MEAT & LIVESTOCK AUSTRALIA

milestone report

Project code: P.PSH.1206

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Date published: 15 October 2019

PUBLISHED BY
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SoleMate (Save our Soles) – Phase Two

FINAL REPORT

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The SoleMate device requires a reliable connection to the user's emergency contacts and cellular connections are not reliable in rural areas due to the low population density making more cell-towers economically unfeasible. This milestone report covers a survey of the available literature on long-range connectivity options for portable, embedded devices, and gives four viable technology pathways for further investigation: LoRaWAN, Sigfox, NB-IoT and satellite phones. It also covers a survey of the field of personal emergency alert devices and compares them functionally and economically against the SoleMate. The SoleMate device's price point and functionality compare favourably against devices on the market and it offers two unique points of difference that we believe are commercially deciding factors: a low-cognitive load and automatic incapacitation sensing.

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Executive Summary

This project includes a detailed report on available literature on various connectivity options, including rural coverage, future technologies, and connection blindspot mitigation strategies. Report to also include SWOT on current competitive products, est value-based pricing, est COG and market size & share analysis.

Project objectives

- To find solutions for the two fundamental issues; connectivity and accuracy.
- To determine the exact limitations of the SoleMate device are, and depending on the result will determine the next steps (Phase Three and onwards).
- Details report on device's event detection accuracy with investigation avenues highlighted.
- Chip algorithm improved and validated.
- Detailed report on research into connectivity solution/s, including rural field testing.
- Summation of Phase Two, including final report and identification of next steps (Phase Three).

Success in meeting the milestone

A report on the connectivity options for an emergency alert device has been compiled and is included in the appendix.

Various connectivity options have been identified and assessed for relevance to the SoleMate device, with recommendations made for future testing. Blindspot mitigation strategies have also been identified.

The report document also details SWOT on competitive products, as well as estimated value-based pricing, cost of goods and market size analysis of the SoleMate device. Market share prediction was made based on alternate products.

Discussion

During the investigation, it became clear that there is a plethora of technology designed to overcome the signal loss and connection range issues, which could readily apply to farmland. Several agriculture companies are already investing in the deployment of these technologies in trial phases.

Now is a good time to develop embedded systems with these channels of communication in mind, where just two years ago it had been inconsiderable from a small company’s perspective.

There are terrestrial and satellite-based connectivity solutions coming into market within the next decade that should entirely alleviate the internet blind-spot problem inherent to most rural work. The recommended technologies’ specifications meet the SoleMate’s reliable connection benchmark but will need to be demonstrated reliably in testing for them to receive the confidence required to ensure farmers’ safety.

Conclusions/recommendations

Technology Recommendation

Of the competing communications protocols surveyed, LoRaWAN, NB-IoT, Satellite Phones and Sigfox seem the most viable technologies for investigation within the next year. Other technologies are either on the cusp of accessibility (satellite systems are 2-7 years away), have no hardware development kits available (due to a lack of adoption of the standards), or are intended for more power intensive use cases (like constantly connected assets).

These four technologies are proven long-range communication systems, are positioning themselves in the Australian market as infrastructure and so are aiming for growth and have support for small scale testing and development.

LoRaWAN and sigfox base stations may be deployed easily, NB-IoT uses existing cellular networks but with up to five times better range, and satellite systems are readily accessible, so these are ideal test candidates.

In terms of their suitability for the device, each might be capable of delivering more than 95% connection time, can transmit more than 12 bytes per message and can have an external system or the internet as an endpoint. However, satellite phones may not meet the low behavioural interference requirement set out earlier in the report, requiring suitable placement for satellite connection, and satellite phones often have standby times measured in days, rather than months like we expect of our device.

LoRaWAN, Sigfox and NB-IoT have been used in emergency alert devices previously, and satellite phones are generally reserved for this purpose too, due to their extreme pricing. We are confident in recommending these four technologies for further testing.

Market analysis

There are several technologies on the market being sold as emergency alert devices, though these are either manually activated or require regular recharging. The value-based costing of similar devices fit into a price bracket of $100-$250, some with yearly subscriptions in the realm of $120-$300 to maintain service.

With our cost of goods estimated as sitting at $90 per device using LoRa, Sigfox or NB-IoT, we are comfortable in the device’s economics.

Long Range Communications Technologies for Australian Farms

Survey of the field of civilian mid-long range communication technologies for use with an embedded personal safety device

> *"Detailed report on available literature on various connectivity options, including rural coverage, future technologies, and connection blindspot mitigation strategies. Report to also include SWOT on current competitive products, est value-based pricing, est COG and market size & share analysis."*

The purpose of this report is to provide a summary of the connectivity options for the developed personal emergency alert device and provide a technology recommendation for future development. This report is also to include some financial analysis for the various technology companies in comparison to the device.

1 Summary of communication requirements for our device

- Connection capability at all times on farm (or >95% of the time if always connected with server-side dropout mitigation strategies)
- Low data rate requirement (less than 20 bits per second for around 2 messages per minute, assuming 20 byte payload)
- Connection to a wider communication system, potentially the internet as an end-point
- Treated like the emergency communication system that it is
- Maintain low behavioural interference strategy of the current device
  - Must remain powered without too much intervention, cognitive overhead, etc
  - Must remain connected in a similar manner

This device is designed to signal an automatic request for medical assistance from a nominated contact based on estimated user incapacitation or user-activated distress.

As an emergency device, the signal output should be reliably sent by the device and received by the response-alerting network in all reasonable cases.

2 Technology Investigation and Summaries

Initially, this project assumed that the user would have reliable access to the internet through a cellular connection. During an on-site trial phase, this presumption that we could rely on a cellular connection proved to be false while testing on farmland, and so a new communication technology was required. To that end, this report investigates three categories of wireless communications technology: Low-Power Wide Area Networks (LPWANs), Satellite communication and traditional networks.

2.1 LPWAN Technologies

LPWAN (Low-Power Wide Area Network) is a type of network architecture defined by its low power requirements and long-range communication capability, enabling battery-powered communication solutions over large areas with minimal infrastructure investment. All of these technologies rely on a base station being within range and connected to a larger network, similar to a cellular network. The primary difference between these and a cellular network is the reliable transmission range at a low power requirement.

There are several competing specifications and companies on the market. In an LPWAN system, tradeoffs must be made between effective range, power use, number of supported devices and transmission speed, and the four market-leading technologies demonstrate these tradeoffs with their own unique offerings.

The four market-leading technologies are LoRaWAN, sigfox, NB-IoT and LTE-M, which will be covered later in this section. Currently NB-IoT and LTE-M are available on current cellular networks, sigfox is being slowly deployed around Australia by Thinxtra and LoRaWAN is an open standard that several Australian city councils have deployed to enable smart business solutions.

Amazon has thrown their hat in the rink recently, too, with the Amazon Sidewalk protocol, though they are only in the testing phase with no consumer hardware available.

Several LPWAN technologies have arisen and since stopped being supported, or have not grown into available consumer hardware, like NB-Fi, RPMA, DASH7 and Weightless.

2.1.1 LoRaWAN

Technology Summary

A Media Access Control (MAC) protocol for wide area networks, to enable low-powered devices to communicate with internet-connected applications over a long-range wireless link. It uses the LoRa standard developed by the Semtech Corporation.

All LoRa devices implement a bi-directional communication channel. Class A transmits an "uplink transmission" with two separate time windows for remote server communication. Class B adds a scheduled receive window with intermittent time synchronisation beacons. Class C always receives while it isn't sending. The frequency band of transmission is Australia 915-928 MHz for uplink and 902-928 MHz for downlink. LoRaWAN uses LoRa modulation.

Supports 5-15km range, 51-222 bytes per message. Configured in a star-of-stars network topology where the central gateways act as a transparent bridge to IP and, thus, the internet. Uses Chirp Spread Spectrum technology to minimise 'collisions'.

LoRa devices can be located by *Differential Time of Arrival* (McHoul 2017), though the accuracy is limited by its distance to several network receivers, where being closer to more receivers will give higher accuracy.

Availability, Legality and Coverage

LoRaWAN runs its frequency emissions in Australia within an unlicensed spectrum, and so is allowed by Australian law, and is able to be run without special dispensation being required.

There are several prominent companies in Australia deploying LoRaWAN systems locally. These vary from companies providing the hardware and knowledge necessary for farmers to run their own networks, to companies building themselves out as Communications Service Providers by constructing LoRa enabled towers or satellites.

NNNCo is one such provider, which has partnered with Discovery Ag for work on the Connected Country initiative (Corner 2017).

The LoRaWAN alliance includes more than 300 companies, and this large industry support should ensure deployment and the availability of support devices.

Coverage Map

In our survey of the literature, we couldn't find a complete coverage map for LoRaWAN in Australia. However, deployments have been made and tested in Launceston, Lake Macquarie (Nelly 2018), Newcastle (Bushell-Embling 2018), Townsville, Sydney (Barangaroo), and Melbourne (Reichert 2016).

License and Pricing

Developing a device that uses the LoRa standard requires a $1000 license per annum per company. The LoRa command set is a closed standard, and there is only one Integrated Circuit (IC) vendor supplying licensed chips, Semtech (Ray 2015). This means that the pricing and availability of LoRa devices may change pending the decisions of one company.

Private LoRa networks are fully supported and may be run for the price of the hardware and power, though likely there will be many subscription services where one may pay by the message processed or on monthly cycles. Some governments are providing LoRaWAN systems as part of a free service for promoting business, like in Newcastle.

Relevance

LoRa is a low-power, long-range communication protocol that can be embedded in our device. The expectation is that LoRa will be deployed by farms for more remote devices, and that our system may piggyback on that system. Mounting a higher-power and better-situated LoRa repeater on a vehicle is also enabled by this architecture.

Future

The future of LoRaWAN is bright, with multiple companies seeking to improve the technology and availability. One company, Lacuna Space, is planning to deploy LoRaWAN receivers as satellites in Low Earth Orbit to enable a world-wide LoRaWAN system.

2.1.2 Sigfox

Technology Summary

Sigfox is a long range, low-power communication system in a star network architecture. It supports 12 bytes per payload for uploads and 8 bytes of data for download but expects fewer than 12 packets to be sent per day per device. As such, the access stations are only able to process 70,000 messages per day (which indicated a data rate of around 10 bytes per second).

Uses a proprietary chirp-spread-spectrum broadcast system that should reduce message collisions. Devices do not require an acknowledgement for message receive and have to initiate data retrieval.

All data packets go to the Sigfox cloud platform, where the user may access the data through an internet connection.

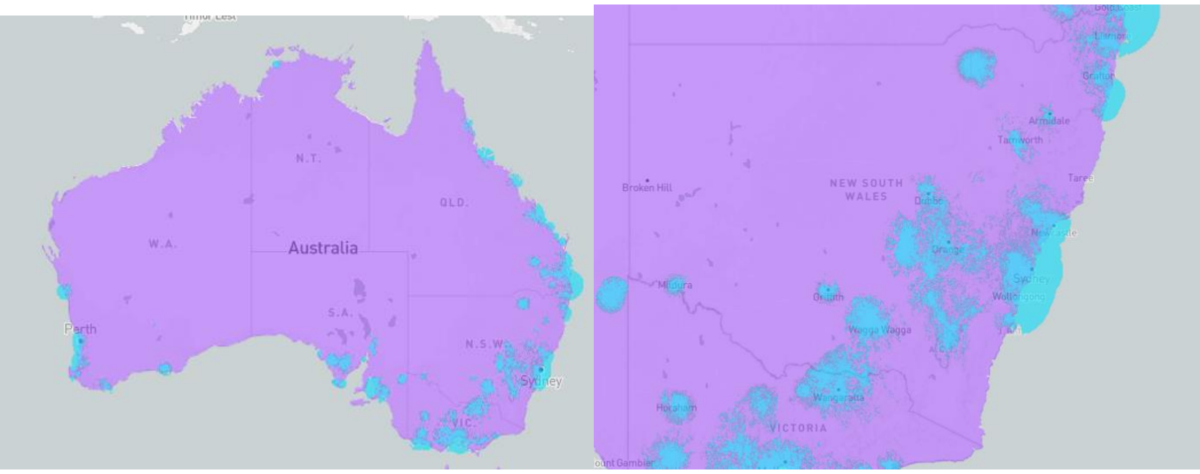
Sigfox provides a device locating feature named Sigfox Geolocation, which supports 500m accuracy (McHoul 2017).

Availability and Coverage

Sigfox is proprietary LPWAN technology common in Europe with a first mover advantage. Thinxtra is the Australian Service Carrier for the Sigfox network. Currently it is still being deployed in Australia, but the coverage may be extended to rural properties using a $20/month base station plugged into their local connection to the internet. These base stations provide around 4km of access, depending on the terrain.

There are several technologies available that use the Sigfox system, and there are ICs available from several vendors that support its broadcast technology.

Coverage Map



Sigfox coverage map of Australia, courtesy of sigfox. Blue is estimated coverage.

License and Pricing

$2 per device per year with 10 messages per day allowed is the price scheme that Thinxtra is using. This is whether the device uses the provided network or rents a local base station.

Relevance

This technology that might be useful for our purposes but will require more distribution and coverage from Thinxtra to be effective. All data goes through Sigfox's cloud network though, which could be a weak link in the information chain.

Future

Thinxtra is pushing Sigfox toward saturation in Australia and is working with industry partners to choose the best locations for deployment. It may become a leading figure, depending on how other technologies develop.

2.1.3 NB-IoT (Narrow Band IoT)

Technology Summary

NB-IoT is a cellular based transmission system that relies on mobile phone reception in the area to communicate (3G/4G networks only, currently). The range of the connection has recently been extended to a maximum range of 100km (Foye 2018) from each cell base station. This protocol is supported by the Telstra network. The protocol, as contrasted with LTE-M, is more suitable for static, low-data rate installations (Sierra Wireless 2018).

Uses Frequency Division Multiple Access on uplink and Orthogonal FMDA on the downlink. Quadrature Phase Shift Keying modulation.

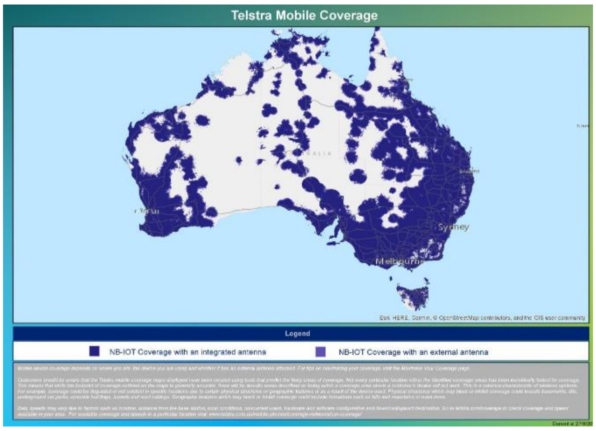
NB-IoT can send far more packets of data than LoRaWAN in a given period, with a higher bandwidth, similar locations supported and less latency. However, the infrastructure requirements are greater than LoRa or Sigfox, requiring a normal cell tower and location licenses from the government, which results in less coverage of rural areas.

NB-IoT consumes higher currents during transmission than non-cellular techniques, being a synchronous communication technology (120mA of current consumption). This technology uses the licensed radio frequency spectrum, which can be problematic to acquire, and often uses the same transmission end points as regular mobile phone connections. NB-IoT uses sim cards, and so has recurring costs on a subscription plan and a sim-card, rather than being operated privately by the user like a LoRaWAN may be.

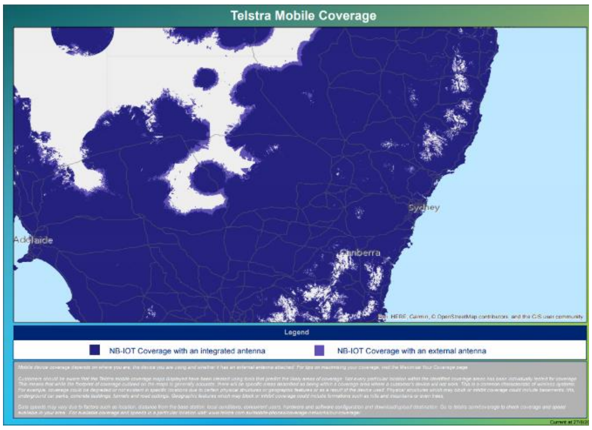
NB-IoT devices can be located spatially by their proximity to cell towers (McHoul 2017), allowing some level of precision in location accuracy determined by proximity to multiple cell towers.

Availability and Coverage

This technology is supported by Telstra's cellular network, and so is available wherever cellular reception is available. The technology also supports longer connection distances than regular cellular (where 1 bar of reception is around 15km (Zhang. A 2017)), with up to 100km of unobstructed connection.



Estimated NB-IoT coverage map (the Cat M1 Network) of Australia provided by Telstra



Estimated NB-IoT coverage map of NSW provided by Telstra

License and Pricing

Uses a sim card, with scaled costs pending data use. The lowest cost of a data-enabled plan is $1.45 per month, which is about parity with the Sigfox network.

Telstra Wireless M2M plans	PAYG	30KB	50KB	100KB	500KB	1MB	3MB	5MB
Monthly Charge Casual month to month	$0.90	$1.45	$1.60	$1.90	$2.30	$3	$4	$5
Monthly Data Allowance	0KB	30KB	50KB	100KB	500KB	1MB	3MB	5MB
What's Not Included	Your plan does not include M2M equipment, hardware, calls, SMS, MMS, circuit switched data services or International roaming.							
Excess Data Charge	$30 per MB	$20 per MB	$20 per MB	$10 per MB	$5 per MB	$3 per MB	$1.30 per MB	$1.00 per MB
Telstra Wireless M2M plans	**10MB**	**150MB**	**300MB**	**1GB**	**3GB**	**7GB**	**12GB**	**20GB**
Monthly Charge Casual month to month	$7	$10	$15	$20	$39	$69	$99	$169
Monthly Data Allowance	10MB	150MB	300MB	1GB	3GB	7GB	12GB	20GB
What's Not Included	Your plan does not include M2M equipment, hardware, calls, SMS, MMS, circuit switched data services or International roaming.							
Excess Data Charge	60c per MB	6c per MB	4c per MB	3c per MB	3c per MB	10c per MB	5c per MB	5c per MB

Telstra's M2M pricing policy, edited for clarity. Retrieved 2019 Telstra

Relevance

Because access to this technology is available with up to 100km of cellular reception, it may be a viable communication channel for our purposes.

Future

As Telstra increases its cellular rollout to underserved and rural areas under the Australian government's mobile black spot program (Aus. Gov 2019) this service should become more and more available to farms.

2.1.4 LTE-M (LTE Machine Type Communication)

Technology Summary

LTE-M uses the same cell towers that provide the 3G/4G phone networks for data carrying, with a similar range for connection. Devices using this system can arbitrarily access internet endpoints though, allowing for more complex server architecture at the cost of more bandwidth requirements per packet sent.

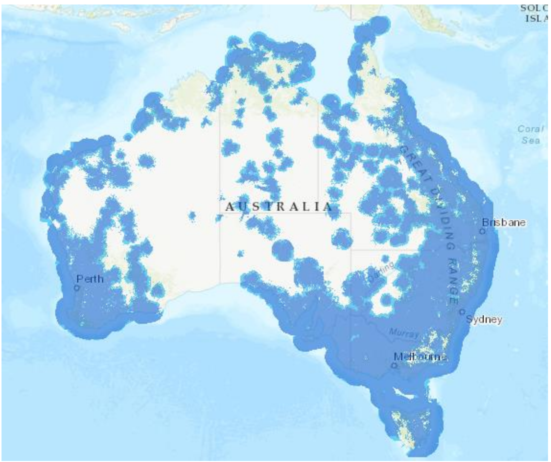
This service is faster than NB-IoT with more bandwidth and may support voice. More expensive to use, rather power hungry compared to other LPWAN technology and supports limited frequency bands. This technology is currently supported by Telstra and Vodaphone in Australia.

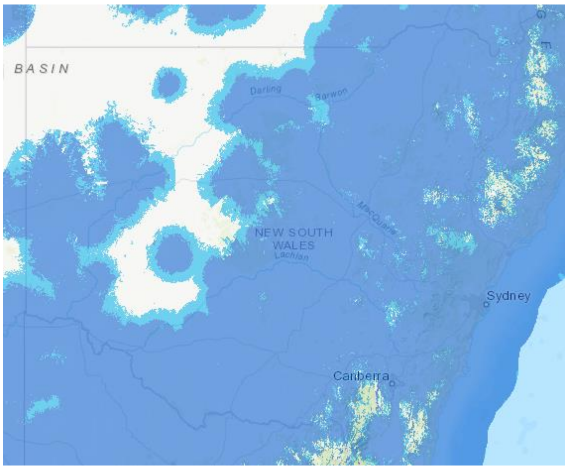
Supports bi-directional communication, allowing the endpoint devices to both send and receive data.

LTE-M devices can be located physically, based on their distance to cell towers (McHoul 2017).

Availability and Coverage

LTE-M is available through the Telstra network wherever cellular reception is available.





Estimated LTE-M coverage map of NSW provided by Telstra

Estimated LTE-M coverage map (the Cat M1 Network) of Australia provided by Telstra

Development modules are readily available for this technology, but as they require a SIM card, they need to be registered to a person.

License and Pricing

Telstra provides similar pricing terms for its LTE-M service as for NB-IoT, in that there are monthly fees based on per-unit data usage. Refer to the M2M fees chart in the NB-IoT section.

LTE-M device modules have a $2.50-$5.00USD license fee from Ericsson (DeGrasse 2017), which is baked into the supplier cost. This will limit the adoption for LTE-M technology in more disposable-style, or saturated-style, devices, but will not be a hurdle for our use case.

Relevance

This technology could be useful for our device, though it has less range than the similar NB-IoT.

2.1.5 Amazon Sidewalk

Technology Summary

Not much is known about Amazon Sidewalk (Lardinois 2019) but it is likely to be a low-power, long range, proprietary access technology that can freely be integrated into other technologies. Amazon is producing it with the goal of introducing it to portable devices that leave WIFI range, like a dog collar tracker.

It uses the 900MHz bandwidth, like other unlicensed spectrum LPWAN technologies.

Availability and Coverage

Tests have been performed in Los Angeles with 700 end-point devices. No announcements have been made for Australian release.

License and Pricing

Unknown at this point. Potentially the system would be a subscription-based model. Amazon Alexa may be a parallel to this service, which has a business price of $7 per device per month.

Relevance

Amazon Sidewalk is a technology that is backed by one of the largest companies in the world. Just as Amazon's Alexa is being integrated into practically every internet-connected device, we're likely to see Amazon Sidewalk be integrated into practically every non-internet connected device, pending roll-out.

Future

This technology is in its infancy and is likely to roll-out around the world quickly, as Amazon's other services tend to. We can expect to see consumer devices and development kits released within the next six to twelve months for an American audience.

Amazon is also building a Low-Earth-Orbit (LEO) satellite constellation (Sheetz 2019) for global internet access, so the Amazon Sidewalk technology could feasibly see satellite coverage in the near future.

2.1.6 NB-Fi

Narrowband Fidelity (NB-Fi) is an open-standard, full-stack LPWAN technology. Each base station can process 2 million node devices and can operate in the license free spectrum space (868 MHz and 915 MHz specifically).

Up to 30km range, with a star-topology network (waviot, 2017). The technology is available, but there are no service carriers using this technology.

2.1.7 RPMA (Random Phase Multiple Access)

RPMA is a proprietary LPWAN technology developed by the company Ingenu.

It supports communication speeds of up to 31kb/s download, and 15.6kb/s upload. It has no built-in location finding system (MCHoul 2017). A single access point can support 535,117 messages per hour (M. Albra *et al*. 2019). The RPMA technology has reportedly "tailed off" and is not considered a viable solution going into the future (everythingRF 2018).

2.1.8 DASH7

DASH7 is an LPWAN technology based around the ISO specification for 433 MHz ISM band active RFID communication in military logistics. The modifications for this standard enable low-latency, bi-directional networking in low-power communication (Haystack 2019).

DASH7 is an open source communication stack with a range of 2km with 20mA of current consumption. It was most recently updated in 2017.

DASH7 supports node-node connections, unlike most of the other LPWANs that work in star-network topologies. This is most similar to Bluetooth, where individual devices connect to each other directly, contrasted with Wi-Fi, where devices connect to each other through a central router device (Mainsah, *et al.* 2015)

As DASH7 is an open standard, it has been implemented in several development kits alongside other systems (like LoRa), however, technology using the DASH7 standard is light on the ground. Free to use license. Not that useful for our use case, due to its short range.

2.1.9 Weightless

Weightless is an LPWAN specification, and is currently the only open standard LPWAN technology (IoT Global Network 2018).

It is designed for more than 4km of range, with lots of frequency ranges available to suit different markets. It supports scalable data rates from 0.6kbps to 100kpbs, bi-directional communication (with high enough bandwidth to allow over-the-air firmware updates and can talk to a cloud server backend.

Since becoming available in 2013, Weightless has released three different standards: N, P and W, each with different ranges and features. Weightless devices do not have in-built location services (McHoul 2019).

This protocol has been noted as lacking hardware availability. The primary source of the silicon chips appears to be the company, Ubiik, and it appears that Nwave is one of the few companies deploying smart devices using this standard. There are currently no notable installations of Weightless in Australia. Weightless has slipped into obscurity in the market, with very few companies offering development kits.

2.2 Satellite Communications

Communication with man-made satellites has been a staple in the safety of ocean-going boats, hikers, inter-continental planes, and 4WD adventurers. There are also satellites in operation that provide broadband internet connections and phone link up to regional Australia. However, there has been significant movement in the satellite business with cheaper launch vehicles following the commercialisation of rocket launches and the development of miniature satellite technology (cubesats).

As such, the time is ripe for considering satellite based IoT connections.

All communication satellites sit in either Geostationary Earth Orbits (GEO) or Low Earth Orbits (LEO).

Geostationary satellites sit stationary relative to a location on earth, and so offer a reliable signal strength. Geostationary satellites orbit further away from the earth's surface and so require larger, more powerful antennas and incur a longer communication delay. Because geostationary satellites hover over one location exclusively, reception in that area is always available.

LEO satellites are in a lower orbit, which requires the satellite to be constantly moving at high speed relative to the earth to maintain its height. This movement means that the LEO satellites are always coming in and out of the range of terrestrial stations, requiring more sophisticated connection handovers to other satellites in the constellation to maintain a stable connection. The advantage of a low-earth orbit is the shorter distance to the ground. This closeness reduces the amount of power that a radio transmission needs to reach the satellite and reduces the delay between the signal being sent and being received.

The currently available communication technologies are primarily geo-synchronous and are massively expensive to build, then launch (the NBN Co has two satellites in orbit that provide internet, and cost $1 billion each with 13 years of expected lifespan).

There are several private companies appearing with aims to launch thousands of small satellites into massive constellations, enabling them to blanket the whole world with connection to the internet. Some use custom interfaces (like a dinner-plate sized receiver from SpaceX), while others are trying to emulate terrestrial technologies (LoRa, 2G cellular, etc) on an orbital platform.

The primary advantage of a space-based system is the ease of getting line-of-sight to one. The biggest hindrance to terrestrial wireless communications systems is the propensity of matter to block their transmissions, with hills, trees and buildings interrupting line-of-sight, which significantly reduces their effective range. Space-based solutions, when they are overhead, have line-of-sight to most of the earth’s surface, which gives them uninterrupted range, and more reliable connections.

2.3 Current Satellite Technology

2.3.1 Satellite Phone

Technology Summary

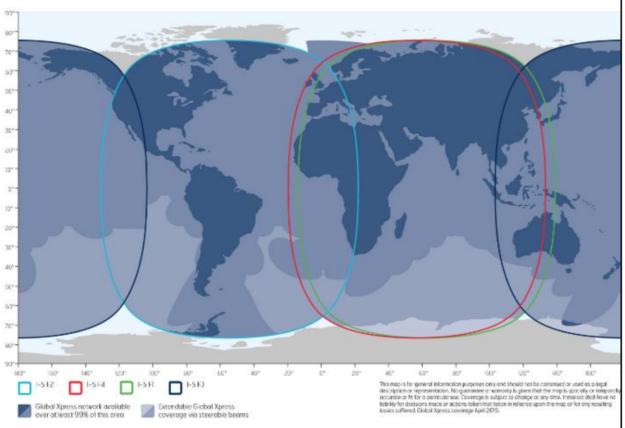
Satellite phones allow phone calls and text messaging like regular phones but use satellite communication instead of cellular communication. These satellite phones are often the size of a normal phone, but are coded to a particular satellite network, and don't work on other services. They are subscription based.

Availability and Coverage

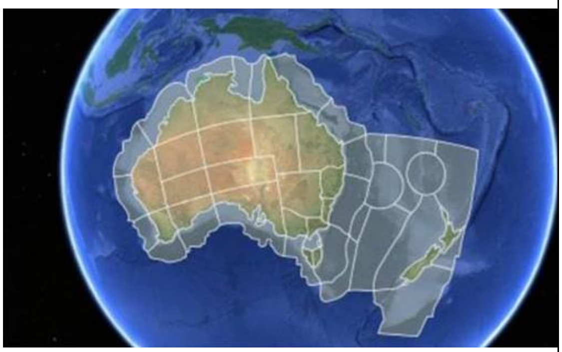
Satellite phones and emergency phone services are provided by companies that maintain satellite phone services, such as Iridium (LEO), Inmarsat (GEO), GlobalStar (regional GEO), Thuraya (regional GEO).

Coverage Map

Each satellite phone provider has a different coverage map, Inmarsat and Iridium are indicative of GEO and LEO satellite coverage, respectively.



Inmarsat's data coverage map (source)



Iridium Australian Coverage map

License and Pricing

The phones themselves cost between $500 and $1145 USD (bluecosmo 2019), and 10 minutes of conversation+10 text messages per month costs an additional $640 USD per year (though incoming calls and text messages are apparently free).

Satellite phones have between 30 and 160 hours of standby time, so will need to be charged at least once a week. Deploying a satellite phone system embedded in the device will likely increase the price prohibitively and require redevelopment for new regions pending satellite service availability.

Relevance

Satellite phones could be used as a second link for our device, where the device communicates first to the phone via some terrestrial link (like Bluetooth), and then the phone communicates the signal via satellite to another phone. Building the technology of a satellite phone into our device is also possible but would likely be exorbitantly expensive per unit to develop and high-power.

2.3.2 Satellite Broadband

Technology Summary

Satellite broadband is a broadband internet service provided by satellite. An 80cm - 120cm satellite dish and receiver are installed on-site and oriented to point toward the best satellite.

The NBN Company has two satellites for providing regional Australia with access to the NBN, Sky Muster and Sky Muster II, which each support 100 communications beams with 80 gigabits of communication data throughput per second (SpaceFlight101 2016).

These satellites then communicate with several ground stations that provide a link to the rest of the internet.

The NBN Co. has demonstrated vehicles outfitted with self-aligning satellite dishes that provide a wireless hotspot for internet activity, which allows mobile, broadband internet access.

Availability and Coverage

The NBN Co. reports that satellite broadband is available to 400,000 homes in Australia (the nbn project 2016).

License and Pricing

$200 per month per dish.

Relevance

If vehicle mounted, this system could be used for the second-link approach, where our device communicates via a shorter-range technology to the vehicle, and the vehicle uses its long-range technology to communicate with the wider internet.

Future

The Sky Muster satellites are projected to have another decade of operation. No additional satellites have been announced.

2.3.3 Emergency Position Beacons

Technology Summary

Satellite Location Beacons are devices that are used to alert emergency services of an emergency and your approximate location (Maritime Safety Authority 2019). These systems communicate with satellites maintained by COSPAS-SARSAT. An individual registers their beacon with the relevant Australian government agency, and when manually activated, the overhead satellite will alert them that there's a problem, allowing the government to initiate search and rescue operations.

These systems are primarily designed for situations where the user will be out of contact with the rest of the world for a while: ocean fishing, bushwalking, 4WDriving, etc.

If a GEO satellite is not reachable due to signal issues, the system must wait for a LEO satellite to come overhead, which may take hours.

Personal Locator Beacons (PLB) are recommended for personal carry, and Emergency Position Indicating Radio Beacons (EPIRB) are larger and intended for vehicle mounting.

Some beacons are outfitted with GPS, to allow for a more precise location determination: accuracy to within 120m within 20 minutes, as compared to the non-GPS equipped systems that can take from 90 minutes to 5 hours for a 5 km radius location determination.

Availability and Coverage

These beacons are available commercially and are covered world-wide.

License and Pricing

PLBs and EPIRBs are around $300, and require no additional financial upkeep.

Relevance

Activating a PLB or EPIRB with our system would be an effective way of reporting distress, and the Australian government's response involves alerting emergency contacts first, allowing people on the farm to provide assistance first if able.

This hybrid system would not convey additional information than the distress, and may have significant time-lag, pending radio operation and government intervention response times.

2.4 Upcoming Satellite Technology

2.4.1 LEO broadband systems (SpaceX, Amazon, OneWeb)

SpaceX are deploying a comms satellite network, called Starlink, to provide broadband access to all regions on the planet. Requires a breadbox sized base station to communicate with the satellite network. Planned by 2027 to have complete land-mass coverage using 12,000 satellites. Requires subscription service. Currently 60 are in the sky for testing. These satellites sit in Low Earth Orbit.

Jeff Bezos is also aiming to provide a satellite service, but less information is available on his, too. One Web is, too.

Technology Summary

Thousands of satellites in Low Earth Orbit (LEO) are linked up via satellite-satellite links (usually using pin-point communication LASERs), and connected with the ground either directly to consumers or via Ground Stations (like AWS's service) that act as intermediaries and spread the connection via traditional terrestrial means.

Direct communication may be performed using "small or medium pizza" sized, powered antennae. The OneWeb satellites are designed to carry 10 gigabits of data (Henry 2019).

Satellite broadband also has a shorter roundtrip latency than traditional fibreoptic or ADSL cables.

Availability and Coverage

There are currently no commercial systems available, as the technology is still in its testing and development phase. SpaceX has launched 60 satellites for testing (Wall 2019) and plans for more.

License and Pricing

SpaceX estimates that 40 million users would generate around $30 billion in revenue (Grush 2018), which would imply $1000 per year as a subscription based internet service. This may be prohibitively expensive for a single-use device’s connection, like an emergency alert device.

Relevance

If these satellite constellations can be accessed from a portable device, or even a vehicle mounted device, then this technology could act as the main carrier for the emergency signal from our device. It would likely be too expensive for our use.

Future

Space X hopes to have global coverage and 12000 satellites in orbit by 2027 (Mosher 2019). OneWeb hopes to have 650 (Sheetz 2019) and Amazon hopes to have 3,236 satellites within the next decade (Sheetz 2019).

This choice of vendors may provide reliable, global access to internet from arbitrary terrestrial locations. If this eventuates, having reliable, roaming internet mounted to a vehicle would be viable.

2.4.2 Nano Satellite IoT (Lacuna, Myriota, Lynk ne UbiquitiLink)

Technology Summary

Nano Satellite IoT systems are networks of small satellites (from cubes of 30cm on a side to as small as cubes 10cm on a side), which implement some normal terrestrial signal as a space-based signal from Low Earth Orbit (LEO). Technologies include satellites that act as LoRaWAN, Sigfox, or other LPWAN tech hubs and satellites that act as long-distance cell towers.

The company Lynk is building a constellation of satellites that provide a 2G cellular connection for regular phones. The satellites appear to the phones as just low-signal strength cell towers and may integrate with normal ground-based service carrier networks, like Telstra. Lynk says that they need one tenth the launch vehicles for a similar coverage compared with SpaceX's constellation and hope to have 24-36 satellites in orbit by 2021 (Mohney 2019). Lynk is in a trial phase currently and have tested their technology in space early in 2019 for 2G connection.

The company Lacuna is aiming to have LoRaWAN satellites in space; the company Myriota is developing its own long range standard; and FleetSpace has developed a traditional satellite-based relay that uses a ground-based LoRa hub with separate satellite connection.

Availability and Coverage

All Nano Satellite IoT service providers are in the development phase and are not yet at the consumer stage.

In terms of coverage, each of the providers have their nano satellites in LEO, which requires satellites to continuously pass over different regions of the planet. This means that even remote areas are likely to have connections for some part of their orbit.

Lynk estimates that each of their nano satellites should provide around 5 minutes of connection per 10 to 12 hour pass. As they increase the number of satellites, the overall percentage of connection time should also increase.

License and Pricing

Lacuna estimates that they will charge $2 per month per device.

Myriota's cheapest plan for their system is $15 per month with 1,000 messages or $200 per year for 10,000 messages.

Fleetspace prices per satellite relay, starting at $29 per month, with an additional $2 per device per month.

Lynk plans to integrate with service providers and license their satellites as cell towers for regular fees. They plan to offer emergency services unrestricted and globally.

Relevance

The promise of IoT satellites is that if an IoT satellite is above a user, that user will have a connection to the wider world. Depending on the density of such satellites, this could provide a constant connection to the wider world for IoT devices, even in extremely rural areas.

This would overcome IoT's normal terrain problems and reduce overall on-ground maintenance required for any network of sensors.

Future

If satellite IoT is able to cover the world, it may become the predominant mode of IoT communication.

2.4.3 High-Altitude Vehicles (Facebook Aquila, Google Loon)

Several companies have proposed high-altitude platforms as internet providing solutions, given the better line-of-sight capability of non-terrestrial transmitters, and the relative ease of launching in-atmosphere technologies when compared to satellites.

Facebook and Google were both investigating such high-altitude, internet providing platforms. Facebook's approach was to launch a solar powered unmanned plane which could stay aloft indefinitely. Google's approach was to build weather-balloon like platforms. These projects were cancelled, in part due to their large cost compared with contemporary satellite-based solutions. Each technology would also require custom terrestrial hardware, adding to adoption costs. As such, it is not suitable for our device.

3 Traditional Communication Networks

Traditional communication networks are the wired or wireless technologies that farms are likely to already employ in one application or another. These were included in this report as comparisons for capability to the LPWAN and satellite-based approaches.

3.1.1 UHF Low Bandwidth / Extremely Low Frequency Radio

Ethernet enabled packet system, 300bps to 115200bps. Some farms already have UHF links installed but is quite a large upfront investment.

Technology Summary

UHF Radio is regularly employed on farms for voice communication from the field, and there are radio modems that convert the UHF link into a system to transfer digital data (like SATEL's devices). These systems support up to 100km of line-of-sight communication, and transfer speeds of between 300bps and 115200 bps. This system usually relies on external antennas.

UHF modems require higher voltage supplies than other technologies (7-28V on some models vs. 3.3-5V on LoRa).

UHF modems operate on licensed and unlicensed spectrums between 300MHz and 1GHz.

Availability and Coverage

UHF systems are deployed by the farm, but the technology is readily available. Coverage is determined by the number of UHF repeater stations set up on the farm and the local terrain.

License and Pricing

UHF systems can be expensive to build up-front, but these systems are privately owned and maintained by the farm and so have no long-term subscription costs.

Relevance

Some farms already have a UHF network on their farms, which simplifies communication with them. However, due to the large power requirements of UHF technology, this likely does not allow for a tightly integrated, low-power device.

3.1.2 WiFi Mesh Network

A mesh network is a network of nodes that ferries information in a non-hierarchical node to node topology, which allows wireless connection across a wide area with only one node needing a connection to the wider internet. Mesh network nodes need to be listening for transmissions to them, and then need to re-transmit the data packet towards the destination node. This makes nodes more power intensive than pure transmitters (which can be in a low power mode until they need to transmit), which is why most low power protocols use a star topology, as the low-power edge nodes only need to intermittently broadcast to one higher power central node.

Wi-Fi mesh networks have been demonstrated with 30-40km line-of-sight links between nodes, but these use directional antennas that will not saturate an area with wireless connections. Wi-Fi hubs that devices can connect to usually offer a maximum of 150m of connection distance. As such, each hub can only cover 0.07 square kilometres, which would require 14 nodes per square kilometre, which is a far worse ratio than what's available in the LPWAN space. As such, it is not suitable for our device.

3.1.3 IEEE 802.22 Wireless Regional Area Network

This wireless communication specifications from the IEEE is designed to provide long-range wireless regional connections, with a range between 1km and 100km.

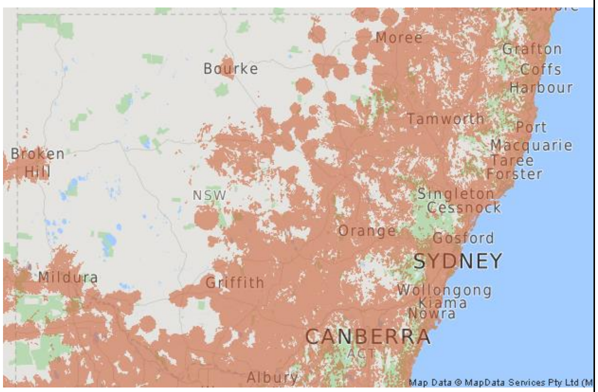
It is technologically and legally feasible in Australia and was announced in 2011 but was not heavily adopted and is not optimised for lower power communication or IoT focus.

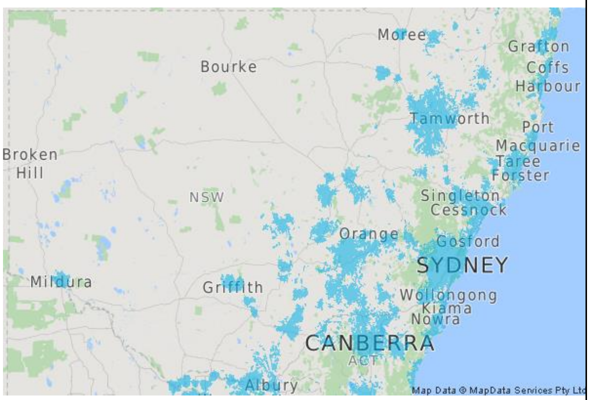
3.1.4 Cellular (2G, 3G, 4G, 5G)

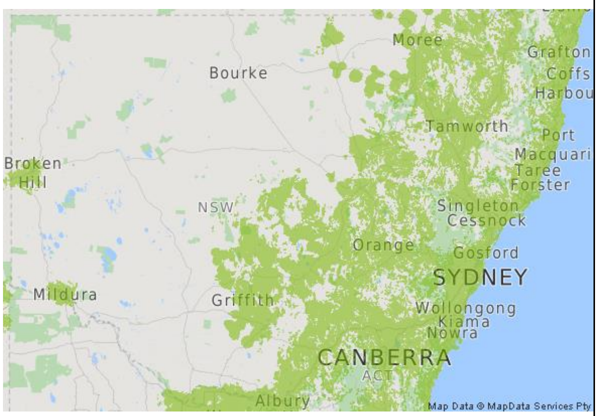
These are the cellular technologies that provide connections for cell phones. Service is delivered to the device via cell-towers, which are themselves interconnected by fibre optics, wires or satellite links. Several IoT technologies piggyback off these technologies, like NB-IoT and LTE-M.

2G and 3G have lost support from Australian cellular service providers (Choros 2019), with 5G being rolled out from 2019 onwards. Base stations/cell towers are expensive to install and are maintained by phone companies who have little incentive to extend their coverage to low population density areas, like farms. This technology is also poor at penetrating hills and terrain depressions, like those often encountered in farms that perform livestock farming.

The lack of a reliable cellular connection in regional settings is the motivation for this report.







Estimated cellular coverage maps provided by Telstra for NSW (source). Clockwise from left: 3G, 4G 1800 MHz, 4G 700 MHz

3.1.5 Bluetooth (LE, 5.1)

Bluetooth is a collection of standards for interfacing consumer devices together wirelessly without the need for a central hub, complex device enrolment processes, or much additional power overhead.

Bluetooth 5.1 is a protocol for transmitting small amounts of data over short ranges between two devices, with variable data rates and power requirements. Bluetooth 5.1 supports communication at up to 240 meters between devices (Hoffman 2018). Newer phones are implementing Bluetooth 5.0, and most phones of the last few years support Bluetooth LE. Bluetooth Low Energy (LE) is a protocol for transmitting small amounts of data at very low power usage.

Bluetooth licensing is built into the cost of the chips. There are no ongoing costs.

The maximum range of 240m for Bluetooth 5.1 is greater than previous tests, which could see this technology used as an intermediate layer between the emergency device and a higher-power, size, etc, signal repeater station.

Bluetooth is constantly being improved upon (in the last year, Bluetooth went from version 5 to version 5.1, for example), and may end up with more range or transmit power. It is to be watched for future capabilities.

4 Blindspot mitigation strategies

Blind spots are areas where a wireless data connection is unable to be established or maintained with a server. Blind spots may occur due to leaving the communication range of the service or device, having obstructions between the two communicating devices, or signal interference from external sources.

Cellular blind spots are common in country towns as cellular technology is only designed for up to 15km range of communication, and cell towers are often deployed based on population density. Cell towers are expensive to build and maintain, so remote areas are usually under-served. Rolling hills can also break line of sight for areas within nominal range of a cell tower, which severely reduces signal strength.

Other electromagnetic-spectrum communications technologies, like Wi-Fi, UHF radio and LoRa also suffer from these issues, though the specifics vary with the frequency spectrum of the transmission and expected bandwidth.

There are a few methods used by communication technology designers to alleviate the issues of blind spots:

4.1.1 Repeater stations

The best way to mitigate blind spots is to remove them. Signal repeater stations (be they cellular, UHF, LoRa, etc) can propagate the signal from an area of connection to an area without (say, on the crest of a hill to provide connection to areas in the hill's "radio shadow"). This is an additional hardware expense but mounting a repeater onto the user's car may be an effective compromise.

4.1.2 Data caching

When an attempt at sending data fails due to a loss of connection, the data may be cached for future transmission when back in an area with reception. This is useful for situations where the entered data isn't time critical.

4.1.3 Increasing transmission power

When an attempt at sending data fails (where no acknowledgement is given from the receiver when one is expected), the sending device may increase its transmission power to attempt reconnection. Normally transmission power is limited to optimise battery life, reduce interference for other devices and stick within government regulations (for interference and safety reasons). Often transmission power is variable in mobile devices, so a higher and higher power may be tried sequentially to attempt to get the message through.

Sometimes the acknowledgement from the receiving system is lost, and so any system using this method of connection loss recovery may end up successfully transmitting multiple of each data packet at higher and higher transmission powers without receiving an acknowledgement.

4.1.4 Increasing antenna size or relocating antenna

Often, larger antennas and better positioned antennas can get better reception. This requires physical intervention. Relocating the antenna to the top of a hill — or on a tall structure like a roof or tower — is the most common strategy.

4.1.5 External server connection loss notification\timeout

A receiving system — the server — may maintain regular contact with a device and signal the connection loss when it can no longer contact the device for some specified length of time. This server doesn't know the cause (the device may be switched off, out of range, in a low power mode, or has simply stopped transmitting), and so the only alert it may give someone is that connection was lost.

In a farm situation, with regular periods of loss of connection, this hypothetical server would regularly signal communication errors, and may be difficult to isolate emergency situations from a regular disconnection.

This technique also increases the number of transmissions that are required of the safety device, which would reduce its battery life.

5 Competition Analysis

5.1 Introduction

This section is an exploration of the SoleMate's competitive environment. Firstly, an exploration of the SoleMate's proposed features and target market is performed to provide context for competitor analysis. Secondly, a competitive product analysis including is carried out for three relevant competitors in detail, with other notable competitors and products being mentioned afterwards. Finally, value-based pricing is performed based on insights from competitive analysis and is combined with an estimated cost of goods sold (COGS) to assess the prospective viability for the SoleMate as a product.

5.2 SoleMate Context

It is necessary to understand the SoleMate's proposed features and target market in order to inform a comparative competitor analysis.

5.2.1 The Problem

Farm workers often work alone or in remote locations. Between 2010 and 2014, more than one in five people who died at work worked in agriculture (Safe Work Australia). Limited network coverage in some areas makes it difficult to track remote workers and respond to emergency situations. Additionally, most remote worker tracking systems require a considerable amount of user interaction and cognitive capacity to operate. Addressing these issues may lead to better response in emergency situations, and more lives saved.

5.2.2 Our Solution

The SoleMate is a low profile IoT emergency alert device, housed within a user's shoe insole. This device shall offer the following features:

- **Remote Emergency Alerts -** In the case of an emergency, the device should alert some outside party with the location and health statistics of the user through a long-range communication technology that works in remote areas.
- **Minimal Cognitive Capacity -** The proposed device is designed for the user to engage in as few interactions as possible, requiring minimal cognitive capacity.
- **Non-intrusive** - Living within the user's shoe, it is designed to be non-intrusive. Users need not worry about placement or activation of the device, they just put their shoes on.

5.2.3 Target Market

Farmer Safety

This product is positioned towards the Farmer Safety market, with a specific focus on lone workers and those working in remote areas. For an idea of market size and segmentation, it is necessary to first explore the wider agriculture and farming industries.

Agriculture **-** There were 334,300 people directly employed in Australian Agriculture, Forestry and Fishing as of May 2019, with 283,400 employed specifically in the Agriculture sub-division (ABS 2019, Catalogue No. 6291.0.55.003). Despite corporatisation of farms and other agribusinesses over the past decade, farming activities are dominated by small, family-based operations and, hence, display low market share concentration. Conversely, processing and manufacturing industries tend to exhibit higher concentration. It is estimated that farm businesses make up around 48% of total agribusinesses, with the total number of businesses being 179,406 in 2018-19 (Thomson 2019).

Farming **-** As of 2016-17, there was 85,681 farming businesses in Australia (National Farmers' Federation 2017). In 2018-19, the number of establishments in the agribusiness industry experienced slight negative growth, and employment in the industry is expected to continue oscillating around 0% growth for the next few years (Thomson 2019). For this reason, market analysis in this report will assume the figure of around 85,000 businesses in the Australian Farming Market.

Lone Workers

In 2018, around 70% of businesses in the Australian Agriculture, Forestry and Fishing sector were non-employing - making up nearly 124,000 people. These figures suggest over 1/3 of people working in this sector work alone. Additionally, around 22% of businesses in this sector only employed between 1-4 employees - representing almost 39,000 businesses. (ABS 2018, Catalogue No. 8165.0). As a result, only the remaining 8% of businesses employ 5 or more people, representing just around 13,500 businesses. This highlights a large market of lone workers in Australian agriculture.

Remote Workers

Australia's geographical mobile phone coverage was estimated at around 30% in 2018 (MLA 2018). While this coverage generally follows the dispersion of Australian farms, this is only predicted coverage and does not include indoor coverage or sub-surface areas. Coverage at any location can be affected by local building density, terrain and vegetation. (Telstra) Although it is difficult to quantify the percentage of farm workers operating in unreliable network connection conditions, it is certainly identifiable as a market opportunity that has not been fulfilled.

5.2.4 Other Relevant Markets

Despite a primary focus on the farmer safety market, it is necessary to identify the following markets that the SoleMate could be applied to more broadly.

Construction and Mining Safety

The SoleMate's relevance can be horizontally applied to the construction and mining safety markets. As of 2017, the Construction industry remained above the all-industry average fatality rate (Safe Work Australia 2017). Additionally, mining represents an analogous industry in terms of people being expose to remote working conditions.

Person Tracking and Safety Awareness

The worker tracking and welfare market - more broadly including person tracking and safety awareness - represents an opportunity for the SoleMate. With Australia's ageing population, it's not hard to believe that the Australian Personal Welfare Services sector has grown 6.5% annually for the last 5 years and is projected to grow at 7.6% annually for the next five. (Munro-Smith 2019). This includes meeting aged care needs, such as providing welfare awareness for carers of people with Alzheimer's or dementia who are at risk of wandering. This 'at risk wandering' group was stated as around 100 million people worldwide by a player in this market, GTX Corp (GTX Corp 2017).

5.3 Competition

We are proposing a novel product, and there are no large direct competitors with a similar offering. In some ways it would be unwise to focus strictly on market share, even for competitors in the farmer safety market, as this suggests focusing on current performance. Instead it may be wiser to focus on opportunity.

Analysis of a few relevant competitors in the markets described above is provided, identifying current alternatives to the product and its advantages. As not all competitors are specifically in the farmer safety market it may not be relevant to discuss market share for all of them. For each however, a small market analysis discussion is provided.

5.3.1 Competitor 1 – Safe AG Systems

Safe AG Systems provide agribusinesses with a 'farmer-friendly, online solution for managing WHS' - designed to help farmers and contractors meet site management and WHS needs, operate more efficiently and manage emergency situations. Their app is an all-inclusive Workplace Health and Safety compliance software, where a team can update and share access to site-specific safety information. Despite being able to operate offline, the true potential of the system is only realised via 3G/4G mobile phone coverage connecting users and allowing emergency notifications.

Why are they relevant?

Their product is not the same, but they represent a direct competitor in the specific farmer safety market - information about this competitor may help understand how much consumers are prepared to pay for farmer safety.

Increasing regulatory requirements for farms are driving farmers to comply to Workplace Health and Safety. By taking on a plan with Safe AG Systems, farmers can meet their WHS requirements, with record keeping taken care of for them, and the use of an emergency alert function. For farmers taking part in this plan with access to mobile data on site, the SoleMate would be close to functionally redundant.

It is also important to consider Safe AG Systems as a potential partner as well as a competitor. As they do not manufacture a physical product and the full functionality of their app is limited to areas with mobile data, this represents not only an area that can be exploited by the SoleMate, but also an area where extended service to complement their WHS compliance-focused system could be offered.

Market Insights

Safe AG Systems operates primarily within the Farmer Safety market, with secondary interests in the Occupational Health and Safety Services market and the Construction Safety market.

There are around 85,000 businesses in the Australian farming market, and Safe AG Systems has around 5570 business customers (an increase of 59% from 3500 reported in August 2018). Some of these are generic contractors, but the product is marketed towards agriculture and it can be assumed the majority are farms.

Product Features

Structured around meeting **Work Health and Safety** compliance, the app allows farmers to:

- Record workers' current training - and identifies when further qualifications may be needed
- Choose from policy templates (including over 250 agriculture-specific templates) or create their own inductions, which can be sent to workers via the app
- Easily keep maintenance records for equipment
- Make use of a farm inspection feature
- Print safety checklist QR codes for machinery that can be scanned in the field for information
- Make use of a collaborative task manager - everyone on farm can be allocated tasks and informed of important safety information instantly

Emergency response functionality allows all workers to:

- Access emergency response plans
- Call 000
- Access Safety Data Sheets (SDS)
- Alert all personnel on farm of an emergency at the press of button
- Pinpoint their location, simplifying critical response plans

The **pricing** for this system is based on a tiered subscription plan:

- Lite - $75/month or $750/year for up to 4 users
- Professional - $150/month or $1500/year for up to 10 users
- Additionally, on-site training from $480 + travel

SWOT

Strengths:

- Program features are structured around compliance to Work Health and Safety legislative requirements.
- High switching costs - customers are provided with a well-rounded system that satisfies a range of WHS legislative requirements, in addition to other features such as GPS tracking via mobile data. If a customer chooses to structure their safety systems around a Safe AG program plan, they may be unlikely to also purchase a personalised emergency alert device.
- Targets agribusiness with a system on which they can base their workflow and safety procedures. In-built agriculture-specific templates provide an easy option for farms that don't have such systems in place.
- Strong recurring revenues through monthly and yearly subscription systems.

Weaknesses:

- The app's emergency alert function is reliant on mobile coverage (3G/4G) to alert others of the user's location. Offline functionality allows workers to complete checklists, undertake inductions or add maintenance records or hazards, and information is stored in the app until mobile coverage improves and data is synced.
- High cognitive capacity required. Users are required to 'manage' the system and keep everything up to date for it to be useful.

Opportunities:

- Increasing regulatory requirements for WHS presents a greater need for this system for agribusinesses.
- Applications for general contractors could be expanded to other industries such as mining through creation of specific templates.

Threats:

- Rural areas not reliably covered by mobile data represent a section of the market where Safe AG Systems are heavily susceptible to competition. There is a threat posed by systems based around more suitable communication technologies for these areas.

5.3.2 Competitor 2 – GTX Corp

GTX Corp offers a range of GPS tracking location-based services. Their product that is most relevant to the SoleMate is the GPS SmartSole - an insole for person tracking and safety that is targeted towards aged care rather than the farmer safety market. The patented GPS enabled smart insoles are fitted easily into most adult shoes and lets you monitor the whereabouts of users who may have a tendency to wander or are at risk of becoming disoriented and lost.

Why are they relevant?

GTX Corp's product is relevant simply because it is the most similar device to the SoleMate in comparison to all other competitors. It is a physical product embedded in a shoe sole aimed at person tracking and welfare, and even has a similar name.

Competitor analysis of GTX Corp's SmartSole can provide us with insights on how we can differentiate and capitalise on their weaknesses. Additionally, it is interesting to see how they can apply their product laterally across different markets, as these avenues could be open to the SoleMate also.

Market Insights

The GPS SmartSole lives within the Person Tracking and Welfare market. In a company profile in 2017, GTX Corp identify other avenues for investment into different markets such as the military and law enforcement, bio metrics, home health and children's markets; although there hasn't been obvious word of expansion since then (GTX Corp 2017). Although it is difficult to quantify their performance in the Person Tracking and Welfare market, it is interesting to observe these as potential avenues for the SoleMate, as well as obtain information about what users are prepared to pay for such a product.

Product Features

Tracking features:

- GPS enabled features (e.g. geofences)
- Patented tracking methods for continuous, real-time location coordinates rendered on a map in a customised portal
- 2G T-Mobile/AT&T GSM support only - notification via SMS or email (not available in Australia)
- Internet/Smartphone access to device info
- Motion Sensor: location tracked on motion and/or every hour
- Depending on plan, location updated every 5 to 60+ minutes
- No body detection (device track also when transported)

Device features:

- Device embedded in sole is bulky, noticeable
- Power: Wireless charging (takes 2-4 hours), with 1-2 days battery life

Pricing - requires monthly service plan (2G/GSM service):

- US$299 + monitoring service plan (US$29.95/month or US$74.95/quarter recurring) + US$5 delivery

SWOT

Strengths:

- Discreet and unobtrusive - device contained within shoe insole.
- Relatively low cognitive capacity required - users won't forget to bring it with them.
- Offers complete end-to-end solution of hardware, software and connectivity.
- Patented tracking methods.

Weaknesses:

- Reliant on outdated cellular coverage - currently still reliant on 2G networks being maintained by partnered suppliers, with a 3G device currently in development.

Opportunities:

- A growing Australian Personal Welfare Services market opens the door for more opportunities to expand further into the Australian market, with the potential for increased government funding in the area in coming years to accompany the ageing population.
- Lateral market opportunities with potential for investment into the military and law enforcement, bio metrics, home health and children's markets.

Threats:

- The current reliance on 2G networks represents a large barrier for GTX's further expansion into the Australian market, as their device is simply not supported. This represents a large competitive advantage for the SoleMate if it were to compete in similar markets and take advantage of the growing Personal Welfare Services industry.

5.3.3 Competitor 3 – Thinxtra

Thinxtra is an official Sigfox technology operator for a nationwide IoT network Australia, in addition to operating networks in New Zealand, Hong Kong and Macao.

Complementing this service, they offer a range of paired products including devices targeted at people tracking. These are generally small, low power-consumption Sigfox-connected devices that range from solely GPS tracking to including a range of additional sensors and can be adapted to meet a range of applications.

Although they demonstrate some applications in agriculture, they don't specifically make any products targeting farmer safety.

Why are they relevant?

Thinxtra represent a competitor in the person tracking market using similar long range communication technology. Although their products are not positioned towards the SoleMate's specific target market, it is important to understand competitors in the market for long range tracking devices.

Additionally, as a SigFox service provider, an understanding of Thinxtra may shed light on: barriers to entry for use of long range communications; the potential for partnering with operators; and, their willingness to support other products outside their own range.

Market Insights

Thinxtra and their partnered products represent a player that displays similar competitive advantage to the SoleMate through similar long-range communications technology.

Understanding the network that's available and the proportion of farms that are outside mobile phone coverage would be helpful for understanding opportunities to capitalise on this competitive advantage. Additionally, understanding the barriers to entry and opportunities for partnership that present themselves when utilising these long-range communication systems is important.

Product Features

A range of Thinxtra-partnered devices utilise Sigfox technology to connect people via IoT and provide services for a range of applications. Examples of Thinxtra-partnered person tracking devices that pose competition to the SoleMate are outlined below:

1. **HidnSeek ST-1A**

   Standalone GPS tracker for tracking and security:
   - No specific built-in application apart from network and GPS location; motion detection; exporting GPS points and events to a '.csv' file - high cognitive capacity required (must be applied by the user)
   - Multiple users can monitor single device and customise their alerts/geo-fences
   - Works on IoT networks e.g. Sigfox ready, or can use LoRaWAN
   - Free mobile/web app - open API's allow developers to craft their own apps and integrate additional sensors

   Device features:

   - Lightweight, small
   - No sim card or installation
   - Not waterproof
   - Rechargeable with 1-6 month autonomy depending on use

   Pricing:
   - 82.50 pounds for the device (service included) and 24.92 pounds for one-year service fee + SIGFOX delivery

2. **Invoxia GPS**

   Functionality:
   - Notifications on entering and leaving customised areas (geo-fencing)
   - Sends position every 10 minutes when moving
   - Currently not available in Australia

   Device features:
   - No sim card - low consumption networks
   - Rechargeable in 90 minutes with 1-6 month battery life depending on usage

   Pricing:
   - 99 pounds for the device + 9.99 pounds/year for the subscription (included for the first 3 years)

3. **SimplePack 3.0 Plus**

   A range of sensors in a small device that can be configured for the user's own use:
   - Accelerometer, LED, button with haptic feedback, temperature, light sensor, buzzer, magnetometer, reed, and wifi for localisation
   - Utilises Sigfox's IOFrog.com IoT platform, support of other platforms
   - High cognitive load for the user to configure the device for their own use

   Device features:
   - Small
   - Waterproof
   - Non-rechargeable, non-replaceable long-life battery (10 years in guard mode)

   Price:
   - Between 20 euros to 34 euros dependant on sensor configuration included
   - 11 euros for the first year and 6 euros/year afterwards for IOFrog.com platform connectivity (3 month free trial)

SWOT

Strengths:

- As Australia's sole official Sigfox operator, Thinxtra are in a position of power when it comes to use of Sigfox technology.
- Long range communication technologies that work without mobile data. Additionally, most devices support other communication platforms such as LoRaWAN.
- Low power-consumption. Devices have a battery life of between 1-6 months rechargeable, and in some cases up to 10 years non-rechargeable.
- Some are waterproof.

Weaknesses:

- High cognitive capacity required in setup. These person tracking solutions provide location and motion information, however they require a significant amount of setup to make them useful in the consumer's context. Additionally, setup is ambiguous in most cases and requires significant enquiry.
- Purchase of device separately to subscription costs for specific paired platforms is necessary.
- Inconvenient to carry around. Although small, the devices require substantial cognitive capacity as they must be consciously carried around.
- Although well developed in Europe, the current Sigfox network infrastructure is not developed in Australia to the extent that it is beneficial to use over mobile data.

Opportunities:

- As Australia's sole Sigfox operator, any companies looking to use the technology must get involved with Thinxtra. Further expansion of Sigfox infrastructure in Australia will put Thinxtra in an increasingly effective position when it comes to other products requiring long range communication technologies.

Threats:

- Being marketed generally as a 'person-tracker' that can be configured for different applications positions these devices at a level of abstraction above specifically targeted devices. Other more specifically targeted or ready-made consumer devices would have significant competitive advantage over these.

5.4 Other Notable Competition

In general, the market for lone worker tracking and asset tracking is quite saturated. Some of the other notable products and services are outlined below.

5.4.1 Lone Worker Safety Apps

There are a large range of lone worker safety apps that are not necessarily marketed directly towards agriculture. Most involve activating some sort of distress signal, or 'fall detection' using the mobile phone's internal sensors - with some variation of support services provided in the case of an emergency. Additionally, none of these options are useful outside of mobile data coverage, which reinforces remote communications as an important gap in the market.

- **WorkSafeGuardian** - $33/month
- **QR-Patrol** - US$35-$113/month depending on plan
- **Duress app** - $249 per user per year

- **Staysafe** - 4.99 pounds per month (UK, US and Canada)

5.4.2 Consumer-ready personal tracking and safety devices

A range of consumer-ready welfare tracking products are available, mainly in the form of small remote GPS trackers with a button-press alarm mechanism such as those provided by Thinxtra. Additionally, some more up-market wearable technology such as watches designed for safety or aged care are available. Again, these solutions do not operate outside of mobile phone coverage.

- **Find-me watch** - $88 setup + $529.10 + $31.80-$56.55/month
- **Duress watch** - $549 + $35/month service fee
- **FSD-03 Lone worker farm GSM/GPS safety alarm** - 80 pounds

5.4.3 Asset tracking and security systems

Asset tracking and security is quite commonplace in farming. In this case, most of the solutions provided involve heavy-duty trackers that are mounted to vehicles and display tracking data, with emergency response detection limited to crash detection or an emergency panic button. One example targeted at primary industries is LINK, by GPS tracking systems:

- **LINK, by GPS tracking systems** - GPS tracking and asset management for farming
    - Heavy duty tracking devices mounted on vehicles and machinery, paired with software
    - Directed at asset tracking and management rather than lone-worker personalised solutions
    - Remote communications enabled via Bluetooth 4.0 and Satellite
    - Not targeted at user safety, but does have a rollover, crash detection and emergency panic buttons
    - Pricing is based on custom quoting for the application, but as a guide a typical heavy-duty LoRaWAN device this system would use would be priced around $129-$199 - and it is assumed there would be some subscription fee on top of this

5.4.4 IoT devices of interest

Over the past few years, IoT connected devices have been the subject of much interest and technological development. One concept that drew similarities with the SoleMate was a smart helmet that was proposed in a range of research papers and has since manifested itself (in a limited functionality form) through a Canadian company called Jannatec Technologies. This device represents prospective competition if the SoleMate was exploring expansion into the construction and mining industries - it seems convenient to deliver the same product within a hard hat for this specific market.

- **Smart Helmet** - like a hard hat with built in IoT systems.
    - Research papers propose features such as air quality and destructive event detection
    - Current iterations of the helmet available for sale only involves radio-frequency identification (RFID) tags to locate workers, high visibility LEDs and on-helmet camera functionality
    - Not designed to be suitable for long-range communication technologies

5.5 Estimated Value-Based Pricing

Based on what has been observed from other products and services in similar markets, a rough estimation can be made on what consumers in the farmer safety market may be prepared to pay for the SoleMate.

Safe AG Systems' app is a good indication that farmers are willing to part with their money for an easy-to-manage safety system, with subscription prices between $75-$150 per month, and a one-time on-site training fee of $480 plus travel. Despite this, Safe AG Systems may represent a more valuable proposition in the consumer's eyes, as their product caters for a range of on-site needs for multiple users who would be regularly interacting with it.

In contrast, SoleMate may be something that they nearly forget about, as ideally distress signals activated are at a minimum over the course of a year. General lone-worker safety apps range from as low as $10 per month to as high as $113 per month, with this range representing some large variance in functionality and user interaction.

Personalised GPS tracking devices - whether targeted towards agriculture or not - all seem to pair a one-time purchase fee with an ongoing service or subscription fee. The SmartSole charges US$299 plus a monitoring service plan (US$29.95 per month), and smart watch options are even more expensive with devices priced in the $500-$600 range and subscriptions around $30-$60 per month. On the other end of the spectrum, generalised tracking devices through Thinxtra cost between $30 - $200, with subscription costs from as low as under $1 per month to just above $4 per month.

If the SoleMate can follow Thinxtra's lead with low service costs for communications - or ideally no service fee at all - the device should comfortably be sold at around $100-$250. If the device is marketed towards the ideal markets of lone and remote working farmers, the lack of a comparable personalised products to meet this need suggests farmers would be prepared to pay this cost, especially if it is a one-time cost and is for their own safety. This price point lies lower than that of Safe AG Systems and the SmartSole (which may provide more user interaction and perceived continual benefit) and higher than the generalised lone-worker tracking options that aren't directly configured to meet this need.

5.6 Cost of Goods Sold (COGS)

Based on the use of LoRa transmitting technology, a Bluetooth low-energy system on a chip (BLE SoC), and inertial measurement unit (IMU) components, the SoleMate's cost of goods sold including labour was estimated at around $90 per unit based on prior work done.

5.7 SWOT - SoleMate

Strengths

- **Long-range communication** systems allow functionality for **remote emergency alerts.**
- A **non-intrusive**, low-profile design that lives within a user's shoe.
- **Minimal cognitive capacity** required, as the device is designed for the user to engage in as few interactions as possible - great for reliable lone-worker safety.
- Offers complete end-to-end solution of hardware, software and connectivity.
- Low power-consumption.

Weaknesses

- Device is not currently positioned to target anything apart from providing information about the user's health and allowing emergency distress signals.
- Current estimated COG puts the device at the top-end of similar products in the market, however this price could be reduced with further development.

Opportunities

- There is a significant gap in the market for providing farmers with reliable emergency response services in lone and/or remote working situations. The SoleMate is positioned to meet this need.
- Using LoRa communications systems means there is an opportunity to operate devices without going through a 'service provider' such as Thinxtra.
- As identified in competitor analysis of GTX Corp, there are potential avenues for exploration into lateral markets, for example the growing personal welfare industry, and to a lesser extent the military and law enforcement, bio metrics, home health and children’s markets.

Threats

- For the farmers who do not have remote communication needs, services such as those provided by Safe AG Systems can provide a more basic emergency alert function whilst meeting a range of other safety and WHS needs. Additionally, a range of lone-worker safety apps provide 'fall-detection' as a low-cognitive-capacity alert method for those with mobile data.
- As identified in competitor analysis of Thinxtra, choosing to operate communications through an established 'service provider' rather than setting up communications independently may result in more recurring costs.
- Increased regulation of agriculture safety may give companies such as Safe AG Systems competitive advantage for approaching customers with mobile data available.

5.8 Competition Analysis Conclusion

Through this competitive product analysis, this report has explored and analysed the SoleMate's proposed target markets and competitive environment. In this process, useful insights and areas of opportunity have been uncovered. The most significant of these areas of opportunity is the gap in the market that remains for providing farmers with reliable emergency response services in lone and/or remote working situations.

As there is no directly comparable products within the same market, value-based costing was estimated from price-points of similar products within comparable markets. The estimated value-based costing of $100-$250 for a one-time product purchase, when paired with an estimated COGS of $90, suggests the SoleMate is a viable product to pursue. Assuming that the technology associated with the creation of the SoleMate meets this need - it is able to provide lone and remote workers with reliable emergency response services through minimal user interaction - and it is marketed carefully, the outcome of this analysis is to recommend the SoleMate as a viable product that displays a significant competitive advantage and is worth pursuing.

6 Recommendation for technology to be tested for use with our device

Of the competing communications protocols surveyed, LoRaWAN, NB-IoT, Satellite Phones and Sigfox seem the most viable technologies for investigation within the next year. Other technologies are either on the cusp of accessibility (satellite systems are 2-7 years away), have no hardware development kits available (due to a lack of adoption of the standards), or are intended for more power intensive use cases (like constantly connected assets).

These four technologies are proven long-range communication systems, are positioning themselves in the Australian market as infrastructure and so are aiming for growth and have support for small scale testing and development.

LoRaWAN and Sigfox base stations may be deployed easily, NB-IoT uses existing cellular networks but with up to five times better range, and satellite systems are readily accessible, so these are ideal test candidates.

In terms of their suitability for the device, each might be capable of delivering more than 95% connection time, can transmit more than 12 bytes per message and can have an external system or the internet as an endpoint. However, satellite phones may not meet the low behavioural interference requirement set out earlier in the report, requiring suitable placement for satellite connection, and satellite phones often have standby times measured in days, rather than months like we expect of our device.

LoRaWAN, Sigfox and NB-IoT have been used in emergency alert devices previously, and satellite phones are generally reserved for this purpose too, due to their extreme pricing. We are confident in recommending these four technologies for further testing.

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