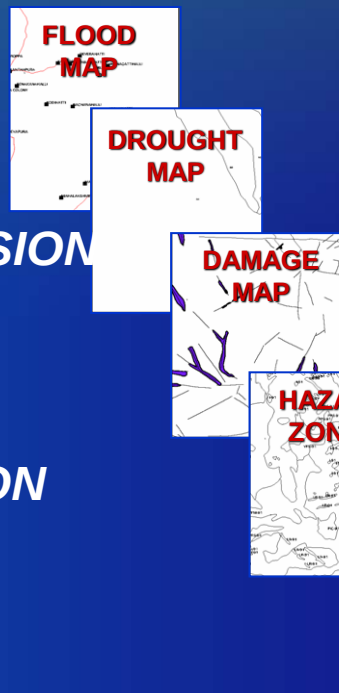
**OBSERVATION FOR INFORMATION**



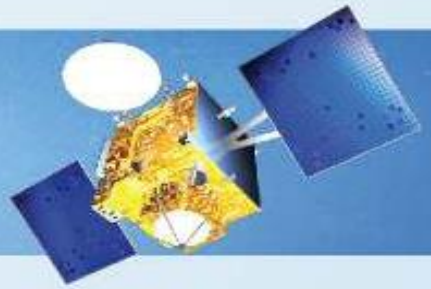





*INFORMATION FOR DECISION*

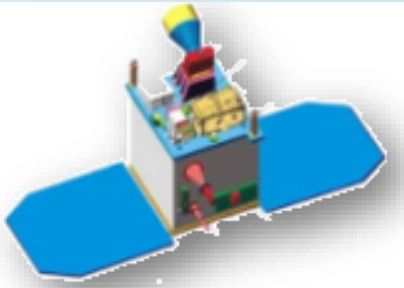



*DECISION FOR ACTION*

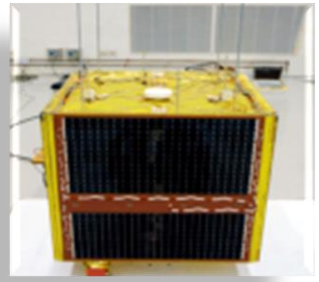


# SMALL SATELLITES

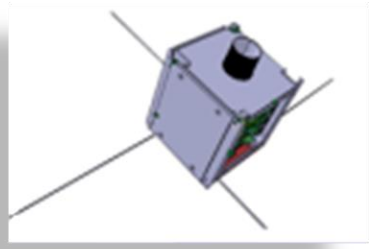
HAMSAT
2005



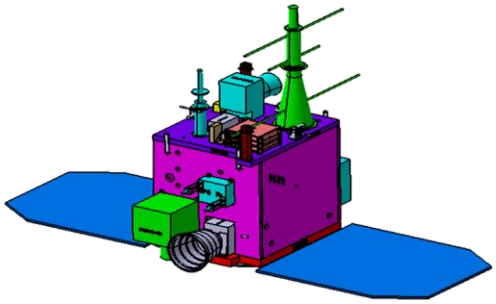
IMS-1
2008



ANUSAT
2009



STUDSAT
2010

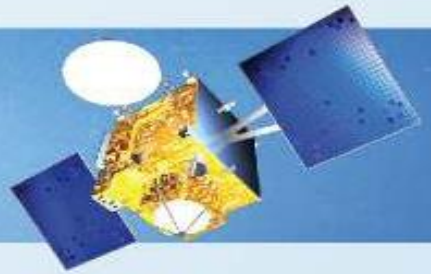


YOUTHSAT
2011

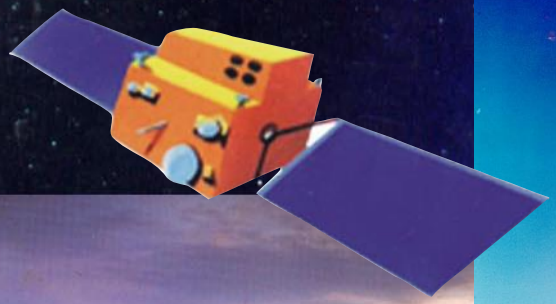
SRMSAT
2011

JUGNU
2011

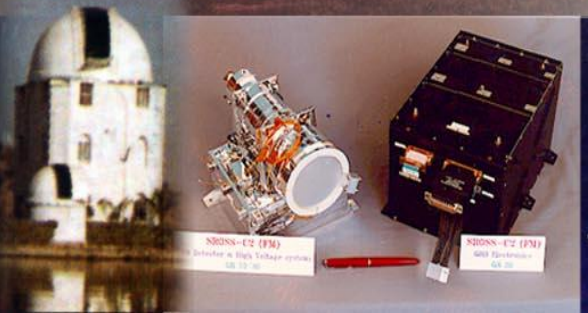
# SPACE SCIENCE SATELLITES



# SPACE SCIENCE - THE QUEST FOR KNOWLEDGE

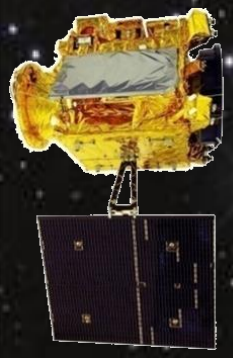


- X-RAY ASTRONOMY
- GAMMA RAY BURSTS
- IONOSPHERIC PLASMA
- MIDDLE ATMOSPHERIC DYNAMICS
- EQUATORIAL ELECTROJET
- SOLAR FLARES AND STORMS
- IONOSPHERIC TOPOGRAPHY
- PLANETARY EXPLORATION

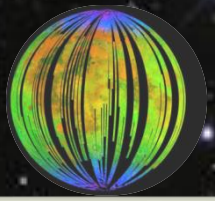


- ASTRONOMY AND ASTROPHYSICS
- AERONOMY AND PLANETARY ATMOSPHERES
- EARTH SCIENCES AND SOLAR SYSTEM STUDIES
- THEORETICAL PHYSICS

# SPACE SCIENCE & PLANETARY EXPLORATORY MISSIONS

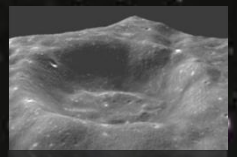


## Chandrayaan-1
## 22.10.08



DISCOVERY OF WATER

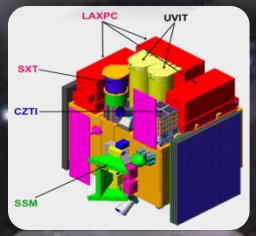
TRI COLOUR ON MOON



CRATERS ON MOON

## FUTURE MISSIONS...

### MARS ORBITER
Study of Martian surface, Martian Atmosphere and Ionosphere




### ASTROSAT
Multi-wavelength Astronomy Satellite for observation of galactic objects

### CHANDRAYAAN-2
Landing in a high latitude region
First Rover-based in-situ studies of lunar chemistry & volatiles

### ADITYA-1
A Space based Advanced Solar Coronagraph to study solar Corona

## FACILITIES ESTABLISHED

*Indian Deep Space Network*


18m Terminal -operational

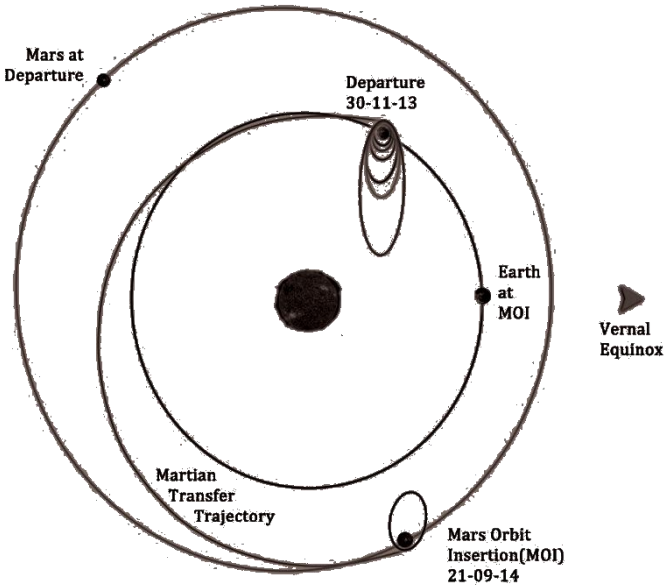
32m Terminal

# MARS ORBITER MISSION

ISRO's first interplanetary mission to Mars planet with an orbiter craft designed to orbit Mars in an elliptical orbit. The scientific payload instruments are intended to study surface features morphology, topology and mineralogy of Mars, Constituents of Martian atmosphere. The Earth-Mars trajectory comprises of three phases namely, Earth-centered phase, Heliocentric phase and Martian phase.

## SALIENT FEATURES

| | | |
|---|---|---|
| **Orbital Location** | : | 370 X 80,000 Kms elliptical orbit |
| **Voyage from Earth's orbit** | : | 300 Days |
| **Mass** | : | 1350 Kg |
| **Power** | : | 750 W |
| **Mission Life** | : | ~ 6 Months |
| **Launcher** | : | PSLV-XL |
| **Payload** | : | Lyman Alpha Photometer, Methane Sensor for MARS, Martian Exospheric Composition Explorer, MARS Color Camera and TIR Imaging Spectrometer |



# MAKING OF A SATELLITE

# MAKING OF A SATELLITE

SPACECRAFT STRUCTURE
IN CLEANROOM

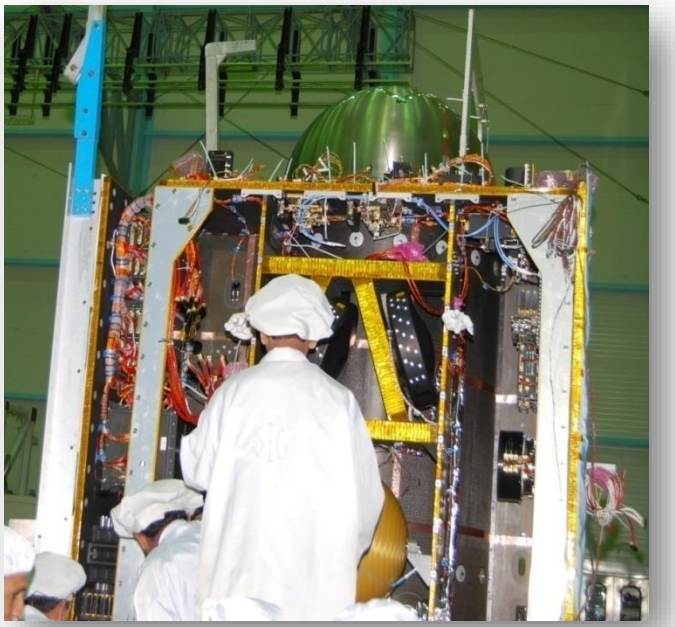
THERMAL
IMPLEMENTATION

# MAKING OF A SATELLITE

SOUTH PANEL READY FOR ASSEMBLY

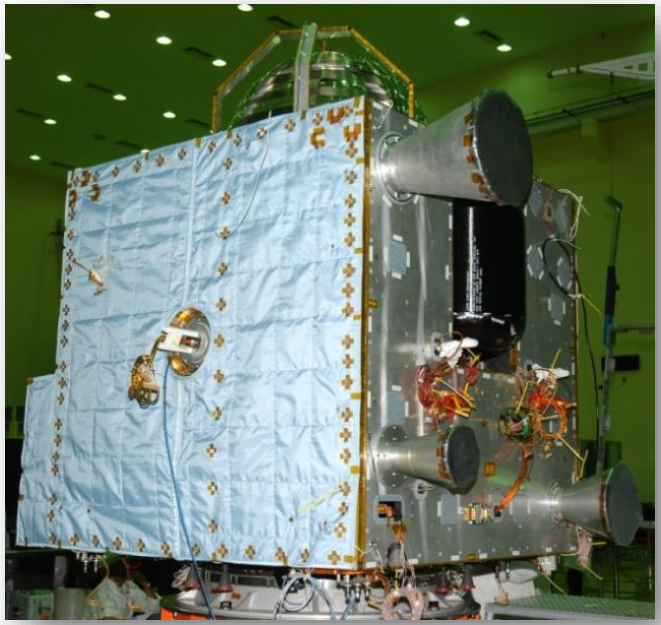
NORTH PANEL READY FOR ASSEMBLY

# MAKING OF A SATELLITE

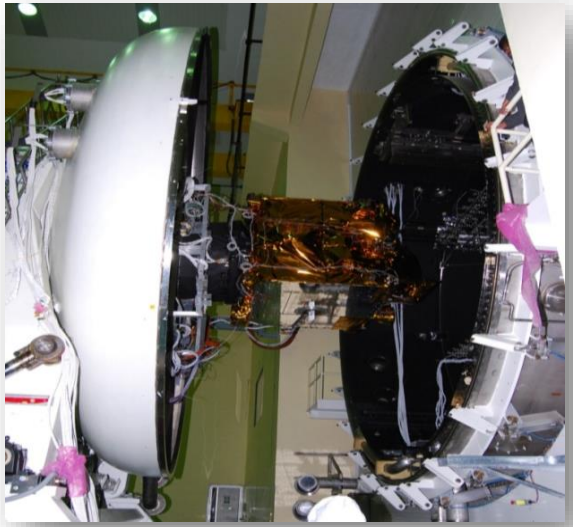


PANEL ASSEMBLY IN PROGRESS

CLOSED MODE IST

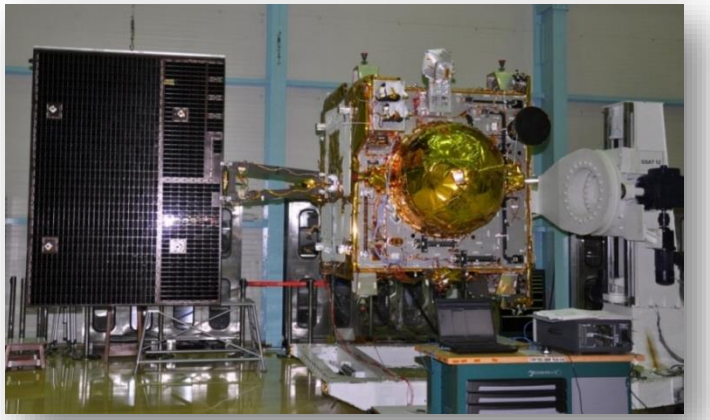


# MAKING OF A SATELLITE



S/C ENTERING TVAC CHAMBER

PANEL DEPLOYMENT TEST



REFLECTOR DEPLOYMENT TEST

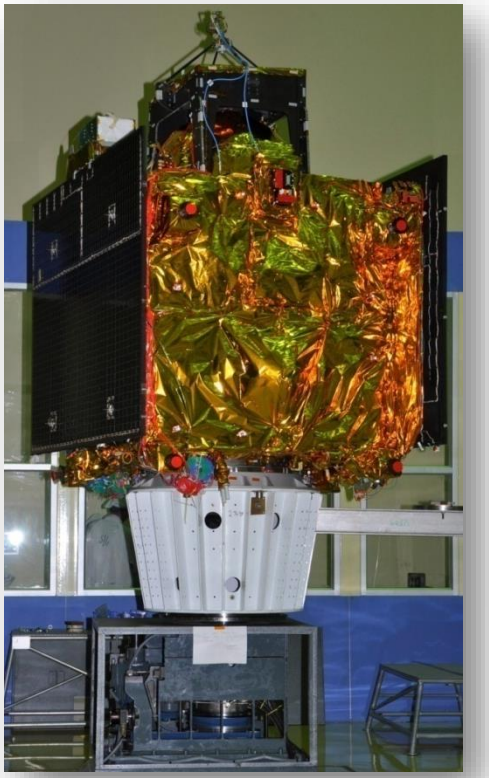
# MAKING OF A SATELLITE

FIT CHECK

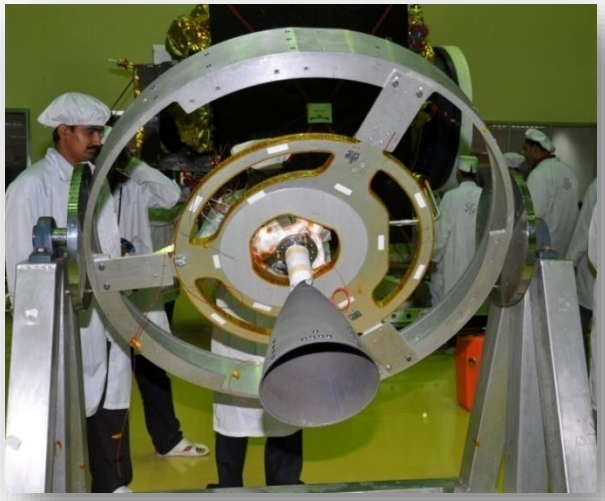
CG MEASUREMENTS

MI MEASUREMENTS

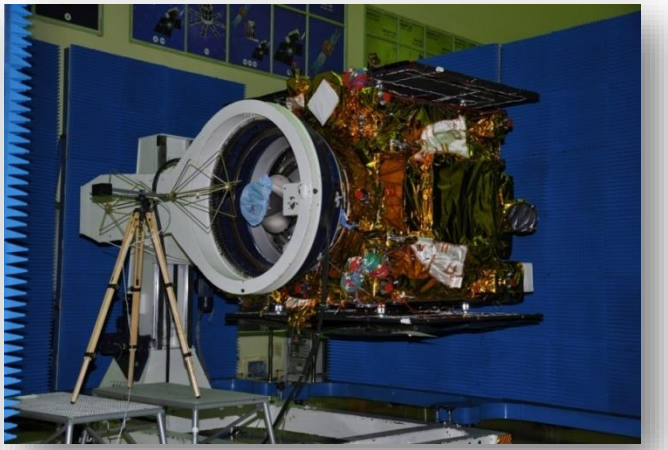
# MAKING OF A SATELLITE



DYNAMIC BALANCING



LAM WELDING



RF INTERFERENCE CHECK

# MAKING OF A SATELLITE

VIBRATION TEST

ACOUSTIC TEST

CATF TESTS

# LAUNCH VEHICLES & LAUNCHERS

# LAUNCH FACILITY & LAUNCHERS


Operational

Operational


New Generation

| PSLV | GSLV | GSLV MK III |
|---|---|---|
| 294 tonnes | 414 tonnes | 629 tonnes |
| 1.3 in SSO/ 1.05 in GTO | 2 in GTO | 4 in GTO / 10 in LEO |

**Two Launch Pads**

**SDSC, Sriharikota**


Thank You