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Emerging NGSO constellations: spectral coexistence with GSO satellite communication systems

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The rapid expansion of Non-Geostationary Satellite Orbit (NGSO) constellations is reshaping satellite communications, creating complex interference scenarios with Geostationary Satellite Orbit (GSO) systems due to shared spectrum usage. This article explores the challenges of NGSO–GSO spectral coexistence, focusing on recent regulatory developments, including the World Radiocommunication Conference (WRC-23), which upheld existing EPFD limits while launching technical studies on aggregate interference. We review state-of-the-art mitigation strategies, such as beamforming and power control, validated through simulations, and highlight the role of AI in enhancing interference detection and response. The paper concludes with a forward-looking research agenda centered on adaptive regulatory tools, probabilistic interference models, and data-driven coordination to support sustainable orbital spectrum sharing.

KEYWORDS
artificial intelligence, EPFD limits, GSO satellite systems, interference mitigation, NGSO constellations, regulatory frameworks, spectrum sharing

1 Introduction

The deployment of Low Earth Orbit (LEO) satellite constellations marks a paradigm shift in space-based communications, enabling global broadband access with reduced latency. These Non-Geostationary Satellite Orbit (NGSO) systems increasingly operate in frequency bands that are already occupied by Geostationary Satellite Orbit (GSO) systems, raising critical concerns regarding mutual interference and long-term spectrum sustainability (Bernhard et al., 2023). The rapid growth of NGSO mega-constellations amplifies the likelihood of aggregate and time-varying interference, potentially degrading the performance and reliability of incumbent satellite services. Consequently, managing NGSO–GSO spectral coexistence has become a pressing issue for regulators, industry stakeholders, and the research community (International Telecommunication Union, 2018).

GSO satellites have traditionally served as the backbone of space communications, offering stable regional coverage from fixed orbital positions. In contrast, NGSO systems operate at lower altitudes with highly dynamic trajectories, creating interference scenarios that are strongly geometry-dependent and time-varying. Recent studies have highlighted that such dynamics fundamentally challenge classical worst-case interference assumptions and motivate more refined modeling approaches that capture aggregate, probabilistic, and spatio-temporal effects (Ahmed and Grace, 2025; Lopez, 2025). These challenges are further compounded by spectrum congestion and sustainability concerns associated with dense orbital deployments (Ravishankar et al., 2021; Jalali et al., 2022).

The integration of NGSO networks within the existing regulatory and operational framework therefore requires coordinated global efforts. While legacy interference protection mechanisms have ensured decades of reliable GSO operation, their suitability in the presence of thousands of agile NGSO satellites is increasingly questioned in recent literature (Lopez, 2025). This tension has triggered renewed interest in advanced interference mitigation, dynamic spectrum sharing, and data-driven coordination strategies that go beyond static protection thresholds.

The International Telecommunication Union (ITU), through its World Radiocommunication Conferences (WRCs), plays a central role in addressing these challenges. WRC-23 reaffirmed the use of Equivalent Power Flux Density (EPFD) as the primary protection mechanism for GSO networks, while rejecting proposals to revise the longstanding EPFD thresholds. Instead, administrations agreed to initiate targeted studies on aggregate EPFD behavior from multiple NGSO systems, to be concluded within the WRC-27 study cycle (ITU-R 2023b). This regulatory outcome implicitly acknowledges the growing gap between static compliance metrics and the increasingly dynamic interference environments created by large-scale NGSO constellations.

Despite a rapidly expanding body of work on NGSO deployment, spectrum sharing, and interference mitigation, a clear gap remains between (i) regulatory protection mechanisms grounded in static or worst-case assumptions, and (ii) recent advances in probabilistic interference modeling, dynamic coordination, and AI-assisted monitoring. In particular, existing surveys often focus either on regulatory aspects or on isolated technical solutions, without systematically connecting recent WRC-23 outcomes to emerging data-driven coexistence frameworks (He et al., 2025).

This article aims to bridge this gap by providing an integrated and up-to-date perspective on NGSO–GSO spectral coexistence that jointly considers regulatory developments, interference mitigation techniques, and emerging AI-enabled monitoring approaches. Our contributions are 3-fold: (i) We contextualize recent WRC-23 regulatory decisions within the broader evolution of NGSO–GSO coexistence; (ii) we review and compare state-of-the-art interference mitigation and detection techniques, including contributions on aggregate interference analysis and dynamic spectrum sharing; and (iii) we articulate a forward-looking research agenda that connects probabilistic interference modeling, AI-assisted monitoring, and regulatory design toward sustainable long-term coexistence.

This integrated perspective is intended to support both researchers and policymakers in navigating the transition from static protection rules toward adaptive, performance-based coexistence mechanisms suitable for future high-density orbital environments.

2 Regulatory and interference challenges in NGSO and GSO coexistence

The growing demand for satellite communication services has necessitated a robust regulatory framework to manage spectrum and orbital resources. The ITU Radio Regulations serve as the backbone of this framework, enabling coordinated use of limited radio frequencies and orbital slots while addressing the interests of multiple stakeholders (Davies and Woodburn, 2021).

To prevent harmful interference, administrations submit applications to the ITU for GSO orbital slots and NGSO constellation parameters. These undergo technical scrutiny and are either approved or returned with feedback. The review and coordination process ensures spectrum efficiency, prevents warehousing, and mandates compliance with relevant articles of the Radio Regulations (Millwood, 2023).

Satellite systems operating within FSS bands must follow a multistep regulatory path: initial notification via Advanced Publication (API) or Coordination Request (CRC), inter-system coordination, notification and bring-into-use procedures, and final registration in the Master International Frequency Register (MIFR). NGSO operators may also be required to meet deployment milestones, depending on frequency band use. Further procedural details are provided in ITU-R workshop documentation (Henri and Maatas, 2024).

While GSO networks are prioritized only in specific portions of the FSS, their protection is maintained primarily through the EPFD mechanism. EPFD limits, defined in dB(W/m^2), restrict aggregate emissions from NGSO satellites received by GSO systems over defined time intervals. These limits are determined through simulation and validated via on-orbit measurements.

Operators must submit EPFD compliance models pre-launch, and these are verified post-deployment. EPFD enforcement is critical during both planning and operational phases, ensuring GSO systems remain free from harmful interference. However, it is essential to differentiate EPFD limits from broader coordination procedures, as both target different regulatory aspects and frequency segments.

2.1 WRC-23 outcomes and technical directions

At WRC-23, the long-debated proposal to revise the current EPFD limits for NGSO systems was ultimately rejected. Instead, administrations agreed to maintain the existing EPFD thresholds while mandating ITU-R Study Group 4 to conduct in-depth technical analyses on their continued adequacy in high-density orbital environments (ITU-R 2023b). The scope of these studies includes methodologies to assess aggregate EPFD contributions from multiple co-frequency NGSO systems and to characterize potential exceedances under realistic deployment conditions.

These studies form part of the WRC-27 preparatory cycle and are intended to inform the WRC-27 agenda, although no formal modification to the EPFD limits is expected before WRC-31. This outcome reflects the cautious approach taken by the regulatory community to balance protection of legacy GSO infrastructure with the rapid commercial expansion of NGSO operations.

In parallel, WRC-23 adopted a new allocation in the 17.3–17.7 GHz FSS downlink band for NGSO systems in ITU Region 2, contingent upon strict EPFD protections for coexisting GSO systems. This marked a significant regulatory step in operationalizing NGSO–GSO coexistence through spatial and power constraints, paving the way for similar sharing mechanisms in other bands.

2.2 Stakeholder perspectives on EPFD reform

Ongoing discussions around Article 22 of the Radio Regulations highlight diverging positions:

- Maintaining current EPFD limits: Advocates argue that existing thresholds preserve service continuity and provide certainty for long-term GSO planning.
- Re-evaluating EPFD limits: Proponents emphasize the need for regulatory flexibility to accommodate high-capacity NGSO systems with modern beamforming and power control capabilities.
- Improving aggregate EPFD modeling: A technical middle ground involves refining simulation models, introducing probabilistic thresholds, or integrating real-time interference metrics, as currently under study by ITU-R Working Party 4A (2024).

2.3 NGSO–GSO interference scenarios

Interference scenarios between GSO and NGSO systems arise from specific transmission paths:

- Downlink Interference: Occurs when NGSO satellites transmit toward Earth in directions overlapping GSO service areas, especially at low elevation angles relative to GSO earth stations.
- Uplink Interference: Arises when earth stations communicating with NGSO satellites inadvertently transmit toward GSO satellites. This depends heavily on antenna orientation and geographic placement.

Mitigating these risks demands coordination frameworks that reflect the dynamic orbital geometries and time-varying traffic patterns characteristic of NGSO constellations. As aggregate interference becomes a growing concern, future regulatory paradigms may need to integrate predictive and real-time interference metrics alongside traditional simulation-based coordination.

Having outlined the regulatory protection framework and the main NGSO–GSO interference paths, we now turn to the technical strategies that operators can deploy to remain compliant with EPFD limits while sustaining NGSO service performance.

3 Strategies for interference management

Ensuring coexistence between GSO and NGSO systems requires a portfolio of complementary strategies that combine satellite autonomy, ground-based coordination, and advanced signal processing. The effectiveness of these approaches depends not only on technical feasibility but also on their scalability as constellations expand.

3.1 On-board and on-ground management

Interference management can be implemented either directly on the satellite or through centralized ground operations. On-board solutions provide rapid responses to uplink interference events by adjusting antenna patterns or transmission parameters in real time. Their main advantage lies in autonomy, but their ability to mitigate external interference from other operators is limited.

Ground-based management, by contrast, leverages extensive computational resources and network-wide visibility. Operators can use predictive modeling and historical data to coordinate transmissions, negotiate spectrum use, and dynamically reallocate resources. Hybrid space–ground strategies are increasingly explored as a promising path forward, combining satellite-level responsiveness with centralized coordination across networks, in line with broader hybrid satellite–terrestrial network (HSTN) visions where cooperative and cognitive operation relies on dynamic interference management across layers (Asgharzadeh-Bonab et al., 2025).

3.2 Mitigation techniques

Several recent works have investigated NGSO–to–GSO interference mitigation in concrete deployment scenarios. Uplink and downlink coexistence studies in the Ku-band for Starlink and Telkom-3S, for example, assess how co-frequency interference can be kept within ITU Article 22 limits through a combination of EPFD compliance, separation angles, and avoidance zones around GSO beams (Susanto and Iskandar, 2024; Hidayati et al., 2024). Other contributions employ physics-based simulators to quantify the impact of NGSO constellations on GSO gateways under realistic propagation conditions, deriving long-term carrier-to-interference statistics that can guide the design of dynamic power control and beam-shaping policies (Polo et al., 2024). At larger scales, efficient spatial sampling methods such as Fibonacci-grid based models have been proposed to estimate aggregate downlink interference from dense NGSO constellations with tractable complexity, providing a basis for evaluating mitigation options at constellation level (Zhang et al., 2025).

In this sense, Figure 1 illustrates the principal strategies explored for NGSO–GSO coexistence (Jalali et al., 2023; Lee et al., 2024):

- Exclusion zones: Restrict NGSO transmissions near GSO beams, effective but service-disruptive.
- Dynamic power adjustment: Reduce NGSO transmission levels when approaching GSO service regions, balancing continuity and protection.
- Antenna orientation control: Adjust pointing angles to minimize interference at sensitive GSO receivers.
- Adaptive beamforming: Shape and steer beams away from GSO earth stations, offering the most precise but computationally demanding solution.

Each method entails trade-offs in terms of complexity, operational cost, and service impact.

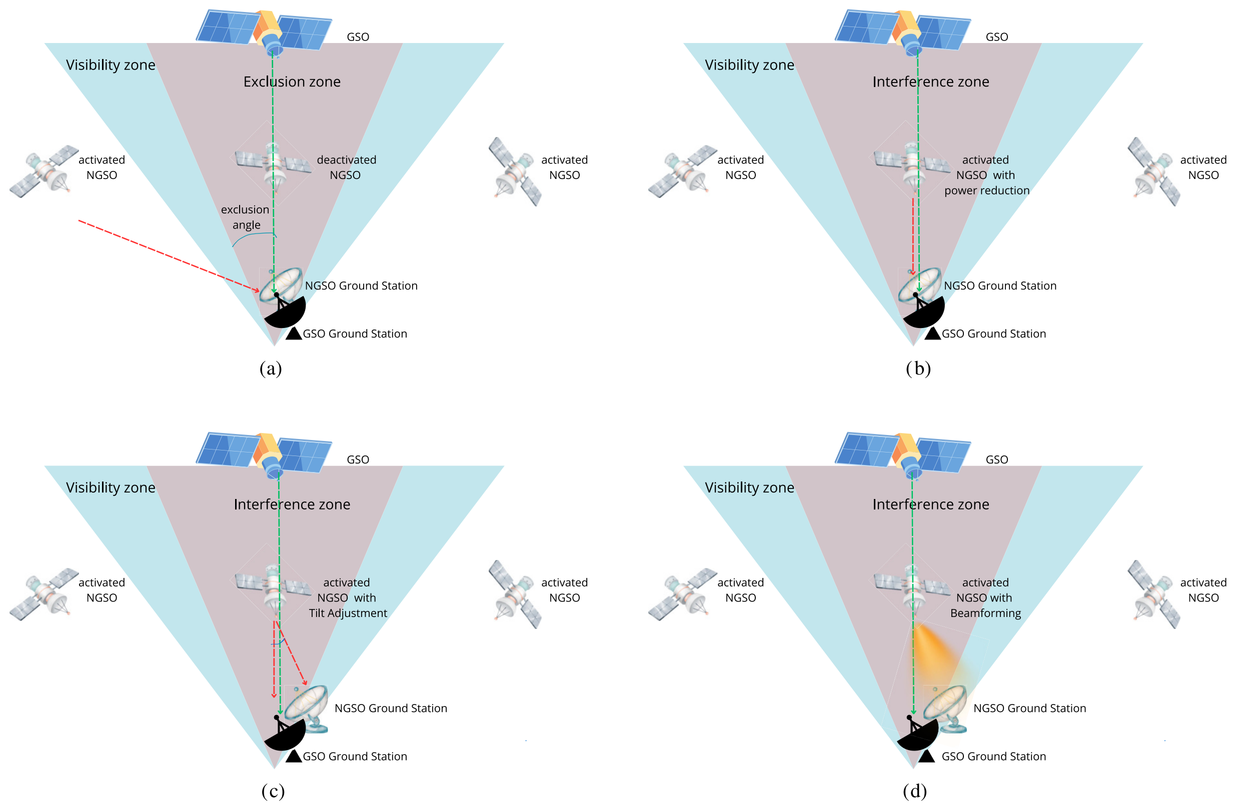

FIGURE 1
Representative techniques for interference mitigation in NGSO–GSO coexistence. All subfigures illustrate a common downlink interference scenario in which multiple NGSO satellites operate within the visibility region of a GSO earth station. The shaded areas indicate the NGSO visibility zone (light blue) and the interference-sensitive region around the GSO link (gray), where aggregate interference is evaluated at the GSO earth station. **(a)** Exclusion zones deactivate NGSO transmissions within a predefined angular separation from the GSO direction, ensuring strong protection at the expense of NGSO service availability. **(b)** Dynamic power adjustment maintains active NGSO transmissions while reducing transmit power inside the interference region, trading partial interference mitigation for improved coverage continuity. **(c)** Antenna orientation adjustment adapts NGSO pointing to steer energy away from the GSO earth station, reducing interference without fully disabling links. **(d)** Adaptive beamforming applies spatial beam shaping and null steering to minimize radiation toward the GSO receiver, offering the most flexible mitigation capability at the cost of higher computational and implementation complexity.

3.3 Evaluation metrics

The performance metrics discussed in this section are evaluated using a system-level, geometry-driven simulation framework intended to provide comparative and illustrative insights into NGSO–GSO coexistence rather than exhaustive performance optimization. The considered scenario models the downlink interference generated by a Walker-Star NGSO constellation toward a reference GSO earth station, capturing the time-varying orbital geometry, satellite visibility windows, and beam illumination dynamics. Interference mitigation actions (e.g., exclusion, power control, antenna orientation, or beamforming) are applied at the NGSO transmitter side based on idealized coordination rules. Propagation impairments, hardware non-idealities, and signaling delays are not explicitly modeled, allowing the analysis to focus on the relative impact of geometry-aware mitigation strategies on aggregate interference behavior. As a result, the simulations are well suited to highlight trade-offs between regulatory compliance and NGSO service continuity, while their limitations should be considered when extrapolating results to operational deployments.

A meaningful comparison of mitigation strategies requires robust performance indicators. Four key metrics have emerged as benchmarks:

1. Normalized Frequency of Achieving EPFD (NFA-EPFD): proportion of time compliance with regulatory thresholds is achieved.
2. NGSO Demand Satisfaction (NDS): ability of the strategy to maintain service quality for NGSO users.
3. Normalized Average Interference-to-Noise Ratio (NA-INR): overall degradation relative to background noise.
4. Mitigation accuracy: precision in reducing interference to agreed levels.

Figure 2 compares techniques under the above-described simulation framework, reflecting a Walker-Star NGSO constellation coexisting with a GSO system at 20° longitude. The results highlight the trade-offs between regulatory compliance and user satisfaction, underscoring the need for hybrid and adaptive strategies as system density increases.

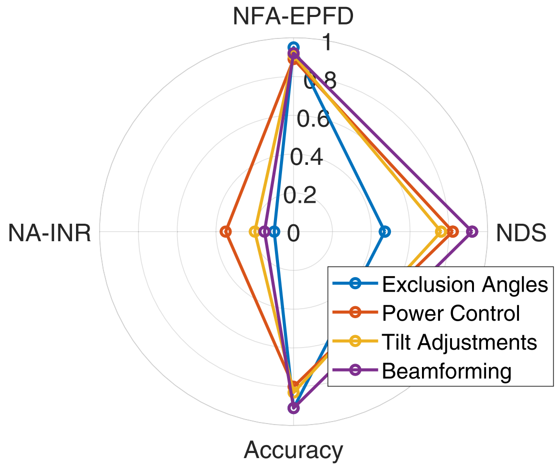

FIGURE 2
Comparative performance of interference mitigation strategies, showing trade-offs between compliance and user satisfaction.

This perspective suggests that future coexistence will rely less on a single mitigation method and more on dynamic combinations, integrating beamforming, power control, and exclusion principles within adaptive frameworks supported by real-time coordination.

While mitigation techniques can reduce interference, their effectiveness in dense NGSO deployments ultimately depends on timely detection and identification of unexpected or aggregate interference events. This motivates the monitoring and sensing approaches discussed next.

4 Interference detection and identification

Reliable coexistence between NGSO and GSO networks depends on the ability to rapidly detect, identify, and classify interference events. As orbital traffic increases, manual supervision becomes infeasible, demanding autonomous monitoring frameworks that can ensure compliance with ITU regulations and maintain service quality across dense spectral environments.

4.1 From regulatory verification to autonomous monitoring

Post-launch verification of EPFD compliance remains one of the most critical yet challenging regulatory tasks. Traditional verification methods rely on ground-based measurements and statistical evaluations, which often fail to capture transient or aggregate interference originating from multiple NGSO operators (Henri and Maatas, 2024). To maintain fairness and transparency in spectrum access, operators must now implement continuous monitoring pipelines capable of measuring emissions, identifying deviations, and reporting anomalies in near real time.

These evolving requirements are steering the industry toward data-driven monitoring systems that integrate telemetry, signal analytics, and AI-assisted interpretation. GEO operators, for instance, increasingly depend on dynamic sensing of interference levels to protect downlink performance, while NGSO networks employ distributed sensors across ground stations to evaluate their own emissions against regulatory limits.

4.2 AI-enabled interference detection

Traditionally, interference detection in satellite communications relies on rule-based or model-driven processing (e.g., energy detection, cyclostationary or statistical tests) that assume some *a priori* knowledge of the desired and interfering signals and often require online feature engineering by domain experts. These approaches are effective when interference types are known and limited, but their robustness degrades as the number, variability, and non-stationarity of interfering sources grow, which is characteristic of dense NGSO environments (Pellaco et al., 2019). In contrast, Machine Learning (ML)-based detectors learn signal/interference features offline from data and then operate online with lower decision latency, enabling a single model to generalize across multiple interference patterns and support automatic classification (Fontanesi et al., 2025). Qualitatively, this makes ML better suited to dynamic NGSO–GSO coexistence, where interference statistics change with orbital geometry, load, and beam scheduling.

Artificial intelligence is redefining interference management by enabling automatic differentiation between nominal and degraded operational states. Learning-based models can extract interference patterns from multi-dimensional telemetry, correlating variables such as power fluctuations, beam pointing vectors, and orbital dynamics. Among these, neural-network autoencoders have shown promise for unsupervised anomaly detection in satellite links, identifying subtle deviations that traditional energy detection or spectral analysis methods often fail to capture (Saifaldawla et al., 2023).

When evaluated in simulated orbital environments, ML models such as autoencoders and classification-based detectors consistently demonstrate higher accuracy, recall, and area-under-curve (AUC) scores (Fontanesi et al., 2025). These gains have been repeatedly observed in satellite spectrum sensing/interference use cases in the literature, particularly when interference is time-varying and multi-class, since ML models can adapt to complex feature distributions that are hard to capture with fixed thresholds (Fontanesi et al., 2025).

Recent simulation-based studies provide quantitative evidence of these advantages across a range of interference regimes. For quasi-stationary single-interferer scenarios, supervised ML classifiers typically achieve detection accuracies above 95% and AUC values exceeding 0.97, compared to 80%–88% accuracy for optimized energy or threshold-based detectors under equivalent signal-to-interference ratios (Fontanesi et al., 2025). In time-varying and multi-source interference conditions, which are more representative of dense NGSO deployments, the performance gap widens: autoencoder-based detectors report recall values in the range of 90%–95% at false-alarm rates below 5%, whereas classical detectors often require higher false-alarm rates to reach comparable recall levels (Saifaldawla et al., 2023; Fontanesi et al., 2025).

In the coexistence scenario considered in Section 3.3, interference at the GSO earth station is strongly *geometry-driven*: short visibility windows of multiple NGSO satellites, rapid changes in elevation/azimuth, and beam handovers create bursty aggregate interference. A conventional monitoring approach in this setting would typically rely on (i) *threshold-based INR/EPFD alarms* computed from received power or predicted EPFD time-series, and/or (ii) *energy/spectral detectors* operating on short integration windows (Pellaco et al., 2019). These methods are transparent and easy to calibrate, but in our simulated dynamics they would likely require conservative thresholds to avoid false alarms during benign geometry-driven fluctuations, which in turn delays detection of short-lived but harmful events and reduces sensitivity to multi-satellite aggregate effects.

By contrast, ML-based detectors retain stable performance across interference conditions with varying duration, intensity, and spatial diversity. In particular, autoencoders trained on nominal multi-dimensional telemetry (e.g., transmit power, beam pointing, serving-satellite ID, and predicted EPFD/INR trajectories) can identify anomalous aggregate interference with detection latencies reduced by tens of percent compared to sliding-window energy detectors, as reported in representative simulation studies (Fontanesi et al., 2025). Classification-based models further enable explicit discrimination between single-satellite, multi-satellite, and mis-coordination-induced interference events, which is not feasible with scalar thresholding approaches.

By learning the *normal* spatio-temporal variability induced by orbital motion, deviations caused by unexpected aggregate interference or mis-coordination appear as reconstruction or classification anomalies even when their instantaneous power is comparable to normal peaks. Thus, for a scenario like Figure 2, ML-based detection is expected to improve *early identification* of harmful interference excursions and to better separate nominal geometry effects from truly disruptive conditions, consistent with reported quantitative trends in the literature (Fontanesi et al., 2025; Ati et al., 2025).

4.3 Outlook

The transition from rule-based verification to intelligent monitoring systems represents a paradigm shift in spectrum management. Future coexistence frameworks will likely integrate AI-powered detection, federated data sharing among operators, and regulatory supervision through standardized reporting interfaces. These developments will not only enhance interference resilience but also promote transparency and accountability in the increasingly congested orbital spectrum.

These detection capabilities, together with evolving mitigation and compliance tools, highlight the need for a structured research roadmap toward scalable NGSO–GSO coexistence, which we detail in the next section.

5 Research agenda and open challenges

As the deployment of large-scale NGSO constellations accelerates, the limits of current regulatory and technical frameworks are increasingly tested. A new phase of coexistence management is emerging, one that shifts from static protection thresholds to predictive, adaptive, and data-driven coordination across GSO and NGSO systems.

To emphasize a coherent path forward, we frame the following open challenges as a coexistence roadmap composed of four coupled layers that build on each other. The first layer concerns probabilistic and aggregate interference modeling, which provides the technical basis to move beyond binary EPFD compliance. The second layer focuses on translating mitigation capabilities into regulatory instruments that can be enforced and audited. The third layer addresses the operational infrastructure needed for data-driven and near real-time coordination, without which performance-based rules cannot be supervised in practice. Finally, the fourth layer considers sustainability and long-term equity, ensuring that future coexistence mechanisms remain inclusive as orbital spectrum becomes more congested. The subsections below follow this layered logic and are discussed in an order that reflects their dependency and relevance across the WRC-27 and WRC-31 study cycles.

5.1 Toward probabilistic and dynamic coexistence models

The inherent dynamism of NGSO networks challenges the long-standing assumption that fixed EPFD limits are sufficient to guarantee protection for GSO systems. While WRC-23 retained current thresholds, it also initiated targeted ITU-R studies to explore aggregate EPFD behavior under real-world deployment densities (ITU-R 2023b; ITU-R Working Party 4A, 2024). These studies aim to characterize interference not as a binary violation of limits, but as a probabilistic function of spatial configuration, user demand, and orbital geometry.

The absence of formal EPFD reform on the WRC-27 agenda implies that the earliest opportunity for regulatory adjustment will occur no sooner than WRC-31. In the interim, the ITU-R is developing advanced methodologies for modeling co-frequency aggregate EPFD from multiple NGSO systems, particularly in densely populated orbital regimes and high-throughput frequency bands. This creates a fertile space for research into interference prediction, quantifiable risk thresholds, and cooperative management algorithms.

5.2 Bridging technical and regulatory design

An emerging challenge lies in bridging the growing sophistication of interference mitigation techniques, such as beamforming, dynamic power control (Susanto and Iskandar, 2024), and real-time nulling, with the relatively rigid architecture of international regulations. While national authorities such as the Federal Communications Commission (FCC) have initiated consultations on modernizing EPFD compliance metrics, international frameworks remain largely reactive.

Research is needed into how technical performance metrics, such as aggregate interference noise ratio (I/N), interference variability, and mitigation responsiveness, can be translated into enforceable regulatory indicators. This would allow regulators to adopt hybrid rules that combine baseline EPFD values with system-specific performance guarantees.

5.3 Data-driven coordination and infrastructure transparency

One major obstacle in current coordination is the lack of real-time operational visibility between systems. Coexistence depends not only on compliance simulations but on active data sharing between operators and regulators. AI-based tools offer the potential to analyze telemetry and interference patterns in near real-time, but require access to cross-system datasets and clear interfaces for standardized reporting.

Future research should focus on architectures for secure, multi-party coordination infrastructures where constellations share anonymized performance indicators, spatial occupation forecasts, or real-time EPFD metrics. This could be a foundation for cooperative spectrum use and compliance monitoring during congestion events.

5.4 Regulatory sustainability and long-term equity

Beyond technical feasibility, the growing asymmetry in constellation deployment capabilities between major and emerging space nations introduces long-term equity challenges. Without reform, spectrum access risks becoming concentrated among a few early movers. The expansion of EPFD-based allocations in bands such as 17.3–17.7 GHz in Region 2 (ITU-R, 2023a) suggests a model for future dynamic sharing, but also requires safeguards to avoid exclusionary effects.

Embedding fairness and long-term sustainability into EPFD coordination, through equitable access metrics, deployment caps, or spectrum reservation schemes, will be critical to ensuring that orbital resources remain viable and inclusive.

6 Outlook and recommendations

Over the next cycle leading to WRC-27, the satellite community faces the dual challenge of maintaining operational coexistence under legacy rules while shaping the evidence base for future regulatory architectures. The new FSS downlink allocation in the 17.3–17.7 GHz band under EPFD protection (ITU-R 2023a) exemplifies this transitional regime: enabling more flexible use while enforcing rigorous technical safeguards.

Technological advances, in particular, adaptive beamforming, autonomous power management, and AI-based interference detection, have outpaced regulatory mechanisms. Future frameworks must integrate these capabilities as native compliance mechanisms rather than external optimizations. Likewise, the shift toward probabilistic and time-aware interference modeling demands regulatory tools that go beyond binary thresholds.

The convergence of regulatory, technical, and computational domains opens new research and policy frontiers. Designing performance-based EPFD metrics, establishing real-time data-sharing architectures, and incorporating fairness constraints into coexistence frameworks will be essential. With no formal EPFD revision expected before WRC-31, the current interregnum offers a strategic window for cross-sectoral experimentation and coordination.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: N/A.

Author contributions

FO: Conceptualization, Investigation, Writing – review and editing, Writing – original draft. EL: Conceptualization, Writing – review and editing, Investigation. AS: Writing – review and editing, Investigation. MJ: Writing – review and editing. LE: Conceptualization, Writing – review and editing. SC: Writing – review and editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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