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CONSIDERATIONS FOR DIRECT-TO-DEVICE SATELLITE TECHNOLOGY

(Item on the Agenda: 3.1 and 3.4)

(Informative document submitted by MOBILE SATELLITE SERVICE ASSOCIATION)

Impact on the sector:

To facilitate understanding regarding regulatory, technical, and operational considerations for the implementation of satellite-based direct-to-device (D2D) communications, this document provides information on the differences between: (i) deployments of D2D in spectrum globally allocated for mobile-satellite services (MSS) on a primary basis and (ii) deployments of D2D in spectrum without a corresponding MSS allocation, including spectrum allocated to the mobile service (MS) and identified for IMT, which is under study in Agenda Item 1.13 for WRC-27.

Executive Summary:

Innovation in mobile device technology, globally harmonized standards, and technology convergence are enabling direct-to-device (D2D) communications between satellites and 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, to close the digital divide and to provide truly ubiquitous coverage throughout Latin America. D2D technology will likely fulfill the following use cases: (i) complement existing mobile network operator infrastructure and connect underserved or unserved parts of urban and suburban areas, as well as mountainous, maritime, aeronautical, isolated, and rural areas, and (ii) facilitate short-term, urgent requirements such as disaster response.

Two approaches to D2D are being contemplated, which differ depending on whether they use spectrum allocated to the mobile-satellite service for non-terrestrial links (referred to as "MSS D2D" in this contribution), or spectrum allocated to the terrestrial mobile service for non-terrestrial links (referred to as "IMT D2D" in this contribution and elsewhere may also be referred to as "MS D2D"). This input contribution discusses the regulatory, operational, and technical aspects of both D2D approaches.

Introduction

There is a growing demand for Direct-to-Device (D2D[1]) technology since significant portions of the world are not covered by terrestrial networks and many can only be served through satellite connectivity, which by its nature can provide coverage anywhere on earth. According to the World Bank, the Americas region has roughly 17-18% of its population residing in rural areas while small Caribbean small states (CSS) have 53% of their population living in rural areas not to mention numerous islands.[2] The GSMA's State of Mobile Connectivity Report from 2023 notes that there is a 6% coverage gap of 40 million unconnected people in Latin America and the Caribbean, and a further 210 million people or 32% usage gap of covered but not connected individuals, who are often reluctant to become active users because terrestrial coverage isn't sufficient where they spend the majority of their time.[3] This presents an opportunity for the mobile satellite and mobile network operator communities to work together to connect the unconnected, leveraging satellite networks' cost models that are far less sensitive to population density than terrestrial networks, such that inclusion of a D2D component can improve the overall business case for serving rural and remote areas.

Two different approaches to D2D service are being contemplated. The first approach, referred to as MSS D2D, uses the 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 MSS allocations. This approach takes advantage of the work already done at the 3GPP to bring satellite capability to mass-market mobile devices through the incorporation of non-terrestrial networks (NTN) into industry standards. This will facilitate the implementation of satellite connectivity in the global 5G ecosystem.

The second approach, referred to as 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.

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, providing service to a variety of terminal types. This has included satellite service to iPhones, Android phones[4] and other devices[5]. Devices with greater capabilities, including broadband connectivity, are being developed.

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 will have to make requests to 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 and hence creates regulatory, technical, and operational challenges. The provision of D2D in spectrum allocated to the MSS does not have similar regulatory, technical, or operational complexities.

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[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.worldbank.org/indicator/SP.RUR.TOTL.ZS

[3] https://www.gsma.com/r/wp-content/uploads/2023/10/State-of-Mobile-Internet-Connectivity-2023-Latin-America-and-Caribbean.pdf

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

[5] As example, see https://www.motorola.com/us/motorola-defy-satellite-link/p.

MSS D2D Approach

The MSS D2D approach offers the ability to provide comprehensive coverage using globally harmonized spectrum allocations. It minimizes interference risk by utilizing existing MSS-allocated spectrum in both the L- and S-bands (among others), which have long-standing regulations defined in the ITU Radio Regulations and Recommendations to manage potential interference issues. MSS D2D does not require spectrum to be repurposed for satellite communications.

MSS D2D is already possible in most jurisdictions without the need for 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 allocations:

- 1518-1525 MHz (space-to-Earth) paired with 1668-1675 MHz[6] (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[7] (Earth-to-space -- 1980-2025 MHz in Region 2) paired with 2170-2200 MHz (space-to-Earth – 2160-2200 in Region 2)

Regarding equipment standards for MSS D2D, 3GPP Release 17 enhances features in the 5G Core Architecture to support NTNs[8] for several use cases, including coverage extension, IoT, disaster communication, global roaming, and broadcasting.

In Release 18, 3GPP identified three specific MSS frequency band ranges[9] under 6 GHz (recognized across all ITU Regions) for NTN, following the duplex mode defined by the ITU table of frequency allocations:

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

These bands offer standardized solutions to mitigate potential conflicts between MSS-based communication and existing terrestrial cellular networks. This includes the addition of the "extended L-band" MSS frequency bands 1518-1525 MHz and 1668-1675 MHz and the "extended S-band" MSS frequency bands

[6] Except in the United States, where the 1670-1675 MHz band is allocated for Fixed and Mobile use.
[7] In Region 2, the MSS Earth-to-space allocation is from 1980-2025 MHz.
[8] 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.
[9] 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

2000-2020 MHz and 2180-2200 MHz. ITU-R Working Party 4B has initiated a procedure to evaluate the candidate radio interface technologies (RITs) and sets of radio interface technologies (sRITs) for the satellite component of IMT-2020 due to conclude in 2024. The only current candidate technology is NTN as specified by 3GPP [10].

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 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 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 internationally harmonized spectrum allocated for terrestrial services without a satellite allocation. In most cases, the spectrum proposed to be used 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.

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

Some preliminary analysis[11] shows that significant separation distance is required to ensure that interference from such IMT D2D operations into terrestrial mobile networks 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

[10] Circular Letter ITU-R 4/LCCE/134: "Invitation for submission of proposals for candidate radio interface technologies for the satellite component of the radio interface(s) for IMT-2020 and invitation to participate in their subsequent evaluation," 23 November 2022; https://www.itu.int/md/R00-SG04-CIR-0134/en.

[11] 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.

International Table of Frequency Allocations.[12] The technical and regulatory challenges associated with IMT D2D are significant and require careful consideration and management to ensure the successful deployment of this technology.

It has been suggested that IMT D2D could operate based on ITU RR Article No. 4.4, which states:

Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.

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 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.

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 the use of ITU RR 4.4 for new satellite systems will place other systems and services at a high risk of interference.
- Any operations must immediately cease if there is interference, even if providing commercial services to consumers—raising significant questions about the quality and reliability of IMT D2D services.
- Measures would be needed required to protect other space and terrestrial services, both at national and cross-border levels, *before* IMT D2D services are allowed to operate.

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

Considerations for CITEL Administrations

Several factors have led to the growing demand for D2D services. Significant portions of the world rely on satellite connectivity as they have little to no ground-based infrastructure that provides coverage. Advances in satellite technology and satellite service standardization, such as the 3GPP NTN standards, have driven momentum for D2D, which can help provide critical connectivity for underserved populations, delivering important social and economic development gains, as well as 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. In general, the MSS D2D approach requires no additional action from national regulators. This approach leverages standardized protocols and frameworks, capitalizing on 3GPP Release 17 and 18 NTN

[12] *See* Article 5 of the ITU Radio Regulations, 2020 Edition ("ITU Radio Regulations").
[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.

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.

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

CITEL administrations are encouraged to:

- At the national level, ensure that MSS D2D is enabled within the existing global regulatory framework that supports today's MSS services as well as massive adoption of MSS D2D in coming years, leveraging the work already done at the 3GPP to complete Release 17 and 18 which includes non-terrestrial networks (NTN) and addresses satellite's role in the global IMT ecosystem;
- Actively participate in studies related to WRC-27 Agenda Item 1.13, to ensure that the regulatory, technical, and operational challenges stemming from the provision of IMT D2D are understood and mitigated prior to the development of such services in their Administrations' territories.