POEM-3 Mission and Space Debris

For Prelims: ISRO's PSLV-C58/XPoSat Mission, PSLV Orbital Experimental Module-3, Vikram Sarabhai Space Centre, PSLV-C53 mission, Low earth orbit, Project NETRA, Space Situational Awareness Control Centre.

For Mains: POEM Mission, Initiatives Around the World Related to Space Debris.

Source: TH

Why in News?

Recently, ISRO's PSLV-C58/XPoSat mission achieved **near-zero debris** in Earth's orbit by converting the final stage into the PSLV Orbital Experimental Module-**3 (POEM-3),** which then safely re-entered the atmosphere rather than remaining in orbit after completing its mission.

What is POEM?

- POEM is an innovative space platform developed by the Vikram Sarabhai Space Centre (VSSC).
  - It repurposes the **fourth stage of a PSLV rocket** into a stable orbital station for conducting in-space scientific experiments with diverse payloads.
  - Its inaugural use occurred during the **PSLV-C53 mission in June 2022.**
    - Normally, the fourth stage of the PSLV becomes space debris after deploying satellites, but in the PSLV-C53 mission, it served as a stabilised platform for experiments.
  - According to ISRO, POEM has a dedicated Navigation Guidance and Control (NGC) system for attitude stabilisation, which stands for controlling the orientation of any aerospace vehicle within permitted limits.
- **POEM-3 Mission:** It was launched as part of the PSLV C-58 mission on 1st January 2024.
  - After deploying the XpoSat satellite, the fourth stage was transformed into POEM-3 and **lowered to a 350-km orbit**, significantly reducing the risk of space debris generation.

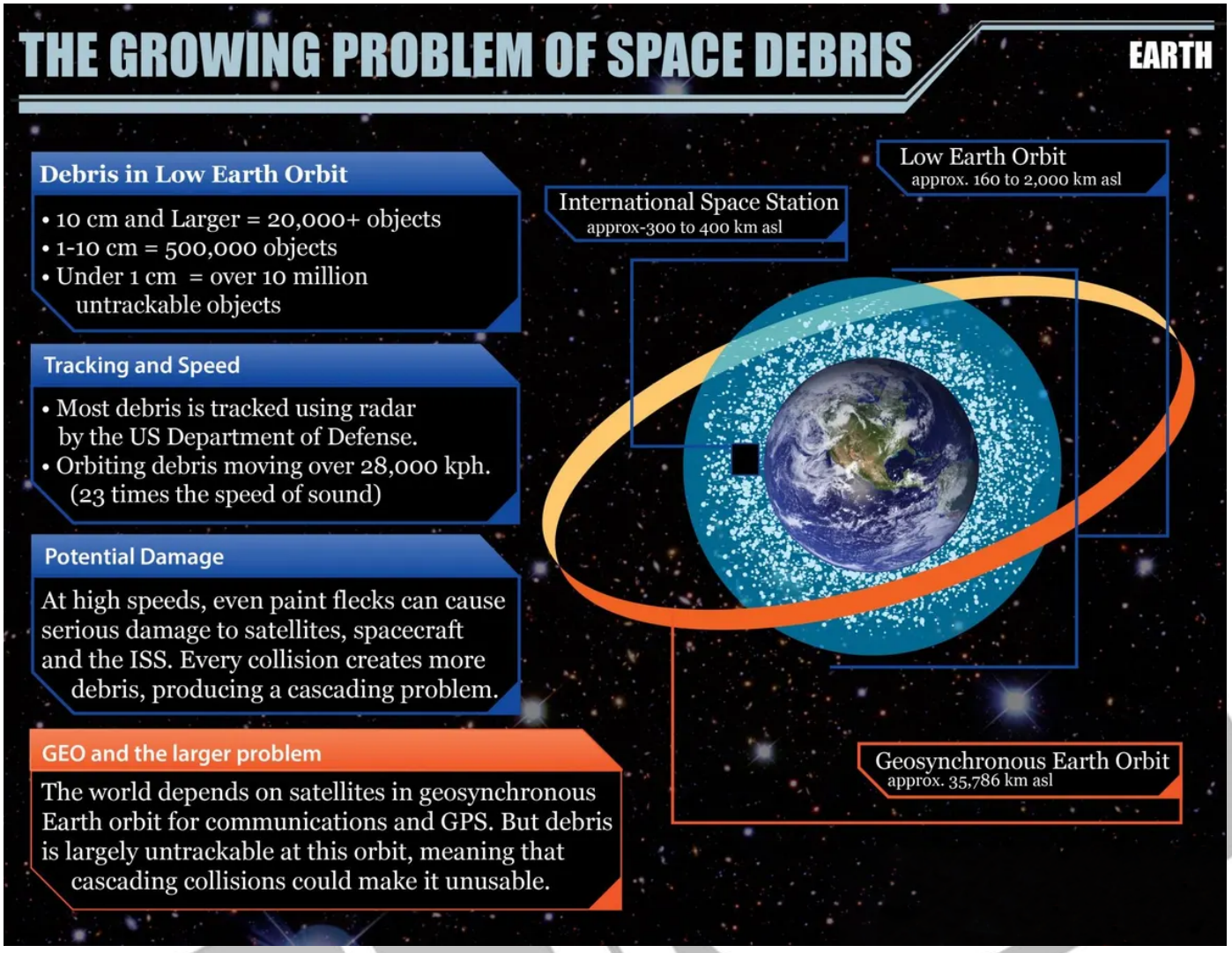
Note: ISRO first demonstrated the capability of using **PS4** (fourth stage of PSLV) as an orbital platform in 2019 with the **PSLV-C44 mission** that injected **Microsat-R** and **Kalamsat-V2 satellites** into their designated orbits. The **fourth stage in that mission was kept alive as an orbital platform for space-based experiments.**

What is Space Debris?

- **About:** Space debris in the low earth orbit (LEO) mainly comprises pieces of **spacecraft, rockets, and defunct satellites,** and the fragments of objects that have deteriorated explosively as a result of anti-satellite missile tests.

    - The **LEO extends from 100 km above the earth's surface up to 2000 km above.**
    - Debris also exists, but in smaller volumes, in the geosynchronous orbit (GEO), which is 36,000 km above the earth's surface.
- **Risk:** Space debris often flies around at high speeds of up to **27,000 kilometres** per hour. Due to their sheer volume and momentum, they **pose a risk to several space assets.**
    - It also leads to two major risks, it creates unusable regions of the orbit due to excessive debris, and leads to the 'Kessler syndrome (creation of more debris due to cascading collisions resulting from one collision).
    - The **number of space objects** (debris or functional equipment) greater than 10 cm in size **in LEO is expected to be about 60,000 by 2030**, per ISRO estimates.
        - The rise of private space agencies is exacerbating the problem.
- **Current Status**: According to **ISRO's Space Situational Assessment Report 2022**, the world placed 2,533 objects in space in 179 launches in 2022 alone.
    - In 2022, three major on-orbit break-up events occurred, contributing to most of the debris created that year:
        - **March 2022:** Intentional destruction of **Russia's Cosmos 1048** in an anti-satellite test.
        - **July 2022**: Break-up of the upper stage of **Japanese H-2A** while deploying the GOSAT-2 satellite.
        - **November 2022:** Accidental explosion of the upper stage of **China's Yunhai-3.**
    - **Other Related Events:**
        - NASA has recently confirmed that a mysterious object, which crashed into a home in Florida, was debris from the **International Space Station (ISS).**
        - In 2023, an object discovered on the Western Shores of Australia was identified as debris from an ISRO rocket.
- **Related International Space Laws**: Currently, there are **no international space laws** about LEO debris.
    - However, most space-exploring nations abide by the **Space Debris Mitigation Guidelines 2002** specified by the **Inter-Agency Space Debris Coordination Committee (IADC)**, which the UN endorsed in 2007.
        - The guidelines outline methods to limit accidental collisions in orbit, break-ups during operations, intentional destruction, and post-mission break-ups.

Note: The Inter-Agency Space Debris Coordination Committee is an international governmental **forum for the worldwide coordination of activities** related to the issues of man-made and natural debris in space. **ISRO is a member agency.**



How are Countries Worldwide Dealing with the Problem of Space Debris?

- **India**: India is actively addressing space debris issues. Besides POEM missions, ISRO established a Space Situational Awareness Control Centre to safeguard valuable assets from collisions.
    - Project NETRA is also an **early warning system in space to detect debris** and other hazards to Indian satellites.
    - **Manastu Space**, an Indian startup, focuses on in-space refuelling, satellite de-orbiting, and extending satellite lifespan.
- **Japan**: Japan has a project, called the **Commercial Removal of Debris Demonstration (CRD2)**, to tackle space junk.
- **Europe:** The European Space Agency (ESA) has adopted a '**Zero Debris charter,'** which includes multiple ways to mitigate space debris. It has also called for **zero space debris by 2030.**
- **USA**: NASA had instituted its **Orbital Debris Program in 1979** to find ways to create less orbital debris and design equipment to track and remove existing debris.
    - Sixth U.S. Armed Forces wing, called the Space Force, tracks space debris and collisions in LEO.

Way Forward

- **Space-Based Recycling and Repurposing**: Developing technologies to collect and process space debris in orbit.
    - These "**space refineries**" could break down debris into usable materials for constructing new spacecraft or habitats in space, reducing the need for new launches from Earth.

    - Techniques like **3D printing could utilise recycled materials,** minimising the amount of raw materials we launch into space.
- **Robotic Arms and Capture Mechanisms:** Developing advanced robotic arms equipped with cameras and sensors for **grappling with debris.** These robots could be deployed from service satellites to **capture and deorbit large pieces of debris** that pose a significant collision risk.
    - **Docking mechanisms** could be installed on satellites during manufacturing, allowing service satellites to easily attach and deorbit defunct satellites.
- **Space Traffic Management Systems**: Developing sophisticated **space traffic management systems** to track debris and predict potential collisions.
    - This would allow active satellites to perform manoeuvres to avoid debris, reducing the risk of accidental collisions that create even more debris.
    - International collaboration is key for creating a **comprehensive space traffic management system** that ensures the safety and sustainability of space exploration.

Drishti Mains Question

Q. In light of the growing threat of space debris, discuss innovative strategies and technologies that can effectively mitigate this global concern. How can international collaboration play a crucial role in addressing this issue?

UPSC Civil Services Examination, Previous Year Question (PYQ)

Q. International civil aviation laws provide all countries complete and exclusive sovereignty over the airspace above their territory. What do you understand by ‘airspace’? What are the implications of these laws on the space above this airspace? Discuss the challenges which this poses and suggest ways to contain the threat. **(2014)**