James Webb Space Telescope

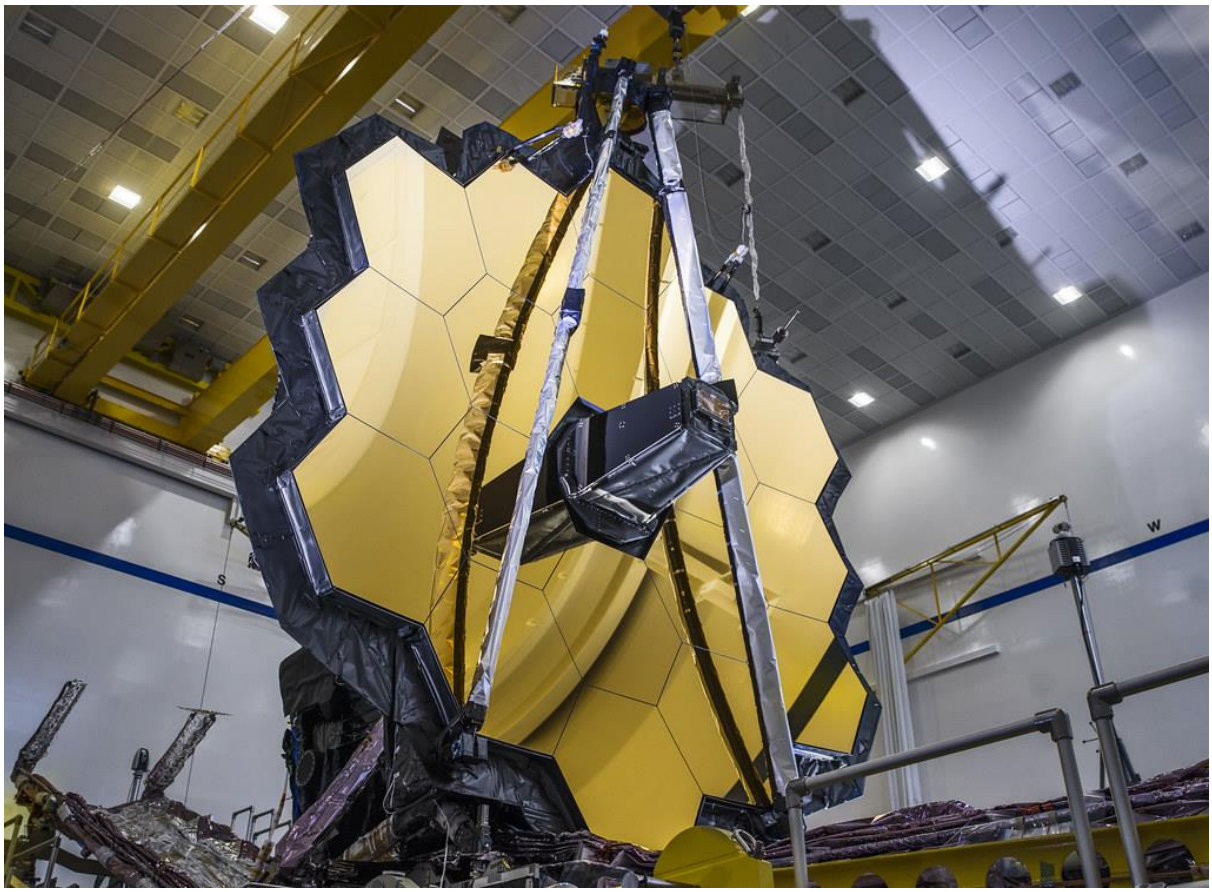
The James Webb Space Telescope (JWST) is an international collaboration led by NASA with significant contributions from the European Space Agency (ESA) and the Canadian Space Agency (CSA). Launched on December 25, 2021, JWST is the most powerful space telescope ever built

JWST aims to address some of the most fundamental questions about the universe:

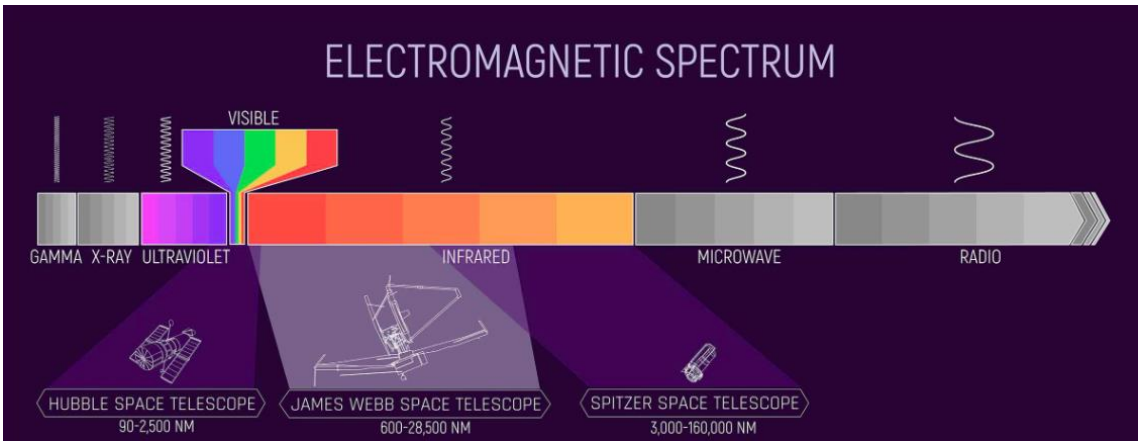
1. **First Light**: JWST seeks to capture the first galaxies that formed in the early universe after the Big Bang.
2. **Assembly of Galaxies**: It will observe the formation and evolution of galaxies.
3. **Birth of Stars and Protoplanetary Systems**: The telescope will explore star formation and the early stages of planetary systems.
4. **Planetary Systems and the Origins of Life**: JWST will study the physical and chemical properties of planetary systems, including our own, and investigate the potential for life in those systems.

JWST features

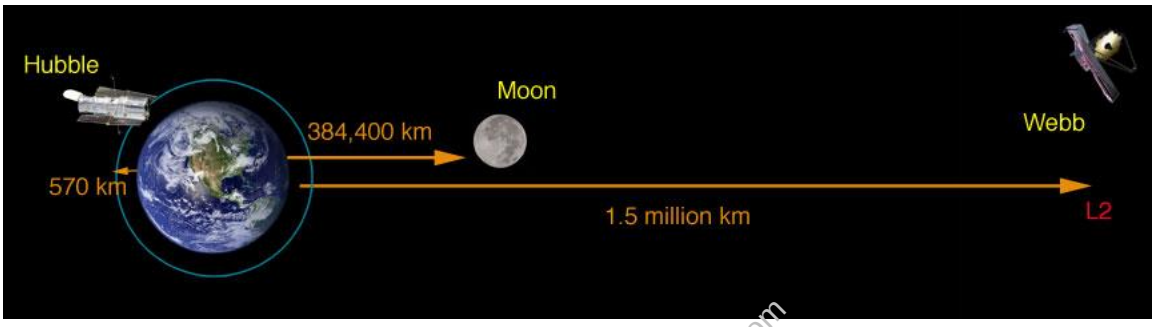
- **Primary Mirror**: The telescope's primary mirror is 6.5 meters in diameter, composed of 18 hexagonal segments of gold-coated beryllium.
    - This large size provides JWST with a significantly larger collecting area than its predecessors like the Hubble Space Telescope.



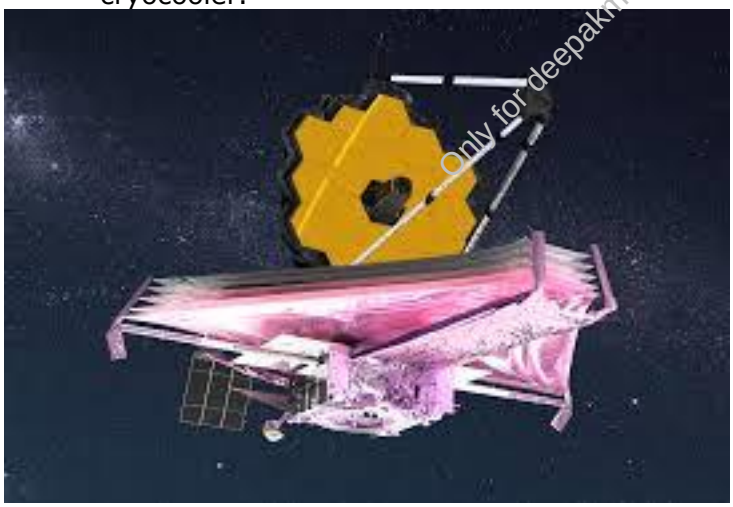
- **Infrared Spectrum**: JWST is optimized for observing in the infrared spectrum. Many regions of space are obscured by cosmic dust, which absorbs and scatters visible light but is transparent to certain infrared wavelengths. This allows observing distant galaxies and exoplanets.

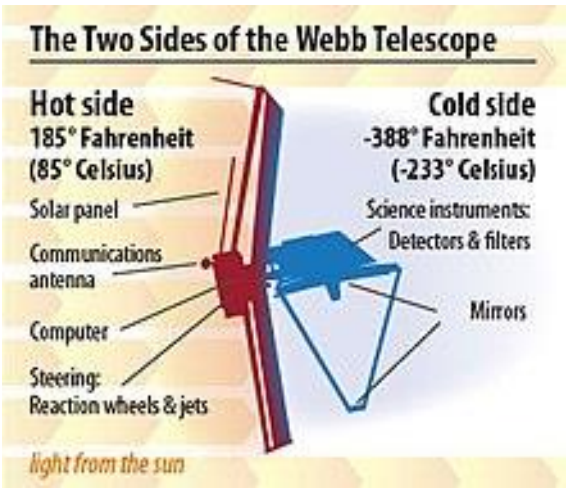


- **Location:** Unlike the Hubble Space Telescope, which orbits the Earth, JWST orbits the Sun, positioned at the second Lagrange point (L2) about 1.5 million kilometres from Earth. This location provides a stable environment, crucial for infrared observations, and allows the telescope to maintain a constant alignment with the Earth and Sun.



- **Sunshield**: The telescope's sunshield, which is the size of a tennis court, protects the instruments from the Sun's heat and light, maintaining them at extremely low temperatures necessary for infrared observations. JWST's sunshield helps maintain the operating temperature of the telescope's instruments below 50 K (-223 °C). Another instrument works around 7 K (-266 °C) provided by a separate cryocooler.





JWST's focus on infrared astronomy, facilitated by its sophisticated sunshield, enables unprecedented observations of the universe's most distant, oldest, and dust-shrouded objects, offering potential insights into the origins of galaxies, stars, and planetary systems.

Artemis Programme

The Artemis program, led by NASA is a pioneering initiative aimed at returning humans to the Moon and establishing a sustainable presence there by the late 2020s.

The program is named after Artemis, the Greek goddess of the Moon and twin sister of Apollo, drawing a direct connection to the Apollo missions which last sent astronauts to the Moon in the 1970s. It is being implemented in various stages:

Artemis I (successfully Completed in Dec 2022)
Objective: Artemis I was an uncrewed mission designed to test the Space Launch System (SLS) and the Orion spacecraft over a multi-week mission orbiting the Moon.

- **Orion Spacecraft**: It did not carry astronauts but was equipped with instruments and sensors to measure performance and gather critical data.
- **Mission Goals**: Test all components of the spacecraft and its ability to return safely to Earth, setting the stage for crewed missions.

Artemis II
Objective: Artemis II will be the first crewed mission of the program, marking a significant milestone as it will carry astronauts around the Moon and back to Earth.

- **Crew**: This mission will include astronauts **but will not involve a lunar landing**. The crew will test the Orion spacecraft's life support, propulsion, and other systems.
- **Mission Profile**: Similar to Apollo 8, Artemis II will orbit the Moon, providing astronauts the opportunity to test manual control systems and how the spacecraft behaves with a human crew in deep space.

Artemis III
Objective: This mission is poised to land astronauts near the lunar south pole, an area believed to contain ice and other resources. This will be the first mission since Apollo 17 in 1972 to return humans to the lunar surface.

- **Crew**: The mission plans to land the first woman and the next man on the Moon, focusing on inclusivity and diversity.
- **Technologies and Goals**: Artemis III will utilize new landing systems developed by commercial partners under NASA's supervision. The mission aims to explore the lunar surface more extensively, conduct a variety of scientific experiments,

test new technologies, and search for resources like water ice that could support future lunar living.

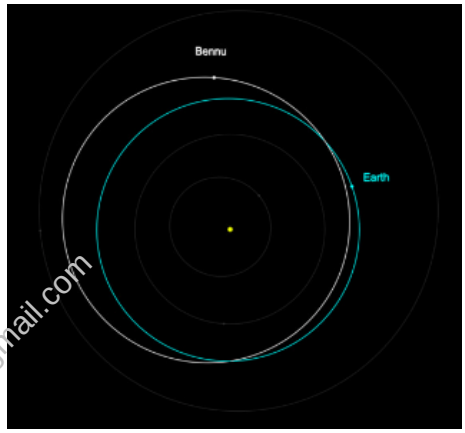
Artemis IV: Following the initial missions, NASA aims to establish Artemis Base Camp, a sustainable outpost for long-duration lunar exploration. This will involve:

- **Infrastructure**: Development of a lunar Gateway—a small space station in orbit around the Moon that will serve as
  - a multi-purpose outpost visited by astronauts,
  - a laboratory for scientific research,
  - a testbed for new technologies, and
  - a hub for missions farther into space.
- **Sustainability**: The use of lunar resources for fuel, water, and building materials. Developing power systems to survive the lunar night and technology for life support systems.

International and Commercial Collaboration

The Artemis program is distinguished by its broad international collaboration, involving contributions and partnerships with various countries and companies.

OSIRIS Rex Mission



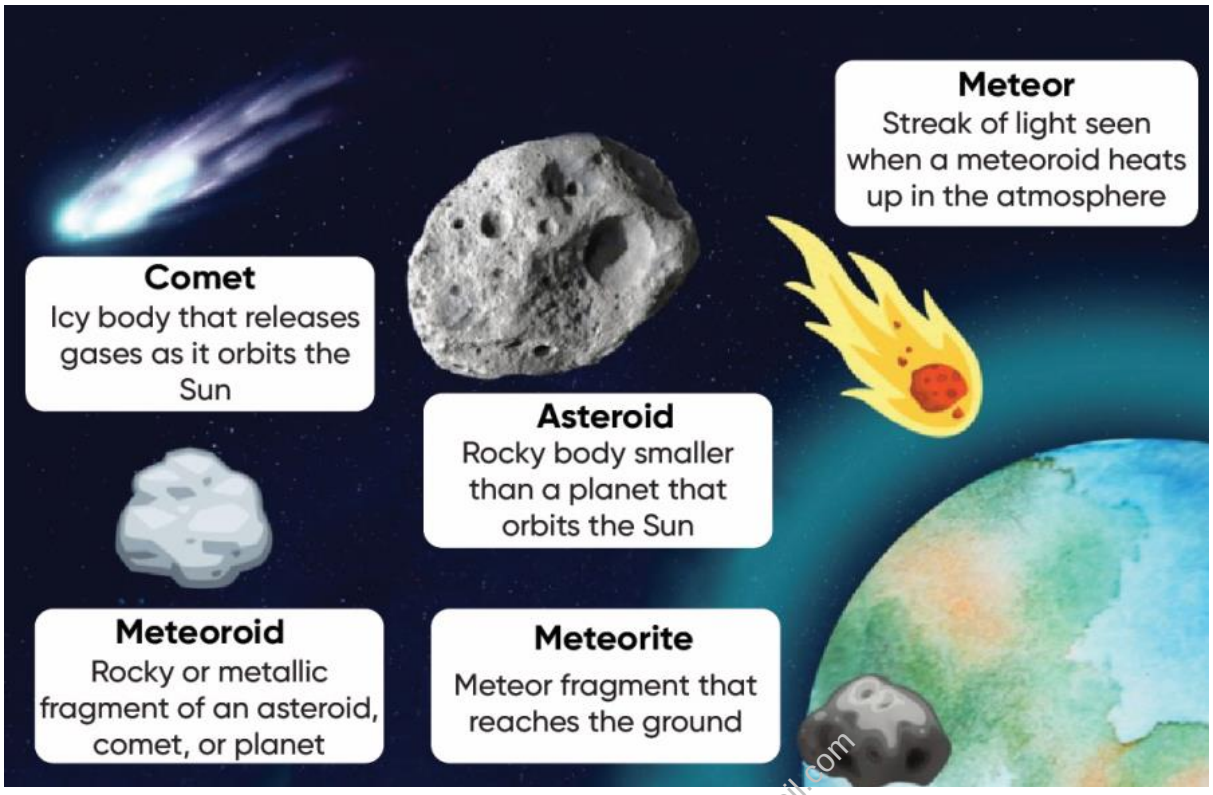
The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer) mission is a NASA-led project aimed at studying an asteroid in unprecedented detail, collecting samples, and returning them to Earth for analysis.

Bennu is of particular interest because it is a near-Earth object (NEO) and is believed to be composed of material that is largely unchanged since the solar system's formation.

- It was launched in September 2016 and arrived at asteroid Bennu in December 2018.
- It spent nearly two years closely orbiting Bennu, extensively mapping its surface using cameras, spectrometers, and laser altimeters.
- In October 2020, OSIRIS-REx executed a precise maneuver, briefly touching Bennu's surface and using a blast of nitrogen gas to stir up and collect regolith.

- The spacecraft departed Bennu in May 2021.
- The capsule landed in the Utah desert in September 2023.

OSIRIS-REx will continue on to a new mission to asteroid Apophis, hence, renamed as OSIRIS-APEX (OSIRIS-Apophis Explorer).



DART Mission

The Double Asteroid Redirection Test (DART) was a NASA mission aimed at testing a method of planetary defense against near-Earth objects (NEOs).

- It was the first-ever mission dedicated to investigating and demonstrating one method of asteroid deflection by changing an asteroid's motion in space through kinetic impact.

Target:

- DART's target was the asteroid moonlet **Dimorphos**, a small body just 160 meters in diameter.
- It orbits a larger, 780-meter, asteroid called **Didymos**. Neither asteroid poses an impact threat to Earth, but their characteristics made them ideal for this test.

On September 26, 2022, the DART spacecraft successfully impacted Dimorphos The impact was carefully orchestrated to alter the moonlet's orbit around Didymos.

The DART mission was a **resounding success**. The kinetic impact significantly altered Dimorphos' orbit, shortening it by about 32 minutes.

This confirmed that a spacecraft could successfully deflect an asteroid's path, proving the viability of kinetic impactor technology for planetary defense.

DART was a groundbreaking mission that marked humanity's first time intentionally changing the motion of a celestial object.

Parker Solar Probe

The **Parker Solar Probe (PSP)** is a NASA spacecraft launched in **2018**, with the mission to explore the Sun's outer atmosphere and understand the mysteries of the solar corona.

Primary Objectives:

- Study the **solar corona** (the Sun's outermost layer) to understand why it is hotter than the Sun's surface.
- Investigate the origins and acceleration of the **solar wind**.
- Examine the dynamics of **energetic solar particles**.
- Improve predictions of **space weather** that can impact Earth and satellites.

Unique Features:

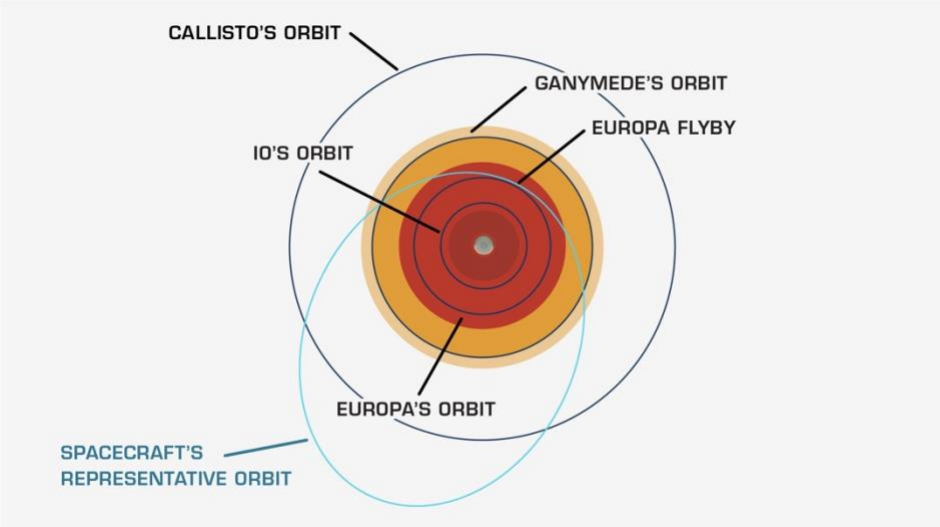
1. Closest approach to the Sun: **6.1 million kilometer** from the solar surface.
2. Travels at a speed of **700,000 km/h (430,000 mph)**, making it the **fastest human-made object**.
3. The spacecraft is designed to endure temperatures of up to **1,377°C** using a **Thermal Protection System (TPS)** made of carbon-composite materials.
4. The Parker Solar Probe uses **seven gravity assists** from Venus to gradually shrink its orbit and move closer to the Sun.

Key Discoveries (as of 2025):

- Detected **switchbacks** in the solar wind (zig-zag magnetic field structures), offering insights into solar wind acceleration.
- Provided unprecedented data on the **Alfvén critical surface**, the boundary where the solar wind becomes supersonic.
- Observed solar wind structures directly at their source.

Europa Clipper Mission

The **Europa Clipper** is a NASA mission set to launch in **October 2024**, targeting **Europa**, one of Jupiter's largest moons, known for its potential to harbor life due to its subsurface ocean.



Primary Objectives:

- Investigate Europa's habitability by studying its **subsurface ocean** and ice shell.
- Map the moon's surface and determine its composition.
- Search for signs of geological activity and potential water plumes.
- Analyze the moon's thin **oxygen atmosphere**.
- The ocean is thought to contain **more water than Earth's oceans combined**.

Outer Space Governance

In 1958, United Nation Committee on the Peaceful Uses of Outer Space (UN COPUOS) was established. It governs the exploration and use of space for the benefit of all humanity.

Five international space treaties:

- **Outer Space Treaty 1967:** Treaty on Principles Governing the Activities of States
- **Rescue Agreement 1968:** Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space.
- **Liability Convention 1972:** Convention on International Liability for Damage Caused by Space Objects.
- **Registration Convention 1976:** Convention on Registration of Objects Launched into Outer Space.
- **Moon Agreement 1979:** Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.

India is a signatory to all five of these treaties but has ratified only four (except Moon Agreement).

More about Outer Space Treaty 1967:

Outer Space Treaty is the cornerstone of international space law. Key provisions include:

- **Peaceful Exploration:** Space is the province of all humanity, to be used for peaceful purposes. Bans the placement of nuclear weapons or weapons of mass destruction in space or on celestial bodies.

- **Non-Appropriation:** No nation can claim sovereignty over any part of space, the Moon, or any celestial body.
- **Freedom of Exploration:** States have the right to explore and use outer space without harmful interference.
- **International Responsibility:** Nations bear responsibility for their own space activities, both governmental and non-governmental. They are also liable for damages caused by their space objects.
- **Assistance to Astronauts:** Astronauts are considered "envoys of mankind" and must be given assistance in case of accidents or emergencies.

Limitations and Challenges

1. **Ambiguity and Changing Technology:** Some language is open to interpretation, particularly with new technologies. For example, the treaty doesn't clearly define "harmful interference" or address activities like commercial space mining.
2. **Enforcement:** No single enforcement mechanism exists, relying on states to regulate themselves and resolve disputes diplomatically.
3. **Emerging Space Activities:** The treaty was drafted before concepts like commercial space stations, space tourism, and large satellite constellations were a reality. It doesn't have specific provisions to address these activities.
4. **Space Debris:** While mentioned, the growing problem of space debris isn't handled in a comprehensive way, leaving room for a lack of coordination and increased risks.
5. **Non-State Actors:** The treaty focuses on the actions of states, but the rise of private space companies adds an additional layer of governance and responsibility that isn't fully addressed.

Artemis Accords

A set of principles and guidelines led by the United States for peaceful, sustainable, and transparent cooperation in civil space exploration, particularly focused on NASA's Artemis program and future lunar missions and space exploration.

It aims to establish a common framework for collaboration in space activities while promoting commercial partnerships and international participation.

Key Principles

- **Peaceful Exploration:** Emphasizes the use of space for peaceful purposes.
- **Transparency**: Encourages open communication of mission plans and scientific data.
- **Interoperability:** Promotes the development of technical standards to ensure compatibility of systems between different nations.
- **Emergency Assistance:** Outlines an agreement to provide assistance to astronauts in distress.
- **Registration of Space Objects:** Reinforces commitments to the UN Registration Convention for identification and tracking of space objects.
- **Release of Scientific Data:** Encourages timely sharing of scientific information.
- **Protecting Space Heritage:** Promotes the preservation of historical space sites and artifacts.
- **Space Resources:** Addresses the extraction and utilization of space resources, aiming to establish international norms under the context of the Outer Space Treaty.
- **Deconfliction of Activities:** Encourages coordination and communication to avoid harmful interference between space missions.

- **Orbital Debris:** Prioritizes the mitigation and safe disposal of space debris.

Criticism

- **Interpretation of the Outer Space Treaty:** Some critics argue that the emphasis on resource extraction could be perceived as promoting commercial ownership of celestial bodies, potentially conflicting with the Outer Space Treaty.
- **Unilateral vs. Multilateral Framework:** The Artemis Accords were initiated by the US, raising concerns about its potential to become a US-centric framework instead of a truly multilateral agreement.
- **Exclusion of Major Space Powers:** China and Russia are notably absent, highlighting geopolitical tensions and potentially hindering broad international cooperation.

As of now India is a party to the accords.