

Summary report: BEREC workshop on secure and reliable connectivity from LEO satellite fleets, 13 April 2023

8 June 2023

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1. Executive Summary

On the 13th April BEREC conducted an external workshop on secure and reliable connectivity from low earth orbit (“LEO”) satellite fleets. The purpose of the workshop was to develop an understanding of direct-to-cell connectivity and relevant regulatory issues which might arise. BEREC’s primary interest was to ignite discussions on the market access issues facing relevant industry stakeholders.

BEREC held an open call for interest to present at the workshop, which was well received by stakeholders across the satellite and mobile industry value chain¹. The final agenda included eight expert presentations from an equipment vendor, a mobile network operator (“MNO”), and several satellite operators (“SNOs”, including some from the LEO subset of satellite industry).

On this occasion, BEREC operated an “elevator-pitch” style of workshop so that it could hear several different perspectives at the event.²

The workshop was virtual only and with prior registration required, 179 participants (from over 260 registrations) attended the event.

Expert presenters were unanimous about the great potential current and future new prospects from satcom connectivity. Expert presenters also framed the discussion so that BEREC should think of direct-to-device (D2D) rather than direct-to-cell. In this regard, the number of devices such as normal unmodified smartphones which may be connected is broad and new use cases can be expected to emerge due to this trend of convergence enabling users to connect with their smartphones directly to satellites. There were discussions about existing services direct-to-device as well as some proof of concepts.

Between the expert discussions, it is clear that the 3GPP standardisation of non-terrestrial networks (“NTNs”) has played a commanding role in establishing a good basis to increase options to close the connectivity divide from space; i.e. that satcom is a complement to terrestrial and can close coverage gaps in hard-to-reach areas.³

The initial satellite-to-device services include emergency services, text services, IoT services. When additional LEO satellites are launched more capacity will be available and services will be extended with voice and data connectivity at locations with no coverage of fixed or mobile terrestrial networks.

¹ The call for interested parties to present is set out at Annex A, which also provides background information on the wanted format of presentations from stakeholders.

² In total there were eight high-level elevator-pitch presentations, not including two stakeholders who had to apologise before the event (one handset and one chipset manufacturer stakeholder). Presentations were from Globalstar, SpaceX, Deutsche Telekom, AST Space Mobile, Ericsson, Echostar Mobile Ltd., Rivada Networks and SES, available [here](#).

³ See also the BEREC report on satellite connectivity for Universal Service [here](#) and the report on the outcomes of the public consultation on satellite connectivity for Universal Service [here](#).

All presenters from the satellite industry referred to future innovations and new launches / satellite upgrades, and so set out an optimism that there's a lot more new and more powerful direct-to-device services / use cases to come which will likely to be supported by increasing satellite capacities.

The topic of space sustainability was mentioned by several expert presenters, with one suggesting that satellite lifetime and de-orbiting procedures would be a feature that would distinguish it from its competitors.

The audience contributed several questions to presenters; some seeking technical factual clarifications on radio frequency bands mentioned in presentations, others asking questions on devices which have been tested on networks, potential for use-cases to support supervisory control and data acquisition ("SCADA") in electric / utility industries, about operations of 112, roaming aspects and more.

Given the time constraints not all questions could be asked or answered. For example, there was insufficient time to explore details about how emergency communications interface with the public safety answering points ("PSAPs") in countries, how satellite connectivity might work to develop to the point that it could work indoor (near window) / in car in the future, and how individual satellite networks might support connections from different mobile network operators when their subscribers were outside of coverage areas (i.e. a neutral host type solution).

Overall, BEREC believes the workshop contributed to achieving the objective to improve its understanding of direct-to-device connectivity. BEREC would like to thank the expert presenters and audience who made the discussions engaging and insightful.

Next steps and recommendations for future work

After careful consideration of the expert presentations and discussions, BEREC believes that it is important that it continues to explore satellite communications, particularly this direct-to-device (D2D) aspect.

On the main topic of market access, and bearing in mind that there seemed to be two main approaches to provide direct-to-device connectivity set out by presenters as follows; via

- (1) mobile satellite service ("MSS") bands⁴ or
- (2) based on a theoretical model, and in absence of real applications until now, an SNO-MNO agreement about the rights to use the respective terrestrial radio spectrum bands identified for IMT has yet to be processed by regulators in Europe

BEREC set out at the conclusion of the workshop two further points:

⁴ 3GPP standardisation of NTN is focusing on MSS/FSS spectrum allocations.

1. Stakeholders should continue to engage regularly and early with regulators, and
2. BEREC should be open to dialogue with other regulators / competent bodies to better understand the possible authorisation requirements.

2. Introduction: Workshop materials

This chapter sets out some context based on the materials provided to registered participants.

2.1. Agenda: BEREC Workshop on secure and reliable connectivity from LEO satellite fleets

Location:	Videoconference
Date & Time:	13 April 2023, 13.30-16.00 CEST

13.30	Workshop starts	
	Opening remarks by WNE WG co-chairs	13.30-13.35
	<i>Mr. Sietse van der Gaast – ACM, the Netherlands</i>	
	<i>Mr. Joe Lynch – ComReg, Ireland</i>	
	Presentations on direct-to-cell (c.6-8 min per speaker)	13.35-15.30
	<ul style="list-style-type: none"> ○ Globalstar <i>Mr. Barbee Ponder - General Counsel & Vice President Global Affairs</i> ● Deutsche Telekom <i>Mr. Thomas Konschak - Senior Manager Spectrum Policy</i> ● SpaceX <i>Mr. David Goldman – Senior Director, Satellite Policy</i> ● AST Space Mobile <i>Mr. Vikram Raval – Head of Global Regulatory Affairs</i> ● Ericsson <i>Ms. Evanny Obregon – Product Manager RAN</i> ● Echostar Mobile Ltd. <i>Ms. Jennifer Manner - Head of Regulatory Affairs</i> ● Rivada Networks <i>Mr. Thomas Grob - Vice President Market Access</i> ● SES <i>Mr. Jean-Pierre Choffray – Vice President, Systems Engineering</i> 	
	Q&A with WNE WG experts between presentations	
	Wrap up and closing remarks by WNE WG co-chairs	15.30-15.40
15.40	End of Workshop (meeting room closes 16:00)	

2.2. Key points of Presentations from expert speakers

BEREC thanks all the expert presenters for their interesting views and discussions.

It is worth recalling that BEREC made a call for interested parties to present and provided some questions/themes in advance (please see Annex A for further details).

Hyperlinks to the relevant presentations by some of the invited speakers are published alongside this report, and these set out the definitive positions of the expert speakers. A summary table of the different presented approaches can be found in Annex B.

To give readers some further insight into workshop, we set out some points below:

Services (including mentioned proof of concepts)

- A presenter set out information about the world's first emergency / distress communications / SOS features it enabled in combination with a handset manufacturer. Usage of this SOS feature in smartphones is growing in its view, and it observed that this can be a vital end-users service in emergency circumstances
- Public safety resilience / backbone / backhaul etc – was mentioned by other presenters, and one also suggested aeronautical use cases
- One presenter mentioned the type of opportunities it can offer for LoRa services, and for IoT connectivity generally
- Most presenters acknowledge that presently direct-to-device services are low bitrate narrowband services which it can be seen as a complement to terrestrial coverage for those who have no connectivity
- Services suiting industrial users (oil and gas offshore platforms) was mentioned by one presenter, and enterprise IoT / logistics set out by another
- One presenter also set out that latency insensitive use cases can be supported (most likely in a combined set up with satellites in other space orbits stationary, making mention of media distribution as an example)
- Another presenter briefly set out the model of wholesaling capacity as a service
- In addition to business-to-business services, a presenter indicated the possibility for business-to-government services. A comment from the audience, seeking more information at the workshop about the status of the European Commission's IRIS² (USC⁵) project was noted, but could not be addressed due to time available at the workshop

⁵ The EU Union Secure Connectivity program, a program established under regulation (EU) 2023/588EU

- A New Proposed RuleMaking (NPRM) currently in process towards adoption in the USA from the FCC was noted, aiming at 2024 to start service provisioning

Coverage

- The coverages mentioned by expert presenters included local / continental / global (polar-to-polar, in the words of one presenter) with many presenters highlighting the importance of reaching dedicated areas where the satellite can cover but that the terrestrial network cannot reach e.g remote / hard-to-reach areas
- Sea and aeronautical (matching to particular use cases / proof of concepts) areas were mentioned

Future services

- 3GPP NTN Wideband direct-to-device services (also voice and VoLTE was mentioned by a presenter, and in the interim since the workshop BEREC notes further proof of concepts being demonstrated⁶)
- 3GPP Release 18 will examine use of higher capacity spectrum bands for NTN, which may open more opportunities – 5G/6G
- One presenter concluded that the innovation is accelerating so the next years (and upcoming launches) will have next generation satellite connectivity capabilities
- Another presenter set out that beamforming antennas will also give rise to dynamic coverage so potentially more use cases that have not yet been identified may emerge

Market access

- The issue of market access was clear for some presenters – based on priority filings and use of MSS bands already assigned – or based on their experience in other continental regions and working with regulators there. In Europe, however, the issue of NTN via terrestrial IMT bands (based on the proof of concepts) seems less clear, and according to one presenter No. 4.4. of the Radio Regulations should be sufficient if an MNO has an agreement in place with a space infrastructure provider
- In the view of another presenter, requirements for lawful intercept and gateways (“GWs”) on the ground is a barrier to concepts of meshed space infrastructure
- Another presenter set out that market access was about jointly going to market together with MNOs; a sort of co-operation rather than a competition

Other issues

- Presenters set out other points some of which BEREC may consider in future work, such as that international roaming may be impacted by satellite direct-to-device, access to spectrum is part of the regulatory certainty needed, working on direct-to-

⁶ <https://spacenews.com/ast-spacemobile-conducts-first-direct-to-device-voice-test/>

device in MSS bands takes time (acceptance and conformity testing time needs to be taken into account) – therefore regulators need to act now, so as to not delay market access.

2.3. Panelist's biographies

Mr. L. Barbee Ponder IV – General Counsel & Vice President Global Affairs, Globalstar

Barbee has served as General Counsel and Vice President of Regulatory Affairs for Globalstar since July of 2010. He has overseen and directed Globalstar's regulatory and licensing efforts around the world. Most recently, Barbee lead the regulatory effort required to enhance and expand Globalstar's network of 28 gateway earth stations in 18 countries to support the commercial rollout of the first commercially available, satellite-enabled direct to handset service.

He holds a law degree from the Emory University School of Law in Atlanta, GA and a Bachelor of Science in Management degree from Tulane University's A.B. Freeman School of Business in New Orleans, Louisiana.

Mr. Thomas Konschak – Senior Manager Spectrum Policy, Deutsche Telekom

Thomas Konschak, born in Berlin in 1966, is Senior Manager for Spectrum Policy in the Department „Group Public and Regulatory Affairs“ of Deutsche Telekom AG.

He studied Electrical Engineering at the Technical University of Dresden and graduated with a degree as Diplom-Ingenieur.

He began his career in 1992 at Detecon GmbH moving afterwards to T-Mobile Deutschland. He worked in several positions in the network planning department.

Beside technology he also dealt with joint venture management and corporate governance issues within T-Mobile International.

In 2011 he joined the Spectrum Policy team and represents Deutsche Telekom in several national, CEPT groups. As part of the German delegation he participated in WRCs in 2012, 2015 and 2019.

Mr. David Goldman – Senior Director, Satellite Policy, Space X

David Goldman is the Senior Director of Satellite Policy for SpaceX. Prior to joining SpaceX in 2018, he was the Chief Counsel for the Communication and Technology Subcommittee since January 2015. Before that, he served as the Senior Legal Advisor for FCC then-Commissioner Jessica Rosenworcel. He was the Commissioner's chief advisor on wireless, international, and public safety issues, along with responsibility for other issues of policy, strategy, public relations, and office operations.

David joined Commissioner Rosenworcel's office from the United States Senate Committee on Commerce, Science, and Transportation, where he served on detail as Counsel to the Subcommittee on Communications, Technology, and the Internet.

Prior to serving on Capitol Hill, David served in a number of positions at the FCC, including in the office of Chairman Genachowski and as a Policy Advisor to the Chief of the Wireless Telecommunications Bureau. He joined the agency as an Honors Attorney, serving as Attorney Advisor in the Spectrum Competition and Policy Division of the Wireless

Telecommunications Bureau. Before this, he served as Staff Law Clerk at the United States Court of Appeals for the Seventh Circuit in Chicago. He also worked as an associate at the law firm Hughes Hubbard & Reed in New York.

David received his law degree from the University of Pennsylvania and his undergraduate degree from the University of Florida.

Mr. Vikram Raval – Global Head of Regulatory Affairs, AST Space Mobile

Vikram is a communications regulatory and policy specialist, with a focus on international telecoms regulatory matters and multi-lateral negotiations. With 20 years telecoms experience Vikram has worked on a range of communications sectors including fixed, mobile, business, consumer, and now a unique direct to mobile satellite solution.

Prior to this, Vikram was Senior Regulatory Director, International Affairs and Technology Policy at GSMA. He led on range of issues with the GCC, CRASA, APT, ATU and CITELE. Including ITU Study Groups, WCIT 2012, WTSA 2016 and Plenipotentiary 2018. Experience includes International Mobile Roaming, Internet of Things and Future Networks/5G. He led a range of capacity building programmes to governments across the world on innovation and technology for the GSMA, partnering with USTTI and the ITU.

Dr. Evanny Obregon – Product Manager RAN, Ericsson

Evanny Obregon is Strategic Product Manager at Ericsson. In her role she is responsible for driving product strategy and execution in multiple areas in 4G/5G Performance and Services. She is involved in corporate strategy for 5G Non-Terrestrial Networks. Evanny's career at Ericsson spans over ten years working across 3GPP standardization, spectrum regulation as well as RAN product design and strategy.

Evanny received her M.Sc. and Ph.D. degrees in Wireless Systems from KTH Royal Institute of Technology, Sweden.

Ms. Jennifer Manner – Head of Regulatory Affairs, EchoStar Mobile Ltd.

Jennifer A. Manner is Head of Regulatory Affairs at EchoStar Mobile Limited. She has significant experience in satellite communications and spectrum management in both the public and private sector. Ms. Manner is also the author of numerous articles and books on spectrum, including her most recent, *Spectrum Wars: The Rise of 5G and Beyond* (Artech House 2022).

Mr. Thomas Grob, Vice President Market Access, Rivada Space Networks

Thomas Grob has 20 years of experience in telecommunication regulation and Internet economics. He served as economic advisor at the Swiss regulatory authority BAKOM and worked as Senior Manager International Regulatory Affairs at group level for Deutsche Telekom AG. At Rivada Space Networks, Thomas Grob is responsible for securing global market access. Thomas Grob holds a master's degree in economics and political sciences from the University of Bern, Switzerland.

Mr. Jean-Pierre Choffray – Vice President, Systems Engineering, SES

Jean-Pierre is leading the SES' Systems Engineering team, responsible for the engineering of innovative satellite systems aligned with SES business targets. Since joining SES in 2001,

Jean-Pierre has triggered multiple initiatives having led to impactful technological developments and associated system deployments in space and on the ground.

Jean-Pierre has been the initiator of the development of the SES' Astra2Connect broadband service in Europe, based on a technology initially targeting interactive TV and repurposed to address residential broadband thanks to the very low cost of the associated customer terminal. Jean-Pierre has led the SES-Next initiative, driving major satellite manufacturers to develop software defined satellites with a mission programmed in orbit. These satellites will use very advanced technologies, reaching imposed aggressive business metrics thanks to industrial processes enabled by the satellite standardization. Airbus' OneSat, Thales' Space Inspire and Boeing's 702x have been triggered by this initiative.

In his role, Jean-Pierre is currently leading the technical evaluations of upcoming SES' multi-orbit satellite systems.

3. Key conclusions

The 3GPP standardisation of NTN is an important step in mobile technology evolution. Together with satellite network operators, innovations such as dynamic coverage, large-phased antenna arrays, and next generation LEO satellite fleets, is changing the model of connectivity. Nevertheless, regulatory predictability remains key to market access.

Some SNOs are using spectrum designated for MSS as a market access means. In another mode still largely at proof-of-concept stage, direct-to-device takes place by the SNOs and MNOs operating on a shared access type of spectrum usage outside of the coverage area of the MNO. There may be technical issues and regulatory issues to be examined in such a mode, such as co-existence studies with adjacent band services or whether the satellite use could internationally be recognised for protection due to the lack of a space service allocation,, and also at the BEREC workshop, it was clear that European regulators do not have a common view on all of the regulatory issues associated with this mode yet. Technical issues may also need to be examined in MSS spectrum when it comes to D2D services, as the individual case in a frequency band may be, regarding adjacent bands or other co-existence issues..

Moreover, there are many technical issues which are beyond the scope of BEREC, some of which may be resolved at Treaty level in decisions made at the World Radio Conference 2023 and other which require additional technical studies and standards work (e.g. at the 3GPP).

The initial satellite-to-device services include emergency services, text services, IoT services. When additional LEO satellites are launched more capacity will be available and services will be extended with voice and data connectivity at locations with no coverage of fixed or mobile terrestrial networks.

In summary, the first generations of use-cases from direct-to-device seem to be aimed at vital communications during emergencies or distress situations, and when the user is outside of the coverage of a terrestrial network. Such use cases would have high societal value and contribute to improving safety of life in remote areas when emergencies occur. BEREC will continue to work with regulators to exchange information and best practices so that stakeholders understand what is required for market access.

4. Next steps and recommendations for further work

BEREC is encouraged by the level of stakeholder interest in this workshop. BEREC also considers that many of the issues it originally sought views on (see Annex A) remain largely unanswered at this point, so there is scope for more work.

After careful consideration of the expert presentations and discussions, BEREC believes that it is important that it continues to explore market access issues in satellite communications, particularly this direct-to-device (D2D) aspect.

On the main topic of market access, and bearing in mind that there seemed to be two main approaches to provide direct-to-device connectivity set out by presenters as follows; via

- (1) mobile satellite service (“MSS”) bands or
- (2) based on a theoretical model, and in absence of real applications until now, an SNO-MNO agreement about the rights to use the respective terrestrial radio spectrum bands identified for IMT has yet to be processed by regulators in Europe

BEREC set out at the conclusion of the workshop that stakeholders should continue to engage regularly and early with regulators and, for its part, BEREC should be open to dialogue with other regulators / competent bodies to better understand the possible authorisation requirements.

BEREC also observes that there is scope for it to continue to better understand the following issues, amongst others:

- EU roaming issues (technical and regulatory) in the context of NTN
- Other regulatory issues associated with NTN in the context of the extension of mobile/fixed communications networks (“MFCNs”)
- Lawful intercept and ground station authorisations
- Numbering (and impacts on the efficient management of the numbering resources)
- Interoperability of devices on the EU market, even if they are 3GPP compliant.
- Integration of the satellite networks in overall integrated radio access Electronic Communication Services, not limited to terrestrial services anymore (RA-ECS instead of TRA-ECS) in regulatory market access and authorisation processes.
- Related competition issues.

There may be other issues that need to be examined too. BEREC may therefore, host another open workshop (format to be decided), or an internal workshop for experts but this would most

likely be in the context of Work Programme 2024. Annex A BEREC's call for targeted presentations to the workshop on 13 April 2023

BEREC invites industry stakeholders to express interest in presenting their views about direct-to-cell connectivity during a virtual workshop on secure and reliable connectivity from LEO satellite fleets

*On **13 April** (from 13:30 CET for 2.5hrs approx), BEREC will hold a virtual workshop on secure and reliable connectivity from LEO satellite fleets, focusing mainly on direct-to-cell connectivity (registration portal open here until 10 April).*

In the first instance, BEREC is inviting interested stakeholders on direct-to-cell connectivity (e.g. LEO satellite operators, terminal equipment vendors, telcos) to express their interest to present to BEREC. Should this open call not be oversubscribed from stakeholders in direct to cell connectivity, or if there is capacity, interest and demand, BEREC would look to accommodate presenters about other future-new services available from low earth orbit / mixed orbit satellite fleets. BEREC does however need to be realistic in terms of number of presentations, and its preference to learn more about the latest terrestrial mobile and satellite network announcements.

*By addressing some of the **Questions/themes (see below)** it is intended that presenting stakeholders may usefully create targeted presentations that address issues of interest to BEREC. In this regard, BEREC would most welcome hearing about practical examples from presenters. Depending on take up, the current thinking is that presentations would be set out in c.6-8min or c.3-5 slides, and addressing at least one of the questions or themes below.*

The audience includes the working group experts and senior policy / decision makers in the national regulatory authorities, though it may be of interest to some Heads of national telecoms regulators (NRAs).

The outcome of the workshop will be a summary report and a list of potential next steps for NRAs to better engage with this topic. It may also generate demand for another workshop or future work by BEREC.

Please express your interest to present by sending email with your contact details to pmatberec.europa.eu by **30 March 2023 or earlier**. Afterwards you will be contacted individually.

Questions/themes for presenting stakeholders

Experts set out some preliminary questions / themes below as a guide, observing that some questions / topics may be more relevant or important to certain groups of stakeholders. The idea is that stakeholder presentations are prepared in a way that would assist the experts in their mission to better understand the market access issues from LEO satellite fleets to markets in Europe.

Given the targeted style being proposed, BEREC would hope that stakeholders can focus on one or two points and give some detail on a few questions/topics rather than setting out a high-level sweep of all points.

The services provided and foreseen, and the service fee(s) for end users, will dictate the focus of presentations. Moreover, the focus will depend on the main target segment(s) for direct-to-cell stakeholders. This should be borne in mind when preparing the presentations.

1. Views on routes to market

- *Status of routes to market access*
 - *Whether regulatory framework needs to be adopted to enable market access?*
 - *Regulatory frameworks encountered at national or EU level?*
 - *Challenges and proposals*
- *What types of market issues (access) may develop in future?*
 - *[access to] Terrestrial IMT bands without satellite service allocation.*
 - *Network identification and numbering/addressing issues*
 - *International roaming / interoperability / handovers within European market*
 - *any other regulatory issue foreseen in market access*
- *Whether regulation for direct satellite-to-mobile technology is needed and why?*

2. Views on competition and differentiation

- *What are the potential competition issues*
 - *To what extent do direct collaborations between telcos and satellite operators impact competition?*
 - *To what extent direct collaborations between telcos and commercial mobile terminal equipment (e.g. handsets) manufacturers impact competition?*
 - *Do collaborations entrench the position of commercial mobile terminal equipment (e.g. handsets) manufacturers – how can smaller telecom operators participate?*
 - *Are there any other firm rivalry issues that might come to fruition and what might they be?*

- *To what extent other satellite operators, at the same frequency bands, can enter the market?*
- *Are there significant differences between stakeholder types (large multinational MNOs, smaller MNOs, MVNOs, verticals) to enter this market?*
- *Whether the sector considers there to be bottlenecks which are in the domain of the national telecommunications regulator?*
- *Interplay with gigabit society and connectivity ambitions*

Where it is beneficial to do so, it might be useful to have presentations that might also elaborate on various technical issues. To be clear, BEREC does not have competence in spectrum assignment, so issues which are being dealt with at ITU level (or through compatibility studies within the CEPT) need not be repeated at this virtual event.

3. Technical: Equipment/technology and sustainability issues

- *Standardization status*
 - *Commercial mobile terminal equipment (e.g. handsets) frequency bands*
 - *Role of chipsets (e.g. in handsets)*
- *Bit rate capabilities and routing issues*
 - *Components of the satellite or/and terrestrial network and relevant operations, how traffic capacity is being routed around the network and bit rate capabilities from the network components*
 - *Again, role of chipsets*
- *What is the impact on sustainability*
- *What is being done / what is the capability to offer network redundancy / resiliency*
- *To the extent not addressed in other fora (such as at CEPT workshop 20, 21 November 2022)⁷*
 - *whether coordination with other satellite operators is sufficient to avoid interference between them, as due to ITU regulatory framework these frequencies are proposed to use inter-alia.*
 - *Methods that authorities could use to protect the terrestrial service from spectrum interference (monitor and resolve) or relevant mitigation techniques established by satellite operators and telcos.*

⁷ <https://www.cept.org/ecc/tools-and-services/cept-workshops/cept-workshop-on-satellite-innovations-and-regulatory-challenges>

Annex B Summary table

Company	Ericsson / 3GPP	Globalstar	Deutsche Telecom	SpaceX
Speaker	Evanny Obregon	Barbee Ponder	Thomas Konschak	David Goldman
Service(s)	Consumer connectivity, industrial service continuity, Public Safety Resilience	Emergency services	Areas without coverage could be served easier with low cost, yet with limited service (SOS, messages, IoT, maritime, complementary to (but not competing with) terrestrial broadband networks	text messaging, VoLTE and data services
Satellite type	LEO	LEO	mainly LEO	LEO
Devices	Handheld devices (see below)	Apple Iphone 14	Conventional next generation cell phones	Existing LTE phones (connected to LTE antennas on Starlink satellites)
Used frequency band(s)	3GPP Rel-17 studied two ranges: - "S-band" & "L-band" (2 GHz & 1.6 GHz): handheld devices (regular smartphones, 23 dBm Tx power). Link budget is tight, but sufficient for outdoor use and two-way communication. 3GPP Rel-18 will study the following ranges: - "Ka-band" (20/30 GHz): high-gain devices with directive antenna (part of Rel-18), IoT and FWA main driving use cases	S band downlink, L band uplink	not specifically mentioned	MNO licensed spectrum for satellite to device communications
Status and plans	Standardisation input / in development, implementation of standards in next years	Nov 2022: US, Canada, Dec 2022: UK, Ireland, France, Germany, Apr 2023: Portugal, Italy, Netherlands, Belgium, Austria, Luxemburg, 17 new satellites in 2025, evolution to more services and growing coverage	Setting up agreements with MNOs and LEO operators	Will be ready in 2024 First text messaging, then VoLTE and data.

Company	AST Space Mobile	Echostar Mobile	Rivada Space Networks	SES
Speaker	Vikram Raval	Jennifer Manner	Thomas Grob	Jean-Pierre Choffray
Service(s)	AST SpaceMobile is building the first and only global cellular broadband network in space to operate directly with standard, unmodified mobile devices based on our extensive IP and patent portfolio. Our engineers and space scientists are on a mission to eliminate the connectivity gaps faced by today's five billion mobile subscribers and finally bring broadband to the billions who remain unconnected.	<ul style="list-style-type: none"> - LoRa and IoT services (Lyra platform in late 2024) - first satellite-enabled LoRa service (hybrid terrestrial-satellite) using EchoStar XXI available today. - 3GPP-NTN compliant direct-to-cell service for two-way messaging later this summer. - plans for larger 3GPP-NTN LEO satellite system in 2026 	IP-based data transport capacity, optimized for B2B and B2G services, LEO system designed to deliver enterprise grade end-to-end connectivity sustainably with low latency and high security over a single private network	<ul style="list-style-type: none"> - LEO : low latency communications, direct to HH & cars, IoT, earth observation, QKD - MEO : Infrastructure backhauling, EO LEO backhauling, ISR backhauling - GEO : Media distribution (direct & indirect), latency insensitive communication
Satellite type	LEO	Today, EchoStar XXI (Geostationary) complemented by 2 LEO satellite systems	LEO	Geostationary, MEO, LEO
Devices	Any standard mobile phone	<ul style="list-style-type: none"> - standard-based GSM-R data terminals - LoRa IoT devices - 3GPP NTN direct-to-device 	Terminals for fixed and mobile satellite services	Handhelds D2D, IoT,, cars based on 3GPP NTN
Used frequency band(s)	MNO licensed spectrum for satellite to device communications Q/V bands for satellite to ground stations	2 GHz band over large portions of Region 1 and using TerreStar 1 and DBSD for the North American market, aiming for 2 GHz band global use; Lyra and larger LEO system are global	Ka-Band frequencies (Liechtenstein ITU Filing)	6GHz LEO will target directly handhelds, IoT and car using 3GPP NTN standards.
Status and plans	Testing phase, partnering with MNOs. April 25 2023: successful completion of first-ever 2-way voice calls, direct to unmodified smartphones using "BW3" satellite. Calls are important step to providing space-based 2G, 3G, 4G LTE and 5G cellular broadband globally. Vodafone, Rakuten and AT&T participated in preparation and testing.	Supporting GSM-R devices for data and voice today. Commercially launched its satellite-enabled LoRa service in Fall 2022 (first of its kind), including hybrid satellite-terrestrial LoRa service. Later this year launching 3GPP-NTN direct-to-cell devices. Lyra LoRa and IoT services in late 2024, 3GPP NTN direct to device LEO services in 2026.	Development and preparation phase. First satellite launch in 2025, service start in 2026	In development. The satellite components shall be integrated in a completely seamless way with the dominant 5G/6G terrestrial networks contributing to the overall network of networks

