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AI-Driven Optimization for High-Throughput & Multi-Orbit Satellite Networks

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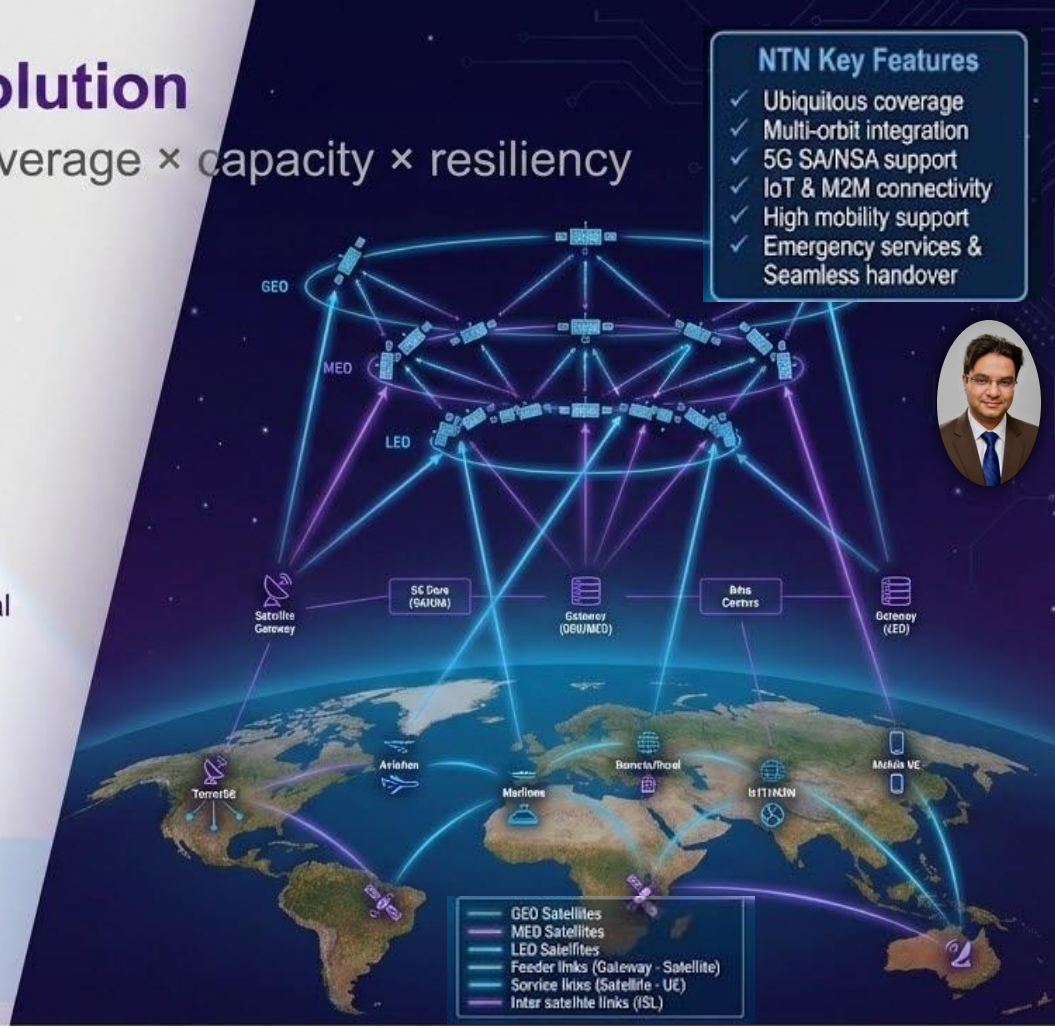
The HTS & Multi-Orbit Evolution

Why multi-orbit matters: latency × coverage × capacity × resiliency

- **Explosive demand** for HTS & VHTS capacity (Ka/Ku/Q/V bands)
- **Dynamic beam steering**, flexible payloads, software-defined payloads
- **Multi-orbit routing** across GEO/MEO/LEO
- **Cloud-native ground segment** (virtual gateways, digital IF)
- **Global mobility use cases:** aviation, maritime, remote enterprise, backhaul, defence

Satellite networks now behave like distributed cloud systems — dynamic, multi-orbit, software-driven, and globally mobile.



Why AI Becomes Essential

The New Space Operations Equation

CHALLENGES

- Thousands of beams across GEO/MEO/LEO
- Rapid traffic shifts (air routes, maritime lanes, hotspots)
- Weather-driven Ka-band fade
- Doppler & latency variability in LEO
- Cross-orbit SLA routing challenge
- Automation gaps between space & ground

AI HELPS SOLVE

Prediction

Anticipate traffic & link conditions

Optimization

Allocate resources at scale

Real-time Reasoning

Intelligent decision-making

Closed-Loop Action

Autonomous network orchestration

Operational complexity has surpassed human scale. AI is now the only viable way to operate multi-orbit networks at the speed they evolve.

AI Application Areas Across NTN

5 Core Opportunities for Operators

1. Predictive Link & Weather Modelling

- Predict atmospheric degradation (Ka/Ku)
- Proactive modulation/power adjustments

2. Orbit-Aware Routing Optimization

- Dynamic GEO ↔ MEO ↔ LEO selection
- Latency-throughput-SLA decisioning

3. Intelligent Beam & Gateway Management

- Forecast Hotspots
- Optimise beam shaping and load balancing

4. AI-Assisted Payload Operations

- Adaptive coding, power & resource allocation
- Payload anomaly detection

5. End-to-End QoE Assurance

- Experience scoring for aviation/maritime/backhaul
- Automated RCA across space + ground

These 5 areas deliver the highest ROI — and can be deployed incrementally on the path to autonomous NTN operations.

Digital Twin for Multi-Orbit Networks

Virtual Replica to Predict, Optimize, Assure

DIGITAL TWIN COMPONENTS

Satellite → Beam → Spot Beam → Gateway → Terrestrial Network

- Real-time telemetry ingestion
- Link budget simulation
- Interference and weather modelling
- Beam coverage & footprint dynamics
- SLA & QoE metrics

CAPABILITIES

What-If Analysis
Beam/frequency adjustments

Orbit Handover Simulation
Validate handover logic before deployment

Traffic Redistribution
Analyse resource shifts safely

Predictive Congestion
Forecast capacity bottlenecks

Digital twin is a living model of the multi-orbit ecosystem — enabling operators to simulate and validate changes before they touch the live network.

Agentic AI for NTN Operations

Four-Step Intelligence Cycle

1. Perception Layer

- Telemetry, RF stats, MCS
- Weather maps
- Gateway logs, GNSS timing
- Orbit ephemeris

2. Reasoning Layer

- Predictive ML models
- SLA risk scoring
- Orbit path selection
- Decision Intelligence

4. Learning Layer

- Feedback assimilation
- Model retraining
- Continuous optimization
- Performance refinement

3. Action Layer

- Beam steering adjustments
- Cross-orbit load balancing
- AI-driven Configuration recommendations
- Automated remediation

This Agentic AI stack gives NTN networks self-optimising behaviour — essential for highly dynamic LEO/MEO environments.

VIAVI Enabling NTN AI, Simulation & Digital Twin

AI-Driven Simulation, Validation & Autonomous Operations

A. VIAVI Toolchain for Simulation & Validation

Ray Tracing
• 3D propagation modelling for beamforming, MIMO & NTN environments

TM500
• NTN delay/Doppler, mobility & timing validation

AI - RSG
• Orbit dynamics, beam patterns & mobility modelling for AI training

TeraVM
• 4G/5G Core validation under satellite latency, jitter & QoS conditions

Partner Ecosystem
End-to-end NTN validation with Rohde & Schwarz

B. AIOps Platform for NTN Modelling & Ops

NITRO | AIOPS

Unified Telemetry Ingestion
Multi-orbit RF telemetry via REST/SNMP/Kafka

AI/ML Analytics Engine
Predictive congestion, weather fade, Doppler insights

Multi-Orbit Digital Twin
What-if planning, beam shaping, handover intelligence

Correlation & RCA Engine
Cross-domain correlation with automated RCA

Closed-Loop Automation
AI-driven remediation, MODCOD tuning, gateway/beam control

SLA & QoE Assurance
Per-beam SLA monitoring & predictive alerts

Simulation → Modelling & AIOps → Insights → Use Cases

Use Case 1: AI-Optimised Orbit Handover

Proactive Selection of GEO/MEO/LEO Paths

Predict Congestion

Forecast LEO congestion 3–5 minutes ahead

Compare Options

Evaluate latency/SLA thresholds vs MEO/GEO

Dynamic Triggers

Adjust handover triggers dynamically

Improve Mobility QoE

Enhance experience across oceans & aviation corridors

IMPACT: AI reduces oscillation, improves SLAs, and significantly cuts dropouts

Use Case 2: Beam Capacity & Hotspot Forecasting

Dynamic Beam Resource Optimization

PREDICT
15–30 min demand hotspots

PRE-POSITION
Beam power & bandwidth

OPTIMIZE
Spectral efficiency

KEY BENEFITS

- **Improve spectral efficiency** through predictive allocation
- **Reduce unplanned load shedding** incidents
- **Proactively position** resource ahead of demand
- **Handle dynamic traffic** from aircraft & vessels

The Future of AI-Powered NTNs

Autonomous Space Networks Within Reach

Higher Spectral Efficiency via AI optimization

SLA-Driven Routing across multi-orbit networks

Faster Multi-Orbit RCA and troubleshooting

Energy-Efficient Payload & gateway operations

"As HTS and multi-orbit systems scale, AI becomes the control plane for space networks."

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