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EDITORIAL ANALYSIS

After SpaDeX — India's Space Autonomy and the Road to a Crewed Station

 **THE HINDU**

14 January 2026

SUBJECTS COVERED**SCIENCE & TECH****GS PAPERS****GS3****CURATED & WRITTEN BY****Bharat Choudhary**

UPSC Educator & Content Creator •

[linkedin.com/in/epicbharat](https://www.linkedin.com/in/epicbharat)

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MAINS RELEVANCE:

GS Paper 3



INTERVIEW ANGLE

"India demonstrated space docking with SpaDeX. What are the strategic and commercial implications? Is India's space programme adequately funded and organised to achieve its stated goals of a crewed station and lunar sample return by the mid-2030s?"

WHY IN NEWS

ISRO's SpaDeX spacecraft completed pre-docking approach maneuvers on January 14, 2026, with India set to become the 4th country to demonstrate autonomous space docking on January 16 — a milestone that places India in an exclusive club alongside the USA, USSR/Russia, and China, and validates the technology foundation needed for Gaganyaan, Chandrayaan-4, and India's planned Bharatiya Antariksh Station.

A MILESTONE THAT MATTERS

India's SpaDeX docking achievement is not merely a symbolic milestone. Space docking is a foundational enabling technology — without it, a nation cannot build a space station, return samples from another planet, or sustain a crewed lunar presence. That India has now demonstrated this capability, on a mission that cost a fraction of comparable foreign programmes, marks a genuine inflection point in its space journey.

The SpaDeX mission cost approximately Rs 124 crore (\$15 million) — by comparison, China's early docking missions cost orders of magnitude more. ISRO's institutional culture of frugal innovation — adapting, indigenising, and building incrementally — has produced world-class capabilities at a fraction of international benchmarks. The Mars Orbiter Mission (Mangalyaan, 2014) cost Rs 450 crore, less than the production budget of the Hollywood film *Gravity*. SpaDeX continues this tradition.

But frugality alone cannot sustain India's space ambitions in the next decade. The missions ahead — Gaganyaan (crewed orbital flight), Chandrayaan-4 (lunar sample return), and the Bharatiya Antariksh Station (BAS) — require capabilities, timelines, and budgets that demand a structural upgrade of India's space ecosystem, not just its rocketry.

WHAT SPADEX ENABLES

Space docking is not an end in itself — it is an enabler for a cascade of future capabilities.

Gaganyaan's expansion: The initial Gaganyaan mission — 3 astronauts in a 400 km LEO orbit for 3 days — does not itself require docking. But the follow-on phases — an Indian mini-space station, crew rotation, resupply missions — all do. SpaDeX validates that ISRO's guidance, navigation and control (GNC) software can manage autonomous rendezvous — the hardest algorithmic challenge in orbital mechanics.

Chandrayaan-4's necessity: Unlike Chandrayaan-3, which was purely a soft landing and rover demonstration, Chandrayaan-4 involves a lunar sample return — requiring an Ascent Module to launch from the lunar surface, rendezvous with a Transfer Module in lunar orbit, transfer collected samples, and then return to Earth. This multi-stage orbital rendezvous is impossible without SpaDeX-class technology. India must demonstrate this in Earth orbit (which SpaDeX has now done) before attempting it around the Moon.

Satellite servicing market: The global market for in-orbit satellite servicing — refuelling, module replacement, life extension — is projected to exceed \$3 billion annually by 2030. India now has the foundational technology to compete in this market through IN-SPACE-authorized private operators. No Indian private company can build satellite servicing missions without ISRO having first demonstrated the underlying docking technology.

THE BAS TIMELINE CHALLENGE

The Bharatiya Antariksh Station is India's most ambitious space project — more complex than anything India has attempted. The plans call for a ~52-tonne station in a 400 km LEO orbit with the first module launched by 2028 and full operations by 2035.

But space stations are qualitatively different from satellites or lunar probes. They require:

- Life support systems that operate without failure for years
- Radiation shielding for prolonged human stays
- Attitude control under continuous crew loading changes
- Regular resupply with food, water, oxygen, and fuel
- Emergency evacuation capability (rescue spacecraft always docked)

The 2028 first-module target is ambitious given that ISRO has not yet launched a crewed Gaganyaan mission. The normal progression for a spacefaring nation — crewed orbital mission → extended crewed stays → space station — takes 10–15 years. India is proposing to compress this into 5–7 years. Whether this is achievable depends critically on whether India's space budget — approximately Rs 12,000 crore per year (approximately \$1.4 billion), roughly 1/15th of NASA's budget — can be sustained and expanded.

THREE STRUCTURAL REQUIREMENTS

1. Sustained budget growth: India's space budget has grown in absolute terms but has remained flat as a percentage of GDP at ~0.04% (compared to the USA at ~0.25%, China at ~0.10%). To achieve BAS and Gaganyaan simultaneously, India needs to double its annual space expenditure by 2030. The Space Activities Bill – long pending – should provide the legislative framework for commercial revenue to supplement the government budget.

2. IN-SPACE must become a genuine enabler, not just an approver: The establishment of IN-SPACE in 2020 was the right structural reform – opening India's space sector to private companies like Skyroot, AgniKul, Bellatrix, and Dhruva Space. But IN-SPACE has sometimes functioned more as a gatekeeping regulator than a promotional accelerator. The model to emulate is the US FAA-AST (Office of Commercial Space Transportation), which has actively streamlined launch licensing to support SpaceX, Rocket Lab, and others. India's private launch vehicle companies need access to ISRO launch pads, telemetry support, and technology transfer at internationally competitive rates.

3. International partnerships without dependence: India's space programme has operated largely independently – a deliberate choice reflecting concerns about technology transfer restrictions (MTCR, Wassenaar Arrangement) and strategic autonomy. But for complex missions like lunar sample return and a space station, international collaboration – with JAXA (Japan), ESA (Europe), and potentially NASA – can reduce costs and timelines without compromising core technology sovereignty. The Artemis Accords (which India signed in June 2023) provide a framework for such collaboration.

★ FACTS CORNER — KNOWLEDGEPEDIA
SPADEX MISSION:

Launch: December 30, 2025; PSLV-C60; Sriharikota
 SDX01 (Chaser) + SDX02 (Target); orbit: ~470 km
 Docking: January 16, 2026; India = 4th country (USA 1966, USSR/Russia 1969, China 2011)
 Cost: ~Rs 124 crore (\$15 million)

GAGANYAAN:

Crewed orbital flight; LVM3; 400 km LEO; 3-day duration
 4 IAF pilots; training at GCTC Moscow + ISRO Bengaluru

CHANDRAYAAN-4:

Lunar sample return; 5 modules; requires lunar orbit docking
 Expected launch: ~2028

BHARATIYA ANTARIKSH STATION (BAS):

First module: 2028 target; full ops: 2035
 Mass: ~52 tonnes; crew: 3-4 astronauts; 400 km LEO

IN-SPACE:

Established: 2020; Department of Space
 Promotes/authorises private space sector
 Notable private companies: Skyroot (Vikram-S, Nov 2022), AgniKul (Agnibaan), Bellatrix, Dhruva Space

INDIA SPACE BUDGET:

~Rs 12,000 crore/year (~\$1.4 billion)
 ~0.04% of GDP; NASA's budget: ~\$24 billion (0.3% of US GDP)

ARTEMIS ACCORDS:

India signed: June 2023 (during PM Modi's US visit)
 Framework for peaceful, transparent civil space exploration
 40+ signatory nations

ISRO KEY MISSIONS (HIGHLIGHTS):

Mangalyaan (MOM): 2014; cost Rs 450 crore; first Asian Mars mission to succeed
 Chandrayaan-3: July 2023; Vikram lander soft-landed on Moon's south polar region; 4th country
 Aditya-L1: Sun observation mission; launched Sept 2023; L1 halo orbit Jan 2024
 PSLV: 58+ successful launches; workhorse; 4 stages (S-L-S-L)
 LVM3: India's heaviest rocket; 4,000 kg GTO; used for OneWeb (now Eutelsat) broadband

Sources: ISRO, IN-SPACE, The Hindu

CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator

 [linkedin.com/in/epicbharat](https://www.linkedin.com/in/epicbharat)

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