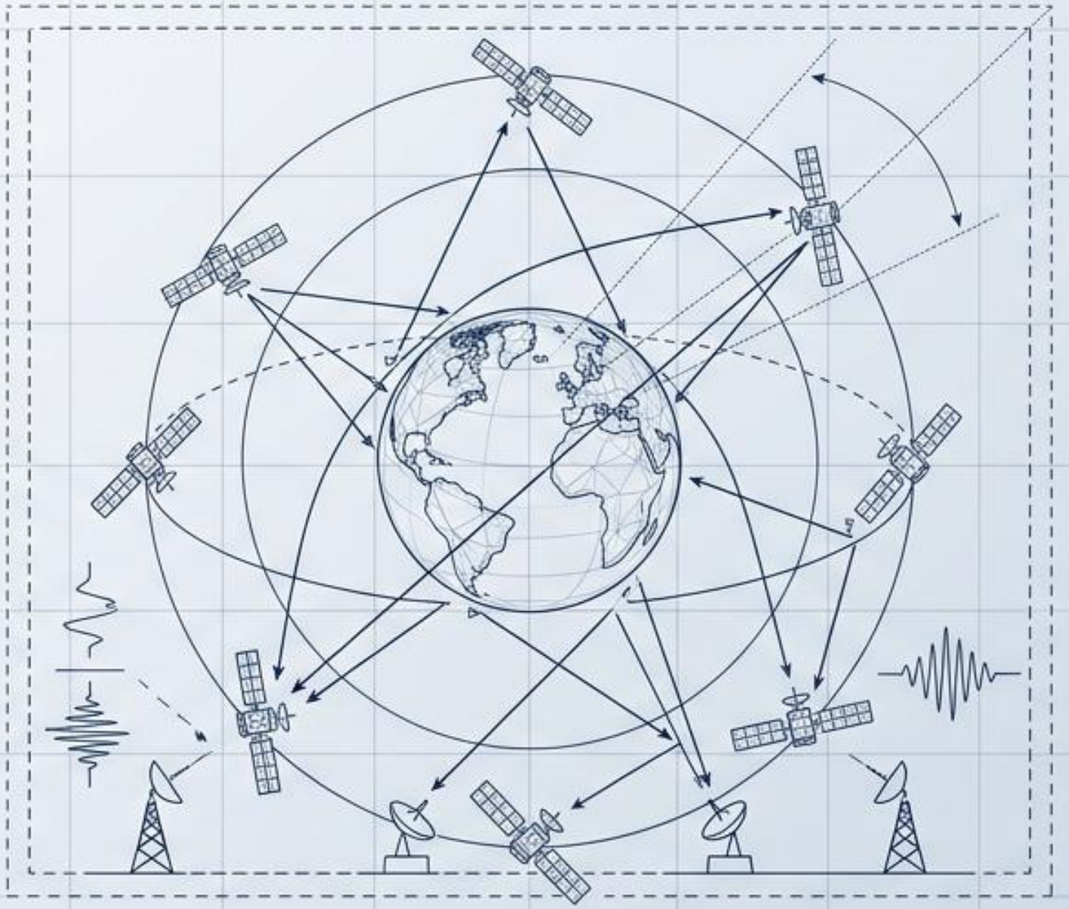
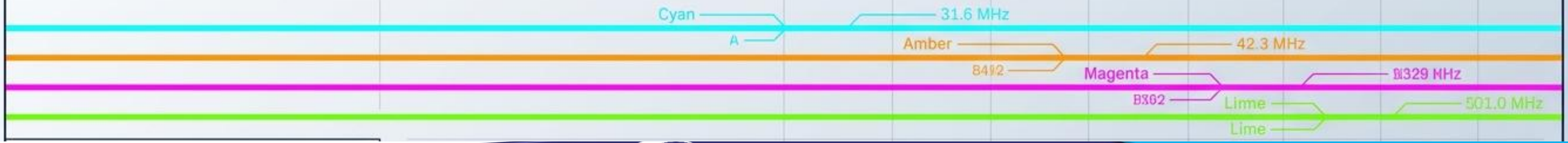
Mapping the Spectrum for Global IoT

A Strategic Atlas of WRC-27 Agenda Item 1.12: Regulatory Actions for Low-Data-Rate Non-GSO MSS Systems.





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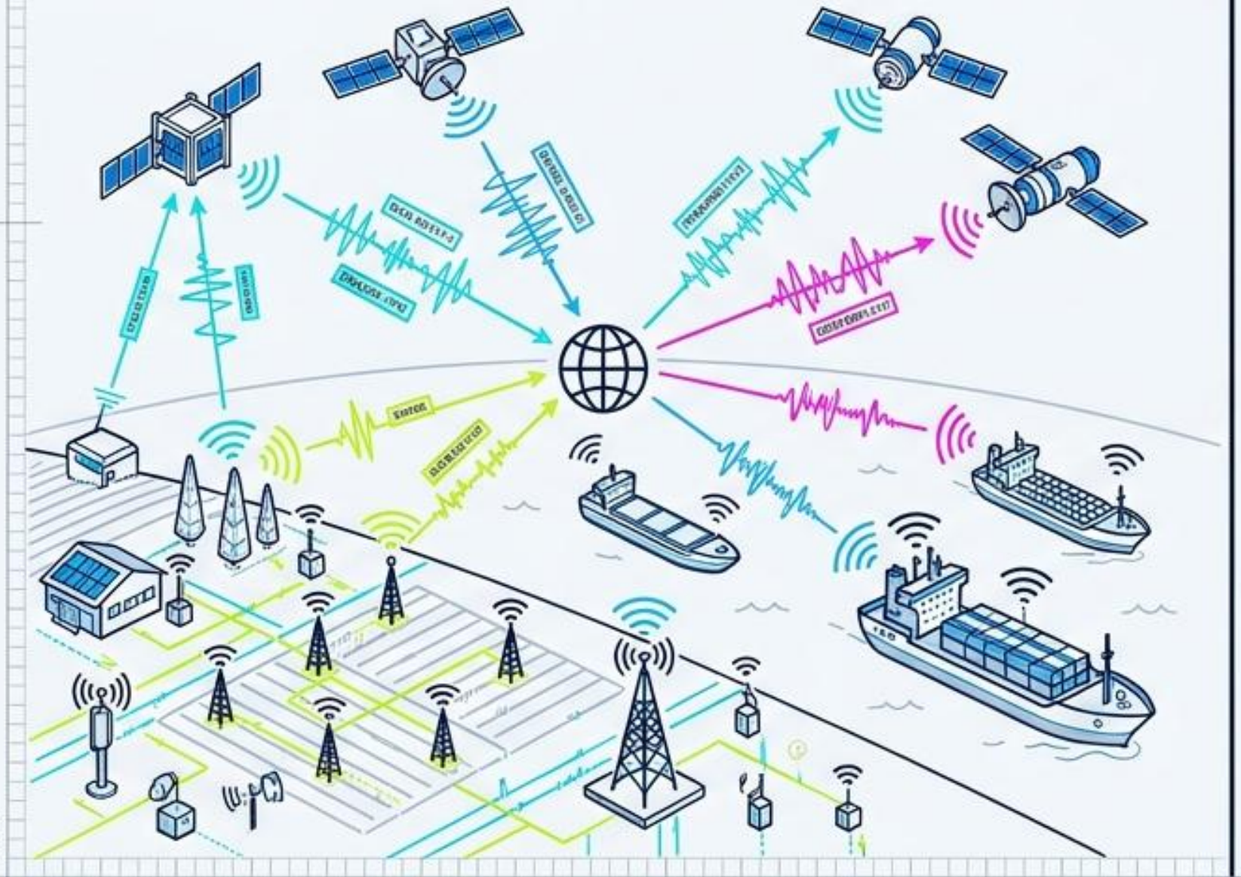
The Sub-5 GHz Spectrum Squeeze

The Demand

The Catalyst

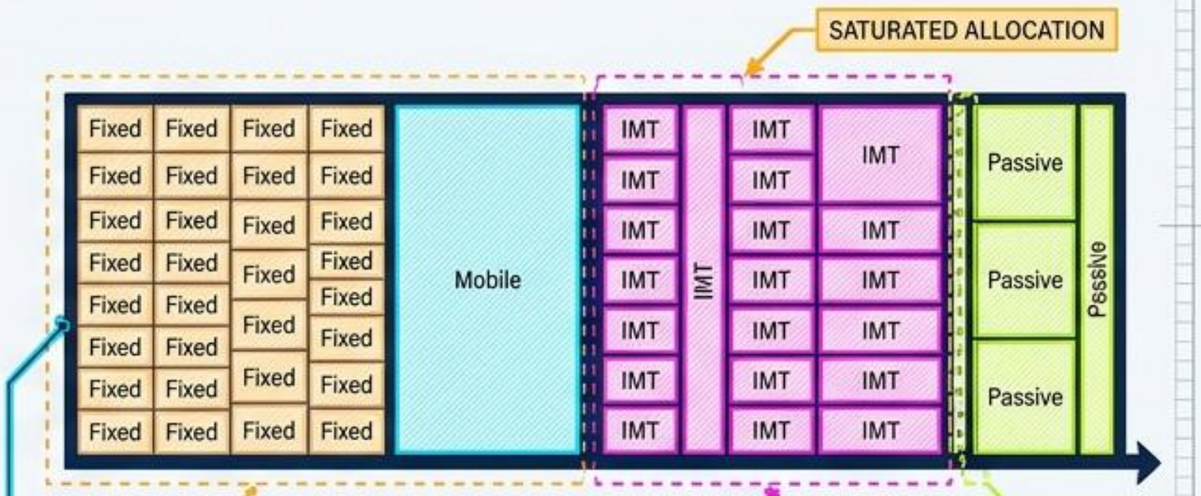
The rapid expansion of the Internet of Things (IoT) and small satellite deployments demands global access to harmonized spectrum.



The Scarcity

The Constraint

Suitable Mobile-Satellite Service (MSS) spectrum below 5 GHz is scarce and currently allocated to deeply entrenched incumbent services.



The ITU-R Directive (Res 252)

Explore the feasibility of establishing a regulatory framework for non-GSO Low-Data-Rate (LDR) MSS across four specific frequency bands, ensuring absolute protection for existing services.

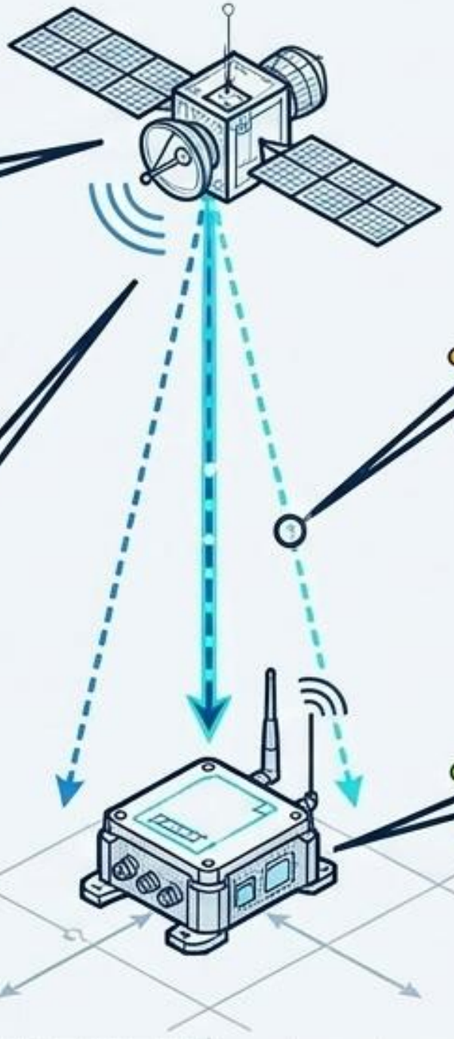
The Anatomy of a Low-Data-Rate (LDR) MSS System

Traffic Profile

Intermittent, burst-mode connectivity transmitting small, infrequent data packets. Traffic ranges from 0.001 to 10,000 kbytes per user terminal/month.

Operational Limits

Strictly no telephony.
No real-time bi-directional communications (e.g., internet browsing or remote control).



Resilience

Capable of maintaining service applications (tracking, alerting, monitoring) while experiencing physical layer packet loss (Target Frame Error Rate up to 10^{-1} on uplink).

Power Constraints

Maximum single user terminal e.i.r.p. operates between -20 to 5 dBW.

-20 -20

The Regulatory Toolkit: Three Paths to Allocation

WRC-27

Method A
(The Status Quo)

- No change (NOC) to the Radio Regulations.
- Resolution 252 is suppressed; LDR MSS deployments are not accommodated in these bands.

Method B
(Primary Allocation)

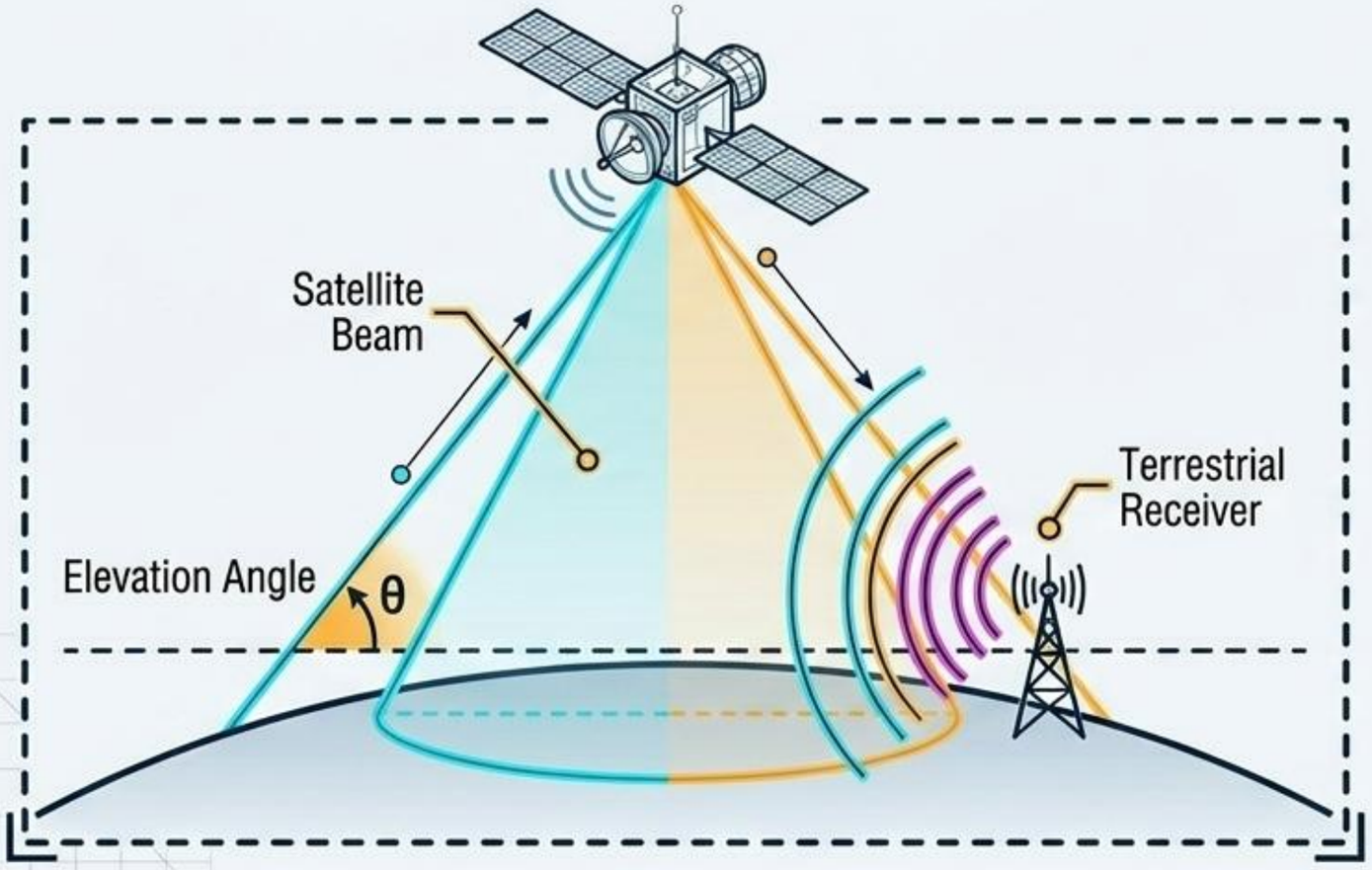
- Introduces new Primary MSS allocations governed by a new Resolution [XXX] (WRC-27).
- Imposes strict technical/operational conditions (pfd limits, e.i.r.p. limits) to protect incumbents.

Method C
(Secondary Allocation)

- Introduces Secondary MSS allocations via Article 5 footnotes.
- Operation is strictly limited by defined maximum aggregated pfd on ground and mandatory separation distances from specific country borders.

Defining Protection: The Power Flux-Density (pfd) Mask

The Geometry of Space-to-Earth Interference



To protect ground-based incumbents, ITU-R studies establish pfd limits—the maximum amount of satellite signal energy allowed to hit the Earth's surface.

The Elevation Variable (θ):

- Limits are dynamic. They are most stringent at very low elevation angles (θ near 0°) to protect vulnerable terrestrial fixed service receivers situated on the geometric horizon. As the satellite moves directly overhead, the pfd limits incrementally relax.

Application:

- Methods B and C rely heavily on these elevation-dependent mathematical masks to guarantee coexistence without halting satellite operations.

Defining Protection: Minimum Coupling Loss and Separation Distances

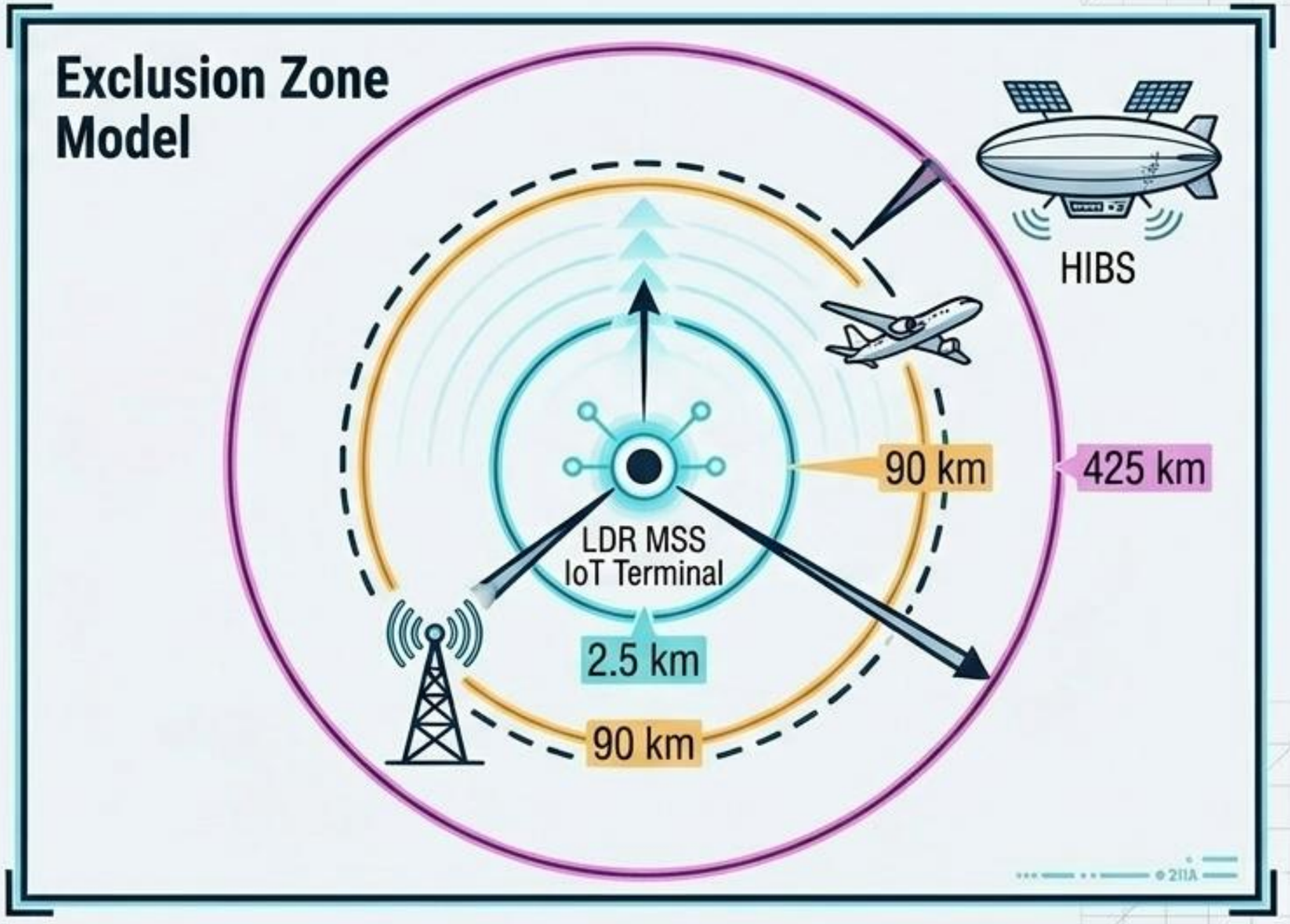
When a ground-based LDR IoT terminal transmits upward (Earth-to-space), it creates a localized bubble of potential interference.

Minimum Coupling Loss (MCL):

- Studies calculate the required signal loss between the IoT terminal and an incumbent between the IoT terminal and an incumbent receiver to prevent harmful interference.

Translating Loss to Distance:

- Using terrestrial propagation models (ITU-R P.1546), MCL is converted into physical separation distances ranging from 2.5 km for ground stations, up to 425 km for aerial platforms (HIBS). Inside these zones, MSS terminals must be silenced.



The Four Frontiers: A Comparative Analysis

1 427–1 432 MHz

Direction: Space-to-Earth →

Focus: Passive sensor protection.

1 645.5–1 646.5 MHz

Direction: S-E / E-S ↔

Focus: Maritime distress systems.

1 880–1 920 MHz

Direction: S-E / E-S ↔

Focus: Terrestrial Fixed & HIBS.

2 010–2 025 MHz

Direction: S-E / E-S ↔

Focus: IMT and Mobile Video Links.

All subsequent technical evaluations assume the suppression of Resolution 252 (WRC-23) in favor of new regulatory definitions.

1 427–1 432 MHz: Protecting Passive Space Sensors

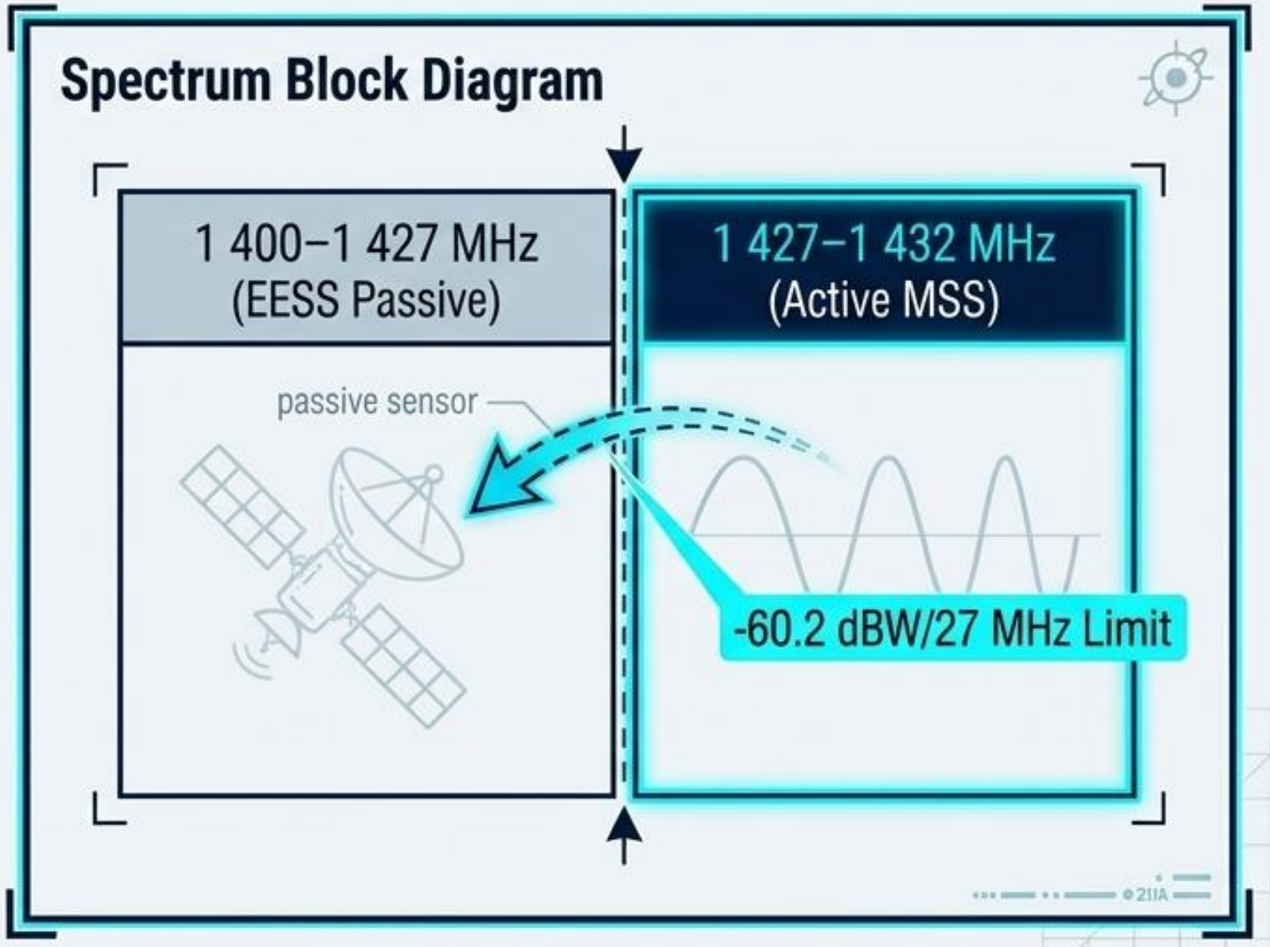
Direction: Space-to-Earth

The Incumbent Risk:

Earth Exploration-Satellite Service (EESS) passive sensors operating in the adjacent 1 400-1 427 MHz band. These highly sensitive sensors measure planetary variables like soil moisture and ocean salinity.

The Proposed Mitigation (Methods B/C):

- Studies applying Resolution 750 (WRC-19) limits show that absolute protection of EESS requires strict out-of-band emission constraints.
- LDR MSS satellites must maintain a strict out-of-band power limit of -60.2 dBW/27 MHz spilling into the EESS channel to meet the interference protection criteria of ITU-R RS.2017.



1 645.5–1 646.5 MHz: The Safety & Distress Conflict

Amber **Direction:** Space-to-Earth & Earth-to-Space

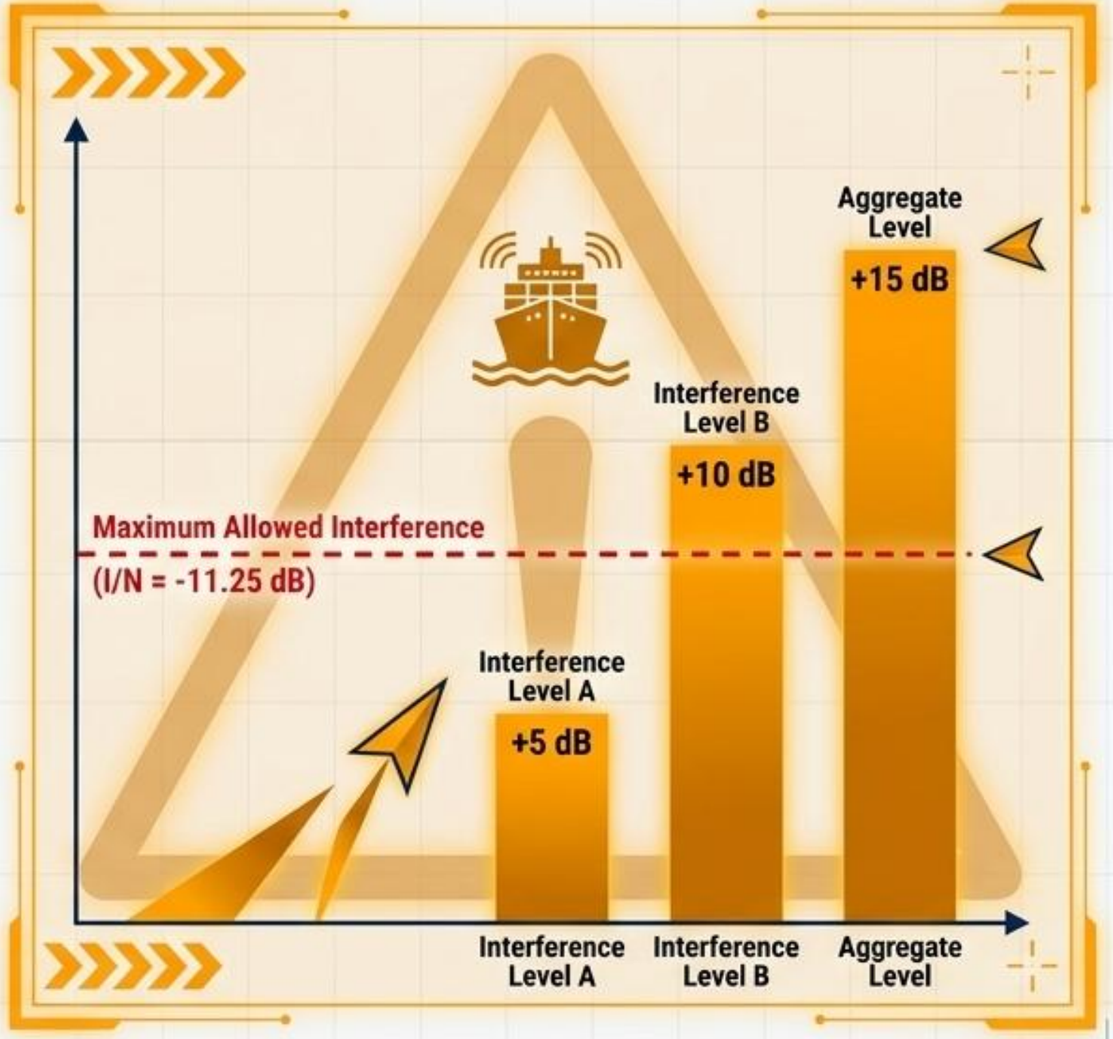
The Incumbent Risk:

This band is utilized by the **Global Maritime Distress and Safety System (GMDSS)**, specifically the **Fleet Safety** service (**RR No. 5.375**).

The Compatibility Findings (High Risk):

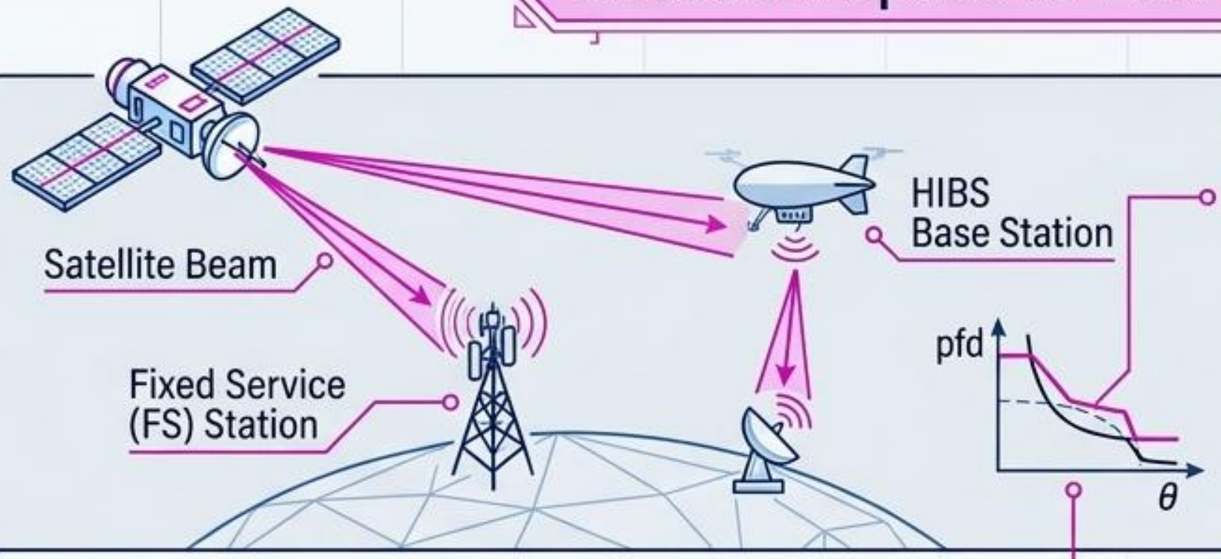
- ITU-R studies indicate excess interference from **non-GSO LDR MSS** systems into current operating GSO systems.
- Interference values far exceed the maximum acceptable levels (protection criteria **I/N = -11.25 dB**).
- Aggregate interference from multiple non-GSO satellites and user equipment has **not yet** been fully modeled, meaning **real-world** interference will be even higher.

Conclusion: Co-channel operation will lead to harmful interference to distress, urgency, and safety communications.



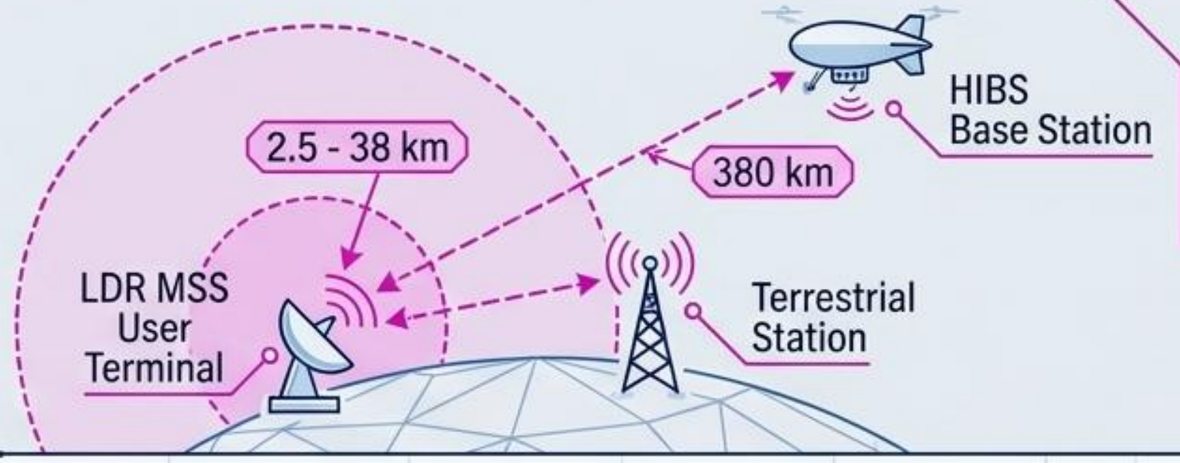
1 880–1 920 MHz: The Dual-Layer Terrestrial Challenge

Direction: Space-to-Earth & Earth-to-Space



Space-to-Earth Mitigations:

- Protection relies on a **composite pfd mask**. At **low elevation angles, Fixed Service stations are the most vulnerable.** At higher elevations, **High Altitude Platform Stations** as IMT Base Stations (HIBS) become the the limiting factor. The final pfd mask must trace the most stringent requirement at every angle θ.



Earth-to-Space Mitigations:

- Required **separation distances** from LDR MSS user terminals range from **2.5 km to 38 km** for most terrestrial stations.
- The **HIBS Exception**: Due to clear non-terrestrial line-of-sight paths, a massive separation distance **of up to 380 km** is required to protect HIBS base stations from a 1W LDR MSS uplink.

2 010–2 025 MHz (Space-to-Earth): The IMT & Video Link Mask

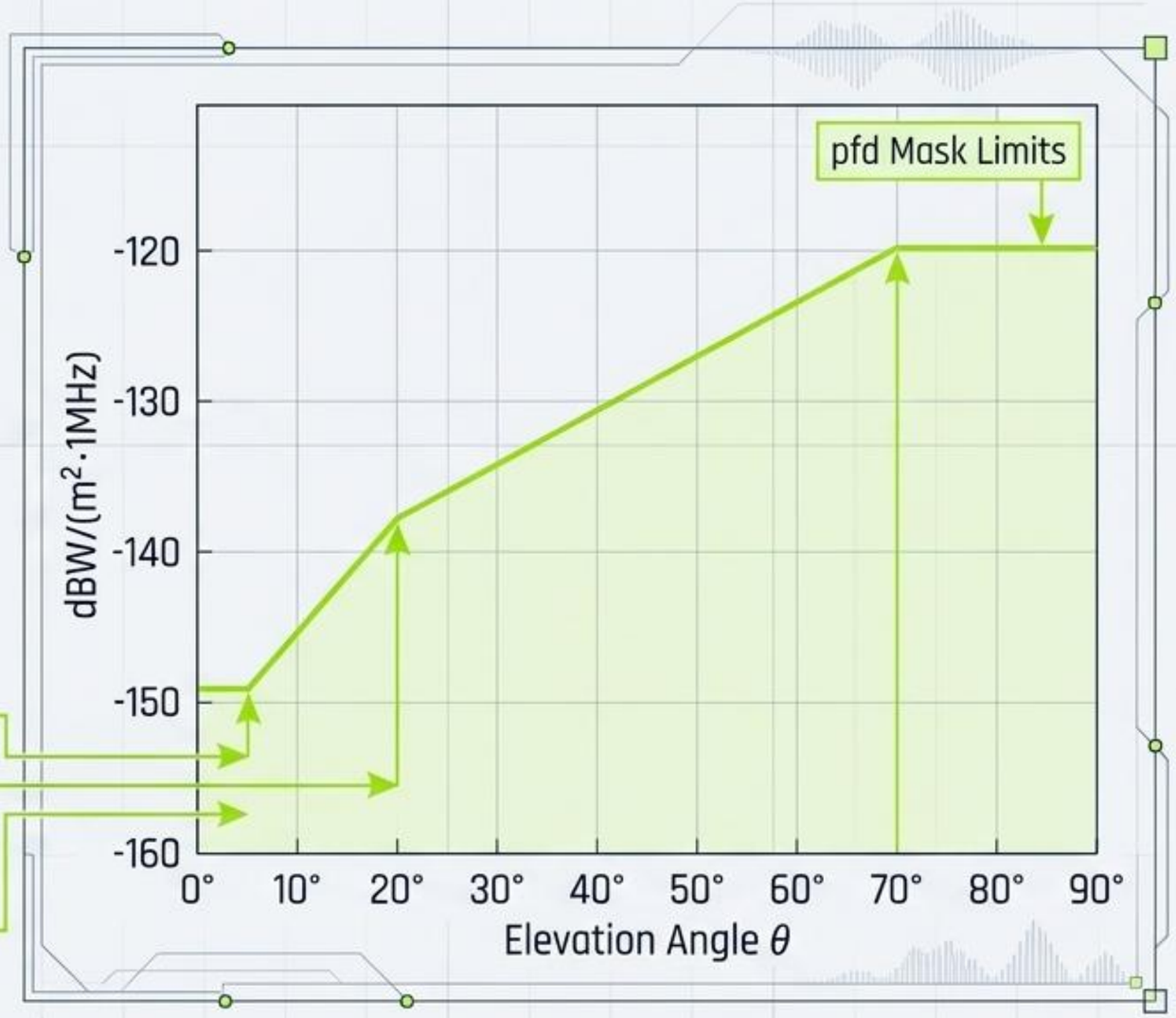
Direction: Space-to-Earth

The Incumbent Risk:

- Fixed service stations (at low elevations), IMT AAS rural/urban macro deployments, HIBS, and SAP/SAB ‘Mobile video link (down)’ scenarios.

The Proposed Mitigation (Method C Formula Limits):

- $0° \leq \theta \leq 5°$: -149 dBW/(m² · 1 MHz)
- $5° < \theta \leq 20°$: -149 + 1.35 · (θ - 5) dBW/...
- $20° < \theta \leq 70°$: -128.75 + 0.18 · (θ - 20) dBW/...
- $70° < \theta \leq 90°$: -119.75 dBW/(m² · 1 MHz)



2 010–2 025 MHz (Earth-to-Space): Airborne PMSE Exclusion Zones

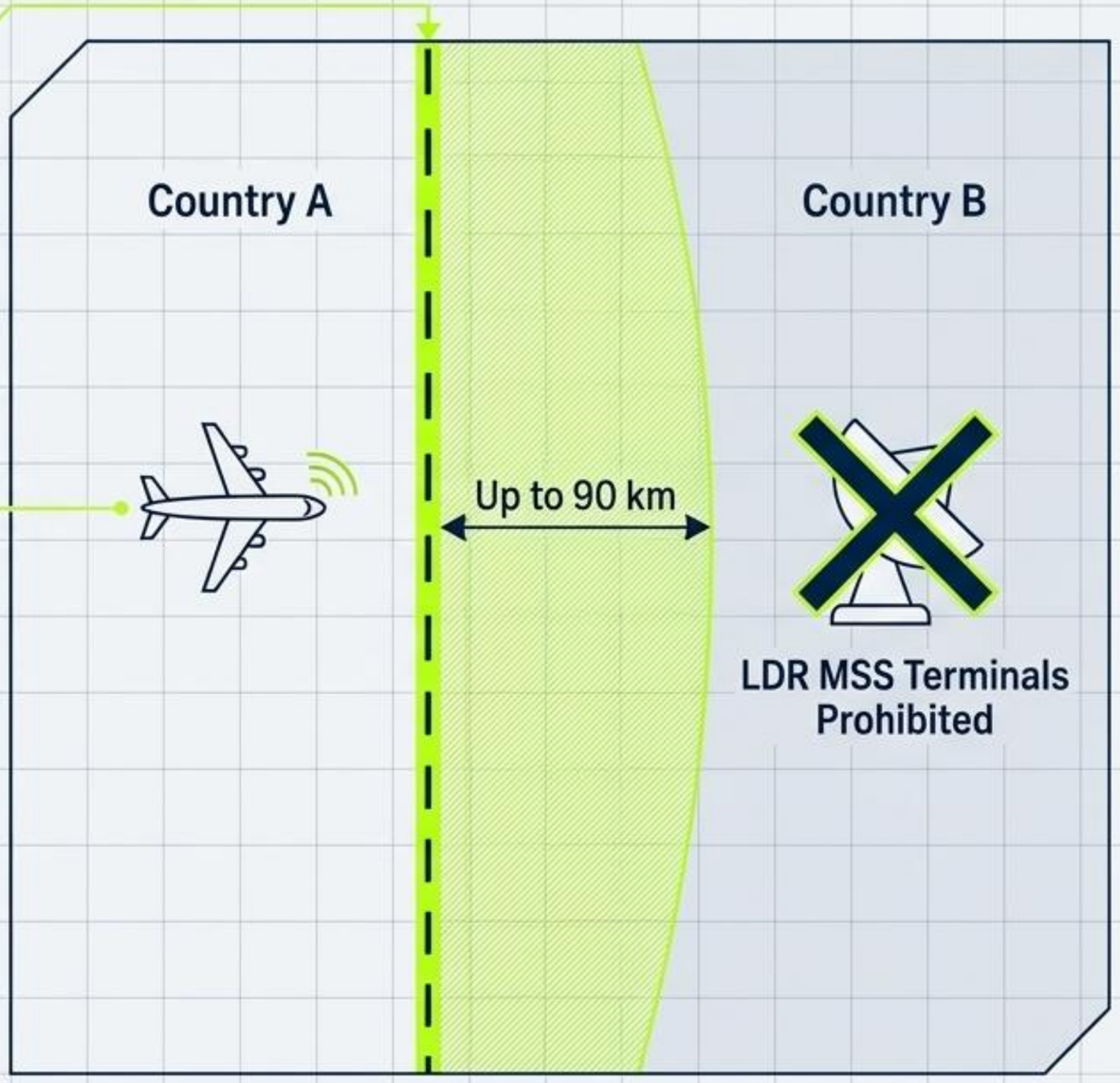
Direction: Earth-to-Space

The Incumbent Risk:

Programme Making and Special Events (PMSE) receivers operating onboard aircraft (SAP/SAB mobile video links).

The Compatibility Findings:

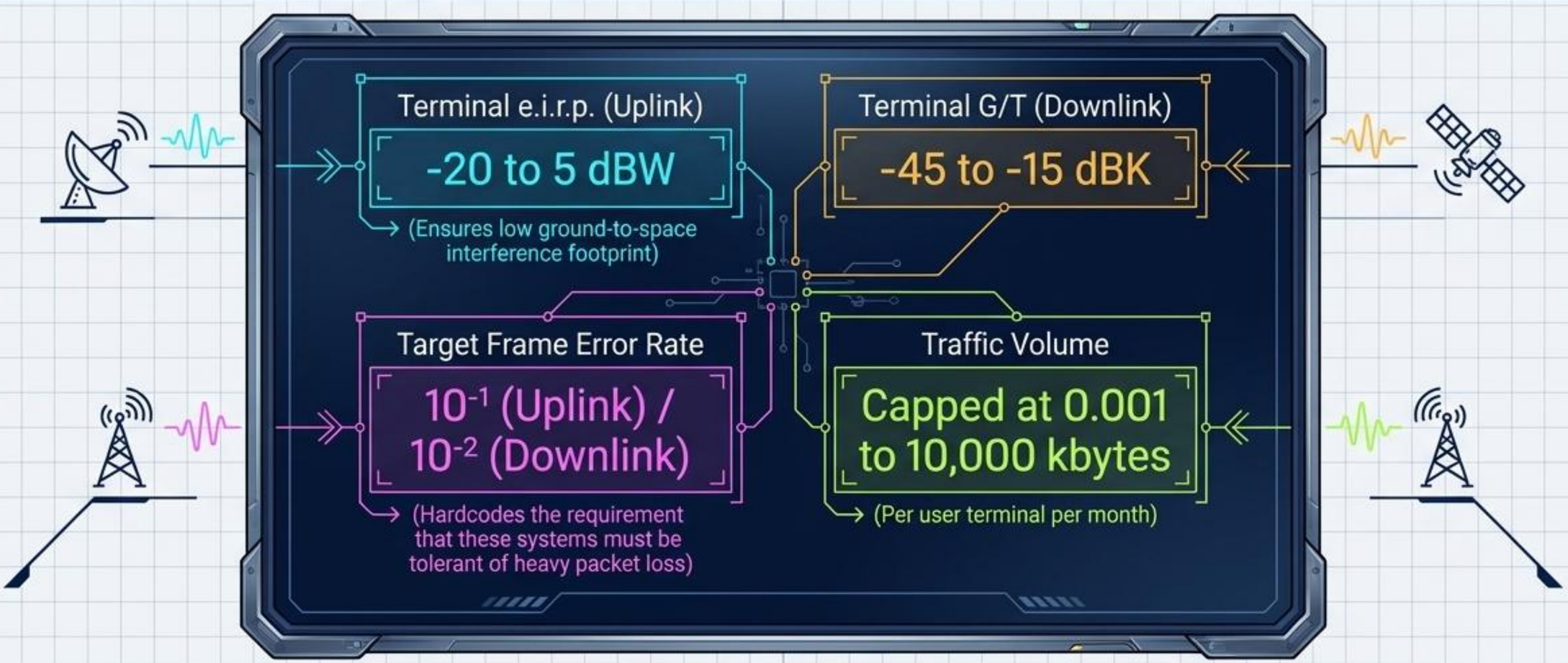
- An **LDR MSS user terminal** transmitting at a maximum e.i.r.p. of 1W requires massive line-of-sight separation to protect airborne PMSE receivers.
- **Required Separation:** 57 km to 88 km (at I/N = -10 dB) or up to 73 km based on geometric horizon limits.
- **Regulatory Mechanism (Methods B/C):** Requires explicit cross-border exclusion zones. LDR MSS terminals must be deactivated up to 90 km inside their own country's border to protect SAP/SAB operations in neighboring countries.



The Operational Framework: Draft Resolution [XXX] Parameters

Core Insight

Regardless of which band is selected, WRC-27 will strictly define what qualifies as an LDR MSS system to prevent regulatory abuse by high-power constellations.



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Strategic Dashboard: Frequency Band Viability Matrix

Frequency Band	Incumbents	Primary Risk	Key Mitigations	Viability
1.4 GHz (Cyan)	EESS (Passive)	Out-of-band emissions.	-60.2 dBW limit.	Viability: High (if limit met)
1.6 GHz (Amber)	GMDSS / Fleet Safety	Maritime distress systems.	None identified; I/N limits exceeded.	Viability: Critical Risk (Harmful interference likely)
1.8 GHz (Magenta)	Fixed, HIBS	380km HIBS line-of-sight.	Strict elevation pfd masks & large MCL separation.	Viability: Moderate
2.0 GHz (Lime)	IMT AAS, PMSE	Cross-border aircraft video links.	Complex Article 5 footnotes mandating up to 90km cross-border exclusion zones.	Viability: Moderate/Complex

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The Path to WRC-27: Achieving Regulatory Certainty

Current State
(Resolution 252)

WRC-27 Negotiation
(Choosing Methods)

Outcome
(New Allocation + Res [XXX])

The Objective

Suppress the exploratory Resolution 252 (WRC-23) and replace it with permanent regulatory architecture.

The Negotiation

Administrations must choose between preserving the status quo (Method A) or unlocking global IoT connectivity via precise, highly conditional allocations (Methods B/C).

The Bottom Line

Successful allocation below 5 GHz is technically feasible but requires aggressive technical concessions—specifically dynamic pfd masks, massive line-of-sight exclusion zones, and strict hardware e.i.r.p. limits—to ensure absolute protection of the incumbent radio landscape.

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Thank You!

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