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Future Forum White Paper on Analysis of Global Progress on 6G and D2D Candidate Frequency Bands, and Perspectives on Study of China's Spectrum

ABSTRACT

This white paper provides an analysis of global progress and strategic trends in identifying candidate spectrum bands for 6G and Direct-to-Device (D2D) satellite connectivity and proposes our views on study of 6G and D2D spectrum for China

Future Forum Spectrum WG

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Executive Summary

This white paper provides an analysis of global progress and strategic trends in identifying candidate spectrum bands for 6G and Direct-to-Device (D2D) satellite connectivity. The primary goal is to inform and shape a forward-looking spectrum policy, with views on the critical discussions at the upcoming World Radiocommunication Conference 2027 (WRC-27).

The transition to 6G and the rise of AI-native applications are driving an unprecedented demand for high-capacity, low-latency connectivity. Spectrum is the foundational resource to meet this demand. WRC-27 is identified as a pivotal global forum for securing harmonized spectrum for 6G and establishing a clear regulatory framework for D2D services, which use mobile spectrum to provide satellite connectivity to standard smartphones.

There is a clear, converging global strategy focusing on mid-band spectrum to balance capacity and coverage for initial 6G deployments around 2030.

- :
    - 6425–7125 MHz (Upper 6 GHz): Already identified for IMT at WRC-23, current work focuses on implementation
    - 7.125–8.4 GHz (7 GHz band): Study under WRC-27 Agenda Item (AI) 1.7.
- Technology Driver: 3GPP standardization is defining a maximum channel bandwidth of 400 MHz in the downlink for bands around 7 GHz, technically necessitating the large, contiguous blocks of spectrum.

The development of D2D spectrum policy is evolving rapidly, marked by a strategic shift and regulatory diversity.

- Divergent Regulatory Approaches: A patchwork of national frameworks exists. The U.S. (FCC), UK (Ofcom), and Japan have established pioneer regimes allowing D2D in IMT bands under RR Article 4.4. The European Union is taking a more cautious, coordinated approach via a detailed EC Mandate to CEPT, aiming to develop a harmonized framework that absolutely protects terrestrial IMT networks from interference.
- Strategic Shift to MSS Spectrum: Industry operators are increasingly pursuing dedicated MSS spectrum (e.g., 2 GHz MSS in Europe) for stability, moving beyond initial reliance on IMT band access under Article 4.4 .
- Long Term solution is seen to harmonize under WRC-27 AI 1.13

The white paper concludes that from an industry perspective:

- For 6G: For 6G's high-bandwidth requirements. Early planning and international coordination are essential for timely deployment.
- For D2D: The protection of terrestrial IMT networks from harmful interference is the non-negotiable principle. A national regulatory framework should be established where spectrum authorization for D2D-IMT is granted under Mobile Network Operator (MNO) licenses, with MNOs partnering with and maintaining control over Satellite Network Operators (SNOs). Regulatory measures must be technically verifiable and aligned with ITU-R processes.

Success at WRC-27 is critical for establishing a harmonized global foundation for 6G in the 2030s and a sustainable regulatory model for D2D. The converging focus on 6G spectrum demand and the structured efforts to enable D2D while protecting terrestrial networks represent the definitive global spectrum development trends that will shape the next decade of mobile and satellite connectivity.

1 China 5G-A development

As of early 2026, China's 5G-Advanced (5G-A) development has experienced its tremendous development in the 2nd years since its commercial launch in 2024. China has built the world's largest 5G-A network, with coverage extending beyond major cities to key industrial zones and other vertical markets. 5G-A commercial networks have been deployed in over 300 cities across China, including all provincial capitals and major economic hubs. The total number of 5G BS exceeds 4.8 million, supporting features like 3CC Carrier Aggregation or RedCap, over 30 million 5G-A package subscribers as of 2025. Users experience enhanced services like naked-eye 3D, XR cloud gaming, and "speed boost packages" for stadiums and high-speed railway. 5G-A supports Industrial Digitalization, deep integration into manufacturing, ports, and mining to support real-time machine control and AI quality inspection. In logistics area, supporting drone delivery routes secured by 5G-A networks has been developed in Shenzhen and Hangzhou. In Smart Grids applications, it is widely deployed for Ultra-reliable low-latency communication (URLLC) in power distribution automation. Industry ecosystem has been formed gradually. In summary, China is currently in the "5G-A Golden Year" (2025-2027), rapidly scaling the technology to serve as the foundational network for the digital and intelligent transformation of its economy, while simultaneously laying the groundwork for 6G research.

2 Global Mobile Development Trends

Based on the Ericsson Mobility Report from November 2025, global mobile network data traffic is characterized by stable and significant growth, primarily driven by the transition to 5G and changing user behaviors. Total mobile data traffic (excluding Fixed Wireless Access) is projected to increase by a factor of approximately 2.2 by 2031. Traffic from smartphones is expected to grow at a Compound Annual Growth Rate (CAGR) of 14 percent, reaching 304 EB per month by 2031. Mobile PC, tablet, and mobile router traffic is also expected to rise significantly, with CAGR projections between 11 and 13 percent. Monthly data traffic per smartphone is forecast to nearly double, rising from 21 GB in 2025 to 39 GB by 2031. The Key Drivers of Traffic Growth are coming from:

- Video Dominance: Video content remains the primary driver of traffic. By the end of 2025, video is expected to account for 76 percent of all mobile data traffic.
- The Rise of Uplink Traffic: The convergence of AI, cloud, and mobile technologies is expected to fundamentally shift traffic patterns, specifically driving significant growth in uplink demands over the next decade.
- New Technologies: The emergence of 6G (standardization of which has already begun) and AI-native networks will enable new use cases like autonomous mobility and massive digital twinning, further contributing to future traffic surges.

Recent global AI development is bringing mobile industry transition as well. While 5G enabled unlimited data and high-definition video, the mission of 6G is to be the wireless technology for the Age of AI as well. The shift to an Agent-Centric ecosystem is happening, AI as a traffic driver, Apps based ecosystem moving from smartphone centric to an agent centric where AI agents to observe, interpret, and act across all devices and the agents require real-time context and generate massive amounts of data at the "edge,". As AI expands from centralized clouds to distributed, real-time inference, the demand for high-performance connectivity will surge. We are entering a new era of hyperconnectivity, where everything that can go wireless will go wireless and that strongly depends on robust mobile network from 5G-A and future 6G.

6G will use wide channels to efficiently support the mobile data demand and accelerate as AI applications. 6G will operates with wider channel sizes than the previous generation. Successful 6G deployments will use contiguous channel bandwidths up to 400 MHz/200MHz wide. ITU-R has defined the requirements and 3GPP would define the maximum channel bandwidth of 400MHz for single operator network.

3 Spectrum is the key to make sure mobile network to support AI applications

A strong increasing demand for mobile network requires right amount of spectrum resources utilization to meet the growing demand of connectivity to ensure low band in rural area and mid-band in urban capacity, high-band spectrum for hot spots. It is significant importance for forward planning for the upcoming WRC-27 to unlock the potential of effective spectrum regulation to support mobile connectivity expansion and to build global consensus on IMT spectrum identification for great economy of scale and technological development. There are 2 critical topics for the coming WRC-27, one is global harmonized 6G spectrum and the other one is DC-MSS-IMT[1] for direct to device (D2D) satellite connectivity that use terrestrial mobile spectrum as long as they don't interfere with terrestrial networks.

4 Background of Future Forum Spectrum White Paper

This Future Forum white paper will focus on analyze the global research on candidate 6G spectrum and D2D (Direct to Device of Satellite Connection) spectrum and regulatory frameworks and will provide a Future Forum views and suggestions on these 2 critical topics. The Chapter 5 will address the global status of study on candidate bands of 6G and Chapter 6 will focus on D2D frequency bands global development status. Chapter 7 will give a Future Forum analysis of the trends on spectrum development from global perspectives and Chapter 8 will suggest a Future Forum view and recommendations in these 2 key areas.

5 Global status of study on candidate bands of 6G

5.1 Europe

Spectrum plays a pivotal role in Europe's mobile development and economy, as timely, harmonized, and investment-certain spectrum policies are fundamental to building future-proof connectivity ecosystems. The work from Europe is from EU level and CEPT level.

5.1.1 RSPG

The RSPG is a high-level advisory group established to feed EU decision-making around spectrum policies, with primary role to act as the "strategic architect" for European spectrum policy. 6G is one of their key focal areas. They completed their first

deliverable on 6G i.e the RSPG Report on 6G Strategic vision, in February 2025, outlines the European Union's policy framework for the development and deployment of 6G, targeting a launch around 2030. The report identifies potential frequency bands for 6G in Europe, emphasizing the need for a coordinated 6G spectrum roadmap and highlights critical strategic areas including the integration of terrestrial and non-terrestrial networks, and the growing necessity spectrum sharing solutions with the incumbent services.

RSPG now focus on the development of a 6G spectrum roadmap for the EU. They have issued a draft Opinion on a 6G Spectrum Roadmap for public consultation in Feb, 2026. The deadline of comments will be 27 March 2026. The roadmap targets to facilitate the launch of 6G on a large scale in Europe, the goal is to create a common ecosystem and market for network and terminal equipment in Europe so that the benefits of 6G services are available to all European citizens in a timely manner, driving industrial and societal transformation and economic growth in Europe from 2030 and beyond. This timeline should also be supported by EU spectrum policy to enable the initial launch of 6G networks and services across the EU.

In the current draft, the RSPG reiterates its opinion that 6G can be implemented in all the frequency bands currently used for mobile phone systems. It proposes that the upper 6GHz band would be the primary band suitable for the introduction of 6G in Europe by 2030, subject to market demand. The RSPG called on equipment manufacturers to develop equipment supporting 6G technology within these bands. The RSPG also encourages mobile network operators to plan the migration of their networks to 6G in line with their market strategies, consumer demands and the availability of relevant equipment.

The opinion of the RSPG on the strategic spectrum roadmap towards 6G identifies the frequency band(s) includes:

- Already Harmonized Bands for ECS (WBB)
  - Low Bands (<1 GHz): 700 MHz, 800 MHz, 900 MHz for nationwide and indoor 6G coverage.
  - Mid Bands: 1500 MHz, 1800 MHz, 2 GHz, 2.6 GHz, 3.6 GHz to support and supplement high - capacity 6G network roll - out in suburban and urban areas.
  - High Bands: 26 GHz, 42 GHz for very high - capacity hot spot 6G coverage.
- Upper 6 GHz Band: Considered the primary band for 6G introduction in Europe by 2030. It can enable 6G use cases requiring more capacity than 5G. The frequency range depends on WRC - 27 outcome but consists of at least 540 MHz of continuous spectrum, helping meet mobile industry and operators' mid - band spectrum demands and consistent with a 2030 6G launch.

- Other Bands
  - 7125 - 7250 MHz Band: Under study at WRC - 27 in Region 1 for possible IMT identification, which could provide additional 6G spectrum.
  - 3.8 - 4.2 GHz Band: Harmonized and suitable for developing low/medium power local area networks using 6G technology to support vertical markets. Other national - level frequency bands for local networks are also noted.
  - 470 - 694 MHz Band: Allocated to the mobile (except aeronautical mobile) service on a secondary basis in almost all EU countries and could enhance 6G coverage and low - band capacity.
  - Very High Frequency Bands (including sub - THz): Currently under research and long - term study at the international level and could facilitate Integrated Sensing and Communications applications.

Mobile equipment manufacturers should develop 6G - supporting network and terminal equipment within already harmonized frequency bands. And mobile network operators should plan network migration to 6G in line with market strategies, needs, and equipment availability.

Spectrum sharing solutions are essential due to rising spectrum demand, and the RSPG encourages research and development of sharing mechanisms. The RSPG encourages research and development of sustainable 6G technologies addressing environmental requirements and integrating them into the standardization process.

6G should build on the coordinated evolution and interoperability of terrestrial and non - terrestrial networks (NTN). NTN implementation in terrestrial spectrum should be pursued based on relevant studies and potential Commission decisions.

The RSPG reflects on the importance of seamless interoperability between mobile and fixed broadband networks with WAS/RLAN wireless access.

The RSPG and CEPT will assess scenarios for flexible use of the 470 - 694 MHz band and provide guidance on repurposing spectrum for alternative mobile service uses. WRC - 31 intends to study possible regulatory actions for the 614 - 694 MHz band.

A final decision on the EU's recommended use of the band would have to come from the European Commission, and then be implemented by national governments in the EU member states. Aside from upper 6 GHz, 6G could eventually be implemented in all frequencies currently harmonized by the EU for use in telecoms and internet services, including low bands in the 700 MHz, 800 MHz and 900 MHz range, mid bands including 1,500 MHz, 1,800 MHz, 2 GHz, 2.6 GHz and 3.6 GHz for suburban and urban rollouts, and mmWave bands 26 and 42 GHz for densified capacity builds. The draft position aims to align with the RSPG's broader 6G strategic vision paper from February 2025,

also integrating earlier findings on EU-level policies in the 470-694 MHz band and satellite direct-to-device technology.

5.1.2 CEPT/ECC level of work:

5.1.2.1 CEPT 6G Roadmap

6G work in CEPT ECC level includes CEPT 6G Roadmap and other relevant reports e.g. U6GHz.

CEPT 6G Roadmap outlines the strategic plan and core tasks for 6G development and spectrum harmonization within the CEPT region. It aims to establish harmonized technical conditions for 6G spectrum in 2027/2028 time frame.

Key tasks consists:

- Harmonization of Bands for 6G in CEPT
- WRC-23 Follow-up (focus on upper 6GHz bands 6425-7125MHz)
- WRC-27 Preparation (CEPT positions for two key WRC-27 Ais, AI 1.7 and AI 1.13
- Other spectrum challenges
- Numbering Aspects

Harmonization of Bands for 6G in CEPT involves considering and deciding on frequency bands (both existing and potentially new) for 6G, including those for the initial launch. It includes reviewing and updating existing ECC Decisions for relevant MFCN (Mobile/Fixed Communications Networks) bands to ensure suitability for 6G, and developing new harmonization measures for potential new bands.

WRC-23 Follow-up (Focus on Upper 6 GHz band: 6425-7125 MHz). This is a major component, centered on implementing the WRC-23 identification of the 6425-7125 MHz band for IMT in Europe, noting its potential shared use with Wireless Access Systems (WAS)/RLANs. The tasks are structured in response to a European Commission (EC) Mandate and include:

- Assessment of coexistence/compatibility with incumbent services (Task 1).
- Feasibility and sharing studies on the potential shared use between MFCN and WAS/RLANs in this band, and determining preferred scenarios (Task 2).
- Developing a harmonized framework for the band (Task 3).

WRC-27 Preparation work is to prepares CEPT positions for two key World Radiocommunication Conference 2027 (WRC-27) Agenda Items of AI 1.7 and AI 1.13

Other Spectrum Challenges include considering supplementary solutions like satellite/Non-Terrestrial Networks (NTN) and Device-to-Device (D2D) to provide

geographical coverage, investigating new spectrum sharing opportunities enabled by 6G technologies and supporting administrations with tools for implementing harmonization, including band reorganization and cross-border coordination etc.

Numbering Aspects involves monitoring relevant 6G standards and their potential impact on numbering resources.

5.1.2.2 U6GHz Development Status

EU Level Work on U6GHz:

RSPG issued its opinion for Upper 6GHz Long Term Vision on Nov 12th, 2025. Having considered the responses to the public consultation and the preferences expressed by Member states,

- The RSPG agree a prioritized use of the band 6585-7125 MHz for IMT.
- For the 6425-6585 MHz the RSPG has agreed to use this as a guard band (together with a BEM applicable to IMT in the 6585-7125 MHz) to protect WAS/RLAN in the lower 6 GHz band (5945-6425 MHz) until the WRC-27 which may identify the additional band 7125-7250 MHz for IMT. Member States will not release the band neither for IMT nor for WAS/RLAN
- Following the WRC-27, RSPG intends to decide on the exact use of the 160 MHz (6425-6585 MHz).
    - If WRC-27 identifies the 7125–7250 MHz band for IMT and no significant new developments or insights suggest otherwise, there is a strong case for designating the 6425–6585 MHz band for primary WAS/RLAN use.
    - If WRC27 does not identify the 7125–7250 MHz band for IMT and no significant new developments or insights suggest otherwise, there is a strong case for designating the 6425–6585 MHz band for primary MFCN use.

EC issued its mandates to CEPT to perform technical work in December of 2024 to study feasibility of and develop least restrictive harmonized technical conditions for the potential shared use of 6425-7125MHz frequency bands.

The EC Mandate of Potential Shared Ues of the U6GHz band is under ECC PT1 in 3 tasks and timeline of task is like the following:

- Task 1: Coexistence with incumbent—July, 2026
- Task 2: Shared use IMT vs WiFi —Oct, 2026
- Task 3: technical conditions —July, 2027

CEPT Report A covering Task 1 – studying the coexistence of IMT/RLAN with Incumbents in the U6GHz band to response to the Task 1of the EC Mandate. The draft was completed for public consultation in January 2026 and approval.

CEPT Report B covering Task 2 – Feasibility of Shared Use IMT/RLAN to respond to the Task 2 of EC Mandate. ECC Report 366 has been developed and a CG was established to continue the work.

CEPT Report C covering the Task 3 – Harmonized Technical Conditions for IMT to response to the Task 3 of the EC Mandate. A draft work item was prepared, reflecting concerns raised. The draft work item will be submitted to ECC for further consideration.

5.1.2.3 WRC-27 AI 1.7 :

CEPT preliminary position for WRC-27 AI 1.7 has been developed in the draft CEPT brief document. The drafting work is still ongoing. Europe Common Proposal is not finalized yet. However, according to their current Preliminary Position for WRC-27 AI 1.7, it shows that they could support 7125-7250MHz for IMT identification.

They oppose 4400-4800MHz for IMT identification, (mainly use by AMS and MMS) that in case deployment scenarios and parameters of IMT have not changed with respect to WRC-15, WRC-19 and WRC-23 studies. Adjacent band of altimeter is also their concern.

They opposed 7250-8400MHz since the range is heavily used by critical military, satellite, and existing fixed services in Europe, making it challenging to clear for mobile.

They opposed the 14.8-15.35 GHz IMT identification due to un-feasible AMS coexistence.

5.2 U.S

5.2.1 Legislative and Regulatory Context

In July 2025, the United States enacted the *One Big Beautiful Bill Act (OBBBA)*, establishing a renewed statutory framework for commercial spectrum policy with a strong emphasis on mid-band spectrum availability for IMT and future 6G systems. A central element of the Act is the restoration of the Federal Communications Commission's (FCC) spectrum auction authority, which had lapsed in 2023 and is now reinstated through September 30th, 2034. This legislative certainty enables long-term planning for spectrum identification, reallocation, and licensing.

While restoring auction authority, the Act also defines explicit exclusions reflecting national security and federal mission requirements. In particular, the 3.1–3.45 GHz band

remains reserved for radar operations, and the 7.4–8.4 GHz range is protected for critical federal functions. These exclusions materially constrain the candidate pool for commercial mid-band IMT spectrum and elevate the importance of adjacent bands.

5.2.2 Spectrum Supply Pipeline Objectives

The OBBBA mandates the identification of at least 800 MHz of spectrum below 10.5 GHz for commercial use, implemented through a dual-track spectrum supply pipeline.

First, a federal spectrum reallocation mechanism requires the NTIA, in coordination with the FCC, to identify and transition at least 500 MHz of federal spectrum within the 1.3–10.5 GHz range, excluding protected bands. This process is staged, with a minimum of 200 MHz to be identified by July 2027 and auctioned by July 2029, followed by the remaining spectrum to be identified by July 2029 and auctioned by July 2033. The Act allows flexibility in the resulting usage model, including exclusive licensing, shared access, or hybrid arrangements.

Second, the FCC is directed to conduct supplementary auctions totaling at least 300 MHz before 2034. Within this category, the Act imposes a mandatory requirement to auction no less than 100 MHz of spectrum in the Upper C Band (3.98–4.2 GHz) by July 2027, effectively anchoring near-term mid-band IMT expansion.

5.2.3 Upper C Band (3.98–4.2 GHz): Primary Near-Term IMT Candidate

The Upper C Band has emerged as the most immediate and consequential mid-band opportunity under the new framework. In November 2025, the FCC initiated a Notice of Proposed Rulemaking (NPRM) seeking comment on opening up to 180 MHz of this band for mobile services, exceeding the statutory minimum of 100 MHz.

Industry stakeholders, including 5G Americas and CTIA, have broadly supported aggressive reallocation, with some advocating release of up to 220 MHz to maintain international competitiveness. In contrast, opposition has been raised by broadcasting and satellite stakeholders, as well as the aviation sector, due to concerns regarding radio altimeter interference and the cost and feasibility of mitigation.

A key constraint identified in inter-agency discussions is the dependency on aviation equipment upgrades. NTIA assessments suggest that approximately 150 MHz may be practically achievable only if new radio altimeters are deployed, potentially affecting more than 10,000 aircraft. As a result, there is a non-trivial risk that although the spectrum may be auctioned by the statutory 2027 deadline, large-scale commercial mobile deployment could lag due to relocation, certification, and mitigation timelines.

5.2.4 Emerging Federal Mid-Band Candidates Beyond C Band

Beyond the Upper C Band, the OBBBA and subsequent presidential memoranda highlight several additional mid-band ranges of strategic interest for IMT evolution and 6G.

The 4.4–4.9 GHz band has been identified by industry as a potential 6G “cornerstone” band, offering favorable propagation characteristics and wide contiguous bandwidth. Importantly, the Department of Justice, a major federal incumbent in this range, has indicated increased flexibility regarding spectrum clearance, reducing a previously significant institutional barrier. A presidential memorandum directs NTIA to initiate immediate feasibility studies for reallocating portions of both the 2.69–2.9 GHz and 4.4–4.94 GHz bands for full-power licensed commercial use.

Similarly, the 7.125–7.4 GHz band has been targeted through a December 2025 presidential memorandum. NTIA is instructed to conduct relocation studies for federal systems operating in this range, including potential migration to the adjacent 7.4–8.4 GHz band, and to report estimated transition costs and timelines within twelve months. While certain fixed satellite telemetry and radio astronomy sites are explicitly excluded, the memorandum concurrently directs NTIA to begin designation of 7.125–7.4 GHz for full-power commercial licensing, positioning it as a longer-term IMT candidate.

5.2.5 Institutional Roles and Resourcing

The implementation of the spectrum pipeline relies on a clear division of institutional responsibilities. NTIA leads technical feasibility analyses, including assessments of net economic benefit, relocation cost, and sharing constraints. The FCC is responsible for auction design, service rules, and commercial authorization, while the President retains oversight to balance economic growth objectives with national security considerations. Coordination with federal stakeholders, notably the Department of Defense, Department of Justice, and NOAA, is explicitly required to preserve essential missions.

To support this process, the Act allocates USD 50 million in fiscal year 2034 to NTIA to fund detailed studies of candidate bands, including 2.7–2.9 GHz, 4.4–4.9 GHz, and 7.25–7.4 GHz.

5.2.6 Implications for IMT and 6G Planning

Collectively, these developments represent a significant shift toward long-term spectrum certainty in the United States. The Upper C Band is positioned as the primary near-term expansion band for IMT, while the 4.4–4.9 GHz and 7.125–7.4 GHz ranges are emerging as critical candidates for 6G-era deployments. However, aggressive statutory timelines, complex federal relocation requirements, aviation coexistence challenges,

and high mitigation costs introduce substantial execution risk. Outcomes from ongoing NTIA studies and FCC rulemakings, as well as alignment with global processes such as WRC-27, will be decisive in determining the ultimate contribution of these bands to future IMT ecosystems.

Frequency Range	Status	MNOs
2.69–2.9 GHz	Reallocation study ongoing	
3.1–3.45 GHz	Study ongoing; excluded from auction	
3.45–3.55 GHz	Auction completed (Jan 2022)	AT&T, Verizon, T-Mobile, Dish
3.55–3.7 GHz	CBRS (shared access)	Verizon, AT&T, Cable Providers, enterprises
3.7–3.98 GHz	Auction completed (Feb 2021)	Verizon, AT&T, T-Mobile, US Cellular
3.98–4.16 GHz	FCC NPRM (Nov 2025)	
4.4–4.94 GHz	Federal band, study ongoing	
7.125–7.4 GHz	Federal reallocation study ongoing	

5.3 Japan

5.3.1 MIC Beyond 5G Proposition Strategy 2.0

MIC (The Ministry of Internal Affairs and Communications) published the “Strategy for Realizing Next-Generation Information and Communication Infrastructure to Support AI Society - Beyond 5G Promotion Strategy 2.0 -” on June, 18th, 2024 since the MIC published the “Beyond 5G Promotion Strategy - Roadmap to 6G” in June 2020 to realize Beyond 5G, the next-generation information and communication infrastructure.

The evolution from Japan’s original Beyond 5G Promotion Strategy (1.0) to the Strategy 2.0 reflects a transition from foundational research and development to a focus on social implementation, economic security, and AI integration. While the 1.0 strategy, established in 2020, was primarily concerned with defining the 6G vision and securing initial R&D seeds—such as a target for 10% of global essential patents—Strategy 2.0 (2024) shifts into an "acceleration phase." Key evolution points include a move toward

an AI-native society, where the network is designed to handle the massive computing demands of distributed AI agents, and a heightened emphasis on Non-Terrestrial Networks (NTN), incorporating HAPS and satellites for 100% geographic coverage. Furthermore, Strategy 2.0 prioritizes Economic Security and global market share, aiming for Japanese infrastructure to capture 30% of the global market by promoting Open RAN and resilient, energy-efficient "Green AI" networks.

5.3.2 MIC/ Radio Regulatory Council Frequency Reorganization Action Plan (FY2025 Version)

The Ministry of Internal Affairs and Communications (MIC) of Japan manages the country's radio wave resources through an annual Frequency Reorganization Action Plan. This plan is a core component of a PDCA (Plan-Do-Check-Action) cycle designed to ensure the effective utilization of the spectrum as demand for new technologies like 5G and 6G grows. The plan was first formulated and announced in August 2004 to address increasing frequency demand and the introduction of new radio utilization systems. It has been updated and published annually. Its primary goal is to ensure transparency and predictability for businesses and carriers, facilitating a smooth transition and reorganization of frequencies. Starting in FY2023, the responsibility for evaluating the effective use of the radio spectrum transitioned from the MIC to the Radio Regulatory Council, with intention of consultation from outside experts and the report will be sent back to MIC for final publishing.

Based on the Frequency Reorganization Action Plan (FY2025 Version), the primary goal is to secure a total of 73.1 GHz of bandwidth by 2040 to accommodate the explosive growth of digital infrastructure, including 6G.

The MIC's broader spectrum initiatives focus on enhancing digital infrastructure and ensuring social resilience including:

- Expansion of 5G and Wireless LAN: The MIC is implementing "value-based competition" for the allocation of the 26 GHz and 40 GHz bands for 5G. It also continues to extend frequencies for wireless LANs to meet diverse consumer needs.
- Non-Terrestrial Networks (NTN): To ensure connectivity everywhere—including at sea and in the air—the MIC is advancing the use of HAPS (High-Altitude Platform Stations) and satellite direct communications, particularly in the 2 GHz and 700 MHz bands.
- Spectrum Reorganization and Migration: The ministry is actively migrating underutilized systems, such as analog MCA wireless, to free up space for new services like 3D positioning systems and broadband low-power wireless in the 800/900 MHz bands.

- Public Service Efficiency: The MIC evaluates the effective use of frequencies by government agencies every year, pushing for the digitalization of analog disaster prevention radio systems to reduce costs and improve performance.
- Strategic Planning for 6G Spectrum: The MIC's 6G efforts are guided by the "Beyond 5G Promotion Strategy 2.0" and focus on three key technical areas: Next-generation Mobile (6G), All-Photonics Networks (APN), and Non-Terrestrial Networks (NTN).
    - Targeting Candidate Bands: Japan is accelerating studies to identify IMT frequencies for 6G, specifically focusing on the bands to be discussed at the WRC-27 (World Radiocommunication Conference 2027):
        - 4.4–4.8 GHz (Sub-6 range).
        - 7.125–8.4 GHz (Centimeter-wave "Golden Band").
        - 14.8–15.35 GHz.
    - Millimeter Wave and High-Frequency Utilization: The MIC aims to secure 36.2 GHz of bandwidth in the high bands (above 30 GHz) for mobile networks by 2040. This includes promoting the use of the terahertz bands (above 100 GHz) for ultra-high-capacity applications like AR/VR and sensing.
- Advanced Network Technologies: Research and development are underway for vRAN-based network control and flexible network construction technologies to support the dense, high-capacity deployments required for 6G.
- Cybersecurity and Resilience: The MIC is prioritizing the development of post-quantum cryptography (PQC) and symmetric key cryptography specifically for implementation within 6G wireless systems.

5.4 India

India is actively preparing for the next generation of telecom innovation. Even as 5G continues to roll out nationwide, the government has already accelerated research investments, policy frameworks, and industry collaborations to develop 6G technology.

5.4.1 The Bharat 6G Vision Statement

The Government of India's Department of Telecommunications published "The *Bharat 6G Vision Statement*" in March 2023, outlines a strategic roadmap to position India as a global leader in the development and deployment of 6G wireless technology.

The Bharat 6G Mission is divided into two phases:

- Phase 1 (2023-2025): Ideation, explorative research, and proof-of-concept tests.

- Phase 2 (2025-2030): Conceptualizing and delivering commercial-ready technology solutions for India and the world.

India government will establish a robust funding mechanism, including a corpus of ₹10,000 crore over 10 years, to support high-risk research by industry, startups, and academia. The government also will implement shared use of spectrum, particularly in higher frequency bands, and rationalise congested bands to support Industry 4.0 and actively participate in and contribute to global standards forums (like 3GPP and ITU) to ensure Indian innovations are incorporated into global products. They aim for a flexible, integrated optical and wireless network reaching every household by the end of the decade.

5.4.2 India Spectrum Roadmap for 6G services

Government of India Ministry of Communications Department of Telecommunications release its Spectrum Roadmap for 6G services on Dec, 30, 2025, providing a strategic and forward-looking plan for making the right spectrum available to enable IMT-2030 (6G) services in India.

It plans for IMT-2030 services across three phases (2025–2035) to make India a global 6G hub. Key focus areas include securing the upper 6 GHz band (6425–7125 MHz), utilizing 37–40 GHz for high capacity, and aligning with WRC-27/WRC-31 for global 6G harmonization. India is making spectrum available in the upper 6 GHz band for IMT. The 4.5 GHz and 7 GHz bands are also being considered following WRC-27 along with 67 MHz in the 1500 MHz band.

Spectrum Roadmap Phases (2025-2035)

- Short Term (2025–2026): 400 MHz in 6425-6725 MHz and 7025-7125 MHz and 3000 MHz in 37-40 GHz.
- Medium Term (2027–2030): 367 MHz, including 300 MHz in 6725-7025 MHz and 67 MHz in 1427-1518 MHz, and 1000 MHz in 42.5-43.5 GHz. WRC-27 studies: 4400-4800 MHz, 7125-8400 MHz, and 14.8-15.35 GHz.
- Long Term (2031–2035): 66-71 GHz Band for mobile telecommunication services. Sub-Terahertz Bands: 102-109.5 GHz to 252-275 GHz, studied under WRC-31.

6 GHz Band: Identified as a crucial mid-band resource for both 5G-Advanced and 6G. And they also try to align with WRC to ensure harmonization with ITU-R studies for 6G global standards. They will also support the indigenous research and development of 6G testbeds and manufacturing under the PIB Bharat 6G Vision.

India’s 6G spectrum roadmap is guided by sound spectrum policies, including making all spectrum technology-neutral and allowing practices such as sharing and leasing to enhance spectrum efficiency. These policies can enable India to efficiently release additional spectrum within existing frequency bands where opportunities exist.

5.5 GCC

The GCC region, led by administrations such as the Communications, Space and Technology Commission (CST) of Saudi Arabia and the Communications Regulatory Authority (CRA) of Qatar, is positioning itself as a global leader in the transition toward AI-enabled network architectures. Their spectrum strategies are closely linked to national digital transformation programs, such as Saudi Vision 2030.

- Early Exploration of Upper 6 GHz for IMT Evolution: GCC regulators have shown significant early interest in the upper 6 GHz band (6.425–7.125 GHz) as a potential candidate for future IMT evolution beyond 5G-A. This band is recognized for its ability to provide a critical balance between wide-area coverage and high capacity.
- Exploratory Studies on Sub-THz and Millimeter-Wave: Regulators are beginning preliminary research into millimeter-wave and sub-THz bands (above 40 GHz). These are being studied as potential candidate bands for future 6G high-capacity communications, integrated sensing, and advanced backhaul solutions.

5.6 Africa

African administrations, coordinated primarily through the African Telecommunications Union (ATU), emphasize a spectrum policy that bridges the digital divide while fostering industrial growth through global standards.

- Prioritizing Mid-Band for Balanced Growth: African nations are actively studying mid-band spectrum ranges (including portions around 4.4–4.8 GHz and 7–8.5 GHz) as potential candidates for future IMT systems. These bands are viewed as the most effective ranges for balancing coverage and capacity across the continent’s vast geographic areas.
- The "Low-Band" Requirement: To ensure rural inclusivity, African nations are advocating for the continued use and optimization of bands **below 1 GHz** (such as the 470–694 MHz range) for 6G. This is essential for providing foundational "AI-Lite" services to agricultural and remote sectors..
- Emphasis on WRC-27 Global Harmonization: The African Group places a high priority on international spectrum harmonization, particularly regarding studies under Agenda Item 1.7 of WRC-27. Harmonization is seen as the primary driver for achieving economies of scale, which will reduce the cost of 6G devices and infrastructure for African consumers.

5.7 3GPP Status

In 5G, the maximum channel bandwidth is100MHz for sub-6GHzbased on 4K FFT. For 6G design, companies have consensus to increase the maximum channel bandwidth for sub-6GHz based on larger FFT size to increase the schedule efficiency, positioning accuracy and other performance.

3GPP started discussion on how to address the support of larger channel bandwidth since Oct 2025 (i.e. RAN1#122bis and RAN4#116bis). RAN1 #122bis (Oct. 2025) approved 400MHz (network side) as maximum channel bandwidth (at the network side) and 30KHz SCS for physical layer design for sub-6Ghz. Extensive discussion continued in multiple RAN4 meetings on how to balance the implementation complexity and address the support of larger channel bandwidth in sub-6GHz for both UL and DL.

RAN#111 (Mar. 2026) approved a WF on Maximum CBW of both DL and UL for ~7GHz, with the following agreements captured.

- In a BS with a CBW of 400MHz, support UEs operating with Maximum CBW of 400MHz in DL(i.e., non-CA single CC) and Maximum CBW of 200MHz in UL, as detailed in the following slides.
- For DL
    - Specification of CBW of 400MHz in DL operation is to be addressed in RAN WGs for one RF and two RF chains implementations aiming at a common air interface description (based on the already identified options in RAN1), covering:
    - Single DCI/PDSCH from UE perspective
    - A single scheduled PDSCH that spans the entire CBW shall be supported with applicable restrictions on resource configuration mapping (e.g. to avoid SSB, PRG/REG spanning across any applicable boundary of RF chains) and UE measurements
    - Design details, if any, to be further studied in RAN WGs.
    - The support of the DL 400MHz operation is optional and subject to UE capability
    - Specifications will support other CBW values in DL between 200MHz and 400MHz as needed based on operator’s spectrum needs
    - CBW definition is referring to the existing definition of 5G NR for CBW equal or less than 200MHz. The UE CBW definition for >200MHz in the DL

will be revised as necessary with the assumption of one RF and two RF chains implementations.

- For UL
    - The data transmission (e.g., frequency alignment, UL switching possibility) and sounding transmission in UL max CBW of 200MHz is to be addressed via further discussions at WGs.
    - Sounding in the UL of all parts of the DL bandwidth over time is to be supported

6 Global status of study on candidate bands for D2D

6.1 Europe

6.1.1 ECC Report 373

A work item was created in June 2023 in CEPT under FM44 (Satellite Communication) WG on Satellite based Direct-to-Device (D2D) communications for smartphones, aiming to study the regulatory and technical elements with respect to national authorization of satellite based D2D in CEPT. It has been finalized after public consultation in Feb 2026 in ECC Report 373. This report investigates the regulatory and technical frameworks required for the national authorization of satellite-based Direct-to-Device (D2D) communications using unmodified, off-the-shelf smartphones.

The study report covers 2 distinct spectrum approaches:

- D2D-MSS: Utilizing spectrum already allocated to the Mobile-Satellite Service (e.g., L-band and S-band).
- D2D-IMT: Utilizing spectrum allocated to the Mobile Service (IMT bands), typically used by terrestrial mobile network operators (MNOs).

The objective of the study is to provide regulators with clarity on national authorization regime, licensing, technical interference, and cross-border coordination to prevent harmful interference between systems. The main content include the description of system, spectrum analysis, regulatory consideration, operational issues. The key conclusions are:

- The existing MSS framework is ready to accommodate compliant D2D-MSS without regulatory changes;
- D2D-IMT requires further regulatory development at both national and European levels, including potential adjustments to licensing conditions and harmonised measures;

- Studies are needed on coexistence of D2D-IMT with IMT and adjacent band services, as well as on cross-border coordination mechanisms;
- Preparations towards ITU-R World Radiocommunication Conference 2027 (WRC-27) Agenda Item 1.13 will be central to addressing long-term regulatory solutions for D2D-IMT.

It proposes CEPT administrations will need to exchange information, study technical compatibility, and develop harmonised ECC approaches to ensure that D2D-IMT services can evolve while protecting existing users of spectrum.

6.1.2 RSPG Opinion of the EU-level policy approach to satellite Direct-to-Device connectivity and related Single Market issues

The Radio Spectrum Policy Group (RSPG) issued its opinion on June 17, 2025 to provide a strategic framework for the EU-level approach to satellite Direct-to-Device (D2D) connectivity and related Single Market issues. It addresses the technical harmonization, national authorization, and European market access issues related to satellite D2D connectivity. It specifically identifies and defines 4 types of D2D services based on their spectrum access frameworks:

- D2D-IMT: Services using bands harmonized for terrestrial mobile services (ECS).
- D2D-MES: Services to mobile earth stations in satellite-specific bands.
- D2D-IoT SRD: Services to IoT devices in short-range device (SRD) bands.
- D2D-IoT MSS: Services to IoT devices in Mobile Satellite Service bands below 1 GHz

Note: The 2 GHz MSS band and international issues under the scope of WRC-27 are excluded from this specific Opinion's core technical scope.

The key conclusions are:

- Given the current EU and CEPT harmonization, national licensing in most Member States only covers mobile terrestrial use. The technical harmonization decisions in relevant ECS bands all support development of mobile terrestrial use, so are the underlying CEPT deliverables. Thus, the introduction of D2D-IMT is currently generally not possible in ECS licenses in EU Member States.
- Within EU, contrary to other parts of the world, there are no “landing rights” for satellites (i.e. space segment authorizations) to offer services on the EU market. In that light, the RSPG has identified a need for a safeguarding mechanism on the basis of national authorizations to enable Member States to react collectively in the benefit of EU interests.
- Possible establishment of common requirements on electronic communications satellites services, as basis of possible safeguarding mechanism(s) to enable Member States to react collectively in case of non-compliance, has been discussed e.g. Compliance of satellite networks with the ITU-R RR including of coordination and notification (ITU Master International Frequency Register

(MIFR) entry) procedures respecting ITU status/dates of protection and carried out in good faith etc

Key Recommendations:

- For D2D-IMT Services
  - Technical Mandate: The European Commission (EC) should mandate the CEPT to develop harmonised technical conditions for D2D-IMT in ECS bands.
  - Regulatory Updates: The EC should consider amending existing ECS harmonisation decisions to allow D2D-IMT while protecting terrestrial networks.
- For IoT and MES Services
  - Registry/Licensing: Member States should consider national licensing regimes or registries to better identify satellite operators in specific bands.
  - Receiver Standards: Recommend improving receiver blocking in L-band MES terminals to reduce interference with mobile downlink services.

6.1.3 EC Mandate to study feasibility of and develop of least restrictive harmonized technical conditions for the use of EU-harmonized frequency bands for terrestrial wireless systems providing electronic communication service by satellite system providing direct to device IMT connectivity

European Commission officially issued a mandate to the CEPT on October 27, 2025. The objective is to develop least restrictive harmonized technical conditions for satellite systems providing D2D-IMT services to off-the-shelf terminal stations (such as smartphones). These satellite services are intended to complement existing terrestrial coverage, particularly in rural, remote, and maritime areas.

The mandate covers a wide range of bands currently harmonized for terrestrial Electronic Communications Services (ECS):

- Sub-1 GHz: 700 MHz, 800 MHz, and 900 MHz.
- Mid-Bands: 1.5 GHz, 1800 MHz, paired terrestrial 2 GHz, and 2.6 GHz.
- High-Capacity/mmWave Bands: 3.6 GHz, 26 GHz, and 42 GHz

Mandated Tasks: The CEPT is required to complete 3 specific tasks to ensure these services do not interfere with existing terrestrial networks:

- Task 1: Feasibility and Compatibility Studies: ensure the protection of existing TN and incumbent services in those bands and adjacent bands. And Identify which specific bands from the list are technically feasible for D2D-IMT deployment. (Draft Report A available in June, 2026, Final in Nov, 2026)
- Task 2: Development of Technical Conditions: Study the technical and operational conditions required to protect terrestrial services without overly constraining them. And Develop the harmonized technical conditions to be implemented into the EU regulatory framework and ensure these

conditions facilitate cross-border frequency coordination. (Draft Report B is available in March, 2027, final in July, 2027)
- Task 3: Post-WRC-27 Review: if necessary, revise the results of Tasks 1 and 2 based on the outcomes of the WRC-27. (Draft Report C available in July, 2028 and final in Nov, 2028)

6.1.4 CEPT Work on D2D-IMT

CEPT has officially started its technical work on the D2D-IMT mandate as of November 2025. The work is currently in the active study phase, with several specialized groups collaborating to meet the July 2026 deadline for the first major deliverable.

The work is being split between 2 main technical bodies:

- WG FM (Frequency Management) / Working Group FM44: Acting as the lead group for drafting the final CEPT Reports for the Commission. Established a skeleton for CEPT Report B (Report on harmonised technical and operational conditions for D2D-IMT in EU). They are coordinating the "regulatory model" for D2D-IMT, which is expected to include a requirement for satellite networks to be registered in an "ECC list" before starting service.
- WG SE (Spectrum Engineering) / Working Group SE40: Leading the technical compatibility and sharing studies (Work Item SE40_49). 2 CGs established for studying protection of terrestrial component of IMT (led by AST) and protection of other incumbent services (led by France).
- ECC PT1: providing specific technical parameters for terrestrial mobile networks (characteristic and deployments, protection criteria, etc.), as well as PFD limits for protection of terrestrial IMT. Based on the mandate's timeline, currently the main focus is on Report A. The groups are currently studying the sub-3 GHz bands (which overlap with WRC-27 preparations) and investigating the challenges and feasibility of D2D-IMT in TDD bands and in the higher bands (3.6 GHz, 26 GHz, and 42 GHz). The result of studies on feasibility of the bands for D2D-IMT is expected to be ready for WG FM's review by May 2026 to meet the July 2026 public consultation target. CEPT Report B Initial discussions have started on "Least Restrictive Technical Conditions" (LRTC), but detailed work will ramp up once the feasibility studies in Report A are more stable.

Key Technical Challenges Under Discussion

- Multi-system aggregate impact: CEPT is debating how to account for multiple satellite constellations operating co-frequency in neighboring countries. They are considering that the "aggregate PFD limits" for protection of IMT might need to be partitioned among multiple systems to ensure that the total interference from all satellite systems doesn't exceed the threshold for terrestrial networks.
- Cross-Border Coordination: There is significant work on how to protect an MNO mobile network in Country A from a satellite service operating co-frequency authorized in neighboring Country B,.

- Adjacent band/channel protection within the country: There is significant work on how to protect the MNO mobile network A from a satellite service operating in adjacent channel/band in the same country.
- Protection of IMT base stations:
- Feasibility of D2D-IMT in TDD bands:
- Compliance verification methodology:
- 6G Evolution: The studies are specifically tasked with ensuring that D2D-IMT does not block the future deployment of 6G terrestrial technologies in these same bands.

6.1.5 WRC-27 AI 1.13

In the CEPT, the work on WRC-27 Agenda Item 1.13 is distributed between 2 main groups:

- Overall Responsibility: CPG-PTC, is responsible for drafting the CEPT Brief and the European Common Position (ECP)
- Technical Support: ECC PT1, performs the sharing and compatibility studies, specifically focusing on the protection of the terrestrial component of IMT. Their technical results are fed back to CPG PTC to be included in ECP.

While they involve different groups, they are highly coordinated to ensure that the European technical rules developed for the EC Mandate are consistent with the positions Europe takes at the global negotiations for WRC-27.

Current CEPT preliminary view is that:

- CEPT is considering possible new MSS allocations for direct connectivity between space stations and IMT UEs to complement the terrestrial IMT network coverage and supports the development of an international regulatory framework that enables such usage in agreed IMT identified bands, in the frequency range 694-2700 MHz, with frequency arrangements in accordance with Recommendation ITU-R M.1036, while ensuring the protection of existing services both in band and in the adjacent bands.
- CEPT is further of the view that terrestrial IMT operations shall be protected both within the countries as well as in cross-border situations, including in the territorial waters. The protection of stations on fixed installations in Exclusive Economic Zones (EEZ) or onboard ships in international waters (Mobile Communication Services onboard Vessels (MCV)) also need to be addressed.
- CEPT is of the view that the frequency band 2300-2400 MHz is not an option for complementary DC-MSS-IMT usage since Recommendation ITU-R M.1036 only considers TDD in this band and aeronautical mobile telemetry systems (AMT) are particularly sensitive to interference from satellites. It is also noted that PMSE is used in this band in CEPT.

6.1.6 D2D Market Development Landscape

Europe has formed two major camps:

- The Starlink-Deutsche Telekom Alliance: Adopts a vertically integrated model, providing coverage extension through a unified global satellite network.
- The SCE (Satellite Connect Europe) Open Platform: Formed by Vodafone, Orange, Telefonica, and AST SpaceMobile, emphasizing European control and multi-operator access.

Technological Capability Limitations:

According to GSMA's analysis at MWC26, D2D technology faces clear performance ceilings:

- Even with a deployment of 42,000 satellites and access to the entire IMT spectrum, D2D could only provide basic 2 Mbps service to about 12% of the global population.
- Service at 20 Mbps would cover less than 2% of the population.
- The main technical constraints are signal loss from space and limited spectrum reuse (with satellite spot beams spanning 25-50 km compared to terrestrial cell ranges of hundreds of meters).

6.1.7 Evolution of Spectrum Usage Trends

Strategic Shift from IMT to MSS

The spectrum strategy of the satellite industry has undergone significant changes:

- Initial Phase: Primarily utilized terrestrial IMT (International Mobile Telecommunications) spectrum bands to enable D2D. This was permitted under Article 4.4 of the ITU Radio Regulations (allowing operation on a non-interference, no-protection basis) in countries like the US, Canada, Australia, New Zealand, Japan, and Tanzania.
- Current Trend: A shift towards competing for scarce Mobile Satellite Service (MSS) spectrum bands:
    - The EU 2 GHz MSS band: Considered a potential "golden band" for D2D in Europe, attracting competition from multiple operators.
    - The US market: AST SpaceMobile acquired L-band MSS spectrum rights from the bankrupt Ligado Networks; Starlink applied for access to the 2 GHz band.
    - Technical Considerations: MSS bands are seen as more suitable for D2D services, but they typically require specialized hardware upgrades in devices.

6.1.8 Current Status of Regulatory Framework Development from administrations

Regulatory Progress in Various Countries

The UK Leads Western Europe:

- Ofcom's D2D regulatory framework, which took effect in February 2026, is a pioneering initiative.
- VMO2 was the first to modify its license to enable Starlink's satellite D2D service.
- The framework covers the 700MHz, 800MHz, 900MHz, 1400MHz, 1800MHz, 2.1GHz, and 2.6GHz frequency bands.
- It employs Power Flux Density (PFD) limits to prevent cross-border interference.

EU Coordination Process:

- A unified D2D regulatory framework has not yet been established.
- The RSPG (Radio Spectrum Policy Group) has recommended that the European Commission develop technical conditions for D2D in mobile bands.
- Luxembourg has become the headquarters for the Vodafone-AST joint venture, but a supporting legal framework is lacking.

Developments in other countries:

- Ukraine: Kyivstar, in partnership with Starlink, began offering services in 2025 using the 1725-1730/1820-1825 MHz bands.
- France: ARCEP (Autorité de Régulation des Communications Électroniques et des Postes) launched a consultation process at the end of 2025.
- Germany: BNetzA (Bundesnetzagentur) is developing a framework but has not yet initiated a public consultation.

Technical Standards Development

3GPP Standardization

- AST Space Mobile’s L-band and S-band profiles have been incorporated into 3GPP industry standards.
- This supports the extension of D2D services over existing “high-quality low-frequency bands” that are already supported by billions of devices.
- However, challenges related to device compatibility and the complexity of manual updates still need to be resolved.

6.1.9 Development trends and challenges

Leading D2D operators are widely adopting a dual-track strategy:

- AST SpaceMobile: Shifting from sole reliance on IMT spectrum to acquiring MSS spectrum.
- Starlink: Acquired MSS spectrum assets through its $17 billion acquisition of EchoStar.
- Lynk Global: Embraced a “multi-spectrum satellite technology platform” following its merger with Omnispace.

Driving factors include regulatory barriers (most countries do not allow MNOs to share spectrum with satellite operators), technical complexity, and market access considerations.

Short-Term Expectations (2026–2027)

- Authorizations for the EU’s 2 GHz MSS band are set to expire in 2027, triggering a new allocation process.
- Commercial D2D services in the UK are expected to launch in early 2026.

Medium- to Long-Term Trends (2027–2030)

- WRC-27 will be a critical milestone for global D2D regulation.
- The integration between satellite D2D and terrestrial networks will deepen.

Success Factors：

- Spectrum Access: The strategic importance of MSS bands is becoming increasingly prominent.
- Regulatory Harmonization: Balancing transnational unified frameworks with local requirements.
- Technical Standardization: Continuous improvement of device compatibility and network interoperability.

6.2 U.S

6.2.1 FCC Supplemental Coverage from Space (SCS) Framework

In March 2024, the FCC adopted the world's first comprehensive regulatory framework for SCS. This framework allows satellite operators to collaborate with terrestrial Mobile Network Operators (MNOs) to provide coverage using the MNO's licensed flexible-use spectrum.

6.2.2 Authorized Frequencies and Technical Parameters

- Authorized Bands: Currently includes 600 MHz (614-652 MHz), 700 MHz, 800 MHz, 1.9 GHz (PCS), and 2.5 GHz.
- Protection of Terrestrial Networks: To prevent interference, the FCC established an aggregate Power Flux Density (PFD) limit of -120 dBW/m²/MHz measured at 1.5 meters above ground level for satellite downlink emissions.
- Emergency Services: Terrestrial providers must route SCS 911 calls to a Public Safety Answering Point (PSAP) using location-based routing.

6.3 Japan

6.3.1 Japan’s -D2D commercial launch

Starlink was issued a license by the MIC (Ministry of Internal Affairs and Communications) to operate the ground station for Starlink service installed at KDDI’s Yamaguchi Satellite Communication Center.

KDDI's AU has launched what it claims is the first direct-to-cell satellite service in Japan, allowing the mobile operator to connect 40% of the coverage area that its terrestrial network cannot reach because of the country's rugged geography. Services available in satellite mode include sending and receiving text messages (SMS), RCS messages (for Android-based smartphone users), and iMessages (for iPhone users); sharing current location data; and receiving earthquake alerts, tsunami alerts, and J-Alert. In addition, users of Android-based smartphones will be able to send queries to Gemini, Google's AI assistant, via the text message app. It is expected that voice and data services will eventually be introduced to AU Starlink Direct.

NTT Docomo announced on Feb, 09, 2026 that it is on track to launch its direct-to-cell satellite services in early fiscal year 202 6. The service does not require a special device and users can access it on Docomo's LTE-compatible phones. The subscribers using the service will be able to send and receive text messages and communicate through compatible apps in areas where communication via ground BSs has not been possible. Details such as partner companies, fees, supported areas, compatible models, and compatible apps will be announced at a later date.

Softbank announced on February 9, 2026, that the company will begin offering direct satellite-to-smartphone communication services in the 2026 fiscal year. He emphasized the importance of prioritizing service availability over differentiation from competitors, aiming for a unified user experience.

Rakuten Mobile is advancing a project with U.S.-based AST SpaceMobile, aiming to launch services in Japan by the fourth quarter of 2026. The project aimed at achieving

direct "high-speed internet communication" (voice and video calls, etc.) using low-orbit satellites and commercially available smartphones.

6.3.2 Domestic Legislation and Technical Parameters:

Japan established its D2D regulatory framework in 2024, with a technical study approved in October and a ministerial order in November.

Technical Study & Regulatory Framework for D2D Satellite Services in Japan

Technical Study:

Defined technical parameters for NGSO satellite systems using the 2GHz band to provide cellular coverage via D2D (Device-to-Device) communication. Reported results of frequency sharing studies between D2D services and existing systems in co-frequency and adjacent bands.

Draft Ministerial Order:

Updated the definition of “earth station” to include D2D user terminals. Specified technical requirements for D2D terminals, including frequency range, output power, modulation, and maximum deviation.

Note on Satellite Licensing:

Satellite station licenses will be issued by foreign administrations under RR 4.4, subject to Japanese government consent.

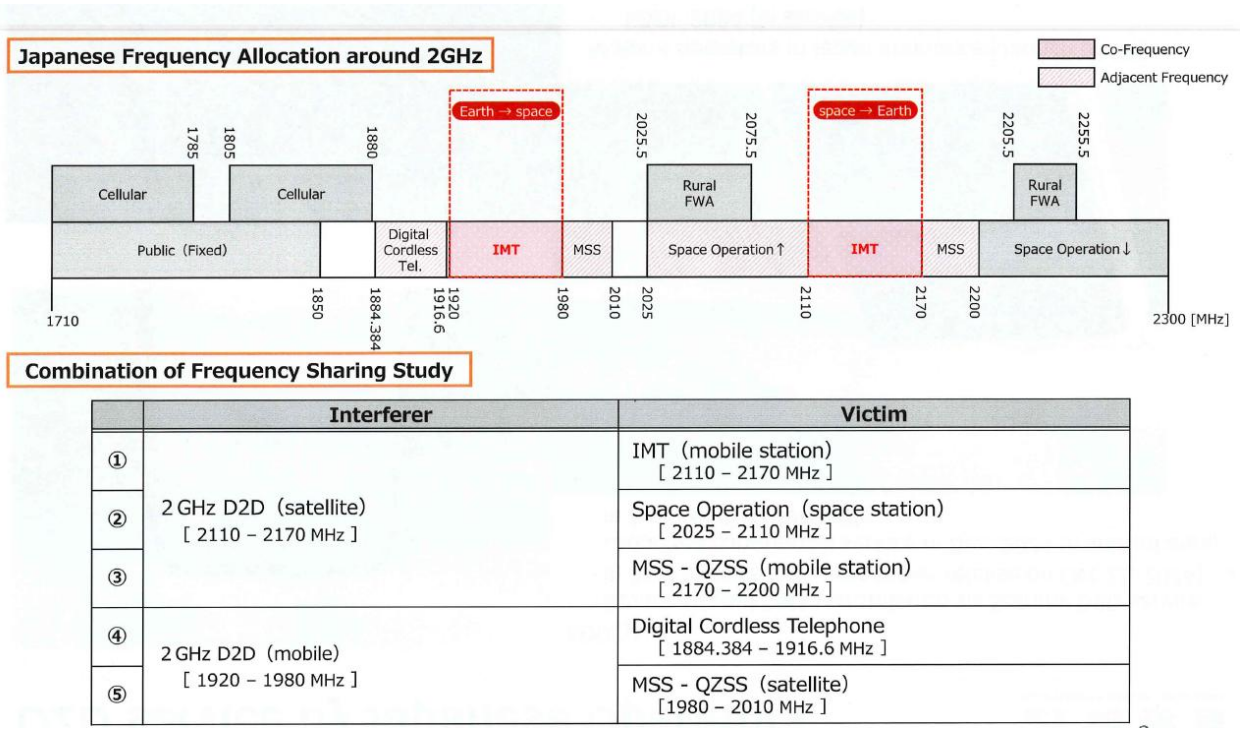
The regulations define the technical parameters for Non-Geostationary (NGSO) satellite systems to provide cellular phone coverage:

The service link for D2D operates in the 2GHz IMT band (Uplink: 1920-1980 MHz, Downlink: 2110-2170 MHz), with a maximum bandwidth of 5MHz per link. The feeder link uses the Ka band.

Key system parameters include a maximum of 7,500 satellites at altitudes of 340 km or 525 km, a maximum of 256 beams per satellite, and a service beam diameter of approximately 50 km.

Frequency Sharing Study:

A sharing study was conducted to assess compatibility with existing services in Japan's 2GHz band allocation. It examined five specific interference scenarios between the new D2D service (both satellite and mobile terminals) and incumbent services, including IMT, Space Operation, MSS-QZSS, and Digital Cordless Telephones.



Combination of Frequency Sharing Study

	Interferer	Victim
①	2 GHz D2D (satellite) [2110 – 2170 MHz]	IMT (mobile station) [2110 – 2170 MHz]
②		Space Operation (space station) [2025 – 2110 MHz]
③		MSS - QZSS (mobile station) [2170 – 2200 MHz]
④	2 GHz D2D (mobile) [1920 – 1980 MHz]	Digital Cordless Telephone [1884.384 – 1916.6 MHz]
⑤		MSS - QZSS (satellite) [1980 – 2010 MHz]

6.3.2 WRC-27 AI 1.13 position

Japan supports ongoing studies in ITU-R in accordance with Resolution 253 (WRC-23).

Japan supports new allocations to the Mobile Satellite Service (MSS) for direct connectivity between space stations and IMT user equipment to complement terrestrial IMT network coverage (DC-MSS-IMT), in accordance with Resolution 253 (WRC-23), provided that the protection of incumbent services, such as Space Operation Service (SOS), MSS and Broadcasting Service, is ensured. It is also essential to implement technical and operational measures to ensure that the stations of DC-MSS-IMT do not cause interference to, or claim protection from stations operating in the Mobile Service, including the terrestrial component of IMT, HIBS and 760MHz ITS.

Japan is generally satisfied with the candidate frequency bands under discussion (including 2GHz and 1.7GHz bands) but has major concerns regarding frequency sharing with specific incumbent services like MSS-QZSS and MSS-N-Star.

Japan has proposed solutions for protecting these services, such as setting hard limits for aggregated Power Flux Density (PFD) or Equivalent Power Flux Density (EPFD).

6.4 India

6.4.1 Current Activities

The national roadmap for D2D satellite communication services is being finalized, with an emphasis on universal connectivity and digital inclusion. It aims to integrate next - generation satellite technologies into standard smartphones.

This initiative will be submitted to the Telecom Regulatory Authority of India (TRAI). TRAI will engage with stakeholders, set regulatory frameworks, and propose a spectrum allocation model for D2D satellite communication (satcom) services.

There are ongoing pilot projects with BSNL and Viasat, which have demonstrated the technical feasibility of messaging and emergency services. Major industry players are seeking clarity on whether D2D will utilize satellite or terrestrial spectrum. The roadmap is in line with international developments, especially the spectrum band identification at the 2027 World Radiocommunication Conference. It also aims to simplify licensing, spectrum access, and business operations to encourage private - sector participation.

The underlying policy goal is to bridge the digital divide and support national objectives. This will be achieved by leveraging hybrid (satellite - terrestrial) infrastructure and new satellite constellations. After regulatory approvals and the establishment of global interoperability standards, the commercial roll - out is likely to accelerate.

Jio claims including L/S bands in the auction (and treating them as equivalent to IMT spectrum) will enable a unified, software - defined network architecture—supporting D2D and other non - terrestrial innovations under the 6G framework, while significantly expanding network coverage.

In its submission to TRAI's consultation paper on spectrum auctions, Jio emphasized these bands should be part of India's IMT (International Mobile Telecommunications) spectrum roadmap.

Additionally, Jio urged pilot trials to establish coexistence parameters between IMT (terrestrial mobile) and satellite services in the 6 GHz band (to ensure seamless integration of terrestrial and satellite networks).

6.4.2 WRC-27 AI 1.13

Proposed Frequency Arrangements:

470-960 MHz Range:

- Recommended FDD frequency arrangements: A3 (832-862 MHz/ 791-821 MHz), A5 (703-748 MHz/ 758-803 MHz), A7 and A9 (subsets of A5), A8 (698-703 MHz/ 753-758 MHz).

- TDD/SDL frequency arrangements: A6 and A10 may require additional considerations.

1427-1518 MHz Range:

- Recommended FDD frequency arrangement: G2 (1427-1470 MHz/ 1475-1518 MHz) to protect existing incumbents.

1710-2200 MHz Range:

- Recommended FDD frequency arrangements: B1 (1920-1980 MHz/ 2110-2170 MHz), B2 (1710-1785 MHz/ 1805-1880 MHz), B3 (1850-1920 MHz/ 1930-2000 MHz), B6 (1980-2010 MHz/ 2170-2200 MHz), B7 (2000-2020 MHz/ 2180-2200 MHz).

2300-2400 MHz Range:

- This range is excluded from studies due to the use of unpaired (TDD) arrangements that cannot be harmonized for MSS.

2500-2690 MHz Range:

- This range is also excluded from studies due to the use of both paired (FDD) and unpaired (TDD) arrangements that cannot be harmonized for MSS.

6.6 GCC

6.6.1 Saudi CST D2D Regulatory Initiative

Saudi Arabia’s CST launched a public consultation on Direct-to-Device (D2D) connectivity to extend mobile coverage to 100% of the Kingdom's territory, including remote areas and maritime zones .

6.6.2 Technical and Spectrum Approach

- MSS and IMT Integration: The CST is evaluating both the use of existing Mobile Satellite Service (MSS) bands (L-band/S-band) and the use of terrestrial IMT bands through sharing agreements .
- Coexistence: Focus is placed on managing interference between satellite D2D systems and incumbent terrestrial MNOs, following 3GPP NTN standards (Releases 17/18).

6.7 Africa

6.7.1 ATU and WRC-27 Agenda Item 1.13 Position

African administrations are actively participating in ITU-R Working Party 4C studies to facilitate D2D connectivity to complement terrestrial networks in rural Africa.

6.7.2 Proposed Frequency Arrangements

Based on regional technical studies, Africa supports the evaluation of the following FDD arrangements for DC-MSS-IMT to leverage existing smartphone hardware :

- **Sub-1 GHz:** A3 (832-862 MHz/ 791-821 MHz) and A5 (703-748 MHz/ 758-803 MHz).
- **Mid-Band (2 GHz):** B1 (1920-1980 MHz/ 2110-2170 MHz) and B6 (1980-2010 MHz/ 2170-2200 MHz) are identified as key ranges for ensuring high-quality satellite-to-mobile data services.

7 Future Forum Analysis of the global spectrum development trends

7.1 Global trends of harmonized 6G Candidate Bands

7.1.1 Analysis of Global 6G Candidate Band Trends

Based on above status from different countries and regions, there is a clear and converging global strategy for identifying and harmonizing spectrum for 6G.

- Upper 6 GHz Band (6425-7125 MHz): A Post-WRC-23 Implementation Focus
    - This band was already identified for IMT at WRC-23. Current global work is focused on implementing this decision, particularly on coexistence and sharing studies (e.g., with Wi-Fi/WAS/RLANs).
    - Europe (CEPT/ECC) is actively working on a harmonized framework under an EC Mandate, with studies on coexistence (Task 1), shared use feasibility (Task 2), and technical conditions (Task 3) scheduled through 2027.
    - India has already outlined plans to release 400 MHz in this band (6425-6725 MHz & 7025-7125 MHz) in the short term (2025-2026).

7.1.2. Analysis for the Regional and National Strategic Trends

- Asia-Pacific: Leading the "Golden Band" Push
  - Rationale: This band offers an optimal balance of capacity and coverage, allowing for the reuse of existing 5G cell site infrastructure, which is critical for affordable and rapid deployment.
  - They emphasize active participation in WRC-27 to ensure these bands are harmonized globally, preventing market fragmentation.
- Europe (CEPT): A Structured, Phased Approach
  - CEPT's strategy is defined by its 6G Roadmap, aiming for harmonized technical conditions by 2027/2028.
  - Its work is split into:
    1. WRC-23 Follow-up**:** Implementing the Upper 6 GHz band (6425-7125 MHz) with a focus on sharing with Wi-Fi.
    2. WRC-27 Preparation: Developing a common European position to possibly support 7.125-7250GHz for IMT, while opposing 4.4-4.8 GHz and 14.8-15.35 GHz based on current studies.
- United States: Legislative-Driven Pipeline with Near-Term Focus
  - The U.S. strategy is now guided by the OBBBA Act, which mandates identifying 800 MHz of spectrum below 10.5 GHz.
  - Near-term focus is on the Upper C-Band (3.98-4.2 GHz), with an FCC rulemaking underway.
  - Mid/Long-term candidates align with global trends: 2.69-2.9GHz, 4.4-4.9 GHz and 7.125-7.4 GHz have been identified for federal reallocation studies. Notably, the 7.4-8.4 GHz range is statutorily excluded for federal use, which may impact the U.S. position on the full 7-8.4 GHz band at WRC-27.
- GCC & Africa: Aligning with Global Harmonization
  - GCC (e.g., Saudi Arabia, Qatar) is showing early interest in the Upper 6 GHz band and exploring sub-THz bands, linking spectrum to national digital transformation agendas.
  - Africa (via ATU) supports Upper 6GHz bands and prioritizes mid-band spectrum (4.4-4.8 GHz, 7-8.5 GHz) for balanced growth and strongly emphasizes WRC-27 harmonization to achieve economies of scale and lower device costs. Africa also advocates for sub-1 GHz bands for inclusive rural coverage.

7.1.3 Technology and Standardization Drivers (3GPP)

- The 3GPP standardization work is defining the technical envelope for 6G spectrum. A key decision is the support for a maximum channel bandwidth of 400 MHz in the downlink (with 200 MHz in uplink initially) for bands around 7 GHz.

- This 400 MHz channel bandwidth target is a major technical driver behind the push for large, contiguous blocks of spectrum in the 6-8.4 GHz range, as it directly enables the high-performance goals of 6G.

7.1.4 Conclusion: Convergence of Global Trends

1. Implementation of Upper 6 GHz is underway. The 6425-7125 MHz band is transitioning from identification to implementation, with major work focused on defining sharing mechanisms with incumbent services.
2. National Roadmaps are Aligning with WRC Process. Countries like India and Japan have published detailed spectrum roadmaps that are explicitly synchronized with the WRC-27 timeline, aiming to allocate spectrum shortly after the conference.
3. Higher Bands for the Future: While mid-bands are the immediate focus, all regions acknowledge the role of millimeter-wave (e.g., 37-40 GHz) and sub-Terahertz bands (above 100 GHz) for extreme capacity in the longer term, with studies targeted for WRC-31 and beyond.

7.2 Global Trends of D2D candidate bands:

Based on the above status review in Chapter 6, there is an analysis of the trends for potential global Direct-to-Device Mobile Satellite Service (D2D) candidate bands, with a focus on harmonization efforts, national developments, and the critical role of WRC-27.

7.2.1 Analysis of Global D2D Candidate Band Trends

The global development of D2D spectrum policy is rapidly evolving, characterized by a strategic shift from initial IMT bands under ITU-R Article 4.4 under national/regional framework to dedicated existing MSS band. World Radiocommunication Conference 2027 (WRC-27) AI 1.13 regulatory framework will be a long-term global harmonized approach.

- Strategic Shift: From IMT Bands to MSS Bands: A major trend is the strategic pivot from using terrestrial IMT spectrum to securing dedicated MSS spectrum.
    - Initial Phase (D2D-IMT): Early movers (USA, Japan, UK) authorized D2D services in terrestrial IMT bands (e.g., 600 MHz, 700 MHz, 1.9 GHz, 2.1 GHz) under ITU RR Article 4.4 (non-interference, no-protection basis). This allowed for rapid commercial launches (e.g., Starlink in Japan, AST SpaceMobile tests).
    - Current Trend (D2D-MSS): The industry is now competing for scarce dedicated MSS bands, recognized as a more sustainable long-term solution. Examples include:

    - The EU 2 GHz MSS band (1980-2010/2170-2200 MHz) is viewed as a "golden band" in Europe.
    - In the US, AST SpaceMobile acquired L-band MSS rights, and Starlink applied for 2 GHz MSS access.
  - Rationale: While IMT bands offer immediate device compatibility, they come with regulatory uncertainty, complex sharing requirements, and lacking of common regulatory framework in EU. MSS bands provide clearer rights and a more stable regulatory home for satellite operators, though they may require device hardware upgrades.
- WRC-27 (Agenda Item 1.13): The Decisive Forum for Global Harmonization: WRC-27 Agenda Item 1.13 is the single most important global process for establishing a future-proof, harmonized regulatory framework for D2D. The positions of key administrations are converging on a common scope.
  - Proposed Candidate Bands (Range 694-2700 MHz):
    - Sub-1 GHz Bands (e.g., 700-900 MHz range): Favored for their excellent propagation characteristics, crucial for coverage in remote areas. Specific arrangements like A3 (832-862/791-821 MHz) and A5 (703-748/758-803 MHz) are supported by India and Africa.
    - 1.4-1.5 GHz Band: India has proposed the G2 arrangement (1427-1470/1475-1518 MHz). This band is seen as promising due to relatively lighter incumbent usage in some regions.
    - 2 GHz Band (1710-2200 MHz): This is the most active and contentious range, with several proposed FDD arrangements:
      - B1 (1920-1980/2110-2170 MHz): This is a globally supported key candidate (Japan, India, Africa) as it aligns with existing 3G/4G IMT bands, enabling hardware reuse.
      - B2 (1710-1785/1805-1880 MHz) and B6 (1980-2010/2170-2200 MHz) are also under study (India, Africa).
    - Excluded Bands: There is a strong objection to include the TDD bands e.g. the 2300-2400 MHz and 2500-2690 MHz ranges in India from D2D-MSS studies. Europe (CEPT) explicitly rules out 2300-2400 MHz due to TDD-only usage (incompatible with MSS FDD needs) and sensitive aeronautical mobile telemetry (AMT) incumbents. India also excludes both 2.3GHz and 2.6GHz bands due to their unpaired/TDD nature.

- Regional Positions for WRC-27:
    - Europe (CEPT): Supports new MSS allocations in the 694-2700 MHz range, with frequency arrangements per ITU-R M.1036, but insists on absolute protection for terrestrial IMT (in-country and cross-border). CEPT's technical studies heavily influence its cautious stance.
    - Japan: Supports the WRC-27 studies and new MSS allocations, provided protection is ensured for incumbents like Space Operation Service (SOS) and its national MSS-QZSS system. Japan is generally satisfied with the candidate bands but has proposed technical solutions like aggregate PFD limits to enable sharing.
    - India & Africa: Have provided the most detailed proposed frequency arrangements (listed above), focusing on FDD paired spectrum in sub-1 GHz and 2 GHz bands to leverage existing smartphone hardware.

7.2.2 National & Regional Regulatory Frameworks: A Patchwork Under Development

Global regulation is a mix of first-mover national frameworks and slower regional harmonization.

- Pioneers (National Frameworks):
    - USA: The FCC's SCS framework (March 2024) was the world's first comprehensive rule-set, authorizing specific IMT bands and establishing aggregate PFD limits (e.g., -120 dBW/m²/MHz) to protect terrestrial networks.
    - UK: Ofcom's framework (effective Feb 2026) is the first in Western Europe, covering seven IMT bands and using PFD limits for cross-border protection. VMO2 has already modified its license for Starlink service.
    - Japan: Established its framework in 2024, specifically for the 2 GHz IMT band (1920-1980/2110-2170 MHz), with detailed technical parameters for terminal and sharing studies. Multiple operators (KDDI, NTT Docomo, SoftBank) have launched or announced services.
- The EU's Coordinated, Cautious Approach: The EU is lacking of harmonized framework and is developing the least restrictive harmonized technical conditions for satellite systems providing D2D-IMT services to off-the-shelf terminal stations (such as smartphones).

- Current Status: There is no unified EU D2D framework yet. The RSPG Opinion (June 2025) concluded that D2D-IMT is currently not possible under existing EU harmonization rules.
- Path Forward: The European Commission issued a Mandate (Oct 2025) to CEPT to study technical conditions for D2D-IMT across a wide range of bands (from 700 MHz to 42 GHz). The work, split into feasibility studies (Report A), technical conditions (Report B (finalization in March, 2027)), and a post-WRC-27 review (Report C), will run through 2028.
- Key EU Challenge: Balancing the introduction of D2D with the absolute protection of terrestrial IMT networks, both domestically and in cross-border scenarios, is the paramount technical and regulatory hurdle. Current key concerns are, SNOs using IMT bands needs to partner with MNOs and under MNOs license and controllable by MNOs, the service should be geographically complementary to terrestrial networks rather than usage complementary to TN. TDD bands need to be avoid. And compliance method should be aligned with ITU-R decision.

7.2.3 Key Technical Limitation and Market Trends

- Dual-Track Operator Strategy: Leading operators (AST SpaceMobile, Starlink, Lynk) are adopting a dual-track strategy, pursuing both IMT-band access for near-term service and MSS spectrum acquisition for long-term stability.
- Technical Limitations: GSMA analysis indicates fundamental capacity limits for D2D; even with vast constellations and full IMT spectrum, it is envisioned as a basic coverage complement, not a substitute for terrestrial networks.
- Standardization: 3GPP standardization (Releases 17/18 and beyond) is incorporating NTN profiles, which is crucial for device compatibility and ecosystem development.

7.2.4. Conclusion: Converging Paths to Harmonization

1. WRC-27 is the primary path to global band harmonization runs through WRC-27 AI 1.13. The most likely outcome is new MSS allocations in specific FDD-paired blocks within the 694-2700 MHz range.
2. Near-Term Deployment Relies on IMT Bands: Until WRC-27 outcomes are implemented, commercial services will continue to roll out using national authorizations in IMT bands under non-interference conditions, leading to a fragmented global patchwork.

3. The MSS Band is a clear strategic shift from IMT bands, that dedicated MSS spectrum is the optimal solution for D2D, leading to a industry rush to secure these scarce resources.
4. Protection of Terrestrial IMT network is the paramount requirement to protect existing terrestrial mobile networks from harmful interference. Technical measures like aggregate PFD limits and stringent sharing studies are central to all regulatory developments.
5. Regional Paces Vary: The USA, UK, and Japan are first movers with active commercial services. The EU is methodically building a complex harmonized framework that may become a global model for coexistence. Other regions like India, GCC, and Africa are actively studying the issue, with their positions for WRC-27 largely aligned on candidate bands.

8 Conclusion and suggestions

Early planning for the U6 GHz band ahead of WRC-27 will help garner wider global support for IMT footnote identification and will be critical for enabling timely 6G deployment in China. Leveraging multiple international forums for coordination will also be an effective way for China to positively influence administrations worldwide during WRC-27.

Regarding D2D, from an industry perspective, it is essential to ensure that terrestrial IMT networks are protected from harmful interference caused by D2D systems. Regulatory measures for protecting IMT should be based on methodologies whose compliance can be verified through the relevant ITU-R regulatory processes.

Notes:

Note 1: DC-MSS-IMT particular refers to the mobile direct to device for satellite connection (D2D) mode using IMT frequency bands in the 698–2700 MHz range under WRC-23 AI 1.13

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