POLICYIMPACT PARTNERS

Direct to Device Communications and WRC-27 AI 1.13

An overview of approaches, market developments and regulatory considerations

June 2026

About this paper

Developed by Policy Impact Partners, an advisor to technology companies working on innovative connectivity solutions, this paper is an overview for regulators on satellite-to-handset, or direct to device (D2D), connectivity. It explains the two main approaches to delivering D2D, using standard MSS frequencies and using MNO/IMT spectrum, and outlines the key market developments around each of these two approaches. It then goes on to consider the significance of WRC-27 for D2D, before exploring regulatory issues, such as how sufficient spectrum can be made available to realise the full potential of this technology, while avoiding interference with other services.

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Introduction

With direct to device (D2D) connectivity, satellites communicate directly with conventional smartphones, removing the need for end-users to have specialist equipment, such as sleeves, external antennas or dedicated handsets, to connect to satellites.

In general, D2D connectivity is meant to supplement terrestrial networks, extending coverage to areas that are either difficult or uneconomical to serve due to the terrain or low user density. A satellite network can serve subscribers across much of the Earth, particularly if the end-user device has a clear view of the sky. Although satellite networks are ideally suited for covering rural and mountainous areas, they cannot match the efficiency and cost of terrestrial networks in more heavily populated locations. Terrestrial networks have the following key advantages over satellites for serving the vast majority of users:

→ **Capacity** – terrestrial networks operate with much smaller cell sizes and can re-use frequencies to a much greater extent than satellites, which operate from several hundred kilometres in orbit. Satellites are also power (and thus capacity) limited due to their reliance on solar power and need to recharge batteries after passing through the Earth's shadow.

→ **Network cost** – satellite constellations cost billions of dollars to build and launch and are unable to start providing reliable, uninterrupted service until the entire constellation is in place. In contrast, a targeted terrestrial network can be deployed relatively quickly and at relatively low cost to serve a specifically defined geographic area. This more limited capital investment can be quickly recovered from the user base served.

→ **Coverage** – terrestrial networks are better able to provide indoor coverage. In urban areas, they use a combination of multiple small cells and high-power base stations to provide some coverage to indoor users, for example in their homes and offices. D2D connectivity capabilities are improving rapidly but are currently unable to provide similar indoor coverage.

Satellites are particularly suited to serving large, sparsely populated areas where the cost of deploying a terrestrial network would never be justified by the potential number of subscribers. D2D can also provide an emergency backup capability in areas that have terrestrial coverage, ensuring continuity of service in cases where the terrestrial network is unavailable, for example, due to natural disasters.

Apple's Emergency SOS via satellite feature, launched in 2022 using dedicated mobile satellite service ("MSS") spectrum, has already demonstrated how supplementing mobile terrestrial coverage can yield life-saving benefits to users experiencing emergencies in remote, unserved or underserved areas[1].

1 Examples here: https://www.nytimes.com/2026/02/18/us/apple-iphone-sos-satellite-rescue.html
https://www.stuff.co.nz/nz-news/360920969/boaties-rescued-after-becoming-stranded-near-milford-sound

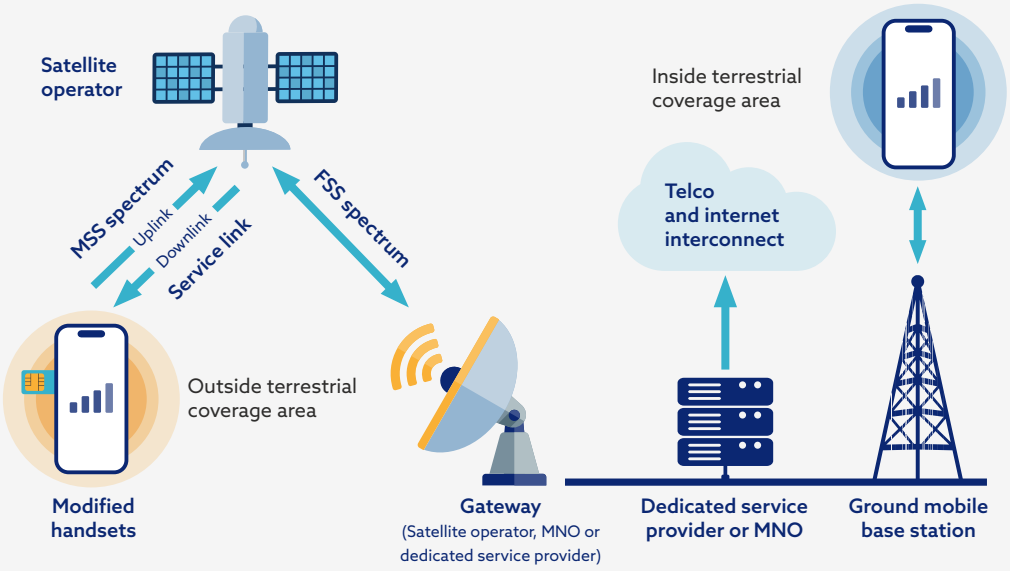
The two main approaches to D2D

D2D connectivity can be provided using spectrum dedicated to mobile satellite services (MSS) or using spectrum dedicated to International Mobile Telecommunications (IMT), in Mobile Service (MS) frequency allocations. Both approaches have their pros and cons.

D2D communications using MSS spectrum

A relatively small amount of spectrum has been harmonised internationally for use by MSS. As different MSS systems can't operate in the same geographical area using the same spectrum (due to their use of omnidirectional antennas), regulators generally authorise specific MSS operators to use a particular frequency band in their national territory.

Key components of a D2D network in **MSS** spectrum



In the case of L-band MSS spectrum in the 1500/1600 MHz band, the assignment of frequencies among several GSO MSS operators is determined under a special MoU process, set up by the relevant administrations many years ago. Inmarsat and Thuraya are examples of L-band MSS operators. This spectrum is predominantly used for safety (for example GMDSS and AMS(R)S) and for mobile satellite phones.

In the case of the S-band MSS spectrum in the 1980-2010/2170-2200 MHz bands, the assignment of spectrum among the operators in Europe was decided by a European Commission-led process in 2008/2009. EchoStar and Inmarsat (now Viasat) are licensed to use the 2 GHz MSS spectrum in the EU until May 2027. In May 2026, the European Commission published plans for a new selection process for use of the 2 GHz MSS bands. The process will be open for prospective new D2D operators. Outside Europe, other administrations have licensed the 2 GHz MSS bands for GSO and NGSO networks to specific operators, such as EchoStar and Omnispace.

Globalstar, which has been operating for two decades, is authorised to provide MSS services in the majority of countries around the world, using the L-band (1610-1626.5 MHz) for uplink and S-band (2483.5-2500 MHz) for downlink. It shares its uplink band with Iridium. The Globalstar downlink band is not used by Iridium but is used by national systems in China (BeiDou Navigation Satellite System – BDS) and India (Navigation with Indian Constellation – NavIC).

Globalstar's satellites cover land masses between 70°N and 70°S, providing a range of MSS services including tracking of remote users, emergency alerting and 2-way voice via satphones. Apple iPhones and the Apple Watch Ultra connect to Globalstar's satellites through Globalstar's licensed MSS spectrum to enable the iPhone's Emergency SOS via satellite feature in a number of countries[2].

The types of D2D services that can be offered using existing MSS constellations are limited in bandwidth, coverage and performance. No current MSS system was designed to provide service to mass-market mobile devices; nor are the majority of mass-market devices in use today able to operate with current MSS allocations. The latest iPhones can use MSS spectrum because Apple introduced custom hardware components to optimise receive and transmit paths for satellite communications without the need for bulky antennas protruding from the phone. It also built a new software stack to handle communication with satellites. Bandwidth limitations were addressed using a compression algorithm to reduce the average size of messages by 3x.

Globalstar is developing a new constellation ("C-3"), with more capable satellites, to provide an enhanced service to iPhone users. Amazon plans to acquire Globalstar and to use its spectrum for D2D services for a broader customer base.

Other satellite operators, in addition to Globalstar, are moving to support D2D services using MSS spectrum. To that end, Space42 and Viasat are forming a joint venture (called Equatys) to wholesale D2D capacity to other satellite operators. The partners say they will have 100 MHz of MSS spectrum available for use by Equatys across 180 markets. They plan to launch Equatys in the next three years.

2 A description of Emergency SOS via satellite and the countries where it is authorised is available at: https://support.apple.com/en-us/101573

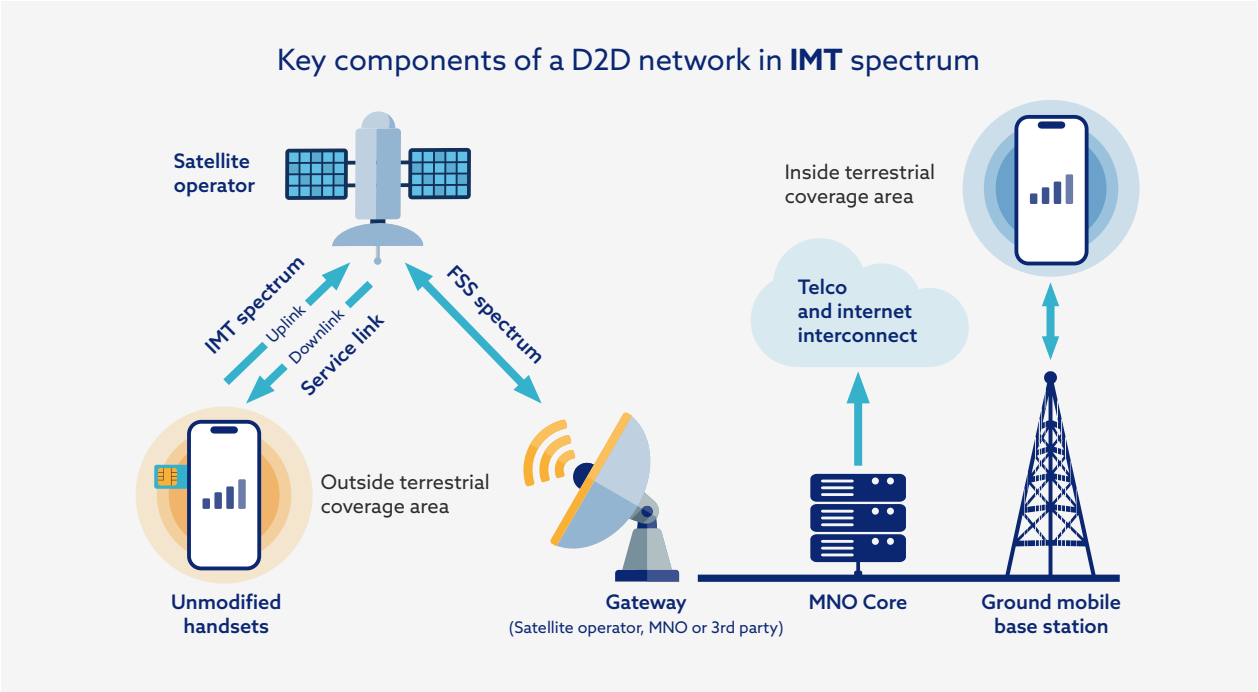
Operator	Coverage	Service	MSS Bands
TerreStar	Canada (GEO)	Voice and data	2 GHz
Starlink/SpaceX	Global (LEO)	Currently using IMT bands, to be launched in MSS bands	2 GHz (acquiring from Echostar)
Globalstar	Global (LEO)	Voice and data	1.6 GHz/2.4 GHz
Iridium	Global (LEO)	Voice and data, including safety	1.6 GHz
Ligado	North America (GEO)	Voice and data	1.5/1.6 GHz
Orbcomm	Global (LEO)	IoT data	138/400 MHz
Space42/Thuraya	North Africa, Asia, Middle East (GEO)	Voice and data	1.5/1.6 GHz
Viasat/Inmarsat	Global (GEO)	Voice and data, including safety	1.5/1.6 GHz + 2 GHz

Table 1: Major MSS operators and related spectrum bands

D2D communications using IMT spectrum

A relatively large amount of spectrum has been harmonised internationally for use by IMT. Utilising this spectrum with satellites is potentially an efficient way of achieving the goal of extending mobile connectivity to the vast geographic areas that are currently unserved by terrestrial mobile networks.

WRC-27 AI 1.13 is exploring this approach. This agenda item is seeking to address the conditions under which IMT spectrum allocations – which are already supported in the majority of mass-market devices – can be used by satellites to provide D2D communications. The section on WRC-27 AI 1.13 provides more detail.



Lynk Mobile, SpaceX and AST SpaceMobile are among the satellite operators developing D2D services using IMT spectrum. In the case of SpaceX, D2D services using IMT spectrum are being provided on a commercial basis to phone users in several countries, through arrangements with an MNO (e.g. T-Mobile in USA, KDDI in Japan, VMO2 in UK). D2D-IMT services from other satellite operators are in a test/pilot phase, as they continue to deploy their constellations.

As things stand, using IMT spectrum for satellite services is not yet specifically permitted under ITU rules and hence is required to operate on a "no interference, no protection" (NINP) basis with respect to those systems which do operate under the ITU rules.

Nevertheless, several countries have adopted, or are currently considering, regulations for D2D in IMT bands. For example, the Federal Communications Commission (the "FCC") has established a Supplemental Coverage from Space (SCS) framework, which introduces new secondary MSS allocations to certain terrestrial IMT bands and some technical rules to control interference to other systems and services in the US.

The FCC requires satellite operators to obtain the agreement of the mobile operators whose IMT spectrum they wish to use. That requirement seems likely to be replicated by other regulators as they consider D2D in IMT spectrum – Australia, Canada and Bahrain have already introduced similar rules to the US. The implications are that a satellite operator will need to negotiate many operator-related agreements to deliver D2D coverage in IMT spectrum globally.

Still, providing satellite connectivity in IMT spectrum will add no extra cost to the production of a mobile device supporting the same frequency bands. Mobile operators can use D2D to extend network coverage and connectivity without investing in terrestrial base stations in remote and less densely-populated areas, with a lower carbon footprint compared to wireless networks.

Market developments

The launch of the first commercial D2D service

In November 2022, Apple launched its Emergency SOS via Satellite feature in partnership with Globalstar under the existing MSS authorisation framework. Apple employs MSS frequencies that are available worldwide. The stable and well-defined MSS regulatory environment also provides the regulatory certainty needed for the swift and widespread availability of this feature.

The Emergency SOS via satellite feature has already demonstrated how supplementing mobile terrestrial coverage with satellite coverage can connect users to help in their time of need and deliver life-saving benefits. This D2D feature has led to numerous emergency and life-saving rescues. In the US, for example, a search and rescue team used information from Emergency SOS via satellite to locate two people whose vehicle plummeted nearly 300 feet off the side of a mountain in the Angeles National Forest. Three college students used Emergency SOS via satellite to be rescued from a deep canyon pool with nearly 500-foot sheer rock walls in Utah.

In Italy, a hiker experiencing a medical emergency in the Alps was rescued by helicopter after using Emergency SOS via satellite in an area with no cellular signal. Two tourists lost in dense forest in Tuscany were also rescued after transmitting their location via satellite. In France, eight hikers stranded overnight in snowbound mountains were reached and later airlifted to safety after a satellite message enabled contact with mountain rescue services[3].

Apple's free emergency feature is now available in 18 countries[4]. It works in places where there is no mobile or Wi-Fi coverage. The user needs to have an active SIM and be able to connect to a satellite. Apple also offers a roadside assistance feature in some markets, such as the US and the UK.

Apple is now expanding its satellite-based features beyond emergency messaging, to support further features and applications. iMessage via satellite, which is being rolled out as part of the iOS 18 update, is now available in North America. The FindMy feature is also available in all 18 countries where the Emergency SOS via satellite feature has been launched.

To ensure no interference when an iPhone user is in an aircraft, the iPhone's satellite-based features do not work when the device is in airplane mode. Further, no transmission from the iPhone would occur without the device first receiving a downlink signal and without establishing the location, so initiating a session inside an aircraft would be extremely challenging. Apple also employs additional proprietary checks to prevent satellite-features from being used on an aircraft other than for emergency-related transmissions.

In April 2026, Amazon announced it will buy Globalstar in a deal that is set to close in 2027. Amazon said that it will continue to support the iPhone's D2D features, as well as launching its own D2D system in 2028.

Further D2D developments in MSS spectrum

In 2024, satellite companies Viasat, TerreStar, Ligado, Omnispace and Yahsat formed the MSSA (the Mobile Satellite Services Association), which is supporting D2D in existing MSS bands and collaborates with the GSMA and the ESA. It has a strong focus on implementing 3GPP NTN standards, which would allow a 5G smartphone to communicate with D2D systems using certain MSS frequency bands. MTN, Qualcomm and Ericsson joined the MSSA in 2025.

3 Examples: https://appleinsider.com/articles/23/07/26/tourists-lost-in-italian-mountains-saved-by-iphone-14-emergency-sos-via-satellite
https://www.corriere.it/tecnologia/23_luglio_25/si-perdono-nei-boschi-in-toscana-salvi-grazie-al-nuovo-servizio-sos-emergenze-di-iphone-14-e9bbba8b-ddc0-4bdd-96fd-ce29744f3xlk.shtml
https://www.laprovence.com/article/societe/81370642362359/huit-jeunes-bloques-en-haute-altitude-par-la-neige-dans-les-alpes-de-haute-provence

4 https://support.apple.com/en-gb/101573

In the US and Canada, specialist service provider Skylo is working with Viasat and Ligado[5] to provide D2D services using MSS spectrum. Skylo has also partnered with Google to support a satellite emergency service for Google Pixel 9 and later phones, and the Pixel Watch 4. Google has said that the satellite feature will be free for two years.

Skylo, which claims to have licences in over 30 countries, says it now has 15 million D2D users, and is now rolling out satellite connectivity in Europe. At the end of 2025, Orange launched a D2D messaging service with Skylo in mainland France. Initially available to 5G and 5G+ customers with a compatible Google Pixel 9 or Pixel 10 handset, Orange said "Message Satellite" will be free for the first six months before a €5 per month fee applies.

In the US, Verizon and Skylo have launched an emergency D2D messaging and location-sharing service for select Google Pixel and Samsung phones. Skylo has since partnered with Syniverse to launch native two-way SMS over satellite for Verizon customers using the same underlying mobile messaging infrastructure – extending beyond emergency messaging to full satellite SMS functionality on compatible devices. In August 2025 Skylo announced the completion of the first voice calls using Narrowband (NB) NTN.

Viasat has demonstrated D2D connectivity using MSS spectrum in India, the Kingdom of Saudi Arabia and the United Arab Emirates. Following the acquisition of Inmarsat in May 2023, Viasat now has a global fleet of L-Band and Ka-Band satellites. Viasat says its D2D technology follows 3GPP release 17 standards and is calling on chipset manufacturers, such as Qualcomm, MediaTek and Sony, to build compatible chipsets. The company has acknowledged it will take time before lower cost phones support its D2D services, underlining its initial focus on developed markets.

Viasat has also forged a partnership with Space42 (based in the UAE) to develop a shared multi-orbit 5G NTN infrastructure employing a standards-based open architecture. In September 2025, Space42 and Viasat announced the formation of a joint venture that will support D2D services across more than 100 MHz of harmonised MSS spectrum, with commercial rollout targeted within three years. Space42 has also signed a MoU with telecoms operator e& to work together on D2D.

The planned joint venture (called Equatys) intends to follow a "shared tower model," which will make capacity available to other operators. Together, Viasat and Space42 plan to build a multi-tenant constellation of up to 2,800 satellites across 60 orbital planes and three altitude layers.

The satellite operators SpaceX and AST SpaceMobile, while focused initially on D2D using IMT spectrum, are also pursuing access to MSS spectrum for D2D. SpaceX has acquired Echostar-licensed 50 MHz S-band spectrum in the US and global MSS spectrum licences. AST SpaceMobile has acquired EllioSat, apparently with the objective to gain that operator's ITU spectrum priority in the 2 GHz MSS bands. AST SpaceMobile also reached an agreement with Ligado for access to L-band MSS spectrum in the US and Canada. These developments suggest that those operators seek to have the option of providing D2D services in both MSS and IMT spectrum.

D2D developments in IMT spectrum

Lynk Mobile, which has launched five test LEO satellites and two commercial satellites, has a commercial D2D service using IMT spectrum in several island nations, such as Papua New Guinea, the Solomon Islands and the Cook Islands. However, users are only able to receive or send SMS text messages every few hours. Lynk intends to also launch voice and mobile broadband services in the future. Lynk says it has regulatory approvals in 30 countries and has more than 40 commercial service contracts with mobile network operators (MNOs) covering approximately 50 countries. Lynk and Omnispace announced a planned merger in 2025, with SES to become a major shareholder (subject to regulatory approval). This may give Lynk opportunities to make use of S-band MSS spectrum, for which Omnispace has ITU filings.

In July 2025, in the US, SpaceX and T-Mobile launched a D2D service in the telco's 1850-1990 MHz band. Supported by 650 Starlink satellites, the service provides messaging and emergency services and is available to T-Mobile customers on premium tariff plans or for a separate charge of US$10 a month.

In March 2025, the FCC granted SpaceX a waiver allowing its Starlink satellites to operate at higher emission power levels in the PCS band to support T-Mobile's D2D service. This approval came despite objections from AT&T, Verizon and EchoStar, who

5 Viasat's and Ligado's satellite constellations reflect signals originating on Earth back down to Skylo's ground stations.

warned of potential interference with terrestrial networks. SpaceX must mitigate any such issues or risk losing the waiver.

US mobile operators are encouraging more satellite operators to serve their market. In May 2026, AT&T, T-Mobile, and Verizon announced plans to form a D2D joint venture to pool their spectrum resources to increase capacity, improve the customer experience, and help satellite providers reach more customers through a unified platform.

In Ukraine, Kyivstar and SpaceX launched D2D services at the end of 2025. In March 2026, Kyivstar said that five million customers had connected to its D2D service and more than seven million SMS messages have been transmitted via D2D. SpaceX has also launched early D2D messaging services in New Zealand, with operator One NZ, enabling certain users to send and receive texts in the 40% of New Zealand's landmass not covered by cell towers.

Having experienced "substantial uptake" of the D2D service, SpaceX and One NZ are increasing the spectrum used for D2D from 5 MHz to 15 MHz, effective from 15 August 2025. This means changing the frequencies used to provide D2D in New Zealand from 1780-1785 MHz to 2500-2515 MHz uplink and from 1875-1880 MHz to 2620-2635 MHz downlink. The increased bandwidth will allow more devices to connect to the D2D service, as well as more advanced data, voice and imaging offerings.

In March 2026, Japanese telco KDDI said that about 60,000 customers a day were using its D2D service, which it launched with Starlink using IMT spectrum in April 2025. KDDI now plans to offer D2D roaming so that customers can access the D2D service offered by T-Mobile when travelling in the US.

In February 2026, Virgin Media O2 launched a D2D service using its IMT spectrum in partnership with Starlink in the UK. Called O2 Satellite, the service supports text messaging and data across various apps, initially for customers with the latest Samsung smartphones.

Both AT&T and Verizon, which has committed US$100 million to AST SpaceMobile, are working with the satellite company to provide a space-based broadband service direct to mobile phones. AST and Vodafone have established a joint venture, called Satellite Connect Europe, in Luxembourg to wholesale D2D connectivity to mobile operators across Europe. The joint venture plans to use both IMT and MSS spectrum. Along with AT&T, Verizon, Google, Rakuten, American Tower, Cisneros Group and Bell Canada, Vodafone is an investor in AST.

AST has started to deploy Block 2 BlueBirds in 2026. They will have 2,400 square foot communications arrays, which are designed to deliver up to 10 times the bandwidth capacity of the BlueBird satellites in orbit today. AST is promising peak data rates of 120 Mbps, supporting voice, full data and video applications. AST has said 45-60 BlueBird satellites could provide continuous space-based cellular broadband in key markets, including the US. In 2026, it plans to launch 45 Bluebird satellites and begin D2D services in the US, Canada, Japan, Saudi Arabia and UK.

AST claims agreements with more than 45 mobile network operators globally, including Vodafone Group, AT&T, Verizon, Rakuten Mobile, Bell Canada, Orange, Telefonica, TIM, Saudi Telecom Company, Zain KSA, Etisalat, Indosat Ooredoo Hutchison, Telkomsel, Smart Communications, Globe Telecom, Millicom, Smartfren, Telecom Argentina, MTN, Telstra, Africell, Liberty Latin America and others.

Demand for the 2 GHz MSS bands

The 2 GHz MSS spectrum – 1980-2010 MHz (uplink) and 2170-2200 MHz (downlink) – could potentially be employed for D2D services. In Europe, exclusive licences held by Viasat and EchoStar were due to expire in May 2027 prompting both the UK and the EU to consult on the future possible uses of the band. In May 2026 the European Commission proposed that the licences be extended a further two years to accommodate a new allocation process, which, amongst other things, will aim to ensure a new European entity has access to some of the band.

Multiple companies, including Vodafone/AST, Skylo, Deutsche Telekom, EchoStar, Globalstar, Inmarsat (Viasat), Omnispace and SpaceX, have noted the spectrum could be used to enable the delivery of D2D services. Vodafone says it would use the spectrum to provide an open platform that European mobile operators could use for narrowband and broadband D2D services. Skylo has noted that its satellite partners in the US have already implemented D2D in the 2010-2025 MHz band.

In September 2025, EchoStar announced it was selling its 2 GHz MSS spectrum to SpaceX for US$17 billion in cash and stock.

In May 2026, the FCC approved the sale of 65 MHz of Echostar's MSS spectrum to Starlink.

SpaceX said it will use the spectrum to deploy a new generation of satellites, which will enable around 20 times the throughput capability compared to the first-generation satellites – a comparable experience to current terrestrial LTE service. SpaceX has said the new satellites, which it plans to launch in 2027, will be able to support D2D video transmissions. As a result, SpaceX plans to use both IMT and MSS spectrum to support D2D services.

Globalstar's planned constellation

Apple is investing approximately US$1.5 billion in Globalstar to fund Globalstar's third generation MSS system. Specifically, Apple is making an infrastructure prepayment of up to US$1.1 billion and acquiring a 20% passive equity stake in a Globalstar subsidiary for US$400 million[6]. It will have rights to 85% of Globalstar's network capacity, including the capacity of the 3rd Generation (C-3) System.

In the meantime, Globalstar's existing satellite fleet consists of 24 satellites, and the company has plans to add up to 26 more to refresh and enhance this existing constellation. Globalstar says its constellation of satellites and ground stations on six continents currently provide mobile satellite services to more than 781,000 end-user customers in more than 120 countries worldwide.

As it takes advantage of the latest technologies, the C-3 System will be more capable than the existing constellation and be able to support more features. Globalstar has said this system will feature higher gain satellite antennas and higher EIRP transmit technology, dynamic beamforming, and more robust signal strength on the ground than Globalstar's existing MSS deployments. The new satellites' spot beams will be dynamically formed based on user traffic, using digital beamforming technology, and their particular EIRP will vary depending on different user services and demand. This dynamic beamforming and beam-hopping design enables efficient and intensive utilisation of the Big LEO MSS downlink spectrum with greater frequency re-use.

Given the greater signal strength and the availability of multiple satellites overhead, users will have access to much-improved in-building and in-vehicle connectivity with less dependency on antenna orientation. With these advanced capabilities, the C-3 System will help stimulate continued development of innovative features and offerings in the D2D marketplace. Globalstar has said it expects revenue will more than double from 2024 levels when the expanded satellite services are operational.

Globalstar has said the C-3 System will consist of 48 operational satellites and up to six in-orbit spares, operating in conjunction with its existing HIBLEO-4 and HIBLEO-X deployments. Like Globalstar's existing satellites, these new satellites will be bent-pipe repeaters. With an expected lifespan of 12.5 years, they will also operate at the same orbital altitude (1414 km), the same inclination (52 degrees), and in the same frequency bands (for service links, feeder links, and TT&C) as Globalstar's existing satellites. Globalstar currently has approximately 24 terrestrial gateways, which its satellites use to connect to the internet and PSTN networks. The C-3 System will be supported by approximately 90 new earth station antennas at approximately 35 gateway earth station facilities located in at least 25 countries and territories around the world – Globalstar is aiming to maximise its coverage of inhabited regions subject to natural and man-made disasters. Globalstar's feeder and TT&C (telemetry, tracking and command) links between a satellite and ground station are at 5091-5250 MHz/6875-7055 MHz.

The C-3 System satellite bus subsystem and payload are being designed and manufactured by MDA Space. Globalstar's purchase of the C-3 satellites, their launch and deployment, and the construction of associated ground infrastructure represent an overall investment of more than US$1 billion.

Amazon, which has agreed to buy Globalstar, has said that the new constellation will operate alongside its Amazon LEO broadband system and Amazon's planned D2D satellite system.

6 Source: https://investors.globalstar.com/static-files/95834b8c-28d2-49c6-b931-e922aa58c25f

In March 2024, the US FCC rejected a request from SpaceX to operate in the same frequencies as Globalstar, noting that no additional "Big LEO" operators are envisaged in those bands. In August 2024, the FCC granted Globalstar's application to extend the term of its senior HIBLEO-4 authorisation by an additional 15 years and operate up to 26 replacement satellites. That means Globalstar can continue to operate satellite and communications solutions. Significantly, the Commission has reaffirmed its prior decisions regarding Globalstar's exclusive operations in its licensed portion of the Big LEO Band.

In some countries, Globalstar also has authorisation of the band 2483.5-2495 MHz (3GPP band 53 and n53) for Auxiliary Terrestrial Component (ATC), also referred to as Complementary Ground Component (CGC in Europe). ATC/CGC operates in TDD mode. The frequencies used for such terrestrial services would be separate from the frequencies used for the Apple satellite service.

Noting that its spectrum is already the most widely used of all the MSS bands, Globalstar has said[7] its usage "of its few megahertz of MSS spectrum in the Big LEO band will continue to increase rapidly as consumers adopt an expanding range of new D2D satellite features." To encourage investment, it is important to ensure regulatory certainty and stability in the Big LEO MSS band.

7 As detailed in Globalstar's response to Ofcom's July CFI "Improving Mobile Connectivity from the Sky and Space".

WRC-27 AI 1.13

Agenda Item 1.13 for WRC-27 aims to establish the conditions under which terrestrial IMT spectrum can be used by satellites to provide D2D communications.

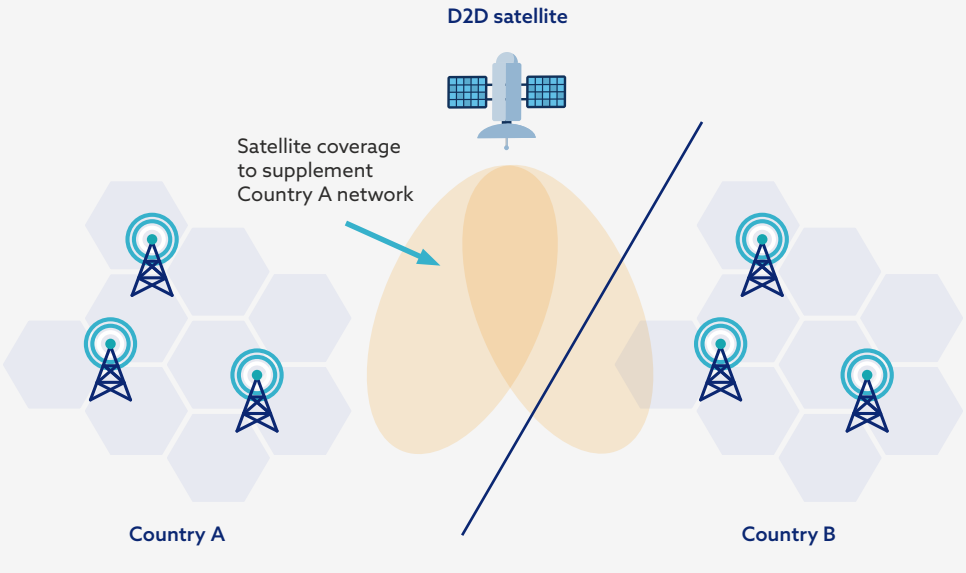
There are multiple co-existence issues that will need to be addressed, however a key priority will be to avoid cross-border interference that could arise from a D2D network operating in IMT spectrum. Unless its power levels are constrained in the areas near national borders, such a network could interfere with terrestrial IMT networks in neighbouring countries operating in the same frequencies (as depicted in Figure 1).

In Figure 1, Country A's terrestrial networks are supplemented by satellite coverage, with an agreement in place between the D2D operator and the terrestrial operator. However, the territory of Country B and its terrestrial networks are affected by the satellite emissions.

To prevent such cross-border interference, a power flux density (PFD) limit is likely to be adopted, that will translate into a separation distance required between terrestrial and satellite coverage areas to ensure the satellite service does not cause interference to terrestrial networks. The D2D operator will wish to minimise the separation distance, to ensure that the valuable spectrum is not wasted by this distance requirement.

Studies under AI 1.13 will also have to take into account existing MSS global and regional allocations that overlap with some of the IMT allocations. In addition to these studies, the ITU will have to determine how use of IMT frequencies would fit into the ITU satellite filing regime. This is important for protection of satellite receivers using IMT frequencies. It also provides a way of managing interference among satellite operators that may be providing service in the same frequencies. As Radio Regulations Article 4.4 does not provide sufficient regulatory certainty to satellite and terrestrial network operators or their administrations, the most effective means of enabling use of terrestrial frequencies by satellite systems would be to adopt additional new MSS allocations for D2D that are subject to specific sharing rules to protect terrestrial networks, other satellite systems and other relevant services.

Figure 1: Cross-border Interference



Implementation of D2D in IMT bands raises several issues from different stakeholders; including the MNOs providing the service, handset manufacturers, satellite operators and the consumers that will use D2D services. As regulators prepare to enable D2D services, the interests of varying stakeholders are worth considering.

Stakeholder key interests and concerns for D2D

Consumers/Users

- Will D2D be affordable?
- Will emergency services be available to the same level of reliability as terrestrial?
- Will users know when they are on satellite networks and know the limitations of satellite services compared to terrestrial service?
- Will information be available to consumers to enable them to make informed choices regarding D2D services both at home and when travelling?

Mobile Network Operators

- Extend coverage of their terrestrial networks, avoiding costly investment to fulfil universal service obligations.
- Build network resiliency through emergency connectivity when terrestrial network unavailable due to natural disasters.
- New revenue streams from providing services to previously unserved areas.
- Pathfinder for identifying potential areas for network extension.
- Revenue from leasing IMT spectrum to satellite operators.
- Keen to ensure satellites' usage of IMT bands doesn't result in interference for terrestrial networks.
- Need to manage users' expectations regarding network quality, emergency services, lawful intercept and service availability.

Network Equipment Manufacturers

- Protect terrestrial IMT from interference.
- D2D may reduce the demand for base stations in some areas.

Device Manufacturers

- Unlike base station/core network manufacturers, user equipment (UE) manufacturers will have to work with both terrestrial and satellite networks.
- D2D must not cause interference to UE.
- Satellite function must not add unacceptable cost to UE.
- Trade-offs between the added cost and benefits versus user expectations with respect to network quality, emergency services, lawful intercept and service availability need to be managed.

Satellite Operators

- New business model and source of revenue from serving unserved areas.
- Opportunity to partner with mass-market telecom services.
- Operation must somehow fit into satellite regulatory framework, including ITU filings.
- Protection for space stations and from interference between satellite-based services.
- Other services must be protected from interference.

Can more spectrum be made available for D2D?

There is a case for making more spectrum available for MSS in a sensible, rational and harmonised way.

As discussed earlier in this paper, both existing MSS and IMT spectrum could be used for D2D with sufficient safeguards to prevent interference with incumbent services. With respect to existing MSS spectrum, the 2 GHz MSS spectrum is a suitable band for D2D and has been harmonised, as recognised by many of the respondents to the European Commission Radio Spectrum Policy Group (RSPG) consultation on the future of this band[8].

WRC-27 will play an important role in identifying potential additional spectrum that can be used for D2D services. Agenda Item 1.13 is particularly significant as it calls for studies on possible allocations of IMT spectrum for direct connectivity between satellites and IMT user equipment to complement terrestrial network coverage and fill in IMT coverage gaps. Other WRC-27 agenda items are also seeking to make available additional spectrum for MSS, that could be used for D2D services: AI 1.12 (focused on narrowband NGSO MSS) and AI 1.14 (focused on new MSS allocations around 2 GHz).

To what extent can MSS spectrum be shared?

In general, there is little scope for two MSS systems to operate on the same frequencies in the same geographic area. This is primarily due to the fact that MSS terminals utilise small, non-directional antennas.

The signals transmitted by two independent satellite systems with equal PFD in a particular country will therefore be received with the same power by an MSS terminal receiver in that country. The interfering and the wanted signal levels would be approximately equal, preventing the MSS terminal from successfully decoding the wanted signal.

In MSS downlink bands, terrestrial systems could receive interference from MSS satellites and could cause interference to any MSS terminals operating in the vicinity. In MSS uplink bands, terrestrial systems could cause interference to MSS satellites and could receive interference from MSS terminal transmitters operating in the vicinity. Some limited sharing is permitted by regulators in some countries, for example for use of MSS bands for wireless microphones or short-range devices that are typically used indoors and therefore present a low interference risk.

To ensure they use frequencies efficiently, MSS systems typically utilise large antennas onboard the spacecraft – up to approximately 20 metres diameter – capable of producing tens or hundreds of individual narrow beams simultaneously. This allows the same frequency to be used multiple times, among different beams covering different geographic areas.

8 Source: https://radio-spectrum-policy-group.ec.europa.eu/consultations-0_en

How to ensure D2D doesn't interfere with other services

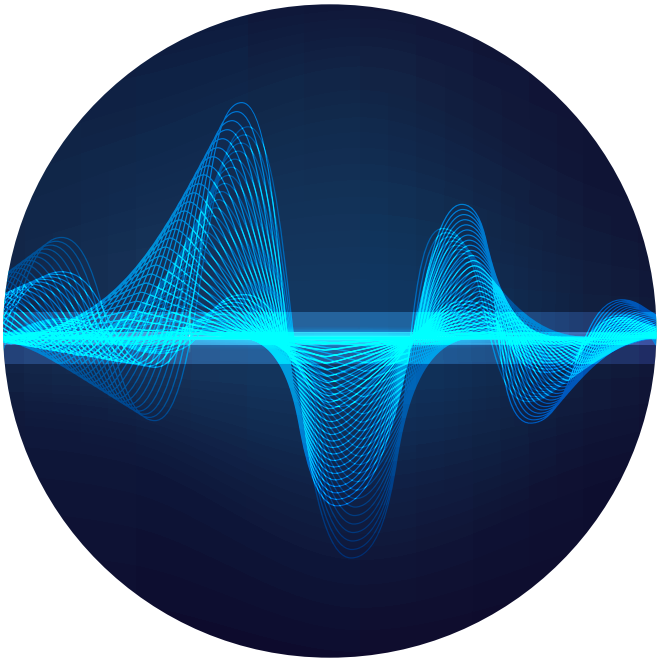
Sharing with terrestrial IMT

A terrestrial network and satellite network can both use the same IMT frequencies so long as the separation of terrestrial and satellite coverage areas is sufficient to ensure that the satellite usage does not cause interference to the terrestrial network, and to ensure that the terrestrial usage does not cause interference to the satellite.

As discussed in the section on WRC-27 AI 1.13, satellite coverage using IMT frequencies will have significant coverage gaps at national boundaries to avoid interference to other terrestrial networks in neighbouring countries.

In Europe, where there are large numbers of relatively small countries, that would significantly reduce the utility of the service. Note, a global ITU allocation for satellite use in mobile bands would not remove the need for cross-border protection requirements for the mobile service and any other service, given that each national market generally has different terrestrial operators.

D2D services in IMT spectrum are best suited to countries with large rural areas and few borders – the US, Canada, Australia and a few other similar countries have already put into place national regulations to allow D2D. Some small island nations have also allowed the practice.



Co-existing with services in adjacent bands

Users of the bands adjacent to the IMT spectrum employed for D2D services will need to be protected from interference. The best way to do this is being studied by the working parties preparing for WRC-27.

It is important to ensure that the protection levels for IMT systems, including for cross-border, should not give a competitive advantage to D2D operators in the IMT bands over MSS operators.

It is also important that any new regulatory limitations for D2D in IMT bands do not spread into the existing and/or future MSS bands. D2D in IMT bands and D2D in MSS bands should be regulated as distinct offerings with no or minimal changes to the MSS authorisation framework.

Nature of the service and user expectations

As D2D technologies will use a diversity of spectrum bands, each with distinct characteristics, terrestrial and satellite operators will need to consider how to ensure a smooth handoff between D2D and other features. Regulators should elicit more details about how terrestrial and satellite operators plan to achieve seamless interconnectivity, including any planned reliance on industry standards.

While most companies proposing D2D communications advertise that using IMT frequencies will allow service to be provided to unmodified cell phones, it is unclear whether they plan to alert users that they have roamed on to a satellite network. User transparency will be essential to the success of widespread satellite connectivity to handsets. Users should be equipped with clear information about how D2D and non-D2D features work and interoperate, including any limitations on functionality that may make them want to opt out of using a particular offering. Users also should know how their personal data, including their location, will be used and protected by D2D and non-D2D features and ecosystem participants.

Emergency services

As described by Apple in comments made to the US FCC[9], Emergency SOS via satellite allows users to contact public safety officials from areas that were previously considered out-of-reach. Apple engages with public safety answering points (PSAPs)[10], other public safety organisations, and local governments early and often to collect feedback and educate them on Emergency SOS via satellite. Beyond the satellite network, Apple built dedicated cloud infrastructure to process the data coming from the phones via the satellite and communicate to the PSAPs. While a growing number of PSAPs are able to handle emergency communications via text in the US, a significant number have yet to adopt this capability. To address this issue and allow all iPhone users to benefit from Emergency SOS via satellite even in areas that do not support text-to-911, Apple put in place relay centres where trained agents receive messages from users and make the call to the PSAP on the user's behalf to convey the information necessary to getting the user the help they need.

With other D2D proposals, it is unclear what will happen when a user dials an emergency number such as 112/911. As Apple's experience shows, significant planning and coordination with PSAPs is required to ensure that an emergency call made from a satellite-enabled phone goes to the right emergency responder. Failure to adequately address the need to provide emergency services and the user expectation that these services will be available could have catastrophic consequences for the user. It is also unclear whether the position information PSAPs rely on to respond to emergency calls will be available.

9 https://www.fcc.gov/ecfs/document/1080625352148/1

10 Call centres that receive emergency calls from the public and coordinate the dispatch of appropriate emergency services (such as police, fire or medical assistance).

Conclusions

D2D in MSS bands and D2D in IMT bands will both have an important role to play in ensuring ubiquitous connectivity. However, the latter needs to overcome significant regulatory and technical challenges to accommodate access to the IMT bands, protect the performance of the mobile network and to manage cross-border interference risks.

In both cases, creating regulatory certainty to promote investment will be critical in enabling the success of D2D features. Any new framework must, of course, take account of stakeholder issues and ensure that neither the deployment of new D2D services, nor any new regulations, result in a loss of features or performance currently available to users.

WRC-27 Agenda Item 1.13 will establish new international regulations, intended to ensure that international interference risks are properly managed, but there will remain national considerations and a need to develop new national regulations for D2D in IMT bands.

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