Satellite-Based Internet

Mains: *GS III – Science and technology*

Why in News?

Recently, Starlink Company has decided to launch the satellite based internet services in India.

What is Internet?

- **Internet** – Sometimes simply called the net, is a worldwide system of interconnected computer networks and electronic devices.
- It is used to communicate with each other using an established set of protocols.



- **Types** – Internet networks can be classified into
  - Ground based network
  - Satellite based network

What are Ground-based networks?

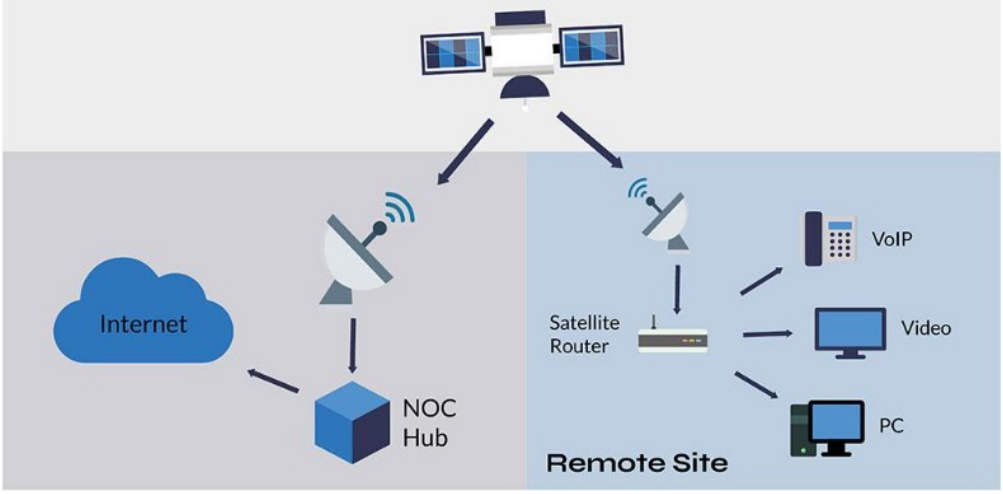
- **Ground-based networks** – They refer to terrestrial communication system that relies

on infrastructure *like cell towers, fiber optic cables, and other ground-based technologies*.

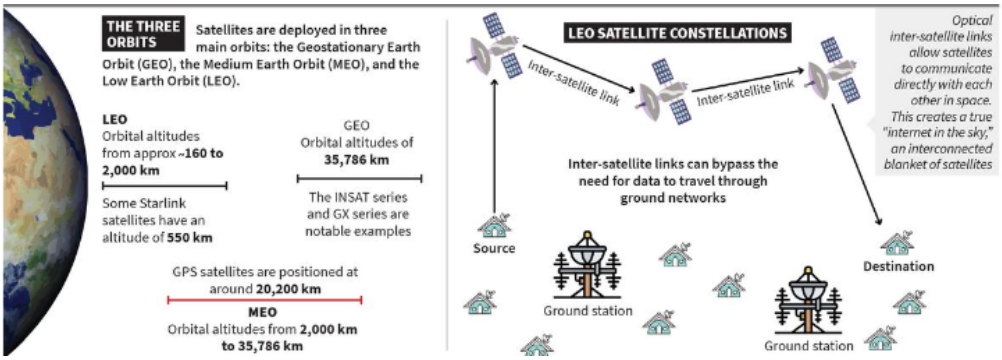
- **Limitations –** They are
  - **Economically unfeasible –** Their *reliance on physical infrastructure* makes them economically unviable in sparsely populated regions.
  - **Susceptible to disasters** – They are also vulnerable to disruptions from natural disasters such as floods and earthquakes.
    - ***For example**, when Hurricane Harvey struck the Texas coast in 2017, it knocked out 70% of cell towers in affected regions.*
- **Cannot meet demand** – They often cannot meet the demand for *on-the-go connectivity in remote locations* or for temporary operations.

What are Satellite based networks?

- **Satellite based networks** – These are communication systems that use satellites *orbiting the Earth to transmit and receive data*.
- **Working**



- **Two segments** – It is composed of a space segment and a ground segment.
  - The *space segment* consists of the satellites in orbit.
  - *Ground segment* includes all equipment on Earth that communicates with them.
- **Life time** – Service life of *5 to 20 years.*
- **Orbits** – Satellites are deployed in three main orbits:
  - The Geostationary Earth Orbit (GEO)
  - The Medium Earth Orbit (MEO)
  - The Low Earth Orbit (LEO).



What are the advantages of satellite based internet over ground based internet?

- **Reduction of user terminals** – This innovation could eliminate the need for separate user terminals altogether.

  User terminal *is the device that is used by an end user to access the services provided by the wireless networks.*

- **Hardware integration** – As the technology becomes mainstream, specialised hardware may be integrated directly into devices like smartphones and laptops.
- **Wide coverage** – It provides extensive and resilient coverage regardless of terrain or the presence of terrestrial infrastructure.
- **Resilient to disaster** – It can work during extreme weather and other natural disasters.
  - ***For example****, when mobile towers fell during Hurricane Harvey in Texas coast in 2017, Viasat's satellite internet became a lifeline for coordinating rescue operations.*
- **Can track multiple users** – It has steerable antennas that can track multiple users and ground stations simultaneously, much like moving spotlights on a stage.
- **Can meet demands** – It can be deployed rapidly to manage sudden demand surges.
- **Can provide temporary connections** – It also provides connectivity within moving platforms like airplanes and remote sites such as offshore oil rigs.
- **Operational readiness** – It also enhances operational readiness in isolated conflict zones.
  - ***For example****, the Indian Army's used it on the Siachen* Glacier.
- **Future prospects** – Companies like AST SpaceMobile and Starlink are testing direct-to-smartphone services for greater accessibility in future.

What are the applications of satellite based internet?

- **Communications** – It provides network access to remote areas and enables the Internet of Everything (IoE).
- **Transportation** – It will enhance navigation systems, support self-driving cars, and improve logistics.

- **Disaster management** – In public administration and disaster management, it can power smart cities, provide early warnings, and coordinate rescue efforts.
- **Healthcare** – The healthcare sector can benefit from telemedicine and remote patient monitoring.
- **Farming** – Agriculture can leverage it for precision farming and crop health analysis.
- **Military applications** – It can serve the defence forces in variety of purposes
    - ***For example**, In the Russia-Ukraine war, SpaceX's Starlink has been pivotal for Ukrainian defence forces.*
- **Other applications** – It also has significant applications in environmental monitoring, energy exploration, tourism, and defence.

• **Starlink** – It is satellite internet constellation operated by SpaceX.
• It provides high-speed internet to users worldwide, including remote locations, by utilizing a network of low Earth orbit (LEO) satellites.
• **Mega constellation** – These are networks of hundreds or thousands of satellites working in unity.
- For example, Starlink has over 7,000 satellites in orbit, with plans for up to 42,000.
• **Key innovation** – The use of optical inter-satellite links.
• These allow satellites to communicate directly with each other in space.



• This creates a true "internet in the sky," an interconnected blanket of satellites.
• **Advantages** – The smaller satellites are *capable of on-board signal processing.*
• This on-board intelligence *simplifies the user terminals* on the ground.
• Terminals become *smaller, cheaper, and more accessible* to individual households.
• This network *can route data globally with minimal reliance on ground stations,* reducing latency and increasing efficiency.
• This enhances data *transmission efficiency, improves signal quality,* and allows for greater flexibility.

What are the challenges?

- **Expensive** – The service is still more expensive than terrestrial broadband.
    - ***For example**, the terminals cost around $500, and monthly services start at about $50.*
- **Connectivity challenges** – Maintaining continuous connectivity is a challenge.

    - ***For example**, LEO satellites move at nearly 27,000 km per hour. They stay within a user's line of sight for only a few minutes.*

- To ensure uninterrupted service, the network must seamlessly "hand-off" the connection from one satellite to the next.

- **Potential for misuse** – Borderless nature facilitates illicit use.
    - ***For example**, Security forces in India have confiscated smuggled Starlink devices from insurgent groups and drug rackets.*

What lies ahead?

- India could develop comprehensive strategies to integrate the technology into national resilience plans.
- India could also leverage it to bridge the digital divide and foster economic development.

Quick facts

The Geostationary Earth Orbit (GEO)
• **Altitude** – They orbit at 35,786 km above the equator. • They match the Earth's rotation, allowing them to remain stationary relative to a point on the ground. • **Advantages** – The high altitude allows a single GEO satellite to cover nearly one-third of the Earth's surface, except the Polar Regions. *- For example, Viasat's Global Xpress (GX) system.* ***Viasat**, is a global communications company specializing in satellite-based internet and networking systems for both commercial and government sectors.* • GEO satellites are also typically large. • They act as "bent-pipes," simply relaying signals back to Earth without processing them. • **Drawback –** They have high propagation latency. ***Latency** refers to the delay, or time it takes, for data to travel from one point to another on a network.* • This makes GEO systems unsuitable for time-sensitive applications like video conferencing or real-time transactions.
The Medium Earth Orbit (MEO)
• **Altitude** – MEO satellites operate at altitudes between 2,000 km and 35,786 km. • **Advantages** – They offer a compromise between GEO and LEO systems • Their latency is lower than that of GEO satellites, • **Drawbacks** – They still require a constellation for global coverage *- For example, O3b MEO constellation, consists of 20 satellites.* • Their latency is often insufficient for many real-time applications. • The satellites remain large and costly to launch.
The Low Earth Orbit (LEO)
• **Altitude** – They orbit at altitudes below 2,000 km • **Advantages** – Their proximity to Earth results in very low latency • They are also smaller, often table-sized, making them cheaper and quicker to deploy. • **Drawbacks** – Smaller coverage area.

Reference

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