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SpaDeX — India's Space Docking Experiment and the Road to Gaganyaan

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SpaDeX — India's Space Docking Experiment and the Road to Gaganyaan

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🗞 WHY IN NEWS

ISRO's SpaDeX (Space Docking Experiment) spacecraft SDX01 (Chaser) and SDX02 (Target) completed pre-docking approach maneuvers on January 14, 2026, positioning India to become the 4th country in the world to demonstrate autonomous space docking — a capability achieved on January 16, 2026, making India the 4th nation after the USSR/Russia, USA, and China to master this critical spaceflight technology.

WHAT IS SPACE DOCKING?

Space docking is the process of connecting two spacecraft in orbit through autonomous or remotely commanded rendezvous and physical coupling. It is a foundational capability for:

Space station assembly and resupply: All crewed space stations (ISS, Tiangong) rely on docking to receive astronauts, cargo, and fuel

Crewed deep space missions: Lunar or Mars missions require orbital assembly of spacecraft modules that cannot be launched as a single unit

Sample return missions: Returning samples collected on the Moon or planets requires a rendezvous between a surface ascent vehicle and an orbiting module (as planned in Chandrayaan-4)

Satellite servicing and refuelling: Extending the operational life of satellites by refuelling them or repairing hardware in orbit — a growing commercial market

Military applications: On-orbit inspection, co-orbiting platforms, and classified satellite operations

THE SPADEX MISSION

Mission Name: Space Docking Experiment (SpaDeX) **Launch Vehicle:** PSLV-C60 (Polar Satellite Launch Vehicle; 61st flight) **Launch Date:** December 30, 2025 **Launch Site:** SDSC SHAR, Sriharikota **Target Orbit:** ~470 km circular orbit

The Two Spacecraft

Spacecraft	Role	Mass
SDX01	**Chaser** — actively manoeuvres to dock with Target	~220 kg
SDX02	**Target** — passive vehicle; waits in station-keeping mode	~220 kg

After launch, both spacecraft were released in close proximity (within a few kilometres) and then deliberately separated to approximately **20 km** through phasing manoeuvres. The Chaser then systematically closed the gap:

Approach phases:

20 km → 5 km (far approach)

5 km → 1.5 km (intermediate approach)

1.5 km → 500 m (near approach)

500 m → contact and capture

Docking achieved: January 16, 2026 — the Chaser successfully latched onto the Target, demonstrating India's autonomous rendezvous guidance and docking mechanism.

Post-Docking Demonstrations

After successful docking, the SpaDeX mission planned to demonstrate:

Power transfer between the docked spacecraft

Undocking and re-docking

Attitude control of the combined docked configuration

These demonstrations will certify India's readiness for the **Bharatiya Antariksh Station (BAS)** module connection technology.

INDIA AS THE 4TH DOCKING-CAPABLE COUNTRY

Timeline of Space Docking History

Country	Mission	Year	Notes
USA	Gemini 8 + Agena	**March 1966**	First ever docking; Neil Armstrong piloted; uncontrolled spin emergency
USA	Apollo 9	1969	First CM-LM docking (critical for Moon landing)
USSR/Russia	Soyuz 4 + Soyuz 5	**January 1969**	First docking with crew transfer via spacewalk
China	Shenzhou-8 + Tiangong-1	**November 2011**	First uncrewed Chinese docking
China	Shenzhou-9 + Tiangong-1	2012	First crewed Chinese docking
India	SpaDeX SDX01 + SDX02	**January 16, 2026**	First Indian autonomous docking

Why did it take so long? Space docking requires extremely precise orbital mechanics — the closing speed must be controlled to within centimetres per second at distances of hundreds of kilometres from ground control. The onboard autonomous guidance, navigation and control (GNC) system must function independently without real-time ground commands (signal travel time makes real-time ground commands impractical at close range). ISRO developed this entire technology stack indigenously.

INDIA'S FUTURE SPACE MISSIONS REQUIRING DOCKING

Gaganyaan — Crewed Mission

Gaganyaan is India's human spaceflight programme — the first crewed orbital mission by an Indian-built spacecraft with Indian astronauts.

Key data:

Mission: 3-day crewed mission in 400 km LEO orbit

Astronauts: 4 IAF pilots selected; have undergone training in Russia (Gagarin Cosmonaut Training Centre, Moscow) and India

Launch vehicle: LVM3 (Launch Vehicle Mark-3; formerly GSLV Mk-III)

Crew module: ISRO-built capsule; space-qualified life support

Timeline: First crewed flight targeted 2026–27 (after uncrewed Gaganyaan-1 and robot Vyommitra demonstration flights)

SpaDeX link: Docking capability is required for the **future expanded Gaganyaan orbital station** and for crewed Moon mission rendezvous

Chandrayaan-4 — Lunar Sample Return

Chandrayaan-4 is India's planned **lunar sample return mission** — to collect 3 kg of lunar soil and bring it back to Earth.

Key data:

Architecture: 5 modules — Ascent Module (AM), Propulsion Module (PM), Lander (LM), Re-entry Module (RM), Transfer Module ™

Docking requirement: After landing and collecting samples, the Ascent Module must dock with the Transfer Module in lunar orbit — directly requiring the SpaDeX-demonstrated docking technology

Expected launch: Around 2028

Bharatiya Antariksh Station (BAS)

India's **own space station** — the Bharatiya Antariksh Station — is planned for initial deployment by 2028 (first module) and full operational status by 2035.

Key parameters:

Mass: ~52 tonnes (full configuration; comparable to early Mir or ISS modules)

Orbit: ~400 km LEO

Crew: 3–4 astronauts; 15–20 day stays

Docking ports: Multiple; to receive Gaganyaan crew vehicles and cargo ships

IN-SPACE AND INDIA'S COMMERCIAL SPACE ECOSYSTEM

The **Indian National Space Promotion and Authorisation Centre (IN-SPACe)** was established in 2020 under the **Department of Space** to promote and regulate private sector participation in India's space activities.

Key milestones:

2020: IN-SPACe Act; private companies can now build rockets, satellites, operate spaceports

2022: India Space Policy 2022 draft; Indian private launch vehicle companies (Skyroot Aerospace's Vikram-S, 2022 — first private Indian rocket to reach space)

2023: Skyroot Aerospace's Vikram-1 orbital mission

2024: AgniKul Cosmos semi-cryogenic engine test and orbital flight

NewSpace India Limited (NSIL): ISRO's commercial arm; handles satellite communications, remote sensing data, launch services

SpaDeX commercial significance: Mastering docking enables India to offer **in-orbit satellite servicing** — a $3 billion/year potential market — to domestic and international customers.

UPSC RELEVANCE

Prelims:

SpaDeX: PSLV-C60; December 30, 2025; SDX01 + SDX02; docking January 16, 2026; 4th country

Countries with docking capability: USA (1966, Gemini 8), USSR/Russia (1969, Soyuz 4/5), China (2011, Shenzhou-8), India (2026)

Gaganyaan: LVM3; IAF pilots; 400 km LEO; training in Russia

Chandrayaan-4: lunar sample return; 5 modules; requires docking in lunar orbit

BAS (Bharatiya Antariksh Station): India's space station; 2028 first module; 2035 full ops

IN-SPACe: established 2020; under Department of Space; promotes private space sector

NSIL: NewSpace India Limited; ISRO's commercial arm

Mains GS-3: India's space programme — from ISRO as a science agency to a strategic and commercial enabler; SpaDeX as technology demonstrator; private sector's role through IN-SPACe; space security dimensions.

📌 FACTS CORNER — KNOWLEDGEPEDIA

SPADEX MISSION:

Full form: Space Docking Experiment

Launch: December 30, 2025; PSLV-C60 (61st PSLV flight); Sriharikota

Spacecraft: SDX01 (Chaser, ~220 kg) + SDX02 (Target, ~220 kg)

Orbit: ~470 km circular

Docking: January 16, 2026

India = 4th country with docking capability (USA 1966, USSR/Russia 1969, China 2011)

SPACE DOCKING MILESTONES:

First docking (world): USA — Gemini 8 + Agena Target (March 16, 1966); Neil Armstrong

First crewed crew transfer: USSR — Soyuz 4 + Soyuz 5 (January 1969)

Chinese first: Shenzhou-8 + Tiangong-1 (November 2011)

GAGANYAAN:

India's human spaceflight programme

Launch vehicle: LVM3 (GSLV Mk-III successor)

Target orbit: ~400 km LEO; 3-day duration

Crew: 4 IAF pilots selected; trained at GCTC Moscow and ISRO Bengaluru

Uncrewed tests before crewed mission

CHANDRAYAAN-4:

Mission: Lunar sample return; target 3 kg lunar soil

Architecture: 5 modules (AM, PM, LM, RM, TM)

Requires: docking in lunar orbit (AM docks with TM post-landing)

Expected launch: ~2028

BHARATIYA ANTARIKSH STATION (BAS):

India's own space station

First module: 2028 target; full ops: 2035

Mass: ~52 tonnes; crew: 3-4; orbit: ~400 km LEO

IN-SPACE:

Full form: Indian National Space Promotion and Authorisation Centre

Established: 2020; under Department of Space

Purpose: promote + authorise private space sector activities

NSIL: NewSpace India Limited = ISRO commercial arm

OTHER RELEVANT FACTS:

PSLV (Polar Satellite Launch Vehicle): workhorse; 4-stage (solid-liquid-solid-liquid); 58+ successes

LVM3 (Launch Vehicle Mark-3): India's heaviest rocket; 3-stage (solid-liquid-cryogenic); GTO payload 4,000 kg

Vikram-S: First private Indian rocket to reach space (Skyroot Aerospace, November 2022)

Vyommitra: ISRO's humanoid robot; being sent on uncrewed Gaganyaan test before human mission

ISRO Chairman: V. Narayanan (assumed January 14, 2025)

Sources: ISRO, IN-SPACe, PIB

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