2. Aditya-L1- Science & Technology

India's solar observatory Aditya-L1 along with six U.S. satellites, has revealed unusual behaviour of the May 2024 solar storm called "Gannon's storm" triggered by a series of giant explosions on the Sun known as Coronal Mass Ejections (CMEs)

Definition and Nature

1. A solar storm is a large-scale disturbance originating from intense activity on the Sun, primarily involving solar flares, coronal mass ejections (CMEs), and high-speed solar wind streams.
2. These phenomena are driven by sudden reconfigurations of the Sun's magnetic field, especially in active regions marked by sunspots.

Coronal Mass Ejections (CMEs)

1. CMEs are colossal expulsions of plasma (electrically charged gas) embedded with strong magnetic fields.
2. A single CME can eject billions of tonnes of solar material and travel at speeds exceeding 1,000 km/s.
3. When directed toward Earth, CMEs typically reach the planet in 1–3 days.

Interaction with Earth

1. Earth is shielded by its magnetosphere, which deflects most charged particles.
2. A strong CME can compress and disturb this magnetic shield, triggering geomagnetic storms.
3. The severity depends on the CME's speed, density, and magnetic orientation (southward magnetic fields are particularly disruptive).

Potential Impacts

Space-based systems- Damage or malfunction of satellites; degradation of solar panels and onboard electronics.
Communication and Navigation- Disruption of radio communication, aviation HF links, and GPS accuracy.
Power Infrastructure- Induced electric currents can overload transformers and cause large-scale power outages.
Atmospheric Effects- Enhanced auroras at lower latitudes and increased atmospheric drag on low-Earth-orbit satellites.
Human Spaceflight- Elevated radiation risks for astronauts.

Monitoring Matters

1. Advanced warning of solar storms enables protective measures such as satellite safe modes, grid load management, and aviation route adjustments.
2. Continuous solar observation is therefore a strategic necessity for technologically dependent societies.

Aditya-L1- India's Solar Observatory Mission (Expanded)

Mission Overview

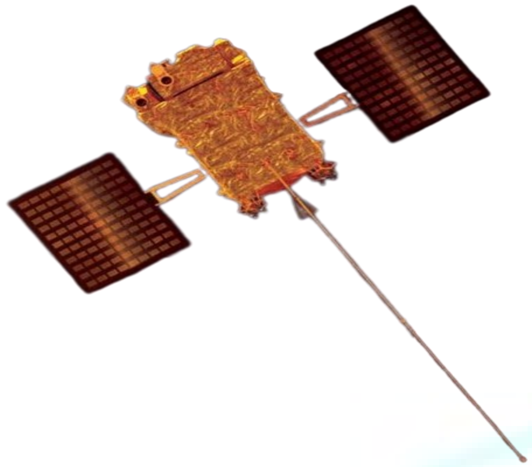
1. Aditya-L1 is India's first dedicated, space-based mission for comprehensive solar studies.
2. The mission is led by ISRO and marks a major milestone in India's heliophysics capabilities.

Launch and Orbit

1. Launched on 2 September 2023 aboard PSLV-C57.
2. Successfully inserted into a halo orbit around the Sun–Earth Lagrange Point L1 on 6 January 2024.
3. The halo orbit allows the spacecraft to maintain a stable vantage point with minimal fuel expenditure.

L1 is Critical

1. L1 lies about 1.5 million km from Earth toward the Sun.
2. It provides an uninterrupted, continuous view of the Sun, free from Earth's shadow.



3. This location enables early detection of Earth-directed CMEs and solar wind variations, offering crucial lead time for space weather forecasting.

Scientific Objectives

1. Study the solar photosphere, chromosphere, and corona to understand energy transfer and heating mechanisms.
2. Investigate the origin and propagation of CMEs and solar flares.
3. Monitor solar wind and interplanetary magnetic fields before they interact with Earth.
4. Improve predictive models for space weather events affecting Earth and near-Earth space.

Payload Configuration

Seven scientific payloads

Four remote-sensing instruments- Observe solar radiation and imagery across multiple wavelengths.

Three in-situ instruments- Directly measure particles, magnetic fields, and plasma conditions at L1.

This integrated approach enables correlation between solar events and their heliospheric consequences.

Strategic and Scientific Significance

1. Enhances India's capacity for space weather forecasting, vital for satellite operations, navigation systems, and power infrastructure.
2. Positions India among a select group of nations with dedicated solar observatories at Lagrange points.
3. Complements global missions such as SOHO, contributing to international solar research.

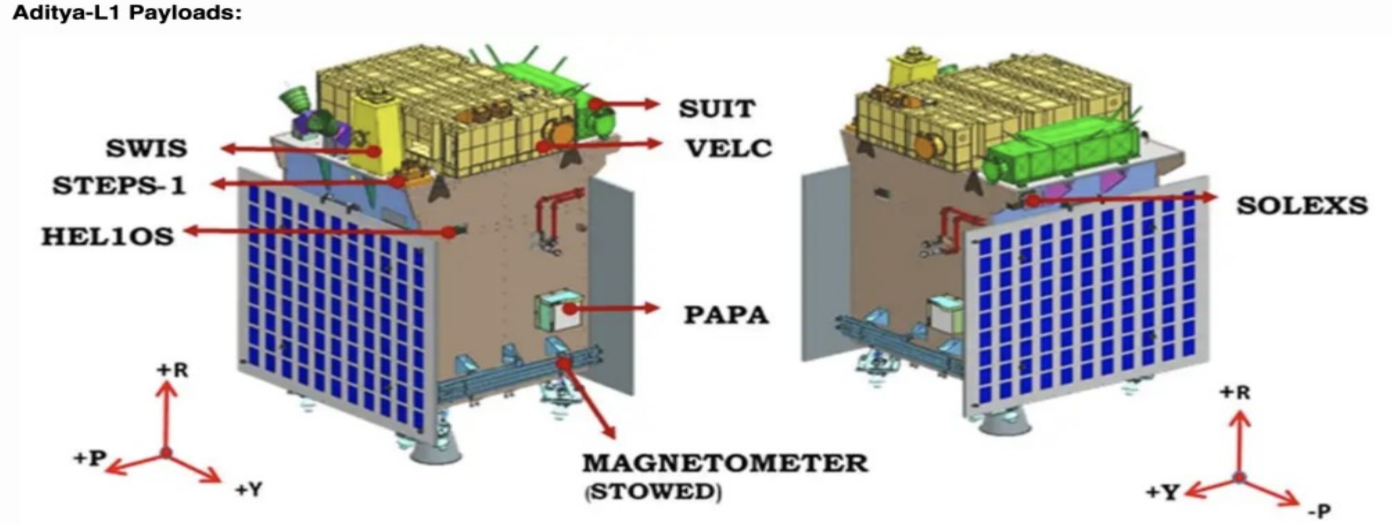
Lagrange Points- Key Facts (Expanded Context)

Lagrange points are locations where the gravitational forces of two massive bodies (e.g., Earth and Sun) balance the orbital motion of a smaller object. There are five Lagrange points (L1–L5) in a two-body system.

1. L1, L2, L3- Dynamically unstable; spacecraft require small station-keeping manoeuvres.
2. L4, L5- Dynamically stable; objects can remain with minimal correction.

Spacecraft positioned at these points benefit from fuel efficiency, stable observation geometry, and long mission lifetimes. L1 is uniquely suited for real-time solar monitoring, making it central to modern space weather early-warning systems.

Aditya-L1 Payloads:



Source- https-//www.thehindu.com/sci-tech/science/aditya-l1-in-a-global-effort-reveals-why-the-2024-solar-storm-behaved-unusually/article70376131.ece