Leveraging terrestrial mobile spectrum for D2D capacity

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The opportunity to use mobile spectrum on the earth's entire surface

Spectrum for satellite-based communications features prominently on the WRC-27 agenda, while mobile services are also seeking access to additional spectrum. Direct-to-device (D2D) LEO satellite technology is among the most interesting recent developments, particularly given that mobile phones account for by far the largest number of radio communications devices. There is a perception that D2D satellite and terrestrial mobile services must compete for spectrum. However, aside from marginal exceptions, the spectrum demand for these two uses does not in fact overlap.

Around 29% of the Earth's surface is land and 71% is sea. Only around 30% of the Earth's landmass is covered by terrestrial mobile networks. Terrestrial mobile coverage varies widely, ranging from close to 100%, such as 99.4% in the Netherlands, to around 39% in Australia, 37% in Canada, and much lower percentages in many countries with low population density.

With mobile only covering 30% of the earth's landmass and only 29% earth's surface being land, terrestrial mobile spectrum is only used on around 10% of the globe's surface. Given the substantial amount of spectrum allocated to mobile, this seems very inefficient. Put another way, in 90% of the globe's surface there is no shortage of spectrum.

With mobile networks covering only around 30% of the Earth's landmass, and with land accounting for just 29% of the Earth's surface, terrestrial mobile spectrum is effectively used across only about 10% of the globe. Given the substantial amount of spectrum allocated to mobile services, this appears highly inefficient. Put another way, across roughly 90% of the Earth's surface there is no shortage of spectrum.

Terrestrial mobile spectrum could be used to substantially increase D2D capacity precise where it is needed the most. Using D2D LEO satellites to serve land areas where there is no terrestrial mobile coverage differs from ocean coverage. In the following I will first look at D2D use to cover land areas and secondly explore using terrestrial mobile spectrum over the oceans.

Terrestrial mobile spectrum could instead be used to substantially increase D2D capacity precisely where it is most needed. Using D2D LEO satellites to serve land areas without terrestrial mobile coverage raises different considerations from providing coverage over the oceans. In the following sections, I first examine D2D use for land-area coverage and then explore the use of terrestrial mobile spectrum over the oceans.

D2D LEO satellites serving land areas

At a global level, more than 96% of the population live in areas with mobile internet coverage. However, while 96% of the population could in principle use mobile services, around 38% of the world's population do not, with barriers other than coverage availability keeping them offline. D2D will not close the usage gap, but it does have the potential to make mobile connectivity possible across the entire surface of the Earth. This matters not only for people, but also for cellular IoT. Seamless global coverage is, of course, a core design objective for 6G.

Demand for mobile spectrum is driven by traffic density (measured as area traffic demand in Mbit/s/m²) which is highest in densely populated urban environments. Areas without terrestrial mobile coverage are typically those where, even if coverage were available, area traffic demand would be very low. Attempting to materially increase coverage in such areas by building cell towers in remote locations defies the economics of terrestrial mobile networks.

Recognising the benefits of 100% geographic coverage, several national regulators have permitted mobile operators to deploy their licensed spectrum on LEO satellites.

This is a pragmatic approach, provided it does not cause interference with neighbouring countries. Large countries with few borders and extensive low-density regions, such as the United States and Australia, were early movers, but others, such as the UK, are now following suit.

Mobile operators generally view terrestrial and D2D use of their licensed spectrum as complementary. However, operators deploying spectrum on LEO satellites must face the issue of potential interference if the same band is used both on satellites and on terrestrial cell sites.

The problem might be manageable:

- Satellite beams can now be as small as around 50 km in diameter and can be switched off as a satellite passes over areas where the same band is used for terrestrial coverage.
- D2D connectivity requires line of sight; in built-up areas, buildings and trees along streets can effectively block satellite beams.
- At many rural cell sites, mobile operators have not deployed all FDD mid-bands, meaning there would be no in-band interference in rural areas.

Mobile operators could choose to use an entire FDD band for D2D use, and this is likely to make economic sense. Legacy FDD bands with relatively narrow spectrum allocations are becoming less useful to operators, as it is much cheaper to build area traffic capacity using TDD bands, which allow the deployment of 100 MHz per operator in a single radio, and soon 200 MHz, for example in the upper 6 GHz band. The cost per bit in a 100 MHz TDD channel is far lower than in a 2 x 10 MHz FDD configuration, such as in Band 1 (2100 MHz FDD).

Band 1 (2100 MHz) is assigned in ITU Regions 1 (Europe and Africa), 3 (Asia and Oceania), and parts of Latin America, and comprises 2 x 60 MHz in total. An operator would typically hold an assignment of only 2 x 20 MHz. While 20 MHz was well suited to LTE (4G), given that LTE's maximum channel bandwidth is 20 MHz, it compares unfavourably with 100 MHz or even 200 MHz TDD channels used for 5G.

The use of spectrum within a country's territory is governed by national administrations and, as mentioned above, several administrations have already permitted the deployment of terrestrial spectrum on LEO satellites. However, a coordinated regional approach could be beneficial in order to avoid cross-border interference.

- The European Union Radio Spectrum Policy Group has issued an *"Opinion on the EU-level policy approach to satellite Direct-to-Device connectivity and related Single Market issues"* (RSPG25-020 FINAL, 17 June 2025), which provides a comprehensive discussion of the key issues. Given that most European countries are small and densely populated, using terrestrial frequencies on satellites may be impractical unless a multinational approach is adopted - for example, one encompassing all CEPT countries.
- Other regions could also benefit from a harmonised approach. For instance, countries within the ATU (African Telecommunications Union) and the ASMG (Arab Spectrum Management Group) grapple with a lack of geographic coverage and could work towards harmonised use of Band 1 for D2D connectivity.

D2D LEO satellite serving oceans

Spectrum identified by the ITU Radio Regulations for land mobile use is licensed by national administrations to operators for use within a country's territorial boundaries, including areas near the coast. This means that across around 71% of the Earth's surface, this spectrum is not licensed and therefore not used.

The only route to making this spectrum useful for D2D would be through the ITU. I briefly discussed this idea with Mario Maniewicz, Director of the ITU Radiocommunication Bureau, at the Global Forum Latin American Spectrum

Management Conference in Brasília in February 2024. He considered the idea worth exploring and agreed that the ITU would be the appropriate forum for this discussion.

Depending on the country and region, around 600 MHz (2 x 300 MHz) of low and mid-band FDD spectrum is allocated to mobile services. Bringing this spectrum into use for communications on ships and remote islands could substantially enhance connectivity for these use cases.

LEO satellite beams can have diameters as small as 50 km. Today's spectral efficiency for D2D use is only around 0.2 to 0.5 bit/s/Hz, but this is expected to increase to around 1 bit/s/Hz, yielding an area traffic capacity of approximately 3.8 Mbit/s/km². While this is modest compared with the area traffic capacity delivered by terrestrial cellular networks in dense urban environments, over oceans the area traffic demand is likely to be low. As a result, users could expect peak and average speeds suitable for email, messaging, browsing, voice calls, and even video calls.

About Stefan Zehle, CEO, Coleago Consulting Ltd

30 years experience in telecoms, Director of mobile operating company, specialises in spectrum valuation, renewal, policy, and other spectrum related issues . Stefan gained his experience working in 65 countries on all continents. As the 2nd person on the ground and Director of Marketing, Strategy & Regulatory he played a pivotal role in launching the 3rd Algerian mobile operator. Speaker at the Mobile World Congress in Barcelona and spectrum international conferences. Recent publications include the "The need for sub-1 GHz spectrum to deliver the vision of 5G", report for the GSMA (2022) and "Demand for IMT spectrum in the 2025-30 timeframe", model and report for the GSMA for WRC-23 (2021). Co-author of the Economist Guide to Business Planning. MBA with distinction from University of Westminster, London.

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About Coleago Consulting Ltd

Founded in 2001, Coleago is a telecommunications consulting and training firm. We offer an experience-based consulting approach, with project teams entirely made up of partner-level consultants, each with a minimum of 20 years' experience in the telecoms sector. Our advice is therefore based on practical experience and proven processes and methodologies developed over many years. Since 2001 we have carried out over 160 spectrum projects in developed and emerging markets on all continents.