Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-enabled Connectivity

Final Report

by Connected Farms Pty Ltd

March 2026

AgriFutures®
National Challenges and Opportunities

Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-enabled Connectivity

by Connected Farms Pty. Ltd.

March 2026

AgriFutures Australia publication no. 26-019
AgriFutures Australia project no. PRO-020848

ISBN 978-1-76053-619-0
ISSN 1440-6845

Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-enabled Connectivity
Publication no. 26-019
Project no. PRO-020848

Author contact details

Susan Maddalena
Connected Farms Pty. Ltd.

1800 497 148
solutionsau@connectedfarms.co

AgriFutures Australia contact details

Building 007, Tooma Way
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2650

02 6923 6900
info@agrifutures.com.au
www.agrifutures.com.au

In submitting this report, the author has agreed to AgriFutures Australia publishing this material in its edited form.

AgriFutures Australia is the trading name for Rural Industries Research and Development Corporation (RIRDC), a statutory authority of the Australian Government established by the *Primary Industries Research and Development Act 1989*.

Research investments made or managed by AgriFutures Australia, and publications and communication materials pertaining to those investments, are funded by industry levy payers and/or the Australian Government.

About the author

Connected Farms is dedicated to providing farms with dependable connectivity solutions, enabling farmers with the ability to make phones calls out in their paddocks and using data in their sheds through to a fully connected farm fence-to-fence to enable precision agriculture technologies, ag-robotics and full automation.

Connected Farms is a licensed telecommunications carrier and a specialist in agricultural connectivity, pioneering global deployment of LEOSat internet in farm operations. Our team combines telecommunications engineering proficiency (including satellite communications, networking, and cybersecurity) with intimate knowledge of agriculture and competency in agriculture project delivery.

Acknowledgements

AgriFutures Australia acknowledges the First Nations people of Australia as the traditional custodians of the lands and waters on which we live, learn and work. We pay our respects to past, present and future Elders of these nations. In particular, we acknowledge the Wiradjuri people of Australia, the traditional custodians of the lands and waters where AgriFutures' head office is located.

This section should detail all funding sources (including AgriFutures Australia) as well as any collaborators etc.

Abbreviations

ABC = Australian Broadcasting Corporation

ACCC = Australian Competition and Consumer Commission

ACMA = Australian Communications and Media Authority

ADII = Australian Digital Inclusion Index

BYOD = Bring Your Own Device

CAPEX = Capital Expenditure

DTH = Direct to Handset

GEO = Geostationary Earth Orbit

GSMA = Global System for Mobile Communications Association

HAPS = High Altitude Platform Systems

ICT = Information and Communications Technology

IMT = International Mobile Telecommunications

IP = Internet Protocol

IoT = Internet of Things

LAN = Local Area Network

LEO = Low Earth Orbit

LEOSat = Low Earth Orbit Satellite

LPWAN = Low-Power Wide Area Network

LTE = Long Term Evolution

MEO = Medium Earth Orbit

MFA = Multi-factor Authentication

MNO = Mobile Network Operator

MSS = Mobile Satellite Service

Nat = Network Address Translation

NB = Narrowband

NBN = National Broadband Network

NTN = Non-Terrestrial Network

OEM = Original Equipment Manufacturer

OT = Operational Technology

RF = Radio Frequency

ROI = Return on Investment

RSP = Retail Service Provider

RTK = Real-Time Kinematic (GNSS correction method)

RTT = Round Trip Time

SD = Secure Digital

SLA = Service Level Agreement

SSL = Secure Sockets Layer

UOMO = Universal Outdoor Mobile Obligation

USO = Universal Service Obligation

VPN = Virtual Private Network

WAN = Wide Area Network

Contents

About the author iv

Acknowledgements iv

Abbreviations iv

Executive summary vii

Introduction 1

Implications for industry 5

Recommendations 40

Addendum 44

References 46

Executive summary

Reliable digital connectivity has become essential infrastructure for modern Australian agriculture. Farm businesses increasingly depend on connected technologies for precision agriculture, automation, environmental monitoring, logistics and worker safety. However, persistent connectivity gaps across regional, rural and remote Australia continue to constrain the adoption of these technologies. Large areas of farmland remain affected by mobile blackspots, unstable broadband and limited coverage across entire properties, creating safety risks and limiting productivity improvements from digital farming systems.

This project, commissioned by AgriFutures Australia and delivered by Connected Farms, examined how next-generation satellite technologies—particularly Low Earth Orbit satellite broadband (LEOSat) and emerging direct-to-handset (DTH) services—could help close these connectivity gaps. The research assessed the technical capabilities of these technologies, their suitability for different agricultural uses, barriers to adoption, and the policy and investment settings required to support reliable on-farm connectivity.

The study combined technical analysis with stakeholder consultation across farmers, agricultural researchers, telecommunications providers, equipment manufacturers and government stakeholders. These consultations explored current connectivity constraints, the real-world performance of emerging LEOSat services, and the opportunities and risks associated with their adoption.

Key findings

Connectivity is now a core production input.

Stakeholders consistently reported that reliable connectivity is fundamental to modern farm operations. Autonomous machinery, remote livestock monitoring, precision application of inputs, cloud-based farm management systems and digital supply chains all rely on continuous data connectivity. Without reliable connectivity across entire properties, many of these technologies cannot operate effectively.

Significant connectivity gaps remain across agricultural landscapes.

Despite ongoing investment in terrestrial telecommunications networks, many farms continue to experience extensive coverage gaps, unreliable data performance and limited telecommunications service options. These constraints reduce operational efficiency, limit remote equipment diagnostics and restrict the use of advanced digital tools.

LEOSat broadband is rapidly transforming rural connectivity.

The commercial maturation of LEOSat constellations has introduced a new connectivity option capable of delivering high-speed broadband with latency comparable to terrestrial networks. Fixed, mobile and portable LEOSat terminals can support farm office connectivity, provide internet access across paddocks and machinery, and enable temporary connectivity at remote work sites.

LEOSat technologies complement terrestrial networks rather than replacing them.

The research indicates that the most effective connectivity models for agriculture combine multiple technologies. Hybrid architectures—integrating terrestrial mobile networks, on-farm wireless systems and LEOSat connectivity—provide greater resilience, redundancy and coverage than any single solution.

DTH satellite services provide an important safety layer.

Emerging DTH technologies allow standard smartphones to connect directly to satellites for emergency messaging and basic communication where terrestrial coverage is unavailable. While these services are not suitable for broadband data applications, they provide significant safety benefits for farmers and workers operating in remote areas.

Adoption barriers extend beyond availability.

Digital capability gaps, uncertainty about integration of technologies, lifecycle costs and limited independent connectivity planning advice all influence the adoption of advanced connectivity systems – including LEOSat-enabled connectivity – on farms.

Implications for industry

The rapid development of LEOSat and DTH technologies is reshaping the connectivity landscape for agriculture. These technologies can significantly improve connectivity in areas where terrestrial networks are limited, enabling greater adoption of digital agriculture technologies and improving safety for workers operating in remote environments.

However, reliance on a small number of satellite providers, as well as technical constraints such as power requirements, clear-sky visibility and shared network capacity, highlight the importance of maintaining hybrid models and encouraging competitive, resilient telecommunications markets.

Recommendations

The project identifies several priorities to support effective adoption of next-generation connectivity technologies in Australian agriculture:

- Improve spectrum access pathways for regional and agricultural use.
- Encourage interoperability and multi-provider resilience.
- Promote adoption of LEOSat-enabled connectivity in agriculture.
- Strengthen sovereignty and security in LEOSat-enabled agricultural connectivity.
- Recognise LEOSat-enabled connectivity as enabling infrastructure for digital agriculture.
- Promote hybrid connectivity architectures to improve resilience and redundancy.
- Ensure telecommunications policy frameworks remain responsive to satellite-enabled connectivity.

Relevance to the Universal Outdoor Mobile Obligation (UOMO)

The timing of this report coincides with increasing national policy attention on the concept of a Universal Outdoor Mobile Obligation (UOMO) – a proposal aimed at ensuring baseline mobile connectivity across Australia's landmass. The findings of this project are highly relevant to that policy debate. They demonstrate that emerging satellite technologies, particularly DTH services and LEOSat-enabled hybrid networks, could play a critical role in delivering universal outdoor coverage in remote agricultural regions where terrestrial infrastructure alone is unlikely to be economically viable.

As policymakers consider how UOMO might be implemented, the evidence presented in this report highlights the importance of technology-neutral policy frameworks that integrate terrestrial and satellite connectivity solutions. Ensuring that agricultural users benefit from these developments will be essential to closing the rural digital divide and enabling a more productive, safe and connected future for Australian agriculture.

Introduction

Reliable, high-performance digital connectivity is now foundational infrastructure for modern Australian agriculture. What was once considered a communications convenience has become a core production input, underpinning automation, precision agriculture, safety systems, traceability, logistics, environmental monitoring and farm business management. Yet persistent connectivity gaps across regional, rural and remote Australia continue to constrain productivity, innovation and resilience in the agricultural sector.[1]

Despite substantial public and private investment in terrestrial mobile and fixed broadband networks, coverage and service quality remain uneven across agricultural landscapes. Large areas of farmland lack signal quality sufficient to support autonomous machinery, real-time data exchange or reliable cloud-based systems.[2] These gaps create structural barriers to the adoption of digital agriculture technologies, limit research capability and constrain the sector's ability to meet national productivity ambitions.

Low Earth Orbit satellite (LEOSat) and emerging direct-to-handset (DTH) technologies are reshaping the connectivity landscape. Commercial services such as Starlink have demonstrated that high-speed broadband can be rapidly deployed in areas historically underserved by terrestrial networks. At the same time, satellite-to-mobile services promise baseline safety and messaging capability in remote regions. These next-generation satellite technologies present both transformational opportunity and strategic risk for Australian agriculture.[3]

This project — Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity (PRO-020848) — was commissioned by AgriFutures Australia to provide an evidence-based assessment of how LEOSat and DTH technologies can close connectivity gaps in agriculture, identify adoption barriers and risks, and recommend policy and investment settings to ensure reliable, equitable on-farm connectivity.[4]

The project was structured around three core objectives:[5]

- Define agricultural connectivity needs and LEOSat opportunities — clearly articulate what Australian farmers and agribusinesses require in terms of coverage, speed, reliability and security, and identify use cases where LEOSat/DTH technologies can unlock new productivity gains.

- Assess barriers, risks and readiness for adoption — examine digital capability, service limitations, market structure risks and resilience concerns associated with increased reliance on satellite-enabled connectivity.

- Recommend policy and investment settings — develop strategic recommendations to ensure telecommunications regulation, spectrum management, co-investment programs and farmer capability initiatives translate technological innovation into practical on-farm outcomes.

---

[1] Connected Farms 2026, Milestone 4 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity, February 2026.
[2] Connected Farms 2026, Stakeholder Group Interview Design and Plans, PRO-020848 working document.
[3] Ibid., 1
[4] Connected Farms 2026, Next Generation Connectivity for Australian Agriculture: Project Overview Presentation, PRO-020848.
[5] AgriFutures Australia & Connected Farms 2025, Research Agreement – PRO-020848 – Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity.

Why this project is a priority

The urgency of this work is shaped by three intersecting national challenges: productivity and competitiveness; resilience and risk; and policy alignment and strategic sovereignty.

1. Productivity and competitiveness

Australian agriculture is increasingly data intensive. Precision application of inputs, autonomous machinery, remote livestock monitoring, digital supply chain integration and climate adaptation strategies all depend on consistent, reliable broadband. Connectivity limitations directly restrict the scalability of these technologies, reducing potential yield gains, increasing input waste and limiting labour productivity.

Industry ambitions to grow agricultural output depend on widespread adoption of digital systems. However, without reliable connectivity, many farms remain structurally excluded from advanced technologies. The Australian Digital Inclusion Index consistently demonstrates that regional Australians experience lower levels of digital inclusion compared with metropolitan populations.[6] Connectivity inequity therefore translates into productivity inequity.

2. Resilience and risk

Connectivity has become integral not only to production but also to safety and disaster response. Floods, bushfires and extreme weather events highlight the need for redundant, resilient communications systems.

While LEOSat services offer rapid deployment advantages, stakeholder consultations undertaken as part of this project revealed significant concern about over-reliance on a small number of foreign-owned satellite providers, weather-related service degradation, power dependency and cascading failures where terrestrial towers rely on satellite backhaul.[7]

The 2024 Regional Telecommunications Review highlights continuing gaps in service quality, resilience and digital capability across regional, rural and remote Australia, and calls for improved connectivity literacy, stronger infrastructure resilience and clearer national strategy for regional telecommunications.[8] As satellite services become embedded within agricultural production systems, resilience and redundancy are no longer optional technical considerations — they are structural risk management issues.

3. Policy alignment and strategic sovereignty

Australian telecommunications policy has historically centred on terrestrial coverage expansion through programs such as the Mobile Black Spot Program and the Regional Connectivity Program.[9] However, the rapid evolution of satellite capability challenges existing regulatory, spectrum and investment frameworks.

---

[6] Thomas, J, Barraket, J, Wilson, CK, Holcombe-James, I, Kennedy, J, Rennie, E, Ewing, S & MacDonald, T 2023, Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2023, RMIT University and Swinburne University of Technology, Melbourne

[7] Ibid. 1

[8] Regional Telecommunications Independent Review Committee (RTIRC) 2024, 2024 Regional Telecommunications Review Report, Australian Government, Canberra.

[9] Australian Government 2023, Regional Connectivity Program and Mobile Black Spot Program information, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Canberra.

Stakeholder consultations identified misalignment between agricultural connectivity realities and current policy mechanisms, including spectrum access constraints, program eligibility limitations and fragmented digital capability support.[10]

As satellite-enabled connectivity becomes more deeply integrated into agricultural operations, questions of competition, sovereign capability, service guarantees and long-term national interest become increasingly material.

The knowledge gap

Although LEOSat adoption has accelerated rapidly in rural Australia, there has been limited sector-specific evaluation of:

- The precise connectivity requirements of diverse agricultural systems
- The technical performance of LEOSat and DTH under real farm operating conditions
- Adoption barriers beyond availability (such as digital literacy, integration capability and lifecycle costs)
- Risks of monopoly provision or insufficient multi-orbit redundancy
- Appropriate regulatory, spectrum and investment responses tailored specifically to agriculture

LEOSat is often framed as either a universal solution or a wholesale replacement for terrestrial infrastructure. This project provides a grounded, stakeholder-informed analysis of where satellite-enabled connectivity genuinely adds value, where it remains constrained and how hybrid architectures can best serve the agricultural sector.[11]

Key issues addressed

Drawing on structured stakeholder engagement across producers, researchers, telecommunications providers, government bodies and industry representatives,[2] the project identifies several cross-cutting issues:

- Connectivity as core production infrastructure rather than lifestyle amenity.
- The need for redundancy and hybrid network architectures (terrestrial + LEO + GEO + MEO).
- Digital capability and integration gaps limiting effective adoption.
- Market structure and sovereignty risks in a rapidly evolving satellite sector.
- DTH safety potential and regulatory clarity requirements.
- Affordability, lifecycle costs and technology obsolescence.
- Alignment of telecommunications policy with agricultural productivity objectives.

---

[10] Ibid. 2
[11] Ibid. 1

By systematically evaluating these issues, the project equips AgriFutures Australia and policymakers with an evidence-based roadmap to bridge the rural digital divide and accelerate safe, resilient and productive connectivity across Australian agriculture.[12]

Ultimately, next-generation satellite technologies are not simply telecommunications innovations. They represent a structural shift in how agricultural communications infrastructure can be delivered. The central question addressed by this report is not whether LEOSat-enabled connectivity will play a role in Australian agriculture — it already does — but how that role can be shaped to maximise productivity, resilience, equity and long-term national benefit.

[12] Ibid. 1

Implications for industry

Ag-sector connectivity baseline

The ag-sector connectivity landscape is defined by the connectivity challenges and pain-points experienced by farmers and the availability, capabilities and limitations of connectivity solutions, including LEOSat-enabled solutions, that may be employed to address them. The degree of adoption of connectivity solutions results in the current ag-sector connectivity experience.

Connectivity challenges and pain-points

Farmers interviewed and surveyed by Connected Farms[13] describe that they operate in challenging digital environments marked by mobile blackspots, poor coverage, and network instability, as expressed in the farmer survey response:

> *"What do you most want to do with connectivity on-farm that you cannot do now?"*
>
> *"To have phone and internet service over all farm so we can take advantage of latest technology. [Lack of connectivity is] also a safety concern that we have no service on most of farm in emergency."*

These conditions inhibit safety, slow operations, and prevent effective use of digital agriculture tools. A synthesis of:

- survey responses from the farmers participating in Connected Farms's Grain Automate project,
- interview transcripts with those participating farmers, and
- relevant Connected Farms's customer insights and market intelligence and literature

describing rural connectivity challenges, collectively present a consistent picture of substantial pre-connectivity barriers across agriculture.

The following consistent connectivity challenges were evident when considering insights from those three sources of information stated above:

- Large-scale mobile blackspots across entire farms.
- High safety risk due to inability to call for help in emergencies.
- Inability to use digital machinery and precision-ag features in real time.
- No functional remote support or remote diagnostics for machinery faults.
- Inefficient logistics coordination during spraying and harvest.
- Delayed or impossible data transfer, resulting in stranded data on machines.

[13] Connected Farms 2026, Milestone 2 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity, December 2025.

- Network instability and dropouts, especially during peak seasons.
- Structural rural telco limitations — insufficient towers, weak signal strength, unreliable data performance.
- Compounded connectivity issues due to network transitions (e.g., 3G shutdown).

These challenges are systemic, long-standing and widely experienced across agriculture, particularly broadacre agriculture.

Gaps in rural-urban connectivity equity affecting availability of connectivity

A review of the 2025 Australian Digital Inclusion Index (ADII) and the 2024 Regional Telecommunications Review (RTIRC) portray a connectivity landscape in agriculture which is inequitable, fraught with challenges and inhibiting agriculture's capacity for consistent modernisation, regardless of location[14].

Considering the ADII and RTIRC together, the main rural–urban connectivity equity gaps can be summarised as:

Access and infrastructure quality

- Digital inclusion is consistently higher in capital cities than elsewhere, with regional and remote areas scoring lower on Access and overall inclusion.
- Regional and remote connectivity is often slower, more expensive, less reliable and with fewer providers, according to ADII case study evidence.
- The RTIRC confirms that smaller and more remote communities still struggle with service quality, reliability and affordability, even as some regional centres catch up.

Reliability, congestion and resilience

- ADII 2024 data show connectivity interruptions are far more common in very remote areas (30.5%) than nationally (15.9%).
- The RTIRC speaks of "diminishing mobile experience" in existing coverage areas and calls for higher capacity, better service quality and more resilient infrastructure, including mandated emergency roaming and backup power.

Digital ability and connectivity literacy

- Outside capital cities, the largest gap is in Digital Ability (7.8 points).
- The RTIRC's first recommendation on connectivity literacy responds directly to this, noting that limited knowledge in regional, rural and remote communities hinders users from selecting and maintaining suitable services.

First Nations and very remote communities

- First Nations Australians face a 10.5-point national digital inclusion gap, widening to 16.5–22.8 points in remote and very remote areas, with 40.9% digitally excluded.

---

[14] Ibid. 13

- RTIRC recommendations around pre-paid low-cost broadband, mesh Wi-Fi networks, and ongoing support for the First Nations Digital Inclusion Advisory Group explicitly recognise this as a structural equity issue.

Information, transparency and consumer protection

- Without a national data platform, rural and remote consumers lack clear, comparable information about coverage and performance, limiting their ability to choose services and advocate for improvements.

- The Review also calls for stronger, consolidated consumer protections, recognising that regional consumers can be especially vulnerable to poor practices and service failures.

Strategic planning and long-term policy

- The call for a regional, rural and remote connectivity strategy, improved evaluation of programs, and continuous oversight (rather than one-off triennial reviews) all signal that current policy arrangements are not yet adequate for rural–urban equity.

Taken together, these sources show that rural–urban connectivity equity gaps in Australia are not just about having a signal on the map; they are about affordability, reliability, skills, data transparency, and the particular disadvantage of First Nations and very remote communities.

LEOSat and DTH capabilities and limitations to address agricultural needs

LEOSat and DTH technologies can now cover almost the full spectrum of agricultural connectivity needs–fixed connectivity, connectivity 'on the move' and portable connectivity – but they remain capacity , power integration- and topography (natural and constructed) constrained[2]. These non-terrestrial network (NTN) technologies should be included as part of a hybrid connectivity architecture along with terrestrial on-farm networks, not as stand-alone replacements. DTH or mobile services are emerging as an overlay: smartphones and standard modules connect directly to LEO / GEO satellites for emergency SOS, basic messaging and low-rate data when terrestrial coverage is absent. Today these are functionally narrowband and best viewed as complementing mobile networks rather than replacing them.

Agriculture's core connectivity demands fall into five domains (see Table 1 below):

1. demand for fixed broadband to farm houses and farm offices,
2. demand for mobile connectivity for machinery and vehicles 'on-the-move',
3. demand for portable connectivity at "pop up" sites (e.g. stock yards and remote sheds),
4. demand for connectivity for low power IoT (LEOSat narrowband IoT constellations plus 3GPP "IoT NTN" (NB IoT / LTE M via satellite) support millions of low power devices for soil, water, livestock and asset monitoring, and
5. demand for connectivity for safety / business continuity communications.

Each demand domain has different throughput, latency, and device availability pattern profiles (see Table 1 below).

Each demand domain may be addressed through different connectivity technologies applied in connectivity layers on-farm.

The commercial maturation of Low Earth Orbit (LEO) satellite constellations has introduced a new layer of connectivity infrastructure that is technologically distinct from its predecessor satellite options. By orbiting at altitudes between 500 and 1,200 kilometers (compared to the 35,786 kilometers of GEOSat used for emergency messaging and older satellite phone options), LEOSat networks deliver latency metrics comparable to terrestrial 4G LTE and throughput capable of supporting real-time enterprise applications.

LEOSat broadband systems (Starlink, Amazon Leo (formerly Project Kuiper), OneWeb, etc.) now deliver 10s to 100s Mbps capacity per connected service with ~40–60ms latency almost anywhere, using three main terminal classes:

1. Fixed terminals (typically used at farm houses / farm offices);
2. Mobile terminals (typically used on machinery and vehicles whilst 'on-the-move'); and
3. Portable / roaming terminals (that can be moved to different locations, i.e. stock yards, remote sheds or temporary work sites).

1. Agricultural connectivity requirements

From a connectivity design perspective, agricultural requirements can be framed as follows.

Table 1: Agriculture's five core connectivity demand domains and their specific connectivity features

Core connectivity demand domains	Typical endpoint use on-farm	Throughput need	Latency sensitivity	Connectivity availability pattern
Fixed broadband to farm houses & farm offices)	PCs, servers, cloud apps, VoIP, video	10–100+ Mbps down; 5–50 Mbps up	Moderate (sub-100 ms)	Continuous
Mobile connectivity for machinery & vehicles 'on-the-move'	Tractors, harvesters, sprayers, trucks, service utes	1–20 Mbps per machine; bursts higher for video	High (sub-150 ms for guidance/autonomy)	Continuous while operating
Portable connectivity at "pop-up" sites	Stock yards, remote sheds, temporary camps	10–100 Mbps shared	Moderate	Episodic (hours–days at a time)
Connectivity for IoT sensing & tracking	Soil probes, weather, tank levels, collars, assets	Bytes–kbytes per report; minutes–hours periodicity	Low–moderate (seconds–minutes)	Continuous but tolerant of buffering
Connectivity for safety / business-continuity communications	Voice, messaging, emergency SOS, critical apps	kbps–Mbps	High for voice/critical alerts	Available even in terrestrial blackspots

Australian data shows that agriculture is highly broadband penetrated but underserved in speed and farmwide coverage, (with the high degree of broadband penetration being a 'fixed local point' connection to a main farm house or farm office building) and with many sites relying on a patchwork of 4G, fixed wireless and GEOSat. This creates both the need and the opportunity for LEOSat and DTH.

2. Applicability of LEOSat and DTH capabilities to address the requirements of the five different connectivity demand domains

2.1 LEOSat broadband capability in addressing agricultural demand for fixed, mobile and portable connectivity

Characteristics of LEOSat broadband:

LEOSat broadband constellations orbit at ~500–1,200 km, providing:

- Latency: typically ~40–60 ms RTT (Round Trip Time), far lower than GEOSat (~600 ms RTT).

- Capacity: 10s to100s of Mbps per terminal today, with capacity shared across users.

- Coverage: near global, with particularly strong value in sparsely populated, remote regions.

These characteristics of LEOSat broadband make this technology suitable to address the fixed, mobile and portable core connectivity agricultural demand domains.

All three of the LEOSat broadband terminal classes are relevant to agricultural applications.

Some of these applications include:

1. Fixed terminals (farm houses / farm offices)
   - Roof mounted dish, static pointing.
   - Provides for backhauls of on farm Wi Fi or private LTE/5G providing single network coverage and Internet access to paddocks, sheds, and housing.
2. Mobile terminals (on machinery and vehicles whilst 'on-the-move')
   - Ruggedised, vibration tolerant units on machinery (tractors, harvesters, trucks).
   - John Deere's partnership with SpaceX Starlink is the flagship example: rugged Starlink terminals plus 4G JDLink modems on new and retrofitted machines enables autonomy, real time data sharing, remote diagnostics and machine to machine communication.
   - Trials in the US and Brazil are targeting "thousands" of machines over the coming decade with this application of LEOSat broadband mobile terminal.
3. Portable / roaming terminals (that can be moved to different locations)
   - Transportable kits that can be dropped at stock yards or remote sheds to provide a local Wi Fi bubble.
   - Newer compact terminals (e.g. "mini" form factors) are backpack sized, DC powered and explicitly marketed for mobile/roaming use, which is directly applicable to farm "pop up" deployments.

2.2 LEOSat narrowband capability in addressing demand for connectivity for IoT & IoT NTN

Characteristics of LEOSat narrowband:

- Multiple LEO constellations (e.g. Myriota, Sateliot and others) provide low power, small packet (low speed) connectivity optimised for sensors and trackers – soil moisture, tank levels, weather, livestock collars.

- 3GPP Release 17 adds IoT NTN for NB IoT and LTE M – adapting link budgets, Doppler compensation, and timing to allow standard 3GPP IoT modules to talk directly to satellites.

- Peak rates for NB IoT / LTE M in Release 17 remain modest (hundreds of kbps max) by design, but support massive numbers of devices at low power and low cost.

- These characteristics of LEOSat narrowband make this technology suitable to address the connectivity for IoT demand domain.

2.3 DTH capability in addressing demand for connectivity for safety / business-continuity communications

DTH refers to satellites talking directly to ordinary or lightly modified mobile handsets, typically in MSS (Mobile Satellite Service) L band or shared IMT (International Mobile Telecommunications) spectrum under 3GPP NTN.

Characteristics of DTH:

- Very low throughput (texts / small packets), within the context of international standards dictated the constraints of consumer handsets, i.e. having very low power output and tiny antennas needing to reach far away satellites not nearby terrestrial base stations.[42][7]
- Mostly outdoor, line of sight use. Indoor, in vehicle and under canopy operation is limited by link budget.
- Designed for low duty cycle traffic, not broadband.
- Early commercial services include:
    - Apple’s iPhone SOS over satellite (via Globalstar), Google Pixel’s satellite SOS and Qualcomm Iridium based messaging – all focused on narrowband emergency or basic messaging in uncovered areas.
    - Operators and satellite providers are piloting 5G NTN DTH messaging and eventually voice / low rate data via LEO constellations with standard 3GPP NTN capable phones.

In agricultural design terms, these characteristics of DTH mean that DTH is best considered a coverage extension and safety layer for people, not a primary bearer of connectivity for farm houses, offices, machinery nor high density IoT.

3. Comparison between LEOSat and DTH technologies to address the five different connectivity demand domains

3.1 Fixed broadband to farm houses and farm offices

What LEOSat brings:

- Throughput and latency comparable to entry to mid tier fixed broadband in urban areas.
- Ability to backhaul on farm Wi Fi or private LTE / 5G networks (“from gate to grid” architectures).
- Particularly valuable where NBN fixed wireless, fibre or robust 4G / 5G are absent or oversubscribed.

What DTH brings:

- DTH can only provide backup low rate messaging during terrestrial or satellite outages.

So, LEOSat fixed terminals are the primary solution for farm house / office broadband. Comparatively, DTH cannot currently address the fixed broadband to farm houses and farm offices connectivity demand domain.

3.2 Mobile connectivity for machinery and vehicles 'on-the-move'

What LEOSat brings:

- Real time coordination between machines, including autonomous and highly automated tractors and harvesters, with cloud based management systems.
- Real time video and data feeds from implements (e.g., sprayers, harvesters) to agronomists and OEM (Original Equipment Manufacturer) support.
- Telemetry and predictive maintenance data flows from fleets across large, sparsely connected properties.
- LEOSat mobile terminals on machinery provide continuous IP (Internet Protocol) connectivity in areas where 4G / 5G coverage is patchy, filling in the "white spaces" critical to delivering the value of existing LTE based telematics and autonomy stacks. e.g. The John Deere–SpaceX architecture (Starlink terminal on cab + LTE JDLink modem to Deere cloud) is a canonical pattern: satellite is used when terrestrial falls away, giving seamless coverage at the application level.
- Clear sky view is essential for LEOSat; trees, terrain and some farm infrastructure create dropouts, especially at low elevation angles between device and satellite.
- Terminals consume tens of watts and add CAPEX; this fits large, high value machines better than smaller implements.
- Capacity is shared; a cluster of heavy data use machines under the same satellite beam could experience congestion, especially if each streams video.

What DTH brings:

- Basic messaging and SOS from operators' handsets in remote paddocks
- Low rate machine exceptions/alerts if integrated via NTN capable modems in the future.

So, LEOSat mobile terminals address the demands for mobile connectivity for machinery and vehicles 'on-the-move'.

Comparatively, today's DTH cannot serve as the primary link for real time autonomy or telemetry due to bandwidth and link budget constraints.

3.3 Portable connectivity at "pop up" sites

What LEOSat brings:

- Portable / roaming terminals can create a local Wi Fi bubble with broadband performance (10s–100s Mbps) for multiple users.
- Newer compact units (e.g., "mini") are optimised for portability (2–3 kg, backpackable, DC power), effectively acting as "connectivity in a backpack" for agricultural field operations.
  i.e. Portability for farmers to take a LEOSat terminal to stock yards on sale days, portable yards during mustering, remote sheds during shearing/maintenance, or temporary worker camps.

What DTH brings:

- DTH is a useful supplement if the terminal is unavailable but cannot match bandwidth.

So, LEOSat portable / roaming terminals address the demands for portable connectivity at "pop-up" sites compared to DTH given its bandwidth limitations.

3.4 Connectivity for IoT – sensing and tracking

What LEOSat brings:

- LEOSat IoT and IoT NTN are well matched to low power sensors distributed across large properties, enabling:
    - Soil moisture, salinity and nutrient monitoring.
    - Weather and micro climate stations.
    - Tank and channel level monitoring; remote pump control.
    - Asset tracking via collars and ear tags using low-power LEOSat IoT for wide-area location and status updates, with battery lives measured in years.

What DTH brings:

- DTH IoT via NB IoT NTN is technically feasible but commercially emerging and not yet ecosystem mature.
- DTH shines for people centric use (e.g. worker safety beacons via phone), not for millions of unattended devices.

So, LEOSat IoT (proprietary – IoT-NTN) is the primary technology addressing the demands for multiple, low-power IoT compared to DTH applied to IoT applications.

3.5 Connectivity for safety / business-continuity communications

What LEOSat brings:

- Traditional MSS phones and LEOSat broadband terminals provide robust voice / data in deep remote areas and during terrestrial outages.

What DTH brings:

- DTH brings this safety enhancement into ordinary smartphones: SOS and messaging when all terrestrial coverage is gone, particularly important for remote and lone workers and contractors.

So, DTH better addresses the demand for connectivity for personal on-farm safety and communications supporting business-continuity than LEOSat does through DTH's utilisation of ordinary phone handsets and their associated benefits in this application.

LEOSat and DTH adoption

Publicly available indicators of current uptake of LEOSat-enabling technologies including DTH in Australian agriculture, case-evidence and market direction information suggest:

- National LEOSat subscriber scale (Starlink ~200k–250k+), heavily concentrated in regional/remote areas where farms are overrepresented.
- Documented on-farm deployments (e.g., MLA R&D case evidence using Starlink in station connectivity stacks).
- Commercial DTH availability via Telstra Satellite Messaging across most outdoor mainland areas (eligibility constraints apply).
- A second MNO pathway (Optus–SpaceX) progressing toward DTH services, implying future expansion of addressable farm users beyond a single provider.
- Institutional mainstreaming: NBN's move to LEOSat via Amazon LEO aimed at very large rural cohorts by mid-2026[15].

Australia is fully encompassed by multiple LEO satellite constellations, including Starlink, Eutelsat OneWeb and emerging systems such as Amazon Leo. From an orbital and technical perspective, these constellations provide continuous national coverage, with one or more satellites visible from any location across the continent at all times. Figure 1 overlays Australian agricultural land use with LEO satellite locations at a single point in time, illustrating the density and distribution of satellites rather than fixed or persistent coverage. Continuous service is maintained through rapid satellite movement and frequent handovers.

Any apparent gaps in LEOSat service availability across Australia are not due to technical limitations of the satellite networks, but are primarily the result of regulatory constraints. In defined geographic areas, restrictions are applied to limit radio frequency emissions and prevent interference with sensitive facilities, including radio astronomy observatories and satellite earth stations. As a result, some rural and remote locations may be subject to operational restrictions despite being fully covered from an orbital perspective.

While coverage is geographically ubiquitous, service performance varies with local conditions. LEOSat services require a clear view of the sky, and natural or constructed obstructions such as terrain, vegetation, buildings, and farm infrastructure can degrade performance or cause intermittent outages. These effects are particularly relevant for portable and mobile-terminals, where obstruction profiles change over time, and for IoT and DTH services that are more sensitive to indoor or under-canopy attenuation.

Network performance is also influenced by shared beam capacity and satellite handovers. In areas with high simultaneous usage (such as during harvest season), localised congestion may occur, and frequent handover events can introduce brief latency variation or jitter, which may affect time-critical applications unless mitigated through buffering or system design. Terminal power requirements further influence suitability across agricultural use cases, particularly for mobile machinery and low-power IoT devices. This is compounded by more lower cost residential (non-prioritised services) currently being adopted by Australian agriculture users rather than business/enterprise grade services (prioritised services).

Accordingly, Figure 1 should be interpreted as a representative visualisation of LEOSat presence over Australian agricultural regions, rather than a depiction of service quality, regulatory availability, or performance at a specific location.

---

[15] Connected Farms 2026, Milestone 3 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity, January 2026.

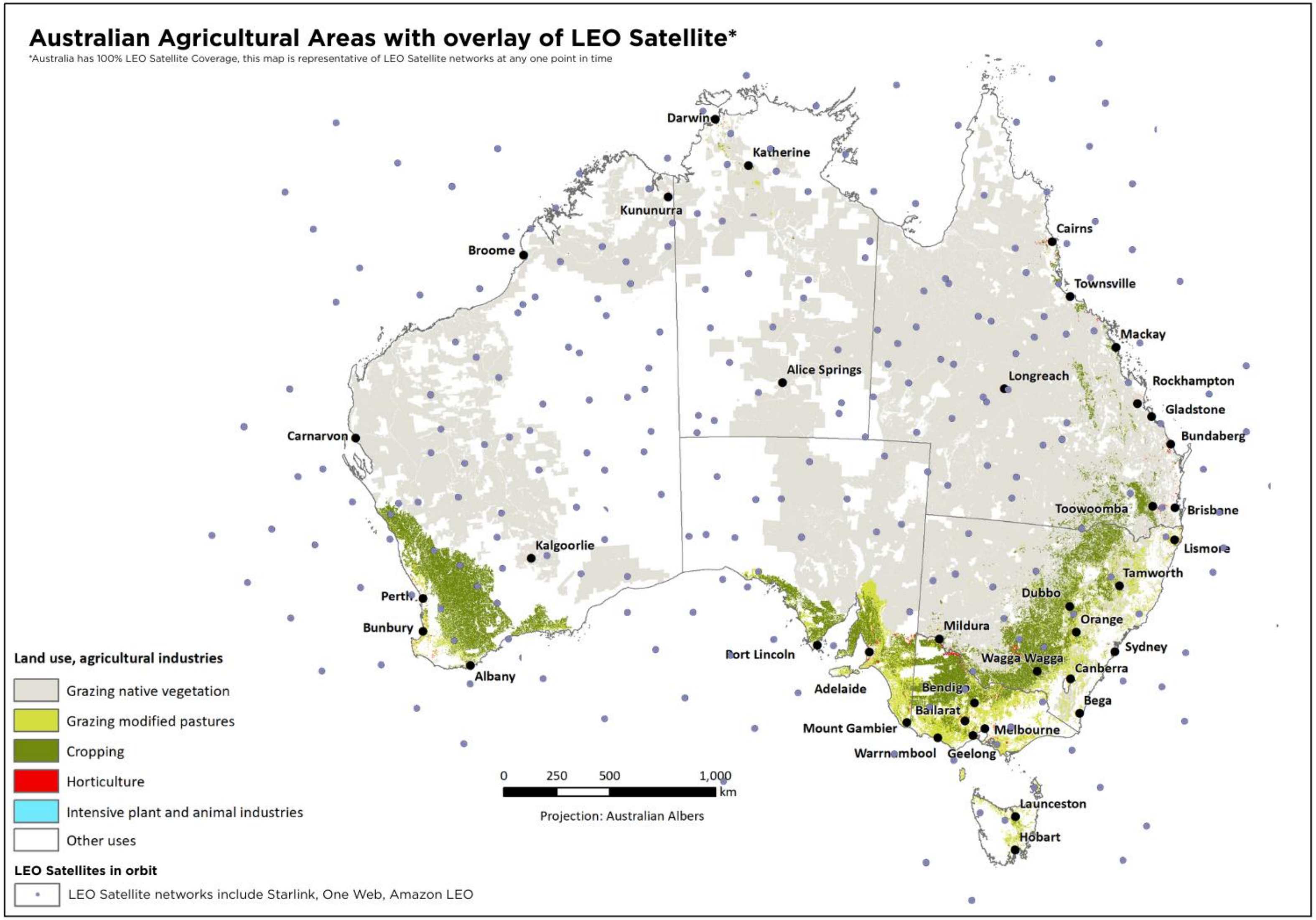

Figure 1: Point in time LEO satellite coverage of Australian agricultural areas.

Adoption is moving quickly for LEOSat broadband and IoT in agriculture (especially in markets like Australia, the US and Brazil), but robust quantitative data is still limited. Authoritative Australian analysis concludes that:

- 99.8% of agriculture businesses have house / office broadband, but most are on slower plans (<50 Mbps) and rely heavily on 4G and GEOSat (NBN Sky Muster etc.) in regional / remote areas.
- Remote businesses were far more likely to have satellite connectivity (9.9% vs 1.6% of capital city businesses), even before the LEOSat boom.
- LEOSat adoption is clearly growing, but "scant publicly available data" exists to quantify it precisely; it is best characterized as early growth, not yet mainstream.

By contrast, DTH is still in early stages of technical development and commercialisation: emergency / messaging services on premium smartphones, early 3GPP NTN device ecosystems, and regulatory frameworks still maturing. The technical functionality and performance statements made by DTH service providers should be read in a broad global context. Capabilities are not equal across international markets and not all mobile network operators provide the same level of service, or no service at all (e.g. only available with Telstra in Australia at the present time).

LEOSat adoption

1. Indicators of current LEOSat uptake in Australian agriculture

(Starlink, the most currently available LEOSat service in Australia at scale in Australia taken as the proxy for agriculture uptake)

LEOSat is widely used as "last-mile" connectivity in regional / remote Australia, including farms, because it bypasses mobile phone tower / backhaul constraints. Public media reporting provides a national subscriber scale that acts as a ceiling / proxy for potential agricultural uptake:

- ~200,000 Australian Starlink customers (reported by ABC, citing Starlink's claim)
- "Over 250,000 customers in Australia" (reported by Reuters)

Agriculture-specific subscriber counts are not published, but given where Starlink demand concentrates (regional / remote) and the prominence of connectivity as an adoption barrier, these totals are a strong indicator that LEOSat is already at material scale in the farm user base—especially in pastoral, broadacre, and remote operations.

2. Case-evidence of LEOSat being deployed in Australian agriculture

There is direct evidence of LEOSat being used as part of operational connectivity stacks:

- Meat & Livestock Australia R&D reporting describes a hybrid connectivity solution used by a major cattle business that includes LEO Sat alongside fibre and other components.
- MLA's digital agriculture materials explicitly treat connectivity as a core constraint and assess "emerging technologies" to improve it, consistent with LEOSat services being part of the solution set.
- Connected Farms (Australia) offers LEOSat based fixed, mobile ("Satellite on the Move") and portable connectivity specifically for farms, indicating commercial, not just pilot scale LEOSat use in Australian agriculture.

- Starlink themselves along with their retail providers (Bunnings, OfficeWorks etc.) promote LEOSat based residential solutions. Due to ease of purchase and set up, rural and agricultural connectivity users are widely adopting residential / public grade connectivity solutions as part of their mainstream product portfolios. The public grade solutions are lower in price and provide lower data transfer priority and security so are liable to poorer service outcomes and overall experience than the enterprise managed service solutions.

- LEOSat IoT vendors report deployments in soil monitoring, automated irrigation, livestock tracking and remote asset monitoring, with constellations explicitly designed for "millions of devices".

- Market research on IoT in agriculture projects strong double digit growth, explicitly citing expansion of LEO satellite IoT and LPWAN footprints as a driver of adoption in underserved rural regions.

These point to rapid early growth adoption: LEOSat broadband is still far from universal on farms but is moving beyond small pilots into specialist provider rollouts. Whilst LEOSat IoT may be considered to be commercially established but not yet saturated in agriculture – especially in high value, remote and corporate operations.

3. LEOSat market direction:

NBN moving to LEOSat (availability & mainstreaming signal)

A strong "mainstreaming" indicator for LEOSat is that NBN Co has partnered with Amazon's Amazon Leo (formerly Project Kuiper) to deliver satellite internet services to remote communities, with reporting that the deal aims to serve hundreds of thousands and begin transition / availability in 2026:

- Reuters reports the NBN–Amazon LEO partnership and notes Starlink's existing customer base in Australia; Amazon LEO is expected to begin replacing aging satellites from 2026.

- The Verge reports the partnership is intended to provide satellite broadband to over 300,000 rural Australians by mid-2026.

- Australian government notes that "consumer subscriptions for LEOSat services are growing and new providers have identified Australia as a target market," with LEOSat seen as the preferred solution outside fixed line and mobile footprints.

NBN's adoption of LEOSat (via Amazon LEO) signals LEOSat is shifting from "alternative" to institutional backbone for remote broadband—likely increasing availability pathways for farms (especially those currently dependent on Sky Muster or poor terrestrial options).

The introduction of additional LEOSat (NBN wholesale, Amazon Leo) in Australia should improve price discipline and connectivity redundancy options, enabling safeguards like multi provider procurement for critical users and clearer quality of service / complaints reporting.

4. Regulatory considerations for LEOSat adoption

The Australian Government introduced the Telecommunications Legislation Amendment (Universal Outdoor Mobile Obligation (UOMO)) Bill 2025, marking a historic expansion of the Universal Service Obligation (USO) framework. Historically, the USO focused on ensuring access to standard telephone services (fixed voice) and payphones. The UOMO fundamentally modernises this by mandating that mobile network operators provide reasonable and equitable access to baseline outdoor mobile coverage—specifically voice and SMS—across the Australian landmass.

This legislative reform is a direct response to the capability of LEOSat to cover the large parts of Australia that currently lack terrestrial mobile signal; it creates a regulatory imperative for the mobile network operators to integrate satellite-based DTH extensions into their core service offerings.

The Australian Competition and Consumer Commission (ACCC) has begun measuring satellite broadband performance (Starlink and NBN Sky Muster) in its Measuring Broadband Australia program, which demonstrates to us that satellite broadband provision is becoming a mainstream Internet service option. A detailed analysis of the ACCC program, and comparison of LEOSat performance to NBN performance, is not within the scope of this project but the latest quaterterly ACCC report (covering 14 September to 13 October 2025) indicated the performance capability of Starlink:

- average downlink speeds of 228.8Mbps during all hours and decreasing to 197.2Mbps during busy hours
- average uplink speeds of 47.5 Mbps during all hours and 46.2 Mbps during busy hours
- average latency was 26.7 ms during all hours and 28.0 ms during busy hours

DTH adoption

1. Indicators of current DTH uptake in Australian agriculture

Operationally, DTH is relevant today only for safety, black spot messaging and limited telemetry, not for broadband like connectivity.

2. Case-evidence of DTH being deployed in Australia

Telstra Satellite Messaging: now commercially available nationally

Telstra's DTH product is already launched and broadly available outdoors across mainland Australia (subject to sky view and Telstra device / plan eligibility):

- Telstra states Satellite Messaging can send / receive texts beyond terrestrial coverage and is available from "most outdoor areas in mainland Australia" with line of sight.
- Telstra's launch article describes it as Australia's first satellite-to-mobile text messaging product, available for eligible consumer and small business customers on certain month-to-month plans with compatible devices.
- Telstra support material differentiates Satellite Messaging (DTH) vs Telstra Mobile Satellite (Iridium) (traditional satphone approach), indicating the DTH product is positioned as a mainstream adjunct to standard mobile plans.

This is the clearest "uptake-ready" DTH signal: the service is not merely trialled—it is commercial and designed for people in black spots, which directly includes many farm contexts (property work, fencing, mustering, remote machinery tasks).

Optus–SpaceX direct-to-mobile: positioned, but "journey"/testing signal

- Optus describes its collaboration with SpaceX to deliver direct-to-mobile satellite connectivity, "starting with text messaging" and later voice/basic data.
- Optus reporting also indicates ongoing work and "local testing" toward direct-to-mobile.

Optus appears behind Telstra on commercial availability, but the public positioning confirms a second national MNO pathway for DTH service provision—important for competition, roaming-like resilience, and future price/coverage dynamics for farm users.

Other current live DTH services

These include Apple / Globalstar SOS, Qualcomm / Iridium emergency messaging, early NTN messaging pilots which are narrowband and low duty cycle, with handset support limited to high end models.

The Regional Tech Hub confirms early-stage DTH in Australia

Regional Tech Hub characterises DTH as early-stage in Australia and notes compatible devices / plans / rollout / cost details are still evolving:

- Regional Tech Hub explains DTH's purpose (SMS in areas without towers / Wi-Fi), its disaster-resilience potential, and that it is in early stages of availability in Australia.

3. DTH market direction

- GSMA (Global System for Mobile Communications Association) and related work characterise DTH as an emerging "Satellite 2.0" strand.
- DTH is positioned to address the "last coverage gap" – adding basic connectivity where terrestrial networks will never be built – with potential to support 2–3 billion IoT devices by the 2030s if fully realised.
- Regulatory and spectrum frameworks for sharing IMT spectrum bands between terrestrial and satellite are still evolving, including in Australia.
- Technically on a trajectory to become more important as 3GPP NTN capable phones and modules proliferate, but still in an early commercialisation phase.

LEOSat-enabled connectivity risk review

The following is a catalogue of risks[16] for LEOSat adoption in Australian agriculture including:

1. Service-resilience risks
2. Data security risks
3. LEOSat service provider market structure risks
4. Technology limits risks

1. Service resilience risks

Scope:

A. Dependence on a single LEOSat service provider
B. Satellite, ground-segment, and systemic outages
C. Australia-specific resilience and governance risks

[16] Ibid. 15

A. Dependence on a single LEOSat service provider

A1. Whole-of-farm connectivity becomes a single point of failure

If agricultural operations consolidate communications (worker safety messaging, telemetry backhaul, remote machinery oversight) onto a single LEOSat provider, a provider-wide outage can disable multiple critical workflows simultaneously. This risk is heightened where national telco offerings rely on a single upstream LEOSat constellation.

Agricultural consequence:
Loss of situational awareness, delayed safety responses, halted autonomous or remotely monitored operations.

A2. Limited service-level agreement (SLA) leverage for farms

Most LEOSat services currently adopted by agriculture are consumer grade, with limited or no enforceable SLAs or service priority, especially for restoration times following outages. Individual farms have little negotiating leverage over performance guarantees, fault transparency, or compensation.

Agricultural consequence:
Extended outages with no recourse during peak seasonal or safety-critical periods.

A3. DTH services do not behave like terrestrial mobile networks

Current DTH services operate with intermittent delivery windows, higher latency, and constrained capacity, and are not substitutes for conventional emergency communications. Availability depends on handset model, satellite visibility, and service phase.

Agricultural consequence:
False assumptions about "always-on" coverage, when relying on LEOSat-enabled DTH connectivity only may undermine safety planning in remote field operations.

A4. Dependency on future capability roadmaps

Some agricultural connectivity strategies assume progression from DTH messaging-only services to voice and broadband data. These capabilities remain subject to regulatory approvals, spectrum coordination, and phased constellation upgrades. Delays or changes in roadmap priorities can strand dependent investments.

Agricultural consequence:
Connectivity solutions fail to mature as expected, limiting scalability of digital agriculture systems.

A5. Device and terminal ecosystems

LEOSat services including DTH may require specific handsets, antennas, or firmware ecosystems, particularly during early rollout phases. Device shortages, incompatibility, or failed updates can translate directly into service outages.

Agricultural consequence:
Operational disruption due to hardware churn rather than network failure.

B. Satellite and ground segment outage risks

B1. Global software failures can disable service across regions

LEOSat networks are software-defined and centrally orchestrated. Failures in core network services can trigger near-simultaneous global outages, irrespective of satellite health or local conditions.

Agricultural consequence:
Widespread, correlated loss of connectivity across rural Australia with no local workaround.

B2. Ground-segment outages can be as disruptive as satellite failures

Even with healthy satellites, faults in ground-segment software, timing systems, or network orchestration layers can disable service for extended periods. Such outages have previously lasted multiple days.

Agricultural consequence:
Prolonged loss of connectivity affecting farm management systems, monitoring, and logistics.

B3. Gateway and backbone concentration risks

Australian LEOSat traffic is routed through a limited number of ground stations and terrestrial backhaul paths. Failures or congestion at these points can manifest as apparent satellite outages.

Agricultural consequence:
Regional or national outages driven by infrastructure beyond the farm's control or visibility.

B4. Power and physical vulnerability at the farm edge

Even where the LEOSat network remains operational, farm-side dependencies (power supply, antenna alignment, environmental exposure) can cause local outages indistinguishable from network failure.

Agricultural consequence:
Reduced trust in LEOSat services and increased troubleshooting burden during critical operations.

B5. Correlated demand during disasters, emergencies and other heavy use events

During busy agricultural periods such as harvest along with bushfires, floods, or widespread terrestrial network failures, LEOSat services may experience sudden congestion as users converge on satellite connectivity as a last resort.

Agricultural consequence:
Degraded performance precisely when communications are most critical for farm operations, safety and emergency coordination.

C. Australia-specific resilience and governance risks

C1. Misalignment between policy obligations and service accountability

Government initiatives to extend outdoor and remote coverage place expectations on carriers, but accountability across telcos, satellite operators, and device manufacturers remains fragmented. This complicates outage responsibility and remediation pathways.

Agricultural consequence:
Unclear escalation and recovery processes following service failures.

C2. Dependence on pre-operational or emerging constellations

Some agricultural connectivity roadmaps reference future LEOSat entrants that are not yet operational at scale. Adoption decisions made on anticipated availability introduce schedule and delivery risk.

Agricultural consequence:
Connectivity gaps if planned services are delayed or reprioritised.

These service resilience risks can be consolidated into the following themes:

- Provider concentration and lock-in
- Software-defined systemic outages
- Ground-segment fragility
- Performance variability of DTH services
- Weak SLAs and accountability gaps
- Correlated demand during disasters

2. Data security risks

LEOSat services are offered at either a residential / public grade or a business / enterprise grade. See below for a comparison of the data security risks associated with each grade.

Scope: confidentiality, integrity, availability as it relates to data security controls (not resilience / outages).

A. residential / public LEOSat services
vs
B. enterprise managed LEOSat services.

A. Residential / public LEOSat services: data-security risks

A1. Higher likelihood of misconfiguration and unmanaged endpoints

Public / consumer-oriented services (including DTH SMS extensions) typically assume the customer manages devices, identity controls, and endpoint hygiene. Where farms use unmanaged phones / tablets / routers, the weakest link becomes the device—not the satellite link. Telstra's DTH messaging is delivered via standard handset messaging apps when the device connects to satellite coverage, which means farms may treat it like "normal mobile" and skip enterprise controls.

Agriculture impact: compromised phones leading to credential theft, unauthorised access to farm SaaS (software as a service) platforms, and leakage of operational / location information.

A2. Shared / public IP behaviours can weaken network security patterns

Many residential LEOSat broadband services are built for simple internet access. Business grade enterprise-style security patterns (site-to-site VPNs, strict IP allowlisting, consistent audit trails, inbound service exposure controls) often depend on predictable IP addressing. Starlink's enterprise documentation explicitly distinguishes support for public IP configurations for business plans—which highlights that this is not necessarily a given across non-enterprise plans such as the mainly residential ones used in Australian agriculture.

Agriculture impact: harder-to-secure remote gateways for IoT / telemetry, brittle vendor integrations, weaker anomaly detection tied to stable egress identities.

A3. Data routing transparency and cross-border processing uncertainty

LEOSat networks are inherently global (space segment + global ground infrastructure). Even if traffic is encrypted in transit, farms and ag-tech vendors may have limited visibility into where metadata is processed, which entities in the service chain can access operational data, and what "lawful access" regimes apply. Starlink's privacy policy explicitly describes security measures (including encryption to / from equipment) but also notes it cannot guarantee prevention of every unauthorised access attempt.

Agriculture impact: compliance and assurance challenges for agribusinesses handling sensitive supply-chain, animal welfare, or commercially sensitive yield/operations datasets.

A4. DTH expands the compliance boundary (telco + satellite operator + spectrum model)

Australia's regulator (ACMA) distinguishes DTH approaches and explains that some DTH services may be delivered via foreign satellite systems operating under international frameworks, with domestic spectrum authorisation applying primarily to the handset emissions under spectrum licences. This expands the practical accountability boundary beyond the telco brand seen by the end-user.

Agriculture impact: harder incident response and evidence collection after a suspected compromise (who holds logs? who is the security operator-of-record?).

A5. Privacy and identity assurance may be weaker in "public coverage extension" modes

DTH services are positioned as coverage-extenders and may be used in ad-hoc ways (field staff, contractors, seasonal workers). Without enforced identity policy (MFA (multi-factor authentication), device attestation, conditional access), farms are more exposed to SIM swap / credential stuffing / account takeover pathways that are independent of the satellite layer. (This becomes more likely as usage spreads across staff devices under BYOD (Bring Your Own Device) conditions.)

Agriculture impact: unauthorised access to farm management systems; fraudulent instruction flows (e.g., changing payment details, logistics directions), denial of service attacks.

B. Enterprise managed LEOSat services: data-security risks and comparative advantages

B1. Managed services reduce endpoint risk, but introduce supply-chain trust dependencies

Enterprise managed offerings commonly package device lifecycle controls (provisioning, configuration, patching, replacement), reducing misconfiguration risk.

However, this can create a supply-chain security dependency: the managed provider becomes a high-value target.

Agriculture impact: if the managed service provider is compromised, many customer sites may be affected simultaneously.

B2. Better support for secure network architectures (VPN/SD-WAN), but still requires correct design

Enterprise satellite deployments are often explicitly designed to support enterprise overlays (IPSec/SSL VPN, SD-WAN). Starlink enterprise material highlights enabling IPSec tunnel / SSL VPN / SD-WAN configurations with public IP/NAT characteristics in business contexts.

Agriculture advantage: easier deployment of "zero trust" access, segmentation of OT/IoT networks, and consistent secure remote access.

Residual risk: farms may still deploy "flat networks" on-prem (no segmentation), negating benefits.

B3. Wholesale / aggregated models can improve governance, but can blur responsibility

NBN Co's planned wholesale LEOSat offering (via Amazon's Amazon Leo formerly Project Kuiper) is explicitly structured to be delivered through Retail Service Providers (RSPs). This can strengthen governance (contracting, support processes, potentially clearer SLAs and reporting), but also creates layered responsibility across NBN Co, the RSP, and the satellite operator.

Agriculture impact: during security incidents, response can be slowed if logging, monitoring, and customer notifications span multiple entities.

B4. Sector-specific managed offerings can align controls to farm operations

Connected Farms describes Amazon Leo-enabled connectivity as supporting "secure, high-performance connectivity" for real-time farm systems integration. This kind of vertically integrated approach can better standardise security baselines.

Agriculture advantage: improved consistency across heterogeneous farm sites.

Residual risk: vendor lock-in—security posture becomes dependent on one integrator's processes and tooling.

These comparative (public vs enterprise) data security risks can be consolidated into the following themes:

- Unmanaged endpoints & BYOD exposure (public services amplify; managed services reduce)[15]
- Network identity / IP predictability & auditability limits (more common in public; enterprise plans may address)
- Supply-chain and accountability complexity across telco–satellite–RSP layers (exists in both, but more explicit in wholesale models)
- Data routing transparency and legal/regulatory boundary ambiguity (global satellite infrastructure)
- Integrator concentration risk (enterprise managed reduces local risk but increases systemic dependency)

3. LEOSat-enabled connectivity service provider market structure risks

Scope: The risks associated with current and developing market forces include:

A. Risks from a monopoly-like structure today
B. Risks and opportunities from new entrants from 2026
C. Interoperability risks

A. Risks from a monopoly-like structure today

A1. "Single dominant provider" dependency becomes embedded in farm digitisation

Where one provider becomes the default for remote connectivity, agriculture adoption can accelerate in the short term—but it also bakes in a single point of market failure (pricing, product terms, deprioritisation of rural features, support model changes). ABC reporting notes the scale of reliance on Starlink in regional and remote Australia, reflecting this concentration dynamic.

Adoption impact: farms hesitate to build critical workflows (telemetry, remote operations, agronomy platforms) on connectivity they perceive as controlled by one vendor's commercial decisions.

A2. Pricing power and cost volatility risk (limited competitive discipline)

A concentrated market structure can allow the dominant provider to adjust hardware pricing, plan structures, traffic management policies, or "business tier" pricing with limited near-term switching options for remote farms.

Adoption impact: uncertainty undermines ROI for connectivity-dependent agtech (especially multi-year sensor deployments and machinery integrations).

A3. Innovation skew: features optimised for mass markets may not match agricultural needs

With limited competition, the dominant provider's roadmap may prioritise consumer mobility, maritime, or urban-adjacent products over agriculture-specific requirements (ruggedness, managed service options, field maintainability, long-lived terminals, and predictable networking characteristics).

Adoption impact: ag deployments incur integration overhead and operational workarounds, slowing uptake outside early adopters.

A4. Channel structure risk: direct-to-consumer models reduce enterprise integration pathways

Where the leading provider relies heavily on direct-to-customer sales and standard plans, farms may struggle to access enterprise-grade procurement, clearer SLAs, tailored support, and integration tooling that managed-service providers typically offer. This becomes relevant as government / wholesale models emerge (see B1 below) that are explicitly channel-structured via retail providers.

Adoption impact: smaller farms either adopt "best effort" consumer services (limiting mission-critical use) or postpone adoption until managed pathways mature.

B. Risks and opportunities from new entrants from 2026

B1. Transition risk: competition arrives, but through a wholesale model with layered responsibility

NBN Co's agreement with Amazon's Amazon Leo (formerly Project Kuiper) positions a new LEOSat wholesale supply for ~300,000 eligible premises with service launch from mid-2026, delivered via retail service providers.

Risk: While this introduces competitive pressure, the layered structure (satellite operator ↔ NBN ↔ RSP ↔ farm) can complicate accountability and troubleshooting—particularly for enterprise agriculture deployments that need clear escalation and performance transparency.[2]

Adoption impact: some farms delay adoption to "wait for competition," slowing near-term uptake; others adopt now but face migration complexity later.

B2. "Announced entry" vs "operational competition" gap

Even with a new entrant scheduled, meaningful competitive discipline depends on service maturity, terminal availability, installation capacity, and performance under Australian conditions. NBN Co and

Amazon materials emphasise the upcoming launch window (mid-2026), but operational parity with incumbents may lag.

Adoption impact: risk of planning around capability that is not yet proven at scale (leading to stalled or partial agtech rollouts).

B3. Market fragmentation risk: multiple partial-coverage propositions increase complexity for farms

The Australian market is also evolving through DTH offerings:

- Telstra has launched DTH messaging based on Starlink Direct to Cell, with service behaviour described as intermittent and dependent on satellite availability and device / location factors.
- Optus has publicised plans with SpaceX / Starlink (including initial SMS), but reporting indicates launch delays.

Risk: farms may face a patchwork: one provider best for broadband backhaul, another for DTH field messaging, another for managed enterprise links—raising integration and training burden.

Adoption impact: higher complexity slows mainstream adoption, particularly for smaller operations without dedicated ICT support.

C. Interoperability risks (and why they matter for adoption)

C1. Proprietary ecosystems limit switching and multi-provider resilience designs

Interoperability is not just a technical issue—it is a market structure amplifier. If terminals, network management, and device compatibility are provider-specific, farms cannot easily dual-source or switch. Telstra's satellite messaging is explicitly tied to Starlink Direct to Cell capability and compatible devices; switching providers is not purely a SIM or plan change.

Adoption impact: lock-in fear increases, especially for farms considering large IoT deployments and long-lived machinery connectivity.

C2. Standards are progressing, but "standards-based" does not equal "seamless roaming"

3GPP's NTN work is intended to integrate satellite into 5G systems and support broader ecosystem compatibility.

Risk: Even with standards, interoperability in practice depends on spectrum / regulatory alignment, commercial roaming agreements, and consistent device chipset / firmware support—none of which are guaranteed by standards alone.

Adoption impact: farms may not see "plug-and-play multi-provider" outcomes quickly, limiting confidence to adopt at scale.

C3. Regulatory guidance seeks to reduce interference and fragmentation, but can slow time-to-market

GSMA guidance (Sept 2025) highlights the need for coherent spectrum / regulatory approaches as mobile and satellite converge for DTH services.

Risk: if frameworks are inconsistent across jurisdictions (or evolve slowly), providers may ship bespoke implementations that work in some markets / devices but not others—reducing interoperability and raising adoption friction.

Adoption impact: uncertainty around "what will work where, on which handset/terminal" slows agricultural procurement decisions.

C4. Mixed service types (broadband LEOSat vs DTH) can create a false sense of interoperability

Broadband LEOSat internet and DTH satellite messaging may share "LEO" branding but differ fundamentally in throughput, latency profiles, identity models, and supported applications. Telstra's description of intermittent satellite messaging reinforces that these services are not interchangeable with broadband links.

Adoption impact: misaligned expectations lead to failed trials and reputational harm ("LEO didn't work for us"), slowing broader sector uptake.

These market structure risks can be consolidated into the following themes:

- Dominant-provider concentration increases lock-in fear and exposure to pricing/terms changes.
- Competition timing risk: new entrants from mid-2026 may not translate into immediate operational alternatives.
- Layered wholesale accountability can slow fault resolution and complicate enterprise agriculture deployments.
- Interoperability constraints (devices / terminals / roaming) reduce switching and multi-provider strategies.
- Fragmentation across service types (broadband vs DTH) increases complexity and training burden.

4. Technology limits risks

The key engineering challenges of LEOSat-enabled connectivity are capacity / latency variability, antenna visibility in real farm topography, integration of multiple serving network provider options, evolving standards and business models, and the skills gap on the ground.
Table 2 summarises key technology risk domains (and those other risk domains catalogued above) and how they manifest across the various LEOSat-enabled connectivity solutions in agricultural deployments.

Risk domain	How it manifests in agriculture	Relative risk exposure of LEOSat-enabled connectivity capabilities				
		LEOSat broadband - fixed	LEOSat broadband - mobile	LEOSat broadband - portable	LEOSat narrowband - IoT	DTH
Capacity & QoS (Quality of Service)	Shared beams can congest under many heavy users (e.g. multiple machines or sites streaming data); DTH channels sized for low duty-cycle traffic.	Medium	High	Medium	Low-Medium	High
Latency & continuity	Handover events and local obstructions cause jitter and brief outages; problematic for tight control loops if not buffered.	Medium	High	Medium	Low-Medium	High
RF & propagation	Clear sky view needed; trees, hills, sheds block LEO. Portable units depend on where they're placed; vehicle-mounted units see changing blockage; IoT and DTH are more sensitive to indoor/under-canopy loss.	Medium	High	Medium	Medium	High
Terminal power & form	Fixed and portable broadband terminals draw tens of watts; mobile units add power/space on machinery; IoT devices are constrained to very low power; DTH is limited by handset RF and battery.	Medium	High	Medium	Low	Medium
Spectrum & regulation	DTH sharing IMT spectrum requires coordination with MNOs) and regulatory approval; national rules may constrain bands/areas where DTH can operate.	Low	Low	Low	Low	High
Vendor / constellation	Reliance on specific LEOSat operators; failures, congestion or commercial changes can impact service.	Medium	Medium	Medium	Medium	Medium
Integration complexity	Multi-bearer routing, QoS and security across LEOSat, mobile, Wi-Fi and LPWAN is non-trivial; skills gaps on farms.	High	High	High	High	Medium
Economics / ROI	Hardware + subscription costs vs marginal yield / efficiency gains; risk of stranded assets as standards evolve.	Medium	High	Medium	Medium	Low-Medium
Security & resilience	Expanded attack surface via cloud-connected machinery and sensors; reliance on space and ground segments; portable/mobile kit adds physical security considerations.	Medium	Medium	Medium	Medium	Medium
Human factors & skills	Farmers and local integrators must install, maintain and operate relatively complex systems; digital skills vary widely.	Medium	Medium - High	Medium - High	Medium	Low-Medium

Table 2: Relative risk exposure of LEOSat-enabled connectivity capabilities to various risk domains in agriculture

Key points for technology / engineering risk management:

- **Capacity and QoS are not deterministic**
  Neither LEOSat broadband nor DTH offers hard QoS guarantees comparable to well-engineered fibre or licensed private LTE. Critical control loops and autonomy stacks should be designed with local autonomy and buffering, using the LEOSat link for coordination and supervision rather than basic safety.

- **Line of sight is the Achilles heel of mobile and portable LEOSat**.
  Field topography, shelter belts and sheds cause outages; equipment mounting and, where possible, height elevation matter. Many users of this still relatively new technology will not be aware of the affects of partial shielding of signals. Specific RF planning on real farms is essential; for portable units, providing sufficient cable length to position the dish in a clear area is a practical mitigation.

- **DTH is spectrum and policy sensitive**
  National regulators, including in Australia, are still working through frameworks for IMT spectrum based DTH, with questions around interference, licensing models, and operator roles. This injects regulatory risk into any design that assumes mass market DTH availability.

- **Economics demand targeted deployment**
  - Fixed LEOSat makes sense where no equivalent terrestrial broadband is feasible or where farm size and value justify the additional backhaul.
  - Mobile LEOSat terminals make sense on high value machinery and for larger, more corporate operations; not on every small implement.
  - LEOSat narrowband for IoT should be prioritised where sensor density is low but coverage area is huge and terrestrial LPWAN is unavailable.

- **Security and resilience must be designed in**
  End to end encryption, strong device identity, segmented networks (e.g., separating machinery, IoT and office IT), and multi bearer resilience (LEOSat + terrestrial + store and forward modes) are essential to avoid new single points of failure.

Stakeholder-informed strategic vision

Structured engagement with industry, government and telecommunications stakeholders was undertaken to understand the participants' view of;

- the role of LEOSat-enabling connectivity including DTH, in various agricultural applications currently;
- the barriers and risks involved in the uptake of this connectivity technology, and;
- how policy and advocacy efforts may best assist in accelerating practical uptake and adoption of the technology in the future.

Consultation of various stakeholders was conducted via various means, including 'one-on-one' virtual interviews, virtual roundtable meetings of multiple members of stakeholder sector groups and written reply by stakeholders to interview questions posed (see Table 3).

Stakeholder sector group	Stakeholder sector group number	Means of engagement
Farmers, growers, producers and their representative groups	1	Virtual roundtable meeting
		Virtual roundtable meeting
		Virtual roundtable meeting
Agricultural Researchers	2	Virtual roundtable meeting
Government and Regulatory bodies	3	Virtual roundtable meeting
Telecommunications sector	4	Written reply to questions posed
		Virtual roundtable meeting
		‘one-on-one’ virtual interview
		one-on-one’ virtual interview
Agricultural OEMs and dealers	5	‘one-on-one’ virtual interview
		‘one-on-one’ virtual interview
Agronomist	6	Audio reply to questions posed

Table 3: Record of stakeholder consultation

The overarching cross-sector picture[17] is highly aligned on fundamentals:

- Connectivity is foundational infrastructure.
- LEOSat has materially shifted the baseline.
- Hybrid redundancy is essential.
- Market concentration is a resilience risk.
- Integration capability and literacy are major barriers.
- DTH improves safety but does not solve digital farming needs.

Where divergence occurs, it is largely about:

- Emphasis (economic vs operational framing)
- Risk weighting (security vs reliability)
- Policy interpretation (historic decisions vs structural constraints)
- User pragmatism vs competition policy concerns

Overall, the consultation reflects strong systemic coherence: stakeholders across agriculture, research, industry and government largely agree on the direction of LEOSat-enabled connectivity in agriculture — but differ in priorities, risk tolerance and strategic framing.

The areas of consensus and divergence of view noted across the different stakeholder sector groups is summarised below[18]. Reference to the stakeholder sector group number, from Table 3 above, is included in parentheses.

Consensus

Areas of strong consensus across stakeholder sector groups was noted as:

Connectivity is now core agricultural Infrastructure

There is near-universal agreement that connectivity is no longer a convenience. It is:

- A productivity enabler (1, 5, 6)
- A research constraint when absent (2)
- A machinery dependency (5)
- A digital systems backbone (4)
- A workforce and liveability necessity (1)
- A public policy equity issue (3)

[17] Ibid. 1
[18] Ibid. 1

Across stakeholder sectors, connectivity is framed as mission-critical operational infrastructure, comparable to power or water.

LEOSat is transformational — but not a standalone solution

All stakeholder groups acknowledge that LEOSat (particularly Starlink):

- Has materially improved connectivity in remote areas
- Is fast to deploy
- Enables digital agriculture use cases previously constrained
- Has driven rapid market-led adoption

However, there is broad agreement that:

- LEOSat should complement terrestrial networks, not fully replace them (4, 3, 1)
- Performance degrades in weather and congestion
- Hybrid architecture (terrestrial + LEO + possibly GEO) is the resilient model

The consistent framing:
LEOSat works extremely well — but redundancy remains essential.

Redundancy and resilience are non-negotiable

Stakeholder sector groups 1, 3 and 4 all emphasise:

- Avoiding single points of failure
- Risks of removing landlines or terrestrial backhaul
- Weather-related service interruptions
- Cascading failures where mobile towers depend on satellite backhaul

There is shared recognition that:
Over-reliance on one network, one orbit, or one provider creates structural vulnerability.

Market concentration and sovereignty risk

Strong concern appears across stakeholder sector groups 1, 3, some 5 perspectives include:

- Heavy dependence on Starlink
- Limited competition in the near term
- Foreign ownership concentration
- Risk of unilateral pricing or policy shifts
- Limited sovereign control

While the intensity varies, the issue of concentration risk is widely acknowledged.

Connectivity literacy and integration gaps

Multiple sectors identify capability gaps:

- Farmers lack structured connectivity planning support.
- Government (3) notes digital literacy and integration weaknesses.
- Telcos (4) highlight the need for integrators.
- OEMs (5) observe behavioural adoption barriers.
- Researchers (2) note workflow constraints due to poor system integration.

There is broad agreement that:
Technology availability is outpacing user capability and integration support.

DTH is a safety layer, not a broadband solution

Stakeholder sector group 3 and 4 explicitly frame DTH as:

- SMS / voice-focused
- A baseline public safety layer
- Limited in bandwidth
- Device and plan dependent
- Farmers (1) express confusion about functionality and reliability.

Consensus:
DTH is valuable for safety but does not enable digital agriculture.

Connectivity enables workforce retention and regional liveability

Farmers (1) and government (3) strongly align that:

- Connectivity affects workforce attraction and retention.
- Family liveability and digital inclusion matter.
- Poor connectivity undermines regional competitiveness.

Connectivity is increasingly seen as social infrastructure as well as production infrastructure.

Divergence

Instances where stakeholder sector group views differed was noted as:

Is LEOSat primarily economic or operationally transformational?

- Telcos (4) emphasise LEOSat's economic efficiency (cost-effective last-mile solution).
- Farmers (1), agronomist (6), OEMs (5) emphasise operational transformation (productivity, autonomy, RTK reliability).
- Researchers (2) focus on scientific enablement and data integrity improvements.

While all value LEOSat-enabled connectivity, the framing differs:

- Telcos (4) → economic complement
- Farmers (1) → operational breakthrough
- Researchers (2) → research quality enabler

Data security: major risk or secondary concern?

- Data security not currently a primary farmer concern (3).
- Assumed but not deeply interrogated (6).
- Moderate concern; secondary to uptime (5).
- Raise cybersecurity and sabotage risks (4).
- Some concern about IP and supply chain power (1).

Divergence lies in emphasis:

- Security professionals elevate risk.
- Producers prioritise reliability and productivity.

Reliability vs LEOSat-service provider diversity

Some nuance appears:

- Many stakeholders stress the importance of competition and avoiding concentration.
- OEM (5) interviews suggest farmers prioritise reliability over having multiple providers.
- Agronomist (6) responses indicate willingness to adopt whichever provider works best.

This creates tension between:

- Policy-level concern about competition
- User-level pragmatism focused on performance

Government policy perception

- (6) and some (1) voices express frustration with historic NBN investment and perceived missed sovereign LEOSat opportunities.
- (3) emphasise spectrum constraints, regulatory levers, and evolving equity frameworks.
- (4) frame issues more structurally (economics, spectrum, integration).

Thus, divergence exists between:

- Ground-level frustration with past decisions
- Institutional framing of systemic constraints and policy trade-offs

4G performance assessment

- 4G is materially failing modern ag use cases (6) and some (1) views.
- Focus more on coverage baselines and equity rather than declaring terrestrial failure (3).
- Do not position terrestrial as obsolete — still preferable where viable (4).

This reflects different vantage points:

- Field operations → frustration with mobile limitations
- Policy/industry → layered network view

Replacement vs Complement in extremely remote areas

Most stakeholders say LEOSat complements terrestrial networks.

However:

- Some acknowledges that in very remote areas, LEOSat may effectively replace terrestrial coverage.
- Some producer experiences suggest LEOSat is already functioning as de facto primary infrastructure.

This creates subtle divergence between theoretical policy framing and lived operational reality.

Ideal on-farm connectivity architecture (Australia)[19]

Properly engineered, LEOSat broadband (fixed, mobile and portable), LEOSat IoT, and emerging DTH can together deliver farm wide connectivity that was previously uneconomic or impossible, unlocking significant productivity, safety and sustainability gains.

However, the physics and economics of LEOSat-enabled communications – shared capacity, line of sight constraints, handset power limits, signal propagation affects and constellation business risks – mean that these NTN technologies must be integrated thoughtfully with terrestrial networks and local autonomy.

[19] Ibid. 1

Below is a consolidated statement of what an ideal on-farm connectivity architecture looks like for Australian agriculture, designed for today's realities (blackspots, congestion, patchwork networks, skills gaps) and incorporating LEOSat-enabled broadband plus DTH as an overlay. It reflects the pain points raised by farmers (whole-farm coverage, safety, machine data, remote support, reliability) and the cross-stakeholder views (hybrid + redundancy, sovereignty / market concentration risk, integration and literacy gaps).

It combines:

- At least two independent backhaul pathways (typically one terrestrial and one non-terrestrial),
- A managed on-farm distribution network extending coverage beyond the farm house,
- A fit-for-purpose IoT fabric suited to large geographic areas,
- A DTH safety overlay,
- Integrated routing, network monitoring and security controls.

This architecture reflects the realities of Australian agriculture: large land areas, patchy terrestrial coverage, seasonal congestion, exposure to extreme weather, and limited on-farm IT hardware and infrastructure capacity.

Layer 0 — Design principles

The architecture is guided by five principles:

1. Coverage where work happens, not just at the house.
2. Safety and emergency response communications always available.
3. Redundancy to avoid single points of failure.
4. Fit-for-purpose network selection (broadband, mobility, IoT, safety).
5. Secure-by-default and simple to manage.

Layer 1 — Backhaul: "two pipes off-farm"

The farm should have two independent backhaul options:

Primary backhaul

- Fibre, fixed wireless, business-grade 4G/5G, or
- LEOSat broadband where terrestrial is absent or unreliable.

Secondary backhaul

- An alternative terrestrial service or satellite link configured for automatic failover via multi-WAN routing.

This ensures resilience during outages, peak harvest congestion, or weather disruption.

Layer 2 — Farm distribution: extend coverage beyond the farmhouse

Farmyard / infrastructure zones

- Enterprise-grade Wi-Fi and point-to-point links between sheds and buildings.

Broadacre / pastoral mobility coverage

- Private LTE/5G or long-range enterprise-grade Wi-Fi across paddocks and operational corridors where viable.
- Backhauled via terrestrial broadband or LEOSat.
- Reduces reliance on public mobile networks.

"Pop-up" nomadic operational hotspots

- Portable LEOSat terminal with integrated router and Wi-Fi access point.
- Creates a secure temporary connectivity bubble at remote yards, harvest zones, or temporary camps.

Layer 3 — Mobility and machinery: connect high-value moving assets

Machinery connectivity should be multi-bearer (able to use more than one communications pathway) and application-continuous:

- Terrestrial 4G/5G where available.
- LEOSat mobile terminals on selected high-value machinery.
- Intelligent routing including network failover to maintain application sessions during network transitions.

Design rule: Target satellite mobility to machinery where operational, productivity, or safety benefits justify the cost — not every implement requires satellite connectivity.

Layer 4 — IoT fabric: right network for sparse sensors

Adopt a mixed IoT strategy:

- LPWAN (e.g. LoRaWAN) for clustered infrastructure near sheds, yards and irrigation hubs.
- The LPWAN sensors may be locally network connected for on-farm monitoring only or additionally may communicate off-farm via the backhaul / Internet-connected gateway device
- Satellite-enabled IoT (LEOSat / NTN) for remote livestock tracking, water points, fence lines and wide-area environmental monitoring.

LPWAN is cost-effective in infrastructure clusters but can be impractical as a property-wide solution on large-scale enterprises.

Layer 5 — DTH overlay: safety and continuity for people

DTH provides a human-centric safety layer, enabling basic messaging when outside terrestrial coverage.

It supports:

- Lone-worker safety,
- Minimal communications during outages,
- Risk mitigation in remote areas.

DTH is not broadband and does not replace structured emergency communications systems. It complements, rather than substitutes for, terrestrial and satellite broadband layers.

The "Glue": Integration, Governance and Security

The architecture is bound together by:

1. Routing and service management

- Multi-WAN or SD-WAN-style routing with automatic failover.
- Quality of Service (QoS) prioritisation for critical traffic (voice, telemetry).
- A single monitoring dashboard for whole-farm visibility.

2. Practical security

- Network segmentation (office IT, machinery, IoT, guest).
- Strong identity controls and MFA for farm platforms.
- Managed configuration and patching where possible.

3. Lifecycle and procurement flexibility

- Standards-based LAN infrastructure to avoid lock-in.
- Flexibility to add or change backhaul providers as markets evolve.
- Modular design enabling incremental upgrades.

Overall:

The ideal on-farm connectivity architecture for Australian agriculture is hybrid, resilient and layered, combining terrestrial broadband, LEOSat backhaul, private on-farm wireless distribution, satellite-enabled IoT, and a DTH safety overlay.

It prioritises:

- Coverage where operations occur,
- Redundancy during peak production windows,

- Targeted satellite deployment where it delivers measurable value (noting GEOSat and MEOSat-enabled connectivity provide alternate satellite connectivity options to LEOSat-enabled connectivity although LEOSat provides significant benefits of high speed and low latency comparable to terrestrial networks,
- Secure and manageable integration,
- Human safety as a foundational requirement.

Rather than relying on a single technology, it deliberately integrates complementary networks to address the scale, operational intensity, and risk environment characteristic of Australian farming systems.

Recommendations

Strategic recommendations for regulatory, spectrum and investment settings planning are required to ensure Australian agriculture can access the full benefits of LEOSat-enabled connectivity, including emerging DTH services. Project stakeholders repeatedly emphasised that resilience, redundancy, sovereignty and practical operability must underpin LEOSat policy settings[20] and that LEOSat should not be the sole connectivity solution for users in rural and remote areas Drawing on the project's analysis[21] and stakeholder consultation, the following recommendations outline priority actions in regulatory, spectrum and investment settings to support resilient and future-ready connectivity for Australian agriculture.

Recommendation 1: Improve spectrum access pathways for regional and agricultural use

Refine spectrum allocation frameworks to:

- Support access to sub-1GHz spectrum in remote and lower-density areas where MNO allocated spectrum is underutilised (e.g. through secondary markets, local or shared licensing models, and tailored pricing) to support scalable regional wireless broadband coverage that complements LEOSat backhaul.
- Ensure spectrum access, pricing and licence renewal settings support investment in hybrid terrestrial-satellite connectivity models, including emerging DTH services that extend reliable outdoor voice and SMS capability across agricultural regions.
- Encourage cross-sector collaboration in spectrum planning and regional connectivity trials, enabling agriculture to benefit from shared infrastructure and lessons learned from other Australian sectors engaging with the space industry, including defence, emergency services and resources.

Recommendation 2: Encourage interoperability and multi-provider resilience

Monitor the development of the non-terrestrial telecommunications market and ensure that regulatory settings do not inadvertently reinforce single-provider dependency.

- Maintain technology-neutral procurement and public investment frameworks that encourage interoperability across emerging LEOSat platforms and incorporate digital education and value uplift not just subsidies for devices.
- Promote multi-provider resilience, through interoperable service standards where feasible.
- Explore sovereign resilience mechanisms where appropriate (e.g. requirements for diverse constellations, on-shore ground infrastructure, or participation in allied satellite programs) where appropriate.

[20] Ibid. 1
[21] Ibid. 15

Recommendation 3: Promote adoption of LEOSat-enabled connectivity in agriculture

Lift digital literacy and practical capability in the deployment of LEOSat-enabled connectivity.

- Support structured whole-of-farm connectivity planning to maximise the benefits of LEOSat deployment. Plans would consider integrated redundancy, lifecycle, whole-of-farm and security considerations.
- De-risk adoption appetite through targeted demonstration projects illustrating integration of terrestrial and LEOSat connectivity layers within the on-farm connectivity technology stack.
- Publish independent performance data from pilot deployments (latency, availability, throughput, device compatibility) to build industry confidence and inform procurement.
- Expand independent advisory and education services to provide practical planning guides, procurement frameworks and redundancy checklists. Improve farmer understanding of LEOSat-enabled connectivity options, device compatibility requirements and deployment considerations.

Recommendation 4: Strengthen sovereignty and security in LEOSat-enabled agricultural connectivity

Ensure growing reliance on LEOSat-enabled connectivity does not introduce new cybersecurity, operational or sovereign risks.

- Promote 'data secure-by-design' practices for LEOSat-enabled farm networks, including segmentation between farm IT systems, machinery platforms and IoT devices and the use of enterprise-grade security configurations where feasible.
- Encourage strong identity management, authentication and monitoring practices across farm connectivity environments, including for remote access to machinery and on-farm infrastructure.
- Incorporate cybersecurity guidance within connectivity co-investment and adoption programs that support LEOSat or hybrid services in regional areas.
- Consider Australia's strategic position relative to peer nations pursuing sovereign or co-developed LEOSat capability, and assess options to reduce long-term dependency on foreign-owned LEOSat infrastructure, for critical agricultural and emergency communications.

Recommendation 5: Recognise LEOSat-enabled connectivity as enabling infrastructure for digital agriculture

Direct digital agriculture gains towards achievement of ag-sector's productivity and profitability goals

- Recognise LEOSat-enabled connectivity as foundational infrastructure for digital agriculture, enabling automation, data-driven decision making and emerging AI-enabled farm management systems, with modelling indicating potential sector-wide productivity gains in the order of $15–20 billion annually.

- Ensure implementation of universal outdoor connectivity obligations considers cost-effectiveness and value for money, recognising the importance of sustainable funding models for regional telecommunications infrastructure and services.
- Consider mechanisms to reduce adoption barriers for LEOSat-enabled connectivity in regional industries, (e.g. targeted subsidies, shared infrastructure or community models) recognising that equipment costs, installation complexity and ongoing subscription fees remain barriers for some users.
- Recognise that LEOSat-enabled connectivity can improve workforce attraction, regional liveability and digital inclusion in agricultural communities where terrestrial coverage remains limited.
- Support targeted demonstrations and innovation programs showcasing agricultural applications of LEOSat-enabled connectivity, including machinery connectivity, IoT networks, robotics and remote diagnostics.
- Recognise LEOSat-enabled connectivity as eligible research infrastructure within agricultural R&D programs.

Recommendation 6: Promote hybrid connectivity architectures to improve resilience and redundancy

Support hybrid layered connectivity stacks combining terrestrial and LEOSat networks to improve resilience and operational continuity in agricultural environments.

- Encourage deployment of hybrid connectivity architectures combining terrestrial broadband, LEOSat backhaul and local on-farm wireless networks (e.g. private LTE/5G, Wi-Fi, LPWAN).
- Support connectivity models incorporating multiple independent communication pathways where feasible. (examples may include terrestrial + LEOSat + radio or mesh), to maintain, as far is reasonably possible, operations during outages or disasters.
- Ensure public investment and program design continue to support complementary terrestrial infrastructure alongside LEOSat-enabled connectivity to maintain redundancy and disaster resilience.
- Promote resilient network design practices, including multi-WAN failover, traffic prioritisation for safety-critical applications, and appropriate backup power arrangements at key sites.
- Provide guidance on whole-of-farm connectivity planning and integration across these layers.

Recommendation 7: Ensure telecommunications policy frameworks remain responsive to satellite-enabled connectivity

Ensure telecommunications policy and universal service frameworks remain responsive to the evolution of LEOSat broadband and DTH connectivity.

- Clarify how LEOSat-enabled broadband and DTH services interact with universal service and emergency communication frameworks particularly where terrestrial mobile providers rely on third-party satellite services to deliver coverage obligations.

- Promote transparent performance benchmarks and consumer information for LEOSat-enabled mobile services, recognising that service quality may vary depending on device compatibility, line-of-sight and environmental conditions.

- Ensure universal service frameworks incorporate enforceable service standards and independent performance monitoring across both terrestrial and NTN delivery models.

- Distinguish between baseline safety connectivity (such as DTH messaging and voice capability) which should be recognised as a core capability expectation for baseline outdoor mobile connectivity frameworks as compared to production-grade broadband required for agricultural operations and digitalisation.

- Ensure telecommunications programs remain technology-neutral and responsive to evolving NTN capability, including future developments in LEOSat, MEOSat, GEOSat and High Altitude Platform Stations (HAPS) systems.

Addendum

Since completion of the main research phase of this project a few developments in the commercial LEOSat-enabled connectivity space have occurred and are summarised below.

Starlink Mini in-motion service limitations

SpaceX (Starlink) has introduced updated operational conditions affecting the use of the Starlink Mini portable satellite terminal. In early March 2026, Starlink communicated through updated support documentation[22] and customer notifications that the Mini service plans (Standby Mode) are intended for stationary or portable use only and do not support operation while the terminal is in motion unless a mobility-enabled service plan and compatible hardware are used.

This clarification has implications for some Australian agricultural users who had adopted the compact Mini terminal for vehicle-based connectivity across large properties, including during spraying, harvesting, mustering or field inspections. While the Mini remains suitable for portable connectivity at temporary locations such as remote yards or field camps, users seeking reliable connectivity while vehicles or machinery are moving may need to consider mobility-approved Starlink hardware or alternative service plans.

The development illustrates the rapid evolution of commercial LEOSat service offerings and usage conditions. It reinforces a key finding of this project: that on-farm connectivity strategies should favour hybrid architectures and avoid reliance on a single service configuration, as product capabilities, pricing and permitted use cases in the satellite sector can change quickly.

Recent developments in DTH satellite capability

Announcements have been made regarding the development of satellite systems specifically designed to support DTH connectivity[23]. In early March 2026, SpaceX (Starlink) confirmed plans to deploy additional Starlink satellites incorporating cellular payloads capable of connecting directly to standard smartphones using mobile network spectrum in partnership with terrestrial MNOs. These developments are aligned with emerging 3GPP NTN standards designed to extend mobile coverage via satellite.

Technical constraints associated with handset antenna size, power limits and satellite distance mean that DTH connectivity is likely to remain a narrowband service layer in the near term. For Australian agriculture, the most immediate implication is improved safety and baseline communications capability across large areas of farmland that currently lack reliable mobile coverage.

Recent industry policy analysis from the GSMA[24][25] also highlights that the future development of DTH services will depend not only on satellite capability but also on regulatory frameworks governing how these services integrate with existing mobile networks. The GSMA has emphasised the importance of clear and harmonised policy settings for DTH services, particularly where satellite operators may seek to provide services outside traditional MNO partnerships. These considerations reinforce a central conclusion of this report: that the most resilient and productive connectivity

---

[22] Starlink Help Center, Can I use Starlink in-motion?, viewed 10 March 2026, https://starlink.com/support/article/50e933eb-54f5-1a77-cc85-c6c8325564cf.

[23] Lynch, G., Chan, T. for Communications Day, Starlink unveils Starlink Mobile brand, outlines D2D satellite network, 6 March 2026.

[24] Chan, T for Communications Day, GSMA highlights the need for standalone D2D regulation, 9 March 2026.

[25] GSMA, GSMA Releases Guidance to Support New Direct-to-Device (D2D) Satellite Services, 12 September 2025

architecture for Australian agriculture will remain a hybrid model, combining terrestrial networks, on-farm wireless systems and satellite connectivity, with DTH providing an important supplementary safety and coverage layer.

Additional stakeholder contribution

Following completion of the primary stakeholder consultation phase of this project, an additional consultation was undertaken with Telstra Limited. The discussion provided the perspective of a national mobile network operator engaged in regional telecommunications policy, infrastructure deployment and emerging LEOSat-enabled mobile services. Input from Telstra broadly reinforces the key themes identified from the wider stakeholder consultation process, particularly regarding hybrid connectivity models, the role of LEOSat technologies and the importance of digital capability in agriculture.

The Telstra contribution reaffirmed the characterisation of connectivity as foundational infrastructure for modern agriculture. It was emphasised that digital transformation across agriculture, depends fundamentally on reliable connectivity infrastructure.

Consistent with the broader consultation findings, Telstra emphasised that LEOSat connectivity should be viewed as a complementary layer within a hybrid connectivity architecture rather than a replacement for terrestrial telecommunications networks. Satellite services are expected to extend connectivity into areas beyond the economic reach of terrestrial infrastructure, while terrestrial mobile networks remain the most efficient and reliable solution where viable.

The consultation also highlighted the importance of connectivity planning and integration capability within agricultural technology deployments. It was observed that agricultural technologies are sometimes deployed without adequate planning for the most suitable connectivity solution, with cellular connectivity frequently assumed as the default even where coverage conditions are marginal. This observation reinforces a theme identified across several stakeholder sectors: that digital capability and connectivity planning remain significant barriers to effective adoption of advanced connectivity solutions in agriculture.

Telstra also confirmed that emerging DTH satellite services should presently be understood primarily as a safety and coverage extension capability rather than a broadband connectivity solution. In practical terms, these services are expected to provide basic messaging capability for workers operating beyond terrestrial mobile coverage, with additional functionality potentially emerging as device ecosystems and standards evolve. This position aligns with the broader stakeholder consensus that DTH services provide an important safety layer but do not address the production-grade connectivity requirements of digital agriculture systems.

While the Telstra consultation was largely consistent with the wider consultation findings, some differences in emphasis were evident. Concerns regarding reliance on a limited number of satellite providers were acknowledged, and the telecommunications sector perspective emphasised the evolving competitive landscape and the role of telecommunications providers in managing infrastructure risk through partnerships with multiple network and technology providers.

Overall, the Telstra consultation further supports the central conclusions of this project: that connectivity is now essential infrastructure for Australian agriculture; that LEOSat technologies are materially improving connectivity options in regional and remote environments; that resilient connectivity will depend on hybrid terrestrial–satellite architectures; and that improving digital capability and connectivity planning will be critical to enabling effective adoption of next-generation connectivity technologies in agriculture.

References

AgriFutures Australia & Connected Farms 2025, *Research Agreement – PRO-020848 – Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, AgriFutures Australia, Wagga Wagga.

Australian Government 2023, *Regional Connectivity Program and Mobile Black Spot Program information*, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Canberra.

Chan, T. 2026, *GSMA highlights the need for standalone D2D regulation*, Communications Day, 9 March 2026.

Connected Farms 2025, *Milestone 2 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, December 2025, [unpublished report].

Connected Farms 2026, *Milestone 3 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, January 2026, [unpublished report].

Connected Farms 2026, *Milestone 4 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, February 2026, [unpublished report].

Connected Farms 2026, *Next Generation Connectivity for Australian Agriculture: Project Overview Presentation*, [unpublished working document]

Connected Farms 2026, *Stakeholder Group Interview Design and Plans*, [unpublished working document].

GSMA 2025, *GSMA Releases Guidance to Support New Direct-to-Device (D2D) Satellite Services,* 12 September 2025, viewed 10 March 2026, https://www.gsma.com/newsroom/press-release/gsma-releases-guidance-to-support-new-direct-to-device-d2d-satellite-services/?utm_source=chatgpt.com

Lynch, G. & Chan, T. 2026, *Starlink unveils Starlink Mobile brand, outlines D2D satellite network*, Communications Day, 6 March 2026.

Regional Telecommunications Independent Review Committee (RTIRC) 2024, *2024 Regional Telecommunications Review Report*, Australian Government, Canberra.

Starlink Help Center, *Can I use Starlink in-motion?,* viewed 10 March 2026, https://starlink.com/support/article/50e933eb-54f5-1a77-cc85-c6c8325564cf.

Thomas, J, Barraket, J, Wilson, CK, Holcombe-James, I, Kennedy, J, Rennie, E, Ewing, S & MacDonald, T 2023, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2023*, RMIT University and Swinburne University of Technology, Melbourne.

References contained within the Connected Farms 2025, *Milestone 2 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, December 2025, [unpublished report]:

Australian Digital Inclusion Index 2022, *Case study: Breaking the inequality cycle – examining affordability barriers to digital inclusion*, viewed 5 December 2025, https://digitalinclusionindex.org.au.

Australian Digital Inclusion Index 2024, *Case study: Digital inclusion and the changing state of connectivity in regional Australia*, viewed 5 December 2025, https://digitalinclusionindex.org.au.

Australian Digital Inclusion Index 2025, *The 2025 findings*, 5 December 2025, https://digitalinclusionindex.org.au.

Australian Government 2025, *Australian Government response to the Independent Review Committee 2024 Regional Telecommunications Review*, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Canberra.

Connected Farms 2024, *The 3G shutdown and 4G struggles: What went wrong during the 2024 harvest?*, Connected Farms Blog & Knowledge Hub, viewed 5 December 2025, https://blog.connectedfarms.com.au/blog/the-3g-shutdown-and-4g-struggles-what-went-wrong-during-the-2024-harvest.

Connected Farms n.d., *Connectivity challenges in Australian agriculture*, Connected Farms website, viewed 5 December 2025, https://www.connectedfarms.com.au.

Regional Telecommunications Independent Review Committee 2024, *2024 Regional Telecommunications Review: Connecting communities, reaching every region*, Department of Infrastructure, Transport, Regional Development, Communications and the Arts, Canberra.

Regional Telecommunications Independent Review Committee 2024, *2024 Regional Telecommunications Review: Recommendations*, viewed 5 December 2025, https://www.rtirc.gov.au.

Thomas, J., Barraket, J., Wilson, C., Holcombe-James, I., Kennedy, J., Rennie, E., Ewing, S. & MacDonald, T. 2025, *Measuring Australia's Digital Divide: The Australian Digital Inclusion Index 2025*, ARC Centre of Excellence for Automated Decision-Making and Society, RMIT University, Melbourne.

References contained within the Connected Farms 2026, Milestone 3 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity, January 2026, [unpublished report]:

3GPP 2024, *Release 17 specifications*, 3GPP, viewed 13 January 2026, https://www.3gpp.org/specifications-technologies/releases/release-17.

3GPP 2025, *Non-terrestrial networks (NTN) overview*, 3GPP, viewed 13 January 2026, https://www.3gpp.org/technologies/ntn-overview.

ABC News 2025a, *Labor promise of NBN completion amid Starlink exodus*, Australian Broadcasting Corporation, viewed 13 January 2026, https://www.abc.net.au/news/2025-01-27/labor-promise-of-nbn-completion-amid-starlink-exodus/104839780.

ABC News 2025b, *Government not concerned about Australians using Starlink*, Australian Broadcasting Corporation, viewed 13 January 2026, https://www.abc.net.au/news/2025-02-07/government-not-concerned-elon-musk-starlink-australians/104905102.

ABC News 2025c, *Elon Musk's Starlink experiences global outage*, Australian Broadcasting Corporation, viewed 13 January 2026, https://www.abc.net.au/news/2025-07-25/elon-musks-starlink-experiences-global-outage/105571446.

Australian Competition and Consumer Commission 2025, *New high-speed NBN plans deliver faster internet speeds for households with FTTP and HFC connections*, ACCC, viewed 13 January 2026, https://www.accc.gov.au/media-release/new-high-speed-nbn-plans-deliver-faster-internet-speeds-for-households-with-fttp-and-hfc-connections.

Amazon 2025a, *Connected Farms chooses Amazon's Project Kuiper to power CommsXtend network*, Amazon, viewed 13 January 2026, https://www.aboutamazon.com.au/news/devices/connected-farms-chooses-amazons-project-kuiper-to-power-commsxtend-network.

Amazon 2025b, *Project Kuiper partners with nbn Co to bring low-Earth-orbit satellite broadband to rural Australia*, Amazon, viewed 13 January 2026, https://www.aboutamazon.com.au/news/innovation/project-kuiper-partners-with-nbn-co-to-bring-low-earth-orbit-satellite-broadband-to-rural-australia.

Coherent Market Insights 2025, *IoT in agriculture market report*, Coherent Market Insights, viewed 13 January 2026, https://www.coherentmarketinsights.com/industry-reports/iot-in-agriculture-market.

Connected Farms 2025, *Not all connectivity is equal: a comparison of on-farm connectivity*, Connected Farms Blog & Knowledge Hub, viewed 13 January 2026, https://blog.connectedfarms.com.au/on-farm-connectivity-knowledge-hub/not-all-connectivity-is-equal-a-comparison-of-on-farm-connectivity.

Department of Infrastructure, Transport, Regional Development, Communications and the Arts 2024a, *Analysis of low-Earth-orbit satellites and implications for Australia's agriculture and mining sectors*, Australian Government, Canberra.

Department of Infrastructure, Transport, Regional Development, Communications and the Arts 2024b, *Future communications could be written in the stars: LEO satellites*, Australian Government, viewed 13 January 2026, https://www.infrastructure.gov.au/department/media/news/future-communications-could-be-written-stars-leo-satellites.

Department of Infrastructure, Transport, Regional Development, Communications and the Arts 2025, *Universal Outdoor Mobile Obligation draft legislation consultation*, Australian Government, viewed 13 January 2026, https://www.infrastructure.gov.au/have-your-say/consultation-universal-outdoor-mobile-obligation-uomo-draft-legislation.

Digital Regulation Platform 2025, *Satellite direct-to-device services*, Digital Regulation Platform, viewed 13 January 2026, https://digitalregulation.org/satellite-direct-to-device-services/.

Ericsson 2024, *Satellite direct-to-device communication*, Ericsson Technology Review, Ericsson, viewed 13 January 2026, https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/satellite-direct-to-device-communication.

Fujitsu 2024, *LEO satellite broadband*, Fujitsu Global Vision Series, Fujitsu Ltd, viewed 13 January 2026, https://global.fujitsu/en-global/about/vision/leadership-challenges/22-leo-satellite-broadband.

GSMA 2025a, *Satellite direct-to-device spectrum considerations*, GSMA Mobile Policy Handbook, GSMA, viewed 13 January 2026.

GSMA 2025b, *Guidance to support new direct-to-device satellite services*, GSMA, viewed 13 January 2026.

GSMA Intelligence 2022, *Satellite 2.0: going direct-to-device*, GSMA Intelligence.

Ground Control 2025, *How satellite connectivity is unleashing precision forestry*, Ground Control, viewed 13 January 2026.

InsightAce Analytic 2025, *IoT in agriculture market*, InsightAce Analytic, viewed 13 January 2026.

IoT Now 2024, *How IoT is transforming yields and optimising resources in agriculture*, IoT Now, viewed 13 January 2026.

IoT Now 2025, *Agriculture satellite functionality supports the smart farms of the future*, IoT Now, viewed 13 January 2026.

International Telecommunication Union 2025, *Direct-to-device satellite connectivity presentation*, ITU.

Johns Hopkins University Applied Physics Laboratory 2024, *Space-enabled agriculture: John Deere, Starlink and the autonomous future*, Johns Hopkins University, viewed 13 January 2026.

Kratos Space 2024a, *Satellite IoT: connecting farming's future*, Kratos Defense & Security Solutions, viewed 13 January 2026.

Kratos Space 2024b, *Deere and Co on deployment of Starlink on farm machines*, Kratos Defense & Security Solutions, viewed 13 January 2026.

MarketsandMarkets 2024, *IoT in agriculture market – global forecast*, MarketsandMarkets, viewed 13 January 2026.

Meat & Livestock Australia 2024, *Connectivity and digital agriculture research report*, Meat & Livestock Australia, viewed 13 January 2026.

Mirage News 2024, *LEO satellites could shape the future of connectivity*, Mirage News, viewed 13 January 2026.

Mobile Satellite Services Association 2025, *Considerations for direct-to-handset satellite technology*, MSSA.

Mobile World Live 2024, *John Deere puts Starlink through its paces in rural areas*, Mobile World Live, viewed 13 January 2026.

nbn Co Ltd 2025, *nbn selects Amazon Project Kuiper for satellite broadband services*, nbn Co Ltd, viewed 13 January 2026.

Omdia 2025, *Satellite IoT market landscape*, Omdia.

Optus 2025a, *Optus connecting regional Australia with fast-tracked 5G rollout*, Optus, viewed 13 January 2026.

Optus 2025b, *Optus and SpaceX satellite connectivity partnership*, Optus, viewed 13 January 2026.

Precedence Research 2025, *IoT in agriculture market*, Precedence Research, viewed 13 January 2026.

Reuters 2025, *Australia's NBN signs Amazon satellite service deal*, Reuters, viewed 13 January 2026.

RMSI 2025, *How LEO technology is revolutionising global connectivity and innovation*, RMSI, viewed 13 January 2026.

Runway Girl Network 2025, *OneWeb outage underscores value of multi-orbit connectivity*, Runway Girl Network, viewed 13 January 2026.

SatNews 2024, *John Deere and SpaceX expand rural connectivity for farmers*, SatNews, viewed 13 January 2026.

Satellite Today 2024, *John Deere selects Starlink for agriculture connectivity solution*, Satellite Today, viewed 13 January 2026.

Space Connect 2025, *Telstra wins race to launch direct-to-cell satellite service*, Space Connect, viewed 13 January 2026.

Starlink 2024a, *Starlink roaming service information*, SpaceX Starlink, viewed 13 January 2026.

Starlink 2024b, *Starlink legal and regulatory documentation*, SpaceX Starlink, viewed 13 January 2026.

Telstra 2025a, *Satellite-to-mobile connectivity trials*, Telstra Exchange, Telstra Corporation Ltd, viewed 13 January 2026.

Telstra 2025b, *Telstra launches satellite messaging service*, Telstra Corporation Ltd, viewed 13 January 2026.

The Verge 2025, *Amazon Project Kuiper satellite internet partnership with NBN*, The Verge, viewed 13 January 2026.

Vocus 2025, *From niche to mainstream: how LEO satellite is transforming remote Australia*, Vocus Communications, viewed 13 January 2026.

Wiggin LLP 2025, *Direct-to-device satellite connectivity outlook for 2025*, Wiggin LLP.

Wyld Networks 2025, *Revolutionising Australian agriculture with LEO satellite IoT connectivity*, Wyld Networks, viewed 13 January 2026.

Zabirov, D. 2025, *3GPP Release 17 NTN direct-to-device developments*, LinkedIn post, viewed 13 January 2026.

References contained within the Connected Farms 2026, *Milestone 4 Progress Report – PRO-020848: Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-Enabled Connectivity*, February 2026, [unpublished report]:

GSMA 2023, *New GSMA report shows low-band spectrum is required to tackle the rural connectivity gap and help unlock rural economic growth*, GSMA, viewed 20 February 2026, https://www.gsma.com/newsroom/press-release/new-gsma-report-shows-low-band-spectrum-is-required-to-tackle-the-rural-connectivity-gap-and-help-unlock-rural-economic-growth/.

Next Generation Connectivity for Australian Agriculture: Assessing the Impact of LEOSat-enabled Connectivity
Final Report

by Connected Farms Pty Ltd
March 2026

AgriFutures Australia publication no. **26-01p**

AgriFutures Australia

Building 007
Tooma Way
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2650

02 6923 6900
info@agrifutures.com.au

agrifutures.com.au