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CONSIDERATIONS FOR DIRECT-TO-DEVICE SATELLITE TECHNOLOGY

Mobile Satellite Services Association

This document is provided by the Mobile Satellite Services Association (MSSA). MSSA is a non-profit industry association that seeks to promote and advance the emerging direct-to-device (D2D) ecosystem and support the efforts of D2D solutions providers – including terrestrial mobile and satellite operators, Original Equipment Manufacturers, infrastructure providers, chip vendors, and others. MSSA seeks to advance global mobile connectivity for D2D and IoT services via open, standards-based solutions. MSSA members support a vision of integrating terrestrial and non-terrestrial network (NTN) services to deliver scalable, sustainable, and affordable connectivity to any device, anytime, anywhere. MSSA believes that D2D has the potential to bridge the connectivity gap by complementing the capabilities of existing terrestrial mobile networks and handsets – particularly in unserved and underserved areas (whether urban, suburban, or rural) – while leveraging economies of scale.

The satellite industry has seen significant consolidation in recent years, driven by financial challenges and competition from emerging LEO constellations. The MSSA exemplifies a collaborative response to these pressures, focusing on a direct-to-device approach using MSS spectrum — a strategy aligned with its members. The association predominantly serves as a platform for collaboration on 3GPP NTN standards, driving adoption of standardized solutions that enable seamless integration and roaming between satellite and terrestrial networks across devices.

Summary

Innovation in mobile device technology, globally harmonized standards, and technology convergence are enabling direct-to-device (D2D) communications between satellites, conventional terrestrial mobile handsets, and other end-user devices, including those in moving vehicles. D2D technology presents exciting new opportunities to complement services currently provided by mobile network operators, close the digital divide, and give truly ubiquitous coverage throughout Latin America and globally. MSSA members anticipate that D2D technology will address critical use cases, including by: (i) augmenting existing mobile network operator infrastructure by enabling connectivity in underserved or unserved areas, including, maritime, aeronautical, and rural regions, and (ii) supporting mission critical and time-sensitive communications, particularly in the context of disaster response and emergency relief efforts.

This document contemplates two D2D approaches. The first approach uses spectrum allocated to the mobile-satellite service for non-terrestrial links (referred to as “MSS

D2D") and the second approach uses spectrum allocated to the terrestrial mobile service for non-terrestrial links (referred to as "IMT D2D" and elsewhere may also be referred to as "MS D2D"). This text addresses the regulatory, operational, and technical dimensions of various D2D methodologies.

I. Introduction

There is a growing demand for D2D[1] technology since terrestrial networks do not cover significant portions of the world, and many underserved areas can only be served through satellite connectivity, which can provide coverage anywhere on Earth.

According to the GSMA's *Satellite 2.0: going direct to device report* from 2022[2], the D2D satellite market is projected to generate $33 billion by 2035, with $20 billion from consumers, $10 billion from enterprise IoT, and $2 billion from government applications. By 2025, 400 million people and 1.9 billion IoT devices across sectors like utilities, automotive, and agriculture will form the addressable base. Additionally, GSMA's *State of Mobile Internet Connectivity Report 2024* highlights a 6% coverage gap in Latin America and the Caribbean, leaving 40 million unconnected, while 33% (220 million) face usage gaps.[3] This underscores the potential for collaboration between satellite and mobile operators to cost-effectively bridge connectivity gaps in unserved and underserved regions

This document contemplates two different approaches to D2D service. The first approach, MSS D2D, uses mobile satellite service (MSS) spectrum for D2D. This approach is feasible within the existing International Telecommunication Union (ITU) allocations and national licensing frameworks that enable today's MSS services – particularly those using the L-band and S-band. This approach takes advantage of the work already done at the 3GPP to bring satellite capability to mass-market mobile devices by incorporating non-terrestrial networks (NTN) into industry standards. This will facilitate the implementation of satellite connectivity in the global 5G ecosystem.

The second approach, IMT D2D, relies on satellite operators transmitting and receiving in spectrum allocated and licensed to the terrestrial mobile service to bring satellite capability to mass-market mobile devices. As discussed below, this approach introduces additional technical complexities and operational risks, which at a minimum require further study and regulatory action prior to implementation.

II. MSS D2D Approach

The MSS D2D approach provides comprehensive coverage using globally harmonized spectrum allocations. It minimizes interference risk by utilizing existing MSS-allocated spectrum in the L- and S- bands (among others). These bands have long-standing

[1] Direct-to-device (D2D) in this document means satellite communications to a conventional terrestrial mobile handset or other end-user devices"

[2] https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=69042417&file=220322-Satellite-2.0-going-direct-to-device.pdf

[3] https://www.gsma.com/r/wp-content/uploads/2024/10/The-State-of-Mobile-Internet-Connectivity-Report-2024.pdf

regulations defined in the ITU Radio Regulations and Recommendations to manage potential interference issues and enable the use of these bands for D2D. MSS D2D does not require spectrum to be repurposed for satellite communications.

MSS D2D is already possible in most jurisdictions without requiring administrations to adopt new regulations. Most CITEL administrations have existing national regulations to enable the use of MSS terminals throughout their territory, using the following L-band and S-band ITU allocations:

- 1518-1525 MHz (space-to-Earth) paired with 1668-1675 MHz[4] (Earth-to-space)
- 1525-1559 MHz (space-to-Earth) paired with 1626.5-1660.5 MHz (Earth-to-space)
- 1610-1626.5 MHz (Earth-to-space and space-to-Earth) paired with 2483.5-2500 MHz (space-to-Earth)
- 1980-2010 MHz[5] (Earth-to-space -- 1980-2025 MHz in Region 2) paired with 2170-2200 MHz (space-to-Earth – 2160-2200 MHz in Region 2)

Regarding equipment standards for MSS D2D, 3GPP Release 17 enhances features in the 5G Core Architecture to support NTNs[6] for several use cases, including coverage extension, IoT, disaster communication, global roaming, and broadcasting.

3GPP Release 18 identifies three specific MSS frequency band ranges under 6 GHz (recognized across all ITU Regions) for NTN, following the duplex mode defined by the ITU table of frequency allocations:

NTN satellite bands in FR1-NTN[7]

NTN satellite operating band	Uplink (UL) operating band Satellite Access Node receive / UE transmit FUL,low – FUL,high	Downlink (DL) operating band Satellite Access Node transmit / UE receive FDL,low – FDL,high	Duplex mode
n256	1980 MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
n254	1610 – 1626.5 MHz	2483.5 – 2500 MHz	FDD
NOTE: NTN satellite bands are numbered in descending order from n256.			

[4] Except in the United States, where the 1670-1675 MHz band is allocated for Fixed and Mobile use.
[5] In Region 2, the MSS Earth-to-space allocation is from 1980-2025 MHz.
[6] Non-terrestrial network (NTN) refers to a Radio Access Network (RAN), which provides non-terrestrial access with 5G New Radio (NR), 4G NB-IoT or 4G eMTC radio interfaces to user equipment by means of an NTN payload embarked on an airborne or space-borne NTN vehicle and an NTN gateway (see 3GPP TS 38.300). The underlying technology, maturity, deployment model, and commercial timelines of a given NTN will vary.
[7] See: 3GPP 38.101-5, NR; User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3982

A recently published report, *Spectrum for Emerging Direct-to-Device Satellite Operators*[8], concludes that MSS bands offer significant advantages for nationwide—and potentially global deployment of D2D services. These advantages stem from established global regulations and market access grants already secured by several existing operators. Additionally, millions of MSS users rely on these services, many for critical safety-of-life applications that must be protected. The most effective way to ensure this protection is through commercial agreements between D2D providers and existing MSS operators—a model that has already proven viable through multiple real-world examples.

III. IMT D2D Approach

The second approach to D2D requires significant changes to regulatory frameworks to allow for different use of spectrum that existing allocations do not support. Furthermore, this approach introduces new interference and coexistence issues concerning existing terrestrial mobile spectrum users that require careful study and management. Before national authorizations are issued to facilitate D2D operations in the spectrum allocated and licensed to the terrestrial mobile service, technical studies must be conducted and recommendations developed to potentially address unresolved issues; including out-of-band emissions, cross-border interference, and satellite-to-satellite interference.

IMT D2D also involves regulatory challenges associated with authorizing satellite use of partially harmonized international spectrum allocated for terrestrial services without a satellite allocation. In most cases, the proposed spectrum will already be authorized to one or more MNOs in the country. As such, domestic regulations and existing authorizations would need significant modifications to allow D2D. Re-certification of legacy handset devices for this new use may also be recommended.

On an international level, WRC-27 has been tasked with studying the technical, operational, and regulatory elements of D2D in terrestrial bands between 698 MHz and 2700 MHz under Agenda Item 1.13. The bands currently being reviewed for D2D under WRC-27 agenda item 1.13 are the following:

- 694/698-960 MHz;
- 1427-1518 MHz;
- 1710-1785 MHz;
- 1805-2025 MHz;
- 2110-2200 MHz;
- 2300-2400 MHz; and
- 2500-2690 MHz.

Currently, ITU-R Working Parties 4C and 5D are evaluating whether terrestrial mobile bands used for TDD mobile systems should be studied for D2D under WRC-27 agenda item 1.13. These and the adjacent bands are allocated to a range of services and used

[8] https://www.satnow.com/news/details/2797-spectrum-challenges-for-emerging-direct-to-device-satellite-services

by various systems and technologies. The use of these bands for new IMT D2D satellite systems introduces many new emerging potential interference issues that are expected to be addressed in the ITU-R studies. Those studies may result in new regulations at WRC-27.

IV. Technical and Regulatory Considerations

D2D services have, until recently, been limited to MSS D2D offerings operating in bands already allocated globally to the MSS by the ITU on a primary basis. These services support various terminal types, including satellite service for iPhones, Android phones, and other devices with more capabilities, including broadband connectivity, which are being developed.[9]

Some satellite operators have begun seeking authorizations to provide IMT D2D services in spectrum allocated to the terrestrial mobile service that does not have a corresponding MSS allocation. These operators or their partners must request regulators to allow them to use frequency bands allocated for terrestrial mobile service, which may already be assigned to mobile operators. The operation of MSS in spectrum allocated only to terrestrial services is contrary to the current international spectrum framework, creating regulatory, technical, and operational challenges. The provision of D2D in the spectrum allocated to the MSS does not have similar regulatory, technical, or operational uncertainty and complexities.

Some preliminary ITU-R Working Parties analysis[10] shows that significant separation distance or exclusion zones are required to ensure that interference from such IMT D2D operations into terrestrial mobile networks or along international borders can be effectively managed. Another example has occurred in the case of proposed Supplementary Coverage from Space operations in the United States in the band 1990-1995 MHz where a terrestrial mobile operator proposes to allow downlink satellite operations in a band that is allocated globally for MSS uplinks-in this case, the 1980-2010 MHz (up to 2025 MHz in Region 2) which is paired with the MSS downlink band 2170-2200 MHz. In this case, MSS operators have submitted technical analyses showing how use of the 1990-1995 MHz band for downlink transmissions of IMT D2D will result in harmful interference to systems that are licensed in other countries, and that conform to the directionality imposed by the global MSS allocation for the S-band in the International Table of Frequency Allocations.[11] The technical and regulatory challenges associated with IMT D2D remain significant and require careful consideration and management to ensure the viability and effectiveness of this technology.

[9] See: https://www.zdnet.com/article/google-pixel-9-is-first-android-phone-to-get-satellite-sos-messaging/

[10] For example, see "Exploring Interference Issues in the Case of n25 Band Implementation for 5G/LTE Direct-to-Device NTN Services", *Pastukh, A.; Tikhvinskiy, V.; Devyatkin, E.*, https://www.mdpi.com/1424-8220/24/4/1297.

[11] *See* Article 5 of the ITU Radio Regulations, 2024 Edition https://www.itu.int/pub/R-REG-RR

It has also been suggested that IMT D2D could operate based on ITU RR Article No. 4.4[12]. However, as noted by the Radio Regulations Board (RRB) in its report to WRC-23[13], the use of ITU RR Article No. 4.4 for satellite networks should be approached with caution due to the increasing number of NGSO systems planning to use a frequency band under RR Article No. 4.4. In some cases, these NGSO systems are proposing to offer commercial services on large constellations without an appropriate allocation in the Radio Regulations. This leads to a potentially high risk of satellite-to-satellite interference in some of the proposed frequency bands.

Additionally, Administrations contemplating potential invocation of ITU RR Article 4.4 must consider the following (among other things):

- Under ITU Rule of Procedure 1.6, Administrations attempting to invoke ITU RR 4.4 must show that the intended use will not cause harmful interference.
- This showing may be difficult or impossible, as ITU RR 4.4 for new satellite systems will greatly increase the risk of interference with other systems and services.
- Any operations must immediately cease if there is interference, even if providing commercial services to consumers—raising significant questions about the quality, reliability, and sustainability of IMT D2D services.
- Before IMT D2D services can operate, measures must be taken to protect other space and terrestrial services, both at the national and cross-border levels.

The ITU has yet to study technical, operational, and regulatory matters related to this non-standard approach.

V. Conclusions

Several factors have led to the growing demand for D2D services. Significant portions of the world rely on satellite connectivity, as they have many underserved areas or have little ground-based infrastructure providing coverage. Advances in satellite technology and satellite service standardization, such as the 3GPP NTN standards, have driven momentum for D2D. This technology can help provide critical connectivity for underserved populations, delivering important social and economic development gains. It can also expand connectivity across multiple large and diverse segments, including industrial, government, agriculture, automotive, and others.

Satellite D2D technology presents promising opportunities and challenges for CITEL Administrations. The MSS D2D approach generally requires no additional action from national regulators. This approach leverages standardized protocols and frameworks, capitalizing on 3GPP Release 17 and 18 NTN specifications, to provide seamless connectivity across terrestrial and satellite networks within existing regulatory frameworks. Conversely, IMT D2D presents significant technical and regulatory hurdles, which are being studied under WRC-27 agenda item 1.13.

[12] *See* Article 4.4 of the ITU Radio Regulations, 2024 Edition https://www.itu.int/pub/R-REG-RR
[13] *See* WRC-23/Document 50-E "Report by the Radio Regulations Board to WRC-23 on Resolution 80 (Rev.WRC-07)." https://www.itu.int/md/R23-WRC23-C-0050/en.

Collaboration between satellite operators, mobile network providers, and regulatory bodies is crucial for unlocking the full potential of satellite D2D connectivity and ushering in a new era of ubiquitous and seamless communications for the benefit of all peoples in the Americas.