# S&T- An Imperative in the Socio-Economic Growth

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**CSIR Directors Conference**
**CSIR-CMIR, Dhanbad**

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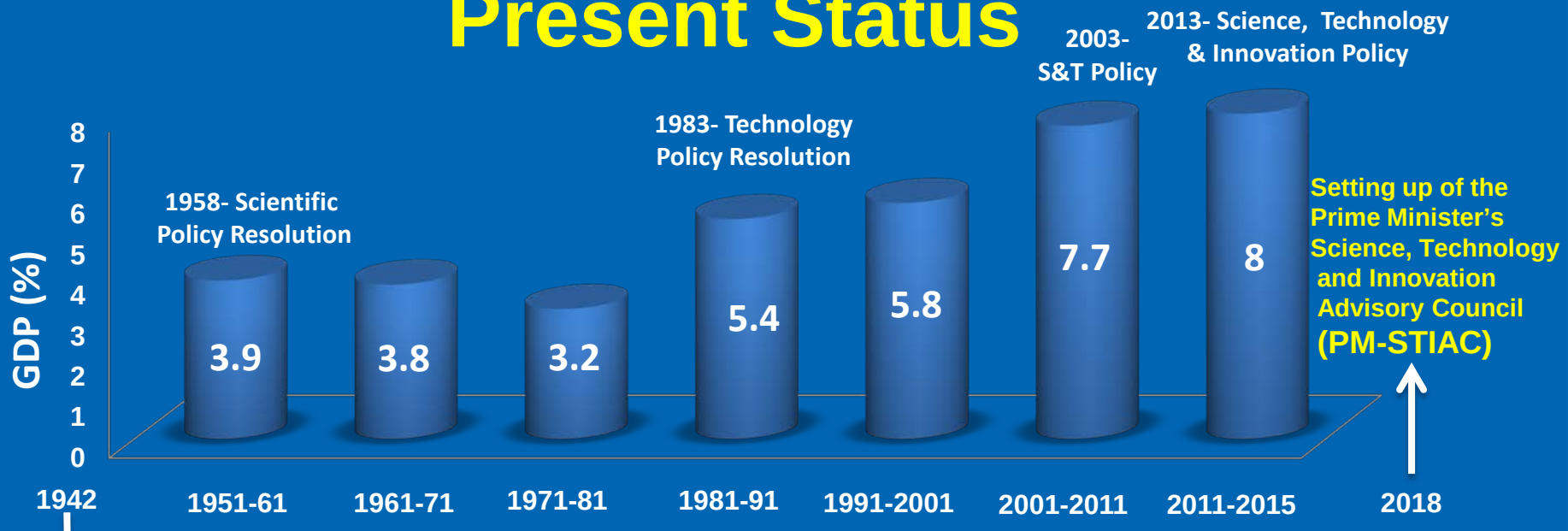
# CSIR- Its Beginnings

- CSIR is the most prominent among the oldest scientific establishments of this country having had its beginnings with the establishment of the Board of Scientific and Industrial Research (BSIR) on April 1940, thanks to the persuasive actions by Arcot Ramaswamy Mudaliar who was the Member of the then Viceroys Executive Council.
- Together with Prof Shanthi Swarup Bhatnagar, who was appointed as the Director of BSIR, the institution soon embarked on development of several new industrial processes and techniques related to cloth manufacture, fuel & lubricants, plastic packing, dyes, preparation of vitamins and pyrethrum emulsifier and cream.
- As a second important step thanks to the persuasion of Bhatnagar, in 1941 the Government setup the Industrial Research Utilisation Centre for translating results into application.
- As a third step, an industrial research fund was constituted including Royalties received from the industry.
- At this stage, the fourth important step of the constitution of the Council of Scientific and Industrial research (CSIR) as an autonomous body was set up on 26 September 1942, based on the framework drawn up Mudaliar and Bhatnagar.
- As a fifth step, Prime Minister Nehru approved the proposal of Bhatnagar to setup 5 national laboratories including NCL, NPL, the Fuel Research Station, and CGRI. All the five establishments were completed by 1950

# Economic Growth Profile of India

- India on the path of economic development
- India's GDP in 2018 of $ 2.69 trillion makes it the fifth largest economy and is destined to reach the third largest position by 2030 with $12 trillion
- India has the advantage of size, population and resources driving its growth
- Creating environment for continued and sustainable growth of economy with good quality employment opportunities is the need of the hour
- It is here that the role of Science and Technology becomes critical.

# S&T Evolution since Independence and Present Status




**CSIR was established**

**S&T base established ( 0.5% GDP)**

- Multiple institutions
- Basic Research
- Scientific education
- Agriculture research

**Visible societal impact (0.82% GDP)**

- Space
- Atomic energy
- Defence research
- Biotechnology
- Agriculture

**Future S&T innovation (expected 2% GDP)**

- Education
- Health
- Energy
- Water
- Environment
- Agriculture
- Private sector R&D
- Mega science initiatives

**Development of S&T human resource base and infrastructure development continued through this period**

# Science & Technology- Present Scenario

- India's R&D spending in 2018 stands at $83 billion. At the global level, India ranks third in S&T manpower, sixth in Scientific publications, seventh in the S&T Research and tenth in the Resident Patent Applications.
- Government of India's National Digital Communications Policy (September 2018) aims to attract $ 100 billion worth of investment and generate four million jobs by 2022.
- The extensive promotion of research parks (RP's), technology business incubators (TBIs) and would promote innovative ideas leading to commercial ventures. India is the world's third largest technology start-up hub with incorporation of more than thousand new companies in 2017.
- As a recent development, two important examples are worth quoting:
  a. India is gradually becoming self reliant in Nuclear technology
  b. India is increasingly becoming a major global space business entity with a sharp rise in ISRO's satellite launch capability.
- The union governments announcement of a grant of rupees 1000 crores in February 2018 is a major step to strengthen and expand research innovation and technology. Further, the Atal Innovation Mission with US $ 24.84 million will help to boost the efforts of academicians, entrepreneurs and researchers to work towards innovation.
- Several new initiatives of promoting and realising innovative S&T products and services by CSIR in areas like pharmaceuticals, agriculture, leather processing, many other industrial processes and so on which include many of the above mentioned elements.

## CSIR - A Powerhouse of S&T Knowledge

# Integrating Innovation with National S&T Endeavour

- Government of India, recognising innovation as a 21st century phenomenon for driving growth and competition, has declared the present decade as "The Decade of Innovation"
- Government has generated a road map towards strengthening the innovation with key elements encompassing sustainability, affordability, durability, quality, global competitiveness and local needs and addressing 5 parameters: platform, inclusion, ecosystem, drivers and discourse
- Further other elements of national innovation system will include:
  - ✓ Nurturing innovation through education, setting up platforms for best practices for scaling up the impact, connecting India for innovation through rural broadband & applications and use of science museums
  - ✓ Strengthening administrative machinery for IPR management

In summary innovation is expected to create significant impact much beyond the S&T in diverse areas such as health & education delivery, governance, entrepreneurship development etc., collectively this can herald a generational change in the country and lay out a chart for a more sustainable and inclusive growth paradigm.

# Five Decades of Indian Space Programme

**72**

Launch Vehicle Missions

HIGH SUCCESS RECORD

42/44 Successive PSLV Launches

BUDGET

~ USD 1.4 billion (2017-18)

APPLICATIONS LEADERSHIP

INDUSTRY

GLOBAL ROLE AND RELATIONS

INTERPLANETARY MISSIONS




**103**

Satellites launched

1 SRE, 1 CARE, 1 RLV-TD

10 Student Satellites,

269 foreign Satellites

SELF RELIANCE & STATE-OF-THE-ART TECHNOLOGY

HUMAN RESOURCES

(17625 strong Manpower)

SPACE COMMERCE

LARGE USER BASE

HUMAN SPACE-FLIGHT MISSIONS

INFRASTRUCTURE

End- to- end capability

# ISRO- An S&T Strategy for National Development

- **Vision of Dr Vikram Sarabhai**

- **Systematic and phased approach to building knowledge, technological capability and organizational systems to ensure efficient application of sophisticated technologies for national development.**

- **Three distinct phases of evolution**
  - **Proof of concept**
  - **End-to-end experimental systems**
  - **Current operational systems**

# India's Space Endeavour – Unique Origin and Vision

- Peaceful uses as a driver
- Extraordinary realism and pragmatism
- National development focus
- Self reliance
- International collaborations
- Institution building
- Innovative organisational culture
- Science, technology and applications harmony
- Inspiring leadership

# INDIAN SPACE – PHASES OF EVOLUTION

**NATIONAL REQUIREMENTS**

- Education
- Health
- Connectivity
- Weather
- Natural Resources Management
- Disaster Management
- Space Research

## 1960-1970's
**INITIATION PHASE**

- Vision
- Scientific Quest
- Learning
- Capability Build-up
- International Cooperation

## 1980's
**EXPERIMENTAL PHASE**

- Experimental Missions
- End-to-end Capability
- Proto-typing
- Research

## 1990's
**OPERATIONAL PHASE**

- Operational Missions
- National Services
- Wide User Base
- Institutional Framework

## BEYOND 2010's
**EXPANSION PHASE**

- Consolidation
- Innovative Missions
- Newer Services
- Newer Mechanisms for partnerships
- Global Outreach
- Commercial Solutions

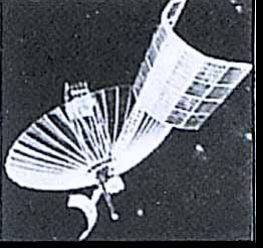
**… Systems to Institutions …**

**Strategy to Systems**

**Institutions, Exploration, Innovation**

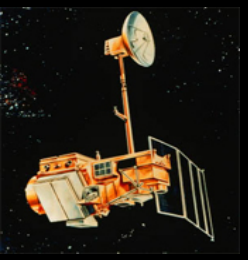
*… … … USER INVOLVEMENT … … …*

building knowledge | technological capability | organizational systems



# Proof of Concept

- The strategy adopted during the proof of concept phase was to use foreign space systems, configuring the ground systems to suit national needs and conditions as well as working closely with the potential user community



- Satellite Instructional Television Experiment (SITE)
  - Telecast included educational programmes on health, family welfare, agriculture, teachers training, etc
- Satellite Telecommunication Experimental Project (STEP)
- Remote Sensing Applications
  - Experience of integrating space based data with conventional aerial and ground based data
- Enabled short turn around time and low cost strategy for evaluating the concepts, the systemic issues including technologies and the institutional frameworks. The proof of concept phase spanning over a decade, accounted for an expenditure that is less than 1% of the total investment in the space program upto 2006 (constant price basis)

# End-to-end Experimental Systems

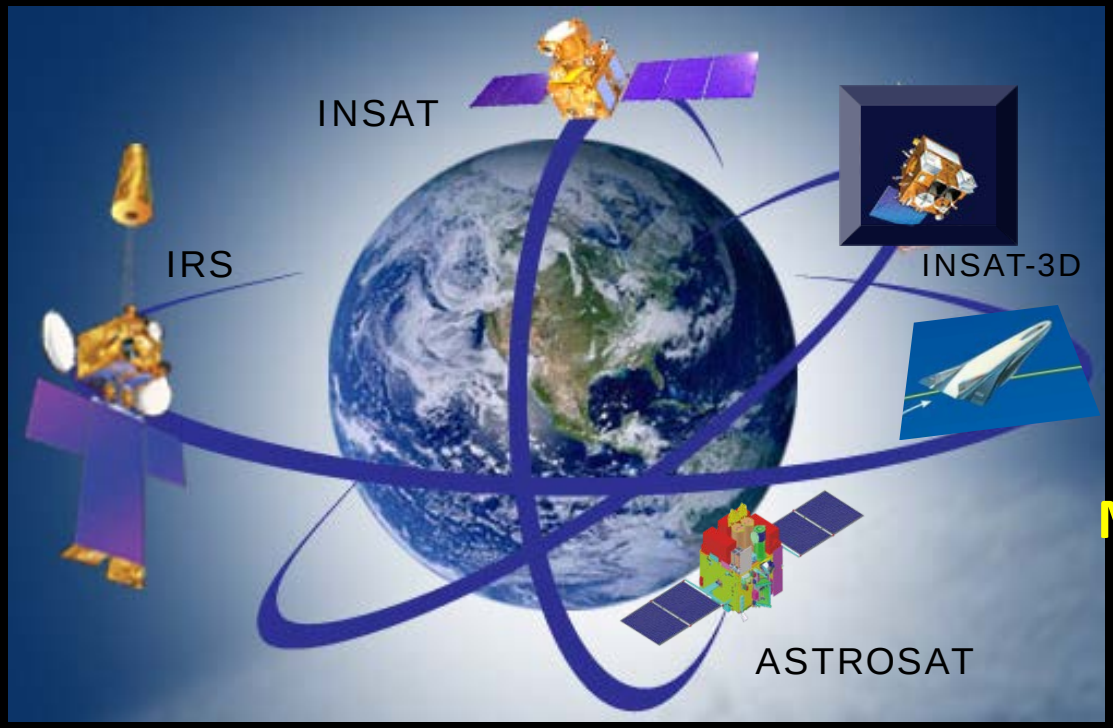
- Identified strategy to derive end-to-end experience in realizing space systems as a follow-up to the proof of concept phase
- Strategy took due cognizance of the fact that space systems are inherently complex, carry high risks and are investment intensive.
- Strategy helped to create heritage in hardware, human resources, methodologies and confidence for developing operational systems
- Building of indigenous APPLE communication satellite and remote sensing satellite, Bhaskara
- Building of experimental Satellite Launch Vehicles like SLV-3 and Augmented Satellite Launch Vehicle (ASLV) towards Polar Satellite Launch Vehicle and Geo-synchronous Satellite Launch Vehicle
-

Apple cart!

# Five Major Programs of ISRO

**Communication and Broadcasting, Navigation**

**Remote Sensing**




**Space Transportation**

**Gaganyaan- Manned Space Flight (2022)**

**Space Science- Applications**

# Strategies for Decision Making and Establishing Institutional Frameworks

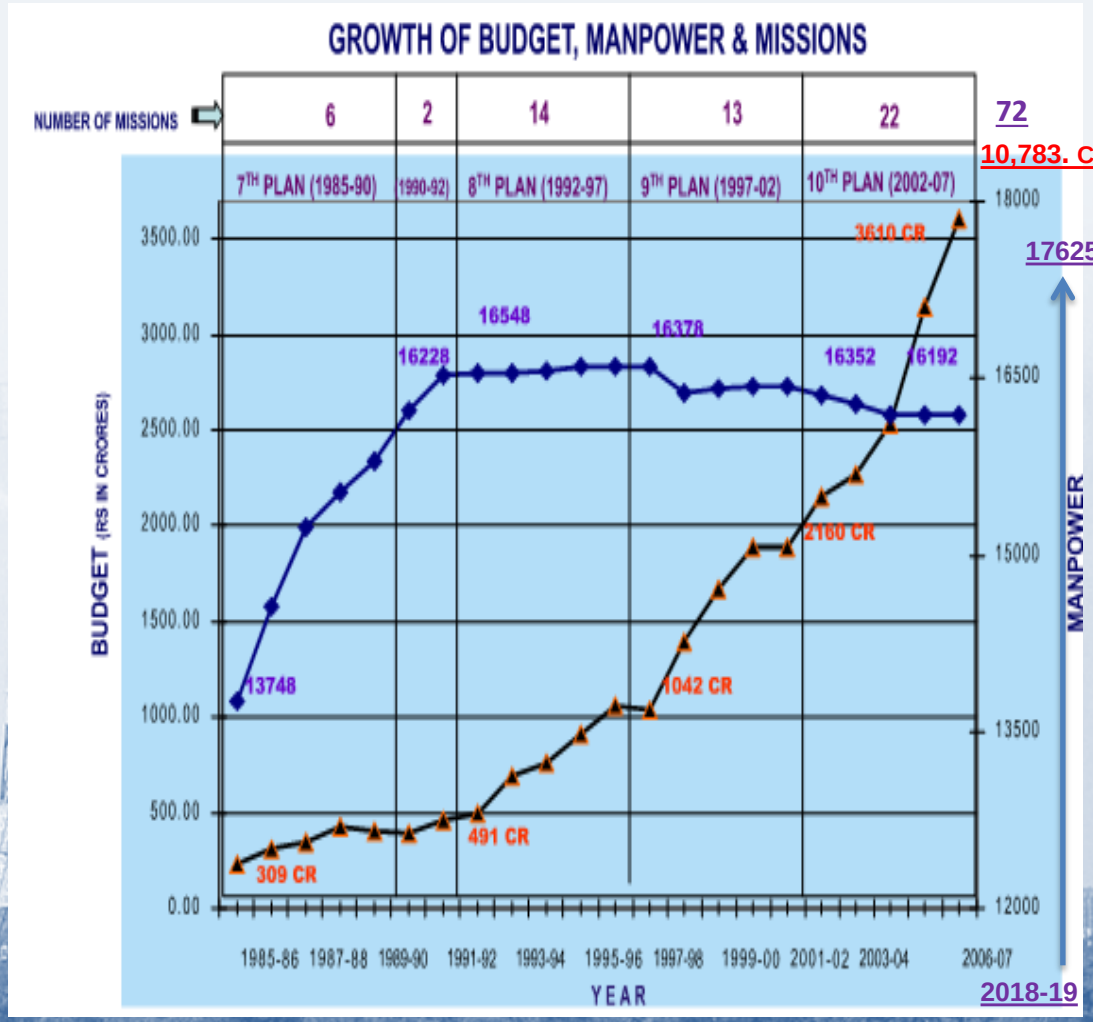
- In the early operational phase, exercised the build/buy options in establishing operational satellites communication system by deciding to procure the first generation INSATs from abroad
- Decision driven by the timeframe for indigenous system
- At the same time decision taken to build subsequent generation of satellites indigenously
- In the case of remote sensing satellites, decided for indigenous design and development recognizing the peculiar needs of resource sensing in the country and factors arising from cost and strategic considerations
- Decision was also taken to procure foreign launch services for early operational satellites considering the timeframe for development of our own launch vehicles capable of launching these satellites

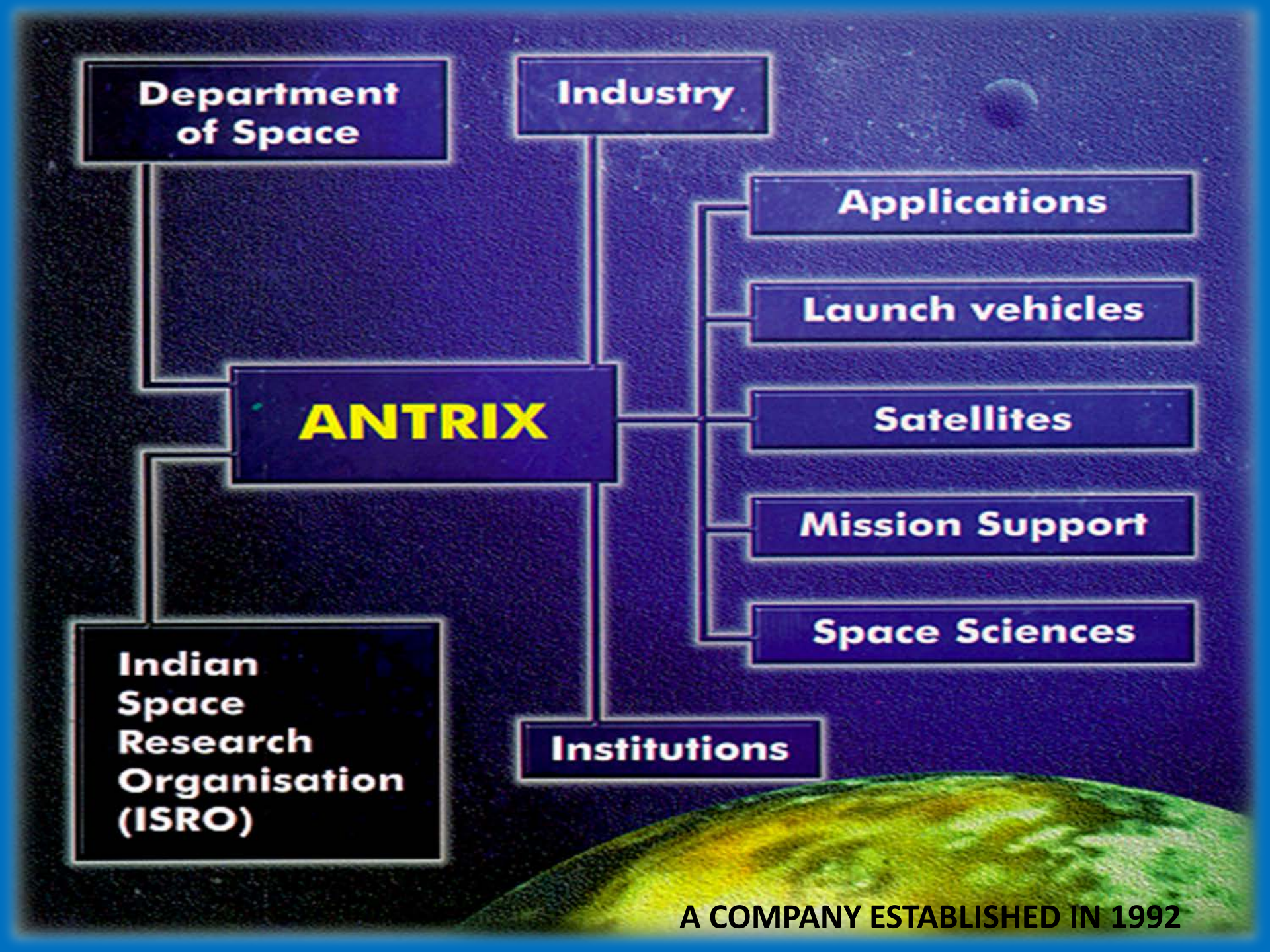
# Strategies for Decision Making and Establishing Institutional Frameworks

- Institutional framework to ensure integration of space based communication capabilities with ground based systems facilitated through creation of a structure called INSAT Coordination Committee (ICC) representing Secretaries of user departments such as Communication, Information and Broadcasting, Meteorology and Information Technology and chaired by the Head of the Space Organization.
- The counterpart of this for remote sensing was the creation of a body called National Natural Resource Management System (NNRMS) under Planning Commission and represented by Secretaries of the line Ministries dealing with Resources Management.
- In the case of Space Science, an Advisory Committee on Space Science (ADCOS) was set up to guide in planning Space Science Missions.
- At the apex level, India's Space Programme is overseen by Space Commission, a body reporting directly to Prime Minister and chaired by the Head of the Space Organization and with members from the highest levels of bureaucracy and eminent technocrats.
- The above organisational structures to manage the space programme have no parallel anywhere else in the world.

# Strategy for Creating/Utilizing Industrial Base

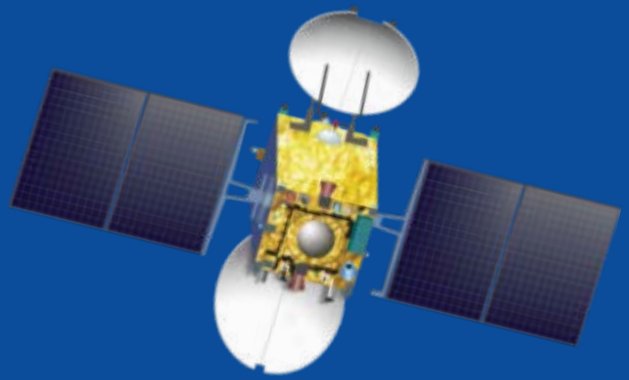
- Farming out major and routine fabrication jobs to industries
- Upgrading industrial capability to compete in the technically advanced international market
- Enabled to progressively increase the strength of highly qualified professionals without increasing the size of the organization
- More than 500 large, medium and small scale industries involved




Department of Space
Industry
Applications
Launch vehicles
ANTRIX
Satellites
Mission Support
Space Sciences
Indian Space Research Organisation (ISRO)
Institutions
A COMPANY ESTABLISHED IN 1992

# India in Space – Economics and Benefits

- TOTAL INVESTMENT OF INR 610 B (TILL 2015-16)
- INSAT – 25% LOWER COST IN MARKET VALUE
- IRS - COSTS MUCH LOWER THAN US LANDSAT AND FRENCH SPOT
- LAUNCH VEHICLE DEVELOPMENT COSTS 3 TIMES LESS COMPARED TO WORLD LV DEVELOPMENT COSTS




**INSAT SYSTEM**
(25% LOWER COSTS IN MARKET VALUE)

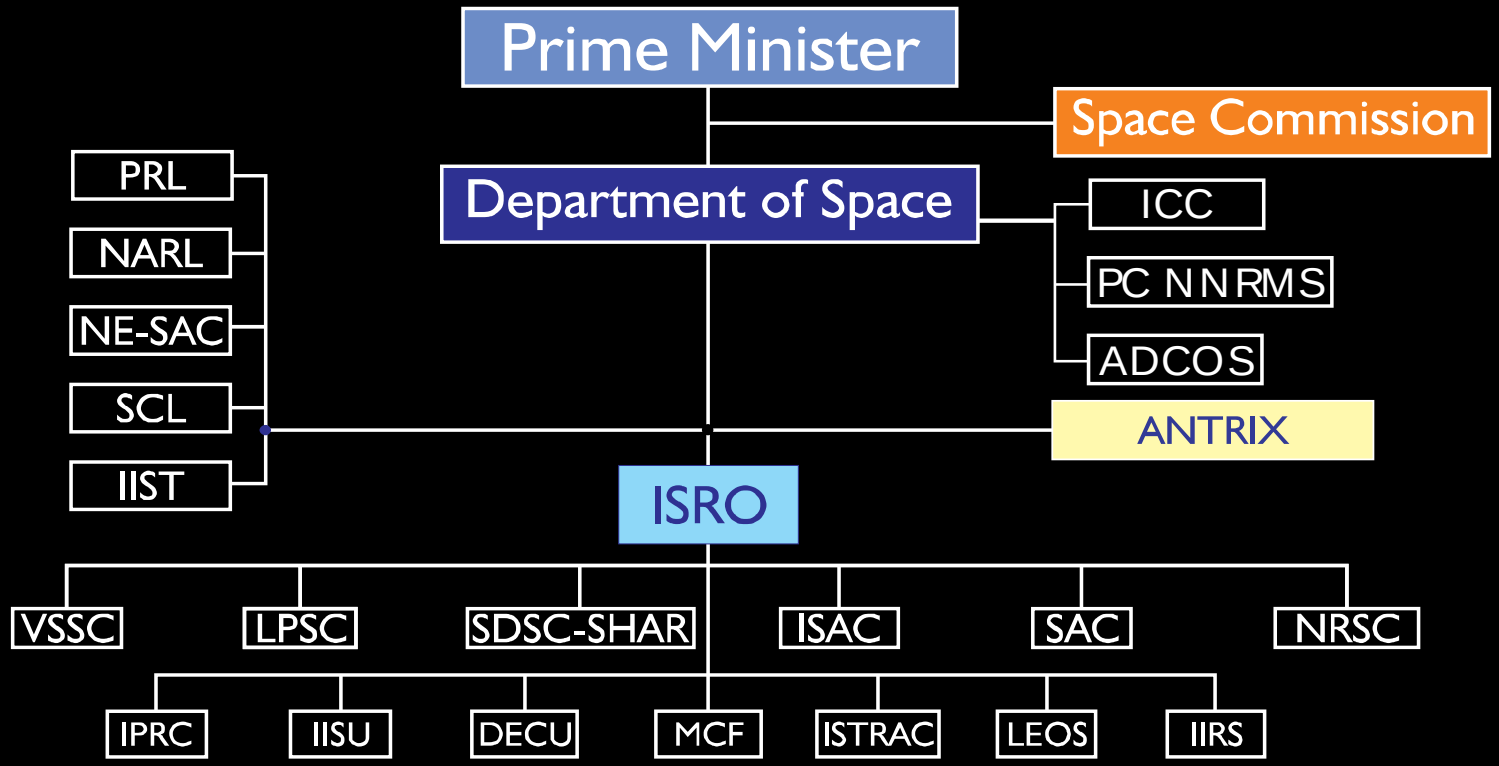
- 600+ TV CHANNELS
- 25K CRORES SERVICE BUSINESS
- 7 DTH OPERATORS
- CRITICAL VSAT/DMS SERVICES

**IRS SYSTEM**
(1:2 BENEFIT)

- 300 USERS
- ~500 CRORES DOWNSTREAM BSUINESS
- NATIONAL GIS
- CRITICAL NR AND DMS SERVICES

# Space Organisational Framework

## Organisation




**PRL:** Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor Laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **IPRC:** ISRO Propulsion Complex **SDSC:** Satish Dhawan Space Centre **ISAC:** ISRO Satellite Centre **SAC:** Space Applications Centre **NRSC:** National Remote Sensing Centre **IISU:** ISRO Inertial Systems Unit **DECU:** Development and Educational Communication Unit **MCF:** Master Control Facility **ISTRAC:** ISRO Telemetry, Tracking and Command Network **LEOS:** Laboratory for Electro-optic Systems **IIRS:** Indian Institute of Remote Sensing

**"In order to promote a rapid development of activities connected with the Space Science, Space Technology and Space Applications, the Government of India consider it necessary to set up an organization, free from all non-essential restrictions or needlessly inelastic rules, which will have responsibility in the entire field of Science and Technology of Outer Space and their Applications" June 1, 1972**

# BUILDING NATIONAL RELEVANCE FOR KEY MISSIONS

**Initiation of activities when justification for measurable direct benefit is lacking. Chandrayaan-1 example:**

## Decision making process of Chandrayaan-I

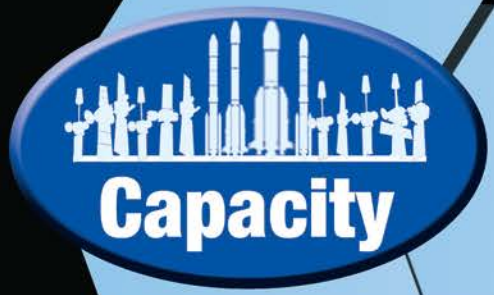
- **Presentation on Technology Day** — Germinating the Idea — May 1999
- **Presentation to Indian Academy of Sciences** — Interests of Scientific Community — Oct 1999
- **Discussions by Astronautical Society of India** — Response from astronautical community — Feb 2000
- **Feasibility assessment** — Detailing / Analysis — Sep 2001
- **Parliamentary Standing Committee** — Political Sensitization — Apr 2002
- **National Task Force** — Defining the Mission — Sep 2002
- **Review by National Committee** — Expert review and endorsement — Apr 2003
- **Endorsement by Space Commission** — Securing support of Policy makers — Jun 2003
- **Announcement By Prime Minister** — India enters planetary era. — 15th Aug 2003

**Process spanned over four years and led to announcement by the Prime Minister on the national decision to enter the new era of planetary exploration**

# Strategy for Future Sustainability


## Industry

- *Complete Realization of Systems*
- *Services*




## International Cooperation/Collaboration

- *Partnership to reduce time for technology development, realisation and production*
- *Procure if cost competitive*
- *Create joint missions to enhance the scope of India's space programme*

## Academia

- *Enhance Research Component*
- *Enhance R&D capacity*
- *Inputs of research into further development for translation through public-private institutions for going to industries totally*

# Some important aspects of S&T Management

1. Realisation of critical technology at the indigenous level : options available- technology transfer, build and buy options and indigenisation, some ISRO examples
   a. Technology transfer of earth storable Viking engines developed in France
   b. Buying outright seven units of Upper-cryogenic stage for GSLV Mk-I
   c. Several aspects of indigenisation based on closely working on technologies with countries like Russia, US and Europe
2. Deliberate promotion of advanced research areas with the idea of being better equipped as a strategy for technology acquisition. Further, this step could be coupled to indigenous technological upgradation and realisation of new generation systems
3. Support research activities in S&T institutions in India like CSIR as an investment towards a solution of many near term technological issues as well as planning for future.
4. Issues of promoting research particularly in areas of Science keeping in mind the tangible/intangible benefits
   1. Would need advanced technology development which could be used in the space missions of launch vehicles and satellites including applications
   2. Easy for collaboration and cooperation with other countries with increased transparency in the technological regimes.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# Some important aspects of S&T Management

- Role of University in research, mechanism for enhanced research funding; setting up of a research foundation is being considered by the Government and thus in the long run create a capability for knowledge generation at the University end.
- Such knowledge could be utilised to guide new directions of applied research say in the University itself in collaboration with research laboratories like those of CSIR.
- Subsequently, the outcome of such applied research could be appropriately linked into translational domain bringing in the market forces.

# Space: Unique Practices

- High level of interaction, communication and documentation (team spirit)
- Rigorous Review Mechanisms (transparency)
- Final product/services delivery only after user approval (accountability and responsibility)
- Mission executed in Project Mode; strict control on technical, cost and schedule elements
- Learning from failures
- Effective public outreach
- Mechanism for encouraging ideas and innovations, both internally and from outside
- Merit driven system

# Liberal education

- A key element in the context of strengthening the innovative component of thinking among the younger generation is to introduce liberal arts education in the late stages of schooling, in Under-graduate education and finally, to the extent necessary even in Post-graduate studies. Experience elsewhere has shown that this strategy allows students to explore the numerous remarkable relationships that exist among the sciences and humanities, mathematics and arts, medicine and physics etc. and more generally to explore the surprising unity of all fields of human endeavour.

- A liberal arts education enables one to truly develop both sides of the brain- both the creative/artistic side and the analytic side. Many of the world's top entrepreneurs have often spoken about how having team members with a liberal education allowed their enterprises to truly excel. For example, Steve Jobs was famous for ideas for products that married top notch aesthetics with top notch engineering. When asked about why the Macintosh computer revolutionised computing? He remarked " I think what made the Macintosh great was that the people working on it were musicians and poets and artists and zoologists and historians who also happen to be the best computer scientists in the world. In India's context, liberal education could be a key vehicle for transforming excellent engineers into excellent innovators also- the present need of the hour.

# In Conclusion

- India realizes that for a sustainable socio-economic development under high GDP growth rates, a stronger intervention from S&T related endeavors is imperative
- India, thus recognizes that as investments in S&T are increasing, a greater penetration of the role of S&T into the National socio-economic development is to be an integral part of the planning and implementation
- India's increasing and multiple developmental demands with limited resources, makes it necessary to integrate innovation with the S&T policy for ensuring sustainability & inclusivity
- For India, it is no longer a question of whether S&T and innovation should be an integral part of development strategy but whether India of today can afford to ignore them

**CSIR's extremely high level of intellectual asset, proven research outcomes of value and its potential to expand and strengthen keeping in mind the future challenges, no doubt is an important factor in transforming ourselves into a knowledge society with strong S&T inputs.**