

Additional Topics on Space Technology

1. James Webb Space Telescope

The James Webb Space Telescope (JWST) is an orbiting infrared observatory that complements and extends the discoveries of the Hubble Space Telescope.

Unique Features

It boasts several unique features that set it apart from its predecessor Space Telescopes. Some of these features include:

- **Enhanced Sensitivity:** The JWST has a larger primary mirror, which allows it to collect more light and observe fainter objects in the universe.
- **Infrared Capability:** Unlike previous telescopes, the JWST is optimized for infrared observations, enabling it to study the formation of stars and galaxies, as well as the atmospheres of exoplanets. It has longer wavelength coverage and improved sensitivity, allowing it to observe closer to the beginning of time and search for the formation of the first galaxies.
- **Improved Resolution:** With its advanced instruments, the JWST provides sharper and more detailed images, allowing scientists to explore the universe with unprecedented clarity.
- JWST can also peer inside dust clouds where stars and planetary systems are currently forming.

The key goals

1. **Studying the Universe's Early Stages**
 - The JWST aims to observe the first galaxies or bright objects that appeared shortly after the Big Bang. This will help in understanding the initial phases of the universe and the formation of current cosmic structures.
2. **Understanding Galaxy Evolution**
 - The mission intends to analyze various galaxies from their inception to the present time. This will unravel the processes that influenced their current structures and characteristics.
3. **Monitoring Star and Planet Formation**
 - The telescope will document the entire process of star and planetary system formation, from the initial collapse of gas clouds to the emergence of planets. This will provide deep insights into the origins of stars and the prerequisites for planet formation.
4. **Exploring Planetary Systems' Properties**

- The JWST will investigate the physical and chemical attributes of different planetary systems, including our Solar System. It will study the atmospheres of exoplanets to assess the potential for life and understand the conditions necessary for a planet to be habitable.

Potential Benefits

- Expanding our knowledge of the universe and its origins
- Deepening our understanding of the formation and evolution of galaxies
- Gaining insights into the processes of star formation and the emergence of planetary systems
- Measuring the physical and chemical properties of planetary systems, including the potential for life
- Inspiring further scientific advancements in astrophysics, cosmology, and planetary science
- Providing valuable information for future space exploration endeavors and missions

2. Hubble Space Telescope (HST)

- **Introduction**
 - Launched in 1990 into low Earth orbit and remains operational.
 - Not the first but one of the largest and most versatile space telescopes.
 - Functions as a vital research tool and a public relations asset for astronomy.
- **Specifications**
 - Named after astronomer Edwin Hubble.
 - Part of NASA's Great Observatories.
 - Managed by the Space Telescope Science Institute (STScI) and the Goddard Space Flight Center (GSFC).
 - Orbits Earth at a speed of approximately 5 miles per second.
 - Equipped with a 2.4m mirror, observing in ultraviolet, visible, and near-infrared regions of the electromagnetic spectrum.
 - Captures high-resolution images due to its position outside Earth's atmosphere, offering a deep view into space.
 - Has facilitated breakthroughs in astrophysics, including determining the universe's rate of expansion.
- **Historical Background**
 - Funded and constructed in the 1970s by NASA with contributions from the European Space Agency.
 - Initially slated for launch in 1983, but faced technical delays, budget issues, and was further postponed by the 1986 Challenger disaster.
 - Launched in 1990, albeit with a flaw in the main mirror that initially compromised its capabilities.
- **Physical Characteristics**
 - Length comparable to a large school bus and weighs equivalent to two adult elephants.

Comparison with the James Webb Space Telescope (JWST)

- **Wavelengths**

- HST: Primarily observes in the ultra-violet and visible spectrum, with some infrared capabilities.
- JWST: Primarily observes in the infrared spectrum, with some visibility in the visible range, enabling it to detect light from older galaxies and stars.
- **Mirror Size**
 - HST: Features a 2.4m mirror.
 - JWST: Houses a significantly larger 6.5m mirror, allowing it to peer further back in time compared to HST.
- **Orbit**
 - HST: Situated in a near-Earth orbit.
 - JWST: Positioned at the second Sun-Earth Lagrange (L2) point, 1.5 million kilometers away, maintaining the Sun, Earth, and Moon at its back indefinitely.
- **Observation Capabilities**
 - HST: Can detect objects at least 60,000 times fainter than what is visible to the human eye.
 - JWST: With a nearly three times wider mirror, it can observe objects almost nine times fainter than HST, enhancing our ability to explore further into space.

Conclusion

- The JWST is designed to surpass the HST's capabilities, primarily through its enhanced observation in the infrared spectrum and a larger light-collecting mirror, promising to further our understanding of the universe.

Feature	Hubble Telescope	James Webb Space Telescope (JWST)
Wavelength	Ultraviolet, visible, and some infrared	Optimised for infrared, some visible light
Mirror Size	2.4 meters diameter	6.5 meters diameter (segmented)
Light Collection	Lower (due to smaller size)	Higher (approx. seven times more than Hubble)
Resolution and Sensitivity	High	Higher
Orbit	Earth orbit, 547 kilometers altitude	L2 point, 1.5 million kilometers from Earth
Orbital Environment	Subject to Earth's shadow, atmosphere, and radiation belts	Stable, protected from Sun, Earth, and Moon heat/light
Launch Date	April 24, 1990	December 25, 2021
Launch Vehicle	Space Shuttle Discovery	Ariane 5 rocket
Serviceability	Serviced/upgraded five times by astronauts	Cannot be serviced due to remote location
Key Missions	Expansion rate of universe, dark energy, galaxy/planet/star formation, exoplanet atmospheres	Origins of universe, galaxy/star formation, planetary systems, potential for life

3. Space Tourism

Introduction

Space tourism refers to human space travel undertaken for recreational purposes. This emerging industry encompasses various forms of space tourism including orbital, suborbital, and lunar. Despite the advancements and excitement surrounding this sector, it is accompanied by significant risks and challenges.

Historical Developments in Space Tourism

- **Initial Phase (2001-2009):** Between 2001 and 2009, seven space tourists undertook eight space flights to the International Space Station (ISS) via Russian Soyuz spacecraft, facilitated by Space Adventures in collaboration with Roscosmos and RSC Energia. Each trip cost between US\$20–25 million.
- **Market Emergence (2007):** By 2007, space tourism was anticipated to be one of the initial markets to develop for commercial spaceflight.
- **Temporary Halt (2010):** In 2010, Russia suspended orbital space tourism due to the expansion of the ISS crew size, allocating the seats to expedition crews instead of commercial participants.
- **Resumption and NASA's Involvement (2015-2021):** Although a resumption was planned in 2015, it was indefinitely postponed. However, in 2021, Russian orbital tourism resumed with the launch of Soyuz MS-20. In 2019, NASA announced plans to allow private astronauts on the ISS from 2020, utilizing SpaceX Crew Dragon and Boeing Starliner spacecraft, with costs estimated at 35,000 USD per day and 50 million USD for round trips.

Current Players in Space Tourism

- **SpaceX:** A leading entity in the space tourism market, known for its Dragon spacecraft and significant contributions to the commercialization of orbital space tourism. The company actively markets its offerings through various platforms and strategies.
- **Blue Origin:** Focuses on developing rocket-powered vertical takeoff and landing (VTVL) vehicles for suborbital and orbital space access.
- **Virgin Galactic:** A prominent player in the suborbital space tourism sector.
- **Space Adventures:** Offers diverse space tourism opportunities including orbital missions and zero-gravity flights.
- **Boeing:** Besides its well-known airplanes, it is also venturing into spacecraft development for space tourism.
- **Axiom Space:** Aims to construct the first commercial space station, providing opportunities for private astronauts to visit the ISS.
- **Other Companies:** Include Space Perspective, Zero 2 Infinity, Armadillo Aerospace, Orion Span, and World View Enterprises, each offering unique space tourism experiences and products.

Market Dynamics

- **Market Valuation:** The global space tourism market was valued at USD 695.1 million in 2022, with an expected CAGR of 40.2% from 2023 to 2030.
- **Market Structure:** The market is consolidated with a few dominant players focusing on research and development to create orbital and suborbital vehicles for future space travels.

Associated Risks

1. **Safety Concerns:**
 - Lack of independent safety certification for space tourism vehicles.
 - Significant risk of mission failures and fatalities, with historical data indicating varying degrees of risk across different spacecraft.
2. **Health Risks:**
 - Potential for DNA damage due to radiation exposure.
 - Adverse effects on bone density, muscle mass, and blood pressure due to prolonged exposure to microgravity.
3. **Environmental Impact:**
 - Potential contribution to global warming and ozone layer depletion.
 - Concerns regarding the increasing number of rocket flights and their impact on Earth's atmosphere and climate change.

Conclusion

Space tourism, while promising and exhilarating, presents considerable risks and challenges. Prospective space tourists must be cognizant of these risks before embarking on such journeys. Moreover, the industry is characterized by significant developments and contributions from various companies, spearheading the commercialization of space tourism.

The sector is poised for substantial growth, with ongoing efforts to mitigate associated risks and enhance the safety and feasibility of space travels.

4. Starship Project

SpaceX Starship

The **SpaceX Starship** is a super heavy-lift launch vehicle under development by SpaceX. It is the largest and most powerful rocket ever flown, surpassing the thrust of NASA's Space Launch System and Saturn V, as well as the Soviet N1.

Key Details

- **Function:** The Starship is designed for sub-orbital spaceflight, orbital spaceflight, and interplanetary spaceflight.
- **Manufacturer:** The Starship is manufactured by SpaceX.
- **Country of Origin:** The Starship is made in the United States.
- **Project Cost:** The project cost is at least US\$3 billion.
- **Size:** The Starship stands at a height of 121 m (397 ft) and has a diameter of 9 m (30 ft). It has a mass of 5,000,000 kg (11,000,000 lb).

- **Stages:** The Starship is a two-stage-to-orbit launch vehicle. It consists of the first-stage Super Heavy booster and the second-stage spacecraft also named Starship.
- **Engines:** Both stages are powered by Raptor rocket engines, which burn liquid methane and liquid oxygen.
- **Reusability:** Both stages are designed to be fully reusable, performing controlled landings on the arms of the launch tower used to lift the vehicles and, eventually, reflown within hours.
- **Payload Capacity:** Starship is designed to have a payload capacity of 150 tonnes (330,000 lb) to low Earth orbit in a fully reusable configuration and 250 t (550,000 lb) when expended.

Launch

The first and so far only orbital test flight was attempted on 20 April 2023. An anomaly caused the vehicle to tumble out of control four minutes after launch. SpaceX activated the flight termination system, which fired the explosive charges but did not destroy the vehicle. Approximately 40 seconds later both stages were destroyed due to increased aerodynamic forces.

5. SpaceX Starlink

SpaceX Starlink

SpaceX Starlink is an ambitious satellite internet constellation operated by the American aerospace company SpaceX. Its primary objective is to provide high-speed, low-latency internet connectivity to even the most remote and rural areas worldwide.

The development facility for SpaceX Starlink is located in Redmond, Washington, USA.

Key details about SpaceX Starlink

- **Launch:** SpaceX initiated the launch of Starlink satellites in 2019.
- **Satellites:** As of August 2023, Starlink consists of over 5,000 mass-produced small satellites in low Earth orbit (LEO) that communicate with designated ground transceivers. The plan is to deploy a total of nearly 12,000 satellites, with a potential future extension to 42,000.
- **Subscribers:** SpaceX announced surpassing the milestone of 1 million subscribers in December 2022, and by May 2023, the number had grown to 1.5 million subscribers.
- **Applications:** These satellites carry a communications payload utilizing the Ku and Ka frequency bands. They utilize optical inter-satellite links, as well as phased array beamforming and digital processing technologies.
- **Lifespan:** Each Starlink satellite has an approximate lifespan of five years.
- **Cost:** SpaceX estimated that the project's cost, encompassing the design, construction, and deployment of the constellation, would be at least US\$10 billion.
- **Concerns:** Astronomers have raised concerns about the potential impact of the Starlink constellation on ground-based astronomy and the already congested orbital environment. SpaceX has taken measures to mitigate these concerns, such as reducing the brightness of the satellites during operation.

Starlink in India

Starlink is expected to launch its services in India soon.

The company has reportedly already written to the Telecom Regulatory Authority of India (TRAI) for facilitating approvals to use satellite technology for internet access in remote areas.

However, as of June 2023, Starlink is not yet available in India.

Starlink can be a major help in a country like India.

1. SpaceX Starlink offers high-speed wireless internet in congested metro cities and challenging terrains where wired connectivity is a challenge.
2. It can connect villages in remote areas such as deserts, hills, forests, and coastal regions.
3. High-speed internet provided by Starlink can have a significant impact on education, farming, transportation, local commerce, and the economy as a whole.

However, there's no specific launch date or pricing plans available currently.

