Satellite Internet
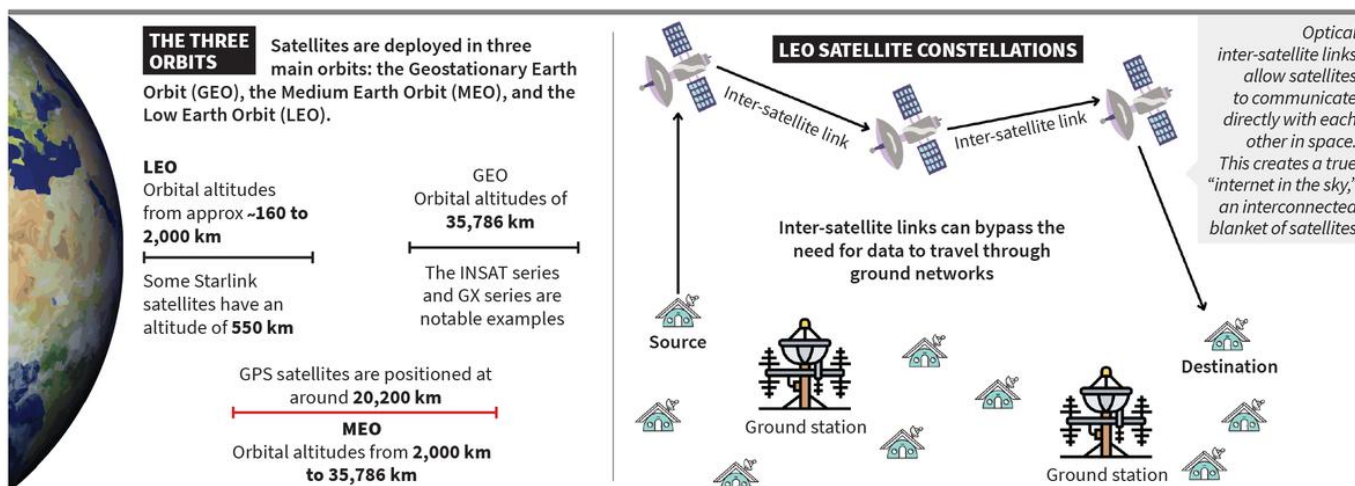
Why in News?

Starlink has received a **Unified Licence** to provide **satellite internet services** in India.

How Does Satellite Internet Work?

- **About: Satellite internet** uses **orbiting satellites** or **mega-constellations**- hundreds to thousands of satellites at varying **altitudes** to transmit **data** between **user terminals on Earth** and space-based infrastructure.
- **Working Mechanism:** Satellite internet operates through a **two-segment system**: the **space segment** and the **ground segment**.
  - **Space Segment:** It comprises **satellites in different orbits** equipped with **communication payloads** for data transmission.
    - Satellites **receive data signals** from user terminals or the ground stations, **process or relay** them, and transmit them back to Earth.
    - **LEO mega-constellations** incorporate **on-board signal processing** and **optical inter-satellite links**, allowing direct satellite-to-satellite communication and reducing reliance on ground stations.
  - **Ground Segment:** It consists of **user terminals** (antennas, modems) and **ground stations** that **communicate with the satellites.**
    - Terminals send requests to satellites, which route the data through the constellation or ground infrastructure to reach the internet backbone.
- **Orbital Deployment:** Satellites are deployed in **3 main orbits:**
  - **Geostationary Earth Orbit (GEO):** Lies around **35,786 km above the equator**. A single GEO satellite covers nearly **one-third of Earth's surface**.
    - It has broad coverage, but **high latency,** so **unsuitable for real-time applications**. Example: Viasat Global Xpress.
  - **Medium Earth Orbit (MEO):** Lies at **2,000–35,786 km altitude**. It has **lower latency than GEO** but requires constellations for global coverage. Example: O3b MEO.
  - **Low Earth Orbit (LEO):** Lies at **less than 2,000 km** altitude. **Very low latency, smaller satellites,** and rapid deployment, but **smaller coverage per satellite.**
    - LEO satellites form **"mega-constellations"** for global reach. Example: Starlink with over 7,000 satellites.

THE THREE ORBITS — Satellites are deployed in three main orbits: the Geostationary Earth Orbit (GEO), the Medium Earth Orbit (MEO), and the Low Earth Orbit (LEO).

LEO Orbital altitudes from approx ~160 to 2,000 km

Some Starlink satellites have an altitude of **550 km**

GEO Orbital altitudes of **35,786 km**

The INSAT series and GX series are notable examples

GPS satellites are positioned at around **20,200 km**

MEO Orbital altitudes from **2,000 km** to **35,786 km**

LEO SATELLITE CONSTELLATIONS

Inter-satellite link

Inter-satellite links can bypass the need for data to travel through ground networks

Source

Ground station

Optical inter-satellite links allow satellites to communicate directly with each other in space. This creates a true "internet in the sky," an interconnected blanket of satellites

Destination

Ground station

What are the Key Potential Applications of Satellite Internet?

- **Connectivity & Communications:** Provides internet in **remote areas** via compact **user terminals**.
  - Future **direct-to-smartphone services** aim to integrate connectivity into **smart devices**, enabling the **Internet of Everything (IoE)**.
- **Transport, Logistics & Public Services:** Enhances **navigation**, supports **autonomous vehicles**, improves **logistics**, powers **smart cities**, provides **early warning systems**, and enables **coordinated disaster response**.
- **Healthcare & Agriculture:** Facilitates **telemedicine** and **remote patient monitoring**, and supports **precision farming**, crop health monitoring, and optimized resource use.
- **Strategic, Industrial & Environmental Uses:** Aids **defence operations**, **environmental monitoring**, **energy exploration**, and **tourism**, while its **dual-use nature** requires integration into **national resilience plans**, bridging the **digital divide**, and shaping **international governance** for **strategic advantage**.
- **Disaster Response & Emergency Communication:** It allows **rapid deployment** of **connectivity** in **disaster-affected regions**, supporting **emergency management**.
  - During **Hurricane** Harvey (2017), **satellite internet** enabled **rescue operations** when **terrestrial networks** failed.

Note:

- **Starlink:** A **satellite internet constellation** by **SpaceX**, providing **high-speed, low-latency internet** globally.
- **Commercial satellite internet services** are **not yet operational in India.**
  - **Eutelsat OneWeb, Reliance Jio-SES, and Starlink** have obtained necessary permits & **government is finalizing spectrum allocation** for its commercial rollout.

Key Satellite Internet Projects:

- **Project Kuiper (Amazon):** Plans to deploy over **3,200 advanced LEO satellites** to provide **affordable, high-speed broadband globally**.
- **Starlink (SpaceX):** Launched in 2019, aims for a **42,000-satellite LEO mega-constellation**.
- **OneWeb (Eutelsat, France):** Operates the **world's second-largest satellite constellation** after Starlink.
- **Qianfan or G60 Starlink Constellation (China):** Planned **LEO mega-constellation** by **Shanghai Spacecom Satellite Technology (SSST)** to provide **global internet coverage**.

Prelims:

Q. For the measurement/estimation of which of the following are satellite images/remote sensing data used? (2019)

1. Chlorophyll content in the vegetation of a specific location
2. Greenhouse gas emissions from rice paddies of a specific location
3. Land surface temperatures of a specific location

Select the correct answer using the code given below.

(a) 1 only

(b) 2 and 3 only

(c) 3 only

(d) 1, 2 and 3

Ans: (d)

Q. With reference to India's satellite launch vehicles, consider the following statements: (2018)

1. PSLVs launch the satellites useful for Earth resources monitoring whereas GSLVs are designed mainly to launch communication satellites.
2. Satellites launched by PSLV appear to remain permanently fixed in the same position in the sky, as viewed from a particular location on Earth.
3. GSLV Mk III is a four-staged launch vehicle with the first and third stages using solid rocket motors, and the second and fourth stages using liquid rocket engines.

Which of the statements given above is/are correct?

(a) 1 only

(b) 2 and 3

(c) 1 and 2

(d) 3 only

Ans: (a)

Q. With reference to Web 3-0, consider the following statements: (2022)

1. Web 3.0 technology enables people to control their own data.
2. In Web 3.0 world, there can be blockchain based social networks.
3. Web 3.0 is operated by users collectively rather than a corporation.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

Ans: (d)

Mains

Q. Discuss India's achievements in the field of Space Science and Technology. How the application of this technology helped India in its socio-economic development? (2016)

Q. Has digital illiteracy, particularly in rural areas, coupled with lack of Information and Communication Technology(ICT) accessibility hindered socio-economic development? Examine with justification. (2021)

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