SPADEX – SCEINCE & TECHNOLOGY

NEWS: India became the fourth country to achieve the feat of successfully docking two satellites in space.

WHAT'S IN THE NEWS?

ISRO's Historic Space Docking Milestone

- **India's Achievement:**
  - On **January 16, 2025**, the Indian Space Research Organisation (ISRO) successfully docked two satellites in space as part of the **Space Docking Experiment (SpaDeX)**.
  - India has become the fourth country globally to demonstrate space docking capability, after the **United States**, **Russia**, and **China**.
- **Initial Delay:**
  - The docking, originally scheduled for January 7, was postponed due to an **abort scenario** identified during pre-docking simulations.
  - Additional ground-based simulations were conducted to improve the precision of the docking procedure.

SpaDeX Mission Details

- **Launch Information:**
  - The mission was launched on **December 30, 2024**, using the **PSLV-C60** from the **Satish Dhawan Space Centre, Sriharikota**.
  - The mission deployed two small satellites, **SDX01 Chaser** and **SDX02 Target**, into a **475-km circular orbit** in Low Earth Orbit (LEO).
- **Docking Process:**
  - The Chaser satellite autonomously approached the Target satellite in a carefully controlled sequence:
    - Initial separation: **20 km**, followed by incremental reductions to **5 km → 1.5 km → 500 m → 225 m → 15 m → 3 m**.
    - The final step involved a precise alignment and connection of the two satellites.
  - The successful docking validated India's capability to autonomously maneuver and dock spacecraft in orbit.

Payloads and Innovations in the SpaDeX Mission

Satellite Payloads:

1. **SDX01 Chaser Satellite:**
    - Equipped with a **high-resolution surveillance camera** for detailed visual data.
2. **SDX02 Target Satellite:**
    - Carries a **multispectral payload** for monitoring **natural resources** and **vegetation**.
    - Also equipped with a **radiation monitor** to study space radiation and maintain a database for future missions.

PS4 Orbital Experiment Module (POEM-4):

- The fourth stage of the PSLV carried **24 innovative technologies**, including contributions from startups and academic institutions.
- Notable payloads include:
    1. **Compact Research Module for Orbital Plant Studies (CROPS):**
        - A platform designed to grow plants in microgravity.
        - Successfully cultivated **eight cowpea seeds**, with **three sprouting leaves** under controlled thermal conditions.
    2. **Relocatable Robotic Manipulator-Technology Demonstrator (RRM-TD):**
        - India's **first space robotic manipulator** with the capability to "walk" in space.
    3. **Debris Capture Robotic Manipulator:**
        - Demonstrated the ability to capture tethered debris using **visual serving** and **motion prediction**.
    4. **Amity Plant Experimental Module in Space (APEMS):**
        - A module developed by Amity University to study plant growth using **spinach callus** in microgravity.

Space Docking

- Space docking is the intricate process of **maneuvering two fast-moving spacecraft into the same orbit,** bringing them closer, and joining them to form a single unit.
    - This capability is pivotal for assembling large structures or transferring equipment, crew, or supplies in space.

- For instance, the **International Space Station (ISS)** was built using this technique, with various modules launched separately and docked in space.
    - Continuous docking missions keep the **ISS operational** by delivering supplies, new crew members, and modules while facilitating the return of the older crew to Earth.

Bharatiya Docking System and Its Applications

- **Significance of Docking:**
    - Docking is a complex process of maneuvering two spacecraft in orbit to align, approach, and connect.
    - It is crucial for missions involving **large payloads**, **modular space stations**, and **sample-return missions**.
- **Androgynous Docking Mechanism:**
    - The mechanism used in SpaDeX is **androgynous**, meaning that both the Chaser and Target satellites are equipped with identical systems.
    - While similar to the **International Docking System Standard (IDSS)**, India's system uses only **two motors** compared to the **24 motors** in IDSS, making it more compact and efficient.
- **Advanced Sensors:**
    - The mission used new technologies like the **Laser Range Finder**, **Rendezvous Sensor**, and **Proximity and Docking Sensor** to ensure precise measurements and smooth docking operations.

- **Future Applications:**
    - Docking capabilities will play a key role in:
        1. **Bharatiya Antariksh Station:**
            - India's planned modular space station, with the first module to be launched in 2028 and the entire station operational by 2035.
        2. **Chandrayaan-4 Lunar Mission:**
            - The mission will involve **sample-return technology**, requiring multiple spacecraft modules to dock in orbit.

Third Launch Pad at Sriharikota

- **Cabinet Approval:**
    - On January 16, the **Union Cabinet** approved the construction of a **third launch pad** at the **Satish Dhawan Space Centre (SDSC), Sriharikota**.
    - Estimated cost: **₹3,984.86 crore**.
    - Timeline: The pad is expected to be operational in **four years**.
- **Significance of the Third Launch Pad:**
    - Designed for the upcoming **Next Generation Launch Vehicles (NGLV)** and existing heavy-lift vehicles like **LVM3**.
    - Critical for India's space ambitions, including:
        1. **Human Lunar Missions** (targeted by 2040).
        2. Supporting launches for the **Bharatiya Antariksh Station**.
- **Existing Launch Pads:**
    - **First Launch Pad (30 years old):** Supports smaller vehicles like PSLV and SSLV.
    - **Second Launch Pad (20 years old):** Primarily used for heavy vehicles like GSLV and LVM3.

Significance of the SpaDeX Mission and Future Impacts

- **Technological Milestone:**
    - SpaDeX establishes ISRO's ability to perform complex docking maneuvers, critical for advanced space exploration and modular spacecraft assembly.
- **Future-Ready Space Infrastructure:**
    - The new launch pad and docking technology will:

- Enable India's independent **space station project**.
- Facilitate **interplanetary missions** and **human spaceflight programs**.

- **Strengthening Global Presence:**
  - ISRO's achievements position India as a major player in global space exploration and technology innovation.

Why is Space Docking Technology Crucial for India?

- **Modular Space Infrastructure:** Docking is a prerequisite for constructing multi-modular space stations. It allows the assembly of structures in space, reducing the size and weight constraints of single-launch missions.
- **Interplanetary and Lunar Missions:** Docking supports orbital refueling, and payload exchange, enhancing mission flexibility for lunar bases and Mars exploration.
  - It is crucial for future missions like **Chandrayaan-4,** space stations, and India's planned **Bharatiya Antariksh Station (BAS).**
- **Human Spaceflight Program:** Space Docking is critical for **crew transfers and emergency evacuations** during long-duration missions like Gaganyaan and beyond.
- **Global Collaboration and Market Potential:** SpaDeX could position **India as the fourth nation,** after Russia, the US, and China, to master space docking, strengthening its presence in satellite servicing and enabling advanced international collaborations.
- **Satellite Servicing:** Docking allows for repairing, refueling, and upgrading satellites, enhancing their operational life and performance.

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