Record of Meetings with Starlink

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts met with members of SpaceX's Starlink team twice.

- On 3 December 2024, the department met with Starlink to discuss technical aspects of the direct to device (D2D) capability and how it operates, including testing and resilience functions. As part of this discussion, Starlink provided information on the use of D2D in the United States (US) during Hurricanes Helene in September and Milton in October 2024.
- On 31 January 2025, the department met with Starlink to discuss details on the presentation at the upcoming Working Group, particularly around the emergency response to hurricanes and the Los Angeles wildfires.

Starlink have attended 6 of the 7 Working Group meetings since the first meeting was held on 10 February 2023. Over the last 12 months, Starlink has been present at 3 meetings of the Working Group.

On 25 February 2025, Minister Rowland's office also met with SpaceX to discuss the Universal Outdoor Mobile Obligation (UOMO) initiative.

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Meeting/Event Brief

MB22-000734

To: Michelle Rowland, Minister for Communications

MEETING: Meeting with Starlink

Timing: Friday, 18 November, 2:30pm

Venue: Commonwealth Parliament Office, Sydney

Meeting with: s47F (biographies are at **Attachment A**).

Following discussions with the Department, Starlink has sought a meeting to brief you on its services and plans for its Low Earth Orbit Satellite (LEOSat) broadband services in Australia.

Our Proposed Objectives:
You may wish to discuss the following issues with Starlink:

a) current and future services, including fixed broadband and/or voice services (including in harder to reach areas), connectivity to vehicles, and potential to fill in terrestrial mobile coverage gaps through future device-to-satellite technology;
b) future commercial partnerships with the telecommunication industry or governments to supply residential, business and/or temporary services (e.g. after natural disasters); and
c) consumer issues (e.g. service levels, robustness of equipment, affordability, installation, local support and long term sustainability).

Their Objective:
The main issues we expect Starlink to cover are:

a) its services, including technology, performance, coverage, pricing, take-up;
b) its commercial plans, including the use of resellers and possible future applications;
c) the prospect of Government support, including funding and/or subsidies – potentially including through the Better Connectivity Plan for Regional and Rural Australia; and
d) your recent announcement of the establishment of a LEOSat Working Group.

Key Points:

1. Starlink is a global satellite broadband communications initiative by Elon Musk, closely associated with, and dependent on, his SpaceX rocket launch and spacecraft business. Its estimated cost is $US20-30 billion. Starlink began commercial services on a best efforts basis in limited areas of Australia in April 2021. In early November 2022, it announced it was providing coverage to almost 100% of the Australian mainland – this is dependent on its use of inter-satellite links. Starlink has primarily promoted its service as a high-speed retail broadband option for customers in regional and remote areas. It is also offering business services and portable and in-vehicle services, and is developing mobile device-to-satellite capability, which would allow users to use conventional mobile devices in areas without terrestrial mobile coverage.
2. Starlink publishes expected performance ranges for services (i.e. for speed, latency, service availability) but actual performance is not guaranteed. In early November, Starlink significantly reduced its performance ranges for residential speed and latency (e.g. the range for download speeds was lowered from 50-200 Mbps to 20-100 Mbps). Starlink is understood

to have around 400,000-500,000 services globally, and less than 50,000 in Australia. Starlink sells services directly to residential and business customers in Australia. However, we understand it is talking to local resellers for business services s47G(1)(b) and so it may also be open to reselling residential services. This could assist with issues of customer support.

3. Take-up of services may have slowed after initial growth, explaining recent efforts by Starlink to stimulate awareness and take-up. Amongst other things, Starlink recently announced a discount until the New Year of more than 50% on the cost of upfront equipment (A$924 down to A$450), which seems at this stage to be unique to Australia. That said, its monthly charges remain high and prices overall may be unaffordable for many consumers. Residential services cost A$139 per month, compared to A$60-70 per month for a basic Sky Muster service. For business services, Starlink charges A$3,740 for equipment and then A$750 per month.
4. Starlink has sought the Department's assistance in undertaking demonstration services in Indigenous communities and schools at its own cost, and to engage with local government and regional community groups. However, Starlink may be interested in Government funding longer term. Funding under the Better Connectivity Plan for Regional and Rural Australia may be an option, noting funding will be allocated through competitive processes. Starlink could be encouraged, if interested, to participate in future consultation on program design/guidelines.
5. Starlink and other LEOSat services are seen in some quarters as candidates to replace existing voice and broadband services in rural and remote areas, provided by Telstra under the universal service obligation (USO) and by NBN Co under the statutory infrastructure provider (SIP) regime. While LEOSats have considerable promise, it is still early days. Their capabilities are still unproven in the mass market (see para. 8 below), and their commercial sustainability is uncertain, noting they involve tens of billions of dollars of investment.
6. Previous briefing (MS22-001913) provided information on the proposed LEOSat Working Group, as well as LEOSats generally and Starlink's main competitors. It is likely Starlink will raise the Working Group, and you may like to gauge its interest in participating. Further information about Starlink and talking points for the meeting are at **Attachment B and C**.

Sensitive and Critical Information:

7. Starlink has previously shown some reluctance to share commercial information, often citing confidentiality. As Starlink is competing with NBN Co, it may be somewhat guarded in commenting on its take-up levels, commercial objectives and future plans. The business is also evolving rapidly with frequent developments, so information may quickly become out of date.
8. In August 2022, US$885.5 million in regional funding initially committed to Starlink by the US Federal Communications Commission (FCC) was withdrawn due to concerns about Starlink's ability to deliver on its service level commitments in regional and rural areas. Starlink has declined to give its perspective on the basis that it is appealing this decision.
9. Starlink could view subsidies paid to Telstra and NBN Co as unfair support for competitors and inconsistent with Australia's free trade commitments with USA and in the WTO. We consider our trade commitments give us full discretion when it comes to universal service arrangements.

Consultation: Starlink, Productivity and Technology Branch, NBN Branch, Spectrum Branch

Name: s47F
Position: Assistant Secretary
Division: CSC/Universal Services Branch
Ph: s47F
Date Cleared: 16 November 2022

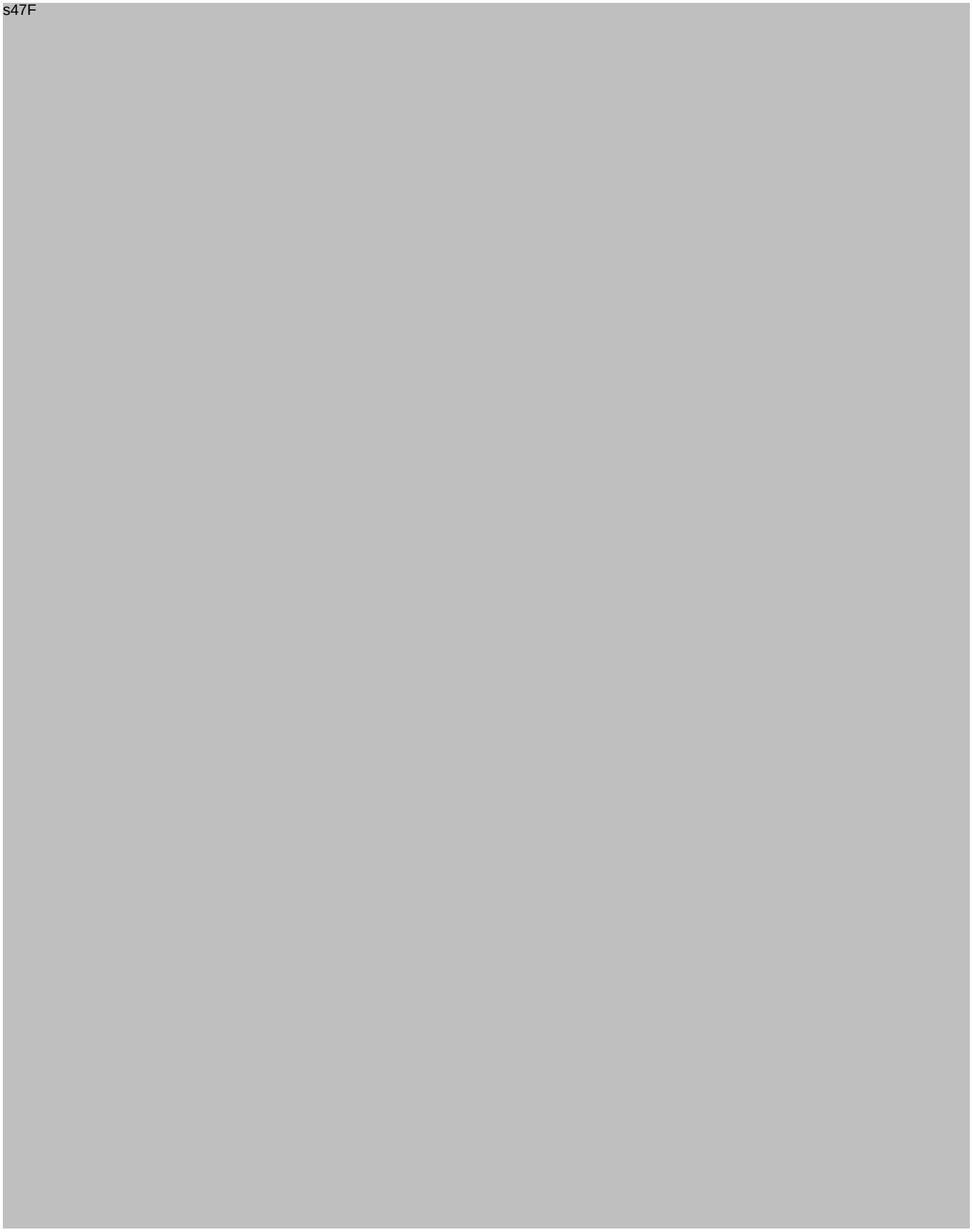
Contact Officer: s47F
Division: CSC/Universal Services Branch
Ph: s47F

Attachments: A: Biographies B: Further background C: Talking Points

ATTACHMENT A

BIOGRAPHIES

s47F



ATTACHMENT B

FURTHER BACKGROUND

LEOSat technology generally

Recent briefing (MS22-001913) provided by the Productivity & Technology Branch provides a general description of LEOSat technology as well as an overview of the LEOSat industry.

LEOSats orbit closer to earth than traditional geostationary communications satellites, with Starlink orbiting at 550km compared to NBN Co's Sky Muster having a 35,786km geostationary orbit. This means LEOSat services have significantly lower latency (i.e. delay in transmission time) and lower launch costs. However, their lower altitude also means that satellites need to be launched in constellations of hundreds or thousands to provide global coverage and need to be replaced sooner.

A LEOSat operator like Starlink provides its customers with a modem and a satellite dish. Starlink's dish has a phased array antenna.[1] The dish transmits its communications to the constellation of LEOSats as they pass overhead. Coverage is reliant on having a line-of-sight connection between the dish and the constellation of satellites. The LEOSat then transmits the communication to a ground station (i.e. gateway) which in turn transits it to the core network and Internet and then to its final destination – e.g. an end-user or data server. The gateways have moving antennas that track the satellites. Starlink has 20 gateways in Australia. Starlink also uses laser inter-satellite links (ISLs) to pass communications between satellites so they can be transmitted to more distant ground stations, reducing the number of ground stations needed. For example, an email sent via Starlink could be uplinked in the Northern Territory and be relayed across the satellite network to be downlinked in another state. Communications to the users follow the reverse path.

Global and Australian rollout of Starlink

Starlink is at present the largest LEOSat network globally, with around 3,000 satellites currently operating in its fleet. Starlink has announced its intention to bring its global fleet size to around 12,000 by 2025, and has sought permission to operate up to 42,000 satellites.

Starlink coverage is currently available to more than 40 countries, including large areas of North America (US, Canada, Mexico), Europe (most countries), South America (Brazil, Chile), Oceania (Australia, New Zealand), and Japan. In May 2022, Starlink informed the US Federal Communications Commission (FCC) that it had over 400,000 services in operation globally.

Coverage during the initial stages of Starlink's rollout was generally limited by the need for satellites to connect directly to a gateway, the number of which was limited due to their cost, including the need to provide backhaul and power to ground stations in dispersed locations. However, Starlink has developed the capacity to transmit data using laser ISLs to prove orbital backhaul, which has allowed coverage to extend to remote areas of land not in close proximity to a gateway, as well as over the oceans.

Starlink began offering a beta best-efforts service in Australia in April 2021 on a fee-for-service basis, initially only in particular areas of New South Wales and Victoria. Coverage steadily expanded as more satellites were launched, further ground stations were completed, and ISL capability developed.

[1] A phased array contains multiple antennas, enabling the radio transmission to be repointed electronically to maintain the connection with satellites without the dish moving. It can be compared with a tracking dish that moves to maintain contact with the satellites. OneWeb is currently expected to use moving tracking antennas.

In early November 2022 coverage was made available to all mainland areas, excluding a small area in Murchison, Western Australia where the Square Kilometre Array radio telescope is located. (Starlink's licence with ACMA prevents it from operating ground transmitters within 70 km.) The Department understands the number of Starlink services in operation in Australia to be less than 50,000 (based on comments by Starlink in September 2022).

Starlink's main focus to date has been on marketing residential broadband services, particularly for regional and rural areas. However, it has expanded its product range to business services and portable and mobile products for the recreation vehicle, aviation and maritime sectors. We also understand it has been offering capacity for backhaul for remote mobile base stations.

Service levels

Starlink advertises that its retail services are expected to provide download speeds between 20-100 megabits per second (Mbps) and upload speeds of 5-15 Mbps, with a latency of 25-50 milliseconds (ms), and around 99% service availability. However, service levels are not guaranteed and may vary. According to recent testing undertaken by Speedtest, in Q2 2022 Starlink's speed in Australia averaged 102.76 Mbps for download speeds and 10.45 Mbps for upload speeds, with a latency of 49 ms. By comparison, NBN's Sky Muster Plus plan offers 25/5 Mbps speeds at least once per day (it has the ability to burst above these speeds where network conditions allow), as well as a latency of around 600ms. Starlink's business services offer higher expected speeds of between 40-220 Mbps for downloads and between 8-25 Mbps for uploads. Business services are designed to support up to 20 users.

There are concerns that performance may deteriorate as more customers join the system, unless the size of the satellite fleet keeps up. This appears to have been an issue in the United States. In December 2020 Starlink was allocated US$885.5 million from the Rural Digital Opportunity Fund (RDOF) following an auction by the Federal Communications Commission (FCC). Starlink was to deliver services supporting 100/20 Mbps speeds, as well as voice telephony, to rural locations in 35 states. On 10 August 2022, the FCC withdrew the funding, highlighting concerns about Starlink's ability to deliver its promised service levels (particularly speeds) and noting the platform was still developing.s47G(1)(b)

Pricing and affordability

Starlink's upfront and ongoing prices are relatively high. To set up a connection, customers need to purchase equipment including an antenna for A$924 (recently discounted to A$450 until the New Year) and pay A$100 for shipping, and then A$139 per month for services thereafter. For business services, Starlink charges A$3,740 for upfront equipment and A$750 per month for services thereafter. Customer support is only offered online and is based in the United States. However, there appears to be an increasing number of local IT installers setting up and integrating Starlink kits for consumers.

By comparison, an entry level NBN Sky Muster service is currently priced at A$60-70 per month (though this does not include the speeds and 'unlimited data'[2] as Starlink is currently offering), and standard installation on the NBN is free.

Residential Starlink services are only provided to the address registered with Starlink, meaning that a customer cannot permanently relocate their existing service to another location (however they may temporarily relocate their service for an additional A$25 each month).

[2] In November Starlink announced it would reduce speed for customers using 1TB or more per month unless they pay extra.

Given these prices, Starlink products may be difficult to afford for some households, particularly those with low incomes. s47G(1)(a), s47G(1)(b)

Changes in Starlink's supply model

Starlink has to date preferred to sell services directly to retail customers rather than through local retailers. However, we understand it is now looking to use resellers to build its customer base and revenue, and to address concerns about a lack of local support. s47G(1)(b) . Starlink has concluded similar agreements with providers in Japan (KDDI), the UK (Clarus) and North America.

Starlink may also be open to other providers resupplying its services in the residential market, either on a wholesale or retail basis. This may provide future opportunities for Australian service providers (including NBN Co and Telstra) to provide regional and remote connectivity via Starlink. s47G(1)(a), s47G(1)(b) .

Given the significant investment involved in Starlink, we consider it will be looking at all reasonable options for increasing take-up of its services and its revenues. This appears consistent with a number of recent developments like expanding its footprint, reducing its hardware cost, and proposing demonstration services in Australia, as well as seeking payment for services providing in Ukraine.

Future developments and applications

Like other LEOSat operators, Starlink has announced plans to develop and provide device-to-LEOSat mobile services, which would allow users to use mobile devices in areas without terrestrial mobile coverage. In August 2022, it announced a partnership with US mobile carrier T-Mobile to provide customers with the ability to send text messages (and, eventually, make calls) in all locations across the United States. s47G(1)(b)

s47G(1)(b) It may also be interested in other demonstrations and trials that would help it to build brand awareness and stimulate local take-up (e.g. Indigenous communities, schools, farms).

Starlink has previously cited re-establishing telecommunications as part of disaster recovery efforts as another possible use case. Starlink swiftly deployed and has funded services in Ukraine during the ongoing Russian invasion, in order to maintain connectivity (particularly for the military) despite damage to telecommunications infrastructure in many areas of the country.

Business case and commercial sustainability

The number of satellites required involves high costs for LEOSat providers. s47G(1)(a)

LEOSat providers are leveraging innovations and technological advances which have lowered the cost of manufacturing and launching satellites. The per-unit cost of satellites has been driven down by advances in satellite technology and miniaturisation (i.e. the ability to make smaller

satellites with high performance), as well as efficiencies gained through using a production line approach. Starlink's satellites have been reported to cost around $250,000 per unit. Starlink has also gained an advantage by using SpaceX's reusable Falcon 9 rockets, which have lowered the cost of launching satellites. Even with such efficiencies, Starlink (and other LEOSat operators) will face ongoing costs to progressively replenish satellites, which are individually expected to last around 5 years.

Given the costs involved, Starlink will need to build and maintain a large global customer base to survive, potentially with individual users paying significant ongoing user charges, unless it is supported by governments (e.g. for defence or other purposes). Past satellite projects like Iridium and Globalstar did not live up to their original expectations. While Starlink is well in the lead, it faces competition from other significant LEOSat undertakings like Amazon's Kuiper and less sophisticated ventures like OneWeb and Telesat. Iridium, Globalstar and OneWeb have all been through bankruptcies. Given the costs and risks involved in the Starlink project, some caution is warranted at this time. Sustainability is an important factor when considering LEOSats as possible alternative platforms for delivery of universal broadband or voice services in rural and remote area, particularly given the hardware and migration costs. Another consideration would be the loss of direct control over service delivery noting most LEOSat infrastructure and systems (apart from ground stations) are based offshore.

Subsidisation of competitors

s47C

Implications for NBN Co

The growth of LEOSat providers like Starlink offering residential broadband services could present an opportunity for the Government and/or NBN Co to explore alternative ways to deliver broadband services in rural and remote areas, noting Starlink is only starting to explore retail re-sale arrangements, and may see NBN Co as a competitor in the Australian market.

As the default Statutory Infrastructure Provider (SIP), absent change, NBN Co must plan for ongoing provision of services to premises in rural and regional locations. Making a substantial future capital investment to compete with Starlink and other LEOSat constellations may not be an efficient use of capital. Starlink and other LEOSat operators could be encouraged to engage with NBN Co to offer wholesale capacity on a commercial basis to relieve pressure on the Sky Muster

[3] Starlink could also conceivably put forward funding proposals, potentially with local partners, under the $200m Regional Connectivity Program, including in First Nations communities, or the $100m resilience programs.

[redacted]

Spectrum

Starlink is licensed by the Australian Communications and Media Authority (ACMA) to operate its services to consumers using spectrum in the "Ku" (pronounced kay-you) frequency band at around 12 GHz for the downlink and 14 GHz for the uplink. It also operates a network of gateway earth stations in the "Ka" (pronounced kay-ay) frequency band (~19 GHz/28 GHz). As of November 2022, Starlink has licensed 20 gateway stations in eastern and southern Australia (7 in NSW, 5 in QLD, 2 in SA, 3 in VIC and 3 in WA).

s47G(1)(b) [redacted]; however, in 2021 the ACMA significantly reduced the relevant apparatus licence tax rates. Satellite operators currently pay approximately $100,000 per annum for 1 GHz of Ku band spectrum. The nature of satellite orbits allows operators to share or re-use the same spectrum so long as the technical and orbital characteristics allow.

Interference between satellite networks is managed through the International Telecommunications Union (ITU) in accordance with the international Radio Regulations. ACMA's licensing process requires satellite operators to coordinate their networks in accordance with the relevant international obligations.

Starlink has recently expressed concerns about possible interference due to a process in the United States to allow spectrum in the 12 GHz band to be used for terrestrial 5G services. ACMA has no current plans to consider such use in Australia.

ATTACHMENT C

SUGGESTED TALKING POINTS

- Australia welcomes innovative new technologies which deliver improved consumer outcomes.
- A key priority for the Government is ensuring all Australians, especially in regional and remote areas, have access to reliable and affordable telecommunications services which meet their needs.
- While it is relatively early days, there have been many positive reports from Starlink users in Australia, though pricing and user support have been raised as issues.
- Demonstrations of Starlink services (e.g. in schools, First Nations communities, on farms or at agricultural field days) may be good ways to raise awareness of the service.

Starlink rollout in Australia

- How has the rollout of Starlink fared in Australia compared to other countries? Are there any specific issues you are facing – e.g. does equipment perform well in Australian conditions? Do you have any initial consumer feedback or performance data you can share?
- Are you able to share any information on current take-up levels (i.e. the number of services in operation) both in Australia and globally?
- Do you know what type of consumers (e.g. tech savvy individuals, families, teleworkers) are typically taking up Starlink services?

Service performance, affordability and consumer support

- Do you have long-term speed, performance and service reliability goals, and if so, what timeframes are you targeting?
- Are laser inter-satellite links now in use? Is the technology now mature and able to provide reliable connectivity or is it still being proven?
- Is performance likely to decline as more customers take up services?
- How do you provide support to consumers experiencing issues with their service, including during installation? Are there future plans for on-shore customer support or to provide assistance with installation and setup?
- You are currently discounting your hardware costs in Australia until the New Year. What is the thinking behind that and what effect is it having on take up?
- Beyond the current discount, are you considering adjusting pricing for Starlink equipment or services in Australia?

- Does Starlink see its current pricing as 'mass market'? Are price reductions feasible with higher customer numbers?
- What role do you see Starlink playing in bringing communications to the less developed countries of the world (e.g. in the South Pacific)? Would you adjust pricing to service these markets? Or would you be looking for support from governments?

Future applications and marketing plans

- What do you see as future applications of the Starlink platform?
- What are your plans and timeframes to provide mobile handset-to-satellite services, including in Australia? How confident is Starlink this can be done? Has any testing started?
- Do you envisage Starlink supporting always-on voice telephony in future?
- To date, Starlink has retailed services direct to consumers. Do you envisage entering into agreements with local partners to resell services? Are you engaging with any service providers in the Australian market?
- What policies could contribute to easier access to satellite broadband services for remote communities, now and in the longer term?

Competition and sustainability

- How does Starlink find competing with established satellite service providers?
- How does Starlink view the competition from other LEOSat systems? Does it see space for multiple systems in the long term?
- Are you confident Starlink will be commercially sustainable into the future? Why?

LEOSat Working Group

- I understand Starlink is a member of the Communications Alliance Satellite Working Group. How do you find that as a forum for discussing issues?
- I have asked my Department to start work on establishing a LEOSat Working Group to help inform Government about how the emerging capability might play a role in future telecommunications policy.
- A model for the Working Group is being developed, which may include LEOSat providers and relevant government agencies.
- Would Starlink be interested in participating in the Working Group? Why/why not?

If raised - Funding opportunities under the Better Connectivity Plan

- As announced in our October Budget, the Government is making a significant investment in regional communications through the Better Connectivity Plan for Regional and Rural Australia.
- The Plan has a number of different objectives and programs. The normal practice is to allocate such funding through competitive processes.
- Usual practice is also to consult industry and other stakeholders on program design and guidelines. Starlink may want to participate in this.
- If Starlink was to seek Government funding in future competitive processes, an ability to demonstrate performance (e.g. through data or trials) is likely to be important.

If raised – s47C

- Providing universal access to telecommunications services across Australia is one of the cornerstones of Australian telecommunications policy and a potentially sensitive issue.
- Australia welcomes competition in the supply of services but Starlink has chosen to enter the market on the basis of the current universal service arrangements and it needs to have regard to these arrangements.

s47C

Australian Government
Department of Infrastructure, Transport,
Regional Development, Communications and the Arts

REQUEST FOR TENDER

For the provision of technical trials and analysis of alternative voice services
RFT No. 10028627

PART A - REQUIREMENTS

Place for Lodgement: https://www.tenders.gov.au

STRUCTURE OF THIS RFT

Before submitting a tender, Tenderers should make sure they have read and understood all Parts of the RFT documentation.

This Request for Tender (**RFT**) is made up of the following Parts:

(this) **Part A: RFT Requirements**

- Part A1 – RFT Details
- Part A2 – Statement of Requirements
- Part A3 – Draft Contract

Part B: RFT Terms and Conditions

- Part B1 – Tendering Rules
- Part B2 – Evaluation of Tenders
- Part B3 – Defined Terms in this RFT

Part C: RFT Response Form

- Part C1 – Tenderer's Details
- Part C2 – Response to Statement of Requirements
- Part C3 – Tendered Pricing / Commercial Offer
- Part C4 – Contract Compliance Statement
- Part C5 – Request to Keep Information Confidential
- Part C6 – Modern Slavery
- Part C7 – Regulatory and Sustainable Considerations
- Part C8 – Tenderer's Deed Poll

Part A1 RFT Details

RFT Description	The name of this RFT is "Request for Tender for the provision of technical trials and analysis of alternative voice services"
Release Date	**9 February 2024**
Closing Time	**2:00 pm local Canberra time on 6 March 2024.**
Offer Period	Tenders will remain open for acceptance by the Department for a period of six months after the Closing Time.
Deadline for Submission of Tenderer Questions	**2:00 pm local Canberra time on 28 February 2024**
Contact Officer	**email:** techtrials@infrastructure.gov.au mail to: Universal Services Branch Department of Infrastructure, Transport, Regional Development, Communications and the Arts GPO Box 594 Canberra ACT 2601
Lodgement of tenders	via the Australian Government's procurement information system, AusTender, at https://www.tenders.gov.au (constituting the electronic Tender Box).
Complaints Officer	Attention: Client Services, Governance Section email: clientservice@infrastructure.gov.au This RFT is a covered procurement for the purposes of the Commonwealth Procurement Rules and the *Government Procurement (Judicial Review) Act 2018* (Cth)

As a minimum, the Department requires Tenderers to comply with the Minimum Content and Format Requirements and the Conditions of Participation provided in section 3 of Part B2 ('Evaluation of Tenders'). Any other requirements identified as 'must' or 'shall' will be considered through the evaluation process.

Part A2 Statement of Requirements

1. Summary of Requirement

The Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts (**Department**) wishes to identify an organisation to trial and provide analysis on the suitability of different technologies to deliver fixed voice services in rural and remote areas of Australia.

Through this RFT, the Department is seeking value for money solutions from the market that deliver the following objectives:

- objectively assess different platforms available outside the NBN fixed-line footprint for their suitability to support high-quality and reliable voice services
- trial voice services in a representative range of regions across Australia, with different geographic, topographic and climatic characteristics
- provide robust analysis to assist in understanding reasons for any variability in performance of services over time, including but not limited to factors such as weather, topography, equipment or local power issues.

More detail about the services required by the Department is set out in this Part A2 below.

The Department is seeking to enter into an agreement for six months, with two optional extension periods of six months each to be exercised at the sole discretion of the Department, on the terms and conditions set out in the Draft Contract (see Part A3 of this RFT).

2. Background

2.1. Context

2.1.1. The Australian Government has an existing framework in place to provide people with access to baseline fixed voice services. The Universal Service Obligation (**USO**) is a longstanding safeguard that ensures all people in Australia are able to access fixed phone services regardless of where they live or work.

2.1.2. Telstra is the statutory universal service provider and is required to supply fixed voices nationally on reasonable request. Telstra provides the majority of USO services over the National Broadband Network (**NBN**), however it continues to deliver voice services over copper and other networks in regional and remote areas.

2.1.3. In October 2023, the Australian Government announced a process to examine universal service arrangements in light of changes in available technologies and consumer preferences over recent years. The Government announced this would involve a consideration of options to modernise the delivery of baseline universal telecommunications services, particularly fixed voice services currently provided by Telstra under the USO.[1]

2.1.4. The deployment of new and emerging technologies shows promise for providing greater options for delivery of voice services in regional and remote areas of Australia. This includes Low Earth Orbit satellite (**LEOSat**) networks, which are now providing commercial

[1] More detail is available from www.infrastructure.gov.au/have-your-say/better-delivery-universal-services

high-speed broadband services across Australia. In addition, the Government's recent $480 million investment to extend and improve the NBN Fixed Wireless network offers a pathway to provide better services to many regional and remote consumers.

2.1.5. A key principle for Government's consideration of existing universal service arrangements is that any change to existing regulatory or contractual arrangements will only be considered if there are tested and proven alternatives to existing technologies and services.[2]

2.1.6. However, existing real-world data on the use of emerging technologies, including LEOSats, for voice services is limited. Existing data is largely focused on the use and suitability of the platform for the delivery of broadband services rather than voice services.

2.1.7. Accordingly, the Government is seeking to better understand the performance and reliability of voice services delivered over alternative and emerging technologies, including LEOSats. This includes assessing how well they can perform in a variety of potentially adverse weather conditions and extreme climates, and on mains or non-mains power.

2.1.8. As part of the broader process to examine existing universal service arrangements, including consultation with stakeholders, the data and analysis provided through the trials will help guide Government consideration of options to improve universal service delivery.

2.2. Purpose

2.2.1. The Government is seeking a provider to undertake technical trials and provide robust analysis of results to assist the Government to consider whether alternative technology platforms can deliver voice services at standards which are broadly equivalent to current services, with a particular focus on regional, rural and remote areas of Australia.

2.2.2. The Government intends that trials will primarily provide quantitative data to help understand how service reliability and performance may be impacted over time by factors such as weather, climate, topography, equipment or local power issues.

2.2.3. Data and analysis from the trials will be provided to the Department, but the Department also intends to publicly share high-level data (see Section 3.6 of this Part A2) for use by interested parties and the wider community to inform public debate.

3. Detailed requirements

3.1.1. Through this RFT, the Department is seeking to enter into a contract for the provision of technical trials of alternative voice services and analysis of results.

3.1.2. To assist Tenderers, the Department has identified a range of parameters for the services which are summarised below.

[2] https://minister.infrastructure.gov.au/rowland/speech/national-farmers-federation-conference

3.2. Scope overview

3.2.1. Tenderers must arrange to trial alternative voice services for six months, with two optional extension periods of a further six months each exercisable by the Department at its sole discretion.

3.2.2. Tenderers must have capacity to trial services at a minimum of **50** sites throughout Australia. The Department intends that trial sites be broadly representative of the variety of conditions that may exist in different rural and remote areas around Australia. A list of trial regions is provided at Attachment A. All trial sites are to be located within these regions, unless alternative regions are proposed and accepted (see Section 3.3.6 below). Further detail on requirements for trial sites is provided at Section 3.3 of this Part A2.

3.2.3. Further detail on networks / services to be trialled is set out at Section 3.4 of this Part A2. Tenderers will need to factor into their tendered prices all costs involved to install services (or arrange for the installation of services) that will be trialled at each site, including meeting any upfront installation or equipment charges and meeting ongoing service fees over the life of trials.

3.2.4. The Department intends for the trials to provide independent and objective advice to Government. As the trials will help guide future Government consideration of options to improve universal service delivery, it is important that the body of evidence gathered is reliable and robust, and that there is a consistent testing methodology adopted across each trial site.

3.2.5. Where tenderers identify any conflicts of interest, relevant information must be disclosed to the Department in accordance with Section 6.2 of Part B1 of this RFT.

3.2.6. Tenderers who have any association with the owners or suppliers of any of the voice services to be tested or any association with a telecommunications service provider carrying on business in Australia (or a related company) must declare the nature of the association as a conflict of interest in Part C, together with proposed mitigation arrangements.

3.3. Geographic scope

3.3.1. Trial sites must be broadly representative of a wide range of Australian conditions and have regard to the following matters:

a) geographic scope (e.g. testing services at a roughly equal number of sites across each state and territory (excluding the Australian Capital Territory) and at a variety of latitudes and longitudes)

b) environmental differences, including differences in topography and local vegetation

c) climatic variation, including to help understand any variations in performance given extremes of temperature, humidity, wind and rainfall

d) other factors such as exposure to dust or smoke

e) include locations where mobile coverage both is, and is not, available (based on the online coverage maps of Telstra, Optus and TPG Telecom[3])

f) include locations within the footprints of both NBN Co's Fixed Wireless and Sky Muster satellite networks.

3.3.2. All trial sites must be located outside the existing NBN fixed-line footprint.

3.3.3. A list of regions for trials is provided at Attachment A. The Department has chosen to list broad regions within each state or territory (excluding the Australian Capital Territory) and some offshore islands, rather than specific towns or other localities, in order to provide tenderers with some flexibility to determine the specific sites within regions where they will arrange for trials to be undertaken. Tenderers must set out how they will arrange to undertake trials in the Department's list of regions, and provide prices for delivering the trials in these regions in accordance with Part C3 of this RFT.

3.3.4. Tenderers should note that the Department may propose changes to the list of proposed regions in Attachment A (limited to no more than 10 regions), prior to entering into a contract with the successful Tenderer. For example, the Department may propose a different region where it considers trialling services at one or more sites within that a different region would improve the broader geographic scope of the full list of trial sites, with regard to Section 3.3.1, or where it has identified opportunities to host trials at specific sites or towns within a region through engagement with state and territory governments or other community stakeholders. Tenderers must factor the possibility of change into their tendered price as no variation in price is permitted for the above changes.

3.3.5. Tenderers should note that the Department will need to approve each specific site where the successful tenderer proposes to undertake trials before testing at that site begins. This includes the town or other locality, as well as the specific site, where trials are to be held.

3.3.6. It is open to tenderers to propose alternative trial regions as part of proposing an alternative solution in accordance with section 4.5 of Part B1 of this RFT. Tenderers should note that any alternative regions proposed should have regard to the Department's expectations set out in this Section.

3.3.7. The Department wishes to prioritise commencement of trials in certain regions, and Tenderers must set out how they will prioritise trials in these regions, and also reflect this in implementation milestones (see section 4.2. of this Part A2). Priority regions are set out in Attachment A.

3.3.8. Where possible, the Department will work with the successful tenderer to identify appropriate testing sites in each finalised region, including providing details of organisations or individuals that may be willing to assist with hosting trial equipment (for

[3] The Australian Competition and Consumer Commission (ACCC) published data on mobile coverage maps as part of its ACCC Mobile Infrastructure Report 2023, published in November 2023. Relevant data, including coverage maps, is available at: data.gov.au/dataset/ds-in relation to the 2023 Report is available at: https://data.gov.au/dataset/ds-dga-4b472a18-d0fa-409c-994a-ab17162bcb90/details?q=ACCC.

example, government buildings (federal, state or local), rural fire service buildings or other public community facilities). However, Tenderers will be ultimately responsible for securing relevant sites to allow services to be trialled, including obtaining and maintaining all necessary permissions and legal access from site owners, and entering into any required lease arrangements.

3.3.9. Within the Department's minimum requirement for trials at 50 sites as per section 3.2.2, Tenderers must arrange to trial services at at least 5 sites that do not have reliable access to mains power and which rely on backup power (for example a generator) in the event of a failure of mains power. Tests at these sites would be carried out using the prevailing power supply in use during the duration of the trial (either mains or backup), but Tenderers would not be required to provide any additional power supply to support trials. Where possible, the Department may assist the successful Tenderer in identifying sites without access to reliable mains power, noting as per paragraph 3.3.8, that Tenderers will be ultimately responsible for securing relevant sites.

3.3.10. Tenderers must provide a proposed **implementation plan,** including the details of how they will finalise the sites where trials to be held, identify and secure trial sites, and begin testing services, with regard to the expectations set out in this Section. In developing their implementation plan, tenderers should have regard to the Department's proposed implementation milestones included in section 4.2 of this Part A2. A final implementation plan will need to be provided to the Department before trials begin as part of settling the final methodology.

3.3.11. During the trials the Department may see benefit in obtaining more data and analysis about the performance of voice services and wish for the tenderer to trial voice service technologies at additional trial sites (whether in existing regions or new regions). In such an event the parties will enter into good faith negotiations on the terms (including price, having regard to the costs the tenderer is likely to incur at each additional new trial site).

3.4. Technologies / networks to be trialled

3.4.1. Tenderers must arrange for the trial of 2 different networks/services to support reliable voice services at each trial site, and must also provide details of any change in price should the Department, at its sole discretion, require trials of 3 different networks/services.

3.4.2. At each trial site, the Tenderer must arrange to trial a voice service supported over a residential grade LEOSat service, noting Starlink LEOSat services are currently generally available for purchase across Australia. Additional services that the Department may require to be trialled may include voice services supplied via the:

a) NBN Fixed Wireless network where available, including newly extended range NBN 4G and 5G Fixed Wireless[4];

b) other 4G or 5G Fixed Wireless networks where available;

[4] The NBN Fixed Wireless network is undergoing an upgrade through the NBN Fixed Wireless and Satellite Upgrade Program, which the Australian Government has contributed $480 million. More information is available on NBN Co's website at: https://www.nbnco.com.au/utility/nbn-fixed-wireless-and-satellite-upgrade-program.

c) other geostationary or medium-earth orbit satellite networks where available; or

d) an enterprise grade LEOSat service.

3.4.3. Noting the networks / services set out above, tenderers are permitted to test both bespoke fixed services delivered directly over a platform, as well as Over The Top (OTT) voice services provided over a broadband service using the platform (i.e. using Voice over Internet Protocol (VoIP) technology).

3.4.4. Tenderers are to assume the mix of services to be trialled at individual sites may vary. This reflects that not all types of voice services/networks set out at section 3.4.2 above will be available at all sites. However, Tenderers should note that the Department expects that different services are to be tested across enough sites to support a comparative analysis of how services perform across a variety of conditions (with regard to the matters detailed in Section 3.3 of this Part A2).

3.4.5. As part of its proposed **implementation plan**, Tenderers are required to set out the voice services they plan to test across sites, based on the regions in Attachment A. Tenderers must provide justification of the suitability of proposed services to be tested, including in regard to the ability of technologies to support voice services and their commercial availability in different areas of Australia.

3.4.6. During the trials, the Department may wish to negotiate with tenderers to trial additional voice service technologies in the event that it sees benefit in testing a platform that has recently entered the Australian market. Tenderers should note that if the Department wishes for more networks/services to be tested at an existing trial site than contemplated by section 3.4.1, the parties will enter into good faith negotiations on the terms for the trial of the additional networks/services including price.

3.5. Testing parameters

3.5.1. Tenderers must detail their capacity to test the performance of each individual trial service at each site on a 24/7 basis throughout the duration of the trials or must otherwise set out the frequency of testing they can provide. The Department prefers fully automated testing, or failing that, testing arrangements that minimise the need for involvement by an end user of a service.

3.5.2. Tenderers must set out a proposed **testing plan**, with regard to the expectations of the Department set out in this section 3.5. This must set out a proposed testing methodology, including an explanation of how the tenderer will ensure consistency and reliability of testing both across trial sites as well as accommodate different networks and services being tested at each site. The Department expects that the trials are undertaken with regard to best-practice methodology and testing standards typically used to measure the performance of services in the telecommunications industry, including for each of the key service parameters identified at 3.5.3. below. Tenderers must justify the suitability of their proposed methodology with reference to relevant guidelines, standards or scientific literature. A final testing plan will need to be provided by the successful Tenderer to the Department before trials begin as part of settling the final methodology.

3.5.3. As part of their proposed testing plan, tenderers must set out the extent to which they are able to monitor and report on key service parameters, including but not limited to:

a) service availability or uptime;

b) latency;

c) packet loss;

d) jitter;

e) echo;

f) noise;

g) peak and average upload and download speeds (of any broadband services over which voice services are being delivered);

h) mean opinion scores;

i) call drops;

j) call setup times;

k) ability of services to support Wi-Fi calling / messaging; and

l) ability of services to support reliable calling to different voice platforms, including to landline, VoIP and mobile services.

3.5.4. Tenderers may propose to monitor and report on alternative or additional metrics to those set out above as part of proposing an alternative solution in accordance with section 4.5 of Part B1 of this RFT. Tenderers must justify how any proposed alternative or additional metrics are relevant to demonstrating the performance of services.

3.5.5. Tenderers must detail their arrangements to monitor or otherwise be able to access data to correlate performance of trial services against local weather conditions at each testing site, including but not limited to:

a) Temperature;

b) Humidity;

c) Wind (direction/speed/gusts);

d) Rainfall (duration, rate and overall amount); and

e) Significant dust events.

3.5.6. Further to 3.3.9 of this Part A2, tenderers must:

a) detail their arrangements for recording and monitoring power supply arrangements at relevant trial sites

b) confirm that their proposed testing methodology will be effective at sites using non-mains power, or otherwise provide details on how any potential limitations can be managed.

3.6. Reporting of data and analysis

3.6.1. Tenderers must have arrangements to collate and provide the Department with raw data collected at each trial site on a monthly basis, including for each of the key service parameters set out in Section 3.5 of this Part A2. This must be presented in a structured, consistent and machine-readable format. Tenderers are required to detail the format in which they will provide raw data to the Department.

3.6.2. Tenderers must also provide the Department with a monthly consumer-friendly 'dashboard' that provides an overall high-level summary of the data results for each month of trials. The Department intends for these dashboards to be released publicly on the Department's website each month to provide ongoing updates of trial results. The Department considers that dashboards could provide overall results for each service technology by breaking out data by key service characteristics and geographic area (e.g. by state/territory), however tenderers are required to propose a suitable format for presenting this data. The final format will need to be agreed with the Department before monthly reporting commences.

3.6.3. Tenderers must arrange to prepare and provide the Department with monthly summary reports analysing the performance of voice services being trialled. Each report must provide:

a) an overall assessment of the performance of different services / networks against key metrics (see 3.5.3 above) and whether each service trialled is considered to be, in the opinion of the tenderer, supporting reliable voice services (refer to 3.6.4 on reliability);

b) identification of patterns or trends in performance of services trialled, including but not limited to considering the implications of climate/weather, topography, vegetation and latitude/longitude across different trial sites;

c) information and analysis of any significant periods where individual services were degraded or suffered outages, including analysis of potential causes for fluctuations in performance;

d) details of any other factors that may impact the performance of services being trialled (e.g. if there are failures of any supplied equipment or devices required to use the service);

e) information about any factors or events that may have impacted the accuracy of data collected, whether due to factors within or outside the control of tenderers (e.g. if there have been any issues with testing equipment or software, or broader faults or outages with services being trialled); and

f) advice on whether any changes to testing methodologies or trial sites are, in the tenderers' opinion, required for any further testing to ensure the availability of accurate and useful data.

3.6.4. Further to 3.6.3(a) above, the Department considers that a 'reliable' voice service would generally have the following characteristics at a minimum:

a) voice calls conducted over the service set up quickly and do not drop mid-call;

b) the service is available nearly all of the time; and

c) call quality is acceptable to allow clear and immediate voice communications.

3.6.5. The Department's preference is that all monthly data and reports are provided no more than two weeks after the end of each month. Tenderers must specify whether they expect to be able to meet this timeframe, or otherwise propose an alternative timeframe.

3.6.6. Within 2 weeks of the end of the fifth month of trials, Tenderers must provide an overall summary report. This report must analyse the overall performance of voice services over the duration of the trials up to that point, with regard to the requirements set out above at 3.6.3, including advice about the merits of continuing testing to support the objectives of the trials. Decisions about whether to continue testing beyond six months will be at the final discretion of the Department.

3.7. Methodology

3.7.1. As noted throughout this Part A2, tenderers must detail their proposed methodology for undertaking trials. This includes how they will collect, analyse and present the data including in a physical, technological and operational sense. Tenderers must propose a methodology that will deliver the best overall outcomes in line with the purpose of the trials and the expectations of the Department outlined in this Part A2.

3.7.2. Tenderers must make clear any potential limitations that their proposed methodological approach will impose, including in relation to the presentation of results and analysis.

3.7.3. The successful Tenderer will need to provide the Department with a final methodology, including a final **testing** and **implementation plan**. Any subsequent changes to this methodology will need to be documented, and the rationale for change will need to be provided to the Department before such change occurs.

3.8. Confidence in the accuracy and reliability of data

3.8.1. The Department expects the data and analysis generated by the successful tenderer to be highly accurate and reliable. Tenderers are required to state the level of confidence they have in the accuracy and reliability of their data and analysis, state the basis and offer evidence in support of it in their tender.

3.8.2. Tenderers must guarantee the integrity of their data and derived material. For example, if data is challenged or queried by the Department, the successful tenderer must be able to defend the data and the methods by which it was collected, analysed and presented. The successful tenderer will be responsible for fixing any data that is incorrect, or invalid, such as in circumstances under which it is found that the methodology or equipment employed by the tenderer has tainted or introduced systematic or random errors in testing results.

4. Proposed Arrangements

4.1. Performance Management and Key Performance Indicators (KPIs)

4.1.1. The Department intends to incorporate a performance management framework into any resultant contract that:

a) incentivises the delivery of timely, quality, accurate and verifiable data, including in a suitable format;

b) ensures maintenance of confidentiality where relevant;

c) maintains high standards of data governance, management and oversight, including in relation to respect for privacy and security; and

d) promotes integrity and honesty in all conduct, including in relation to the treatment of any conflict of interests, whether actual, potential or perceived.

4.1.2. As a result, tenderers are required to propose Key Performance Indicators (KPIs), monitoring and review mechanisms, and service levels for all services contained in this tender in line with these requirements that provide:

a) reasonable targets for performance;

b) regular and accurate reporting of performance; and

c) review by the parties throughout the life of any resultant Contract to ensure the KPIs remain suitable and appropriate to encourage the achievement of quality service outcomes.

4.2. Proposed Contract Milestones

4.2.1. Tenderers will have some flexibility to meet cumulative implementation milestones rather than be required to begin testing at all trial sites at the same time. Proposed implementation milestones are included in the indicative due dates in the table below.

4.2.2. Tenderers will be required to deliver the services in the table below. Proposed due dates are calculated based on a nominal contract Commencement Date of 28 March 2024 and where the Commencement Date is later than that date then the dates below will be adjusted accordingly.

NO	MILESTONE	DUE DATE
1	Acceptance by the Department of final methodology (including testing and implementation plan) Tenderer begins trials at priority regions (as finalised with the Department)	5-April-2024 19-Apr-2024
2	Tenderer has trials running at minimum 50% of trial locations	3-May-2024
3	Tenderer has trials running at 100% of trial locations Acceptance by the Department of format for monthly public data dashboard	17-May-2024

4	Acceptance by the Department of monthly trial data and analysis in relation to trials undertaken up until end of April 2024	17-May-2024
5	Acceptance by the Department of monthly trial data and analysis for May 2024	14-June-24
6	Acceptance by the Department of monthly trial data and analysis for June 2024	12-July-24
7	Acceptance by the Department of monthly trial data and analysis for July 2024	12-Aug-24
8	Acceptance by the Department of monthly trial data and analysis for August 2024 Acceptance by the Department of summary report of entire duration (i.e. 5 months) of trials	13-Sep-24
9	Acceptance by the Department of monthly trial data and analysis for September 2024	14-Oct-24

4.3. Timeframe for RFT process

4.3.1. The timetable set out below provides an outline of the expected RFT process. However, the Department reserves the right to amend the timetable as it considers necessary and at any time in the process.

Event/Activity	Proposed Date
Deadline for submission of questions	2:00pm 28 February 2024 (local Canberra time)
Closing time	2:00pm 6 March 2024 (local Canberra time)
Contract signed	By 28 March 2024 (indicative and provided for convenience only)

4.3.2. Additional or other activities may be specified or undertaken by the Department.

4.4. Standards

4.4.1. The Department requires services to be undertaken in accordance with:

a) Relevant Australian, international and industry standards;

b) applicable legislation, legislative requirements and standards relevant to contracted organisations – including but not limited to the *Privacy Act 1998 (Cth);* the *Archives Act 1982 (Cth);* the *Public Governance, Performance and Accountability Act 2013 (Cth);* and

c) relevant Commonwealth policies, including but not limited to the *Protective Security Policy Framework* (**PSPF**); the *Information Security Manual* (**ISM**); Australian Standards for Document Management (AS ISO 15489); The APS Values and APS Code of Conduct; the Commonwealth Fraud Control Framework 2017 and Management Guide No. 201 (Preventing, detecting and dealing with fraud); applicable Accountable Authority Instructions (AAIs); and standards acceptable to the Australian National Audit Office.

4.4.2. The successful Tenderer will be required to keep accurate and up to date records in accordance with Departmental procedures and guidelines.

4.5. Contract management requirements

4.5.1. The Department intends to manage any resultant Contract in an open, honest and collaborative manner and expects Tenderers to reflect this philosophy in their proposed contract management approaches. The Department intends to incorporate a contract management framework that includes:

a) contract management meetings which require the Supplier and Department to meet at least monthly or as requested by the Department throughout the term of any resultant Contract; and

b) contract management meetings include consideration and management of risks, assessment of performance against required objectives and deliverables, delivered outcomes and achievements, identification of issues requiring attention and otherwise reviewing the requirements of any resultant Contract.

5. Draft Contract

The Draft Contract (see Part A3 of this RFT) will form the basis of the contractual arrangements between the Department and the successful Tenderer(s).

Where provisions of the Statement of Requirements in this Part A2 conflict in any way with provisions of the Draft Contract, the provisions of the Draft Contract will prevail.

Part A3 Draft Contract

To be issued as an addendum.

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting Minutes

Date/Time: 10 February 2023, 1.00pm to 4.00pm

Location: Online (MS Teams)

Chair: Mr Richard Windeyer, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Digital Inclusion and Sustainable Communications Branch, Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Agenda

No.	Description
1	Welcome The Chair opened the meeting and welcomed participants with an Acknowledgement of Country
2	Opening Remarks The Chair introduced the Minister for Communications, Hon Michelle Rowland MP to working group members. The Minister noted that this space is moving fast and LEOs provide opportunities to better deliver communication services to Australian's. The Minister considered that the Group was well placed to inform government decision on policy and regulatory issues in relation to LEOs. The Minister also noted that it was important understand what longer-term role LEOs can play, especially in rural, regional and remote Australia.
3	Review and Agree Agenda and Draft Terms of Reference (ToR) Members were generally satisfied with the drafting of the terms of reference but noted several areas with the potential for review: • The ToR cover the expected areas but would benefit from a specific focus on Closing the Gap Target 17 and First Nations communities. • Other technologies, including MEO and HEO, could be included in the ToR. • Collaboration between operators and the various strengths of different orbits can create positive outcomes/solutions and the ToR could include examining integrated approaches between operators and technologies. • Beneficiaries of LEOs are not necessarily limited to Australians (and Australia) with LEO presenting opportunities across the Pacific Region.

No.	Description
	Outcomes • The Department will redraft the ToR to specifically note first nations communities as an area of focus for the working group. • The department will look at including regional opportunity(s) as a point of interest or focus in the ToR. • While noting that there is an array of related satellite technologies, the scope of the ToR will not be further expanded. Future discussions will not specifically exclude these technologies. • LEO WG members were invited to propose additional amendments to the ToR.
4	**Introductions and Key Issues** Working Group Members were provided a brief overview of themselves and their role in the group. The list of attendees is at Appendix A. s47F provided an explanation of the role of the First Nations Digital Inclusion Advisory Group in advising Government on matters related to Closing the Gap Target 17, noting that LEOsats had been identified by the group as a promising possible means. They identified a lack of digital inclusion, in particular, digital support for health, housing, schools and other essential services as a key barrier for First Nations communities achieving equal levels with the Australian population in Closing the Gap outcomes. They also noted that mobile coverage during emergencies when normal services are not available is critical to public safety in these communities. Industry participants introduced themselves and included start-up companies offering tailored services, newly established and emergent participants with multi-billion dollar planned or operational LEO constellations, established companies with significant experience in satellite communications, terrestrial downlink and backhaul network providers as well as wholesale and retail satellite service providers. Industry participants identified some key issues in the sector with a focus on connectivity. Participants highlighted the benefits LEOs can have for broadband connectivity but also in supporting IoT applications. It was also noted that there is a need to acknowledge the critical importance of terrestrial infrastructure to the success of the industry.
5	Industry Overview Communications Alliance provided the LEO WG with an industry summary that noted the potential benefits of LEOs but that they are not a new topic to government and regulators. Communications Alliance stressed the important role of access to sufficient spectrum as a critical enabler for these services' success and that access to spectrum would be an important issue going forward.
6	Government Agency Roles Government agencies provided summaries of their respective roles and responsibilities in relation to LEOs. The group heard from the Department of Infrastructure, Transport, Regional Development, Communications and the Arts, the Australian Communications and Media Authority and the Australian Space Agency.
7	General Discussion The chair opened the meeting for general discussion, topics focused on areas the working group could focus and build an agenda for another meeting or deep dive.

No.	Description
	The potential for LEOs to contribute in closing the gap was identified as an area that the working group may be able to advise government on. Members highlighted that the support of industry will be essential to achieving Closing the Gap Target 17. The broader role of LEOs in providing universal telecommunications services, including non-terrestrial mobile networks was a focus of discussion by the working group. There was a concern from industry that regulations proscribing particular technologies may be hindering the uptake of LEO services in Australia in favour of legacy technologies. Industry also noted that they considered that incumbent regional connectivity solutions have an advantage in the market due to existing government policies. Industry representatives noted that they considered there was merit in considering the benefits that LEO based services could provide and comparing them to current offerings. Industry further noted the need for solutions that fit the context into which they are being deployed. Beyond providing broadband connectivity the group also discussed how LEOs can support IoT and drive innovation, especially in in Australia's mining, energy and agriculture sectors. Industry noted that because a large portion of Australia's industries are remote, LEOs that provide connectivity for IoT can play a significant role. Industry also noted the importance of matching the needs of customers versus providing raw connectivity. Additionally, the group discussed potential benefits to resilience and reliability of Australia's telecommunications services. Given the reach of LEOs there was a view from industry that they could enhance the resilience and reliability of Australia's telecommunication through providing either backhaul to terrestrial services or providing services in the event of network disruptions. There was a brief discussion about the potential impacts LEOs might have on the environment through enabling other sectors and if they could support the net-zero 2050 target. Sovereign satellite capability was also flagged as a possible topic, given most LEO operators are global. The meeting also identified the importance of data and accurate reporting to inform government on options in this space. Industry agreed that there was a need to separate vapourware from products that were going to deliver effective services to Australia.
8	Meeting Close - Agreement and Next Steps The LEO WG agreed: • To expand and expressly identify First Nations (Target 17) as an area of focus in the ToR • To provide members with the opportunity to provide comments on the ToR. • To provide members with a list of WG participants Next Steps • DITRDCA would call for Submissions/Proposals from WG Members for priority themes/topics for Discussion Papers and Presentations

	Action item register
1	Department to redraft the ToR to expressly identify First Nations (Target 17) as an area of focus. Note: Draft has been circulated with these minutes.
2	Department to provide members with the opportunity to provide comments on the ToR. Note: Comments requested by 28 April 2023.
3	Department to distribute participants list from meeting one in the minutes. Note: Included in Appendix A.
4	Communications Alliance to provide words on satellite technologies in non-LEO orbits for inclusion in the ToR, noting that the ToR will not explicitly include or exclude these technologies as areas of interest. Note: Text was provided by Communications Alliance.

Appendix A: Attendees

Sector	Organisation	Attendees
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts	Richard Windeyer, Deputy Secretary, Communications Group s22(1)(a)(ii) [redacted]
	Australian Space Agency	s47F [redacted]
	Australian Communications and Media Authority	
First Nations	First Nations Digital Inclusion Advisory Group	
Industry	Amazon Project Kuiper	
	Commpete	
	Comms Alliance	
	Echostar Global	
	Fleetspace	
	Inmarsat	
	Intelsat	
	IPSTAR	
	Lynk Global	
	Myriota	
	NBN Co	
	Omnispace	
	One Web	
	Optus	
	Pivotel	
	SES/O3b	
	Speedcast	
	Starlink	
	Telesat	
	Telstra	
	TPG	
	Viasat	
	Vocus	

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 2: Minutes

Date/Time: 4 May 2023, 2.00pm to 4.00pm

Location: Online (MS Teams)

Chair: Mr Richard Windeyer, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Digital Inclusion and Sustainable Communications Branch, DITRDCA

Agenda Items

No.	Description
1	Welcome The Chair opened the meeting and welcomed participants with an Acknowledgement of Country.
2	Introduction The Chair noted the attendance of ACCAN, BIRRR and NFF as additional participants for this meeting to provide a consumer perspective. The minutes of the previous meeting were accepted without amendment. There was a brief discussion of the terms of reference, with endorsement from the group noting the changes that had been made to add specific areas of focus for the group. While not seeking to amend the terms of reference there was a discussion on the confidentiality of the discussions in group. Outcomes The terms of reference were accepted as presented, and a copy will be provided to the Minister. In relation to confidentiality, the minutes will continue to be drafted in a manner that does not seek to identify or attribute specific points to members of the group. The terms of reference may be published on the Department's website, while minutes will not be published.
3	**Thematic Discussion**: The potential role of LEOSats in closing the gap in digital inclusion, and in particular for First Nations people consistent with Closing the Gap Target 17 The Working Group received a presentation on digital inclusion in Australia, with a focus on First Nations people. The presentation is attached. This presentation included a representative from the First Nations Digital Inclusion Advisory Group discussing the potential benefits in relation to Closing the Gap Target 17. The presentation also provided an overview of the Australian Digital Inclusion Index as well as a proposal to undertake LEOSat connectivity trials in partnership with First Nations communities.

No.	Description
	Following the presentations, the group had an open discussion in relation digital inclusion and the potential for LEOs to address Closing the Gap Target 17. Topics discussed included: • The technology mix in areas of disadvantage, particularly the reliance on pre-paid mobile phones, Wi-Fi hotspots rather than ongoing subscriptions. • The challenge of identifying what solutions are needed for particular communities owing to the diversity of communities and the mix of needs. • We need to remain open about how to approach the issue, particularly in relation to the technology mix that could be used to supply connectivity. There may be a role for new GEO based technologies not simply LEOs. • Providers also noted that they are global entities and undertake work to addresses digital inclusion in a range of countries and expressed interest in participation. • Connectivity literacy is another challenge as people in areas of disadvantage may have different levels of understanding of connectivity options, and making an informed choice as to what solution will most efficiently address their needs can be challenge. <u>Outcomes</u> There was an agreement that LEOs have the potential to provide a capability that can contribute towards addressing the digital divide. The group considered that it was important to think holistically about the connectivity needs of individuals and communities. The group also considered that the First Nations Digital Inclusion Advisory Group's proposal around pilots had merit and some members indicated they are interested in taking part. It was also noted that there is a need to consider the range of satellite options carefully.
4	**Thematic Discussion**: The potential role of LEOSats in delivering universal telecommunications services As background, the Department gave the working group a presentation on the Universal Service Guarantee (USG), which covers access to baseline voice and broadband. The Department outlined the rationale and operation of the USG. It then noted the longstanding and broad interest in the better delivery of USG outcomes from industry, consumer and Government. The Department then set out some of the key policy considerations in this area and what industry could do to make a case for change, including providing performance data, challenging flawed regulatory and policy assumptions, and building consumer confidence. The presentation is attached. The invited consumer representatives were then asked to give their perspective on universal service delivery and the potential role for LEOSats. They noted the importance of focusing on outcomes for consumers, particularly in relation to service quality, reliability and affordability, over particular technologies. They noted connectivity literacy was important in helping consumers make informed choices about connectivity solutions. Quality reliable services, including mobile, would enable consumers to take advantage of digital applications, such as medical monitoring or smart farming systems that require connectivity. Rain fade was cited as a particular concern with the reliability of LEOSat services. The representatives also noted that the NBN unlimited Sky Muster trial was producing positive results. The discussion focused on whether all historical requirements and expectations applying to existing universal services continued to be valid, or whether some should be identified as essential and others secondary, or even obsolete. It also canvassed whether there could be trade-offs between requirements. Operators noted that there were many requirements that should be considered in the delivery of universal services but some may be less important going forward. Consumer representatives noted there are certain characteristics they consider should never be traded away, particularly reliability and availability. Industry

No.	Description
	representatives acknowledged rain fade could affect many satellite solutions but it was best to look at the hard data. Consumer representatives also noted the potential negative consequences and costs for consumers from the 3G shutdown that is currently occurring. Despite concerns, consumer representatives also noted that there were many people using new technologies and many would be enthusiastic about trialling new technologies. Outcomes Comms Alliance offered to provide information on rain attenuation. There was agreement that additional discussion on universal service delivery may be useful in the future. A pertinent focus would be using LEOSats to deliver voice services.
5	Meeting Close - Agreement and Next Steps The LEO WG agreed: • That the terms of reference for the WG were now final and will be provided to the Minister. • To include additional discussion on the use of LEOSats to deliver direct to device and emergency services at the next meeting of the group. Next Steps • The Department would follow-up on views about LEOSats and universal service delivery. • The Department would keep the Working Group informed about relevant developments in the First Nations Digital Inclusion Advisory Group, particularly in relation to a potential connectivity pilot program, where appropriate. • Use of LEOSats to provide direct to device communications and emergency services was identified as a priority issue for discussion at the next meeting. • The WG will meet again in July 2023, with a date to be circulated. • DITRDCA would call for Submissions/Proposals from WG Members for Discussion Papers and Presentations for the next meeting.

	Action item register
1	Circulate presentations from the Working Group meeting
2	Comms Alliance to provide a paper on rain attenuation to the next meeting of the group
3	Department to distribute participants list from meeting one in the minutes. Note: Included in Appendix A.
4	Department to keep Working Group informed about relevant developments in the First Nations Digital Inclusion Advisory Group, particularly in relation to a potential connectivity pilot program, where appropriate.

Appendix A: Low Earth Orbit Working Group - Membership and additional participants

Sector	Organisation	Attendees
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts	Richard Windeyer, Deputy Secretary, Communications Group s22(1)(a)(ii)
	Australian Space Agency	
	Australian Communications and Media Authority	
First Nations	First Nations Digital Inclusion Advisory Group	
Industry	Amazon Project Kuiper	
	Commpete	
	Comms Alliance	
	Echostar Global	
	Fleetspace	
	Inmarsat	
	Intelsat	
	IPSTAR	
	Lynk Global	
	Myriota	
	NBN Co	
	Omnispace	
	One Web	
	Optus	
	Pivotel	
	SES/O3b	
	Speedcast	
	Starlink	
	Telesat	
	Telstra	
	TPG	
	Viasat	
	Vocus	

Additional participants for this meeting

Sector	Organisation	Attendees
Consumer	Australian Communications Consumer Action Network (ACCAN)	s47F
	Better Internet for Regional and Remote Australia (BIRRR)	
	National Farmers' Federation (NFF)	

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 3: Minutes

Date/Time: 27 July 2023, 2.30 to 4.30pm

Location: Online (Teams)

Chair: Mr Richard Windeyer and Mr Matthew Brine, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Broadband Policy Branch, DITRDCA

Agenda Items

No.	Description
1	Welcome The Chair welcomed LEO WG members with Acknowledgement of Country.
2	Introduction The Chair outlined the Meeting 3 Agenda and provided and update from Meeting 2 • Participants were notified that the Secretariat has moved to the Broadband Policy Branch of DITRDCA • The previous meeting minutes were accepted without comment
3	**Thematic Discussion**: The potential role of LEOSats in delivering direct to device connectivity • Presentation by Lynk Global s47F Lynk Global provided a presentation (attached) on the technical and commercial readiness of D2D. Service will progress from intermittent SMS to voice and data as the constellation is deployed over the next few years. Lynk Global noted its capability timeline from its current 2G and 4G payload up to 5G with 100MB in a few years. Lynk Global noted that no modifications to current handset would be needed and that mobile phones would be able to roam on to the satellite – similar to how they currently roam on to terrestrial mobile base stations. Lynk Global further noted that the means through which the user accessed the service would be up to commercial partners, and that its first announced service, Palau National Communications Corporation (PNCC) were enabling all of their subscribers to automatically use the service where available. • Mobile network operators (MNOs) Optus, Telstra and TPG provided views to the group. Common to each operator was the view that LEOSats will provide a complementary service to their terrestrial networks, noting that it will likely never compete on latency or bandwidth but

No.	Description
	will be useful for deploying into areas where the terrestrial network would be absent for reasons such as economic viability or planning restrictions. MNOs noted the importance of managing customer expectations as to LEOSat capabilities, especially due to the possibility of customers conflating LEOSat broadband internet supported by phased array antenna and LEOSat mobile networks supported by handset antenna (which are significantly less capable). An MNO noted that an important aspect of deploying D2D would be securing social license and that environmental and cultural sustainability would come into this. Telstra noted that the emissions associated with launching LEOSats as well as the impact on the night sky will need to be managed. It was also noted that there are two available approaches with regard to spectrum, using MNO-held terrestrial spectrum or using mobile satellite services (MSS) spectrum, and that each have their own pros and cons. One MNO noted that they expect to see consolidation in the market and policies to support competition and ensure good value for customers may be needed. • General Discussion There was a general discussion on D2D readiness and capability including potential technical issues such as spectrum management to manage interference between terrestrial and non-terrestrial mobile networks (including as a result of doppler shift). Multiple participants noted that despite the lower capacity likely available through LEOSat mobile networks, they will have a significant impact. They also noted that if there are limitations, something is still better than nothing. It was noted that the S, L and MSS bands have been identified by the International Telecommunications Union (ITU) for the satellite component of international mobile telecommunication (IMT) – and that these bands can operate alongside terrestrial mobile signals with less interference concerns. A LEOSat operator noted that after 30 trials with MNOs using terrestrial spectrum it had not received feedback that interference had been an issue. It was also noted that a potential solution to interference could be for an MNO to dedicate some of its spectrum to support its LEOSat extended network rather than having it be shared between terrestrial and LEOSat base stations. The Australian Communications and Media Authority (ACMA) noted that direct-to-mobile services are being contemplated in both bands with and without a MSS allocation. In bands with an MSS allocation the ACMA noted that there are established processes for prospective operators to follow. It was noted that direct-to-mobile in bands with no MSS allocations (especially those used by terrestrial mobile/fixed broadband services) raises various issues given such uses were not envisaged in the development of current regulatory arrangements. The ACMA noted that its analysis of current spectrum licensing arrangement in various bands has not identified anything that precludes direct-to-device communications with satellites. The ACMA has also identified

No.	Description
	interference management considerations and the graphic extent of spectrum licences as factors it expects industry will have views on and which will need to be considered. The ACMA also noted that there would be various telecommunications obligations for providers to consider. The ACMA directed participants to look at the upcoming Five-Year Spectrum Outlook (FYSO) which is currently in the clearance process which discusses the spectrum management implications of direct to device systems and next steps. Fielding a question about congestion during emergency events, a LEOSat operator noted that it might be appropriate to throttle some users in order to support overall connectivity (for example, reducing access to data in order to protect access to voice and SMS) and that emergency services traffic could be prioritised. It was noted by another participant that 3GPP 5G releases will support network slicing in this way. It was also noted by a participant that consultation about proposed United States Federal Communications Commission (FCC) regulatory reforms to support supplementary mobile network coverage from space could be relevant to the Australian context.
4	**Thematic Discussion**: The potential role of LEOSats to support greater resilience and redundancy of communications networks in emergency circumstances • DITRDCA's Telecommunications Resilience Branch s22(1)(a)(ii) provided a presentation (attached) on telecommunications resiliency in Australia. The presentation covered recent natural disasters, the effect they had on communications networks and Australia's approach so far in mitigating their effects in the future, including the Strengthening Telecommunications Against Natural Disasters (STAND) and Telecommunications Disaster Resilience Innovation (TDRI) Programs. The presentation also raised the Public Service Mobile Broadband (PSMB) and the National Messaging System programs and asked participants how LEOSats might contribute. The Department also asked participants for their views on rain-fade and smoke-fade. • General discussion It was noted that for broadcast alerts, LEOSat augmented networks can reach any mobile phone in any location irrespective of terrestrial network with an emergency broadcast alert. This would include people beyond the terrestrial network edge, and also the people within the terrestrial network who suddenly experience an outage. Lynk Global noted that it is enabling MNOs to message their subscribers to inform them about an outage. It was noted that where the Ultra High Frequency bands are used (700, 800, 900 MHz), propagation through rain and smoke is not an issue. It was also noted that it is not so much the satellite technology but the spectrum used and gateway locations (e.g., one static gateway versus many distributed) that affect rain-fade and smoke-fade vulnerability, with frequencies above 5Ghz being susceptible. It was also noted that geosynchronous orbit satellites are also capable of supporting Public Safety Mobile Broadband (PSMB) as well as non-terrestrial mobile networks generally.

No.	Description
5	Meeting Close - Agreement and Next Steps • The chair noted that the next meeting will be to discuss the business and economic benefit that might flow from greater use of LEOSats, including in facilitating the Internet of Things (IoT). • The chair reminded participants they can submit any additional views to the secretariat, including on a confidential basis and that the Department remains open to one-on-one meetings with participants. • The chair outlined an approach for the report to the Minister. Towards the end of the year, the secretariat will prepare a report which will be a summary of discussions but without attributing views. The Working Group will have an opportunity to comment on the report.

Appendix A: Low Earth Orbit Working Group - Organisations Present

Sector	Organisation
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
	Australian Space Agency
	Australian Communications and Media Authority
First Nations	First Nations Digital Inclusion Advisory Group
Industry	Amazon Project Kuiper
	Commpete
	Comms Alliance
	Echostar Global
	Fleetspace
	Intelsat
	IPSTAR
	Lynk Global
	Myriota
	NBN Co
	Omnispace
	Optus
	Pivotel
	SES/O3b
	Starlink
	Telesat
	Telstra
	TPG
	Viasat
	Vocus

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 4: Minutes

Date/Time: 26 September 2.00-3.30pm

Location: Online (Teams)

Chair: Mr Matthew Brine, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Broadband Policy Branch, DITRDCA

Agenda Items

No.	Description
1	Welcome The Chair welcomed members and made an Acknowledgement of Country. He noted that he was filling in for Richard Windeyer for this meeting.
2	Introduction The Chair outlined the meeting 4 Agenda. The Chair noted that the ACMA had suggested some edits clarifying their comments in the last meeting. No further adjustments to the minutes were suggested and they were accepted without comment.
3	**Thematic Discussion:** *The potential to deliver economic benefits by enabling business innovation, including uplift of industrial sustainability, particularly through use cases outside providing broadband data services and through facilitating the Internet of Things.* • Presentation by Myriota s47F Myriota presented on the potential economic benefits, including sustainability uplift, of low earth orbit satellites (LEOSat) supporting Internet of Things (IoT) networks in Australia. Myriota noted that while the market size for satellite IoT has been relatively small, there is expected to be strong growth in the next decade, from about 5 million devices currently to 60 million in 2032. Myriota's solution uses an Australian-developed proprietary standard but it anticipates that the development of 5G low-power and low-data standards will lead to expansion of the market.

Myriota noted that narrowband services are complementary to broadband services, with the latter focusing on connecting people and narrowband focusing on connecting things in order to provide insights and facilitate management activities. Myriota advised that the need to efficiently collect data and control equipment related to resources and materials, which are distributed widely and well beyond population centres, has existed for some time in Australia. This issue can be resolved through narrowband services.

Myriota noted that there are many IoT use cases in Australia which have become economically viable because of the low-power and low-data requirements of IoT networks. They allow inexpensive devices to operate remotely for years on small batteries without needing to be replaced. Examples include: asset tracking, water resource tracking and use management, minerals exploration and mining, agriculture, ground truthing, fire prediction and management and environmental tracking. Businesses are able to do things they already do (such as meter reading) more efficiently, and will be enabled to do things they couldn't previously do, allowing business to positively transform their practices.

By way of example, Myriota noted that they are participating in the Murray Darling telemetry trials which are looking at how resources are managed so that the right amount of water is being extracted. This process helps water users to avoid fines while protecting other water users and the environment. Previously, water usage would need to be checked each year by an officer/ team of workers who would often travel large distances to check these resources manually. If overuse were detected this would often lead to fines. Now usage can be monitored on an ongoing basis and adjusted appropriately before over-use occurs.

- Presentation by Internet of Things Alliance Australia – s47F

The Internet of Things Alliance Australia (IoTAA) presented on IoT and LEOSats in Australia. IoTAA noted that that their vision is for a 'Data Smart Australia', and it has expanded its focus recently to include Net Zero, the circular economy, and building community trust in IoT through good practices in addition to productivity.

IoTAA noted that in terms of use cases you can plot a spread of use cases with distribution of devices on one axis and bandwidth requirement on the other. Where there is a confluence of high bandwidth need and high device distribution costs, Satellite IoT best fills the niche. IoTAA noted that for IoT there are many use cases which are viable because narrowband services can support a high quantity of data points at a low cost per unit and that this data can be extremely valuable. An example is being able to monitor the status of power lines and knowing whether a power-line pole is damaged. This process may not require a lot of data but may prevent millions of dollars in fines. IoTAA also explained that what is on the 'end' of the connection is important. It noted the importance of standards in terms of device availability and interoperability but also accessibility to users in terms of how easy it is to take up services, how they are billed, whether power-efficient devices are provided, etc.

IoTAA outlined the importance of robust competitive markets, where multiple options are available to address a particular business need or provide redundancy and noted that terrestrial and satellite services should therefore be considered as complimentary (even if they overlap). IoTAA noted that the availability of devices became an issue during the Covid 19 pandemic. Some devices disappeared without suitable alternatives being available because they were proprietary. IoTAA noted that if there are no standards then affordability and availability can disappear. Resilience and security were also identified as being important factors in IoT networks.

IoTAA also noted that the 2023 Productivity Commission Report had commented on the multiplier effect of digital technology on productivity and that there is a knowledge gap around comparative analysis of this multiplier effect in metropolitan versus regional, rural and remote Australia for IoT. IoTAA suggested looking at this area as a potential opportunity for industry and government.

- General discussion

Participants noted that there has been much theoretical discussion about what could be done in this space but that the technology has progressed to the point where it is technically feasible to put solutions into place. They further noted that it would be appropriate to start practical trials to reinforce proof of concept. It was further argued that entities like Starlink have benefited greatly from US government support without a high level of confidence in the ability to solve a problem at the outset, providing a benefit to lead in the international market. Some members noted that Australia has an opportunity to propel its burgeoning space and IoT industry in a similar manner. Participants expressed interest in helping the department and Government develop this opportunity.

Participants noted Fleetspace's work in lithium exploration and the opportunity to lead globally by developing and implementing carbon offset credit quality verification methodologies. Participants also noted the implications for land stewardship and First Nations outcomes, with the examples of enhancing the capabilities of Indigenous rangers and providing connectivity for use cases at remote outstations which are not always occupied.

A participant noted that there is a gap in mandated financial environmental disclosures in the context of carbon credit quality and that IoT could help close this gap. The participant explained that Treasury has acknowledged that quantitative data, being more valuable, is difficult to collect in this field and that as a result mostly qualitative data is collected. Participants noted that because of the greater and more affordable data collecting capacity enabled by IoT, qualitative data can now be collected more easily. Participants also noted that this data can serve dual purposes, such as supporting various business needs in addition to regulatory compliance.

The conversation also covered the role of standards for devices and data in the market. Participants noted that interoperability of data is an issue where there is a 'yawning gap'. There is no lack of data collecting ability but there is a lack of common data taxonomy and trust for that data to be shared and used. The issue is exacerbated because data sharing tends to be along business lines rather than being open.

Members of the Working Group however cautioned against setting standards too aggressively as this could have a stifling effect on innovation. A participant noted that standards tend to follow innovation and that you need to find the right point of commonality to set. There needs to be enough leeway for business to innovate and there is a balance point where the implementation of a standard is most beneficial in realising benefits, building availability, accessibility, and resilience. The participant noted that it is currently innovating in an area that is yet to be standardised, and that standardisation is on the horizon, but that if standardisation occurred now its innovation would be diminished.

Participants also noted that large companies can sometimes stifle a field by holding up standardisation processes in order to delay competitors from progressing in a market.

No.	Description
	Building on discussions around the merit of trials, there was discussion around what economic multipliers could be identified to help justify government action in this field. A participant suggested that an alternative approach could be to use trials to identify and demonstrate real world benefits and that further research to identify theoretical economic multipliers might not be warranted.
4	Reflections on earlier discussions • Presentation by Communications Alliance on their understanding of LEOSats in the Australian market and potential to the future. Communications Alliance provided an outline of the ecosystem of technologies with the capacity to address Closing the Gap target 17 and more generally, to close the digital divide, noting that the overall aim is to provide First Nations people and other regional, rural and remote communities with access to similar connectivity as their urban counterparts (not merely uplifted connectivity). Communications Alliance noted that the capacity to do this currently exists and will only improve. The presentation covered geostationary and non-geostationary mobile and fixed satellite services including 3GPP and proprietary narrow band services, non-terrestrial mobile networks and broadband internet services. Communications Alliance explained that these technologies can work together with terrestrial technologies such as Wi-Fi and terrestrial mobile networks. The presenter also noted that across different geographies, population densities and use cases, these technologies form a greater ecosystem and complement one another. Communications Alliance advised that the main focus should be on how to deliver services to users where ever they are across Australia, rather than on particular technologies. The presenter also noted that some technologies that may have been discounted in recent years, have also seen technological enhancements and remain valuable options to address certain needs. • General discussion Reflecting on Communications Alliance's comment that terrestrial technologies such as Wi-Fi 6 and 7 as well as mobile networks can be used to reticulate connectivity in regional hubs and remote towns, a participant noted that mobile network reticulation may be better in some communities. This is based on experience reticulating satellite signal in Mexico and Brazil, and reflecting on the distribution of populations in northern and central Australia, that Wi-Fi suffers from signal propagation limitations. Participants noted that a trial (particularly in a Closing the Gap Target 17 context) would be appropriate and expressed interest in taking part. It was noted that the First nations Digital Inclusion Advisory Group is also looking at trials and there could be some opportunities for synergy here. Participants noted that the process of scoping and determining how a community service trial will work may be complex and that there may be many moving parts which will need to be considered. A participant noted that there are questions as to the service integrator, how to go to market and how to engage with the average customer.
5	Meeting Close - Agreement and Next Steps • Next Steps

No.	Description
	The chair noted that this would be the last meeting this year. The Secretariat will prepare a Chair's report to the Minister on the group's discussion and would circulate a draft to members of the Working Group to identify and correct misunderstanding or misrepresentations. We would not be seeking endorsement of the report by the Group. In the report, the Chair would seek guidance from the Minister on the next steps. The Chair reflected that this forum has enabled an open discussion early in the policy consideration process. The Chair noted that the Secretariat is happy to meet with participants individually or take on board additional material.

Appendix A: Low Earth Orbit Working Group - Attendance

Sector	Organisation
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
	Australian Space Agency
	Australian Communications and Media Authority
First Nations	First Nations Digital Inclusion Advisory Group
Industry	Amazon Project Kuiper
	Commpete
	Comms Alliance
	Echostar Global
	Fleetspace
	Inmarsat
	Intelsat
	IPSTAR
	Lynk Global
	Myriota
	NBN Co
	Omnispace
	One Web
	Optus
	Pivotel
	SES/O3b
	Speedcast
	Starlink
	Telesat
	Telstra
	TPG
	Viasat
	Vocus

Additional Participants – Meeting 4:

Internet of Things Alliance Australia (IOTAA)

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 5: Minutes

Date/Time: 21 June, 10am to 12pm EST

Location: Online (Teams)

Chair: Mr James Chisholm, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Broadband and Emerging Communications Branch, DITRDCA

Agenda Items

No.	Description
1	Welcome The Chair – Welcomed LEO Working Group members with Acknowledgement of Country The Chair noted that the First Nations Digital Inclusion Advisory Group representatives could not attend as they were hosting meetings in Darwin. The Chair noted that the secretariat invited Connected Farms and National Farmers Federation to join the Working Group for the second session to consider the economic research project.
2	Introduction Chair – Meeting 5 Agenda and Update from period since last meeting **Staff changes (James Chisholm,** s22(1)(a)(ii) The Chair noted some staff movements within the department. The previous Chair, Richard Windeyer, has moved to the Department of Finance, the new Chair is James Chisholm who joins the department as Deputy Secretary, Communications and Media group, from the Department of Prime Minister and Cabinet where he worked on energy policy. The Director of the Emerging Communications team which provides the secretariat support to this group has changed. s22(1)(a)(ii) has moved across to lead the telecommunications security team and s22(1)(a)(ii) is the new Director. **2023 Chair's report to the Minister**

No.	Description
	The Chair thanked participants for their input on the 2023 Chair's report to the Minister, noting that their contributions have been informing the work program of the department and the Australian Government. The Chair noted that the Minister remains committed to ensuring that Australia is ready to best embrace new technologies in communications, particularly LEOSats and LEOSat-enabled technologies. The Chair noted that while the Working Group discussions last year were thematic, the aim in forthcoming meetings is to consider and provide advice on more specific issues and opportunities. **Update on government workstreams** The chair noted the department has been progressing the following key workstreams: o Considering how the existing regulatory framework applies to satellite-based services, including direct to device (D2D); ▪ The department will distribute to the working group a consultation paper on D2D regulation via email in coming weeks. o Working with the ACMA following consultations on spectrum arrangements for D2D; o Running separate consultation processes on the universal services framework and funding arrangements, which has provided opportunities for stakeholders to share their perspectives on a range of issues, including evolving technologies and implications arising out of LEOSats; o Considering implications for the triple zero call service arising from the commercial deployment of D2D voice services. o Participating in in international spectrum arrangements, particularly through engagement with World Radiocommunication Conference (WRC) 2023. o Digital inclusion, especially for First Nations communities in the context of Closing the Gap Target 17. ▪ Working with NBN Co on Wi-Fi deployments in around 20 communities. ▪ The next tranche of this work will be looking at using a range of technologies, including LEOSats, with consultations on program design out at the moment. This is expected to be an area of key focus for the Working Group and likely to be on the agenda for July. o Assessing the potential economic impacts of LEOSats on the agriculture and mining sectors. • Communications Alliance (CA) noted that its Satellite Services Working Group (SSWG) will be producing a paper for the 2025 Regional Telecoms Independent Review Committee (RTIRC) updating material that it submitted to the 2021 RTIRC. The paper would look at operators in

No.	Description
	the sector, their constellations and capabilities and how this can feed into connectivity solutions in Australian. CA noted that the FNDIAG and USO review would also be interested in the paper. CA also noted that increasingly it is seeing operators in multiple orbits, with orbits collaborating.
3	Working Group 2024 forward work program. The Chair noted that that the Minister agreed to the Working Group continuing on an ad-hoc basis, addressing issues as needed. **Terms of Reference** The Chair invited participants to discuss the Terms of Reference (ToRs) for the Working Group, noting substantial revision is not proposed. A participant argued that there is a trend towards hybrid networks (where multiple orbits are used) and that ToRs could be adapted to reflect this, otherwise Australia would be out of step with international counterparts. The participant noted that the sector will change significantly over the next 24 months with new offerings coming online including micro GEO satellites. Another participant proposed the focus of the group should be specifically LEOs given its established purpose. Multiple participants noted that the ToRs do currently contemplate all orbits as well as the existence and relevance of integrated solutions. The Chair advised he was of the position that the ToR already account for hybrid and multi-orbit technologies, and therefore a change would not be needed at this time but welcomed further views offline. Assistant Secretary Broadband and Emerging Communications (AS BEC), advised the Working Group's that the key focus for the Government is reliable, affordable, and equitable connectivity for Australians, using a range of technologies, and that the department is happy to engage with participants outside of the Working Group to discuss technology solutions beyond LEOSats. **Forward Work Program** The Chair invited participants to discuss the group's forward work program and potential issues of focus. The Chair noted the department has identified several areas where insights from the Working Group will be particularly helpful: • Topic for current meeting 5: o Input into research on economic impacts of LEOSats

- Topics for meeting 6 (late July)
    - Pre-paid satellite broadband (Chair's report rec 1.2)
    - First Nations Community internet access options

The Chair noted that the secretariat has circulated information to the Working Group about the current First Nations Digital Inclusion Advisory Group consultation on the Digital Inclusion Roadmap and specific connectivity and digital literacy measures. Following that consultation, the Chair proposes the Working Group discuss relevant outcomes including the design of a contestable program to provide free community Wi-Fi to remote communities.

        - NBN Co noted that the Roadmap discussion paper currently out for consultation closes end of June. NBN Co undertook to circulate links to the consultation so members could consider prior to the July Working Group meeting.

The Chair noted that for meetings beyond July, he is looking for Working Group participants to champion issues at a future meeting, through providing materials and presentations.

- Topics proposed for subsequent meetings
    - Universal Service Framework post-consultation. The Chair noted that there is potentially a good opportunity to have the Universal Services Branch provide an update on some of the key issues and themes arising from those consultations, at the appropriate time. He would be interested in any further views from this group, in an advisory capacity, as to how it might best contribute to further policy consideration – noting that the Government remains interested in data on the uptake, pricing and performance of existing LEOSat services, as well as further services come to market.
        - Participants expressed support for this topic.
    - Promoting LEOSats and related industry (e.g. IoT). The Chair noted that Working Group received a suggestion last year around promoting the use of LEOSats and LEOSat enabled technologies.
    - Policy issues arising out of LEOSats (particularly D2D). The Chair noted there could be potential to look at what sort of policy issues may be affected by the proliferation of LEOSat enabled technologies. There could potentially be a role for the Working Group in informing other policy areas about impending impacts. For example, should transport or infrastructure policy be adjusted given the ease of backhauling connectivity? Are there privacy implications for D2D connectivity?
        - A participant noted that there would likely be interesting policy topics following the Working Group considering the department's forthcoming consultation on the satellite regulatory framework.
    - Other

The Chair invited participants to reach out if anything occurs to them.

No.	Description
	The secretariat noted that the Minister's office is also very interested in further discussion on LEOSat connectivity for emergency resilience, particularly in the D2D context.
4	Chair - Other Business • No other business
5	Break
6	Presentation – Telstra Starlink rain-fade measurements **Presentation by Telstra** Telstra presented its work on the effect of rain-fade on voice services over Starlink using consumer grade terminals. Telstra noted that this work is in the USO context so there is a comparison to other USO technologies and the focus is on voice outages. Telstra noted that there is some effect from rain fade but overall availability is still very high with dropouts only lasting an average of 4 minutes. Telstra also noted that there is a small data rate decrease during rainy periods. During the only period where rainfall as high as 100ml per hour was measured, connectivity was not interrupted and the data rate was 80Mbps. Telstra noted that overall rain is a very small contributor to satellite link and LEOSat connectivity outages and that LEOSat broadband compares favourably to the other USO technologies. **Discussion** Participants complimented Telstra on this work. A participant noted that it has been doing similar work at a smaller scale, with similar results. The participant noted that during cyclone Jasper (4 Dec 2023 – 13 Dec 2023), connection reliability only dropped when the host building was washed away. The participant noted that the more industry can utilise data like this the more able industry is to advise their customers and to create confidence in the technology and service. Also, that it appears clear from this data that LEOSats have equal to, or likely superior, uptime compared to legacy copper voice, High Capacity Radio Concentrator (HCRC), etc., and can be fixed virtually instantly when they drop out, rather than requiring technician visits when the network does not work and or connectivity is interrupted The Chair noted two significant takeaways from the presentation; that there is no statistically significant interruption during rain and also that heavy rain is actually reasonably infrequent. Telstra undertook to distribute the slides from the presentation.

No.	Description
7	Workshop on research into the Economic Impacts of LEOSats on agriculture and mining sectors in Australia The Chair noted that during Meeting 4 last year, the Working Group discussed the potential benefit of quantifying the economic impacts of LEOSats in Australia and that it is also something that Minister Rowland is interested in pursuing. AS BEC noted that for this project, the Minister was particularly interested to initially look at the economic benefit of LEOSats in Australia's Agriculture and Mining sectors. We know there are also going to be large social, mental, and wellbeing benefits across different areas of Australia. AS BEC also noted that being a relatively newer technology, one of the challenges of the research analysis so far has been a small amount of data being available. The department is considering a second stage of analysis to obtain some economic modelling capability to build on the data this project collects. **Presentation by Bureau of Communications, Arts and Regional Research (BCARR)** BCARR noted it is at arms-length from policy areas and shared data is kept private and secure. BCARR noted that both the agriculture and mining sectors are generally outside of the fixed wireless and traditional terrestrial telecom service areas, where access to high-speed broadband can be limited. BCARR noted although there is a high proportion of connectivity in agriculture, it is often not at a high capability and not across an entire property. Other challenges also affect utility of connectivity, e.g., lack of understanding. Agriculture has been one of the least connected sectors in Australia and it is clear that there is substantial potential to enhance connectivity. BCARR noted that the mining industry does tend to be well connected. However, businesses appear to be less satisfied with connections than the average Australian business. To some extent, this may reflect the appetite for digital use cases being relatively high compared to average business. The larger players are heavily invested in technologies such a digital twin, autonomous vehicles, but there is still room for improvement across the sector. Many repetitive or low skill tasks are suitable for digital replacements. LEOSats appear to be well placed to help, including for small orgs and isolated workers, exploration and backhaul redundancy. Skillsets in the industry and capital investments are potential roadblocks to the adoption of LEOSat technologies in this sector. BCARR noted that the adoption rates in each sector were likely to be hampered by skills and asset allocation and affordability. BCARR advised they would like to take this research further and noted there are a number of factors that drive demands and expected benefits that might hold back investment. Possibly an area for further research BCARR detailed some example impacts and use cases across; operational, social and health and environment for each sector. **Discussion** Participants complimented the presentation and paper, noting that this is an important area of research for the Working Group and department.

No.	Description
	A Participant noted that some of the research was based on figures from 2021 which will now be out of date given the uplift in capability since then, including for the Sky Muster satellite service. The participant also noted that although the bush has never been better served, it is not seeing universal uptake; likely due to insufficient digital and connectivity literacy. The participant reflected that people often don't know what they are looking for. Other participants agreed that digital and connectivity literacy is considered a significant roadblock for the agriculture sector. A participant noted that in the mining and resources sector, a recent development is bonding of services, where multiple smaller services can be combined into a larger service (e.g., 1.3Gbps) at a relatively low price point. The participant also flagged a potential policy issue for the department. Historically, if a customer needed 1.3Gbps it would be provided through fibre, but due to expense and other factors these kinds of connections will be achieved through LEOSat instead. As a result, regional areas might get lower levels of incidental fibre backhaul. A participant noted that LEO is often essential, but not a silver bullet for agriculture; and applications must be supported by a technology stack which varies between users. For broadacre farming LEOSat terminals would be installed directly onto large machines; these machines can be connected to each other and the internet through a mesh network. However, for a fruit orchard, a private network may be needed, due to overhead cover. The participant also noted there is not a one size fits all solution, high end customers are pursuing precision agriculture and know what they are looking for in terms of a technology stack. On the other hand, family operators might be interested in connectivity but will need to learn about the tech stack and how it can benefit them. The participant also noted the effect of price sensitivity, for example, people are concerned about ongoing pricing. This can be exacerbated when services are over-specified and over dimensioned for what people need. The participant noted that connectivity allows automation which enables significant savings. The participant also noted that there are machines worth multiple millions of dollars currently on farms, with applications that cannot be utilised due to lack of connectivity. Another participant noted that the economics of space infrastructure is changing rapidly, partially due to hybrid networks. The participant would like to see a comparison of Mbps costs for different options. The Participant posited that in Australia and New Zealand, customers are always looking for the lowest cost per Mbps and that the lowest cost will come from the ability of the network to manage its CAPEX. The participant also noted that most IoT connectivity is not being provided by LEOSat. The oil and gas sector is largely served by GEO and new hybrid capabilities that integrate LEO. AS BEC asked participants to get in contact offline to share any useful data and insights they may have access to.
8	Meeting Close - Agreement and Next Steps 1. Summary of Discussion The Chair summarised the discussions. 2. Agreed Outcomes a. The Terms of Reference will remain unchanged as they already address concerns raised during the first session.

No.	Description
	b. Future topics on forward work program can be added offline, noting there was no objection to any of the topics raised. There was support for the next meeting (proposed late July) to consider First Nations connectivity, and subsequent meetings to further discuss universal services reform as well as other policy issues arising from the satellite regulatory framework consultation. c. The economic research project will continue. 3. Next Steps a. Telstra will share presentation slides b. Communications Alliance will share its SSWG 2024 RTIRC paper c. NBN Co to share roadmap consultation paper d. Participants are encouraged to contact department with further data and insights on the economic impacts of LEOSats in mining and agriculture. 4. Next meeting a. The next meeting will be on First Nations connectivity challenges and opportunities.

Appendix A: Low Earth Orbit Working Group - Membership

Sector	Organisation
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
	Australian Space Agency
	Australian Communications and Media Authority
First Nations	First Nations Digital Inclusion Advisory Group
Industry	Amazon Project Kuiper
	Commpete
	Comms Alliance
	Echostar Global
	Fleetspace
	Inmarsat
	Intelsat
	IPSTAR
	Lynk Global
	Myriota
	NBN Co
	Omnispace

	One Web
	Optus
	Pivotel
	SES/O3b
	Speedcast
	Starlink
	Telesat
	Telstra
	TPG
	Viasat
	Vocus

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 6: Minutes

Date/Time: 25 July, 1:30pm to 3:30pm EST

Location: Online (Teams)

Chair: Lisa La Rance, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Broadband and Emerging Communications Branch (BEC), DITRDCA

Agenda Items

No.	Description
1.	Welcome - The chair welcomed the working group and completed an Acknowledgement of Country.
2.	Introduction • Meeting 5 minutes - The Meeting 5 minutes were accepted. • Update from period since last meeting - The Chair noted that the department is conducting targeted consultation on satellite systems regulation, noting that submissions will not be published. - The Chair noted the department recently held a roundtable on LEOSats with state and territory officials. The secretariat provided a brief update. • Chatham House Rule - The Chair reminded participants that the intention for the Working Group is to operate as per the Chatham House rule, advising that information provided here is not distributed, discussed or attributed to anyone unless the party who provided the information agrees.
3.	Working Group 2024 forward work program s22(1)(a)(ii) discussed topics for future meetings.

No.	Description

	• Topics for Meeting 7 (potentially September)
	  ○ Universal Service Framework post-consultation, and
	  ▪ AS BEC noted this will be an opportunity for the Universal Services Branch to reflect on the framework process so far and for the Working Group to discuss some of the key themes from the reform process.
	  ○ Promoting and supporting D2D for Australia
	  ▪ AS BEC noted that the department also proposes to hear from participants on ways to encourage D2D connectivity in Australia.
	• Topics for Meeting 8 (potentially November)
	  ○ Network Resilience including the role of D2D, flyaway kits, HAPS etc.
	  ▪ AS BEC noted this will be an opportunity to discuss the role of LEOSats and or hybrid solutions as redundancy options for Australian networks in the future and the progress of the Telecommunications Disaster Resilience Innovation (TDRI) program.
	  ▪ Meeting 8 will also be an opportunity for participants to provide information about developments in satellite telecommunications that are relevant to network resilience.
	AS BEC invited participants to propose additional topics or presentations for future meetings. A topic does not necessarily need to encompass an entire meeting, and the department welcomes participants championing topics

4.	First Nations community internet access options • Presentation by department to provide background on the program s22(1)(a)(ii) s22(1)(a)(ii) provided an initial outline of the Government's recent budget announcements relating to First Nations digital inclusion (slides attached). s22(1)(a)(ii) advised the Working Group that digital connectivity in remote locations and the expansion of data collection on digital inclusion for First Nations people, is a key part of the Government's digital inclusion agenda. Establishing and maintaining strong digital literacy skills in community and enabling First Nations people to access connectivity wisely, is critical for the success of this program. That is why the Government has provided $18M in funding for digital mentors as well as additional funding of $20M over 3 years starting from this financial year to deliver additional free community Wi-Fi connectivity solutions in First Nations communities. s22(1) advised that we are encouraging telco providers to deliver connectivity solutions in community and we are keen to explore LEOSat options as part of this consideration. s22(1)(a)(ii) advised that government is keen to deliver programs as early as possible and align the measures collectively between the digital support hub and mentors, and connectivity solutions.

No.	Description
	Government is keen to consult with members of community and industry, and we want to make sure that there is effective engagement with communities to deliver appropriate solutions that meet the needs of communities. • Presentation by First Nations Digital Inclusion Advisory Group s47F s47F, co-chair of the First Nations Digital Inclusion Advisory Group (FNDIAG), discussed emerging outcomes of the FNDIAG engagement with stakeholders and communities to inform development of a First Nations digital inclusion roadmap, particularly as they relate to LEOSats (slides attached). s47F noted that the initial Report from the FNDIAG identified that LEOSats have potential to help close the digital divide, but that there needs to be a considered approach that maximises the benefits to First Nations Communities. He noted that First Nations people can often feel locked out of technology and that there is a need to provide confidence, especially outside of coverage footprint of traditional technologies. s47F also noted the need to make sure consumer protections are in place, like connection quality, reliable hardware, responsive repairs, encryption and privacy by default. Other important factors include clear billing with multiple options to suit consumer preferences, prepaid broadband access, universal services reform, and direct to device services may feed into these considerations. There is a need to provide a holistic approach to connectivity that facilitates the community and to enable First Nations Communities to be the decision makers for their own solutions. This approach could include an option for turning off connectivity. s47F also highlighted the need to make sure First Nations Communities have the technical literacy to understand and utilise their options, instead of providers or the government simply providing technology and leaving. He noted that the sector could utilise community resources such as local first nations broadcasters and media for translations, service announcements and general engagement to assist in this process and to help communicate effectively with First Nations Community members. Discussion was deferred to after the following presentation due to the closely related subject matter.
5.	Pre-paid satellite broadband (Chair's report rec 1.2) AS BEC noted that the intention of this item is to identify how prepaid satellite products can be provided, given they have been shown to be important to remote communities and have been recommended by the FNDIAG as a cohort-responsive measure to extend access and affordability capacity. • Presentation by department s47F provided background around pre-paid satellite broadband in order to guide discussion (Slide attached). s47F provided a presentation on the scale of premises connected to various options in Australia, including take up of NBN solutions and proposed some products and equipment to offer

No.	Description
	service solutions for pre-paid broadband, including, for example LEOSat pre-paid broadband. s47F noted there are wider opportunities for service take up for broadband connectivity and noted there is a larger market than just traditional NBN and retailer products. LEOSats may see opportunities for connectivity solutions in traditional NBN serviced areas and non-serviced areas, with prepaid broadband used to deliver more consumer options and meet gaps in the market. A contrast to the mobile market product and services was also made. The Department was open to participants following up to discuss specific examples or further consumer insights within their global businesses. • Discussion (including for item 4) Roadblocks for providers and barriers for consumers. Participants noted the start-up and or signup cost is probably the biggest bottleneck (affecting suppliers and consumers) to the widespread implementation of prepaid fee structures in satellite. It was also noted that some consumers would have trouble accessing any service, even if it is prepaid. It was also noted NBN Co could have a role to play in providing the initial cost, with a retail provider assuming the ongoing risk onwards. It was noted NBN Co is already working on place-based solutions through the first Nations Community Wi-Fi program. Placed based solutions are likely to be essential to address the market gap. Further relationships with partners beyond the network will be essential for connectivity solutions in communities. A participant also noted that marketing costs for suppliers can be high, with hard to reach consumer cohorts and a geographically dispersed market. This is exacerbated by relatively low returns. A participant also noted that they have looked into a prepaid model in the past and another challenge is distributing elements essential for service provision, such as pins, cards, vouchers and so on. They also noted wholesalers do not tend to offer products conducive to prepaid because they are inflexible, typically based on a monthly billing cycle rather than a rate for data used. The participant noted interest remains in the model because it can be suitable for many cohorts. Noting not all income or habitation is regular. The participant noted seasonal workers in particular have a cyclical income and may require to buy a plan with data options when financially suitable, which would be utilised during low-income periods. Other participants noted other cohorts such as retirees, over 50s and people with holiday homes or investment housing may have an interest in a similar model. This flexibility would suit the bespoke needs of the customer. A participant asked if more options existed at the front end of service delivery, would customers be more likely to engage with a provider earlier and be able to stay connected for longer without some of the ongoing complications previously advised? It was noted this will depend on the customers digital literacy and may also be dependent on their financial situation. Balancing needs versus costs and education is the key consideration for providers as often prepaid products are bought because customers are familiar with the product, but it could be reducing access to competitive market options Overseas examples of pre-paid broadband

No.	Description
	Participants discussed overseas examples, particularly in the context of Pacific island countries (PIC)s Participants noted Thaicom has had a similar experience providing services in the Philippines and the company assisted in running a community Wi-Fi based program based on a prepaid service. The local government provided support funding through a levy to encourage service providers to supply a retailer service and they were able to apply scalability options to local and displaced markets. It was noted the establishment costs were sizable and provider interests may be impacted by costs rather than regulatory barriers. A participant also noted Starlink is involved in connectivity programs, for example, through a subsidy program in Quebec, where it was noted local RSPs are the face for Starlink and have the relationship with consumers on the ground. Participants noted there would be value in looking at further examples. Participants noted the current wholesale model in Australia is not conducive to such an arrangement working here. Further clarifying there is no technical challenge, rather the challenge arises out of the financial element and the underlying product construct of the NBN. The participant later noted however Sky Muster is the closest to hand opportunity and that GEO satellites should be considered alongside LEOSats. Consumer insights A participant noted it would be useful for the department to conduct research to better understand the need for prepaid broadband, particularly in terms of assessing latent consumer demand. Market profile A participant identified a connection with USO reform, noting the aim of USO reform should be to set up the dimensions of the market and to see how it can serve community needs. The participant contended the LEO satellite broadband market is currently monopolised by Starlink, but new providers will be investigating ways to make an impact. The participant noted that previously there was a program where the government would provide a rebate if you can provide a service that meets certain requirements and this could be revisited. The participant noted the NBN is there to solve a failure in market, but that there is no indication there will be a market failure, rather, the market is likely to be quite healthy with lots of providers who are integrated and can lean into providing services that are fit for purpose. A participant noted an infrastructure owner like Starlink could bring prepaid broadband access more easily to market, because it does not have to work within constraints affecting other providers in Australia. It was also noted that although the upfront cost of an antenna and modem remain, this cost could be built into the business model. It was separately argued that Starlink is somewhat monopolistic and unlikely to provide bespoke solutions to a market as small as Australia and there is therefore currently not enough flexibility in the market. A participant reiterated there are inherent complexities and challenges in trying to resolve connectivity solutions when we don't know what technology will be available in the future and or how to consider the impacts on the regulatory environment, wholesale environment and what will

No.	Description
	be available to the consumer. It was noted there may be a need to broaden scope of the consideration and potentially develop a roadmap. Connectivity Literacy Participants noted that connectivity literacy is an issue, regardless of whether particular products are 'set and forget' or not. Some consumers are unfamiliar with what options exist or the associated costs. Some consumers are buying based on how much they want to spend rather than need Outcomes from this consumer behaviour mean some buy a smaller plan and encounter problems because it is under provisioned. A participant reflected on the importance of marrying the needs versus the cost. Customers who are still purchasing Sky Muster are doing so mostly because of cost, and sometimes because they don't need low latency. The participant further noted some people will buy prepaid mobile because it's what they know but they may then be disconnected from aspects of the digital economy because their level of access is limited. Regulation A participant noted that regulation treats prepaid and post-paid products differently and this could be difficult for retailers of prepaid products. It was noted for post-paid services there are steps an operator needs to undertake to discontinue service or set up debt recovery but in prepaid, the process is different. A company servicing a prepaid market would need to comply with different regulations which would introduce different costs. The participant noted even if the government subsidised the currently prohibitive cost of entry, regulatory disparities would likely remain a roadblock.
6.	Other business Participants expressed interest in an update on satellite regulation consultation and whether there is a roadmap. The Secretariat noted that the Competition and Regulation team are responsible for the consultation and that the Secretariat will update the Working Group on developments.
7.	Meeting Close - Agreement and Next Steps [Lisa La Rance closed the meeting] 1. Next Steps a. Secretariat to circulate presentation materials b. Secretariat to set a date for the next meeting c. Secretariat to keep Working Group updated on satellite regulation consultation d. Starlink and department to meet offline for a briefing on connectivity programs that Starlink is involved in overseas. Next meeting The date for the next meeting is yet to be set but late September is likely. The meeting agenda will likely include discussion of USO consultation and promotion of D2D services in Australia.

Appendix A: Low Earth Orbit Working Group - Membership

Sector	Organisation
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
	Australian Space Agency
	Australian Communications and Media Authority
First Nations Communities	First Nations Digital Inclusion Advisory Group
Industry	Amazon Project Kuiper
	Commpete
	Comms Alliance
	Echostar Global
	Fleetspace
	Inmarsat
	Intelsat
	IPSTAR
	Lynk Global
	Myriota
	NBN Co
	Omnispace
	One Web
	Optus
	Pivotel
	SES/O3b
	Speedcast
	Starlink
	Telesat
	Telstra
	TPG
	Viasat
	Vocus

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Low Earth Orbit Satellite Working Group (LEO WG)

Meeting 7: Minutes

Date/Time: 11 February, 9am to 11am AEDT

Location: Online (Teams)

Chair: Mr James Chisholm, Deputy Secretary, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA)

Secretariat: Broadband and Emerging Communications Branch (BEC), DITRDCA

Agenda Items

No.	Description
1.	**Welcome and apologies** *Chair – Welcome LEO WG members with Acknowledgement of Country* *Apologies:* - See: Appendix A: Low Earth Orbit Working Group – Meeting 7 Attendance
2.	**Introduction** *Meeting 6 minutes* • No notes were received on the meeting 6 minutes. *Staffing and membership update from period since last meeting.* • The Chair welcomed s22(1)(a)(ii), Senior Advisor to the Hon Michelle Rowland MP, Minister for Communications. • The Chair welcomed a new Working Group member, AST SpaceMobile to the meeting. • The Chair introduced the new Emerging Communications (EC) s22(1)(a)(ii) *Housekeeping* • The Chair noted that these meetings are conducted according to the Chatham House rule. *Other* • The Chair noted the department is very interested in direct to device (D2D) services and is looking to gain a fuller understanding of what is occurring in the D2D sector. Noting that the intent of this meeting is to check in with the subject matter experts to confirm what the government and the department know, particularly in a fast-moving space.

No.	Description
	• The Chair also stressed that the Australian Government cannot develop good policy in a vacuum, and that it is essential that members keep the department as well informed as possible.
3.	## Updates *Update from department* • s22(1)(a)(ii) provided an update from the department. • a/g AS BEC apologised for s22(1)(a)(ii) was unable to attend due to other circumstances. • a/g AS BEC noted the topics for discussion may touch on commercial sensitivities but requested members participate where they can. • a/g AS BEC reiterated government interest in D2D and that this strong interest will continue in 2025. Further noting that; o Direct to device (D2D) has been commercially deployed in New Zealand by Starlink partnered with One NZ. o Starlink is approaching first D2D deployment in Australia and is in partnership with local MNOs. Based on recent consultation by the department and the Australian Communications and Media Authority (ACMA), the regulatory and spectrum arrangements are ready for deployment to proceed. • a/g AS BEC noted that the department's recent confidential LEOSat regulation consultation process indicated that there weren't any major regulatory issues identified. o The department's preliminary view is that the telecommunications regulatory framework does not pose a barrier to satellite systems in their traditional and D2D configurations. o The department understands that commercial and operational issues are likely to be the next challenge in the progression of deployment. o Members did not identify further barriers. *Universal Services Branch: update on the concluded Universal Service Framework Modernisation consultation, Regional Telecommunications Independent Review Committee (RTIRC) report and the ongoing voice trials.* • a/g AS BEC invited s22(1)(a)(ii) to provide an update on the concluded Universal Services Framework (USF) consultation, Regional Telecommunications Independent Review Committee (RTIRC) report and the ongoing voice trials. • AS USB commented on the recent conclusion of universal services framework modernisation consultation and noted a summary paper was publicly released in October 2024 and the link would be shared with Working Group members (the summary paper is available from www.infrastructure.gov.au/department/media/publications/modernising-universal-telecommunications-services-summary-feedback). • AS USB noted a range of stakeholders now consider universal services reform is needed and noted that Australia cannot continue to rely on copper for regional communications. A technology neutral approach needs to be considered which is it for purpose for Australian consumers. • The department also went to market last year for independent voice trials of technology to support fixed voice arrangements.

No.	Description
	○ AS USB explained that there are a number of trial sites distributed across regional and remote Australia established to test voice connectivity through GEO and LEO technology. These trials will also capture data on weather and other local characteristics. The voice data produced by the trials will be made accessible and uploaded to a public dashboard on an ongoing basis. ○ The initial version of the dashboard is being finalised and will be shared after the meeting. Once live, the department would welcome feedback from the WG members on the design and functionality of the dashboard. • AS USB also noted the 2024 RTIRC report considered modernisation of the USF, how this could be done in an efficient manner and noted that for modernisation to be successful, supporting technologies such as LEOSats will also need to be proven. The Government will announce its preferred approach in due course; this will potentially be discussed at the next LEOSat WG meeting. *Discussion on department update* • The department undertook to provide a link to the 2024 RTIRC report. *Update from Working Group members* *General news* • A member noted a trend of questions had emerged in communications forums about D2D and the potential that Australia may be dependent on foreign commercial sources. ○ The Chair noted there is a significant degree of partnership between multijurisdictional companies, with a range of factors involved, but that this has been productive and beneficial. ○ D2D partnerships between Telco's and LEOSats operators are not unlike the way international subsea communications cable partnerships work and telecommunications companies are often foreign owned. ○ Other industries have similar arrangements, for example, some energy utilities are owned by overseas entities. a/g AS BEC further noted that as the market develops, competition will reduce potential risk factors. • Communications Alliance (CA) provided an update on the Satellite Services Working Group (SSWG). The SSWG is preparing for the World Radio Congress 2027 (WRC2027) cycle and will publish an agenda position paper soon. CA will meet with the department and with the Australian Communications and Media Authority (ACMA) to discuss WRC2027 in coming weeks. CA noted the agenda of this meeting is relevant to WRC 2027. *Updates on trials underway and timelines for future trials* ○ There were no updates
4.	## D2D discussion – compatibility and equity of access • The Chair reiterated that D2D capability is of great interest to government. It has the potential to change the way Australians connect to the internet and each other. In order to make the most of this capability it is essential that everyone, including government, has reasonably accurate expectations of what D2D is, what D2D will be and an understanding of the roadmap between those points. It is also essential to understand how Australians will access the capability and how they will be able to use it. *Discussion: D2D handset capability and handset market penetration; equity of access in Australia, particularly affordability, compatibility and availability of the service; consumer education*

No.	Description
	• The Chair noted the level of expectation for D2D is high and that there is a risk that some of these expectations becoming unrealistic. The Chair also acknowledged that this topic may be commercially sensitive for members. • The Chair asked members to comment on the compatibility of in-market mobile handsets with D2D and how this might develop over the next 6, 12, 18 months? Further, how can government/industry ensure consumers are aware of handset compatibility? The Chair clarified that the department was aware of commercial sensitivities in this area and that high-level advice would still be useful. • The Chair further noted that government and industry had recently worked on the 3G transition where device compatibility was a significant issue. There was an outreach process to consumers, consumer groups and vulnerable users. The need for orderly transition is acute in some markets and this will likely be true for D2D. o The department is interested in exploring whether there will be handset limitations, plan expenses and other potential barriers to equitable access. The Chair also noted there could be a risk that investment in D2D will not pay off if consumers do not see the benefit. • A member noted that commercial beta trial data from mostly the Asia-Pacific region supports its position that all handsets will be compatible, the member has not encountered a handset that would not work on the network. The member noted nuances, but their goal is that all handsets are compatible and that no one will be disenfranchised. • A member noted that, while they cannot talk to the development of the tech and specific details on timelines, they anticipate the progression to be intermittent SMS, then voice. On emergencies, the participant noted that SMS to Triple Zero (000) will be important and that they have advocated for this functionality to be enabled for some time. As voice calling will not initially be available, SMS to 000 would be a vital stepping stone. o Another member noted they are trialling D2D SMS with automatic global positioning system coordinates embedded in their service. This will potentially help emergency responders locate a person in distress. SMS to 000 is a potentially life-saving service, particularly in scenarios where people cannot express themselves. • A participant noted a view based on their personal expertise (rather than the member organisation's position) that AST SpaceMobile D2D will be compatible with handsets that are in market today, particularly where spectrum that is already in the market is used. • The Chair noted that those members who may not be actively participating in the meeting are encouraged to provide further comments offline, noting that the department is providing a significant amount of advice to government about this at the moment.
5.	D2D discussion - Emergency communications, redundancy and resilience • The Chair noted that although this topic was discussed at an earlier meeting, it is worth revisiting as the sector has continued to develop. There have been several notable events, for example, we have seen the use of D2D in emergencies in the United States of America (US) and this may provide useful insights. • The Chair noted the US had authorised the use of supplemental coverage from space technology during recent natural disasters, namely hurricanes Helene and Milton as well as the Los Angeles (LA) fires. • The Chair invited s47F , to present on Starlink's response to emergencies including hurricanes and wildfires in the US.

No.	Description
	SpaceX: presentation on roll out of D2D in USO and D2D in emergencies (hurricanes Helene and Milton, Los Angeles wildfires) • SpaceX noted the Falcon 9 rocket is essential to establishing its satellite services. Starlink has over 7200 satellites in orbit, serves 118 international markets and connects about 4.6 million households globally. • SpaceX launched the Starlink beta in 2020, and expanded it to include Australia in 2021. In 2022 Starlink received its station in motion licence for Australia. Starlink passed 200,000 subscriptions in 2024 and is currently on the precipice of launching D2D with partners. • SpaceX noted a rapid proliferation of the technology internationally and countries like Australia are embracing the D2D opportunity. Starlink is able to provide coverage in countries that are seeking access to D2D when governments are proactive about; encouraging regulatory reform, enabling integration and providing a platform for partnerships to evolve. SpaceX noted the importance of the work of the department, CA, and the ACMA in streamlining their entry into the market, this will support D2D to enter the market quickly. This environment has helped Starlink to offer D2D solutions in Australia. • SpaceX noted the primary goal for Starlink D2D is to achieve ubiquitous connectivity in locations where there is no terrestrial network or where it is temporarily unavailable because of factors such as storms, earthquakes etc. The intent is for D2D to be accessible to unmodified devices. The initial use cases for D2D will be non-latency sensitive, such as SMS messaging. Gradually more latency sensitive and data intensive use cases will be enabled. The ultimate goal is for Starlink D2D to be able to work with any device. • In terms of handset capability, Starlink D2D is able to provide services to unmodified Android devices such as Samsung Galaxy and Google Pixel phones. Messages were being delivered during emergency events and SpaceX noted good integration between terrestrial networks and Starlink network including information transmitted through ground stations. • SpaceX has been able to test the D2D service in several countries such as Japan and has launched services in the US and NZ. Starlink also intends to begin s testing and launching in other regions in the short to medium term. • SpaceX noted that Starlink fixed broadband services have been utilised in emergency management across the world and that this has sometimes sped up regulatory approvals. This is because the relevant government authority has seen the benefits of the redundancy and resiliency provided during the emergency. SpaceX expects a similar scenario may play out for D2D in some markets. • In the US, SpaceX worked with state entities to manage some of the effects of Hurricanes Milton and Helene. SpaceX requested and were granted emergency licences by the US Federal Communications Commission (FCC) and shortly after announcement the network was in use. T-Mobile customers and customers of other networks were invited to use the messaging service. SpaceX noted this was a precursor to deployment of these services in the US and occurred ahead of the intended beta trial (which was underway at the time of the meeting). • SpaceX noted that in the case of emergency text messaging in LA, thousands of D2D messages were sent by thousands of users. In addition to this, Starlink broadband kits supported data and Wi-Fi calling. SpaceX noted that D2D and Starlink broadband are considered complementary tools in the network resilience toolkit. • SpaceX has been commercially authorised in the US and NZ and anticipates other jurisdictions will soon follow. SpaceX noted that in the short term the capability will provide connectivity where there would otherwise be none, with an initial progression of SMS, then IoT and low data applications to follow.

No.	Description
	• Work has been done behind the scenes to understand how potential use cases can be resolved with Starlink partners and how best to support emergency services. There are a number of positive use cases from SpaceX's recent experience which can be shared with the department upon request. • SpaceX is happy to engage and provide further metrics to the department. *Discussion: Emergency communications, redundancy and resilience.* • The Chair thanked SpaceX and noted that Australia is interested in events unfolding in the US because of similarities between the jurisdictions. • The Chair asked SpaceX to elaborate on US Wireless Emergency Alert (WEA) system in the US. Further noting that it is important to understand the differences between the jurisdictions in order to identify the key things Australia needs to address. o SpaceX undertook to provide additional information offline. • a/g AS BEC asked whether there were complexities in terms of facilitating thousands of text messages for customers of other carriers? o SpaceX noted it had already been working on the T-Mobile beta program to support T-Mobile messaging and noted other carriers' operational complexities were addressed quickly. The WEA alerts system operates differently from customer to customer messaging, it is an FCC requirement that WEA messages need to be facilitated across the network. SpaceX offered to provide information about this offline. • A participant asked if SpaceX is aware of any instances where people had any difficulty picking up the service based on their type of device, particularly with reference to the recent LA wildfires? o SpaceX noted the intention for D2D is for it to work with unmodified handsets that are currently available in the market. For the LA wildfires they were focussed on deploying quickly and supporting as many people as possible. There have been some media reports about coverage during the emergency events but SpaceX advised they are not in a position to provide further details on these reports. A further consideration on D2D capability should include whether a partner elects to have a satellite mode or not for devices as some devices may not be able to implement this mode. SpaceX could not comment on whether Australian partners would be using satellite mode. • A member asked whether the process of emergency authorisation could be streamlined in anticipation of another emergency? o SpaceX noted that it needed emergency authorisation in the US because it did not previously have authorisation outside of testing. Starlink advised they now have authorisation for a commercial D2D service in the US and further authorisations are not necessary. • a/g AS BEC asked about the factors influencing delays between the sending and receipt of messages? o SpaceX noted it can provide further information offline, but that it is has a goal of less than one-minute for delays initially. SpaceX further noted that there were a large number of devices involved in the emergency deployments and it was very pleased with the performance of the network. • Addressing device compatibility issues: a participant noted that Telstra has a list of 'Blue Tick' phones that have been tested and work well in regional Australia. The participant noted there are large number of phones on the market to assess. One NZ is working through phones and advising customers about them over time, Telstra could do something similar with Blue Tick. • A participant noted D2D is a nascent technology that operators will need to work through with partners, it is important to note that the partner will manage a lot of this process.

No.	Description
	○ Another participant noted the devices are also feed into the equation, they are very much operating at the limits of their capabilities when they connect to D2D. • A participant noted that all of the connections between the different players in these scenarios are best effort trying to apply the 3GPP standards.
6.	## Wider policy implications • The Chair noted the department is also interested in how the wider policy landscape might change in response to the impacts associated with LEOSats. This could include connectivity programs but potentially other policy areas without an obvious direct connection to the communications portfolio. The chair asked for participant views. *Discussion: D2D wider policy implications (5 minutes)* • a/g AS BEC further noted that issues around devices, such as compatibility, and consumer educations is front of mind for government. • A member noted a potential opportunity around STEM programs and educational projects looking at emergency scenarios, there could be a focus on D2D particularly around assessing handsets. • Referring to a paper of interest distributed before the meeting about Starlink terminals being used during emergencies in Florida: A member noted that Florida had pre-armed itself with terminals. There may be similar applicable examples for Australia and it would be interesting to look at how D2D will evolve, for example, whether it will be possible to get vital point of sale (PoS) services working quickly in an emergency. ○ A member noted that most devices support Wi-Fi, including for calling, so it would be prudent to distribute as many back-up LEO broadband terminals as possible to emergency centres. ○ A member noted that Florida acquired over a 1000 Starlink units, which were dispersed throughout the state in different regions. These units are managed through a 'parent' account that allows for 'child' accounts, allowing the full fleet of units to be activated centrally (by the parent account) at any time. D2D capability is a wonderful tool, and being able to deploy a Starlink in motion, or at a fixed site to address connectivity outages during the emergency and continuity of service after the fact is powerful. Starlink terminals were used for a variety of supporting services such as PoS, traffic lights, etc. ○ a/g AS BEC further noted the WA police use Starlink particularly in remote areas to provide a "bubble of connectivity" around police patrol vehicles. • A member noted that distributing information about the capabilities and limitations of D2D would be essential to support consumer education. Several suggestions were provided including how to leverage existing frameworks, for example, the Regional Technology Hub and community groups like Better Internet for Regional Rural and Remote (BIRRR). The member noted this work may be similar to work around expectations management for the initial National Broadband Network (NBN) deployment. ○ The Chair noted the department has not looked into these different avenues yet. ○ a/g AS BEC agreed that education should capture limitations alongside benefits. • A member noted that it would be happy to work together with the department on consumer education. It noted that there will be specific implementation nuances and that industry saw this with the 3G closure as well, for instance some devices would be able to call 000 from the Optus network but not from Telstra.

No.	Description
7.	**Working Group 2025 forward work program** *Topics for Meeting 8 and future meetings* *Promoting and supporting D2D for Australia* *Continued discussion on consumer education for D2D* • Consumer education around D2D, especially handsets, was added to the forward work plan. • The department will also present on the government's preferred approach to RTIRC recommendations and may provide more information about USF modernisation. • The Chair encouraged members to contact the secretariat about other matters to consider at future meetings.
8.	**Other business** *Discussion (2 minutes)* • No other business was suggested.
9.	**Meeting Close - Agreement and Next Steps** *Next Steps* • The department will follow up with several members about matters they were not able to discuss during the meeting due to commercial sensitives. • The secretariat will distribute the minutes for confirmation before the next meeting. • The secretariat will distribute links to several papers that were raised during the meeting; o 2024 Regional Telecommunications Independent Review Committee Report o First Nations Digital Inclusion Advisory Group Roadmap o Comms Alliance WRC2027 position paper • The secretariat will distribute a link to the USO voice trials public dashboard and the Department would welcome any member feedback *Next meeting* • It is currently expected the next meeting will consider the design and implementation of consumer education around D2D. It is expected to take place sometime after results from the Australian Federal Election have been finalised.

Appendix A: Low Earth Orbit Working Group – Meeting 7 Attendance

Sector	Organisation	
Government	Department of Infrastructure, Transport, Regional Development, Communications and the Arts	Present
	Australian Space Agency	Present
	Australian Communications and Media Authority	Present

First Nations	First Nations Digital Inclusion Advisory Group	Absent
Industry	Amazon Project Kuiper	Present
	AST SpaceMobile	Present
	Commpete	Absent
	Comms Alliance	Present
	Echostar Global	Present
	Fleetspace	Present
	Inmarsat	Absent (Viasat Present)
	Intelsat	Absent
	IPSTAR	Present
	Lynk Global	Present
	Myriota	Present
	NBN Co	Present
	Omnispace	Present
	One Web	Absent
	Optus	Present
	Pivotel	Present
	SES/O3b	Present
	Speedcast	Absent
	Starlink	Present
	Telesat	Present
	Telstra	Present
	TPG	Present
	Viasat	Present
	Vocus	Present

Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts	Meeting/Event Brief MB23-001354

To: Michelle Rowland

MEETING: First meeting - Low Earth Orbit Satellite (LEOSat) Working Group (WG)

Timing: 10 February 2023, 1.00pm

Venue: s22(1)(a)(ii)

Meeting with: Stakeholders from across LEOSat industry and relevant government agencies.

Our Proposed Objectives:

To host the first Working Group meeting, including identifying issues and informing government of industry developments, and consider the Working Group's future activities.

Their Objective:

Industry members may seek to promote their own commercial interests and seek regulatory concessions or subsidies.

Key Points:

1. You will be attending the first hour and providing opening remarks to the first meeting of the Low Earth Satellite (LEOSat) Working Group (WG) on 10 February 2023. A list of attendees is available at **Attachment A.** Your draft remarks and possible question and answers are available at **Attachment B.** The draft terms of reference is at **Attachment C** and the agenda for the meeting is at **Attachment D**.
2. At the Charles Todd Oration on 21 October 2022, you announced that you had asked the Department to:

   commence work on the establishment of a Low Earth Orbit working group to help inform Government about how this emerging capability might play a role in future telecommunications policy.
3. You reiterated this at the ACMA RadComms conference on 15 November 2022.
4. We provided advice on the LEOSat WG's establishment (M22-001913) and have been working on details with your office since. You approved the draft terms of reference and agenda on 24 January 2023 (MS23-000122).
5. The meeting will be chaired by Mr Richard Windeyer, Deputy Secretary, Communications and Media Group.

6. Key outcomes for this first meeting will be to hear from the interested members on their roles within the industry and what future actions they consider the government could consider. This will help focus the nature of the WG going forward.
7. Comms Alliance will be providing a specific presentation on the state of the industry and other industry participants will be invited to provide a short overview of their work. The ACMA and the Australian Space Agency will also provide short presentations.
8. Minutes of the meeting will be taken and circulated to members.

Sensitive and Critical Information:

While participants will have many common interests and some are working together in different ways, as many are competitors and potential suppliers and customers, including NBN Co, there may be some reluctance to share more commercially sensitive information. Talking Points aim to address any concerns attendees have about NBN Co's commercial interests.

Proposed Notetaker: s22(1)(a)(ii) and team

s22(1)(a)(ii)

s22(1)(a)(ii)

Attachments:

Attachment A: Biographies of attendees

Attachment B: Minister's remarks and possible questions and answers

Attachment C: Draft terms of reference

Attachment D: Draft agenda

ATTACHMENT A

BIOGRAPHICAL DETAILS

GOVERNMENT
AUSTRALIAN COMMUNICATIONS MEDIA AUTHORITY (ACMA) ACMA is an independent Commonwealth statutory authority whose role is to regulate communications and media services in Australia.
s47F
AUSTRALIAN SPACE AGENCY The Australian Space Agency is a non-statutory entity within the Department of Industry, Science and Resources that was established to coordinate civil space matters across government, and to create and sustain the conditions necessary to grow and transform Australia's space industry.
s47F

OFFICIAL

FIRST NATIONS DIGITAL INCLUSION ADVISORY GROUP	
The First Nations Digital Inclusion Advisory Group has been established to advise on the development of policies to support digital inclusion for First Nations people across Australia. The Advisory Group will work closely with First Nations people and communities and will provide advice to the Minister for Communications on initiatives that will support progress towards Target 17 of the National Agreement on Closing the Gap, which aims for equal levels of digital inclusion for First Nations people by 2026.	
s47F	

INDUSTRY

COMMPETE

Commpete is the industry association for competition in digital communications representing non-dominant providers in Australia that advocates for pro-competition policy and regulation in telecommunications markets.

s47F

COMMUNICATIONS ALLIANCE

Communications Alliance is the primary telecommunications body in Australia. Its membership is drawn from a wide cross-section of the communications industry, including carriers, carriage and internet service providers, content providers, search engines, equipment vendors, IT companies, consultants, and business groups. Its mission is to provide a unified voice for the Australian telecommunications industry and to promote the growth of the Australian communications industry.

s47F

ECHOSTAR GLOBAL

EchoStar Global is an Australian subsiduary of EchoStar. It is developing a global Internet of Things (IoT) and 5G Non-Terrestrial Network (NTN) Mobile Satallite Services (MSS) capability supported by its S-band spectrum filing and sister company Echostar Mobile which announced the commercial availability of a similar system in the EU in November 2022.

EchoStar were also involbved in including Band 65 in the 3GPP 5G NR standards, effectively expanding 5G to include satellite services in the S-band and the potential breadth of 5G services.

s47F

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FLEET SPACE

Fleet Space is a start-up space company based in South Australia, whose aim is to connect IoT devices around the world using a fleet of low-cost nanosatellites. The company's core business is nanosatellite manufacture and deployment, satellite propulsion systems, IoT connectivity and software as a service platform development. They also advertise surveying solutions for the exploration sector, supported by satellite IoT connectivity.

s47F

INMARSAT

Inmarsat is a major provider of L-band data services through GEO Satellites, as well as having a large government services division. Inmarsat maintains indirect distribution channels with a wide range of satellite service providers (e.g., Pivotel). Their global mobile satellite communications services and solutions serve the aviation, maritime, and enterprise sectors, and governments.

s47F

INTELSAT

Intelsat is a multinational satellite services provider that owns and manages a constellation of communications satellites providing international broadcast services. They have signed a global distribution partnership agreement with OneWeb to enable them to distribute OneWeb's LEO satellite services to airlines worldwide.

s47F

IPSTAR

IPSTAR is a satellite internet service provider that strives to improve internet connectivity for regional, rural and remote Australians. IPSTAR Broadband offers retail broadband service in regional Australia based on NBN's Sky Muster Satellite.

s47F

OFFICIAL

LYNK GLOBAL

Lynk has successfully completed initial space-to-ground tests of the fundamental technology required to provide connectivity for cell phone users virtually anywhere on the globe using low-earth-orbit nanosatellites. Their technology allows standard cell phones, without any changes in hardware or software, to be connected everywhere, seamlessly shifting from a terrestrial tower to a satellite overhead.

s47F

MYRIOTA

Myriota is an emerging South Australian-based satellite IoT company which aims to provide IoT communications for the South Australian Government's planned SASAT1 LEOsat. This satellite will support data collection from ground-based sensors and hyperspectral earth observation imaging. Myriota aims to offer disruptively low-cost and long-battery-life global connectivity through direct-to-orbit satellite IoT connectivity.

s47F

NBN CO

NBN Co is one of Australia's principal satellite operators and service providers, that operates on a wholesale-only basis and is owned by the Australian Government. It is the default statutory infrastructure provider for all of Australia.

s47F

OMNISPACE

Omnispace is a global communications provider that offers a 3GPP 5G-based 'one global network', using 'mobile ready' mid band spectrum to establish a 'seamless' hybrid network between terrestrial networks and their satellite based network. Omnispace also offer IoT and machine to machine connectivity.

s47F

ONEWEB

OneWeb is a global communications network powered by a constellation of 648 low earth orbit satellites. OneWeb enables high-speed, low latency connectivity for governments, businesses, and communities everywhere around the world. OneWeb was one of the first companies since the late 1990s to file at the ITU for non-geostationary spectrum rights to support a large LEO constellation.

s47F

OPTUS

Optus is one of Australia's principal satellite operators and service providers. In partnership with LEO satellite provider, Lynk, Optus has successfully undertaken a live demonstration of LEO satellite direct-to-mobile technology. Optus provides satellite connectivity service across Australia and New Zealand for commercial business, government and end-users.

s47F

PIVOTEL
Pivotel is an Australian service provider specialising in rural and remote communication services with a focus on mobile satellite services that provide reliable and secure satellite and cellular communication solutions. They sell consumer services based on Iridium, Inmarsat, Thuraya, Globalstar, Intelsat, OneWeb, NBN and SES satellite capacity.
s47F
PROJECT KUIPER AT AMAZON (Attendance TBC)
Amazon's Project Kuiper is an initiative that was developed to launch a constellation of LEO satellites that will provide low-latency, high-speed broadband connectivity to unserved and underserved communities around the world.
s47F
SES
SES is a Luxembourgish-French satellite telecommunications network provider supplying video and data connectivity to broadcasters, content and internet service providers, mobile and fixed network operators, governments, and institutions. Their MEO satellite constellation O3b mPOWER launched in 2022.
s47F

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SPACEX (Attendance TBC)

SpaceX is an American spacecraft manufacturer, launcher, and a satellite communications corporation. The Starlink project was first revealed by founder Elon Musk in January 2015, when he announced that SpaceX would set up a factory in Seattle to build over 4,000 LEO satellites. Starlink currently offers consumer connectivity through its LEO network, including to Australians in regional, rural and remote communities at rates competitive with NBN SkyMuster but with superior data allowances and significantly lower latency.

s47F

SPEEDCAST (Attendance TBC)

Speedcast is a satellite communications network service provider that specialises in communications satellite technology, delivering critical communications services to industry, NGOs, government, and enterprise sectors. In 2018, Speedcast secured a 10-year contract with NBN Co to design, build and manage NBN Co's enterprise satellite services.

s47F

TELESAT

Telesat was founded in 1969 to provide satellite communications services in Canada. Telesat's first LEO satellite was launched in 2018 and is now supporting live demonstrations across a variety of markets and applications. Their emerging Lightspeed system is a global network composed of 188 LEO satellites, seamlessly integrated with on-ground data networks.

s47F

TELSTRA

Telstra is the major communications service provider in the Enterprise and Government sectors. They have little direct investment in satellite infrastructure of their own, however they have partnered with OneWeb to conduct testing on OneWeb's network of low earth orbit satellites. They are exploring new options for providing high-quality and continuous coverage across the country to boost digital connectivity.

s47F

TPG TELECOM

TPG is the second largest telecommunications company listed on the ASX. Their Business Satellite internet uses Ka-band High Throughput Satellite (HTS) technology, which is a cost-effective solution for delivering internet access to enterprises in remote locations.

s47F

VIASAT

Viasat is a global communications company that aims to bring connectivity to consumers, businesses, governments, and militaries, in places where cable or fibre are not available. They have built up considerable expertise in satellite networking and have acquired their own broadband satellite covering the United States. Viasat also provided the ground segment for the NBN Sky Muster satellites.

s47F

VOCUS
Vocus is a satellite service provider in the Enterprise sector but also "sees a significant opportunity in leveraging its extensive fixed infrastructure to support emerging LEOsat services". Vocus owns and operates almost 25,000km of fibre network across Australia and New Zealand, that is purpose-built for business and government. Their LEO satellite network, *Vocus Satellite – Starlink*, is powered by Space X's LEO constellation.
s47F

ATTACHMENT B

FIRST MEETING OF THE LOW EARTH ORBIT SATELLITE WORKING GROUP

10 FEBRUARY 2023

MINISTER'S REMARKS AND POSSIBLE QUESTIONS AND ANSWERS

Thank you, Richard.

Good afternoon and thank you all for joining us for the first meeting of the Low Earth Orbit Satellite Working Group. We have broad participation from across industry and government and I thank you all for making the time.

I'm speaking to you from the lands of the Gadigal People of the Eora Nation.

I announced the formation of this group in October last year, and I am delighted it has come to fruition.

From my perspective, the LEOSat industry is moving fast:

- Constellations being established and new entrants into the market
- Services are being taken up or trialled
- Use cases being expanded - from internet connectivity - to messaging - to voice, including for mobile phones
- The changing nature of the market for both space and terrestrial communications services.

Given these developments, I am keen to understand what role LEOSats can play in our telecommunications future. The draft terms of reference, which have been circulated and will be discussed later, talk about:

- understanding of the technology and its capabilities
- identifying positive outcomes for consumers
- identifying policy or regulatory issues, and

- supporting Government decision making.

I see the forum as a useful mechanism for cutting through any hype and better understanding the realities.

A key interest is what roles LEOSats might play in regional and remote Australia in the future delivery of fixed - and possibly mobile - services.

As Minister for Communications, I am acutely aware of the need to consider long-term delivery of telecommunications services in rural and remote areas and the expectations consumers have about services.

With the USO contract with Telstra and Sky Muster satellites reaching the end of their lives around 2032, like others, I am interested in whether LEOSats might have a role to play here?

Equally, the extension of mobile services in such sparsely populated areas is a priority for many in the community and the Government. The Government has allocated significant funding to this end. There is considerable interest, therefore, in whether LEOSats and other emerging satellite technologies can improve outcomes in this regard, with potentially revolutionary implications to mobile service provision long term. These are important issues for the Government and our nation.

In the context of rural and remote service provision, other themes of interest are how services provided by LEOSats might help advance disaster resilience and recovery, help contributing to the Government priority of closing the gap in First Nations communities, and looking more broadly our agenda to improve outcomes in the wider South Pacific.

Amongst all the promise of the technology, I am intensely conscious to ensure it serves the consumers and reasonable consumers expectations are built into product design and delivery – that they know what they can expect, get what they expect and have effective recourse if they don't.

I have an open mind on how this group moves forward. I expect today's meeting will be a broad-ranging discussion to identify specific issues to take forward.

I also recognise there are range of competitors, customers and vendors in this meeting. If there are issues that you are not comfortable discussing in an open forum I understand that. In such cases I extend an invitation for you to discuss separately with my office or my Department. However, I appreciate there will be a range of issues common to members in this meeting and I urge you all use the opportunity of this forum to put your ideas and any issues while you have me and officials in the (virtual) room.

I look forward to today's discussions.

Possible Questions and Answers

Will LEOSat trials/demos as recommended by RTIRC be funded?

The Government's Better Connectivity Plan provides significant funding for a range of programs, such as the Regional Connectivity Program and the On-Farm Connectivity Program.

A hallmark of our programs is that they will encourage innovative solutions. All programs are being designed to allow innovative solutions to be put forward and considered. All proposals need to be assessed against the program criteria and provide overall value for money.

Will LEOSat trials be funded under the Telecommunications Resilience Disaster Innovation (TRDI) Program?

Satellite solutions can play an important role in ensuring that communities are able to remain connected when terrestrial network infrastructure is damaged or otherwise offline as a result of power outages.

The TRDI program will be aimed at funding innovative solutions and technologies to strengthen the resiliency of Australia's telecommunications networks against the impacts of natural disasters, and I see satellite connectivity as playing a key role in this program.

Is the Government looking to reform the USO?

The USO continues to support the delivery of services critical to many people in Australia. However, I have long held the view that the USO needs reform to make it more forward-looking and appropriate.

I expect to be considering this issue more closely during this year. As I've said, I see the LEOSat Working Group as being an input in this regard.

Will LEOSats be a key platform for USO reform?

LEOSats provide a new way to deliver broadband and voice services in rural and remote areas. I have heard some positive reports from current users. A number of Australian carriers have been looking at using LEOSats for just this purpose.

Clearly, we would want to look at what LEOSats could offer in thinking about future USO delivery.

Will LEOSat providers be able to access USO funding?

We would consider issues like this if and when we look at possible reform options.

Can Regional Connectivity Program (Round 3) funding be sought for LEOSat solutions?

As part of the Better Connectivity Plan for Regional and Rural Australia, the Government has committed a further $200 million to two new rounds of the Regional Connectivity Program

(RCP) to improve the accessibility and reliability of mobile and broadband services in regional, rural and First Nations communities. A hallmark of our programs is that they will encourage innovative solutions.

Draft guidelines for round 3 of the RCP were released on 20 December 2022. Submissions close today. Following consideration of feedback received, the call for applications for Round 3 is expected to take place in the second quarter of 2023.

The draft guidelines are technology neutral, so it would be open to industry to put forward proposals that incorporate use of LEOsats. However, there are criteria about locations where projects can be funded, and a requirement that projects must either deliver new infrastructure or an upgrade / improvement of existing infrastructure.

What would it mean for existing mobile programs if LEOSat can provide viable mobile services in the medium to long term?

There is significant Australian Government funding directed to improving terrestrial mobile coverage, including seeking co-investment, in regional and remote areas where carriers have less-commercial incentives to invest.

Recent announcements about new technologies enabling 'conventional' handsets to communicate directly with satellites are exciting, particularly if this can improve the economics of how mobile services are delivered in less populated areas. This would be a notable development if the promises can be delivered. We want to see what happens. Obviously relevant (and proven) technological developments are considered in designing programs. In the meantime, there are Australians in need of mobile coverage and we have funding to expand terrestrial coverage.

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Agenda
Low Earth Orbit Satellite Working Group

Date/Time: 10 February 2023, 1.00pm to 4.00pm

Location: s22(1)(a)(ii)

Chair: Mr Richard Windeyer, Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Secretariat: Digital Inclusion and Sustainable Communications Branch, Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Agenda items

No.	Description	Timing	Responsible
1	Acknowledgement of Country Welcome	5 minutes	Chair
2	Opening remarks • Purpose of the group and this meeting	10 minutes	The Hon Michelle Rowland MP, Minister for Communications
3	Review and Agree Agenda and Draft Terms of Reference	5 minutes	Chair
4	Introductions – commercial enterprises • Each member to briefly discuss their interest in LEOSats, their company's role and activities in Australia to date	45 minutes (2 minutes per organisation)	Commercial Representatives
5	Industry Overview	15 Minutes	Comms Alliance
	Break	15 Minutes	

No.	Description	Timing	Responsible
6	Government agency roles: • Department of Infrastructure, Transport, Regional Development, Communications and the Arts • Australian Communications and Media Authority • Australian Space Agency	15 minutes	Government representatives
7	General discussion • What LEOSats can do for connectivity • What's holding back development or implementation • What participants would like from the Working Group and how can the Group best help inform government	55 minutes	All
8	Close and agreement on next steps	15 minutes	All

Attendees

Sector	Organisation
Government	• Department of Infrastructure, Transport, Regional Development, Communications and the Arts • Australian Communications and Media Authority • Australian Space Agency
First Nations	• s47F • s47F
Industry	• Amazon Project Kuiper (TBC) • Commpete • Comms Alliance • Echostar Global • Fleetspace • Inmarsat • Intelsat • IPSTAR • Lynk Global • Myriota • NBN Co • Omnispace • One Web • Optus. • Pivotel • SES/O3b • Speedcast (TBC) • Starlink (TBC) • Telesat • Telstra • TPG • Viasat • Vocus

OFFICIAL

EC23-002707

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

To: Richard Windeyer (for noting)

MEETING: First meeting - Low Earth Orbit Satellite (LEOSat) Working Group (WG)

Timing: For meeting on 10 February 2023

Venue: s22(1)(a)(ii)

Recommendations:
1. That you Note the information provided in this brief. Choose an item.
Richard Windeyer Date: **Comments:**

Meeting with: Chairing the first meeting of the Low Earth Orbit (LEO) Satellite Working Group with representatives of various LEO satellite operators and telecommunications industry representatives.

Prior meetings: This is the first meeting group of this Working Group since its announcement at the Charles Todd Oration on 21 October 2022.

What do the attendees want:

Industry members may seek to promote their own commercial interests and seek regulatory concessions or subsidies for their operations in Australia. Participants may seek to use this forum as a way to bypass existing mechanisms for decision making in relation to the industry.

Industry may raise spectrum and related issues. A line has been included in the draft terms of reference noting that this Working Group is not seeking to replace other forums where such issues can be raised.

What does the department want:

The Department's principle objective is to have a successful meeting where industry participants are able to share their views on the future of the LEOSat market in Australia and the potential benefits of this technology. The Department will also be seeking support for the proposed terms of reference.

OFFICIAL

Key outcomes for this first meeting will be to hear from the interested members on their roles within the industry and what future actions they consider the government could consider. This will help focus the nature of the Working Group going forward. It would be beneficial for future meetings to identify actionable work items that the Working Group can support.

Key Points:

1. The meeting will largely be held in a roundtable format with a focus on all invited members being able to participate and provide their views. The agenda for the Working Group meeting is at **Attachment A**.
2. An annotated run sheet with talking points is provided at **Attachment B** to provide guidance and talking points on chairing the meeting.
3. The Hon Michelle Rowland MP, Minister for Communications, will be providing an opening statement following the acknowledgement of country. She will be staying for the first hour of the meeting. The remainder of the first hour will largely be taken up with different industry stakeholders providing introductory remarks outlining their role in the sector.
4. The final substantive item is an open general discussion between participants with a focus on the benefits and challenges for LEOs and what the opportunities for the Working Group are. It will be beneficial in this item to push participants to identify a purpose for the group and to develop ideas that could form the basis of a work plan for the group going forward.
5. The timing and tempo of future meetings is a key decision that needs to be taken (possibly after the meeting has concluded) and should reflect the outcomes of this meeting. If participants are unable to articulate a series of issues for the Working Group to examine it may be more appropriate to consider holding future Working Group meetings yearly to serve as a 'pulse check' on the industry. If the group identifies a substantial pipeline of work, not already underway elsewhere, more frequent meetings may be warranted. The frequency of meetings could be reflected through an update to the terms of reference at **Attachment C**.

Stakeholder Implications:

The department does not anticipate that this meeting will have particular implications for the stakeholders involved. Biographical information of participants is provided at **Attachment D**.

Sensitive and Critical Information:

1. While participants will have many common interests and commercial interactions, participants are also competitors and there may be some reluctance to share information or actively contribute.

Proposed Notetaker: The Sustainable Technology section will be providing secretariat services and preparing the meeting minutes.

s22(1)(a)(ii) [redacted]

s22(1)(a)(ii) [redacted]

Attachments:

A: Agenda, Low Earth Orbit Satellite Working Group
B: Meeting Run Sheet and Talking Points
C: Terms of Reference
D: Biographies of Participants

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Agenda
Low Earth Orbit Satellite Working Group

Date/Time: 10 February 2023, 1.00pm to 4.00pm

Location: s22(1)(a)(ii)

Chair: Mr Richard Windeyer, Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Secretariat: Digital Inclusion and Sustainable Communications Branch, Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Agenda items

No.	Description	Timing	Responsible
1	Acknowledgement of Country Welcome	5 minutes	Chair
2	Opening remarks • Purpose of the group and this meeting	10 minutes	The Hon Michelle Rowland MP, Minister for Communications
3	Review and Agree Agenda and Draft Terms of Reference	5 minutes	Chair
4	Introductions – commercial enterprises • Each member to briefly discuss their interest in LEOSats, their company's role and activities in Australia to date	45 minutes (2 minutes per organisation)	Commercial Representatives
5	Industry Overview	15 Minutes	Comms Alliance
	Break	15 Minutes	

No.	Description	Timing	Responsible
6	Government agency roles: • Department of Infrastructure, Transport, Regional Development, Communications and the Arts • Australian Communications and Media Authority • Australian Space Agency	15 minutes	Government representatives
7	General discussion • What LEOSats can do for connectivity • What's holding back development or implementation • What participants would like from the Working Group and how can the Group best help inform government	55 minutes	All
8	Close and agreement on next steps	15 minutes	All

Attendees

Sector	Organisation
Government	• Department of Infrastructure, Transport, Regional Development, Communications and the Arts • Australian Communications and Media Authority • Australian Space Agency
First Nations	• s47F • s47F
Industry	• Amazon Project Kuiper (TBC) • Commpete • Comms Alliance • Echostar Global • Fleetspace • Inmarsat • Intelsat • IPSTAR • Lynk Global • Myriota • NBN Co • Omnispace • One Web • Optus. • Pivotel • SES/O3b • Speedcast (TBC) • Starlink (TBC) • Telesat • Telstra • TPG • Viasat • Vocus

ATTACHMENT B

FIRST MEETING OF THE LOW EARTH ORBIT SATELLITE WORKING GROUP

10 FEBRUARY 2023

MEETING RUNNING SHEET AND TALKING POINTS

1. **Welcome and Acknowledgement of Country, 5 minutes (Richard)**
   - (introduce self)
   - I start by paying respect to and acknowledging the Traditional Custodians of the lands on which this meeting takes place across Australia, and I also pay respect to Elders both past and present. I am speaking to you today from the lands of the Ngunnawal people.
   - So that the meeting runs smoothly, I ask you to mute your mike when not speaking and 'raise your hand' in Teams if you wish to speak.
   - I welcome the Minister for Communications, the Hon Michelle Rowland MP, who will speak to us shortly.
   - I welcome all participants with an interest in the LEOSat industry and government agencies that are here today.
   - This is the first-off meeting of this Working Group, and I look forward to hearing from you all, including your priorities, what outcomes you might like to see from the group and how we might take it forward.
   - I'll now invite the Minister to make some opening remarks.
2. **Opening Remarks, 10 minutes (Minister)**
   - Invite Minister to speak.
3. **Terms of Reference, 5 minutes (Richard - All)**
   - Thank you Minister.
   - We now turn to the terms of reference. These have been circulated as draft in advance of the meeting. They have been set up relatively flexibly so they may change depending on what we discuss today.
   - The order for the agenda has moved around slightly since you first received it, but you should all have the latest version now.
   - I now open up for any comments on the draft terms of reference.
   - If during the general discussion towards the end of the meeting the group identifies issues that could be covered or included in the terms of reference there will still be an opportunity to amend them to reflect the discussion.

4. Introductions – commercial enterprises, 45 minutes (Richard)

- We have a wide and varied participation across the industry and First Nations representation and I'd now like to invite each member – starting with First Nations representation and then in alphabetical order – to provide a brief outline (2 minutes each) of their interest in LEOSats and their role and activities in Australia. I'll leave out Comms Alliance, who have agreed to present at the next agenda item.
- Noting the large number of participants we have, if these introductions could be kept to a couple of minutes.
    - s47F
    - Amazon project Kuiper (TBC)
    - Commpete
    - Echostar Global
    - Fleetspace
    - Inmarsat
    - Intelsat
    - IPSTAR
    - Lynk Global
    - Myriota
    - NBN Co
    - Omnispace
    - One Web
    - Optus
    - Pivotel
    - SES/O3b
    - Speedcast (TBC)
    - Starlink (TBC)
    - Telesat
    - Telstra
    - TPG
    - Viasat
    - Vocus

5. Industry overview, 15 minutes (Comms Alliance)

- We have Comms Alliance with us today, who are key players in the industry, including being convenors of their own Satellite Services Working Group – and there are many crossover members here today. And I'd like to invite them to introduce themselves and provide an overview of the industry.

BREAK, 15 minutes

6. Government agency roles, 15 minutes (Richard – ACMA – ASA)

- We now have some time to hear a government perspective. I'll start with the Department of Infrastructure, Transport, Regional Development, Communications and the Arts, and we'll then move on the ACMA and the Space Agency:
- As the Minister has flagged, the Department has a range of interests in LEOSats.
- We support the Minister in advising on policy across the communications sector, including emerging technologies such as LEOSats, and have led the practicalities of setting up this group.
- In our role advising the Minister we have an interest from:
    - A service access perspective – particularly voice and broadband, both fixed and mobile, particularly in regional, rural and remote Australia, but also generally
    - A spectrum perspective – although as noted in the terms of reference, we are not proposing to use this group as a forum to raise issues for which there are other fora.
    - An NBN Co shareholder perspective – welcoming the opportunities LEOsats may offer
    - A consumer perspective, in ensuring they benefit and are not harmed,
    - A telecommunications security and resilience perspective, and
    - More broadly, the perspective of being well informed and understanding of industry.
- We will also be the conduit for feedback to the Minister coming out of this group.

ACMA

- I'd now like to invite s47F from the ACMA to provide its perspective.

Australian Space Agency

- And we can't talk about satellites without talking space, so I'd like to invite s47F from the Australian Space Agency to give the Agency's perspective.

7. General discussion, 55 minutes (Richard- All)

- Now we have close to an hour for a general discussion, as outlined in the agenda:
    - What LEOSats can do for connectivity
    - What's holding back development or implementation – and what can Govt do to help
    - What participants would like from the Working Group and how can the Group best help inform government
- Essentially – what can LEOSats do for us, are there issues or areas where government could potentially assist you, and what do you want out of this group.
- I open the floor.

Prompts

- Products and opportunities LEOSats offer
    - fixed
    - mobility

- Future of emergency messaging, general messaging and voice
- Costs, pricing and affordability
- Product development and consumer support (how services are installed and maintained, on-shore vs off-shore customer support)
- How do you see the market evolving and timeframes for maturity
- Technology limitations
    - Coverage
    - Capacity/congestion
    - Rain and earth fade
- Risks of reliance on LEOSats
    - Commercial sustainability, level of competition and choice
- Relative roles of GEOs and MEOs with the advent of LEOs
- Role for Government in progressing LEOSat solutions

8. Close and agreement of next steps, 15 minutes (Richard)

(Recommend summing up the discussion and picking a couple of key themes that may be the focus of discussion at future WG meetings and put to the group for their views)

- Minutes will be circulated to members.
- We will be in touch on timing and agenda for the next meeting.
- Thank you all for your participation and attendance.

ATTACHMENT D

BIOGRAPHICAL DETAILS

GOVERNMENT
AUSTRALIAN COMMUNICATIONS MEDIA AUTHORITY (ACMA) ACMA is an independent Commonwealth statutory authority whose role is to regulate communications and media services in Australia.
s47F
AUSTRALIAN SPACE AGENCY The Australian Space Agency is a non-statutory entity within the Department of Industry, Science and Resources that was established to coordinate civil space matters across government, and to create and sustain the conditions necessary to grow and transform Australia's space industry.
s47F

FIRST NATIONS DIGITAL INCLUSION ADVISORY GROUP
The First Nations Digital Inclusion Advisory Group has been established to advise on the development of policies to support digital inclusion for First Nations people across Australia. The Advisory Group will work closely with First Nations people and communities and will provide advice to the Minister for Communications on initiatives that will support progress towards Target 17 of the National Agreement on Closing the Gap, which aims for equal levels of digital inclusion for First Nations people by 2026.
s47F

INDUSTRY
COMMPETE Commpete is the industry association for competition in digital communications representing non-dominant providers in Australia that advocates for pro-competition policy and regulation in telecommunications markets.
s47F
COMMUNICATIONS ALLIANCE Communications Alliance is the primary telecommunications body in Australia. Its membership is drawn from a wide cross-section of the communications industry, including carriers, carriage and internet service providers, content providers, search engines, equipment vendors, IT companies, consultants, and business groups. Its mission is to provide a unified voice for the Australian telecommunications industry and to promote the growth of the Australian communications industry.
s47F
ECHOSTAR GLOBAL EchoStar Global is an Australian subsiduary of EchoStar. It is developing a global Internet of Things (IoT) and 5G Non-Terrestrial Network (NTN) Mobile Satallite Services (MSS) capability supported by its S-band spectrum filing and sister company Echostar Mobile which announced the commercial availability of a similar system in the EU in November 2022. EchoStar were also involbved in including Band 65 in the 3GPP 5G NR standards, effectively expanding 5G to include satellite services in the S-band and the potential breadth of 5G services.
s47F

FLEET SPACE Fleet Space is a start-up space company based in South Australia, whose aim is to connect IoT devices around the world using a fleet of low-cost nanosatellites. The company's core business is nanosatellite manufacture and deployment, satellite propulsion systems, IoT connectivity and software as a service platform development. They also advertise surveying solutions for the exploration sector, supported by satellite IoT connectivity.
s47F
INMARSAT Inmarsat is a major provider of L-band data services through GEO Satellites, as well as having a large government services division. Inmarsat maintains indirect distribution channels with a wide range of satellite service providers (e.g., Pivotel). Their global mobile satellite communications services and solutions serve the aviation, maritime, and enterprise sectors, and governments.
s47F
INTELSAT Intelsat is a multinational satellite services provider that owns and manages a constellation of communications satellites providing international broadcast services. They have signed a global distribution partnership agreement with OneWeb to enable them to distribute OneWeb's LEO satellite services to airlines worldwide.
s47F
IPSTAR IPSTAR is a satellite internet service provider that strives to improve internet connectivity for regional, rural and remote Australians. IPSTAR Broadband offers retail broadband service in regional Australia based on NBN's Sky Muster Satellite.
s47F

LYNK GLOBAL Lynk has successfully completed initial space-to-ground tests of the fundamental technology required to provide connectivity for cell phone users virtually anywhere on the globe using low-earth-orbit nanosatellites. Their technology allows standard cell phones, without any changes in hardware or software, to be connected everywhere, seamlessly shifting from a terrestrial tower to a satellite overhead.
s47F
MYRIOTA Myriota is an emerging South Australian-based satellite IoT company which aims to provide IoT communications for the South Australian Government's planned SASAT1 LEOsat. This satellite will support data collection from ground-based sensors and hyperspectral earth observation imaging. Myriota aims to offer disruptively low-cost and long-battery-life global connectivity through direct-to-orbit satellite IoT connectivity.
s47F
NBN CO NBN Co is one of Australia's principal satellite operators and service providers, that operates on a wholesale-only basis and is owned by the Australian Government. It is the default statutory infrastructure provider for all of Australia.
s47F

OMNISPACE

Omnispace is a global communications provider that offers a 3GPP 5G-based 'one global network', using 'mobile ready' mid band spectrum to establish a 'seamless' hybrid network between terrestrial networks and their satellite based network. Omnispace also offer IoT and machine to machine connectivity.

s47F

ONEWEB

OneWeb is a global communications network powered by a constellation of 648 low earth orbit satellites. OneWeb enables high-speed, low latency connectivity for governments, businesses, and communities everywhere around the world. OneWeb was one of the first companies since the late 1990s to file at the ITU for non-geostationary spectrum rights to support a large LEO constellation.

s47F

OPTUS

Optus is one of Australia's principal satellite operators and service providers. In partnership with LEO satellite provider, Lynk, Optus has successfully undertaken a live demonstration of LEO satellite direct-to-mobile technology. Optus provides satellite connectivity service across Australia and New Zealand for commercial business, government and end-users.

s47F

PIVOTEL
Pivotel is an Australian service provider specialising in rural and remote communication services with a focus on mobile satellite services that provide reliable and secure satellite and cellular communication solutions. They sell consumer services based on Iridium, Inmarsat, Thuraya, Globalstar, Intelsat, OneWeb, NBN and SES satellite capacity.
s47F

PROJECT KUIPER AT AMAZON (Attendance TBC)
Amazon's Project Kuiper is an initiative that was developed to launch a constellation of LEO satellites that will provide low-latency, high-speed broadband connectivity to unserved and underserved communities around the world.
s47F

SES
SES is a Luxembourgish-French satellite telecommunications network provider supplying video and data connectivity to broadcasters, content and internet service providers, mobile and fixed network operators, governments, and institutions. Their MEO satellite constellation O3b mPOWER launched in 2022.
s47F

SPACEX (Attendance TBC) SpaceX is an American spacecraft manufacturer, launcher, and a satellite communications corporation. The Starlink project was first revealed by founder Elon Musk in January 2015, when he announced that SpaceX would set up a factory in Seattle to build over 4,000 LEO satellites. Starlink currently offers consumer connectivity through its LEO network, including to Australians in regional, rural and remote communities at rates competitive with NBN SkyMuster but with superior data allowances and significantly lower latency.
s47F
s47F
SPEEDCAST (Attendance TBC) Speedcast is a satellite communications network service provider that specialises in communications satellite technology, delivering critical communications services to industry, NGOs, government, and enterprise sectors. In 2018, Speedcast secured a 10-year contract with NBN Co to design, build and manage NBN Co's enterprise satellite services.
s47F
TELESAT Telesat was founded in 1969 to provide satellite communications services in Canada. Telesat's first LEO satellite was launched in 2018 and is now supporting live demonstrations across a variety of markets and applications. Their emerging Lightspeed system is a global network composed of 188 LEO satellites, seamlessly integrated with on-ground data networks.
s47F

TELSTRA Telstra is the major communications service provider in the Enterprise and Government sectors. They have little direct investment in satellite infrastructure of their own, however they have partnered with OneWeb to conduct testing on OneWeb's network of low earth orbit satellites. They are exploring new options for providing high-quality and continuous coverage across the country to boost digital connectivity.
s47F
TPG TELECOM TPG is the second largest telecommunications company listed on the ASX. Their Business Satellite internet uses Ka-band High Throughput Satellite (HTS) technology, which is a cost-effective solution for delivering internet access to enterprises in remote locations.
s47F
VIASAT Viasat is a global communications company that aims to bring connectivity to consumers, businesses, governments, and militaries, in places where cable or fibre are not available. They have built up considerable expertise in satellite networking and have acquired their own broadband satellite covering the United States. Viasat also provided the ground segment for the NBN Sky Muster satellites.
s47F

VOCUS
Vocus is a satellite service provider in the Enterprise sector but also "sees a significant opportunity in leveraging its extensive fixed infrastructure to support emerging LEOsat services". Vocus owns and operates almost 25,000km of fibre network across Australia and New Zealand, that is purpose-built for business and government. Their LEO satellite network, *Vocus Satellite – Starlink*, is powered by Space X's LEO constellation.
s47F

MS22-001913

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

To: The Hon Michelle Rowland MP, Minister for Communications (for decision)

Subject: Low Earth Orbit Satellites Working Group

Critical Date: Routine (Starlink meeting on 18 November. OneWeb meeting being confirmed)

Recommendation/s: That you
1. **Agree** to the approach to establishing a Low Earth Orbit Satellite Working Group. s22(1)(a)(ii) **Agreed / Not Agreed**
Michelle Rowland Date: 23/11/22
Comments: Yes to include entities in para 5.

Purpose:

1. To provide a proposal for the establishment of a Low Earth Orbit Satellite (LEOSat) Working Group (WG), consistent with your announcement at the Charles Todd Oration on 21 October 2022, and to provide an overview of the LEOSat market as requested by your office in advance of upcoming meetings with Starlink and OneWeb, for which separate briefings will be provided.

Key Points:

2. LEOSats by their design can be global in their service provision and, in recent years, new LEOSat internet providers have begun entering the Australian market. LEOSats can offer a high-speed broadband solution, particularly to regional and rural Australians, otherwise dependent on NBN's Sky Muster or other communications solutions. They can potentially support low latency voice services, helping with Universal Service Obligation (USO) reform. Starlink is the largest player, OneWeb has entered into arrangements with Telstra and Pivotel and there are other market participants and aspirants. Further information on the market is at **Attachment A.**

3. LEOSats have significant potential, with relevance to a range of policy issues, including:
   a. their technical capability, commercial sustainability and affordability
   b. their role in rural/regional connectivity, including mobile coverage and USO reform
   c. competition and their role relative to other older satellite technologies, including as a useful complement and potential for accelerated replacement for existing technology
   d. use cases, including use by households and businesses; Internet of Things; emergency telecommunications; broadband for high mobility locations, such as transportation and
   e. the role of government, including regulatory/policy certainty for industry participants in the event of intervention and existing regulatory impediments, in relation to use of spectrum, consumer protection, data protection and national sovereignty issues.

4. Your announcement included that the WG would 'help inform Government about how this emerging capability might play a role in future telecommunications policy'. We propose that the WG commence with a large initial meeting early in 2023, with invitations to be sent by the end of the year, to explore the issues raised above. Known players in the market, including relevant members of the Communications Alliance Satellite Services Working Group would be invited (particularly its LEOSat members – Starlink, OneWeb, Telesat). The Department could chair at a senior level, although you may wish to chair or open the meeting.

5. We could also invite other relevant government agencies, including the Australian Communications and Media Authority, the Department of Industry, Science and Resources and the Australian Space Agency.

6. With your agreement, we would develop terms of reference including the items in paragraph 3, outlining that the WG would not be a decision-making body, but would be used to better understand the technical capability of the technology, including possible use cases; and identify and advise you/the Government on regulatory and policy issues and be available for information sharing as appropriate.

7. Though promising, the sustainable pricing model and the enduring technical offering of LEOSats is unclear. Current operators are relying on wealthy backers making substantial ongoing losses which will need high levels of continuous funding. Connection is typically still more expensive than terrestrial options and not as fast or reliable as modern 5G or fibre optic broadband. This gap could potentially widen in future, and services may slow down as more people connect to and make use of them. The WG could be used to inform government as the industry evolves.

Stakeholder implications: We see clear benefit in engaging with LEOSat operators and other stakeholders, and have been doing so. While there has been industry interest in your announcement, it is possible LEOSat operators and others in industry may prefer to discuss their plans directly with Government rather than in a group with competitors and customers. If this proves the case, an alternative approach may be to establish a WG within the Department or wider public service that works with industry and others more discretely.

Attachments:

Attachment A: Background to low earth orbit satellites

s22(1)(a)(ii) [redacted]

s22(1)(a)(ii) [redacted]

Cleared Date: 3 November 2022

Instructions for MPS: Nil

Responsible Adviser: s47F [redacted]

PDMS Distribution List: Jim Betts, Richard Windeyer, s22(1)(a)(ii) [redacted]

s22(1)(a)(ii) [redacted]

Attachment A – Background to Low Earth Orbit Satellites

Advantages of LEOSats

LEOSats offer several advantages over more traditional satellites; being closer to the earth, communication distances are shorter compared to other satellites. This means that LEOSats can transmit with lower latency, require less power, and are much smaller than their traditional communications satellite counterparts at higher orbits. Lower altitude, however, means more satellites are needed and they are launched in constellations of hundreds or thousands to provide global coverage. Constellations involve high costs. Starlink, OneWeb, Amazon and Telesat are reportedly investing at least $US10 billion, $US $3.3billion (invested to-date), $US10 billion (launch costs alone) and $US5 billion respectively. However, the small size and low altitude of the satellites reduce per unit and launch costs, which are also benefitting from advances in rocket technology.

Major players

The leading players in the LEOSat broadband market are Starlink, OneWeb and Amazon's project Kuiper. Starlink is currently offering consumer broadband to around 75% of the Australian land mass. Starlink had been focusing on the home broadband market but is branching out into enterprise and vehicular markets. OneWeb is still launching its fleet and is marketing to businesses. Telstra has signed a memorandum of understanding and letter of intent with OneWeb in advance of testing and a commercial agreement. Telstra has told us previously it is interested in using OneWeb for USO delivery and wider applications but this will depend on field testing (see further below). Amazon project Kuiper is still in early stages and has not yet announced if it will sell directly to consumers, although this is foreseeable.

Telesat of Canada is planning to launch 188 LEOSats. It launched a demonstration satellite in 2018 which Optus has trialled but it has recently downsized it plans and its funding is unclear. Lynk Global and AST, international start-ups, are hoping to offer 4G connectivity over LEOSat by the end of this year. Other players include Myriota and Fleetspace, both Australian LEOSat startups with an Internet of Things (IoT) focus. Iridium and Globalstar, with 66 and 24 LEOSats respectively, are earlier generation systems providing lower data rates, but which also have invested in system upgrades. They have offered data and voice service in Australia for many years, through retailers like Pivotel and Telstra.

Starlink: Operated by SpaceX and owned by Elon Musk. It currently has the most mature LEOSat network with over 2,500 satellites operating in its fleet, with 1,584 making up its phase one network. It has sought permission to operate up to 42,000 satellites and has announced its intention to bring its fleet size to 11,943 by 2025. It is unclear whether its ambition will be realised. Its main focus appears to be on marketing home internet packages for remote locations, however other applications are being explored. In Q2 2022, Starlink's speed in Australia averaged 102.76Mbps download speed and 10.45Mbps upload speed, with a latency of 49ms.

On 10 August 2022, the United States Federal Communications Commission (FCC) rejected Starlink's application for support through its Rural Digital Opportunity Fund program. Starlink was initially allocated US$885.5 million through the initial auction, but the FCC was not convinced it could deliver the promised service. The FCC found that the technology had real promise but is still developing.

OneWeb: Currently has 462 satellites operating in its fleet. It plans to bring its total fleet size to 648. One Web expects to reach full deployment in 2023. It has signed an MOU with Telstra and they are working together to bring their LEOSat offerings to Australia. OneWeb has also recently

entered into an arrangement with Pivotel and has other distribution partners. It has stated that it is primarily intending to target businesses and governments rather than consumers. Telstra notes on its website:

> *"LEO satellite connectivity creates lots of interesting opportunities for our consumer, small business and enterprise customers – especially those that require continuous coverage or added redundancy – from backhaul to back-up for resiliency, from IoT to supporting emergency services, from home broadband to supporting agritech."*

In 2020, OneWeb filed for bankruptcy and was bailed out in part by a $500 million investment by the UK government, which now controls 17.6% of the company.

Amazon Project Kuiper: Planned to be a network of 3,236 satellites put into orbit over 83 launches. It is scheduled to launch its first LEOSats by the end of 2022. Amazon has not announced if it plans to sell broadband directly to consumers but has said it will "offer broadband services through partnerships with other companies".

Australian participation in the market

All broadband over LEOSat services are currently being offered by foreign entrants into the market. Myriota and Fleetspace are both Australian startups offering LEOSat internet connectivity for commercial Internet of Things applications. Their satellites do not offer continual connectivity, rather they periodically offload data from IoT devices. They do this irrespective of the device's geographic location. Both companies have limited fleets and do not offer broadband connections.

Telstra has signed an MOU with OneWeb and has since begun promoting the potential of LEOSat broadband in Australia. In response to recent ACCC questions on the impact on competition of the proposed TPG-Telstra mobile network deal, Telstra argued that LEOSat coverage is the future for regional Australia. It argued that LEOSat internet would likely be able to replace ADSL and copper-based services in regional areas. Telstra also argued that outdoor mobile coverage may soon reach all of Australia using direct mobile to LEOSat connectivity.

Technology developments – present and future

The leading emerging use of LEOSats is as last mile connection for broadband internet. Like other satellite solutions, LEOSat connectivity is (or will be) available in many locations as the constellations have large footprints. Future opportunities include:

- Local telco providers may begin to use LEOSat internet in parts of their networks (e.g. for mobile backhaul) or begin reselling LEOSat services directly to consumers and business.
- LEOSats with inter-satellite links (ISLs) are being deployed (e.g. by Starlink) to provide LEOSat broadband coverage to areas that do not have a ground transmission station with which a satellite can communicate. Space based backhaul should make it easier for LEOSat operators to extend their coverage globally.
- Direct connection to consumer mobile handsets is a goal of many LEOSat operators. Already the latest models of iPhone can connect directly to LEO satellites for reception when sending emergency distress signals. Companies, such as the start-up Lynk Global and AST, are aiming to commercially offer 4G connections direct to LEOSat by as early as the end of the year, and 5G connections following afterwards.
- OneWeb in partnership with Stellar Blu Solutions have demonstrated the ability to connect a commercial passenger airline flight to LEOSat internet. This allows for continued access to high speed internet for passengers during their flight. There is an aim to have the technology certified for market by mid-2023.

How the technology works and practicalities

LEOSats work by relaying transmissions from a ground transmission station, up to a satellite then back down to a recipient ground station. This limitation means that for internet to be available, there needs to be an internet transmission station that can see the same patch of sky as the recipient station. This limitation is expected to dissipate in the near future as LEOSat networks are upgraded to allow for backhaul over inter-satellite link. Recipient stations require a small antenna, which often is able to track the satellite on its path through the sky.

Due to their lower altitude orbits, LEOSats move very quickly across the sky. They will often only have 5-20 minutes of visibility to a given location on the ground per orbit. This means that to be used effectively, a network of them is required, so that there is at least one satellite in the network visible from the ground at any given time. Recent technological advances have allowed for communications signals to be handed off rapidly between LEOSats in a network as one passes out of view and another enters. This allows for continued communication without interruption. Seamless hand-offs will be important to supporting quality voice communications and uninterrupted high-speed internet.

LEOSat operations greatly reduces latency and power consumption when using them for communications, as the signal has to travel a much shorter distance. The reduced latency is one of the largest draws for LEOSat internet over other satellite internet solutions. The round-trip latency for a signal to an LEOSat is roughly 40ms with some variance depending on the satellites' orbit. LEOSat latency is significantly lower than that of satellites that orbit further from the earth such as medium earth orbit satellites (MEOSat) and geostationary earth orbit satellites (GEOSat). Low latency is important in supporting quality voice communications and certain broadband internet applications.

Several technological improvements have enabled the current growth in the LEOSat market including improvements in areas of satellite launching, satellite manufacturing, improved transmission capacity and service flexibility, which have lowered costs. The sector can be expected to continue to change rapidly in the near future as the technology progresses.

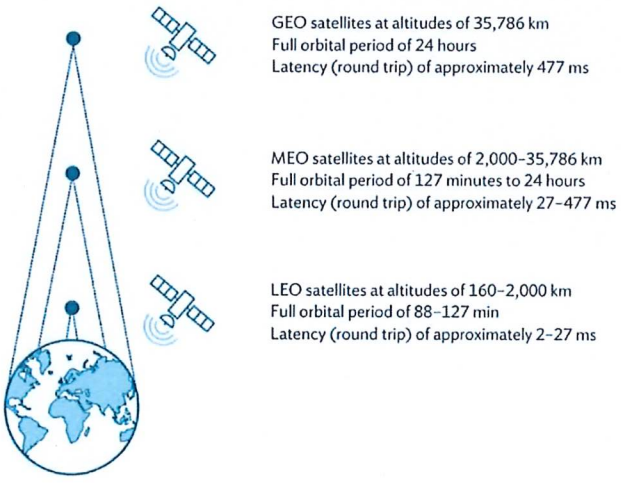


Image Source: Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific (SDWP No. 76) (adb.org)

As an example, to set up a Starlink connection, users need to purchase a small portable receiver dish for roughly $1000 (currently on sale at $450) and pay for a subscription, currently $139 per month. In Q2 2022, Starlink in Australia averaged 102.76Mbps download speed and 10.45Mbps upload speed, with a latency of 49ms. For comparison, NBN's Sky Muster top tier plan offers 25Mbps down and 5Mbps up with a latency of around 600ms. The way Sky Muster's plans are advertised is that the top speed of the plan will be achievable at least once per day, with speeds at other times being potentially lower or spiking higher for brief periods. Starlink's speed is

comparable to those seen by the initial 5G rollout, however Australia's 5G speeds have already outpaced this significantly.

Limitations

Speed and latency: LEOSats' transmission will always have some latency, even if much less than GEOSats. Even under perfect theoretical conditions 5-10ms is added in latency by relaying communications to low orbit and back. As such terrestrial fibre optic broadband will likely continue to outperform LEOSat broadband on latency. LEOSat networks are not set up as replacements for fixed line technology as a whole.

Rain fade: is when precipitation in the atmosphere obstructs the transmission path of a radio signal. All satellites are affected by this and the degree depends upon its transmission frequency. In general, the higher frequency the band, the more it is negatively impacted by the effects of rain fade.

Earth fade: LEOSats require a line of sight between the ground station and the satellite it is communicating with. Earth fade occurs when terrestrial obstructions such as trees, mountains or tall buildings block the line of sight to the satellite. This can be mitigated by choice of receiver location and by increasing the number of satellites in the fleet. However, earth fade will always make LEOSat communications less suited to certain areas due to their ground environment (for example highly built-up urban areas).

Security: Concerns exist for the potential for interception of LEOSat communications. LEOSat signals, like all satellite signals, are capable of being intercepted and eavesdropped. Encryption can be used to protect them, however as always there is a tug-of-war between manufacturers and bad actors. LEOSats use long range telemetry to communicate with earth, this can potentially be eavesdropped and deciphered, or jammed to disrupt communications.

Collision risk and space pollution: Low-earth orbits are a finite resource. As more and more satellites are launched into this narrow band of space, the risk of collisions between them increases. Satellite operators generally have plans in place to remove old satellites from orbit to mitigate the risks posed by space debris to other satellites, but these sometimes fail leaving additional objects stranded in orbit. Additionally, astronomical research organisations have expressed concerns about the impact of large LEOSat constellations on visual observation of the nights sky.

Throughput limits: As with all satellite communications services, LEOSats are a shared access medium and there is a limited amount of bandwidth available. As more customers in an area connect to a LEOSat, their performance may suffer. As such current LEOSat technology is poorly suited to servicing large populations.

Spectrum

Access to spectrum for satellites is managed internationally by the International Telecommunication Union (ITU) under the Radio Regulations and domestically by ACMA in accordance with the *Radiocommunications Act 1992*. Spectrum is planned and allocated to support the range of demand for different satellite communications applications in different frequency bands. The Radio Regulations contain well-established frameworks for the international coordination and notification of frequencies used by satellite networks. ACMA's licensing framework governs the authorisation of space system operations in Australia.

Processes exist for operators to seek changes to international and domestic regulations as market conditions change. For example, at the World Radiocommunication Conference 2019 (WRC-19), a new regulatory regime was established for large LEOSat constellations (like that of SpaceX), to support a competitive satellite industry and prevent spectrum warehousing.

Technical issues for Low Earth Orbit satellite network delivered telecommunications services V2.1

Prepared for: s47F

Client: Department of Infrastructure, Transport, Regional Development, Communications, and the Arts

15 August 2023

Nova Systems

Issue	Prepared by	Nova Reviewed by	Date
1.0	s47F		3/08/2023
2.0			11/08/2023
	Client Acceptance		

Contents

1. Executive Summary

This report reviews the performance of existing and potential LEO-Sat fixed broadband services, and the emerging Direct-to-Device (D2D) services that are using or are likely to use LEO-Sat constellations.

LEO-Sat fixed broadband services is defined as a broadband Internet service through a low earth orbit constellation to a fixed location. Starlink is a LEO-Sat constellation and has reached the minimum viable number of orbiting satellites to offer consistent ubiquitous coverage across Australia and is operational. OneWeb will reach a similar coverage and be fully operational in Australia towards the end of 2023.

The report highlights that LEO-Sat constellations with a minimum viable number of orbiting satellites require Australian users to find a terminal location with close to a perfect uninterrupted view of the sky from horizon to horizon. For locations with some signal blockage, there is a possibility that the Internet service experiences intermittent interruptions when satellite handovers occur close to the horizon. The service reliability for locations with some blockage will improve once additional satellites are added to the constellations.

Starlink's single-size consumer antenna is concerning as it cannot cater for all the different weather regions in Australia. The larger business-grade version will be more suitable for high rainfall areas like Darwin. As a comparison, the NBN satellite service is aware of this and recommends larger antennas for the Australian sub-tropical and tropical regions.

D2D services are defined as low data-rate text, voice, and data services from a satellite. They are primarily from LEO constellations, however there are also D2D services from GEO satellites. D2D services are targeted to work directly with mobile phones.

D2D services should not be considered reliable until the next generation satellites are launched with 3GPP standards for mobile networks included. All tests to date are proof of concept on either test satellites or existing satellites. The concept has proven to be feasible, but there is not yet enough link margin (additional gain built into the link to the satellite for poorer weather conditions) to offer D2D as a reliable, commercial service. However, the availability and accessibility are expected to increase in 2024 as new satellites are launched with enhanced D2D capability.

D2D services are not yet robust enough to be relied on in large scale emergencies. They are not yet in a position to replace terrestrial mobile or fixed line telephony for universal service obligation services.

2. Introduction

2.1. Background

The Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (DITRDCA) is seeking expert advice on the performance of LEO-Sat and D2D networks that is independent of current marketing information by service providers. A more thorough understanding will help guide the department's future policy considerations.

This study provides information based on a mixture of knowledge through first-hand experience, expert knowledge on propagation and link budgets, and some real-world results from operational LEO-Sat systems.

It is highlighted that the LEO-Sat networks are either in their initial stages of deployment, or still under development. Their performance and business plans are continually evolving, so the advice will be limited to the information available from the network operators today.

LEO-Sat networks are associated with fixed broadband Internet as the primary service. We are now seeing new emerging services on LEO-Sat networks, including D2D. While the D2D services are mostly (but not all) running on the LEO-Sat networks, they are primarily narrowband data services. These services need to be compatible with mobile phones.

A tabulated summary of the current and planned LEO-Sat networks and D2D services reviewed is provided in Annex 7.2 at the end of this document.

2.2. Methodology

DITRDCA requested Nova place an emphasis on real-life test scenarios. Often the published information focusses on the best performance expected, whereas the user experience is dependent on several environmental factors.

Only the Starlink service is tested in this report. The OneWeb service is only in early deployment trials in the southern Australian states, with the remainder of Australia coming online towards the end of 2023. Amazon's Project Kuiper is moving into the satellite manufacturing stage.

Nova has selected test-site locations that vary in:

a) **Lack of NBN fixed-line access**. The sites chosen currently can only access Internet via either 3G / 4G mobile, wireless NBN or satellite NBN.

b) **Amount of sky blockage** (e.g., from open farmland to sub-tropical areas with a greater foliage coverage). The reliability of a LEO-Sat service is dependent on uninterrupted sky coverage.

   The Starlink App helps determine the percentage of sky blockage from trees and buildings. It has a feature where the user rotates the phone camera around until the App has calculated the amount of clear sky available.

c) **User density** (rural vs regional areas)

   The throughput speed is dependent on the number of users and their Internet activity when sharing the same satellite beam. There is no accurate measurement of user density. This is a subjective measure based on the cell size and likely number of users in nearby towns.

The cell size can be visualised using the Starlink Coverage Tracker website (https://starlink.sx) and setting the “home location” at each test site. Towns in the same cells as the test site cell are assumed likely to have other Starlink users.

d) **Rainfall**. This is a variable that can’t be controlled; however, weather conditions are noted in all test scenarios.

The same 2nd Gen Standard Starlink terminal was used at each site. The Starlink App helped to identify the best location at each site where there was the least blockage. Each site experienced the Starlink service between three and seven days in addition to our technical comparison testing.

The test methodology changed between sites as part of a learning process. Location 1 required the user to manually record the speeds several times a day using the Ookla speed test on their computer. In hindsight this proved to be the most reliable method of data capture as Starlink does not restrict the Ookla speed test. However, it proved to be very onerous on the user to continually take manual recordings.

Location 2 used an automated speed tester that recorded up and download speeds every 30 minutes. This worked very well on the NBN wireless service, but not on Starlink. Location 3 was then chosen to help troubleshoot the Starlink speed test issue. The same pattern was noted at Location 3 where the speed tester worked perfectly on the NBN satellite service, but we noted the same speed-limiting issue on Starlink. Our hypothesis is that Starlink only allow speed tests via Ookla and Starlink’s own App. Speed test traffic from other devices seems to be speed-limited to reduce the load on the satellite with this type of traffic.

We recorded a non-technical “user experience” from each landowner, and asked whether the user could justify the additional Starlink cost based on their experience.

3. LEO-Sat Background

This section provides an overview of the LEO-Sat performance expectations. This will cover:

a) Performance expectations today compared to GEO satellites, and when their constellations are complete.

b) Theoretical expectations based on different weather events.

c) Comparison of Starlink, OneWeb and Amazon (Project Kuiper) expected performance.

3.1. Advantages of LEO Satellites

- **Lower Latency:** LEO satellites operate at much lower altitudes than GEO satellites, resulting in significantly shorter distances between the satellite and users compared to GEO Satellites. This reduces the time delay (latency) between making requests and receiving information on the internet. The lower latency is advantageous for applications that require real-time communication, such as video conferencing, online gaming, autonomous vehicles, and remote control of machinery.
- **Lower Signal Power Requirements:** LEO satellites orbit closer to Earth, which means they require less signal power from the user terminal and the satellite for communication. This advantage leads to reduced energy consumption and cost-efficiency for both the satellite and the user terminals, making LEO satellite services more accessible to a wider range of users.
- **Increased Capacity:** LEO constellations consist of numerous smaller satellites, which allows for increased capacity compared to a single GEO satellite. Smaller coverage cells and frequency re-use (non-adjacent cells re-use the same frequency band) greatly increases the available bandwidth across a region.

  This higher bandwidth enables faster data speeds, which is beneficial for high-data-rate applications like streaming video content or transferring large files.
- **Improved Access:** The LEO constellation density means most locations will see multiple satellites at any time. Increasing the LEO constellation density further improves network access and increases the Internet capacity available at a location, leading to higher throughput speeds.

  A location is less likely to experience signal blockage compared to a GEO satellite that requires clear access to a single point in the sky.

3.2. Disadvantages of LEO Satellites

- **Limited Ground Coverage per Satellite:** LEO satellites illuminate a smaller area on the ground due to their lower altitude. As a result, a higher number of satellites are required to provide continuous global coverage, leading to more complex and expensive satellite constellations.
- **Higher Infrastructure and Launch Costs:** Deploying and maintaining many LEO satellites involves significant upfront infrastructure costs, including satellite manufacturing, ground stations, and launch operations. A LEO constellation must provide continuous global coverage before a service can be offered and revenue received.

  LEO satellites have a lower life expectancy and need to be replaced more often. That said, the satellites are cheaper to build due to being less bespoke, operate in a lower radiation environment, and are mass produced.

While advancements in technology and reusable rockets may help reduce costs in the future, currently, the initial investment required for LEO satellite networks is typically higher than GEO systems.

- **Frequent Satellite Handovers:** LEO satellites require frequent satellite handovers as they move across the sky. This continuous handover may introduce complexities for seamless connectivity, especially for applications that require uninterrupted communication, such as voice calls or real-time video streaming.
- **Increased Complexity in Network Management:** Managing a constellation of LEO satellites is more complex compared to a single GEO satellite. Coordinating the orbital positions, maintaining inter-satellite communication, and ensuring seamless handoffs between satellites require advanced network management systems. This complexity adds challenges to the design and operation of LEO satellite constellations.

Noting the above points, it is worth highlighting that neither Starlink nor OneWeb are profitable businesses at this stage. This makes their reliance on continual financing more susceptible to external market “shocks”. Several LEO constellations have previously entered Administration before being able to offer services, including OneWeb, Globalstar and Iridium.

3.3. Performance expectations today and once constellations are complete.

This section focuses on the Starlink current and future constellation performance. The performance expectations of the OneWeb and Kuiper constellations would be purely theoretical until they determine their minimum viable number of satellites and commence their respective services. Section 2.5 compares these three constellation operators.

Starlink have over 4,000 satellites in a 550 km altitude low-earth orbit. They have received FCC approval to expand to 12,000 satellites in 3 orbital “shells”, which will also include 1,150 km and 340 km altitudes. There are additional filings to substantially increase to 42,000 satellites, however these filings are “placeholders” and are being continually modified.

The future performance will be a battle between two opposing variables:

a) Performance will increase as more satellites become operational, versus

b) Performance will decrease as more users and devices connect to the service.

The ~4,000 satellites in the 550 km altitude shell operational today are considered the minimum viable number of satellites required to provide reliable, ubiquitous coverage around the globe. From a user’s perspective, a satellite handover must occur before the connected satellite disappears below the horizon to maintain continual connectivity.

Each satellite has 16 beams designed to provide *acceptable performance* for up to 130 users. Acceptable performance assumes a wide range of Internet use at a particular point of time. This may vary from a user reading an article (minimum data transfer) to a user streaming or gaming (high data transfer). It is typical for the Internet Service Provider (ISP) industry to accept a natural contention of 6 users to share the same bandwidth without users noticing slower Internet during most of the day.

This argument fails at peak evening times (6 pm to 10 pm) when there is a significantly higher percentage of users streaming / gaming simultaneously. The bandwidth demand can triple for the same number of users during the peak time.

It was reported by Starlink in their June 2023 Australasian Satellite Forum presentation that they have 131,000 customers in Australia. It is therefore likely some beams may reach or exceed the maximum 130 users per beam. Our experience suggests that 130 users sharing the same Starlink beam may see degraded performance during peak times.

Figure 1 shows the Starlink spot beam (yellow circle) over Location 2 on the farm west of Toowoomba. This location can see up to seven Starlink satellites at any time based on a clear view of the sky. The potential Starlink satellites are shown as dotted green lines. The active Starlink satellite (solid green line) has the shortest path to the satellite and the ground station, hence chosen due to the lowest latency.

The hexes on the diagram below are a visual representation of spot beam circles when a LEO satellite is directly overhead. Hexes are used as it is easy to create a grid. The spot beam (yellow circle) becomes elongated and stretched as the satellite moves to a lower elevation. As the spot beam stretches, a larger area is covered (equivalent to multiple spot beams as represented by multiple hexes in the yellow circle).

Connecting to a lower LEO satellite has several implications that may result in a slower Internet experience. These include:

- More potential users share the same bandwidth in the satellite beam,
- There is a longer path length to the satellite resulting in longer latency, and
- The longer distance means greater link losses to the users' terminal.

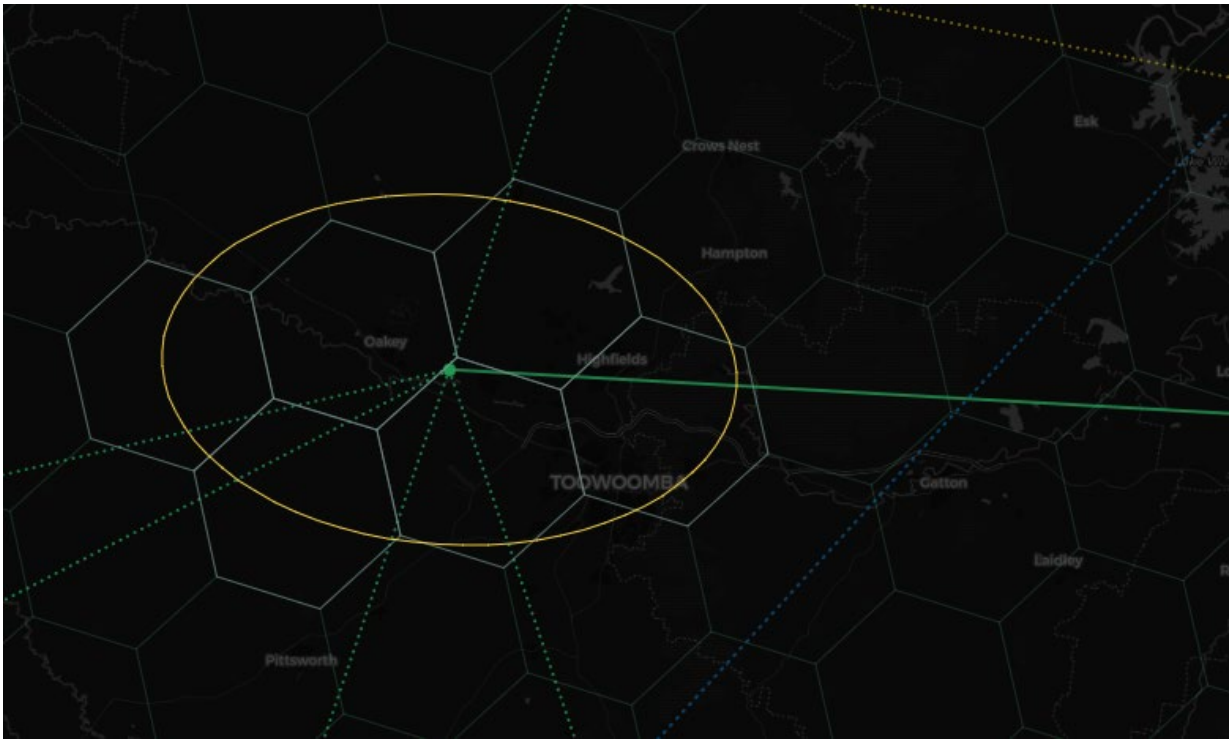


Figure 1: Starlink satellite connections from farm site west of Toowoomba

It is envisaged that each user will have a larger choice of satellites to connect to as more Starlink satellites are launched. Starlink may be able to share users between satellite beams to increase data throughput. However, there are technical challenges that need to be addressed in how additional bandwidth will be offered to the same region (e.g., higher frequency reuse with smaller spot beams, different frequency bands, etc).

An additional variable is the impact of new services being offered by Starlink in Australia, including "direct to device" (D2D) SMS, voice, and data. Optus have announced an agreement with Starlink to offer SMS direct to the handset in late 2024, and voice / data in late 2025. Elon Musk mentioned in an August 2022 interview that the 2nd generation Starlink satellites will include new fold-out antennas for communications direct to a mobile device (~5m^2 aperture area).

3.4. Theoretical expectations based on different weather events

The performance of the LEO satellite service is determined by the link budget between the satellite and user ground terminal. The important variables in the link budget calculation include:

- Satellite antenna gain and transmit power.
- User ground terminal antenna gain and transmit power.
- Link loss as determined by the distance between the user ground terminal and satellite.
- Modulation choice (higher order modulation means higher data rates but requires stronger signals).

Both Starlink and OneWeb use Ku-band frequencies (12 – 14 GHz) to the user terminal and Ka-band frequencies to their respective gateways. Both frequency bands are affected by weather that leads to attenuation of the signal.

The LEO-Sat gateways have much larger antennas and higher transmit power available and therefore have greater flexibility to adjust for rain attenuation. The rain attenuation therefore primarily affects the link path between the satellite and smaller user terminals with their limited transmit power.

There are several ways to adapt to poorer weather conditions:

- Increase transmit power to make up for attenuation losses,
- Reduce the modulation co-efficient. This means slower data rates, but can still connect with a weaker signal, or
- Switch to another LEO satellite where the rain path loss is less. The height and width of the rain cell will affect the amount of signal attenuation. A wide rain cell means greater attenuation, particularly for lower elevation satellites (a longer path is traversed through the rain cell and hence more signal attenuation). However, LEO satellites are continuously moving across the sky, and it may not be possible to avoid larger rain cells.

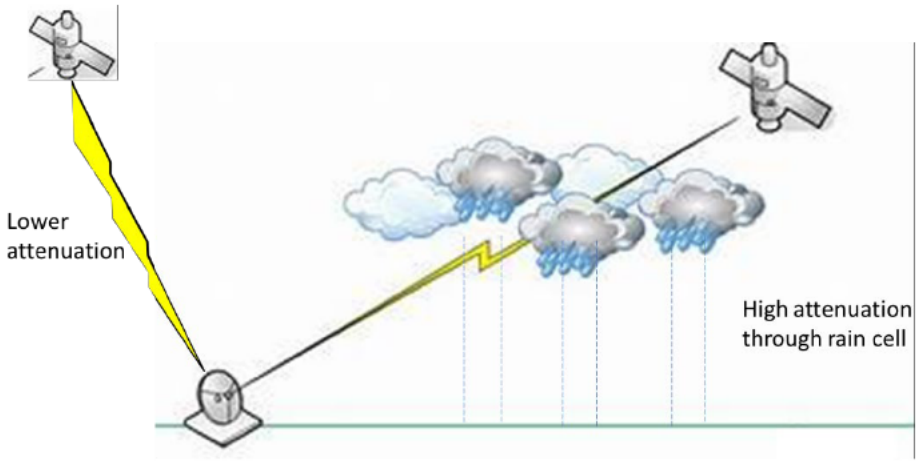


Figure 2: Rain attenuation at different satellite angles

The expected amount of rain attenuation differs between locations. For example, a tropical location will expect a much higher intensity rainfall and hence greater attenuation compared to an arid location.

Table 1 shows the expected additional attenuation due to rain at Ku-band frequencies for a sample of locations within Australia. The elevation is the angle to the satellite relative to the ground. These attenuation figures were developed by CSIRO and used in link budget calculations to calculate the dish size and transmit power, and to ensure that communications will be maintained for 99.9% of the year at a specific location.

The data in Table 1 highlights the following:

- Satellites at lower elevations suffer more attenuation in rainy weather. There is greater rain attenuation at lower angles because the signal must travel longitudinally through more of the rain cell (the model assumes the rain cell is much wider than its height).
- Tropical areas suffer more in rainy weather. The model considers that the *intensity of rain* is greater in tropical areas, which in turn causes greater signal attenuation.

	ELEVATION FROM GROUND				
Location	**20 deg**	**30 deg**	**40 deg**	**65 deg**	**90 deg**
Sydney	4.3 dB	2.6 dB	2.3 dB	1.9 dB	1.8 dB
Brisbane	5.2 dB	3.1 dB	2.7 dB	2.4 dB	2.2 dB
Toowoomba	4.4 dB	2.6 dB	2.2 dB	2.0 dB	1.8 dB
Darwin	13.8 dB	8.2 dB	6.9 dB	6.1 dB	6.7 dB

Table 1: Additional rain attenuation expected at different locations and elevations

LEO satellites are continually moving, so the rain attenuation will continually change. However, the user terminal must be designed for the worst-case scenario, which is when it moves to lower elevations. LEO services are potentially going down to 25 degrees until the LEO constellation density increases.

In comparison, GEO satellites like the NBN satellite service are fixed over the equator and the rain attenuation will be more consistent. The elevation to GEO satellites increases the closer the user is to the equator. For example, a Sydney terminal elevation to the NBN satellite is 49 degrees, a Brisbane or Toowoomba terminal is 55 degrees, and a Darwin terminal is 72 degrees. A GEO satellite service also must design for worst-case scenario. The lowest elevation for the NBN satellite service would be Hobart at 41 degrees elevation.

Example: Compare Darwin to Toowoomba performance for a satellite at 30 degrees elevation.

A Darwin based satellite terminal would require 8.2 – 2.6 = 5.6 dB additional gain to have a similar reliability in rain to a terminal located in Toowoomba.

This is equivalent to requiring:

- 4x transmit power, or
- 2x antenna aperture area, or
- Reduce modulation (e.g., 16PSK down to 8PSK), will reduce the data throughput speeds.

The Starlink antenna dimensions are fixed, so the Starlink terminal is reliant on adjusting the output transmit power and/or the modulation to compensate for rain attenuation in a range of locations. The output transmit power is likely to be very limited considering it is a consumer device.

The best option for high rainfall areas is to purchase a larger terminal size. In Starlink's case, this would be the business grade terminal, which has twice the antenna aperture size compared to the consumer terminal.

3.5. Comparing Starlink, OneWeb and Amazon (Project Kuiper)

All three LEO-Sat services market themselves as "Connecting the Unconnected" and have highlighted that a third of the earth's population is yet to access the Internet. However, the reality is that most of these regions cannot afford the user ground terminal cost, let alone the on-going Internet service fees. The current pricing is still considered at the high-end for developed countries like Australia and the US and will be a limiting factor on the service take-up rate.

Starlink

Starlink is testing the price elasticity of the Australian market, with reductions in the consumer terminal cost from just under $1,000 to $599, then down to $199 to increase demand. The on-going consumer service cost of $139 per month has remained unchanged and is at the high end of what the Australian market will pay for high-speed Internet.

The Starlink service is primarily a consumer service, with an emphasis on:

- Low-cost terminals
- Simple, self-installation, self-aligning antennas

- Only a few service options available – consumer, business, and RV mobile markets
- Minimal customer support for the consumer service. The business service relies on local partnerships to provide customer support.

SERVICE PLAN	STANDARD (FIXED)	PRIORITY (FIXED)	ROAM (Comms on the Pause)	MOBILE PRIORITY (Comms on the Move)
Terminal Size	0.15 m^2	0.29 m^2	0.15 m^2	0.29 m^2
Terminal Cost	From $199	From $2,999	From $599	From $2,999
Service Cost	$139 / month	$374 / month	$174 / month	$399 / month
AVAILABILITY	≥99%	≥99%	≥99%	≥99%
DOWNLOAD	90-240 Mbps	120-270 Mbps	75-240 Mbps	85-275 Mbps
UPLOAD	10-25 Mbps	12-35 Mbps	8-30 Mbps	10-30 Mbps
LATENCY	25-60 ms	25-60 ms	<99 ms	<99 ms

Table 2: Starlink pricing and specifications

OneWeb

OneWeb's service is now ready for testing for locations south of a line across Australia between Brisbane, QLD and Geraldton, WA. Regions north of this line will be activated towards the end of 2023.

The OneWeb constellation orbital shell is further out at 1,200 km. This will increase the latency to approximately 100 milliseconds, but means the constellation requires fewer satellites and the spot beam sizes will be larger. Hence OneWeb's service is not designed as a higher density consumer service.

OneWeb will also offer self-installation and self-aligning antennas. They will differentiate from Starlink by focussing on Government and enterprises as their core customer base.

OneWeb will also offer:

- Service Level Agreements
- An option to create private corporate / government networks (enhanced security), rather than pure Internet.
- Bandwidth bundling for entities with multiple sites.
- Customer support will come from local service integrators like Vocus, Speedcast and Ursys.
- The service and equipment are likely to be more expensive, however actual figures for the Australian market have yet to be released.

There is limited information available on the OneWeb user terminals, or the performance expected. The terminals will need to be slightly larger due to the greater distance to the LEO constellation shell.

- Intellian OW1 terminal - 0.21 m^2 aperture size
- Kymeta u8 mobile terminal - 0.8 m^2 aperture size for speeds greater than 200 / 40 Mbps

Amazon Kuiper

Amazon's Kuiper plans to launch a basic service in 2024. They are not yet disclosing their strategy however Australia is considered to be a "high priority" customer. They have a similar plan to Starlink to provide global coverage for internet connectivity.

A hint of their target markets can be derived from the customer terminals designed for Project Kuiper. There are three terminals planned:

- 0.03 m^2 terminal aperture size for speeds up to 100 Mbps
- 0.08 m^2 terminal aperture size for speeds up to 400 Mbps
- 0.36 m^2 terminal aperture size for speeds up to 1 Gbps

Kuiper will operate in Ka-band (20 – 30 GHz), hence the smaller terminal sizes. This service will be more susceptible to rain compared to Starlink and OneWeb's Ku-band services, however the higher gain mid-sized terminal will have greater link budget margin to help compensate for these losses.

Kuiper's constellation orbital shell is expected to be slightly higher than Starlink at ~600km altitude, yet their terminal sizes are significantly smaller (even taking account of their higher Ka-band operation). It suggests that the satellite spot beams will be narrower and more powerful to get the required power to the user ground terminal. This means less users per spot beam and hence expect better performance in higher density locations. The consequence is a more complex and expensive satellite.

Project Kuiper's satellite internet services are likely to be integrated with Amazon's existing ecosystem of products and services. This could include seamless connectivity with Amazon's smart devices, cloud services, and other offerings, allowing Amazon to provide a more comprehensive internet experience to its customers.

Amazon is expected to launch its first test LEO satellites around October 2023.

4. Field Trial Results

Three locations were tested with the Starlink service where NBN fixed line Internet was not available. Below are the locations and their current Internet access method. None of the sites have access to fixed NBN Internet.

LOCATION	CURRENT INTERNET ACCESS
Booroobin 4552 (South-West of Maleny)	Telstra 3G/4G cellular network
Kelvinhaugh 4401 (West of Toowoomba)	TPG (NBN fixed wireless link)
Flagstone Creek 4344 (East of Toowoomba)	NBN Skymuster Plus

While Nova was not specifically asked to compare to existing connectivity options, this has been done for completeness. Each user was also asked on their opinion of the Starlink service compared to their existing service at the end of each test period and is summarised in Annex 7.2

4.1. LOCATION 1: Booroobin (SW of Maleny, Sunshine Coast)

Description

This location is considered sub-tropical and is on acreage with substantial tree growth. The property is off-grid and surrounded by tall trees. While there is adequate clearance around the house for the solar panels to generate enough power, the sky clearance for the Starlink antenna was considered borderline.

A 270-degree panorama shot is shown in Figure 3. The garage roof provided additional height, however the Starlink App calculated that this antenna location still experienced 15% blockage due to some tall trees near the house.

Figure 3: Booroobin panorama with Starlink location

Weather

Booroobin was chosen as a higher rainfall area with the plan to test the Starlink service in rainy conditions. The Starlink performance was measured under the following conditions:

- Clear sky (27th, 28th and 30th of June)
- Full cloud cover (29th of June 2nd and 3rd of July)
- Light rain and fog (4th of July)

Performance

COMPARISON: Starlink was compared to the existing Telstra mobile 3G/4G Internet service.

Below are a range of manual speed tests captured on the Starlink service from the 27th of June to 4th July. Please note that these are only snapshots in time but provides a general picture of overall performance.

The speed tests demonstrate that Starlink performed significantly faster, averaging 145 Mbps download and 12 Mbps upload speeds. In comparison, Telstra mobile could only offer 5 Mbps download and 1.6 Mbps upload speeds. This is with an external antenna mounted on the roof to improve performance.

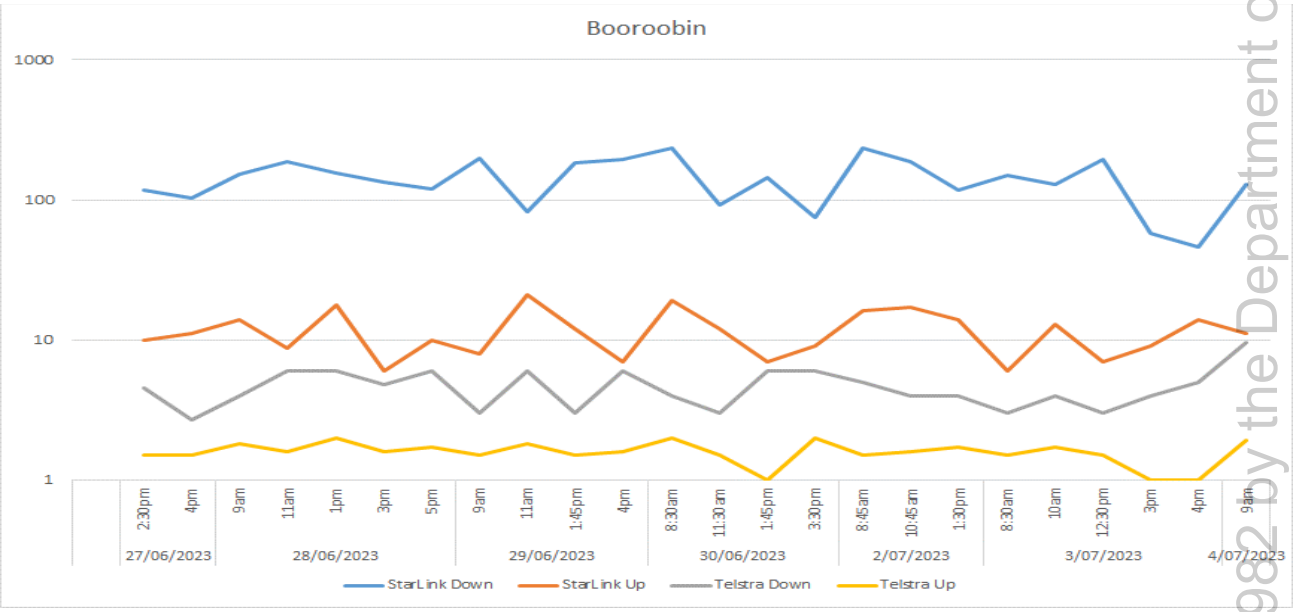


Figure 4: Booroobin speed tests – Starlink vs Telstra mobile

The user experience was acceptable in **clear weather** and **full cloud cover** even with the 15% blockage. It was noted that there were some intermittent short outages that may have been during satellite hand-over, with one satellite potentially being temporarily blocked by trees. These outages were relatively infrequent (~every half to one hour) and would last ~30 seconds until the next satellite was picked up.

It is important to note that cloud cover generally does not attenuate the signal greatly unless they contain a significant amount of moisture. It is the water content that causes the greatest attenuation effect.

4th July was a day of light to medium rain across the Sunshine Coast and hinterland area. It was a chance to capture more detailed measurements as rain cells moved across the region. Figure 5 shows a 10-minute window measuring the Starlink latency every 5 seconds. The measured average latency was 70 milliseconds.

The graph goes red when there is packet loss – e.g., when the satellite connection is temporarily lost. Figure 5 showed that service outages occurred regularly under rainy conditions, making the Starlink service in this location frustrating to use. The outage time generally varied between 10 to 30 seconds.

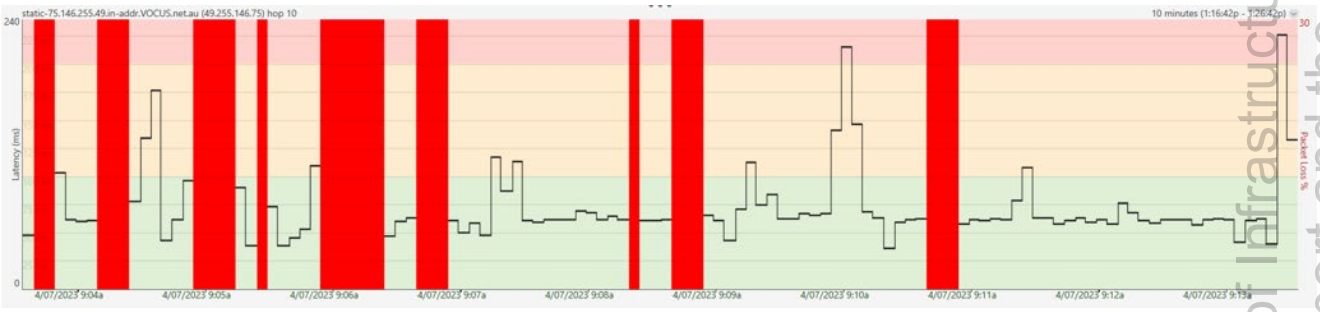


Figure 5: Booroobin Pingplotter – latency measurement during rain

It should be noted that the Booroobin location was already affected by the 15% blockage by trees. It is likely that the addition of rain attenuation exacerbated the number of outages. The user experienced intermittent Internet rather than totally losing Internet connectivity during rain.

Voice calls were not tested during the rain. Voice calls are more sensitive to outages compared to Internet so the user would have experienced continual drops and reconnections. The outage times represent 100% packet loss and were too significant to maintain a voice call. Our experience has previously shown that voice calls with the new codecs can only be maintained with up to 5 to 10% packet loss. The traditional voice codecs are even more sensitive and will fail even with 1 to 2% packet loss.

4.2. LOCATION 2: Kelvinhaugh (west of Toowoomba)

Description

This location is significantly drier, being dairy farmland to the west of Toowoomba. It is much more open acreage that provides full sky coverage for Starlink.

The Starlink antenna has been located on a flat section of roof to ensure there is no blockage by the house or any trees close to the house.

Figures 6 and 7 show the open topography of the farmland from both an eastern and western perspective.

The Starlink App confirmed that this location had an unobstructed view of the sky.

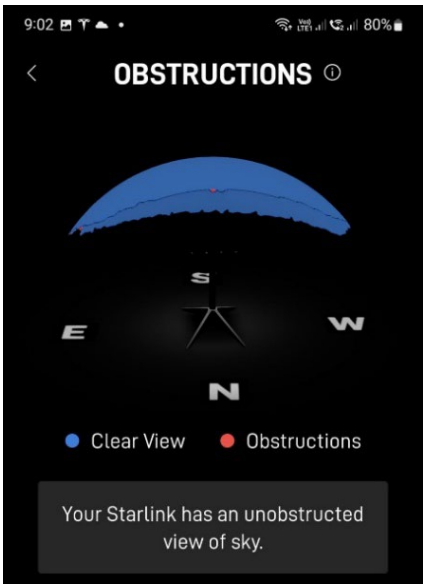


Figure 6: Kelvinhaugh 180 deg panorama – East Aspect

Figure 7: Kelvinhaugh 180 deg panorama – West Aspect

Weather

Kelvinhaugh was chosen as a low rainfall area that is typical of rural Australia. The Starlink performance was able to be measured under the following conditions:

- Clear sky (5th to 23rd July)
- Full cloud cover (24th July)

Performance

COMPARISON: Starlink is compared to the existing TPG wireless Internet service.

An automated speed test analyser was set up for Kelvinhaugh to take and record samples every 30 minutes for the Starlink service and the existing TPG wireless Internet service. The analyser reliably collected the TPG data (showing average speeds of 20/5 Mbps in Figure 8). In comparison, the Starlink data was unexpectedly very low (~1/0.3 Mbps) and didn't align with the good user experience.

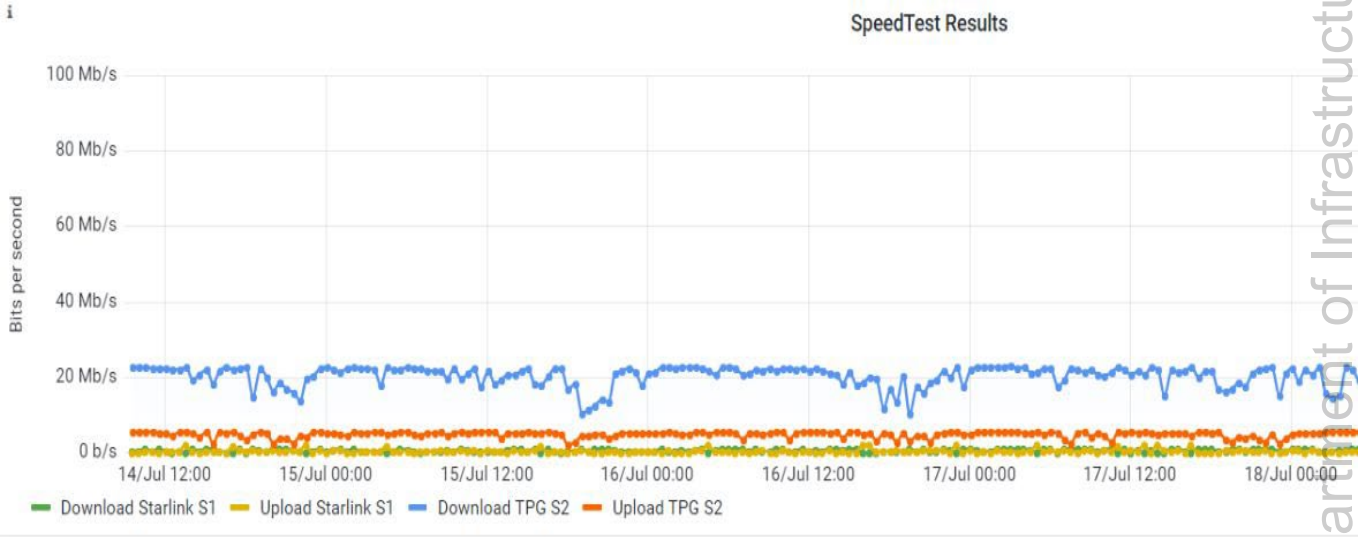


Figure 8: Kelvinhaugh Starlink and TPG wireless speeds

We believe that Starlink may be shaping the traffic to de-prioritise the external speed test and to minimise this type of traffic over the satellite. Similar slow speeds were noted at Location 3 using the external speed test analyser. In comparison, the Starlink App speed test and Ookla showed significantly higher throughput speeds that better aligned to the user experience. Unfortunately, both of these speed tests only allow for single point of time measurements and cannot be automated for long duration measurements.

While the external speed test analyser throughput may have been throttled, the latency measurements proved reliable. Figure 9 shows the Starlink latency measurements over four days. The average latency was 80 milliseconds, with a variation generally between 60 and 100 milliseconds.

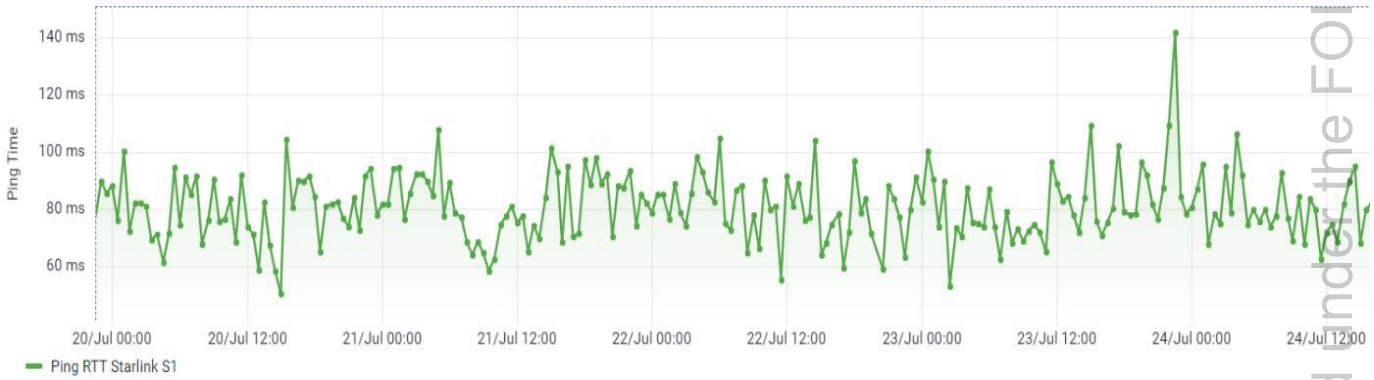
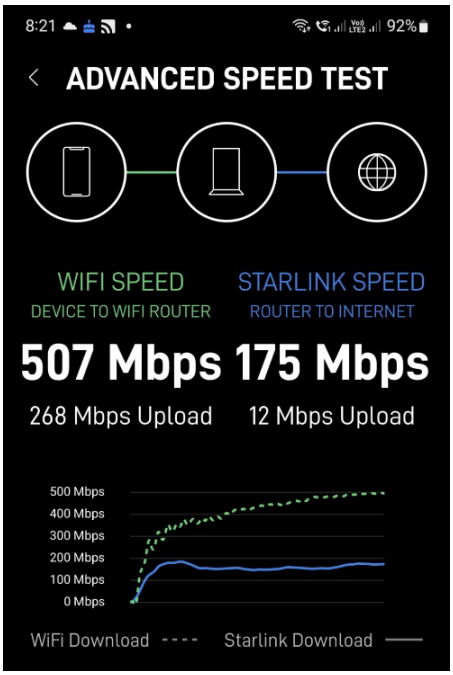


Figure 9: Kelvinhaugh Starlink latency measurement

The Starlink user experience was significantly better than what the external speed tests captured. In comparison, the Starlink App recorded speeds greater than 250 / 12 Mbps over the satellite service.

Please note that the Starlink App also captures the router Wi-Fi speeds. It is important that the Wi-Fi speeds are significantly greater than the external Internet speeds to ensure that the Wi-Fi isn't the cause of limiting the performance.

This speed test was captured on a completely overcast day, confirming that generally clouds do not significantly impact the satellite performance. Only high atmospheric moisture content will significantly attenuate satellite signals.



4.3. LOCATION 3: Flagstone Creek (East of Toowoomba)

Description

This location was chosen as an alternative near Toowoomba, and 50 km away from Location 2. Testing at Location 2 using conventional speed tests consistently showed a poor performance compared to the Starlink speed test on the App. Location 3 showed the same poor response for Starlink speed tests using conventional speed tests, hence strengthening the hypothesis that Starlink is purposely restricting this type of traffic from outside its network.

Location 3 is between Brisbane and Toowoomba, and in an area not yet covered by either NBN fixed line services or wireless.

NBN satellite is the only broadband Internet option available at this location.

The Starlink antenna has been located on a flat section of roof to ensure there is no blockage by any trees close to the house.

The Starlink App confirmed that this location had an acceptable unobstructed view of the sky.

Performance

COMPARISON: Starlink is compared to the existing NBN satellite Skymuster Plus Internet service via IPStar.

The Flagstone Creek site has been reliant on the NBN satellite (Skymuster Plus) service via the IPStar satellite. As can be seen in Figure 10, the NBN satellite service struggles at evening peak times between 6 pm and 10 pm. The service is significantly better outside of this peak window, achieving ~70 / 15 Mbps at most other times of the day.

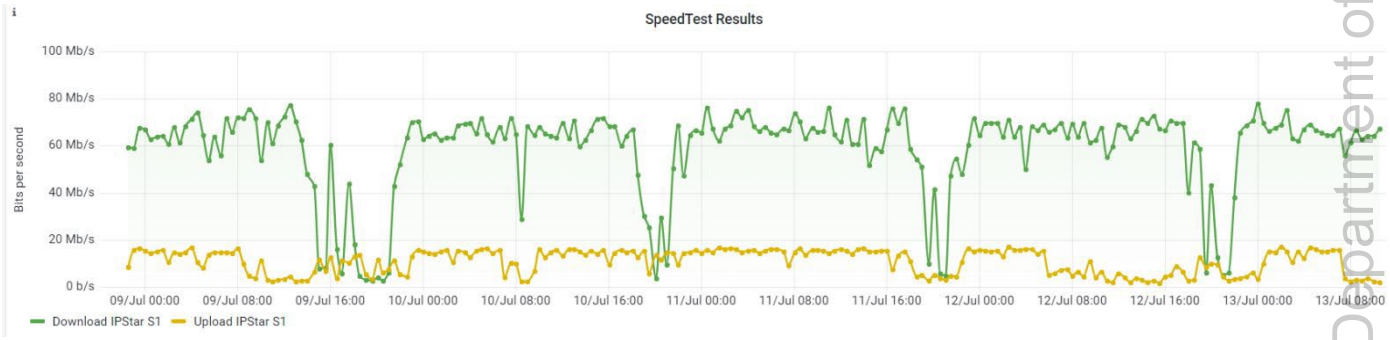


Figure 10: Flagstone Creek NBN satellite service (Skymuster Plus) performance

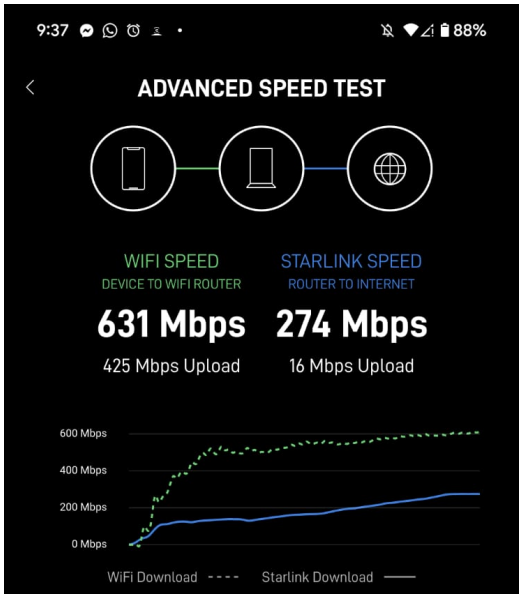
The Starlink speeds were not captured in Figure 10 as the same speed limiting issue with the automated speed tester was noted as in Location 2 (very low speeds around ~1/0.3 Mbps which didn't align with the good user experience).

The Starlink user experience was significantly better than the NBN Skymuster Plus service, especially in the evening peak time.

The Starlink App recorded speeds up to 425 / 16 Mbps over the satellite service, which was the highest speed recorded so far. It suggests that there are very few other Starlink users in the area, as this is close to the maximum speed available on a Starlink cell.

The Wi-Fi speeds are also captured to ensure that the Wi-Fi isn't the cause of limiting the speed to the end-user.

This speed test was captured on a fine, clear-sky day.



5. FUTURE LEO-Sat Services

This section covers satellite direct to the device (D2D) services that are in the test stages or early-stage release.

There are numerous big financial investments in play to offer satellite D2D. The primary driver is the potential market for customers in both developed and undeveloped regions that already use smart mobile devices as part of their everyday life (estimated to be ~1.5 billion users). Manufacturers like Qualcomm have started implementing the 3GPP Standard 17 into their latest chipsets, so new iPhone and Android mobile devices could become satellite compatible.

The technology has been successfully demonstrated; however, it is difficult to predict the winners and losers at this early stage. The best technical solution does not always determine the market winner. This comes down to marketing, timing the market and access to significant capital raising.

The expectation is that satellite D2D services will merge with terrestrial mobile carrier services, and the switching between satellite and terrestrial will eventually become seamless and invisible to the end-user.

We are at the very early technical development stages with D2D (equivalent to the brick mobile phone in the 1980's). The D2D proof of concept has been demonstrated for low data-rate communications (SMS and emergency communications) using today's satellites. Future higher data-rate D2D services will require satellites with higher sensitivity receivers, larger antenna arrays and potentially the creation of virtual higher-gain arrays by combining multiple LEO satellites to continually improve the data throughput.

The way users access the D2D services will require more thought. Today's satellite D2D services require the user to stand outside with an unobstructed view to the satellite. This is impractical as most phone use is either inside buildings, inside vehicles, or at least standing under a shady tree. None of these scenarios will work for D2D and interim repeaters may need to be considered for these scenarios.

Some of the initial product offerings are cumbersome as they require handset pointing to the satellite. It is expected that this is due to pushing the limits of the current satellite performance and that handset alignment to the satellite will improve connectivity. Handset pointing should become less important as the next generation satellites improve their sensitivity.

There are likely to be two important challenges to consider with each service:

1. Access reliability – what may block the signal, and
2. Battery consumption

Access Reliability - The lower L and S-bands are ideal frequencies for D2D services as the signals may penetrate through some objects (e.g., trees and some building materials). The signals from satellites are currently too weak to penetrate buildings but may work under trees. They will be less affected by rain compared to fixed broadband services at the higher frequency bands. However, the current satellite constellations are very narrowband, so will be limited to low bandwidth applications.

Battery Consumption – This is currently an unknown, but it is suspected that today's applications will result in higher battery usage. These services are pushing the satellite link budgets to the limit and will demand full power from the user device. The power demand should drop in future as the next generation satellite capabilities improve.

5.1. Apple Emergency SOS Service

As of May 2023, Apple is offering an emergency SMS service in Australia and New Zealand to iPhone 14 users. It requires the latest Qualcomm X65 chip design, hence limited to the latest iPhone releases.

This service uses Globalstar's satellite network and ground stations. Globalstar is another LEO satellite constellation, however it operates on the lower L and S-Bands (1-2 and 2-4 GHz respectively). The lower frequencies are more robust with regards to weather, however Globalstar are allocated relatively narrow frequency bands (16.5 MHz at S-band). This means they are restricted to low bandwidth applications.

Qualcomm and Globalstar have worked together to integrate Band 53 (2.4835 to 2.495 GHz) into the X65 modem, which Globalstar use for broadcast messaging. Band 53 is part of the 3GPP LTE spectrum and used for both uplink and downlink.

The Globalstar satellites operate as a 'bent pipe' with all protocol processing at the ground stations. Therefore, upgrading from the original 1990's 2G technology to 4G to support Apple SOS only required modifying the ground station infrastructure. Third-generation satellites were ordered in 2022 and 17 new satellites are due to be launched 2025.

The user still needs to be outside with clear view to the satellite position on the current second-generation satellites. The low antenna gain on the phone and low transmit power means that this service is currently restricted to low-speed data transfer. This should improve in future as Globalstar increase the sensitivity of their ground infrastructure and/or satellite fleet. Increasing sensitivity will improve the signal to noise ratio which in turn allows higher data throughputs. Apple is investing US$450 million to improve Globalstars' existing infrastructure.

Other phones may start to offer a similar service soon as the Qualcomm chipset is incorporated into new phone models.

5.2. Bullitt Satellite Messenger Service

The Bullitt satellite messenger service can either be accessed via an external dongle for existing IOS and Android smartphones, or recently has everything built into the Motorola Defy 2 phone.

The messenger service currently accesses the GEO Inmarsat satellites (L-band frequency) for SMS text-based services but is satellite agnostic and has the capability to also connect to LEO satellites. However, there are no existing L Band constellations to support this at the moment.

The Inmarsat satellites have the capability, through high transmit power and high antenna gain, to connect to small IoT devices from their GEO service, so it makes sense to run on this platform for text-based services. The high-power satellites also mean that the user does not have to aim their phone towards the satellite to get messages. The L-band frequency will be more resilient to poor weather and may penetrate light tree foliage.

Bullitt will struggle to offer higher speeds as the L-band GEO satellites have limited RF bandwidth and are too far away to get a strong enough signal to a low-gain, internal antenna in a smartphone. Inmarsat's higher data-rate services require a user terminal with a larger antenna that is pointed to the satellite (e.g., Inmarsat's BGAN terminals).

5.3. Snapdragon Messenger Service

Snapdragon Messenger Service is a satellite-based messaging service for Android phones that allows users to send and receive text messages even when they don't have cellular or Wi-Fi coverage. The service is powered by the Iridium satellite constellation, which provides global coverage (also on L-band frequencies). Unlike Apple SOS and Bullit which are both repurposing 3GPP mobile phone standards, Snapdragon devices will add an Iridium low data-rate modem developed by Qualcomm into the 5G modem.

Compared to the above Bullitt service on Inmarsat GEO satellites, the Iridium LEO satellite service offers 100% global coverage including polar coverage. Although Iridium satellites are much closer to earth in their LEO orbits, they are also smaller and less powerful than the Inmarsat satellites. Both satellite services are L-band and enjoy the benefits of this band, however the signal strength at the user handset dictates the end performance.

Unlike Apple, which supports satellite services only during emergencies, smartphones connected to the Bullitt and Snapdragon Satellite solutions will be able to exchange text messages with anyone, not just during emergencies. Emergency messaging is expected to be available in Q3/4 2023.

5.4. D2D using Terrestrial Mobile Spectrum

There is significant interest in the recent proposal for D2D using terrestrial Mobile Spectrum and unmodified 4G smartphones. Three proposals of most interest are AST SpaceMobile, Lynk Global and SpaceX.

AST SpaceMobile

AST SpaceMobile currently has one satellite in operation after previously launching two cubesats to test concepts. The current test satellite includes an 8m x 8m antenna to overcome higher altitude (~800 km) path loss, but also to provide a higher signal strength to the smartphone and smaller cell sizes (which increases system capacity). Initial demonstrations have been conducted using the 850 MHz band in Hawaii and claimed a peak download speed of 10 Mbps to a smartphone, however there was no mention of the upload speed.

Initial service will likely be contiguous coverage of equatorial countries with medium to high-speed data (+10 Mbps) and voice calls. Even with the system proposed with a smaller number of satellites (~188), AST SpaceMobile will likely require huge upfront funding to be able to offer initial and then global coverage due the size / weight of each satellite (~1500 kg).

Lynk Global

Lynk Global could be described as taking a lean startup approach, developing a minimum viable product to provided D2D services. Initially conducting tests on a hosted payload since 2019, Lynk Global currently operates four satellites with square antenna arrays of ~1-2 m.

Lynk Global has received an interim licence from the FCC to operate up to 10 satellites in the 614 - 960 MHz range. This reduces complexity of the satellites (antenna size ~1-2 m) at the expense of a larger cell size (500-700 km diameter). Initial services are likely to consist of text and low speed data on an intermittent basis due to the small number of satellites.

While increasing the number of satellites will improve service availability, the combination of sub 1 GHz band and relatively simple satellite design will limit the system capacity. It is unknown what Lynk Global's medium to long term strategy is, i.e., will they move towards larger antenna arrays and high data rates?

SpaceX

In August 2022, SpaceX, and T-Mobile (US) announced a partnership to provide cellular connectivity outside of the terrestrial mobile coverage area. SpaceX will provide the service as a hosted payload on future (larger) Starlink satellites, while T-Mobile will provide access to their existing 1900 MHz spectrum in the US as well as retail the service to consumers. The choice of using the 1900 MHz band is largely pragmatic, a trade off on a higher frequency (compared to other proposals) leading to a moderate increase in payload complexity, against availability of T-Mobile existing nationwide (US) licence for the 1900 MHz band and a small increase in system capacity.

Demonstrations of the service are expected to begin in Q4 2023, with initial services late 2024. Initial services are likely to consist of text and low speed data on an intermittent basis due to the small number of Starlink satellites that will carry the hosted payload. Availability will increase as the number of satellites with the hosted payload increase, but capability will remain limited.

Full system capability (higher speed data and voice) will only be possible once larger Starlink Gen 2 satellites are deployed, which requires a new launch vehicle to become operational.

Summary

While there are differences in orbital shell, frequency band, antenna size and the approaches of these D2D proposals using terrestrial spectrum, the end state if / when they become fully available will be roughly equivalent, and picking a winner or timeframes is highly problematic.

6. DITRDCA Questions

6.1. Evaluate the technical capabilities of existing LEO broadband services (at present Starlink consumer grade and Starlink enterprise grade, OneWeb) and of existing direct to device (D2D) capabilities (this could include but is not limited to Apple emergency satellite messaging service, Bullitt Satellite Messenger Service and Qualcomm snapdragon 8 series SoC) subject to commercial availability.

The performance expectations of Starlink, OneWeb and Kuiper are provided in Section 2.5. Kuiper has the potential to offer a higher performance service, however it is likely Starlink will be able to match by the time Kuiper launches.

OneWeb is primarily focussing on the corporate / government market. We expect the cost of the antenna terminal and service to be too expensive for the average consumer. The additional service offerings of SLA's, security and multi-site data bundling will only be of interest to the corporate / government market.

All services will be affected by rain. Kuiper, being Ka-band will experience higher rain attenuation than Starlink and OneWeb (Ku-band). However, it is the system design that determines how well the network can compensate for rain attenuation.

The smaller Starlink, Oneweb and Kuiper terminals will suffer more compared to the larger alternative terminals offered by each company. The additional antenna gain with the larger terminals provides a greater "link margin" to cope with rain attenuation (the Link margin is the additional gain in the system above the minimum required to maintain a reliable connection). It will be a "terminal price vs reliability" choice for LEO users.

Section 4 explored the D2D market for SMS, voice, and data direct to the handset. This is a fast-emerging market, and the satellite industry has demonstrated proof of concept and basic services using either test satellites, existing GEO satellites or existing LEO constellations.

The next generation satellites will be designed specifically for this market so there will be an expectation of significant performance improvement once these satellites are launched. The lower L- and S-band frequencies are ideal for this market, but the current bandwidth restrictions on the satellite bands at these frequencies will limit the amount of data throughput available for these services.

The potential sharing or combining of the frequency bands allocated to the satellite operators and mobile carriers around 1 - 2 GHz may help alleviate the shortage of satellite bandwidth, but then the sharing of these bands between mobile terrestrial and mobile satellite services will need to be managed to avoid interference. Either Satellite bands will need to be added to future phones (e.g., Globalstar or Iridium bands) or existing support bands will need to be re-used (e.g., Lynk, AST, and future SpaceX).

6.2. Provide a measurement of network availability under normal operating conditions for both broadband and existing D2D services. This could be first established through both bench and then through real-world testing.

Only the Starlink service is fully operational across Australia and is available for testing at the time of preparing this report. The OneWeb service is just coming online in the southern Australian states, but test equipment is not available.

The Starlink service proved to have high service availability under clear sky and cloudy conditions when it had unrestricted sky coverage. This was demonstrated at the two sites near Toowoomba.

Unrestricted sky coverage is a big expectation around Australian homes. It is not uncommon to have tall trees near a residence, whether to provide additional shade or privacy. The first location at Booroobin (near Maleny) demonstrated a location with limited sky coverage (15% blockage measured).

The location of the dish has a significant impact on the overall network availability. The Starlink App helps the user calculate sky coverage and encourages the user to find a location with minimal blockage. The Starlink dish aligns itself to best cover one of the LEO orbital planes. The optimal alignment is where there is minimal blockage at both horizons at each end of this orbital plane. It was observed at Location 1 that the dish tried different alignments over time. The dish eventually found an alignment that had no outages during the satellite hand-over period and was then able to provide a high availability service and good user experience.

The impact of slightly restricted sky coverage is expected to reduce as the density of the Starlink LEO constellation increases. There should be a greater choice of satellites for hand-over that are not at or near the horizon.

The D2D services today are limited in availability due to several restrictive requirements:

- The user must have a specific handset or dongle, and
- The user must be located outside with unlimited sky coverage, and
- The user must align the handset with the satellite in some cases.

D2D services should not be considered reliable until the next generation satellites are launched with 3GPP standards for mobile networks included. All tests to date are proof of concept on either test satellites or existing satellites. The concept has proven to be feasible, but there is not yet enough link margin (additional gain built into the link to the satellite for poorer weather conditions) to offer D2D as a reliable, commercial service. However, the availability and accessibility are expected to increase in 2024 as new satellites are launched with enhanced D2D capability.

Higher D2D data rates require stronger signal levels at the user device and enough capacity on the satellites to support a substantial number of users. Voice requires higher data rates than text messaging, and broadband data requires higher data rates than voice. The network availability and reliability for the lower data rate services will increase as high data rate services are brought online. There will be more than adequate link margin for reliable text messaging once voice is offered as a D2D service. Similarly, there will be more than adequate link margin for both reliable voice and text messaging once broadband data is offered as a D2D service.

6.3. Evaluate network availability during inclement weather, in particular the effect of rain and smoke fade conditions for both broadband and existing D2D services. Including a real-world assessment in the northernmost regions of Australia during the wet season (existing data can be used for this purpose if it exists)

Rain outages will occur at Ku and Ka-band frequencies. Figure 5 shows that the Location 1 user experienced numerous outages rather than just slower speeds. Unfortunately, there was no rain during the Toowoomba location tests, which would have provided measurements using Starlink terminals with unrestricted sky coverage (Toowoomba unfortunately missed this rain band).

Table 1 showed that rain attenuation losses increase at lower elevation angles. This is due to the signal travelling a further distance longitudinally through the rain cell. This also coincides with satellite handovers occurring at the time satellites are either disappearing into the horizon or rising above the horizon. Increasing the density of the Starlink LEO constellation should provide some improvement as there will be more hand-over choices rather than waiting until satellites are near the horizon.

The Starlink business-grade terminal is twice the aperture area of the consumer terminal. This will provide an additional 6 dB gain and extra resilience against rain attenuation. However high rainfall areas such as Darwin can experience ~8 dB attenuation at 30-degree elevation angles, so even the larger business-grade terminal may have reduced availability in high rainfall areas. It is recommended that users located in higher rainfall areas purchase the larger terminals.

The effects of smoke on satellite signals are complex and can vary based on the altitude of the smoke layer, the type and size of smoke particles, weather conditions, and the frequency bands used for communication. The smoke particles can absorb and scatter the electromagnetic waves, leading to weaker signals reaching the user ground terminal.

It is difficult and complex to determine which frequency band will be affected by smoke and fire. Even the fuel type being burnt will affect the particulate size and hence significantly attenuate some frequencies but not impact others. For this report, it should be noted that smoke *may* have a significant impact on LEO-Sat and D2D services.

In severe cases of smoke concentration, particularly during large-scale wildfires or industrial emissions, the attenuation can be significant enough to cause temporary or even permanent signal loss. This can result in interrupted or disrupted satellite communication services. Smoke particles can also deposit on the surface of satellite dish antennas, leading to potential signal blockages or interference with the reception and transmission of signals.

There is one paper[i] that studied the effect of RF propagation during the Australian 2019-2020 bushfires. It does not specifically look at eucalypt forest fires but shows the complexity of several effects, including particulate matter size and temperature inversions that can rapidly change and interact with each other.

D2D services at L-band are less likely to suffer from rain attenuation. However, there is not yet enough link margin (additional gain built into the link to the satellite) to compensate for poorer weather conditions.

D2D services are not yet robust enough to be relied on in large scale emergencies. They are not yet in a position to replace terrestrial mobile or fixed line telephony for universal service obligation services.

6.4. Provide reliable indications of key network performance metrics, such as latency and data throughput for LEO Broadband connections.

The latency is expected to vary depending on the satellite location and the distance to the satellite. The shortest distance and lowest latency are when the satellites are directly overhead. The longest distance and highest latency are when satellites are near the horizon.

The Starlink service can change satellite and / or ground station every minute or two. The network attempts to minimise the latency by selecting the closest satellite and ground station combination. A higher number of ground stations will help keep the satellite to ground station distance (and hence latency) to a minimum.

Each ground station will have multiple dishes to simultaneously track several satellites in the constellation. The ground station must also have a dish available to track the satellite of interest to be chosen as part of the satellite / ground station combination.

Network congestion is primarily caused by a fixed amount of RF bandwidth allocated per spot beam, the size of the spot beam and the number of users sharing the spot beam. The RF bandwidth allocation is controlled by international regulations, typically by the International Telecommunications Union and the respective Communications Authority in each country.

The ground stations can handle significantly more bandwidth than that allocated and generally do not contribute to network congestion. There are several ways to minimise congestion, including but not limited to smaller spot beams (less users sharing each spot beam) and higher signal levels at the user terminal to run at higher modulation.

Australia currently has ~22 Starlink ground stations around the country. It is difficult to determine how many tracking dishes each site has. Google Earth has shown that some sites have up to 9 tracking dishes. Increasing the number of ground stations, their locations and the number of tracking dishes is not a constraint on capacity at this time. Additional tracking dishes may be required as the constellation sizes increase. However, this requirement may be negated by the take up of inter-satellite links.

Location 1 (Figure 5) and location 2 (Figure 9) measured the average latency around 70 milliseconds and 80 milliseconds respectively. As a comparison, the latency from Brisbane to Sydney is around 30 milliseconds. International Internet traffic generally traverses through Sydney (assuming non-peer to peer traffic), so the slightly slower experience through Starlink would be practically unnoticeable.

The LEO latency is a significant improvement to GEO satellite communications, where the latency is around 600 milliseconds.

Starlink are currently providing a superior service with regards to data throughput compared to the existing solutions at each site. A comparison of the data throughput of each service is shown in Table 2 below.

Table 2 shows that Starlink's average data throughput is more than double the average throughput of the next nearest service, however it is the most expensive service to purchase. Starlink's service latency is comparable to the alternative terrestrial services.

Service	Downlink speed	Uplink speed	Latency	Pricing
Starlink	145 Mbps	12 Mbps	70 – 80 msecs	$139 / month
Telstra mobile	5 Mbps	1.6 Mbps	Not measured	$65 / month
TPG wireless **(NBN25 Unlimited)**	20 Mbps	5 Mbps	65 msecs	$70 / month
NBN satellite **(SkyMuster Plus)**	70 Mbps	15 Mbps	600 msecs	$100 / month

Table 2: Internet service comparison (average data throughput and latency shown)

6.5. Evaluate LEO broadband connectivity options to determine if they can support a voice over IP (VoIP) solution and the quality of that solution compared to existing voice solutions such as copper analog voice, ADSL VoIP, and fiber VoIP.

The Starlink LEO broadband service is capable of supporting VoIP services. It is an expectation that all LEO broadband services will have ample data throughput as well as low latency to enhance the user VoIP experience.

VoIP has been running over GEO satellites for two decades. The longer latency is only problematic in that users have to adjust for the satellite delay. The call latency is no longer an issue with the LEO satellites.

Tests were run over Starlink using Telstra Wi-Fi calling as well as VoIP Over-the-top (OTT) Apps (Skype, WhatsApp, and Bria). Tests are qualitative based on user experience and were all acceptable with regards to latency and call quality.

The VoIP OTT Apps utilise either proprietary or the Opus codecs that have forward error correction built in. These codecs are designed for mobile and wireless scenarios where the connection quality is continually changing as the user moves around. This is important as the basic Starlink consumer service only offers connectivity via Wi-Fi. The user is therefore likely to move about the house while connected to a VoIP call.

The voice quality is a combination of the Starlink satellite service and the local Wi-Fi connection in the house. The Bria App used a 48 kHz Opus codec (high-fidelity quality) and can achieve a high MOS score of 4.5 if the wireless connection within the home is strong.

There was no noticeable interruption during the frequent LEO satellite handovers, which would have occurred multiple times during each test call. It is likely that codecs like Opus would have corrected for any intermittent packet loss with its forward error correction capability. Hence the user would not have detected any lost or corrupted voice packets.

VoiP calls are very susceptible to poor Internet quality. From experience, the latest voice codecs are able to adapt up to 5-10% in corrupt or lost Internet packets such that the user would not detect any degradation of service. 5% corruption means 1 packet in 20 is damaged or lost.

The signal losses experienced at Location 1 during rain show outages lasting up to 30 seconds (equivalent to several hundred adjacent packets lost). This would cause a VoIP call outage.

6.6. Identify the impact on network performance from improper LEO broadband terminal installation and set-up.

Improper installation and setup of LEO broadband terminals can have several negative impacts on network performance. The correct installation of the satellite dish is crucial for optimal performance. LEO terminals have either self-alignment and / or electronic tracking.

Some potential impacts of improper LEO terminal installation and setup include:

- **Signal Quality and Strength:** Improper alignment of the satellite dish can lead to a weaker or unstable signal. LEO systems rely on clear line-of-sight to communicate with the satellites, and any obstructions or misalignment can result in signal degradation or intermittent connectivity.

- **Latency and Packet Loss:** Incorrect installation may cause higher latency and packet loss, affecting the overall internet experience. Both issues can negatively impact real-time applications like video conferencing, online gaming, and voice calls.
- **Reduced Throughput:** Improper installation can lead to reduced data throughput, limiting the speed at which data can be transmitted and received. This could result in slower internet speeds and poor performance for data-intensive activities like streaming high-definition videos or downloading large files.
- **Intermittent Connectivity:** An improperly installed LEO terminal may experience frequent drops in connectivity due to poor signal reception or alignment issues. This could lead to a frustrating user experience with internet services becoming unavailable or unreliable.
- **Need for Repositioning:** If the satellite dish is installed incorrectly, it may require repositioning or adjustments to improve performance. This was a requirement in Location 1 which took multiple attempts to find a position that minimised blockages. This can be time-consuming and may require assistance from a trained technician, leading to delays in achieving proper connectivity.

To mitigate these issues, SpaceX provides installation guidelines and instructions to users when they receive their Starlink kits. Users are encouraged to carefully follow these guidelines and use the Starlink app to assist in aligning the satellite dish correctly.

Additionally, SpaceX may offer support and troubleshooting assistance to users facing installation challenges. It's essential for users to take the installation process seriously and seek assistance if needed to ensure the best possible network performance from their Starlink broadband terminals. Starlink has very limited support available for the consumer service.

6.7. A consideration of any other factors that may be relevant to the potential of LEO services to provide connectivity solutions that may improve regional communications.

Beyond proper installation, there are several other factors that contribute to the potential of LEO services to improve regional communications and provide effective connectivity solutions:

- **Scalability:** The new LEO-Sat constellations are scalable by design. As the demand for connectivity increases in a specific region, more satellites can be added to the constellation to enhance coverage and capacity. This scalability allows LEO services to adapt to changing communication needs in different regions.
- **Flexibility:** LEO satellites can be dynamically repositioned and reconfigured to optimize coverage for specific areas or regions. This flexibility enables targeted communication solutions, allowing LEO services to focus on underserved regions or respond to disasters and emergencies where conventional infrastructure might be unavailable or damaged.
- **High Data Throughput:** The large number of LEO satellites in a constellation can result in higher aggregate data throughput compared to a single GEO satellite. This capability supports data-intensive applications and services, improving the overall user experience in regions with increased demand for data connectivity.

- **Interoperability with Terrestrial Networks:** LEO services can integrate with existing terrestrial networks, including 5G infrastructure, to create hybrid communication solutions. This integration enhances connectivity and can extend coverage to remote areas while also supporting seamless handover between satellite and terrestrial networks.
- **Space for Innovation:** The development of LEO services has attracted large investments from various technology companies and startups. The competitive nature of this sector fosters innovation in satellite design, communication protocols, and ground infrastructure, potentially leading to further advancements in regional connectivity solutions. As an example, the work on autonomous vehicles has been limited to city areas with good mobile network coverage. LEO services could soon be able to extend this into regional areas.
- **Environmental Sustainability:** Some LEO satellite providers have expressed a commitment to mitigating space debris and ensuring sustainable operations. This dedication to responsible space practices aligns with broader environmental goals and regulations. However, with an ever-increasing number of satellites entering orbit, there is a greater chance of collision risks and space debris. If a significant collision occurs, it can create a cloud of smaller debris fragments, triggering a chain reaction of collisions. This scenario, known as the Kessler Syndrome, could exponentially increase the amount of space junk and make certain orbits unusable for future missions.

Overall, the combination of these factors positions LEO services as a promising solution for improving regional communications and addressing connectivity challenges around the world.

7. Annexes

7.1. Terms and Abbreviations

Abbreviation	Definition
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D2D	Direct to Device
FCC	Federal Communications Commission
GEO	Geostationary Earth Orbit
GHz	Gigahertz
IoT	Information of Things
ISP	Internet Service Provider
IT	Information Technology
Ku-band	12 GHz to 18 GHz
K-band	18 GHz to 27 GHz
Ka-Band	27 GHz to 40 GHz
L-Band	1 GHz to 2 GHz
LEO	Low Earth Orbit
LEO-Sat	Low Earth Orbit communications Satellite
Mbps	Mega Bits Per Second
MHz	Megahertz
MOS	Mean Opinion Score (measure of voice quality 1.0 to 5.0)
OTT	Over The Top
PSK	Phase-Shift Keying
SMS	Short Messaging Service
VoIP	Voice over Internet Protocol

7.2. User Feedback

At the end of testing at each location, the landowner was asked whether they would consider purchasing the Starlink equipment and could they justify the additional on-going Starlink Internet service fees based on their experience.

All three landowners enjoyed the testing but could not justify the additional on-going service expense. There is an expectation in Australia that reliable broadband Internet should be available for no more than $100 per month. The upfront equipment pricing was considered reasonable.

While it is acknowledged this is a very small sample, this finding came from people of different backgrounds, including a retired IT professional, a younger family working in the medical field and a bookkeeper.

It is an interesting response as each landowner was unhappy with their existing service, either being always too slow (Telstra mobile and NBN fixed wireless), or unreliably slow during peak evening movie streaming times (NBN satellite).

7.3. Power Usage

The maximum power draw of the standard Starlink antenna was measured on a car 12V / 240V inverter. The peak value of 71 Watts aligns with that published in the Starlink literature, being "…the standard Starlink hardware uses 50 – 75 Watts on average. This includes the antenna, Wi-Fi router, power supply and cables…".

Figure 11: Maximum Starlink power draw (in Watts)

7.4. LEO-SAT and D2D Service Summary

Company	System	Service Type	Service Description	Technology	Spectrum	Satellite System	Orbit	Altitude (km)	Availability
LEO-SAT Fixed Broadband Internet Services									
SpaceX	Starlink	Fixed	Consumer Broadband Internet	Proprietary	Ka	StarLink	LEO	560	2021
Amazon	Kuiper	Fixed	Consumer Broadband Internet	Proprietary	Ku	New	LEO	600	2026+
OneWeb		Fixed	Commercial backhaul	Proprietary	Ka	OneWeb	LEO	1200	Q4 2023
Telesat	LightSpeed	Fixed	Commercial backhaul	Proprietary	Ka(?)	New	LEO	1000	TBD
Direct 2 Device (D2D) Services									
Apple	SOS Emergency	Mobile	Emergency text messaging	Modified 4G	L/S Band	GlobalStar	LEO	1400	2023 (Limited)
Bullit	Bullit Messenger	Mobile	Text Messaging	4G NB-IoT	1600 MHz mobile/satellite	Inmarsat	GEO	36500	2023 (Limited)
Lynk Global		Mobile	Text Messaging / limited Voice	Modified 4G	Sub 1 GHz mobile terrestrial	New	LEO	560	2023 (Limited)
Qualcomm	Snapdragon	Mobile	Text Messaging	Proprietary	1800 MHz mobile/satellite	Iridium	LEO	780	2024+
SpaceX	TBD	Mobile	Text Messaging / limited Voice	Modified 4G	1900 MHz mobile terrestrial	Starlink	LEO	560	2025+
AST	SpaceMobile	Mobile	Basic Voice / limited data	Modified 4G	Sub 1 GHz mobile terrestrial	New	LEO	800	TBD

8. References

[i] Wildfire Smoke Particulate Matter Concentration Measurements Using Radio Links From Cellular Communication Networks - Guyot - 2021 - AGU Advances - Wiley Online Library