From Knowledge to National Prosperity

Building Bharat's Technology Ecosystem

Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, Government of India, and the Asian and Pacific Centre for Transfer of Technology (APCTT) of UNESCAP

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SANKALP LECTURE SERIES,

UN House, New Delhi

16th July 2026

Knowledge to Prosperity

From Knowledge to National Prosperity:

Building India's Innovation and Technology Ecosystem

India today produces more than 45,000 PhDs every year, files thousands of patents, launches satellites, builds vaccines, develops digital public infrastructure, and has become the world's third largest startup ecosystem.

- Yet, only a fraction of our laboratory innovations become globally competitive products.
- The challenge before India is not only creating knowledge.
- It is converting knowledge into national wealth.
- It is also about generating new knowledge in upcoming areas.

Nations invest in Science & Technology

- Every nation desires economic prosperity, peace and power.
- Every nation invests in education and infra to enable that.
- Every nation supports research in academia and industry.
  - Yet only a few nations become global technology leaders. Why?
- It is that **knowledge alone does not create prosperity.**
  - Knowledge must be transformed into technology.
  - Technology must become products.
  - Products must create industries.
  - Industries must improve lives.
  - Only then does science fulfil its ultimate purpose.

Indian Science and Engineering Power

23rd August is celebrated as the National Space Day to commemorate the landing of Chandrayaan-3 at Shiv Shakti point

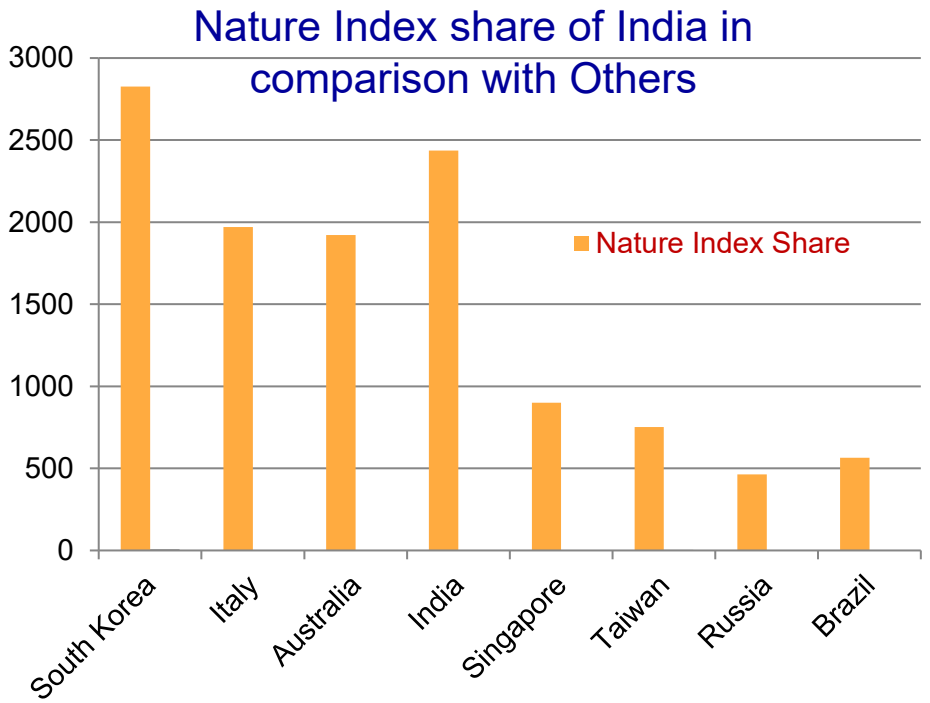
11th May is celebrated as National Technology Day to highlight the achievements of Engineers and Scientists in the field of technology and science.

Indicators in Science & Technology domains

- One among the most attractive destinations for technology investments, innovation and digital enterprises in the world.
- Expanded IIT, IISER and other HEI system, ranked 3rd on scientific publications and 6th on patents,
- India ranked 9th overall at the Nature Index research leaders in 2024
  - based on counts of high-quality research outputs in natural sciences.
- India stood 3rd in the number of Science and Engineering publications in the world.
- India is 4th largest in PhD production and overall STEM talents
- India's R&D expenditure doubled in last decade and is 7th largest
- Government investments for S&T in different sectors such as
  - agriculture, healthcare, space research, and nuclear power and other scientific research.
- One of leading IT development / service destinations
- India's Global innovation index has improved to 38th position in 2025.
- India host worlds largest stratup eco system currently.

Publications status, R&D Expenditure

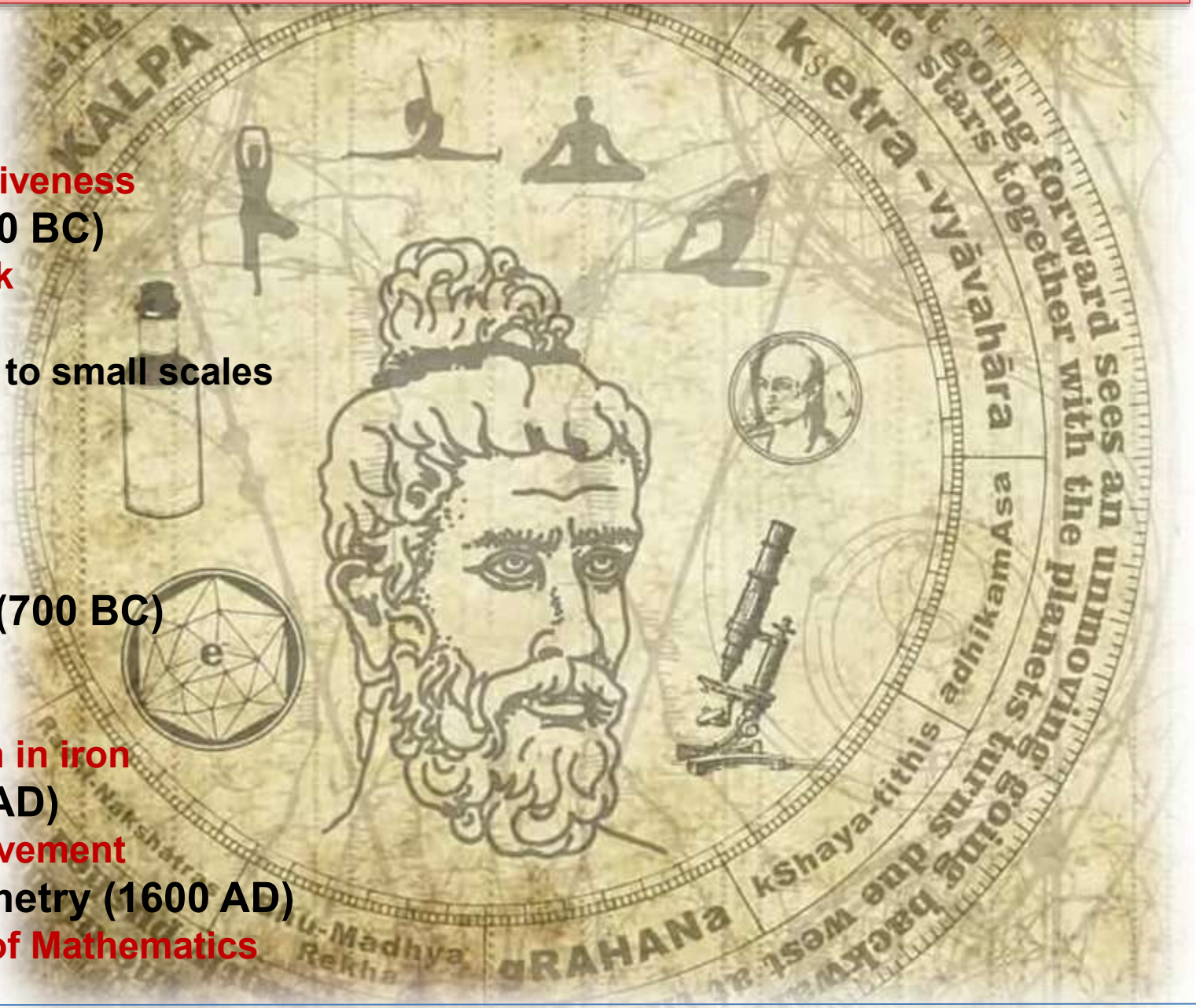
- According to the **U.S. National Science Foundation (NSF) Science & Engineering Indicators**, India's scientific publication output has grown remarkably over the past two decades.
- The number of **Science and Engineering (S&E) journal articles and conference papers** published by Indian researchers increased from **48,998 in 2008** to **135,788 in 2018**, representing an average annual growth rate of **10.73%**.
- In **2018**, approximately **2.56 million Science and Engineering publications** were produced worldwide. **India ranked third**, contributing **135,788 publications (5.31%)** of the global total.
- The latest **NSF Science & Engineering Indicators (2024)** show that India has **maintained its position as the world's third-largest producer of Science and Engineering publications**.
- India's publication output increased further to **207,390 publications in 2022**, demonstrating sustained growth in the country's research enterprise.



- India achieves very high research output despite relatively low R&D expenditure.
- South Korea and Taiwan have among the world's highest R&D intensities.
- Nature Index data: 2025 publication year (Research Leaders 2026). India: 2437
- GERD values for India is 0.64% are latest internationally reported figures (OECD/UNESCO).

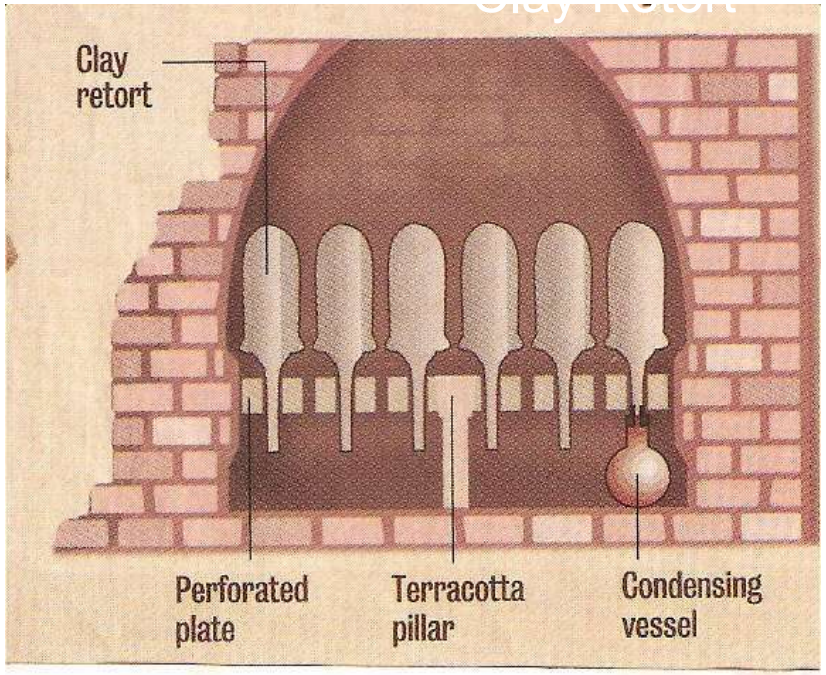
Science & Technology in Ancient India

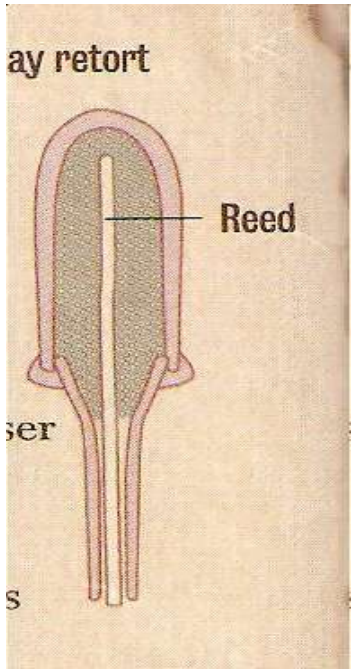
- Ancient Dentistry (7000 BC)
  - With drilling teeth to repair
- Ayurveda (5000 BC)
  - Still surviving with proven effectiveness
- Ancient flush toilet systems (2500 BC)
  - With sewage connection network
- Ruler (2400 BC)
  - Concept of length measurement to small scales
- Weighing scale (2400 BC)
  - Balances to compare weight
- Plastic surgery (2000 BC)
  - Art of moulding malleable flesh
- Pythagorean theorem equivalent(700 BC)
  - Baudhayana Sulba Sutra
- Steel processing (200BC)
  - With technique to reduce carbon in iron
- Charkha or spinning wheel (500 AD)
  - Later our symbol in freedom movement
- Mathematical theorems, trigonometry (1600 AD)
  - Eary works of Madhava School of Mathematics



Metallurgy – eco friendly Zawar process for Zinc

Retort is heated to 1200 C to vaporise zinc. At this temperature reed gets burnt and other materials release CO to create reducing atmosphere. Zinc trickles down through a path created by burnt reed.





Ref. Rasaratna samucchay

The furnace has two chambers. One with inverted retorts another with condensing vessels under each retort.

Proof of the process came from excavations at Zawar in Rajasthan.

- Zinc metallurgy traveled from India to China to Europe. In 1738 William Champion established Bristol Process and patented it.
- Recognised by ASM in 1989, as an "International Historical Landmark of Metallurgy".

Retort is filled with calcined ore, charcoal,salt etc. A reed is set in the middle and a funnel like condenser fitted at the end and sealed with the vessel.

Indias Engineering Strengths

Engineering Education & Talent

- **Largest Engineering Pipeline**: Over **1.5 million engineers graduate annually** from ~3,500 engineering colleges. **Prestigious Institutes**: IITs, NITs, IISc, BITS, and others produce globally recognized engineers. **Global Workforce**

Industrial & Sectoral Strengths

Information Technology & Software

- World leader in IT services, with well known firms, Expertise in AI, cloud, cybersecurity, fintech, and digital engineering.

Space & Aerospace

- ISRO, HAL, NAL, DRDO, and private startups.

Automotive & Mobility

- Major hub for vehicle design & manufacturing, Strong in **EV development**, battery tech, and automotive software.

Civil & Infrastructure Engineering

- Mega projects like Delhi Metro, Atal Tunnel, Delhi–Mumbai Expressway, large **bridges, dams, urban transport systems**.

Energy & Power Systems

- Strong in thermal, hydro, and nuclear plant engineering, Global leadership in **renewable energy integration** and grid management.

Manufacturing & Heavy Industry

- Strength in steel, cement, machinery, shipbuilding, and defense production, India as a **global hub for engineering R&D centers** (over 1,400 multinational design centers).

Indias Engineering Strengths

Global Impact

- Indian engineers hold leadership roles in Global Multi-national companies
- India supplies skilled engineers to **Middle East, Europe, US, and SE Asia** for infrastructure and IT projects.
- Recognized as the **“backbone of global tech support & engineering design.”**

Emerging Strengths

- **Semiconductors & Electronics Design** (India Semiconductor Mission).
- **AI, Robotics, Quantum Computing** research hubs growing.
- **Defense Tech & Space Startups** innovating with global potential.
- **Sustainable Engineering**: green buildings, EV infra, smart grids, water tech.

India’s engineering strength lies in its **massive talent pool, cost-efficient design capability, and ability to execute large-scale projects**, making it a key player in global technology and infrastructure.

India's Biosciences

Biotechnology

- **Global Position**: India ranks among the **top 12 biotech destinations** worldwide, and **3rd in Asia-Pacific**.
- **Biopharma**: Known as the "**pharmacy of the world**," India supplies **60% of global vaccine demand** and exports medicines to 200+ countries.
- **Bio-industrial**: Fermentation, biofuels, biodegradable materials.
- **Biotech Startups**: Over **6,000+ startups**, growing rapidly under the Biotechnology Industry Research Assistance Council (BIRAC).

Medical Research

- **Institutions**: AIIMS, ICMR, NIBMG, NCCS, and Translational Health Science and Technology Institute.
- **Clinical Trials**: India is a global hub due to cost-effectiveness, diverse genetic pool, and skilled researchers.
- **Vaccines & Therapies**: Covaxin (Bharat Biotech) and Serum Institute's Covishield showcase indigenous capability.
- **Traditional & Integrative Medicine**: Major research in Ayurveda, Yoga, Siddha, and Homeopathy under **AYUSH Ministry**.

Biosciences

- **Molecular Biology & Cell Science**: Research at NCBS (Bangalore), IISc, IISERs.
- **Stem Cell Research**: Work in regenerative medicine and disease modelling (e.g., CMC Vellore, NCCS Pune).
- **Marine & Plant Biosciences**: Bioprospecting for drugs, nutraceuticals, and green chemistry.
- **Neurosciences & Biomedical Imaging**: Advanced brain imaging, cognitive neuroscience labs emerging.

India’s Bioscience

Genomics

- **Genome India Project**: National initiative to map the genetic diversity of Indian populations
- **Genomics Startups**: MapmyGenome, MedGenome, and Strand Life Sciences affordable diagnostics.
- **Agrigenomics**: Crop improvement, livestock genetics, climate-resilient varieties.

Brain Research & Neurosciences

- **National Brain Research Centre (NBRC), Manesar: Flagship institute focusing on cognitive neuroscience, brain mapping, neurodegeneration (Alzheimer’s, Parkinson’s).**
- **Human Brain Project (India’s role): Linking computational models with brain disorders.**
- **Neuroinformatics & AI: Integration of brain imaging with machine learning for early disease detection.**
- **Brain-Inspired Computing: Growing research in neuromorphic chips and brain-computer interfaces.**

India’s Emerging Edge

- **Affordable Innovation: Low-cost vaccines, diagnostics, and therapies with global reach.**
- **Talent Pool: Strong biomedical and computational sciences workforce.**
- **International Collaboration: Partnerships with NIH (USA), Wellcome Trust (UK), EU projects, and Indo-Australian biosciences consortia.**
- **Future Potential: Precision medicine, synthetic biology, neurotech, and AI-biotech convergence.**

India’s Agriculture

Agricultural Base

- **Scale**: India is the **2nd largest agricultural producer** globally.
- **Major Outputs**: Rice, wheat, pulses, spices, milk, fruits, vegetables, cotton, sugarcane.
- **Employment**: Agriculture supports ~40% of India’s workforce.
- **Global Role**: Largest exporter of rice, major supplier of spices, tea, and seafood.

Technology Infusion in Agriculture

- **Mechanization & Precision Farming**
  - Tractors, harvesters, and drones becoming common in many states.
  - Precision agriculture with **GPS, IoT sensors, soil health cards**.
  - Startups introducing **AI-driven crop advisory platforms**.
- **Digital & Data-Driven Agriculture**
  - **Digital India initiatives**: e-NAM (electronic National Agriculture Market)
  - **Farmer apps**: Kisan Suvidha, AgriStack (digital ID for farmers).
  - Use of **satellite data** for crop monitoring and yield (collaboration with ISRO).
- **Biotechnology & Crop Science**
  - Ongoing research in stress-resistant rice, maize, and pulses.
  - Biofertilizers, biopesticides, and microbial solutions reducing chemical dependence.
  - Seed companies introducing **hybrid and climate-resilient varieties**.

India’s Agriculture

- **Irrigation & Water Tech**
  - **Micro-irrigation** (drip, sprinkler) expanding under Pradhan Mantri Krishi Sinchayee Yojana.
  - Solar-powered pumps and smart irrigation systems.
  - Watershed management projects integrating geospatial data.
- **Post-Harvest & Supply Chain**
  - Cold chain infrastructure for fruits, vegetables, dairy, and fisheries.
  - Agri-logistics platforms reducing middlemen.
  - Blockchain pilots for **traceability** in spices, coffee, and fisheries.
- **Agri-fintech & Insurance**
  - Digital credit platforms for farmers.
  - PM Fasal Bima Yojana (crop insurance) integrated with satellite monitoring.
  - Fintech startups offering real-time weather-based micro-insurance.
- **Emerging Agri-Tech Startups**
  - **Ninjacart, DeHaat, AgroStar, Stellapps, BharatAgri** – working on supply chain, advisory, fintech, and dairy tech.
  - **Drone startups** (Garuda Aerospace, Marut Drones) providing spraying, mapping, and pest control services.
- **India’s Edge & Challenges**
  - **Strengths**: Large diversity of crops, global supply chains, big farmer base, fast-growing agri-tech ecosystem.
  - **Challenges**: Small farm holdings, low mechanization in some regions, water scarcity, fragmented supply chains, climate risks.
  - **Opportunity**: With digital and biotech infusion, India can transition from **food security focus to sustainability leadership**

CSIR

CSIR is India's **largest publicly funded R&D network**.

38 national laboratories + 39 outreach centers + 5 units

Known for **multidisciplinary research**, industry partnerships, and technology transfer.

Health & Biotechnology

Drugs & Vaccines:

- Developed anti-TB drugs, anti-malarials (Artemisinin-based), and affordable generics.
- Contributions to COVID-19 diagnostics, drug repurposing, and genome sequencing.

Genomics & Molecular Biology:

- CSIR-IGIB (Institute of Genomics & Integrative Biology) **Genome India Project**
- **Biotech Platforms**: Stem cell research, biosensors, molecular diagnostics.

Agriculture & Food Tech

- Improved crop varieties (wheat, rice, aromatic plants).
- Post-harvest technologies, food preservation, nutraceuticals.
- Soil microbial technology for biofertilizers and waste-to-wealth solutions.

Energy & Environment

- Indigenous technologies for coal gasification, fuel cells, hydrogen energy.
- CSIR-NCL & CSIR-IIP working on **green fuels, petrochemicals, biofuels**.
- Air quality models and environmental monitoring systems.

Engineering & Materials

- Advanced materials: specialty alloys, composites, nanomaterials.
- MEMS, sensors, and electronics for defense and civilian use.

CSIR - Continued

Water & Earth Sciences

- CSIR-NGRI: Groundwater mapping, seismic studies.
- Water purification technologies (low-cost filters, arsenic/fluoride removal).
- Climate & oceanographic research for fisheries and disaster prediction.

Technology Development & Translation

Technology Transfers: Thousands of patents licensed to Indian industries (pharma, food, chemicals, aerospace, defense).

Affordable Innovation:

- **SwasthVayu**: Indigenous non-invasive ventilator (during COVID).
- **Soleckshaw**: Solar-powered rickshaw.

CSIR Aroma Mission: Boosting lavender, mentha, and aromatic crop cultivation

Indigenous Equipment: Parallel computing systems (Anupam), water purification units, leather processing machinery.

Industry & Societal Impact

- CSIR has partnered with **Tata, Reliance, DRDO, ISRO, BHEL, HAL**, and thousands of MSMEs.
- Plays a key role in **Make in India** and **Atmanirbhar Bharat** through indigenous technology development.
- Contributions to **rural development**: bio-toilets, agri-mechanization, health diagnostics.
- Exports technologies & processes, building India's global scientific credibility.

Future-Oriented Initiatives

- **Mission-mode programs**: New energy systems, quantum materials, genomics, AI-driven drug discovery.
- **Translational Research**: Emphasis on startups via **CSIR Innovation Centre & incubation programs**.
- **Sustainability**: Circular economy, waste-to-wealth, climate change mitigation technologies.

Sustainability

Policy & Commitments

- **Paris Agreement**: India committed to reduce emission intensity of GDP by **45% by 2030** (fro 2005 levels).
- **Net Zero by 2070**: Announced at COP26, balancing development with climate responsibility.
- **National Action Plan on Climate Change (NAPCC)**: Eight core missions (solar, energy efficiency, sustainable agriculture, water, etc.).
- **Panchamrit strategy**: Targets include **500 GW non-fossil power capacity by 2030**, 50% renewable energy share, and reducing carbon intensity.

Energy & Climate Action

Renewables:

- **4th largest renewable energy capacity globally (~190 GW).**
- **World's largest solar park in Karnataka (Pavagada).**
- **International Solar Alliance (ISA), initiated by India, driving global solar adoption.**

Energy Efficiency:

- **Bureau of Energy Efficiency's star ratings, PAT scheme, and LED distribution**
- **Green Hydrogen Mission: Targeting 5 MMT annual production by 2030.**
- **Nuclear & Hydro: Expanding clean baseload options.**

Sustainable Agriculture

- **Organic & Natural Farming: Sikkim declared the first fully organic state**
- **Micro-irrigation: Reducing water use with drip & sprinkler systems.**
- **Soil Health Cards: Promoting balanced fertilizer use.**
- **Climate-resilient crops: Biotechnology & traditional breeding for stress tolerance.**

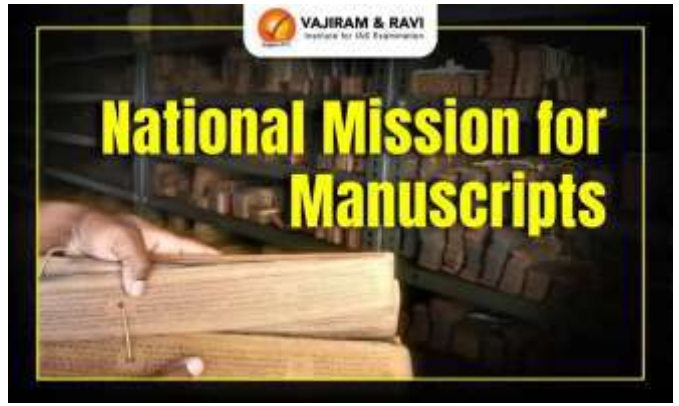
Indias National Missions

Industry & Innovation

- **Make in India (2014)**: Manufacturing and R&D boost.
- **Startup India** & **Atal Innovation Mission**: Startup/innovation ecosystem.
- **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)**: Robotics, IoT, Industry 4.0.
- **Gati Shakti Mission (2021)**: Multi-modal logistics & infrastructure tech.

National Missions under NAPCC (Climate & Sustainability)

- **National Solar Mission**
- **National Mission on Enhanced Energy Efficiency**
- **National Mission on Sustainable Habitat**
- **National Water Mission**
- **National Mission for Sustaining Himalayan Ecosystem**
- **National Mission for a Green India**
- **National Mission on Sustainable Agriculture**
- **National Mission on Strategic Knowledge for Climate Change**



Recent High-Tech Flagship Programs

- **National Supercomputing Mission (NSM)**: Indigenous HPC infrastructure.
- **Quantum and AI Mission**
- **National Mission on Bio-Economy**: Leveraging biotechnology for sustainable growth
- **National Skill Development Mission**: Tech-enabled workforce training.
- **Smart Cities Mission**: ICT-driven sustainable urban development.

Academic research

Institutes of National Importance (IITs, IISc, AIIMS, NITs) have strong industry linkages through:

1. Sponsored research projects
2. Internships and co-op programs
3. Technology Business Incubators (TBI) and entrepreneurship cells

Private universities (BITS, Shiv Nadar, Amrita, VIT, SRM) are agile in creating:

1. Corporate labs
2. Industry-led courses
3. Start-up incubation

Government Initiatives:

1. **Atal Innovation Mission (AIM)** promotes entrepreneurship and industry-academia collaboration.
2. **DST, DBT, MeitY, DRDO, CSIR** provide grants linking universities to industry projects.

Challenges

- Limited **scale and depth** of collaboration; only a few large companies actively engage.
- **Fragmented ecosystem**: Many small/medium industries lack structured R&D partnerships with academia.
- **Slow commercialization**: Academic research often doesn't reach market-ready products.
- **Skill mismatch**: Industry expects ready-to-deploy talent; academia produces theoretical knowledge.

possibilities. This often makes the strategy clearer at a glance.

Academic Industry linkage Creation

Joint R&D Labs

- Co-funded labs for cutting-edge research (AI, semiconductor tech, renewable energy, biotech).
- Example: TCS Innovation Lab at IITs; similar collaborations in clean energy, aerospace, pharma.

Internships and Co-op Programs

- Expand semester-long or year-long industry placements to enhance **hands-on experience**.

Curriculum Co-creation

- Involve industry experts in designing **curricula aligned with emerging technology needs**.

Innovation & Entrepreneurship Hubs

- Foster **start-ups from academic research**, with industry mentors providing market guidance.
- Encourage **IP creation and patent commercialization**.

Flexible Funding & Policy Support

- Tax incentives and grants for companies investing in academic research.
- Support for **industry-sponsored PhDs**.

Global Collaborations

- Leverage international partnerships for **technology transfer, joint research, and student exchange**.

In summary

- **India has strong pockets of industry-academia collaboration**, especially in IITs, IISc, and top private universities.
- **Opportunities are huge** in AI, semiconductors, clean energy, biotech, space tech, and advanced manufacturing.
- **Way forward:** Institutionalized partnerships, applied research focus, entrepreneurship culture, flexible funding, and global linkages.

Research & Knowledge Creation

National Research Foundation (NRF)

- Robust institutional framework for research funding, coordination, and **capacity building across disciplines** (sciences, social sciences, arts, humanities).
- Envisaged to **mobilize significant public and private funding for research**.
- **Support to all universities and colleges** with weaker research capacity, thereby democratizing research opportunities.
- Encourage **collaborative research across disciplines** to address complex societal challenges (e.g., climate change, AI ethics, public health).
- Strengthen India's position in global research rankings and outputs by **incentivizing publications, patents, and knowledge transfer.**

Incubation and research ownership

- Greater space for faculty to lead research clusters, incubators, and interdisciplinary projects, generating patents, licensing, and sustainable revenue.

Innovation and Start-ups

- By connecting vocational learning with research, **universities can serve as incubators for entrepreneurship and innovation ecosystems**.

Technology is moving at an incredible pace.

- Artificial Intelligence
  - Deep Learning, Computer Vision, Natural Language Processing, autonomous cars, navigation, robotics, pattern recognition, medical diagnosis, Digital assistants.
- Natural User Interfaces
  - Voice-driven interactions, object detection algorithms, Conversational experiences , haptic . The combination of multiple signals from the environment
- Virtual Reality
  - E-commerce, gaming, social applications, learning, education, healthcare, online VR environments,
- Augmented Reality
  - Content experiences, data exploration , visualizations, intelligent and contextual object annotation, dynamic physical world mapping and discovery,
- Analytics and Visualization
  - New ways to summarize, visualize, and present data
- Blockchain
  - Blockchain being distributed, decentralized, and immutable make it the ideal way to store and track data across numerous domains and use cases.
- Robotics
  - Proactive behaviours, advanced context understanding, able to adapt to human sentiment, enforce ‘personalities’ and communication styles.


ISRO Story

Beginning of our space era

- Indian National COmmittee for SPAce Research (INCOSPAR) created on February 1962
- TERLS dedicated to UN on 2nd February 1968,

Nike-Apache

The First sounding rocket launched from Thumba

21-Nov-1963

RH-75

First indigenous sounding rocket

20-Nov-1967

- Earth's Magnetic Equator Passes near to Thumba
- In 1962, the St. Mary Magdalene's church served as the Office and Laboratories."

TERLS dedicated to UN 2nd February 1968

A Lesson in Understanding Complex System Interactions

The ASLV-D2 flight of 13th July 1988

The failure that was a stepping stone to success

T= 50.26 s

T= 50.35 s

T= 50.38 s

T= 50.41 s

T+50.42 s

T+50.51 s

- The four stage launch vehicle broke up after 50 seconds into the flight
- Due to a rapid increase in vehicle in yaw resulting in flight loads exceeding the structural limits.
- Lack of knowledge in Aero-control interactions
- Changes in the Vehicle Design implemented.

Bharat's Accomplishments in Space

100+ Launch Vehicle Missions

SLV ASLV
SSLV PSLV
GSLV LVM3

225+

Missions

125+ Satellites

Remote Sensing
Communication
Navigation

Chandrayaan-1 / 2/ 3
Aditya-L1
Mars Orbiter
Astrosat

432 Satellites of 34 countries

15 Students satellites **2 Re-entry Missions**

Technology Demonstrators

Pad Abort Test
For Crew Escape System
Demonstration

Crew Module
Atmospheric
Re-entry Experiment

Reusable Launch Vehicle-
Technology Demonstrator &
Landing Experiment

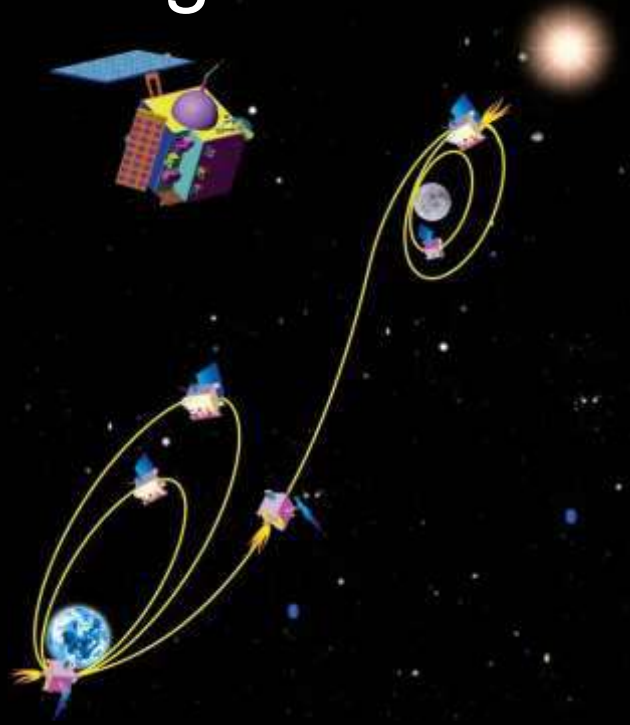
SCRAMJET

Chandrayaan-1: Reaching the moon

Total Satellite Mass: 1380 kg
Designed Life: 2 Year

Payloads

India: 5
Europe + India: 2
Europe: 2
US: 2



Discovered the presence of Hydroxyl & water molecules on the lunar surface (M3)

>180 Scientific publications

- Reflected hydrogen from lunar surface as detected by SARA payload
- Detection of presence of Mg, Al, Si, Ca on the lunar surface
- Detection of Argon-40 in the lunar exosphere

CHANDRAYAAN 1

Chandrayaan-2: Landing attempt

Total Spacecraft Mass: 3877 kg
Designed Life: 1 Year
Expected Life: 7.5 Years

Lift off mass **641 T**

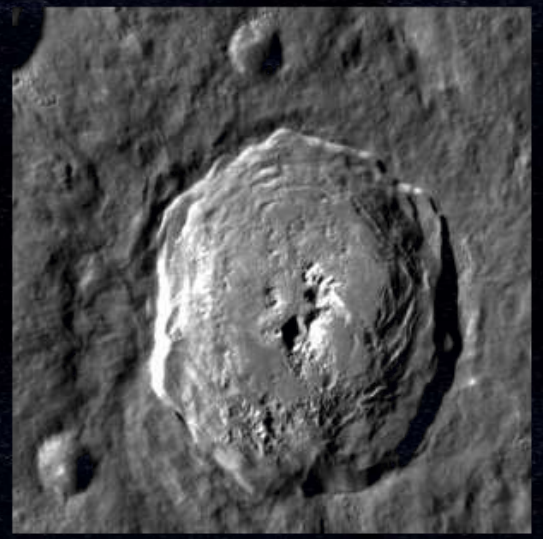
GTO payload **4.0 T**

- Orbiter
- Lander
- Rover

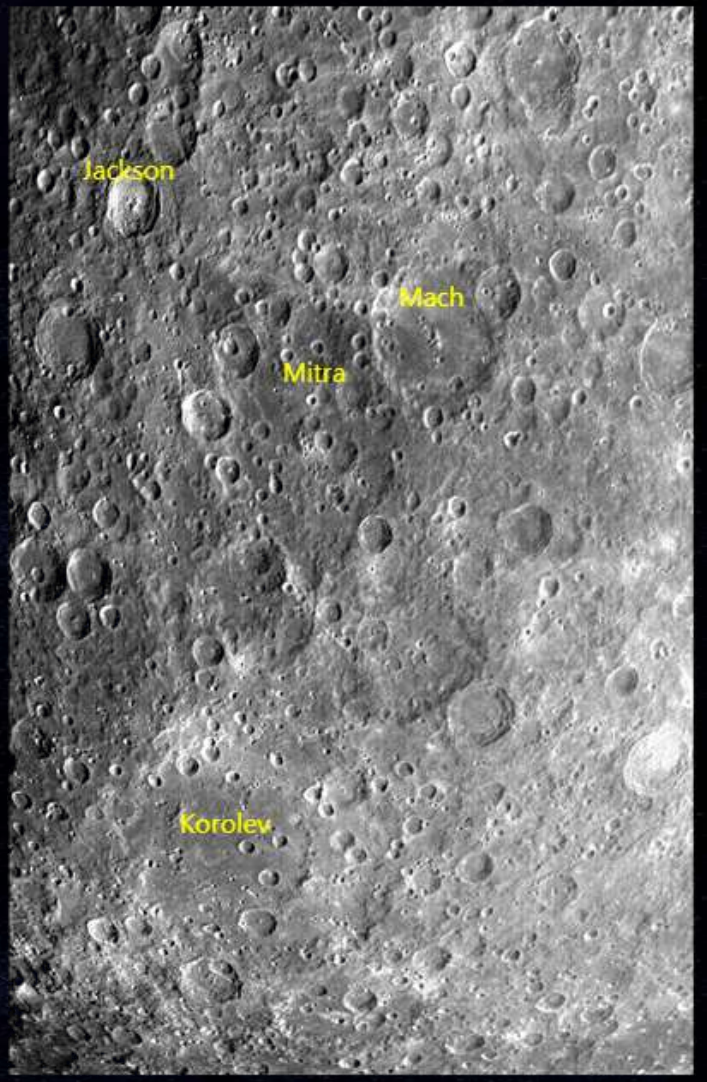
LVM3- M1

CHANDRAYAAN 2

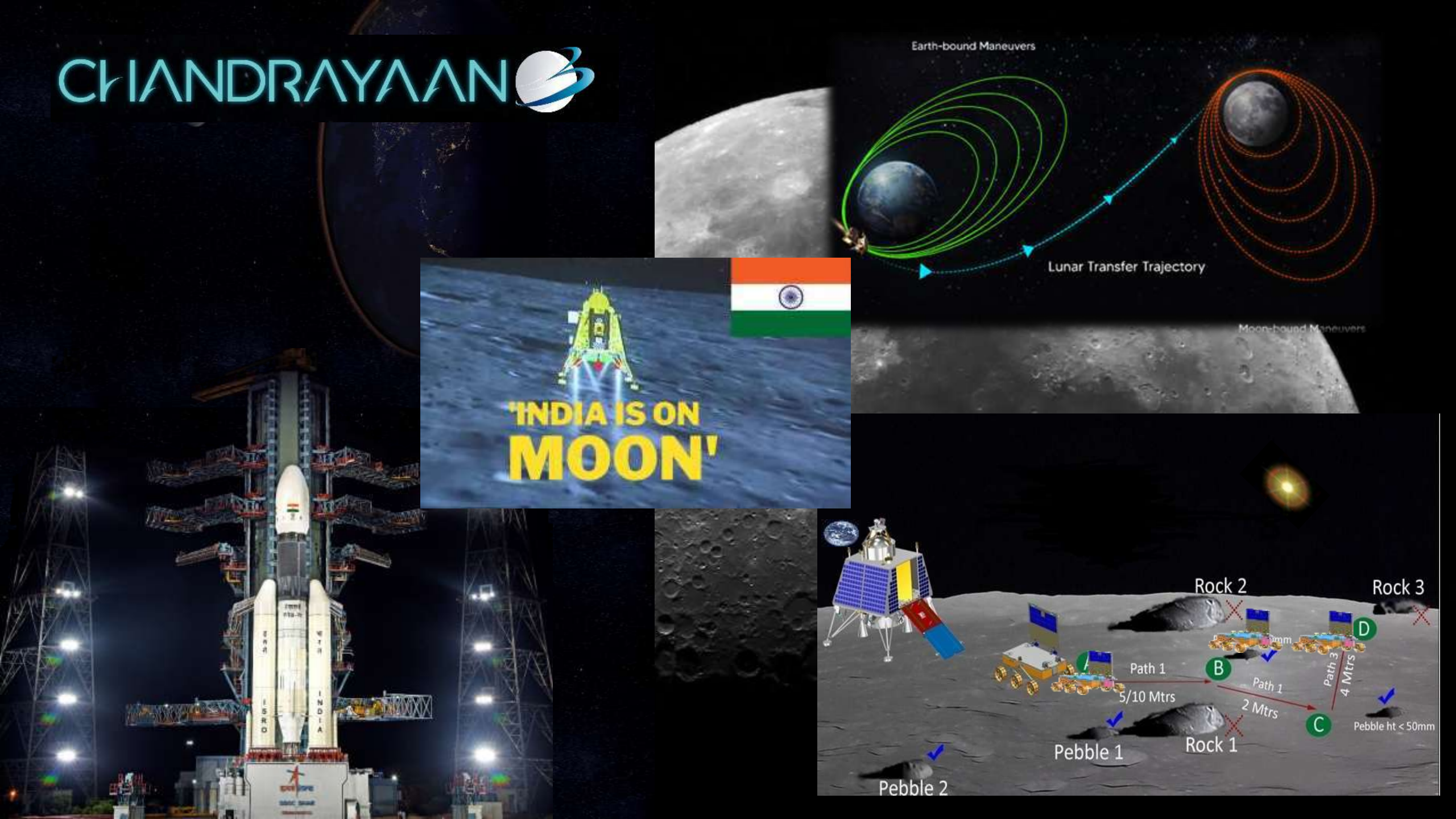
Jackson Crater
Diameter: 71.3 Km



Moon as viewed by Terrain Mapping Camera



CHANDRAYAAN



Launch Vehicle Building & Production through Industry

PSLV: *End-to-End realization in Industry*

ISRO – Tech Advisor

FUTURE PLAN *: @ 6-8 vehicles / year*

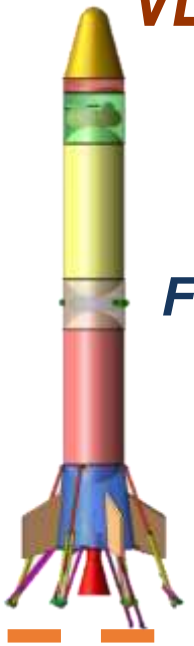
LVM3 *: Realization through Indian Industry.*

TT EOI announced

ISRO - Tech Lead

FUTURE PLAN *: @ > 10 vehicles / year*

VLV *: Development in ISRO & Industry*



FUTURE PLAN *: @ 6 – 10 vehicles / year*

SSLV: *Technology Transfered to Industry*

ISRO Tech provider

FUTURE PLAN *: @ 20 vehicles / year*

NGLV *: Development in partnership with industry*

FUTURE PLAN *: @ 6 – 10 vehicles / year*

Pvt Rockets *: Industry*

PRODUCTION PLAN *: @ Market demand based*

Spacecrafts Production through Industry

Com-Sats:

End-to-End realization in Industry

ISRO – Key National Projects

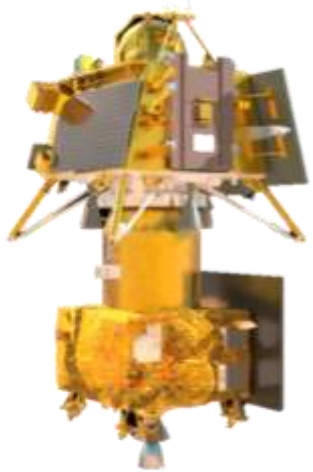
***PLAN** : @ 6-8 / year*

Large EO :

Realization through Indian Industry

ISRO – Some Strategic S/C

***PLAN** : @ 6 – 10 vehicles / year*



Scientific :

Development in ISRO & Industry

***PLAN** : @ 2 missions / year*

Small Sats:

Technology Transfered to Industry

ISRO Tech provider

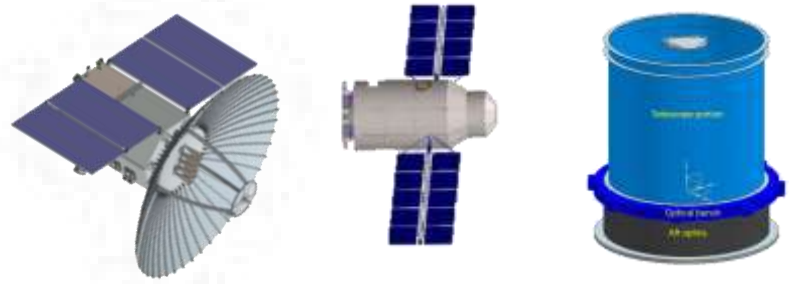
***PLAN** : @ 20-100 S/C / year*

NaVIC :

Development in ISRO & partnership with industry

***PLAN** : @ 2-4 S/C / year*

Spl. Sata : *ISRO to develop*



***PLAN** : @ Market demand based*


Innovation beyond Earth bound:
India's Space Vision 2047
इसरो ISRO
Indian landing on Moon
Chandrayaan Missions
Bharathiya Antariksh Station
Gaganyaan
NGLV

India's emerging Private Space Sector

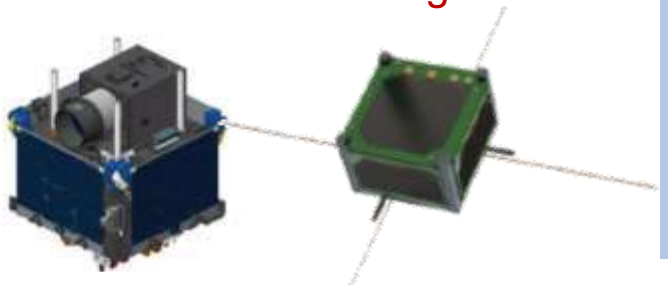
Skyroot Aerospace

Suborbital flight

Agnikul Cosmos

Suborbital flight

Private Satellite launched by ISRO Launch Vehicles



NGE in Space

- 4 Rocket Companies
- 5 Satellite Integration Facilities
- 1 SSA Company
- 2+ Space Operations Companies
- 2+ Spacecraft Prop Companies
- Many GeoSpa appl Companies
- Many Subsystem Companies

Non-Governmental Entities in the Space business in India

AGNIKUL
SKYROOT AEROSPACE
ANANTH TECHNOLOGIES
LARSEN & TOUBRO
HAL
ALPHA DESIGN TECHNOLOGIES
BELLATRIX AEROSPACE
DHRUVA SPACE
Azista
CENTUM
DATA PATTERNS
AMP Astra Microwave Products Ltd. On A Winning Wavelength
avantel connect • create • conserve
SatSure
MIDHANI
MapmyIndia
WALCHANDNAGAR

Solutions by Indian Private sector

- Development of advanced small satellites
- Small satellite launch vehicles
- Space debris management & mitigation
- Geospatial solutions
- Communication services
- Orbital transfer vehicles

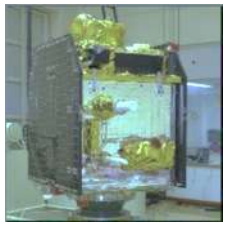
Technology Transfer from ISRO to Industry

Technologies Transferred

ISRO	NSIL	IN-SPACe/ NSIL
Till 2020	2020-23	Current (2023 onwards)
450+	27	80+

Li-Ion Cells

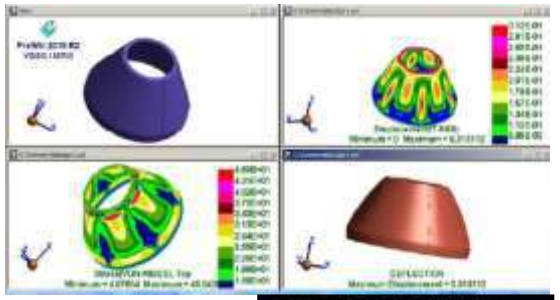
Supercapacitor

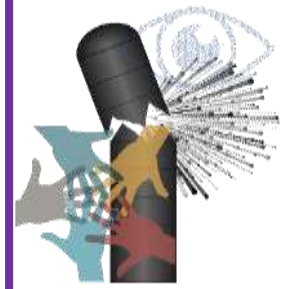


IMS-1 bus

Silica Aerogel

Distress Alert Transmitter





Utilization ISRO's technology for other sectors

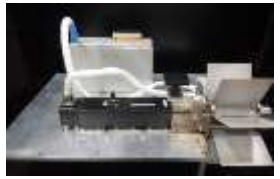
- Discussions held with Automobiles sector - Facilitated by IN-SPACe
- Technologies: Sensors (~80 Nos.) | Chemicals | Coating

Major Technology Development & Advanced R&D Projects

Systems

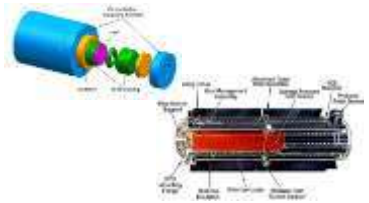
Deployable structures, Bus Systems

Atomic Clock (NVS-01)



TWTA

Hybrid propulsion



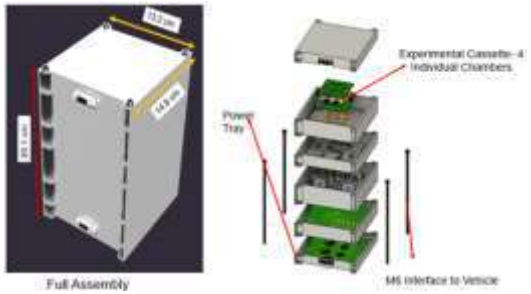
Nuclear propulsion – RHU/ RTG

- Real time EO streaming & Analysis ready products
- High accuracy PNT & Global Navigation
- Adv. Science payloads

Human Space

Intravehicular flight suit

ECLSS Simulator



Microgravity Experiments

Vyommitra

- Life support systems
- Inflatable habitats
- MMOD shielding
- Space biology & bioastronautics

Mechanisms

ITRB- ISRO Technology & Research Board

Synergizing R&Ds across centres & Prioritization

Mini projects – Linkage to Space Vision 2047

Dronet, Supersonic parachute development ……

Atmanirbharata - through Industry

100 items | EoI released | short-listed 54 items

Academia – Collaboration

Mission focussed projects, Centre of Excellence

Space: New Approaches

- Communication – direct from LEO to device at high speed everywhere
- Constellations of small satellites with commercial electronics
- Earth observation - analytics delivery, not images
- Space based data collection at scale
  - Strategic, surveillance, safety
  - IoT, agriculture
  - Drones piloting
- Space based data centre, AI compute infra and power generation
- Interplanetary human travel at scale, colonization
- Intercontinental human travel through rockets
- Large scale additive manufacturing of entire rocket
- Fast turn around from concept to operation

Universities are new innovation hubs

- Universities cannot remain degree-granting institutions. They must become centres of innovation.
- The future university must simultaneously educate, research, incubate startups, develop intellectual property, and create entrepreneurs.
- Students should graduate not only seeking employment. Some should graduate creating employment.
- Every university should aspire to establish innovation centres, prototype laboratories, industry partnerships, technology business incubators, and startup ecosystems.
- The classroom alone cannot create innovators. Innovation requires experimentation. Experimentation requires freedom. Freedom requires trust.

Technology Transfer – The missing Link

- Many publish excellent research. Yet relatively few convert research into wealth.
- The missing bridge is technology transfer.
- Technology transfer is often misunderstood.
  - It is not merely licensing patents.
  - It is transferring confidence.
  - It is transferring know-how.
  - It is transferring manufacturing capability.
  - It is transferring quality culture.
  - It is transferring engineering experience.
- Technology is far more than documents. Technology resides in people.
- During my years in ISRO, I realised that successful technology transfer depends less upon paperwork and more upon relationships.
- Scientists must trust industry. Industry must trust research institutions. Government must trust innovators. Trust accelerates innovation. Suspicion delays it.
- A transfer of culture and passion is needed along with technology.

A Message to Young Scientists

- Your greatest limitation is not lack of resources. It is lack of belief.
- Dreams become missions. Missions become institutions. Institutions build nations.
- Never underestimate the power of one committed individual. Every major institution began with a handful of determined people.
- Every technological revolution began with an idea that appeared impossible.
- You are the generation that will build the technologies of 2050.
  - May your ambition always exceed your comfort.
  - May your curiosity always exceed your certainty.
  - May your commitment always exceed your challenges.

Bharat 2050

Future is a Technology driven world. Absorb the change and adapt to remain relevant. Prosperity is built by creating knowledge and translating to products and services

Multipronged approach needed to incubate new enterprises, Create Tech driven companies, customer service orientation, skill based learning & education, self-reliance.

Advice Governments and decision makers towards embracing technology for growth.

Thank You