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Beyond IT: Exploring India's New Infrastructure for Autonomous Systems and AI

Space * AI * Computing

Introduction: From IT Services to Sovereign Deep-Tech Infrastructure

The 2024-2025 biennium marks a structural pivot in the scientific trajectory of the Republic of India. Moving beyond information technology services, the nation has invested in sovereign hardware architectures, autonomous physical systems, and foundational research infrastructure. Synthesizing developments from the Indian Space Research Organisation (ISRO), the Defence Research and Development Organisation (DRDO), and the private deep-tech sector, this report examines four pillars of India's technological ecosystem: orbital rendezvous and sample-return missions, high-performance and quantum computing, autonomous robotics, and sovereign generative artificial intelligence.

Orbital Dynamics, Autonomous Docking, and Launch Architectures

India's space program has transitioned from utility satellites to modular, multi-launch architectures for sample return and human spaceflight. Approved in September 2024 (2,104.06 crore), the Chandrayaan-4 lunar sample-return mission exceeds single-launch LVM3 capacity, adopting a dual-stack strategy that executes an autonomous orbital rendezvous in elliptical Earth orbit via Hohmann transfer orbit principles before lunar transit.[1] Stack 1 carries the Descender (DM) and Ascender (AM) modules, while Stack 2 houses the Propulsion (PM), Transfer (TM), and Re-entry (RM) modules.[1] A robotic arm and sub-surface drill extract 2-3 kg of regolith shielded from solar radiation weathering, sealing volatile water-ice traces in vacuum containers before lunar ascent, orbital transfer, and atmospheric re-entry.[1]

Orbital rendezvous required for Chandrayaan-4 and the Bharatiya Antariksh Station (BAS) was validated by the Space Docking Experiment (SPADEX), launched December 30, 2024, on PSLV-C60.[2] Using a Chaser (SDX01) and Target (SDX02) moving at ~7.8 km/s, SPADEX achieved autonomous capture on January 16, 2025, making India the fourth nation to master orbital docking.[3] Guided by LIDAR and optical navigation sensors through 15 m and 3 m hold points, the satellites docked, undocked in March 2025, and executed a fully autonomous second docking and inter-satellite electrical power transfer in April 2025.[3][4][5]

| Mission ID | | Primary Objective | | Timeline | | Key Engineering Validation |

| TV-D1 / TV-D2 | | Abort Missions 1 & 2 | | Completed / 2025-2026 | | Crew Escape System (CES) separation and Crew Module-Service Module separation qualification (Oct. 2026)[6][7][36] |

| G1 | | Uncrewed Orbital Flight 1 | | Target: No earlier than Feb 2027 (shifted from Dec 2026) | | HLVM3 orbital integrity; "Vyommitra" humanoid sensor suite[6][7][36][37] |

| G2 / G3 | | Qualification Flights | | 2027 (Planned) | | Environmental Control and Life Support System (ECLSS) endurance[6] |

| H1 | | First Crewed Flight | | 2027-2028 (Target) | | Crewed orbital mission to Low Earth Orbit[7] |

While Gaganyaan qualifies the human-rated HLVM3 and Crew Escape System (completing Crew Module-Service Module pyrotechnic and umbilical separation testing on October 16, 2026, while ISRO officials indicated in November 2026 that the uncrewed G1 flight carrying humanoid Vyommitra is unlikely before February 2027 to complete final safety validations)[36][37], the Aditya-L1 solar observatory at Sun-Earth Lagrange Point 1 (1.5 million km from Earth) uses its Visible Emission Line Coronagraph (VELC) to track Coronal Mass Ejections (CMEs) and coronal heating.[7][11] Meanwhile, IN-SPACe reforms enabled Skyroot Aerospace to develop the all-carbon-composite Vikram-I launcher (solid Kalam stages with a 3D-printed liquid upper orbital module) -- which completed its maiden orbital flight (Mission Aagaman) on July 18, 2026 from SDSC-SHAR, deploying rideshare payloads into a ~450 km Low Earth Orbit[35] -- and Agnikul Cosmos to launch Agnibaan SOrTeD in May 2024 using Agnilet, the first single-piece 3D-printed semi-cryogenic engine burning liquid oxygen (LOX) and kerosene.[8][9][10]

Silicon and Quantum Sovereignty: HPC, Superconducting Qubits, and RISC-V

Under the National Supercomputing Mission, three PARAM Rudra clusters deployed in September 2024 combine Intel Xeon Gold 6240R CPUs with NVIDIA A100 GPUs over InfiniBand HDR100 interconnects.[12] These systems power fast radio burst (FRB) detection at GMRT Pune, ion-beam simulations at IUAC New Delhi, and quantum materials modeling at the S.N. Bose Centre in Kolkata.[13][14]

Backed by 6,000 crore, the National Quantum Mission (NQM) achieved domestic hardware realization in August 2024 when TIFR, DRDO, and TCS tested a 6-qubit superconducting quantum processor.[15][16] Cooled near absolute zero inside a dilution refrigerator to operate as a quantum harmonic oscillator, the processor validated indigenous pulse control electronics and cloud execution en route to 24-100 qubit systems.[16][17] In classical silicon, IIT Madras and C-DAC utilized the open-source RISC-V architecture to build the Shakti and Vega processor families -- including a 7nm server roadmap for 2028 and the radiation-hardened, fault-tolerant IRIS aerospace chip booted with ISRO.[18][19][20]

Autonomous Robotics in Defense, Surgery, and Precision Agriculture

Coupling edge deep learning with hardware actuation has expanded Indian robotics into hazardous and clinical domains:

* Littoral Mine Countermeasures (DRDO MP-AUV): Unveiled in November 2025, this Man-Portable Autonomous Underwater Vehicle pairs side-scan sonar with onboard neural networks to classify Mine-Like Objects at the edge, coordinating multi-vehicle sweeps via acoustic swarm links.[21]

* Modular Surgical Robotics (SSI Mantra): Deployed across 100+ hospitals by 2025, SSI Mantra uses independent robotic arm carts and an open-console 4K 3D display to

democratize minimally invasive cardiac and general surgery.[22][23][24]

* Agricultural Computer Vision (Niqo Robotics): Operating at 4.5 mph, Niqo Sense solves real-time green-on-green weed segmentation (down to 1 inch), triggering micro-dose spot-spray nozzles that cut herbicide use by up to 60%.[25][26]

Sovereign AI Compute and Indic Large Language Models

The 10,000+ crore IndiaAI Mission empanelled over 38,000 GPUs and accelerators (NVIDIA H100/A100, AMD MI300X, Intel Gaudi 2) by mid-2025, subsidizing up to 50% of domestic training compute costs.[27][29][30] This compute fabric supports foundation models designed to eliminate the "tokenization fertility tax," where English-centric tokenizers split single words in Indic scripts into 4-5 tokens. Sarvam AI's Sarvam-1 (2B parameters) uses a custom Indic tokenizer across 10 languages for efficient edge inference, while Ola's 12B-parameter Krutrim-2 (trained on 2+ trillion Indic-enriched tokens) and the IIT Bombay-Reliance BharatGPT (Hanooman) multimodal suite (1.5B-40B parameters across 22 vernacular languages) deliver superior cultural and linguistic accuracy per parameter.[31][32][33][34]

Conclusion: The Convergence of Sovereign Capabilities

India's 2024-2025 scientific landscape is defined by cross-domain convergence: orbital docking vehicles use indigenous RISC-V avionics, underwater robots run edge AI, and national GPU clusters train linguistically tailored foundation models.

| Domain | | System / Breakthrough | | Core Technical & Strategic Capability |

| Orbital Spaceflight | | Chandrayaan-4 & SPADEX | | Dual-stack assembly, autonomous LIDAR docking, orbital power transfer[1][3][5] |

| Launch Propulsion | | Agnibaan Agnilet / Vikram-I | | 3D-printed LOX/kerosene semi-cryogenic and carbon-composite stages[8][9] |

| HPC & Quantum | | PARAM Rudra & TIFR 6-Qubit | | GPU-accelerated clusters; domestic superconducting qubit control stack[12][16] |

| Semiconductors | | RISC-V Shakti / IRIS Chip | | Space-qualified fault-tolerant avionics and 7nm server roadmap[18][20] |

| Field Robotics | | DRDO MP-AUV / SSI Mantra / Niqo | | Edge-sonar mine countermeasures, modular surgery, spot-spray vision[21][23][25] |

| Sovereign AI | | IndiaAI & Sarvam-1 / Krutrim-2 | | 38,000+ GPU fabric; low-fertility Indic script tokenization[28][31][33] |

By pairing state foundational missions with private hardware engineering, India has transitioned from a consumer of imported technology stacks to an architect of sovereign deep-tech infrastructure.

Updates... (Nov 23, 2026): Updated Gaganyaan G1 launch timeline to reflect November 2026 ISRO reports that the uncrewed flight carrying humanoid Vyommitra is unlikely before February 2027 (Ref [37]); corrected Reference [24] publication year from 2025 to June 12, 2024; and upgraded References [2], [23], [31], [32], and [33] with verified exact dates from ISRO, SS Innovations, and Hugging Face model records (consolidating prior Nov 18 and Nov 22, 2026 updates).

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