Space Policy Conference

ASPC-26

# Direct-to-Device (D2D)

## - *From Pilot to Policy*

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# AGENDA OVERVIEW

## NTN Ecosystem

Key component | Architecture | Spectrum

## D2D Technical s Regulatory Building Blocks

International Regulation | Spectrum coordination | Interference management

# NTN Ecosystem

Key Components & Architecture

Satellite Network Operators

Satellite Manufacturing

Ground Systems

Satellite System (NTN)

**TN-NTN Networks**

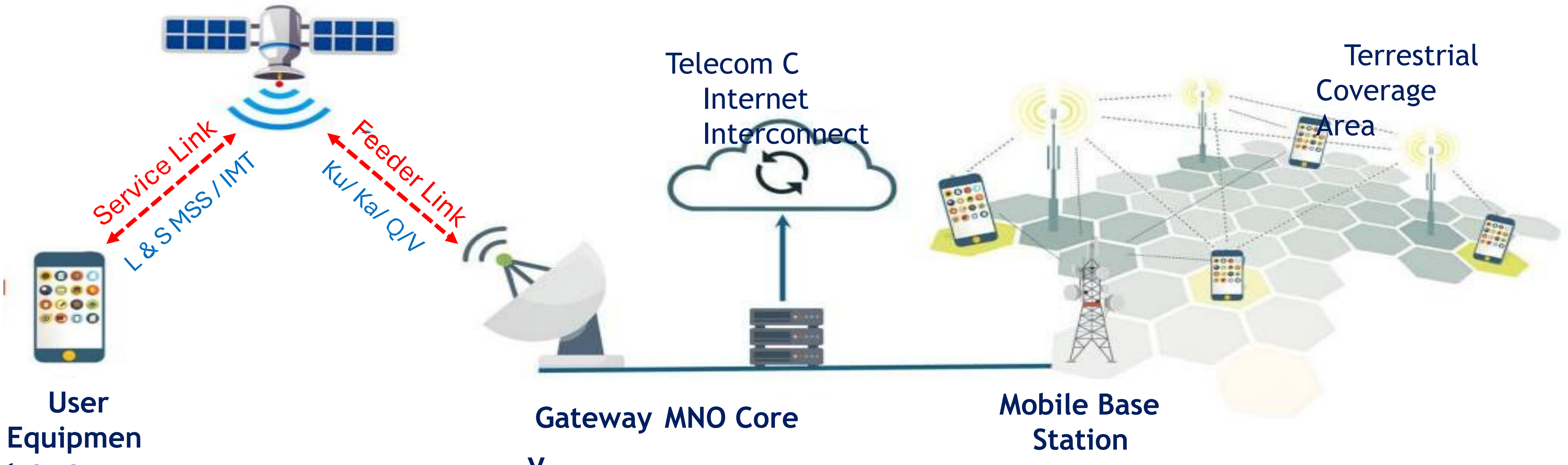
Terrestrial System (TN)

Mobile Network Operators

Network Equipment Manufacturers

Device C Chipsets

**Spectrum access** - Critical enabler and Primary constraint for D2D deployment




**Successful D2D requires simultaneous evolution of** Space Segment, Mobile Network, Integration s spectrum framework

# Satellite D2D - Spectrum Strategies

Different way of connecting a smartphone

| MSS - Based D2D (Standard Based C OEM-led Proprietary) | IMT Spectrum -Based D2D (Operator specific |
|---|---|
| 1 Dedicated Spectrum for Satellite services | 1 Spectrum access through agreement with licensed MNOs |
| 2 Existing ITU regulatory framework | 2 Larger addressable market with unmodified smartphones in use. |
| 3 Well-established frequency coordination mechanism internationally. | 3 Potential to support higher capacity services through wider IMT spectrum. |
| 4 Requires NTN capable modem/ chipset support by phone manufacturers- **Device ecosystem is emerging.** | 4 Spectrum sharing, cross-border coordination C interference management remain key regulatory priority. |
| **User Link Spectrum:** L (n255) C S (n256) | **User Link Spectrum:** below 2.7 GHz |

**KEY Findings**

- ✔ MSS based D2D – a strong foundation for early deployment for Narrow-Band use cases. But framework needed about responsibility of ownership – **end user, security & traceability.**
- ✔ D2D-IMT **next evolutionary phase** but requires coordinated spectrum policy & coexistence frameworks at both national & international level.

# Satellite D2D - Connectivity

Technology Evolution & Key Enablers

## The Real Breakthrough

The breakthrough is not the satellite itself — satellites haveexisted for decades. **It is enabling a standard mobile device to become satellite-connected.**

## The True

The real foundation of a scalable D2D ecosystem is **spectrum access, coexistence, and commercial sustainability** — not just constellation size.

## User link Spectrum Sharing &

**IMT Spectrum -** Not Yet a settled matter.

**MSS Spectrum** –Co-coverage & Co-frequency sharing challenges. Therefore, spectrum becomes the limiting resource.

## Feeder link Spectrum

**Gateway Spectrum & licensing:** Larger spectrum for Feeder link create more challenge on sharing spectrum at gateway locations.

## Multi-Constellation

FSS spectrum shared among multiple NGSO Constellation.

Potential for constellation congestion when **xx NGSO systems** operate in same band.

D2D service may require regulatory clarity on all of these key enablers. **Missing one of these may have impact on deployment AT SCALE.**

# Satellite D2D - User Spectrum Coexistence

**IMT SPECTRUM**

| Risk Area | Options for risk mitigation |
|---|---|
| 1. Co-frequency sharing with terrestrial mobile.<br>2. Adjacent-channel & Out-of-Band emission.<br>3. Cross Border Interference.<br>4. Protection to co-primary services. | ✔ **Evolving Framework:** Still evolving internationally \| ITU-R Studies underway.<br>✔ **The Core Question:** Can large-scale satellite operation in IMT bands coexist with existing networks without causing harmful interference? |

**Key Watch Point -** The WRC-2027 will be a critical milestone. Decisions on sharing studies & coexistence would shape the D2D commercial success.

**MSS SPECTR**

| Risk Area | Options for risk mitigation |
|---|---|
| 1. Limited spectrum in L & S band.<br>2. Co-frequency sharing between constellation is fundamentally challenging. | ✔ **Preserve access to MSS spectrum:** Portion of capacity reserve for National resilience, public safety & future constellations.<br>✔ **Reviewing the future use of MSS spectrum:** Forward looking policy to support sovereign satellite capability for national infrastructure. |

**Key Watch Point - Countries are moving beyond traditional Spectrum Assignment,** e.g: EU's proposal on 2 GHz | ACMA licensing framework for 2 GHz | Japan's J-LEO concept | China's support for national constellation.

# Feeder link - The Hidden Capacity Enabler

## From a system engineering perspective - A scalability challenge

- Unlike user spectrum, Gateway carry "aggregated traffic", requires access to very large BW – **in fact entire available spectrum**
- Gateway locations with high-capacity, high reliable fiber connectivity – **critical for PoP interconnection**
- Prefer proximity to Internet exchange points and hyperscale data centres - **to optimize latency**

This leads to the Geographical clustering of Gateway stations.

## The technical challenges -

- **Interference potential -** as operator requires access to the majority of the **SAME feeder-link spectrum (Ku / Ka / Q&V)**.
  - ✔ **Operators may need** – additional separation distance or frequency segmentation.
- **Create barrier for future entrants-** The first few gateways deployed at a strategically valuable (fiber-rich) locations
  - ✔ **New Operators may encounter** – Reduced spectrum availability | stricter coordination conditions | relocation to less optimal sites | longer fiber backhaul routes | Higher latency

Gateway access should be coordinated using both geographic and spectrum planning – **to preserve constraint free locations for future NGSO systems for Broadband & D2D**

# Multi-Constellation Coordination

Need – Building Scalable coordination frameworks

## Global satellite landscape is changing-

- **Earlier** – Few GSO and limited NGSO systems - **Primely for DTH & VSAT based broadband services**
- **Future** – Multiple mega-constellation with 1000s of satellite – **Home Broadband (FWA) + Mobility (D2D)**

Multi-constellation ITU coordination is feasible – but not infinitely scalable.

## The technical challenges -

- Limited amount of spectrum | Ku & Ka band most congested and shared among existing operators | No inter-constellation coordination framework beyond ITU First-Come-First-Served (FCFS) notification - Potential for constellation congestion when **xx NGSO systems** operate in same band.
- No theoretical limit in ITU-RR, however there is a practical engineering limit.
  - ✔ Suppose – N constellations, then required bilateral coordination needed is N(N-1)/2
  - ✔ So, 5 Constellation -> 10 coordination **(it may still work)** BUT 10 Constellation -> 45 coordination **(Very Challenging)**
- Whether the existing ITU coordination framework is sufficient to ensure multiple constellation can coexist.
  - ✔ Frequency coordination complexity grows rapidly than number of constellation – This is a scalability challenge.

The Next-gen of spectrum policy should not merely determine who gets access to spectrum—it should determine if the existing framework is sufficient to scale multiple systems to coexist efficiently.

# Key Takeaways

## D2D - Natural NTN evolution

D2D-MSS provides the earliest pathway| D2D-IMT offers opportunity for mass-market connectivity but requires spectrum sharing & coexistence mechanism -WRC-27 Agenda Item 1.13 is critical.

## Roadmap for D2D services

Spectrum management to promote future constellations | Remain Open to both MSS & IMT based D2D| Advances
in 3GPP standards & handset capabilities for service improvement

## Long Term scalability

Plan for Scale: Accelerating NTN chipset through 3GPP to widen the MSS based device ecosystem

## Spectrum sovereignty preservation

Suitable framework for national control over spectrum resources to ensure TRUE sovereignty & security and establish mechanism to increase in constellation scale.