3. New Fight for Spectrum in Space- Science & Technology

The rapid expansion of satellite mega constellations, driven by soaring demand for high-speed connectivity, has intensified the global race for limited spectrum and orbital slots

Satellite Spectrum- Conceptual Overview

Satellite spectrum refers to the portion of the radio frequency spectrum used for communication between

1. Satellites in Earth's orbit (LEO, MEO, GEO)
2. Ground stations, user terminals, and gateways.

It enables

1. Broadband internet
2. Navigation (GNSS)
3. Weather forecasting
4. Remote sensing
5. Disaster management
6. Defence and strategic communications

Unlike terrestrial spectrum

1. It is non-territorial in nature.
2. Signals traverse national boundaries.
3. Hence, governance is global rather than national.

Global Governance of Satellite Spectrum

Satellite spectrum and orbital resources are coordinated by the International Telecommunication Union (ITU). Key principles

1. Spectrum and orbital slots are treated as limited natural resources.
2. Allocation follows the doctrine of equitable access, especially for developing countries.

Allocation mechanism

1. First-come, first-served filing system.
2. Requires technical coordination to avoid interference.

Frequency Bands Used in Satellite Communications

L-band (1–2 GHz)

1. Used for GPS, mobile satellite services, aviation and maritime communication.
2. High reliability but limited bandwidth.

Ku-band (12–18 GHz)

1. Widely used for satellite TV, VSATs, broadband.
2. Moderate bandwidth; vulnerable to rain fade.

Ka-band (26–40 GHz)

1. Used by high-throughput satellites and LEO constellations.
2. Enables high data rates but more sensitive to atmospheric conditions.

Spectrum Allocation in India- Legal basis The Telecommunications Act, 2023. Satellite communication spectrum is included in the First Schedule of the Act.

Key Provision

1. Section 4(4) mandates spectrum auction as the default rule.
2. However, spectrum listed in the First Schedule (including satcom) is assigned through an administrative process.

Administrative assignment implies

1. No competitive bidding or auction.
2. Allocation based on policy priorities, coordination with ITU filings, and national interest.

Rationale

1. Satellite spectrum is globally harmonised.
2. Auctions may distort equitable access and international coordination.

The Fight for Spectrum in Space

Spectrum Congestion- Exponential rise in demand for Ku, Ka, and L bands.

Causes

1. Growth of LEO mega-constellations.
2. Expansion of satellite broadband, Earth observation, and navigation services.

Risks

1. Signal interference.
2. Degradation of critical services like GPS, aviation navigation, and weather monitoring.

Orbital Crowding and Space Debris

Current scenario

1. Over 40,000 tracked objects orbit Earth.
2. Around 27,000+ pieces are debris larger than 10 cm.

Projections- More than 50,000 active satellites by 2030, largely in LEO.

Consequences

1. Increased collision probability.
2. Kessler Syndrome risk (cascade of collisions).
3. Disruption of scientific and astronomical observations.

Structural Bias in ITU Allocation System

First-come, first-served system advantages -Countries and firms with Advanced technical capacity, Early filing capabilities, Strong regulatory ecosystems

Disadvantages- Late entrants, particularly developing nations, receive Inferior orbital slots Congested or less commercially viable spectrum bands

Outcome- Inequitable distribution of space resources.

Digital Divide and Affordability

LEO satellites- Latency as low as 20–40 milliseconds.

Enable- Telemedicine, Online education, Disaster response in remote regions

Affordability challenge- High terminal costs (e.g., ~$600 for Starlink user equipment). Subscription costs remain prohibitive for rural and low-income populations.

ITU estimate- $2.6–2.8 trillion required globally by 2030 to bridge digital connectivity gaps.

Consequences of an Unregulated Spectrum–Orbit Race

Technological Consequences- Increased radio-frequency interference. Reduced reliability of

1. Remote sensing satellites
2. Climate observation missions
3. Navigation systems

Astronomical disruptions

1. Bright satellite trails affecting optical astronomy.
2. Radio noise affecting radio telescopes.

Economic Consequences

Early movers gain

1. Market dominance in satellite broadband.
2. Control over prime orbital–spectrum combinations.

Late entrants face

1. Higher entry costs.
2. Reduced commercial viability.

Risk of private monopolisation of space-based infrastructure.

Geopolitical Consequences- Strategic asymmetry between

1. Advanced spacefaring nations
2. Developing and emerging economies

Space becomes a domain of

1. Strategic competition
2. Technological dominance
3. Influence over global digital infrastructure

Social Consequences- Satellite internet risks becoming

1. A premium service for affluent users.
2. Not a universal public good.

Failure to address affordability

1. Undermines SDG-9 (Industry, Innovation, Infrastructure).
2. Weakens SDG-10 (Reducing Inequalities).

Reforms under the World Radiocommunication Conference (WRC)- The World Radiocommunication Conference 2023 introduced important governance reforms.

Resolution 8

1. Requires operators to report deviations between- Planned filings, Actual satellite deployments
2. Aims to curb speculative filings and "paper satellites".

Phased deployment milestones for mega-constellations

1. 10% deployment within 2 years
2. 50% within 5 years
3. 100% within 7 years

Significance

1. Prevents hoarding of spectrum and orbital slots.
2. Promotes accountability and efficient resource use.

International Telecommunication Union (ITU)- Key Facts- A specialised agency of the United Nations.

Membership

1. 194 member states.
2. India has been a member since **1869**.

Core functions

1. Allocation of global radio spectrum.
2. Coordination of satellite orbital slots.
3. Development of technical standards for interoperability.
4. Promoting ICT access in underserved regions.

Way Ahead- Policy and Governance Imperatives

Modernise global space governance- Update ITU rules to reflect mega-constellation realities.
Strengthen debris mitigation norms- Mandatory de-orbiting. Active debris removal.
Promote equitable access- Safeguards for developing countries in spectrum allocation.
Affordability-centric regulation- Universal service obligations for satellite broadband.
India's role- Proactive participation in ITU and WRC negotiations. Align national space policy with sustainability and inclusivity.

Conclusion

Satellite spectrum is emerging as a strategic global common, critical to connectivity, security, and scientific advancement. Managing the spectrum–orbit race effectively will determine whether outer space evolves into an inclusive digital infrastructure or a domain dominated by a few early movers.

Source- [https-//www.thehindu.com/sci-tech/science/satellites-science-and-the-new-fight-for-spectrum-in-space/article70380429.ece](https://www.thehindu.com/sci-tech/science/satellites-science-and-the-new-fight-for-spectrum-in-space/article70380429.ece)