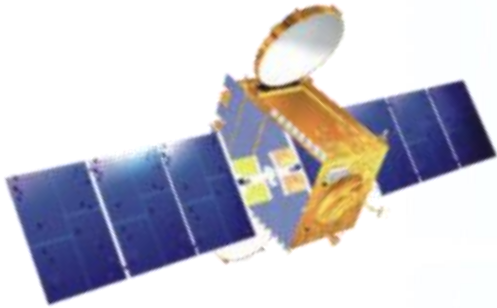


PARTENSHIP WITH ISRO PROGRAMME

Dr. SVSharma

Deputy Director, ISAC

Presentation Overview

1. Indian Space Programme

- National Space Systems & Current Space Assets
- Satellites applications for societal benefit
- Space Science & Planetary Exploration
- Commercial Venture

2. Partnership with Satellite Programme

- Challenges of Space Systems
- Mechanical Systems - Productionisation
- Electronic Systems - Productionisation
- Indigenization Efforts - Towards Make in India
- Major Industry Support

3. Conclusions

Indian Space Programme

- An Overview

National Space Systems

Launch vehicles (PSLV, GSLV)



Satellites (GSAT, IRS, IRNSS & SPACE SCIENCE)

Indian Remote Sensing
(IRS) Satellites

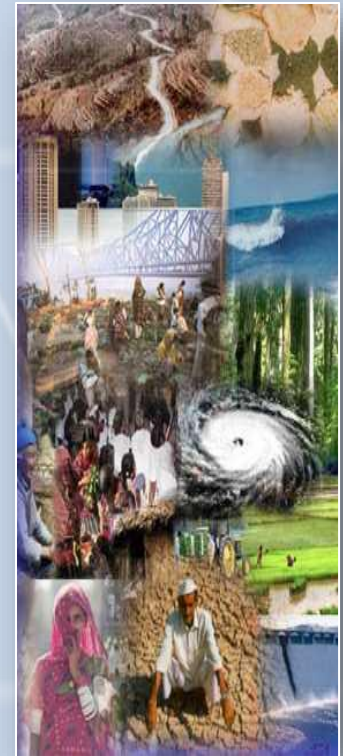
Indian Communication
& Meteorological
Satellites

Indian Navigation
Satellites

Space Science &
Planetary Exploration
Satellites



Societal Applications



SPACE INFRASTRUCTURE

**SPACE
COMMERCE**

INFRASTRUCTURE
End- to- end capability

HUMAN RESOURCES
EXPERTISE - 16500

**STATE-OF-THE-ART
TECHNOLOGY**

BUDGET
Rs 7300 Cr/ annum

**ACADEMIA
PARTICIPATION**

**INTERNATIONAL
COOPERATION**

**INDUSTRY
SUPPORT**

India's Launch Vehicles



Two launch pads in Sriharikota



Launch Vehicle	SLV	ASLV	PSLV	GSLV	GSLV Mk III
Lift-off weight (Tonnes)	17	40	295	450	644
Payload (kg)	40 (LEO)	150 (LEO)	1750 (SSO) 1400 (GTO)	2200 (GTO)	4000 (GTO)

ISRO LAUNCH PORT

- Satish Dawan Space Centre (SDSC) Launch centre of ISRO.
- Facilitates solid propellant motors required for launch vehicle programme.
- Two Launch Pads – PSLV & GSLV



Two Launch Pads, SDSC, Sriharikota



**First
Launch Pad**

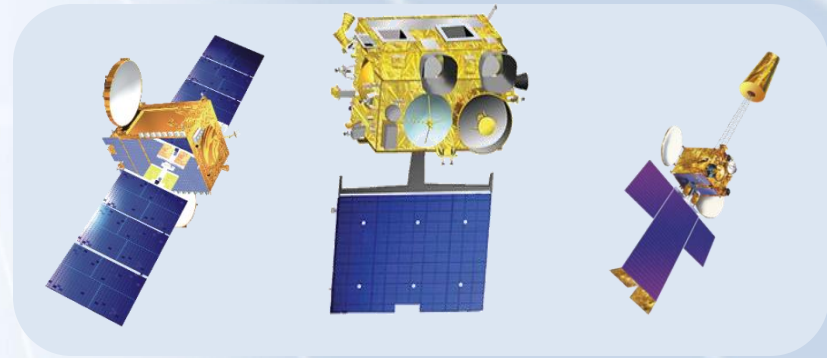


**Second
Launch Pad**

India's current Space Assets

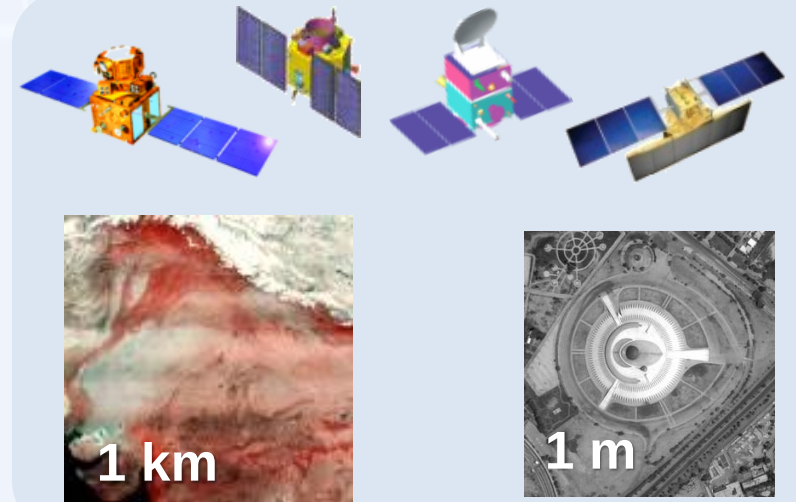
Communication Satellites

- **11 Operational** (INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-7, 8, 10, 12, 14, 16)
- **240 Transponders** in C, Ext C & Ku bands



Remote sensing Satellites

- **3 in Geostationary orbit** (INSAT 3D, Kalpana & INSAT 3A)
- **10 in Sun-synchronous orbit** (RESOURCESAT- 2; CARTOSAT-1, 2, 2A & 2B; RISAT-1 & 2; OCEANSAT 2; MEGHA-TROPIQUES; SARAL)
- **Both Optical & Microwave Sensors** providing wide range of spatial, spectral, radiometric & temporal resolutions



Navigational Satellites : IRNSS 1A, 1B ,1C,1D

Inter Planetary Mission: Mars Orbiter Mission



Satellite Applications – Societal Benefits



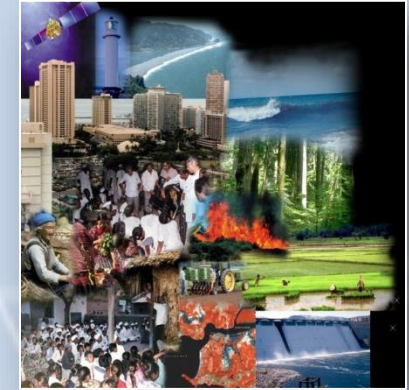
COMMUNICATION

- SPEECH CIRCUITS ON TRUNK ROUTES
- TV BROADCASTING
- BUSINESS COMMUNICATIONS
- MOBILE SATELLITE SERVICES
- RADIO NETWORKING
- SEARCH AND RESCUE SERVICES
- VSAT CONNECTIVITY
- METEOROLOGY IMAGING
- DISASTER WARNING SYSTEM



NAVIGATION

- IMPROVED POSITION ACCURACY
- NAVIGATION SERVICES : AIRCRAFT, SHIPS, VEHICLE, FLEET MOVEMENT, ROUTING / ALIGNMENT
- SCIENTIFIC RESEARCH APPLICATIONS FOR ATMOSPHERIC STUDIES
- IONOSPHERIC SCINTILLATIONS



REMOTE SENSING

- AGRICULTURE & CROPS
- FOREST & BIO-RESOURCES
- WATER RESOURCES
- GEOLOGY
- OCEAN/COASTAL
- ENVIRONMENT
- RURAL DEVELOPMENT
- URBAN MANAGEMENT
- CARTOGRAPHY/MAPPING
- CLIMATE MODELLING
- GLOBAL CHANGE

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 & ASTROPHYSICS
- ◆ AERONOMY & PLANETARY ATMOSPHERES
- ◆ EARTH SCIENCES & SOLAR SYSTEM STUDIES
- ◆ THEORETICAL PHYSICS
- ◆ GROUND SEGMENT ESTABLISHMENT
- ◆ DEEP SPACE NETWORK IN BENGALURU



Chandrayaan-1
22.10.08



MOM
05.11.13

18m Terminal



32m Terminal



Commercial Venture - Satellites Built For International Customer

Developed and Built for EUTELSAT
Jointly with EADS Astrium, France under a contract through Antrix Corporation , India



**W2M High power
communication Satellite**

Payload:	32 Ku band Tr.
Power:	7000 W
Lift off Mass:	3460 Kg
Orbit:	GEO
Mission Life:	15 Years

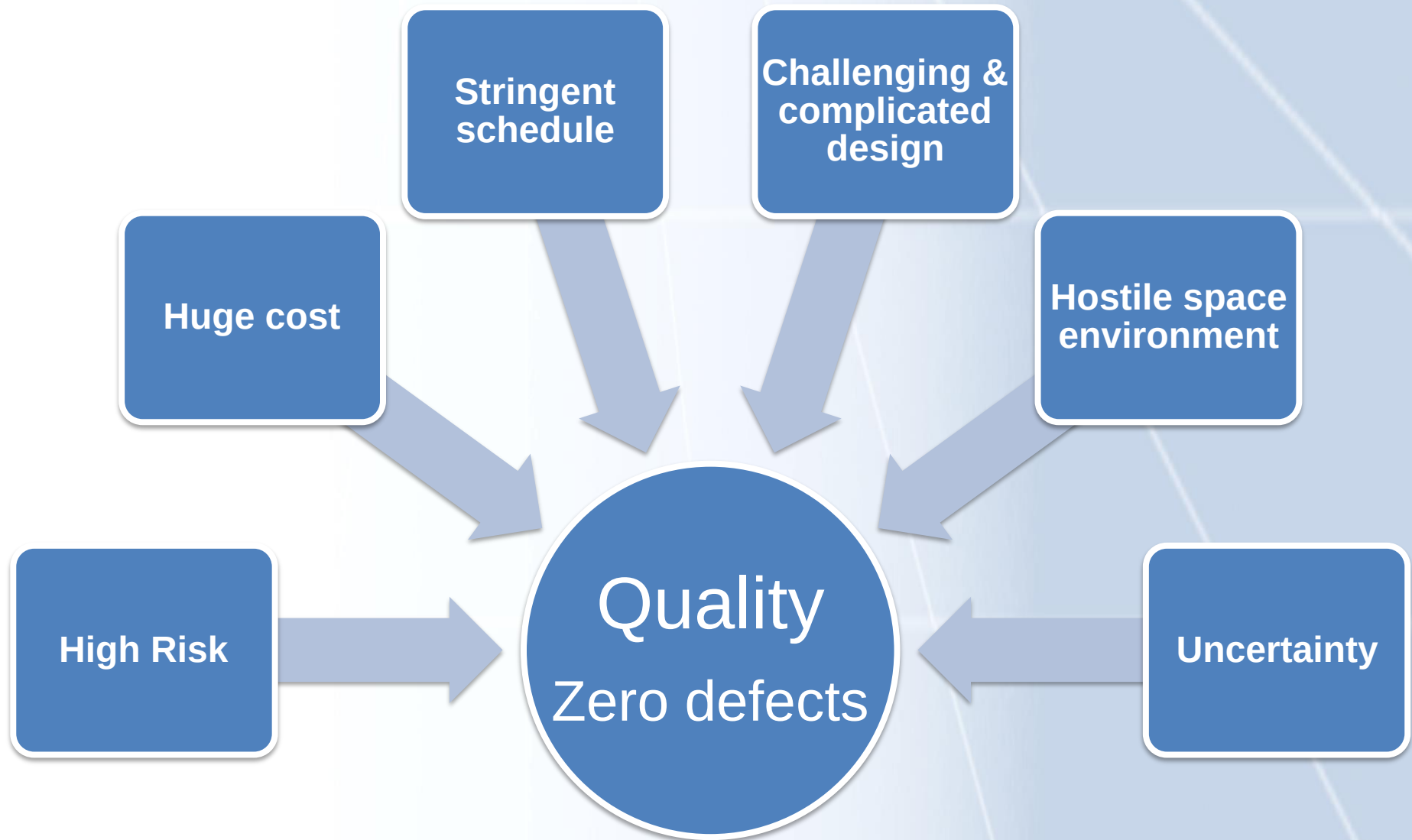


**HYLAS - Highly Adaptable
Satellite**

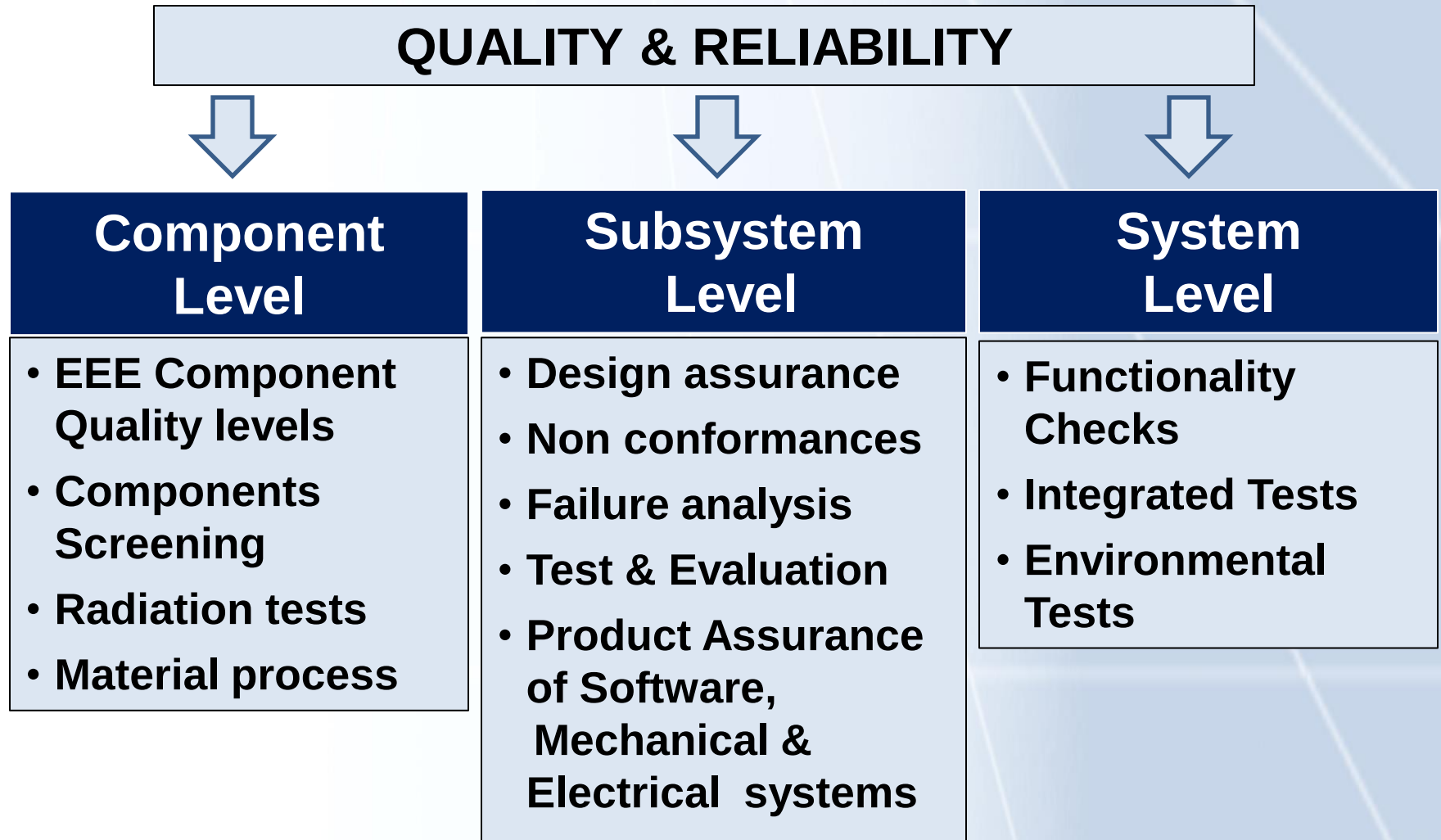
Payload:	8 spot beams Ka + 2 Ku
Power:	3200 W
Lift off Mass:	2542 Kg
Orbit:	GEO
Mission Life:	15 years

Partnership with Satellite Programme

Challenges of Space Systems



Quality Management



Contamination control, ESD Control

Need for Productionisation of Space Systems

- To meet the huge demand for satellites
- To strengthen basic Research & Development
- Encourage the increased participation of vibrant space Indian Industries in Space Programme in the areas of
 1. Electronic systems
 2. Mechanical systems
 3. Assembly, Integration & Testing of satellites.
- Promotion of “Make in India” concept for end-to-end production of satellite from Industries.

Self Reliance

Vendor Identification/Qualification Process

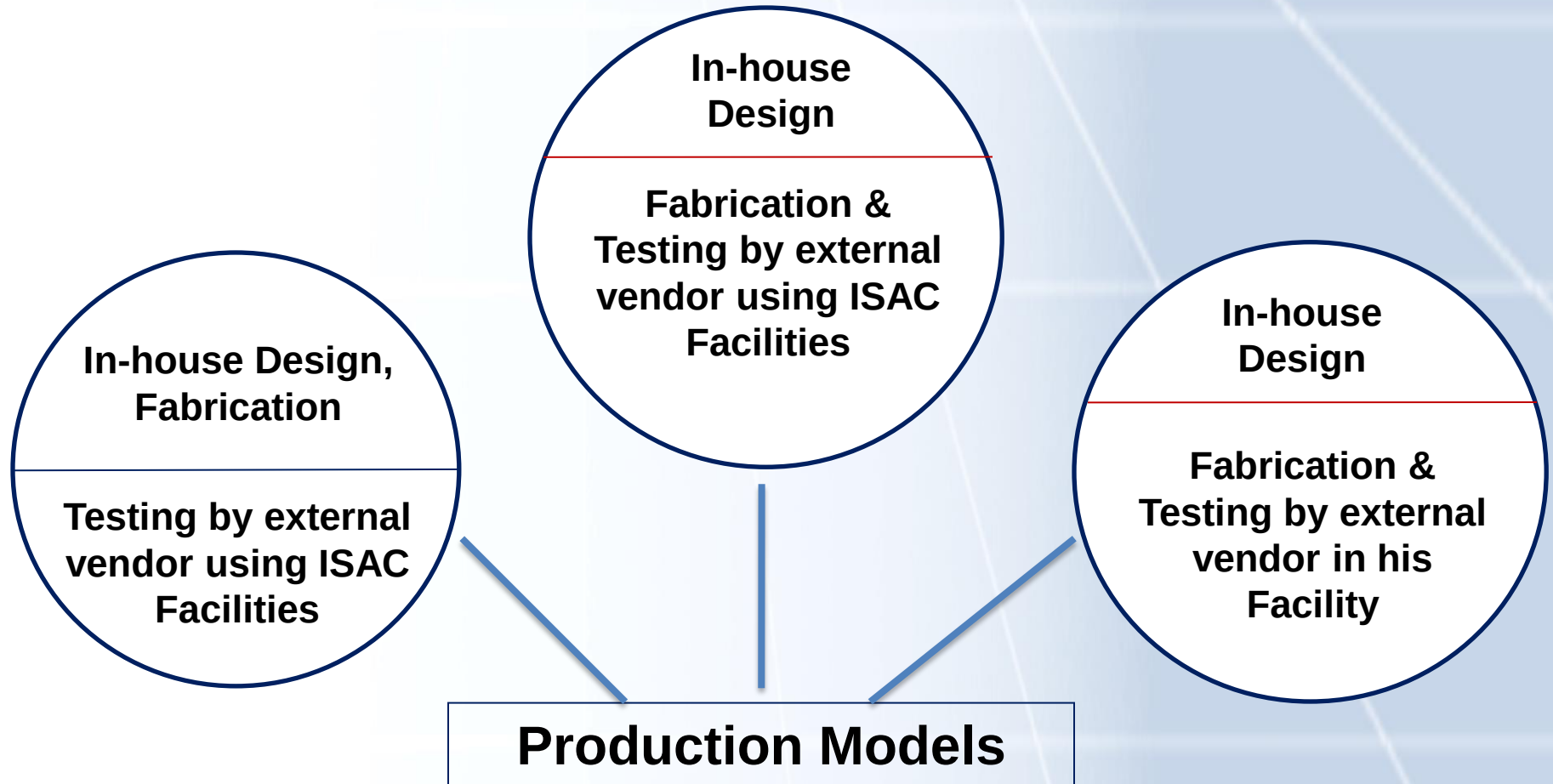


Ensuring Quality at External vendor:

- Surveillance of Labs
- Online quality Control
- Periodic Audits
- Implementation of ISO quality system

ZERO DEFECT SYSTEMS is the quality policy at ISRO

Production Models



Future: End-to-End production at vendors location

Mechanical Systems – Productionisation

Mechanical system work flow process



Mechanical Systems

1. Main cylinder of spacecraft structure & structural elements
2. Thermal control elements including heat pipes
3. Sub-assemblies of solar array deployment mechanism & reflector deployment mechanisms
4. Mechanical ground support equipment
5. Design, modelling and analysis

Mechanical Systems – Productionisation

Structural elements - suitable for I-1K, I-2K, I-3K & I-4k & I-6k Bus

1. CRFP based Composite Structures
2. Universal heat pipe panel manufacturing
3. Interface rings
4. Structural inserts
5. Structural angles
6. Cut-out doublers



CFRP Structures

Thermal elements - suitable for I-1K, I-2K, I-3K & I-4k & I-6k Bus

1. Rigid optical solar reflector, MLI Blankets
2. Heat pipes
3. Foil heaters
4. Thermistor
5. PRT sensor
6. Tape heater
7. Polyester net
8. Aluminized polyimide
9. Aluminized polyester
10. White paint
11. Non conductive black paint
12. Coolers



Thermal elements

Mechanical Systems – Productionisation

Mechanism elements for Satellites

1. Sub-assemblies of solar array deployment mechanism (SADM)
2. Subassemblies of reflector deployment mechanisms (RDM)
3. Load caps
4. Rotary actuator mechanism



Reflector Deployment Mechanism



Solar Array Drive Mechanism

Mechanical Component for Satellite subsystem

1. CNC Machines for Milling, machining, turning and polishing (5 axes)
2. 2D and 3D Modeling

Mechanical Components

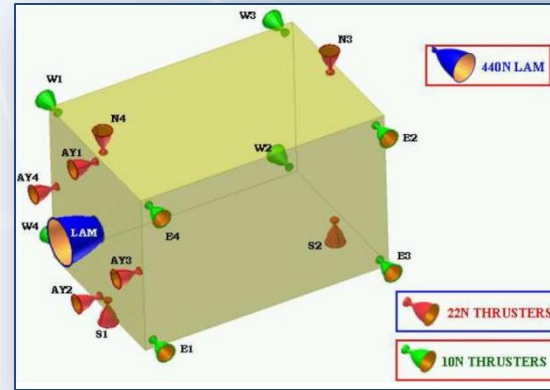


Mechanical Workshop



Mechanical Systems – Productionisation

Propulsion Elements

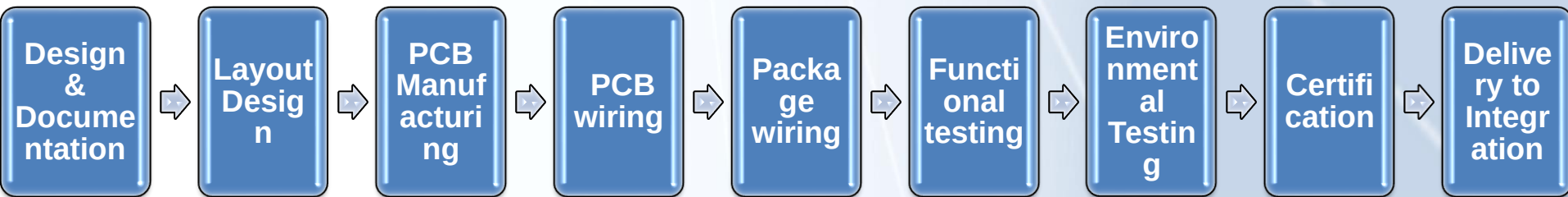


AIT Fixtures & Satellite Transportation Containers



Electronic Systems – Productionisation

Electronic system work flow process



Electronic Systems under Productionisation

1. Power Electronic Packages
2. Control systems
3. TMTC Packages
4. RF systems
5. DC-DC Converters
6. Solar Panels
7. Battery
8. Magnetic Torquers
9. HMCs & MMICs
10. Harness Fabrication
11. Test Systems
12. Checkout Systems

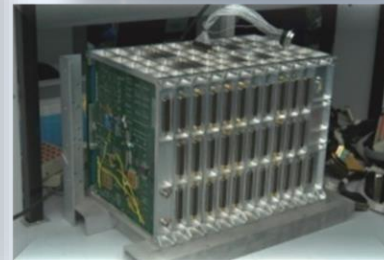
CHECKOUT SYSTEMS



MAGNETIC TORQUER



BMU ASIC



BMU FPGA



Electronic Systems – Productionisation

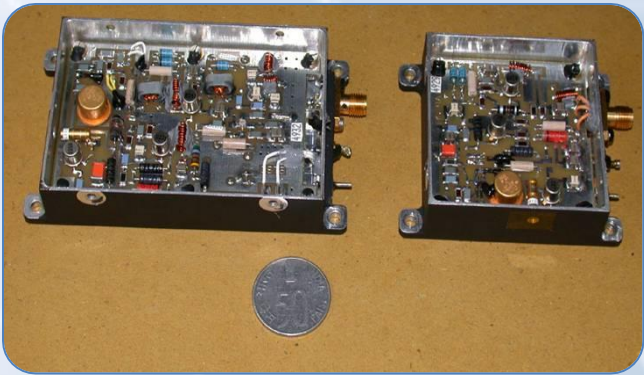
PAA



REFLECTOR



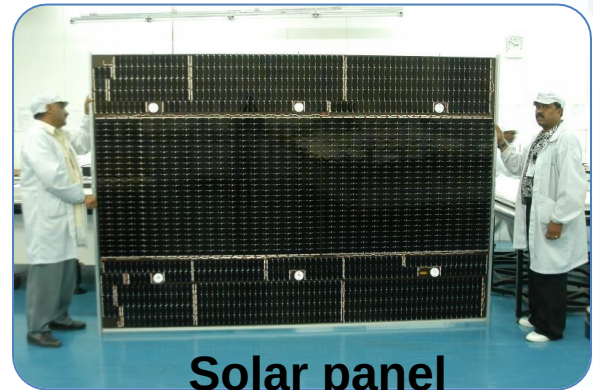
TCXO



Battery



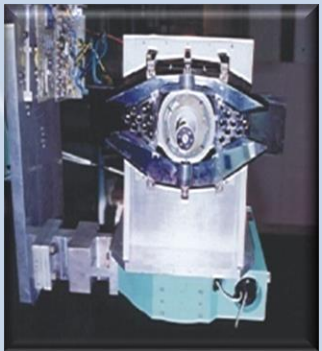
SENSORS



Solar panel



Static Earth Sensor



Dual Cone Earth Sensor



Power Electronics



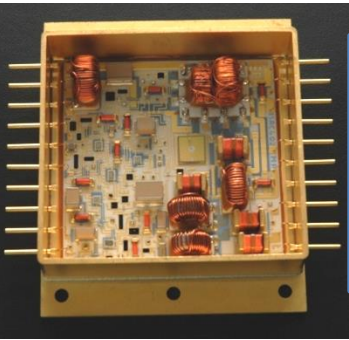
Star Sensor



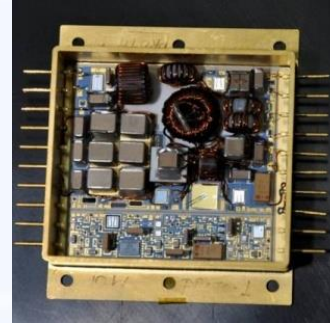
Active Pixel Sun Sensor

Electronic Systems – Productionisation

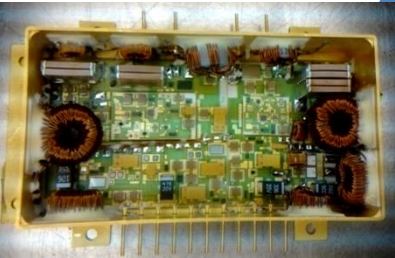
DC-DC CONVERTERS



**4.5W HMC DC-DC
CONVERTER-402MP**
(+15V: 200mA, -15V: 80mA,
+5V: 60mA)



**10W HMC DC-DC
CONVERTER**
(+15V: 250mA, -15V: 250mA,
+5V: 500mA)

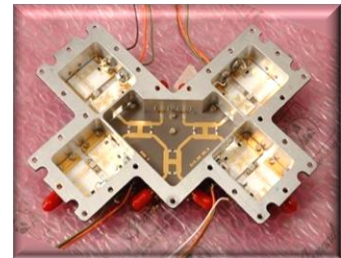


**20W HMC DC-DC
CONVERTER**
(+15V: 350mA, -5V: 100mA,
+8V: 1.8A)

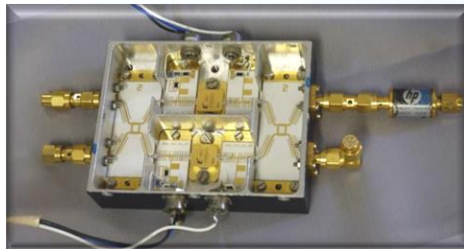


**30W HMC DC-DC
CONVERTER**
(+15V: 500mA, -15V: 500mA,
+5V: 3A)

THIN FILM PRODUCTS

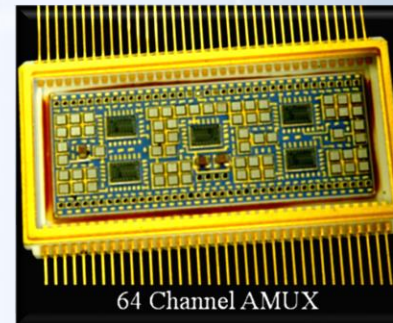


**12W X-BAND SSPA –
OCEANSAT-2**

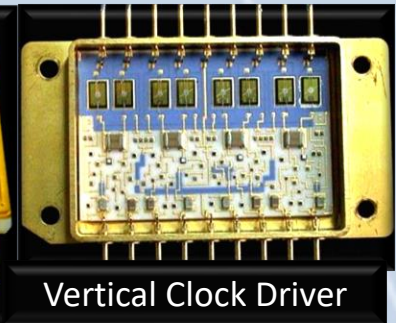


**8W X-BAND SSPA –
CHANDRAYAAN-1**

THICK FILM PRODUCTS



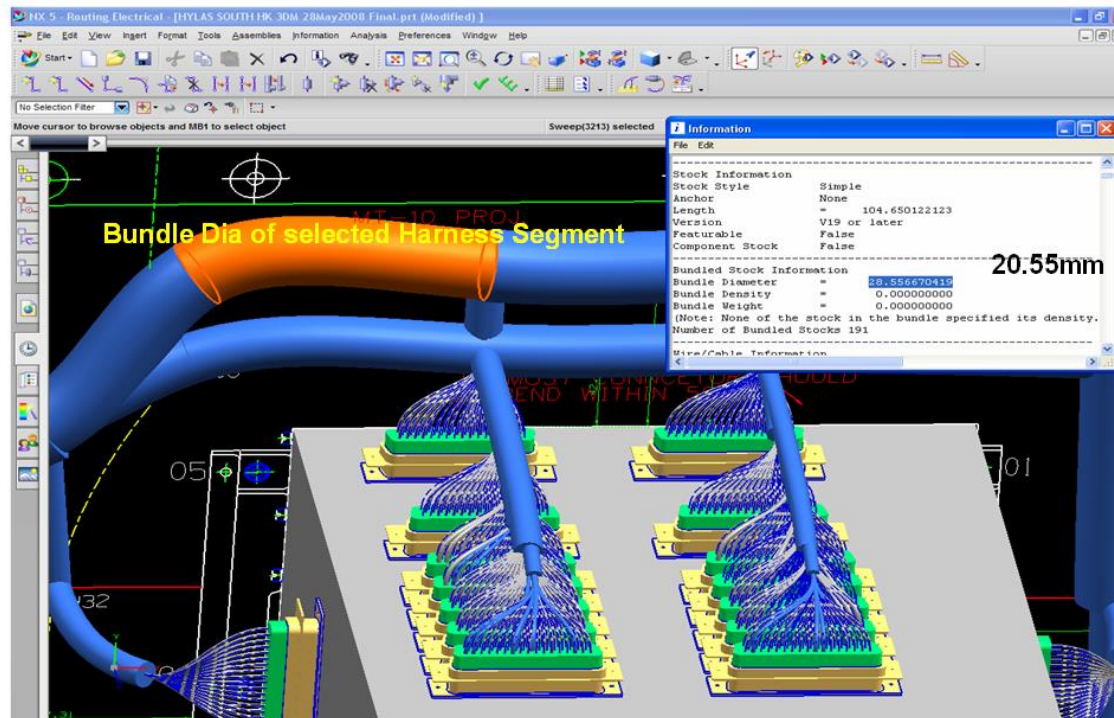
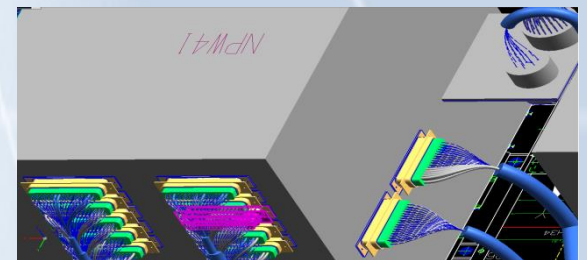
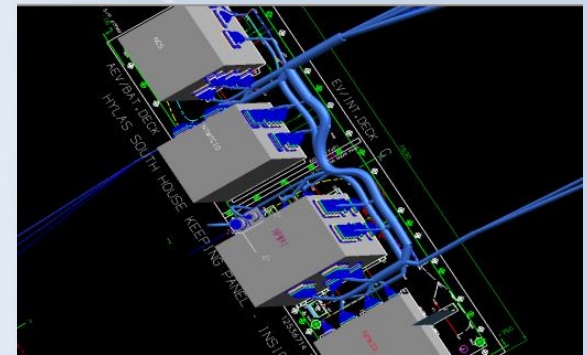
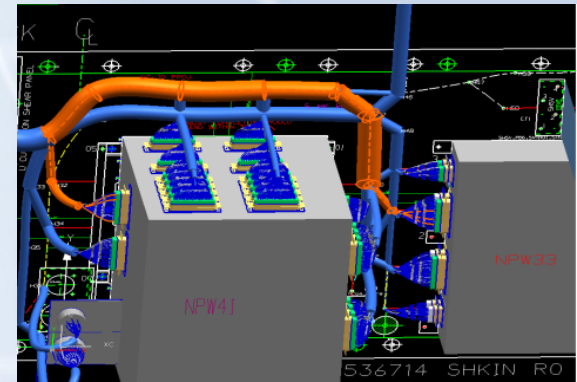
64 Channel AMUX



Vertical Clock Driver

Spacecraft Harness 3D Modeling

- MODELS ENTIRE SPACECRAFT HARNESS AUTOMATICALLY : POWER & SIGNAL PATHS USING LAYOUT DESIGN AND EID DATABASE FILES.
- PANEL LEVEL HARNESS MODELING & SPACECRAFT LEVEL MODELING IN PROGRESS



Indigenisation Of Electronic Components

60W C-Band TWTA

- C-Band TWT (3.6 to 4.2 GHz) with 47dB Gain
& 50% Efficiency
- EPC Module to the C-Band TWT
- Integrated C-Band TWTA has also been tested & qualified



VCXO

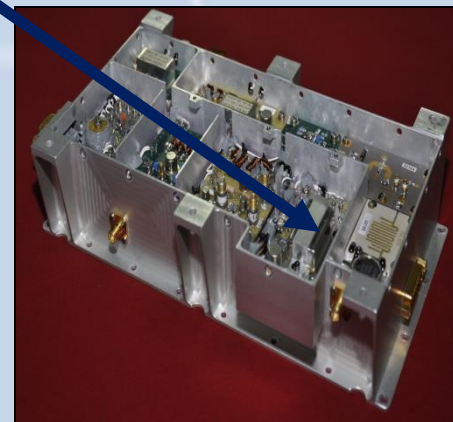
- One unit of both 19.108 MHz and 19.154 MHz VCXO has been used in the Mars Mission Satellite.

Freq Stability: ± 10 ppm -30°C to $+60^{\circ}\text{C}$

Aging: ± 1 ppm / year

Harmonics: < -30 dBc

Spurious: < -80 dBc



Indigenisation Of Electronic Components

Clock Oscillator

- Clock Oscillators (256 kHz to 12 MHz) with accuracy of $\pm 15\text{ppm}$ and stability of $< \pm 25\text{ppm}$ in the operating temperature range qualified.
- TCXO in the range of 5.5 to 375 MHz with stability of $< 1\text{ppm}$ & ageing of 0.1ppm/week qualified & used in payload of satellites.
- Clock Oscillator (256 kHz to 12 MHz) manufactured by an industry is qualified.



Other onboard components

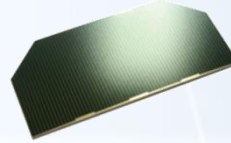
- Wires & Cables
- Bipolar ASIC and many other ASICs
- D-Sub connectors
- Thermistors
- Heaters



Other major areas of indeginisation

Multi junction Solar Cell Development

- Multi junction solar cells for ISRO missions.
- Efficiency around 30%
- Spin off for ground applications.

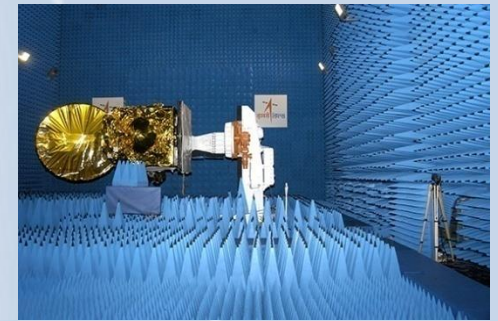


Proposed Solar Panel & Battery Lab



Assembly Integration And Testing Of Satellites

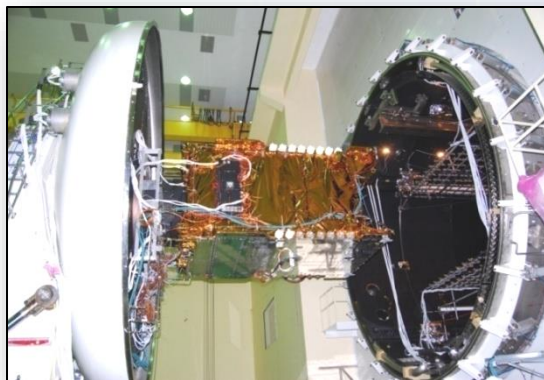
- Realizing satellite on end-to-end basis from Industries
- Systems integration – Electrical & Mechanical
- Integrated Spacecraft level testing
- Environmental Testing



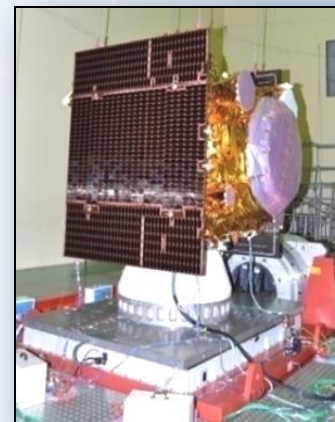
EMI/EMC Test



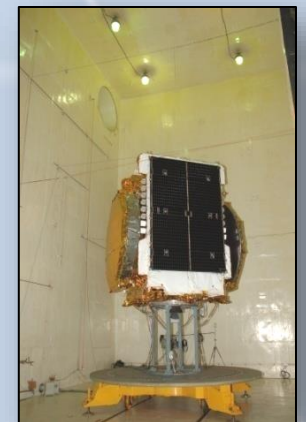
Dis Assembled mode
IST



Spacecraft
Thermovac Test

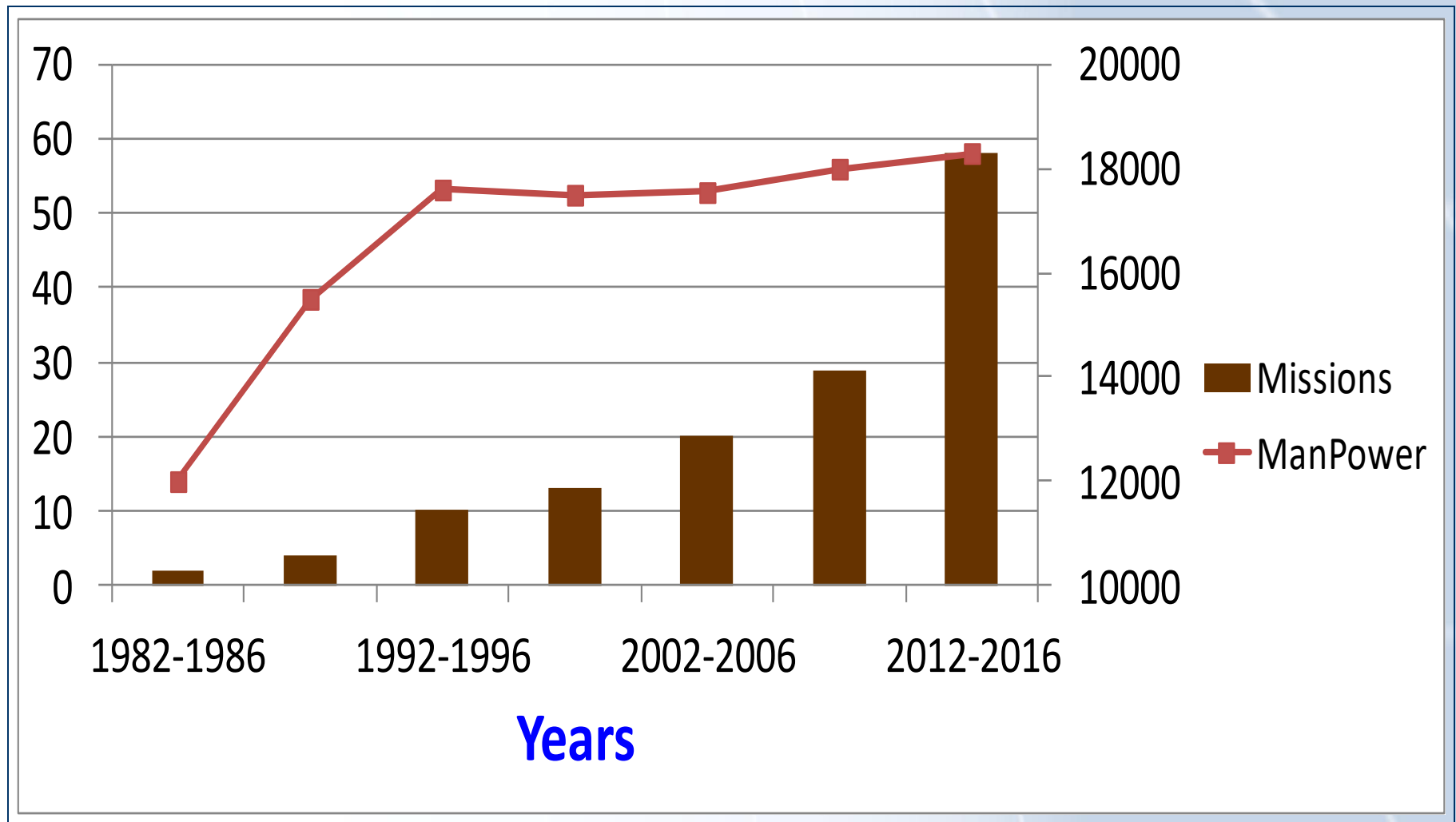


Vibration Test



Acoustic Test

ISRO: Past , Present & Future..



Major Industry Partners

No	System/Service	Vendor
1	Spacecraft structures	M/s HAL, Bangalore
2	Heat pipes	M/s Avasarala Technologies Ltd., Bangalore
3	Rigid OSRs	M/s GOAL, Pondicherry ; M/s BEL, Ghaziabad
4	Substrates for Rigid OSRs	M/s ASTRA Optics
5	ISRO FLEX HEATERS	M/S Thakarsons,PUNE
6	Solar Array Drive assembly	M/s L & T, Mumbai M/s Avasarala Technologies, Ltd, Bangalore
7	Solar panel substrates	M/s TAML, Bangalore
8	Wires and cables	M/s Sanghvi, Ahmedabad, M/s Flutef, Ahmedabad
9	Metal forgings	M/s Midhani, Hyderabad
10	PCB fabrication	M/s Micropack, M/s.Multi tech,Bangalore, M/s.Ascent Ckts, Hosur
11	General optics fabrication	M/s GOAL, Pondicherry
12	Deployment mechanisms	M/s Dynamics Solutions Ltd., M/s Avasarala Technologies Ltd, Bangalore, M/s L & T, Mumbai
13	Structure fabrication and Testing	M/s SMART, Bangalore M/s Business Solution International, Bangalore
14	Thermal Implementation	M/s Avasarala Technologies Ltd, Bangalore
15	Thermal Testing	M/s Multi-Tech Systems, Bangalore

Major Industry Partners

16	Surface treatment	M/s Pushpak Industries, , Bangalore M/s Garden City Environment Services, Bangalore
17	Mechanical Fabrication	M/s GTTC, Mysore & Bangalore M/s MTAR, Mysore; M/s Simulation Design, M/s Techno Tools,; M/s Ducom, Bangalore M/s Smart Technologies, Bangalore M/s Shoma Enterprises,Bangalore M/s Cipet, Chennai, M/s Ducom, Bangalore M/s. Simulation Design, M/s SLN Tech, Bangalore M/s Ankit Fasteners, Bangalore, M/s JoJo Industries, Etummanar M/s Fab Equipment Pvt Ltd, Blore M/s Raksha Polycoats Pvt Ltd,Pune M/s Divya Electro Technical Pvt Ltd, Mumbai M/s Sree Venkateshwara Hightech Machinery Pvt Ltd, Coimbatore
18	TTC Main Antennae	M/s HCL Technologies
19	Checkout systems fabrication	M/s Digitronics, Bangalore M/s Advanced Electronics Systems Ltd M/s Aum Infotech

Major Industry Partners

20	Electrical Systems: Power packages, TMTC, OBC, AOCE, DC-DC Converters, HMC fabrication and testing	M/s New Tech Solutions, Bangalore M/s Centum Electronics, Bangalore M/s Ananth Technologies Ltd, Bangalore M/s Kaynes Tech, Mysore M/s Data pattern, Chennai M/s Transpace , Bangalore M/s. Keltron, Bangalore M/s. Sasmos, Bangalore M/s. Aidin Technologies , Bangalore M/s Rajesh Global Solutions, Bangalore
21	Miniaturized circuits, Crystal Oscillator, HCMOS clock, VCXO,TCXO, Connectors, Capacitors, Relay drives	M/s Centum, Bangalore; M/s. Amphetronix, Pune M/s. J V Electronics, Pune M/s BEL, Bangalore.

Major Industry Partners

22	Mechanical ground test systems, Fixtures Support for TVC	M/s Venkateswara Industries, Coimbatore M/s. L & T, Mumbai M/s Godrej & Boyce, Mumbai M/s Vacuum Techniques, Bangalore
23	Online inspection/ testing / documentations/ machinists	M/s Smart, Bangalore M/s Broose & Broose, Bangalore M/s U4e Software Solution, Bangalore M/s Business Solutions, Bangalore
24	Battery & Related	M/s BHEL, Bangalore M/s KHMD, Bangalore
25	TTC transponder	M/s SAMEER, Chennai
26	TCXOs	M/s Andhra Electronics, Kakinada
27	SPS	M/s Accord Software systems, Bangalore
28	X band data transmitter 8 W SSPA, Phase shifters	M/s Astra, Hyderabad

Conclusions

1. Building Satellites to build nation
2. Standardized communication satellites and Remote sensing satellite bus systems.
3. Host of consultancy & Training services
4. Expertise available in the industry has to be tapped
5. Enough scope for industry to contribute in satellite programme

**Creating a better world requires teamwork,
partnerships & collaborations**

Let us begin our journey towards this.....



THANK YOU