

AI-Optimized LEO Satellite Internet Constellations

1. Relevance

Low Earth Orbit (LEO) satellite constellations, operating between 200–2000 km, enable **low-latency, high-throughput** broadband at **lower cost** than traditional systems. Ideal for global coverage—including remote and underserved areas—these networks are led by mega-constellations such as:

- **SpaceX Starlink** (~7,500 satellites by mid-2025)
- **OneWeb** (648 satellites for global coverage)
- **Amazon Project Kuiper** (~3,200 planned satellites)

Applications span **internet access, IoT, and autonomous systems**, impacting **military, commercial, and civilian** sectors while enhancing and augmenting terrestrial infrastructure.

2. Key Challenges at Scale

As LEO networks expand, several technical challenges have emerged:

- **Dynamic Topology**
Rapid satellite motion leads to frequent link changes. Intersatellite links (especially laser-based) drop during maneuvers or blockages, complicating routing and handoffs.
- **Scalability**
Coordinating thousands of satellites and user terminals requires **automated** resource planning (spectrum, power, routing) beyond manual control.
- **Interference & Spectrum Sharing**
LEO systems share Ku/Ka bands with terrestrial and GEO systems. Managing **time-varying co-channel interference** while staying within **regulatory limits** (ITU, FCC) is essential.
- **Resource Constraints**
Limited **power and bandwidth** demand optimized **scheduling** for downlinks, beamforming, and inter-satellite communications under tight constraints.
- **Fault Tolerance**
Component failures (e.g., satellite or link outages) are inevitable. Networks must support **real-time rerouting, self-healing, and anomaly detection**.

3. AI Techniques for LEO Optimization (State-of-the-Art)

AI methods address these challenges through:



- **Deep Learning**
- **Reinforcement Learning (RL)**
- **Graph Neural Networks (GNNs)**
- **Swarm Intelligence**

Key Optimization Tasks:

- Satellite scheduling and resource allocation
- Routing and network traffic management
- Coverage optimization and constellation design
- Interference mitigation strategies
- Fault tolerance and network resilience

4. Datasets and Simulation Environments

Explore tools and datasets supporting research in this domain:

-  **LEO Satellite Network Simulation (NS-3 Module)**
[NS-3 LEO GitHub Module](#)
-  **Self-similar Traffic Prediction using LSTM**
[IET Research Paper on LSTM Prediction](#)