CORSnet-NSW

Evaluation Report

| Document number: 1	Date: August 7, 2020

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July 2020

This document

How to read

This report has several levels of reading depending on the role or perspective of the reader as explained in the reading guide pictured in Figure 1. Sections have active headings in the form of key findings to make it easier for the reader to identify areas of interest.

Figure 1.   How to read guide
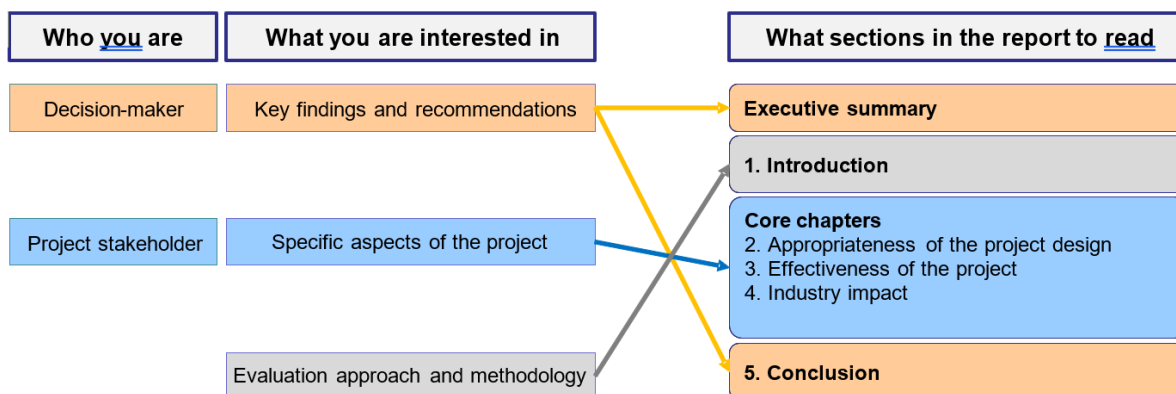
Acknowledgement

This work was completed with the assistance of Florent Gomez, Better Regulation Division Manager Planning and Evaluation.

We would also like to thank the users, hosts, resellers and equipment suppliers of CORSnet-NSW information that we interviewed as part of this evaluation. We thank them for their time and insights and trust that their views are adequately represented in this report.

The evaluation team

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Glossary

Term	Definition
AUSPOS	Free online GPS data processing facility provided by Geoscience Australia.
Authorised Resellers	An organisation who was permitted to on-sell CORSnet NSW products on behalf of Spatial Services. Authorised Reseller arrangements have been discontinued.
CORS	Continuously Operating Reference Station – an installation that is precisely located and continuously observing GNSS data. Arrays of CORS are often linked together as part of a network to deliver precise positioning solutions over large areas.
CORSnet-NSW	The CORS network infrastructure available in NSW from 1 July 2009.
COVID-19	COVID-19 is a respiratory illness.
DCS	Department of Customer Service
GNSS	Global Navigation Satellite System – a global network of satellites producing navigation signals for positioning and navigation applications on earth. This includes but is not limited to GPS, GLONASS, Galileo, BeiDou and QZSS.
Host	An organisation who agrees to provide a property or structure to house CORSnet-NSW equipment.
Infill process	The accuracy of high precision GNSS equipment is affected by the distance a user is from their nearest CORS. The infill process refers to the construction of CORS in between existing sites in order to provide CORS services in areas where the nearest existing CORS is too far away to be used.
Overlapping redundancy	The area of land which is 50km or closer to two or more CORS. In the event of a single station outage, a real-time CORS user in this area will still be able to continue high precision activities.
Positioning Australia	The Geoscience Australia program delivering a national capability of accurate and reliable positioning anywhere, anytime.
RINEX	Receiver Independent Exchange Format – a data interchange format for raw satellite navigation system data.
Value Added Reseller (VAR) or formerly known as Premium Reseller	An organisation who is permitted to access CORSnet-NSW raw data services and on-provide data and derived data to their clients, initially via standard product definitions and approved value-added products. Since the introduction of VARs or Premium Resellers, Spatial Services have transitioned from a cost per product sold fee structure to a more flexible cost of delivery flat fee model.
SIIP	Survey Infrastructure Improvement Program

Station redundancy   Where two or more CORS are constructed nearby each other in key areas to provide full-time, active backup. In the event of a station outage, users will not be affected.

Survey Control   An accurate survey of a region forming a basis for more detailed surveys.

Executive summary

CORSnet-NSW

The CORSnet-NSW project is a precise geolocation positioning service that gives direct users and resellers of CORSnet-NSW data access to fast and accurate positioning and guidance solutions across NSW. The service is delivered by a network of permanent Global Navigation Satellite Systems (GNSS) receivers – known as Continuously Operating Reference Stations (CORS) – that are strategically located across NSW (202 active sites in total).

The project stages are outlined below, with this evaluation primarily focusing on Stage 3 to determine the success of CORSnet-NSW through its transition from a build project to an ongoing operational program.

Stage 1: Proof of Concept, initial Sydney CORS network 2004-2009.
Stage 2: Asset under Construction, 2009-2018.
Stage 3: Project to program transition, 2018-current.

The project objectives are outlined below.

- Provide three key data services via the network:
    1. Differential GPS (DGPS) data that is available in real time and used in the field (sub-metre accuracy across all of NSW).
    2. Real Time Kinematic (RTK) data that is available in the field (2cm accuracy).
    3. Receiver Independent Exchange (RINEX) data that is archived and available via desktop for post processing.

    These services outlined above are delivered directly by CORSnet-NSW to internal users, CORS hosts, Positioning Australia and for educational and research purposes. All other users access CORSnet-NSW services via a VAR using a paid subscription.

- Provide positioning and guidance solutions to the surveying, agriculture, construction, emergency services, and mining and scientific industries.

- Provide a flexible, reliable, efficient solution that is easy to use.

The evaluation

The purpose of the evaluation is to:

- Gain an understanding of the satisfaction of users and resellers with the service.
- Share experiences and lessons learnt to enable improvements more broadly across the Department of Customer Service and NSW Government for future similar infrastructure projects, as well as for the CORSnet-NSW program itself.

In addition, key internal stakeholders flagged the following specific objective during scoping interviews:

- Determine whether CORSnet-NSW has been successful in its transition from a build project to an ongoing operational program.

The evaluation relied on a mix of quantitative and qualitative methods.

Several important documents were also considered for this evaluation. The topics for the documentation that was reviewed are listed below, with the titles in Appendix 3.

- Papers written documenting the rollout of CORSnet-NSW
- Site plans and installation agreements
- Briefings and project planning documents
- Planning and evaluation documents for the benefits of precision positioning

Data for this evaluation was obtained from the following sources, which are explained further in section 1.2.3.

- Trimble Pivot (CORSnet-NSW network operating software)
- Pingdom reports provided the external availability of CORSnet-NSW servers
- GIS maintenance and construction database (External third-party monitoring service)
- SAP records
- Sales and usage reports from data wholesalers (Premium Resellers)
- Census data from the Australian Bureau of Statistics (ABS)
- Geoscience Australia

A quantitative customer satisfaction survey was the initial piece of research conducted to evaluate key aspects of the CORSnet-NSW program evaluation. The survey focused on the type of usage, user benefits and potential areas for improvement. It was important to determine the level of satisfaction of the key program stakeholders to identify how the program has performed. A total of 91 respondents completed the survey across the following groups:

- Internal user – Spatial Services
- Internal user – Other NSW Government department
- Host
- Education/research
- External
- Value Added Reseller
- Equipment supplier/reseller

Following the survey, eleven (11) in-depth interviews were conducted with at least one identified respondent from each of the above groups. Important qualitative data was gained through this research to further address the key evaluation questions.

Key findings

The current business model is meeting the needs of stakeholders

There are two main types of CORSnet-NSW stakeholders, the user and the Value Added Reseller. Each of these stakeholders have very specific needs.

- The Value Added Reseller requires secure and complete raw data from the highest quality equipment. Streams should contain all available GNSS satellite constellations and every frequency possible in a format that is able to be used by a variety of different software and hardware brands. The data latency must be as low as possible and delivered via secure VPN in preferably less than 500ms from receiver to the reseller's server. Resellers expect streams from two independent server systems to allow for single server outages without affecting customers. The service is expected to be available 24 hours a day, 7 days a week. A VAR needs to be able to package data products for sale in a flexible way that suits the nature of their market and users.
- The user requires reliable processed real-time data that is compatible with their hardware in formats that can be used by both new and old equipment. It needs to be receiver and antenna independent, and available from a single CORS or as a Network Real-Time Kinematic (NRTK) CORS solution. Latency of the processed streams needs to be less than 2000ms from base through the processor. Base data should be available for download from the network for three months without gaps to be used for post processing applications.

Stakeholders' current needs are being met as intended.

97% of respondents to the customer satisfaction survey indicated that CORSnet-NSW is fit for purpose for their current needs. Also, there is a strong belief in CORSnet-NSW data supporting their future needs, with 98% of respondents trusting CORSnet-NSW data to support their foreseeable future needs.

There was a general feeling of satisfaction with the business model, whilst there were a few VAR respondents who weren't completely satisfied with the current business model of supplying wholesale data to them. While 81% were satisfied, 19% were not satisfied with the business model specifically for VARs.

Sales data supports the orderly transition from retail to wholesale and the evolution of the project to a program. This transition (retail to wholesale) brought the program to its current position in 2018/19, where CORSnet-NSW entered into an agreement with the Federal Government to supply all of its CORS data and thus becoming the single largest contributor to the Positioning Australia program.

There are potential opportunities to improve the CORSnet-NSW network

Overall, the CORSnet-NSW network is performing quite well. This was supported by respondents in the customer satisfaction survey, with the majority complimentary about the technology, data and service they receive from CORSnet-NSW and the team.

However, there are potential opportunities to improve the CORSnet-NSW network. In the qualitative in-depth interview's interviewees were asked to think 'blue sky' and consider what they would change if they had to. Responses were analysed and categorised into the following themes for future consideration.

- More consultation.
- Explore uses in relation to intelligent transport.
- Effective management of existing (and new) infrastructure and maintenance importance.
- Investigate new applications, software and development opportunities.

Wholesale data is being effectively provided and meeting important needs

Data analysis conducted indicated that the number of active users has risen during the program transition over the past few years. The effective supply of wholesale data was measured in the customer satisfaction survey, with the following benefits gained from using CORSnet-NSW services.

1. Fast
2. Reliable
3. Easy
4. Station location/coverage
5. Direct connection to datum

Value Added Resellers (VARs) are satisfied with the availability (uptime) of CORSnet-NSW servers

The CORSnet-NSW team continuously monitors and maintains two server systems (primary in GovDC Silverwater and a backup in DCS Spatial Services Bathurst). External monitoring indicated the availability of each server between June 2019 and June 2020 was in excess of 99.4%, including downtime for routine maintenance.

When asked about their satisfaction with the availability (uptime) of CORSnet-NSW servers in the customer satisfaction survey almost all respondents were either 'Very satisfied' or 'Extremely satisfied'.

CORSnet-NSW stations are performing well, however some potential opportunities to improve station locations and network software were identified

CORSnet-NSW stations are performing well in regard to uptime, latency and reliability. 95% of respondents were satisfied with the performance of CORSnet-NSW stations. However, there are opportunities for improvement when it comes to the location of CORSnet-NSW stations and the derived network software.

When considering potential locations of new stations, it is important to refer to station redundancy figures. CORSnet-NSW designed the station rollout and infill process using a risk reduction principle. In key high use areas and identified high risk areas, stations were installed to provide overlapping redundancy.

The qualitative in-depth interviews were a mechanism to probe further into the effectiveness of the program, specifically in relation to the network and its capabilities for resellers. Generally, densification of the network is an area that was identified by stakeholders on how CORSnet-NSW can be improved. There was some feedback on network software, which provides an area for potential investigation and improvement.

The data being provided is up-to-date, however the supply of CORSnet-NSW data can be further improved

Most users (93%) in the customer satisfaction survey indicated that the data being provided is up-to-date for their needs. Respondents were also satisfied with real-time services, with most (93%) either 'Very satisfied' or 'Extremely satisfied' with real-time services in their area.

A minority of respondents indicated that there are opportunities to improve the supply of CORSnet-NSW data, with the common suggestions including higher levels of accuracy, flexibility and reliability, as well improvements relating to RINEX data (stored positioning data for post-processing).

CORSnet-NSW is beneficial to industry and the economy in NSW

Evidence from the research conducted amongst stakeholders concluded that CORSnet-NSW is beneficial to industry and the economy in NSW. All respondents answered in the positive when asked whether they see CORSnet-NSW as beneficial to industry and the economy in NSW.

Relating to this, there were a significant amount of comments from the qualitative in-depth interviews to support the view that CORSnet-NSW is an authoritative source of CORS data in the industry. Whilst stakeholders were very complimentary when asked about the reputation that CORSnet-NSW has in the industry.

94% of 'Host' users also believed that hosting a CORSnet-NSW station is beneficial to the region/industry.

Recommendations

Key recommendations and areas for improvement in the current program (which can be applied to other infrastructure programs or projects) relate to:

- Effective communication to industry on new CORSnet-NSW products, services and developments.
- Consultation on important new changes prior to commissioning, for example the location of any new CORS station sites.
- Infrastructure, maintenance and development of individual stations to improve product delivery across NSW. For example, continue to investigate emerging battery technology.
- Infrastructure, maintenance and development of the IT architecture for risk mitigation and to aim for a system that provides 100% up time. For example, cloud-based data centres.
- Further testing and development on applications, software and development. Consider market opportunities and feedback from users.
- Investigation into locations for new CORSnet-NSW stations to densify the network.
- Continued focus on the supply of CORSnet-NSW data, including improving accuracy, flexibility and reliability, and improvements relating to RINEX data.
- Continued collaboration with industry for better connectivity and advocating for better mobile phone network coverage and availability.

1. Introduction

1.1 CORSnet-NSW

1.1.1 Background

The CORSnet-NSW project is a precise geolocation positioning service that gives direct users and resellers of CORSnet-NSW data access to fast and accurate positioning and guidance solutions across NSW. The service is delivered by a network of permanent Global Navigation Satellite Systems (GNSS) receivers – known as Continuously Operating Reference Stations (CORS) – that are strategically located across NSW (202 active sites in total). See example pictured below.

The CORSnet-NSW network continuously observes and corrects satellite navigation signals in order to achieve international standard, high accuracy positioning data for NSW. The data is streamed to users via the mobile phone network.

The primary values and original aim of CORSnet-NSW are to aid the Surveyor-General to deliver the office's legislated imperatives and as a means for the survey industry to comply with their legislative obligations. The CORSnet-NSW network underpins the NSW foundation spatial data supplied by the Department of Customer Service to a wide variety of internal and external stakeholders and is fundamental to survey and positioning in NSW. It is important to note also that CORSnet-NSW stations form part of the State control survey as required by the *Surveying and Spatial Information Act 2002*.

Figure 2. CORSnet NSW station at Williamsdale (between Canberra and Cooma)

1.1.2 Project design

The **target group(s)** of this project are both direct users and resellers of CORSnet-NSW data and services.

The primary **focus** of this project is to provide reliable, modern, fit-for-purpose survey infrastructure for the state of NSW. The focus is also to supply wholesale data, maintain the network and

capability, provide guidance and leadership within the industry, and supply the Office of the Surveyor General (OSG) and other organisations with real-time and post process products to support operations and research into the future.

The project includes the following **main components**:

- **Concept testing and research** – Originally named Sydnet, the GPS reference station network was constructed in partnership with RailCorp who provided sites at seven locations across Sydney and the University of NSW, who assisted with software development. The system expanded between 2004 and 2009 as a service available to the public in both Sydney and Bathurst. Testing and research is still conducted by the CORSnet-NSW team as technology improvements are rolled out.
- **Survey quality infrastructure (CORS)** – Following a very successful testing and research phase, CORSnet-NSW entered a planning and construction phase. Stations were planned to support internal operations and provide modern survey control across the state. Project partners provided CORS sites and some funding for various stages of construction. New stations were installed based on providing positioning infrastructure for locations that would benefit from accurate positioning infrastructure for industries such as agriculture, mining, construction and surveying, as well as reducing the risk through redundancy in high use areas relying heavily on existing CORS. Between 2009 and 2019 DCS Spatial Services constructed and surveyed more than 180 CORS.
- **Network software** – Sydnet began using software developed in partnership with the University of NSW. After a successful concept testing and development stage Sydnet was renamed CORSnet-NSW. Commercial software was purchased, and the service was converted from a free service in Sydney to a paid subscription access service growing to cover most of NSW. Over time the paid subscription model has changed from one where DCS Spatial Services managed all payments and accounts to a reseller model and now to a wholesale model.
  The network software currently in use allows DCS Spatial Services to:
  - Monitor all CORS streams for quality and completeness.
  - Connect all incoming CORS data streams and route raw streams to resellers.
  - Directly provide CORS products to internal users, hosts, and research and education users.
  - Monitor CORS for physical stability.
  - Archive all data and dispense through the reference data archive system.
- **Ongoing research and industry direction** – CORSnet-NSW is responsible for publishing performance results, procedural recommendations and linking the use of CORS to legislation through documents such as the Surveyor Generals' directions.
- **Maintenance and continual improvement** – CORSnet-NSW is responsible for the maintenance and upgrade of equipment at approximately 180 sites across the state. Current and ongoing programmed activities are scheduled to enable CORSnet-NSW to fulfil its contractual obligations to data VARs. Activities include general maintenance visits (24-month cycle), cellular modem upgrade program, communications duplication, GNSS receiver upgrades and upgrading the battery system to lithium-based batteries.

The **key project partners** are:

- DCS Spatial Services as the lead agency; construction and operation of CORSnet-NSW is undertaken within the Office of the Surveyor General. DCS Spatial Services' internal users have unlimited access to CORSnet-NSW data and services which are used for operational requirements.
- Geoscience Australia (GA); provided funding for the construction of 11 tier 2 CORS under the AuSCOPE project 2009-2014. GA is currently the lead agency for Positioning Australia, of which CORSnet-NSW is the largest contributor (under contract).
- NSW Local Government; more than 130 CORS are hosted by 86 individual councils across NSW. They provide a hosted location, power and network connections in exchange for subscription access to CORSnet-NSW data and services. This partnership extends to RFS facilities which are commonly managed/funded by Local Government.
- Other NSW Government departments; various NSW Government departments have contributed to both the construction and ongoing operation of CORSnet-NSW. Examples include:
  - NSW Public Works; partners in constructing five CORS under the GPS in Schools Program.
  - Crown Lands; hosts of a number of CORS.
  - Department of Planning Industry and Environment; CORS hosts and funding provider for tide gauge research CORS at Fort Denison and Newcastle.
  - Transport for NSW.
- Victorian Government (through Department of Environment, Land, Water and Planning); cross-border partnership along the NSW-VIC border for seamless surveying near the State's border.
- ACT Government; hosts and construction partners for four CORS in the ACT.
- Private and semi-government corporations; hosts and construction partners for numerous CORS including:
  - Yancoal, South 32; hosts and hardware providers for Mount Thorley and Cordeaux CORS.
  - Port Authority of NSW and NSW Ports; hosts for three NSW Port CORS and additional access support for Fort Denison CORS.
  - University of NSW; CORS host and research partner.
  - South Australia Water; hosts of Rufus CORS.
  - Water NSW; hosts of Warragamba CORS.
- Education and research organisations; subscriptions are provided free of charge for education and research purposes to Universities, TAFE, and schools and for specific research applications. Research results are supplied to DCS Spatial Services and the department is referenced in any published material.
- Data resellers; VARs are sold data under contract as a customer of DCS.

The **timeframe** for the project is from 2004 until current, with the stages outlined and described below.

Stage 1: Proof of Concept, initial Sydney CORS network 2004-2009.

The advent of the Global Positioning System in the late 1980s – early 1990s saw large changes in the way positioning could be used across a wide variety of applications. The standalone accuracy of the GPS system was not of sufficient accuracy for survey applications; however, the addition of a ground-based reference station could open up the possibility of high precision positioning.

In 2004 a capital budget of $1.5m was allocated to construct a network of CORS in the Sydney metropolitan region. The Proof of Concept (PoC) proved successful with a network of seven CORS constructed in 2004-2005 and the system became available to the public under the name Sydnet in 2005 (Roberts et al., 2007). Between 2005 and 2009 two more stations were added to the network and the Sydnet service offered free CORS data using non-commercial software to industry and the general public (Roberts et al., 2007).

Stage 2: Asset under Construction, 2009-2018.
In 2009 the Department identified the need for further improvement of survey infrastructure in NSW. It was clear that CORS would form an integral part of survey infrastructure moving into the future, but an investment needed to be made to:

- Ensure the people of NSW has access to state-of-the-art positioning services.
- Reduce unnecessary duplication of effort and infrastructure.
- Encourage the uptake of GNSS positioning across a wide variety of industries.
- Deliver a standardised level of service and quality.
- Provide connectivity to the official NSW datum.
- Provide legal traceability for GNSS measurements (White et al. 2009).

As a result of the above, $7.25 million of capital was allocated for the Survey Infrastructure Improvement Program (SIIP) in 2009 with most of the investment going to the further development of a CORS network in NSW. From 2009 the name Sydnet was changed to CORSnet-NSW and there was a renewed construction focus to deliver 70 CORS by 2013. The planned upgrades also saw the purchase of new commercial CORS network operating software along with the introduction of an operating model which recovered some of its costs through charging external users for subscription access. Towards the end of the 2013-2018 project phase, CORSnet-NSW became the first and largest CORS network in Australia to be capable of providing all-in-view satellites across the entire network. The entire project was undertaken entirely by DCS Spatial Services staff. This included planning, design, construction, testing, and all the steps necessary to get the project from a concept to becoming fully operational positioning service.

Stage 3: Project to program transition, 2018-current.
The end of financial year 2017/18 marked the end of CORSnet-NSW being an asset under construction and the beginning of a transition phase from a capital-based project to operational program with one-off funding bids for special purposes. This evaluation will focus primarily on the transition, consisting of three main components.

1. Cost recovery; change from a data retail model to data wholesale.

One of the first steps taken towards the transition of CORSnet-NSW was to refine the way that cost recovery of the network worked. Utilising a model to recover some operating costs, CORSnet-NSW has continued to grow its income steadily over the past eleven years. The original model from 2009 to 2014 involved the sale of subscriptions by CORSnet-NSW and Authorised subscription resellers (who would sell subscriptions for a commission). Under this model, regardless of the sales type,

every transaction and subscription created was processed and administered directly by the department's staff, who also provided customer support via phone and email. This process required a great deal of manual input and staff resources.

In 2014, Premium Resellers were introduced to the data sales model for CORSnet-NSW. These resellers received raw data feeds for a fee and managed their own data subscriptions, which became an effective wholesale platform for CORS data in NSW. During financial year 2015/16 CORSnet-NSW proposed a new business model, then following stakeholder consultation later that year it was announced that direct subscriptions would be phased out. Over the next 18 months subscribers were encouraged to renew with one of three Premium Resellers. This move considerably reduced the Departments' resource overheads while encouraging industry growth.

The final direct subscription to CORSnet-NSW was sold in October 2017. 12 months later any subscriptions purchased had expired and there were no longer any active paid subscriptions (CORSnet-NSW still maintains free subscriptions for CORS hosts, internal operations, education and research purposes).

The final step in the process was to remove the obstacles to market innovation and reduce the administrative overhead. The retail data sales contracts and software restricted data resellers to specific products and styles of subscriptions. Removing those restrictions enabled resellers to create innovative and unique products in a competitive market. This was achieved in financial year 2019/20 by entering into new contracts with VARs which uses a flat rate price, thus eliminating the need for sales reporting and allows for creation of product types specific to industry needs.

The net result of the cost recovery model refinements has been growth in CORSnet-NSW income from data sales averaging 59% per annum from the project start in 2009 to the final wholesale implementation. Income generated by wholesale data sales now covers a large proportion of operating costs and capital investment in upgraded equipment.

2. Team and role changes to increase efficiency.

During the entire time of its construction CORSnet-NSW has been fully operational, delivering spatial products in real-time and archive data. Between 2009 and 2016 adjustments in staffing and roles had been made ad-hoc to match the changing operating model and ongoing construction. The result was that in 2016, CORSnet-NSW functions were spread between 14 staff in three separate teams within the department. Eight staff from the Geodesy and CORS team provided between 1 and 0.25 FTE each for project management and research (the project team). The Survey Information and Systems team, amongst their other duties, shared systems operations, including customer support and IT systems across five staff (the operations team). A single staff member from Business Development & Delivery provided support (0.5 FTE) for financial and business relationships. The planning for rationalisation of the CORSnet-NSW staff and functions began (in conjunction with the completion of CORS construction and the transition of data sales) in October 2016 (Business Case, CORSnet-NSW Transition from Project to Operating Unit). Implementation of the Business Case led to the creation of a specialist CORSnet-NSW team and a resulting reduction in operating costs of approximately 20% (capital excluded).

3. Move from a capital-based funding model to operational budget with funding bids for upgrades.

The final stage of the transition was to use income from wholesale to form a planned proportion of the Survey Operations Operational budget. Bids for capital funding for specific tasks can still be entered. In financial year 2018/19 two successful capital funding bids were launched for funding to update all CORSnet-NSW cellular modems to 4G industrial modems and to replace the oldest GNSS receivers in the network. Equipment purchased with this funding will continue to be rolled out over the next three years.

The **budget** for the project is detailed below. It is important to note the figures do not include depreciation. Also, some of the operating costs for CORSnet-NSW are recovered through the commercial wholesale of data. CORSnet-NSW currently has contracts in place with three VARs and GA.

Stage 1: $1.5 million capital for the Proof of Concept, initial Sydney CORS network 2004-2009.
Stage 2: $7.25 million capital as part of the Survey Infrastructure Improvement Program (SIIP), with an additional $3.5 million capital for project expansion.
Stage 3: $1.2 million per annum operational budget plus capital of approximately $1 million per annum for maintenance of capital assets.

1.1.3 Project objectives

The objectives of the CORSnet-NSW project as identified in the project plan are to:

Provide modern survey and positioning infrastructure suitable for use in National Geodesy initiatives, the State survey control network & State cadastre, as well as wide variety of industries including construction, surveying, mining and agriculture etc.

- Provide three key data services via the network:
    1. Differential GPS (DGPS) data that is available in real time and used in the field (sub-metre accuracy across all of NSW).
    2. Real Time Kinematic (RTK) data that is available in the field (2cm accuracy).
    3. Receiver Independent Exchange (RINEX) data that is archived and available via desktop for post processing.

    These services outlined above are delivered directly by CORSnet-NSW to internal users, CORS hosts and for education and research purposes. All other users access CORSnet-NSW services via a VAR using a paid subscription.

- Provide positioning and guidance solutions to the surveying, agriculture, construction, emergency services, mining, academic and scientific industries.
- Provide a flexible, reliable, efficient solution that is easy to use.

The CORSnet-NSW project was aligned with organisational outcomes with a focus on:

- Services – Simplified, efficient spatial services to improve government outcomes and customer satisfaction.
    - o Increase the number of location-aware NSW Government services.
- Innovation - Innovative NSW Government spatial services are digital, lean and connected.
    - o Digital spatial infrastructure readiness.

- o Economic benefits of location-aware government data analytics.
- o Flagship initiatives that drive the digital and spatial data agenda.

(Source – DCS Spatial Services Strategic Plan 2016 - 2019)

CORSnet-NSW has transitioned from a project which focused on the construction of the network and supplying data direct to industry and individual users to the current model, a program where the objectives are to:

- Supply wholesale data.
- Maintain the network and capability.
- Provide guidance and leadership within the industry.
- Supply the Office of the Surveyor General (OSG) and other organisations with real-time and post processing products to support operations and research into the future.

CORSnet-NSW is used extensively for internal DCS Spatial Services projects and operations both directly and indirectly. An example of direct use is the Surface Model Enhancement Project where CORS data was used for tasks such as calculating airborne trajectories and ground targets for airborne scanning and imagery. The internal use of CORS data is variable based on projects, however between 2013 and 2020 CORSnet-NSW delivered more than 81000 hours of RINEX (post processing) data and 6000 hours of real time data to internal users. Noting that one hour of CORS data is equivalent to approximately one hour of FTE. The internal indirect use of CORSnet-NSW has been growing and now far exceeds the direct use. The AUSPOS free online GPS data processing facility provided by Geoscience Australia is an example of an indirect use. Between 2010 and 2020 the service was used worldwide more than a million times, an estimated 30,000 times (roughly ten times a day) within NSW. All AUSPOS results generated within NSW utilise data from up to fifteen CORSnet-NSW stations (provided to Geoscience Australia by DCS Spatial Services). Internally DCS Spatial Services has utilised AUSPOS for the national control network adjustment, and in the realisation of the national datum more than 8800 times with an average session length of 11 hours per session. Conservatively, each AUSPOS utilises connection to at least 7 CORSnet-NSW stations. That equates to more than half a million hours of CORSnet-NSW data utilised internally for AUSPOS alone.

The amount of data delivered in real time to internal customers is significant, however it is relatively small when considering the usage of CORS data outside the department. CORSnet-NSW supplies wholesale data to four organisations who then either sell or pass on that data to the general public. Based on sales and usage figures from 2018-19, industry usage of CORSnet-NSW is approximately 50 times that of internal usage. A few examples of direct industry usage of CORSnet-NSW include:

- Pacific highway upgrade at Ballina, which was a $4.9 billion project that uses CORSnet-NSW for machine control and survey.
- Enhanced weather prediction research using ionospheric modelling generated from CORSnet-NSW, Bureau of Meteorology.
- TAFE NSW use of CORSnet-NSW for education purposes in surveying courses.
- Studies of sea level rise by the Office of Environment and Heritage.

The program logic below outlines the overall rationale of the project.

A program logic is a core evaluation tool, which is essentially a one-page diagram that represents the ideal sequence of outcomes a program intends to achieve. It is a tool used to:

- Clarify and communicate the rationale of a project and its intended outcomes.
- Make causal assumptions explicit.
- Provide a framework for monitoring and evaluating activities.

Figure 3. Program logic
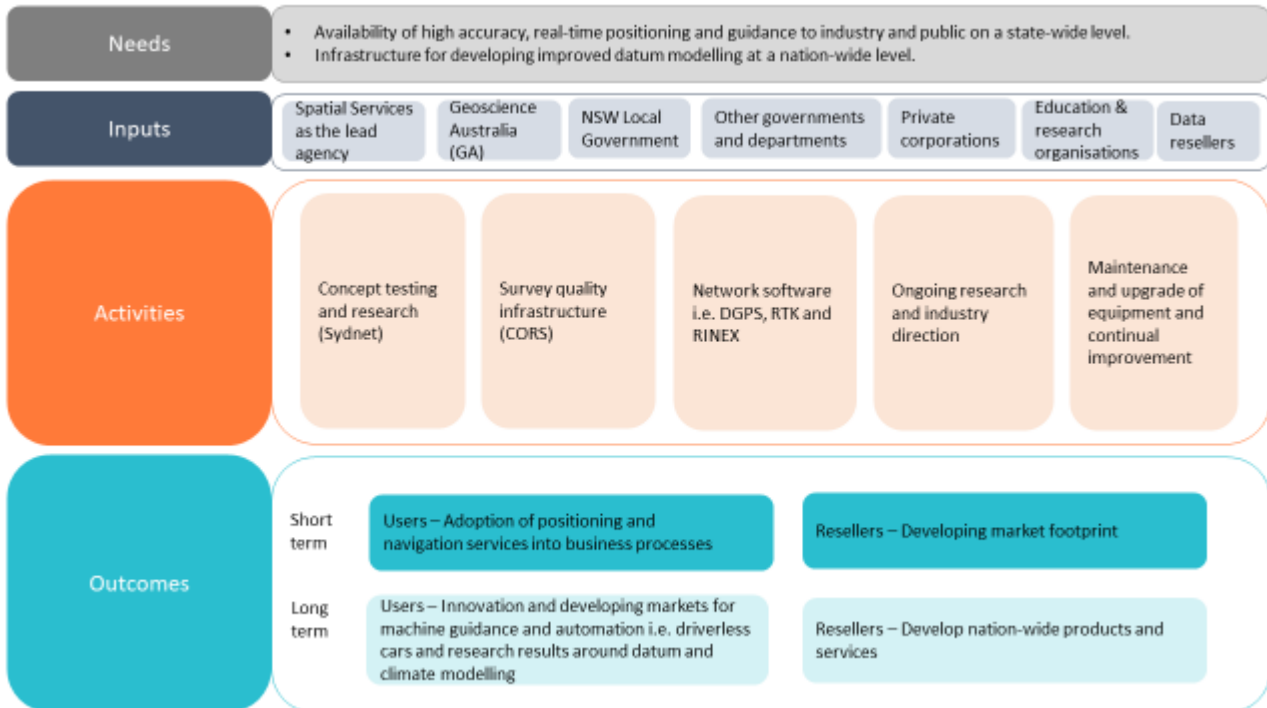
1.2　The evaluation

1.2.1　Purpose

The **purpose** of the evaluation is to:

- Gain an understanding of the satisfaction of users and resellers with the service.
- Share experiences and lessons learnt to enable improvements more broadly across the Department of Customer Service and NSW Government for future similar infrastructure projects, as well as for the CORSnet-NSW program itself.

In addition, key internal stakeholders flagged the following specific objective during scoping interviews:

- Determine whether CORSnet-NSW has been successful in its transition from a build project to an ongoing operational program.

DCS Spatial Services determined that this project be evaluated for several reasons. The timing was ideal as the project was transitioning from a build to maintenance phase. It is also a large-scale infrastructure project involving stakeholders in multiple sectors and would benefit the whole of government. It is also important to note the evaluation was completed internally.

The **focus** of the evaluation is to understand the evolution of the program by measuring the satisfaction of users.

The **scope** of the evaluation includes an analysis of the project deliverables and outcomes based on results to be gathered via the evaluation methods. What is **not in scope** of the evaluation is a procurement audit given procurement processes have changed significantly since the CORSnet-NSW project originally commenced in 2004.

The **key target audiences** for the evaluation are:

- The CORSnet-NSW team and management responsible for future project planning.
- Department of Customer Service and wider NSW Government departments that are looking to build infrastructure projects.
- Treasury NSW.

The final evaluation report will be beneficial to the CORSnet-NSW team, management as well as the wider NSW Government who may be planning or implementing similar infrastructure projects.

1.2.2　Key evaluation questions

The evaluation answers six (6) key evaluation questions across three (3) evaluation areas as identified in the evaluation plan (Table 1). These questions are a mix of standard evaluation questions and questions of interest to key internal stakeholders as discussed during scoping interviews.

Table 1.   Key evaluation questions

Evaluation area	Key evaluation questions	Section in the report where to find the answer
Appropriateness of the project design	To what extent is the current business model (or the way in which the project operates) for CORSnet-NSW the most suitable one?	2.1
	What other technological opportunities (products or concepts) can be considered in the future?	2.2
Effectiveness of the project	To what extent does CORSnet-NSW effectively provide wholesale data? Is the wholesale data of the quality, quantity, format and style required by resellers for supplying purposes?	3.1
	To what extent does CORSnet-NSW effectively maintain the network and our capability?	3.2,3.3
Industry impact	To what extent does CORSnet-NSW supply the Office of the Surveyor General (OSG) and other organisations with real-time and post process products to support operations and research into the future?	4.1
	How well does the project provide guidance and leadership (e.g. through positioning infrastructure) within the industry?	4.2

1.2.3   Evaluation methods

The proposed evaluation was conducted internally and is primarily an outcome evaluation, with process elements.

The evaluation relied on a mix of qualitative and quantitative methods, building on existing program documentation and data and collecting additional feedback from users and key stakeholders. The evaluation methods are outlined below:

a)   Program documentation

The evaluation considered key program documentation, firstly to develop a sound understanding of the project, and secondly to assess the appropriateness of the project design. Key project documents reviewed included:

- Papers written documenting the rollout of CORSnet-NSW (listed in Appendix 3).
- Site plans and installation agreements – this includes more than 180 individual plans produced for every CORS constructed, containing information on site partners agreement and build date, as well as equipment required at every site.
- Briefings and project planning documents (listed in Appendix 3).

- Planning and evaluation documents for the benefits of precision positioning (listed in Appendix 3).

b) Data analysis

Data that was analysed for this evaluation was obtained from the following sources:

- Trimble Pivot – CORS network operating software provided in-depth current and historical data for the number of active subscriptions, data supplied to customers and wholesale, session times and lengths as well as individual station uptime, latency and system availability.
- Pingdom reports – provided the external availability of CORSnet-NSW servers.
- GIS maintenance and construction database.
- SAP records – used to quantify income from wholesalers and retail data sales.
- Sales and usage reports from data wholesalers (VARs) – provided insight into external subscriber numbers. Commercial in confidence prevents the release of some financial figures.
- Census data from the Australian Bureau of Statistics (ABS) – used to create population coverage estimates along with spatial buffers created by the CORSnet-NSW team.
- Geoscience Australia – provided confirmation of new subscriber numbers and Auspos service usage.

c) Customer satisfaction survey

A customer satisfaction survey was conducted at the beginning of the evaluation to collect feedback from key user groups and inform further consultation via the in-depth interviews covered at (d).

The customer satisfaction survey consisted of:

- Survey name: CORSnet-NSW Customer Satisfaction Survey
- Survey program used: Survey Monkey
- Survey length: 10 minutes (32 questions)
- Fieldwork dates: Tuesday 7 April 2020 – Sunday 26 April 2020
- Who was invited: Direct invites (and a follow up reminder) were sent to current internal and external users, hosts, VARs, equipment supplier/resellers and education/research customers. Indirect invites were also sent via the Association of Consulting Surveyors (ACS) and the Institution of Surveyors NSW (ISNSW) member email newsletters to encourage users to participate. Given the exact number of invites sent is not quantifiable, a response rate is not able to be provided.
- How many completed: 91 respondents completed the survey as per the final breakdown of groups below.

Answer choices	Response n=	Response %
External user	26	29%
Internal user - Spatial Services	24	26%

Internal user - other NSW Government department	17	19%
Host	9	10%
Value Added Reseller	6	7%
Equipment supplier/reseller	6	7%
Education/research	3	3%
I am not a current user in any of the above groups	0	0%
Total	91	100%

d) In-depth interviews

Qualitative data from interviews provides evidence about the types of experience. Contrary to quantitative data, it is not possible to assess the *extent* of the feedback from qualitative data – frequencies are only indicative – qualitative data explores the *depth* of the evidence available.

Respondents who completed the customer satisfaction survey were asked the following question at the end of the survey. 38 respondents answered 'Yes' and provided their details for potential follow up.

> *We would potentially be interested in following up with some respondents who have completed this survey. This would involve a phone interview to address some questions not addressed in this survey. Would you be interested in participating in a phone interview at a mutually convenient time in the next month?*
> *a) Yes*
> *b) No*

It was important to have a good cross-section of respondents participate in the in-depth interviews, with eleven participants selected (at least one from each group outlined earlier). The interviews were conducted from Tuesday 28 April 2020 – Wednesday 6 May 2020 for approximately 30 minutes each via video conferencing.

1.3   Confidence in the findings and limitations

We were able to implement the methods largely as intended. We are confident that the data collected provides a sound basis for the evaluation to draw conclusions about the project.

2. Appropriateness of the project design

This chapter examines the design of the project. It answers the following evaluation questions:

- To what extent is the current business model (or the way in which the project operates) for CORSnet-NSW the most suitable one? Suitability is assessed in terms of providing CORS services to a wide variety of market segments, a model that is able to support traditional uses as well as provide flexibility for emerging technology, and also provide direct support for end users.
- What other technological opportunities (products or concepts) can be considered in the future?

2.1 The current business model is meeting the needs of stakeholders

CORSnet-NSW has undergone a number of changes that have impacted the business model and operation. During financial year 2012/13 CORSnet-NSW initiated a planned transition to allow established industry partners to take on commercial/retail sales of CORS data. This transition was planned in order to promote the spatial products industry and allow private companies the opportunity to market and value add products. This transition enabled CORSnet-NSW staff to focus on the provision of infrastructure and therefore reduce administrative overheads. During financial year 2013/14 at the start of the transition, CORSnet-NSW staff administered and separately invoiced approximately 700 subscriptions, which were either sold directly or by Authorised resellers. By the end of financial year 2017/18 subscriptions sold and administered by Premium Resellers had increased to more than 2000, and the CORSnet-NSW team were no longer administering any paid accounts. This transition achieved the desired outcome, enabling CORSnet-NSW staff to reduce administrative overheads and therefore the focus on the provision of infrastructure. The pricing structure of the subscriptions was modelled on a cost recovery model with market growth forecasts expected to cover the running costs by 2017.

The transition away from this retail model began in financial year 2013/14 with the introduction of Premium Resellers. Premium Resellers were given access to raw CORS data of which they were able to process and sell to users through their own network software and administrative channels. During this phase Premium Resellers provided usage reports to CORSnet-NSW and were billed according to the number of subscriptions sold per quarter. The pricing model for the subscriptions to Premium Resellers was that each subscription sold had significant discounts applied to help stimulate market growth with the discount reducing each year based on targets reached.

Following two years of transition to the Premium Resellers model, the second phase of the transition started. This involved a consolidation of the CORSnet-NSW staff and functions to a more efficient model and the complete cessation of retail sales through Authorised resellers. By the end of financial year 2017/18 CORSnet-NSW data sales were entirely wholesale to three VARs. During the time of transition, a major project was announced by the Federal Government. The Positioning Australia project sought to purchase CORS data from all the major CORS providers in Australia and make it available free of charge in order to stimulate innovation and extend use of high precision positioning in Australia. This was a major market disruptor, however, was also completely compatible with the final stage of the CORSnet-NSW wholesale transition.

In financial year 2018/19, CORSnet-NSW entered into an agreement with the Federal Government (through Geoscience Australia) to supply all of its CORS data and thus becoming the single largest contributor to Positioning Australia. At the same time, CORSnet-NSW further simplified its cost recovery model by moving to a flat fee for all services. Extra income provided through Positioning Australia, combined with the reduced administrative costs associated with the flat fee model, allowed a new pricing structure and more flexible contracts.

NSW was the first and largest government owned CORS network to provide data to Positioning Australia, followed shortly after by the Victorian Government and other states. The 'Blue' dots in the map below shows the current public availability of real time CORS across Australia. Due to an early uptake of the technology and investment by both the NSW (and Victorian) Governments, both these states are at a considerable advantage regarding the availability of spatial infrastructure.

Figure 4. Public availability of real time CORS across Australia

Source Geoscience Australia https://gnss.ga.gov.au/network
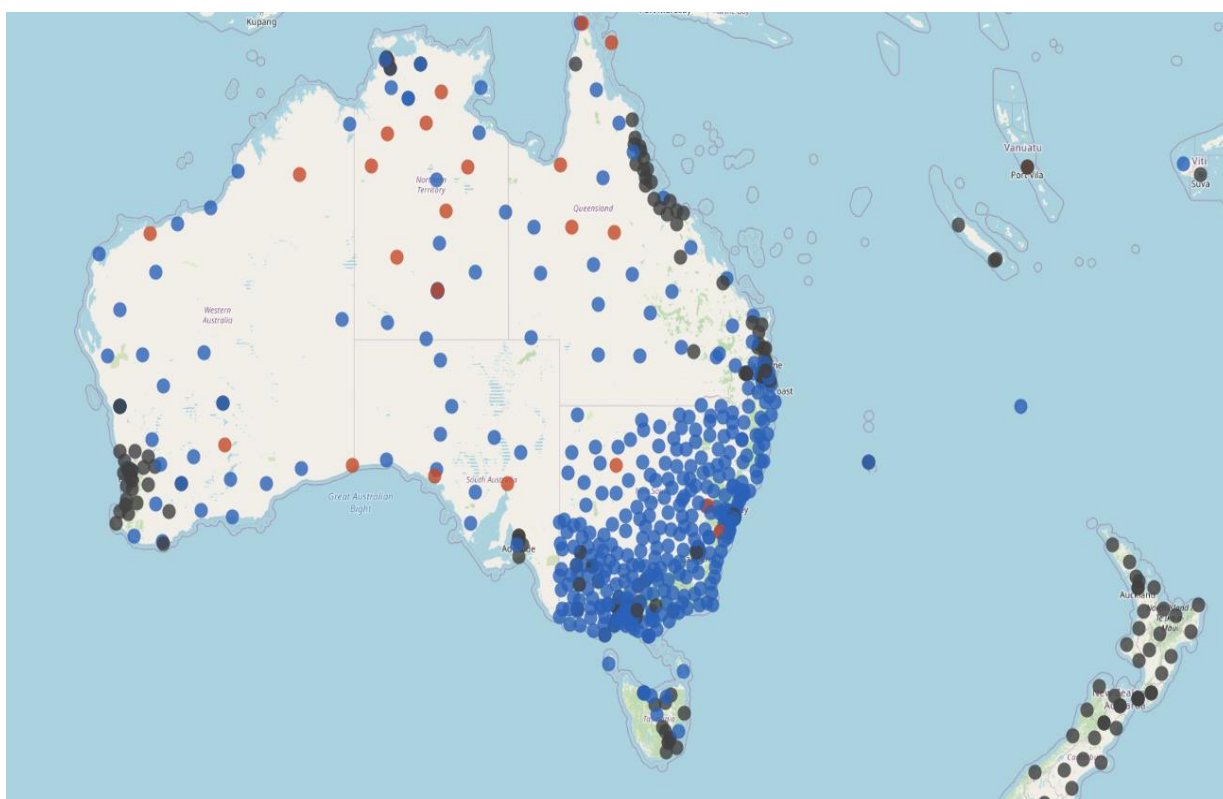
In the graph below, CORSnet-NSW sales data show the transition from retail to wholesale.

Figure 5. CORSnet-NSW sales data
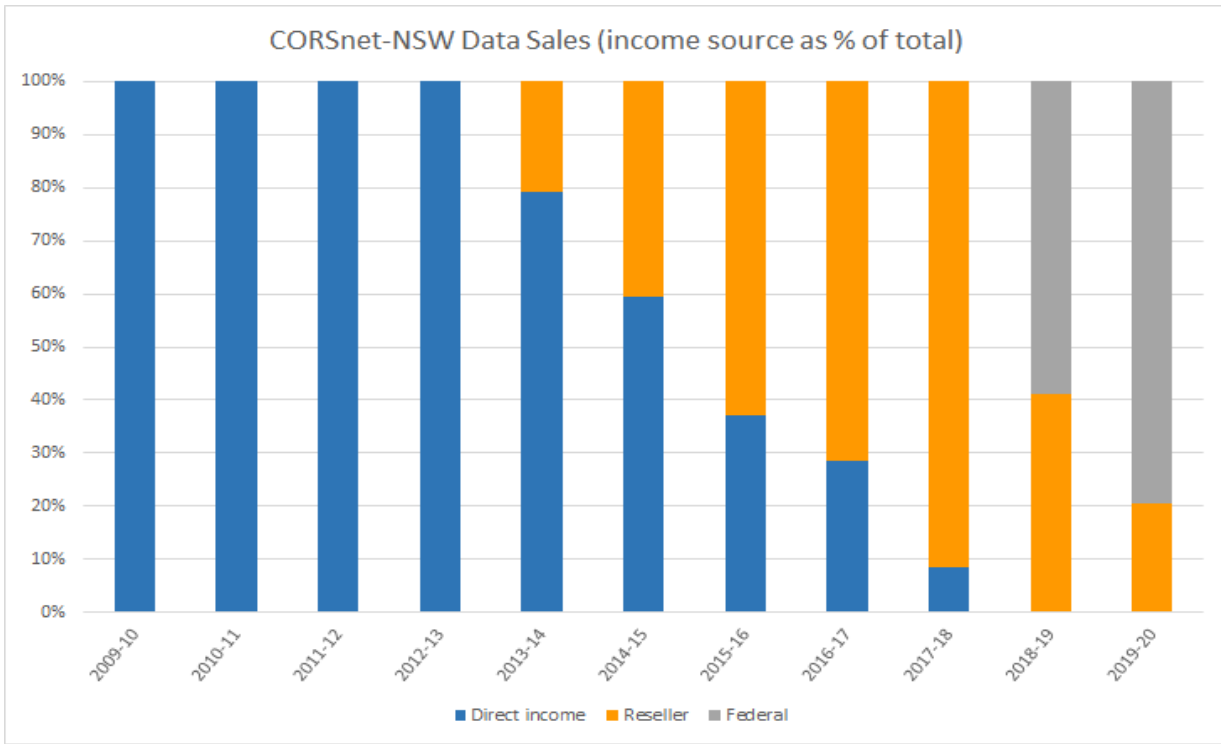
Between 2013 and 2020 the amount of retail data has fallen in line with expectations during the transition to wholesale. A gradual decline in retail data was expected as customers transferred away from receiving data direct from CORSnet-NSW servers to one of the Premium Resellers. The rise in wholesale data is attributed to the onboarding of each new Premium Reseller. The remaining data supplied directly is free of charge to internal users, research/ education providers and CORSnet-NSW station hosts. Conversely the amount of wholesale data provided to the industry has grown through the transition. CORSnet-NSW now delivers more than 5 million hours of wholesale CORS data per annum.

Figure 6. Wholesale data delivered

Wholesale Data Delivered (Hours)
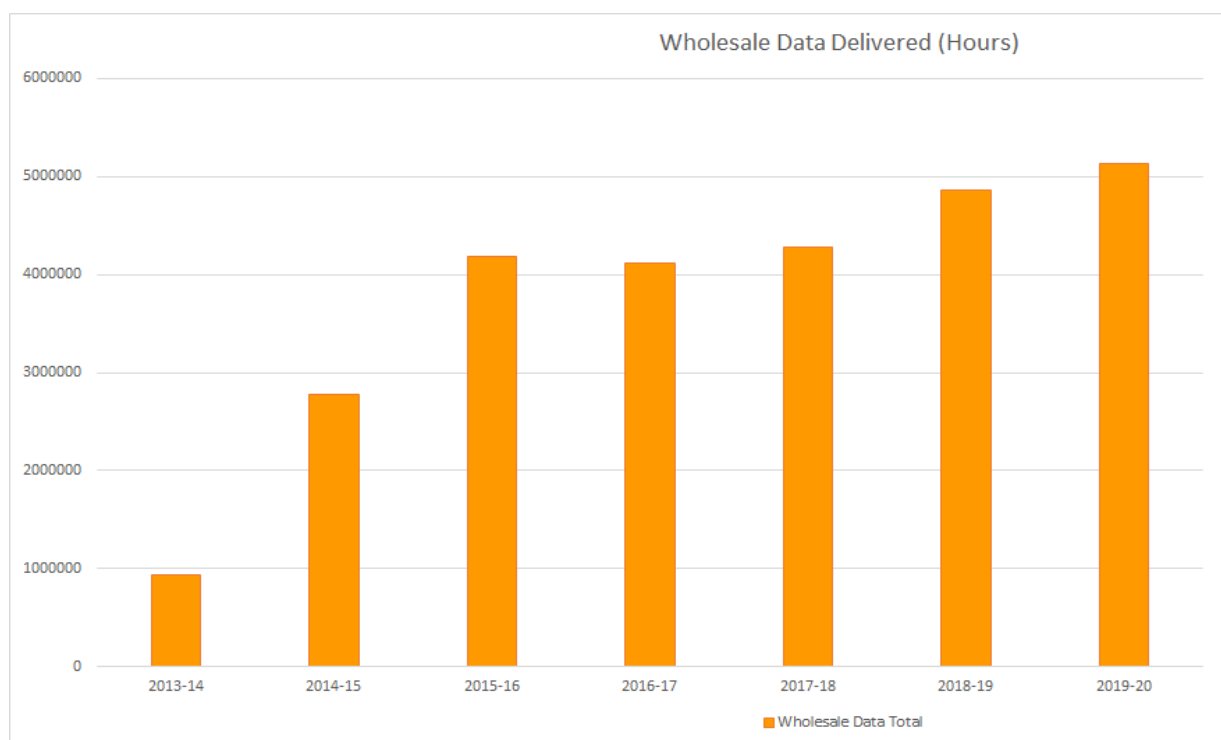
Two important findings from the customer satisfaction survey concluded that:

- CORSnet-NSW is fit for purpose to address current needs and;
- CORSnet-NSW will support foreseeable future needs.

Respondents were initially asked "*Do you see CORSnet-NSW as fit for purpose for your current needs? I.e. meeting the needs for you/your customers as you had originally intended.*"

An overwhelming majority answered 'Yes' as per the breakdown below. Of the three who selected 'No', one was a Host, one an External and one an Internal user – Other NSW Government department.

Answer choices	Response n=	Response %
Yes	85	97%
No	3	3%
Total	88	100%

A follow up question as below was then asked, *"In your opinion, do you think CORSnet-NSW data will support your foreseeable future needs?"*

Once again, an overwhelming majority of respondents who answered this question indicated 'Yes'.

Answer choices	Response n=	Response %
Yes	86	98%
No	1	1%
Unsure	1	1%
Total	88	100%

The reason provided by the respondents who indicated 'No' or 'Unsure' related to limited coverage in their particular area. The respondent who answered 'No' was an Internal user – Other NSW Government department.

The question below was asked (where applicable) during the in-depth interviews.

"What are your thoughts on the current CORSnet-NSW subscription model? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?"

There was a general feeling of satisfaction with the current model, with some comments noted below.

- "We also expose a lot of students who may not come across it (including those in civil engineering). The model is open and easy for us." (Education/Research user)
- "It's good that you have flexibility relating to the free subscription based on contribution, that is a good idea." (Internal user – Other NSW Government department)

It was also important to measure the satisfaction with the current business model from the perspective of the VARs. The following question was asked and answered by the VARs who participated in the survey.

"Are you satisfied with the current business model where CORSnet-NSW supplies wholesale data to Value Added Resellers (VARs)?"

81% of respondents who answered this question responded with 'Yes' to indicate their satisfaction. Of the five respondents who answered 'No' three were External users, one a VAR and one a Host.

Answer choices	Response n=	Response %
Yes	22	81%
No	5	19%
Total	27	100%

Please note that data is provided free of charge to research institutions (for education), internally, and to CORSnet-NSW station hosts. Benefits are spread across levels of government with 135 NSW CORS hosted on properties managed by 86 different local councils.

Figure 7. CORSnet-NSW Local Government Hosts

CORSnet-NSW Local Government Hosts
May 2020

Legend

▲ Operational Sites

☐ NSW

■ Local Government Hosts

A total of 86 Local Councils provide a combination of location, power and/or backup network communications for 135 CORS in NSW. Many councils host more than one CORS.
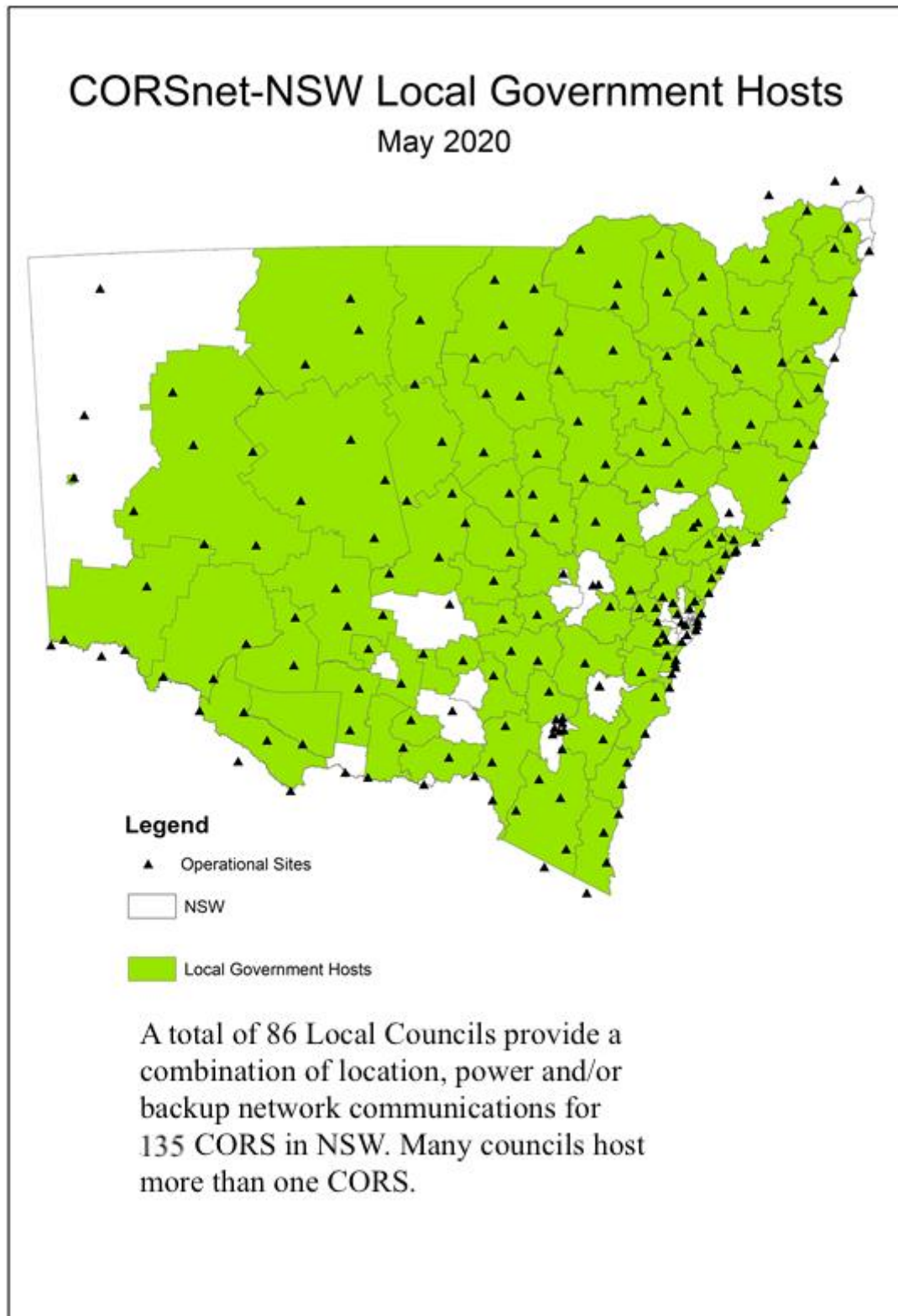
2.2   Opportunities to improve the CORSnet-NSW network

In the customer satisfaction survey, respondents were asked the following final optional open-ended response question.

"Do you have any other comments, feedback or suggestions in relation to your experiences with CORSnet-NSW?"

The majority of comments were quite complimentary about the technology, data and service they receive from CORSnet-NSW and the team. As per the results in 2.1 above and further reinforced in 4.2 below, CORSnet-NSW is effectively meeting the needs of customers and has a meaningful impact on the industry and economy.

There are opportunities that can be considered to improve the CORSnet-NSW offering. Suggestions to improve NRTK were common. Respondents provided suggestions on potential improvements to CORSnet-NSW, including:

- *"Real time Positional Uncertainty for NRTK."* (Internal user – Spatial Services)
- *"It would be great if one can connect the points with precise levelling to be able to contribute to the overall geoid assessment and better height datum definition. Also, a review of the stability of points can be done by monitoring time series of the points in real time as well as multi GNSS and maybe GBAS implementation as a concurrent service to RTK etc."* (External user)

Interviewees were asked the following two questions to explore how the CORSnet-NSW offering could be improved.

1. *"If you had one thing to change in the way the program is conducted, what would it be?*
2. *Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?*

Some of the important comments/suggestions are included below, based on identified themes.

More consultation

- *"If there was anything going forward it would be more consultation on where new sites are going prior to them being commissioned."* (VAR)

Explore uses in relation to intelligent transport

- *"Intelligent transport is certainly one sector that would benefit from accessing positioning data that CORS provides."* (External user)
- *"I suppose the one with all the recent fanfare is looking at Positioning Australia, that is intelligence transport systems and driverless cars and that sort of stuff. CORSnet-NSW could support the PA infrastructure to feed into this."* (Internal user – Spatial Services)

Effective management of existing (and new) infrastructure and maintenance importance

- *"Second data centre as a back-up is really important."* (Education/Research user)
- *"I would think there is the potential to expand some of the CORSnet stations to other long tide gauge records in NSW along the coast and around the country. We desperately need the utility of*

the type of information that we get out of Fort Denison and Newcastle at other long tide gauge records around the country e.g. Adelaide and Fremantle." (Internal user – Other NSW Government department)
- "The role of CORSnet-NSW is to focus on the maintenance of the network as users don't want to plug into a system which is not working." (VAR)
- "From a Trimble perspective - a combination of a CORS-based and satellite-based service/system to deal more with the less dense areas of service where no phone coverage is offered or is limited." (Equipment supplier/reseller)

Investigate new applications, software and development opportunities

- "Supporting apps to hook into CORS stations would be very handy to determine distances for static sessions." (Host)
- "From a software perspective when I have had less experienced surveyors that actual having to input the GPS time, maybe an option on the website where you can switch between the local time and the GPS time for the inexperienced users." (Internal user – other NSW Government department)
- "I'd like to have the ability to have the web service and API where you give it the timeframe (start time and end time of the data) and it gives you the RINEX data." (Internal user – Spatial Services)
- "What we would really like is to be able to mirror the data depository that CORSnet has with ours and fill in any data gaps that arise with real time network issues, or having access to their data as a whole and having access to an API." (VAR)

3. Effectiveness of the project

This chapter assesses the effectiveness of the project against its initial objectives. It answers the following evaluation questions:

- To what extent does CORSnet-NSW effectively provide wholesale data? Is the wholesale data of the quality, quantity, format and style required by resellers for supplying purposes?
- To what extent does CORSnet-NSW effectively maintain the network and our capability?

3.1 Wholesale data is being effectively provided and meeting important needs

It is important to identify how wholesale data is being provided and determine whether it is meeting the needs of users.

The graph below demonstrates how the private sector continued to grow the number of active users during the program transition, and effectively supply data to their customers and the industry. This is in comparison to DCS Spatial Services (SS) survey focus.

Figure 8. Active logins comparison
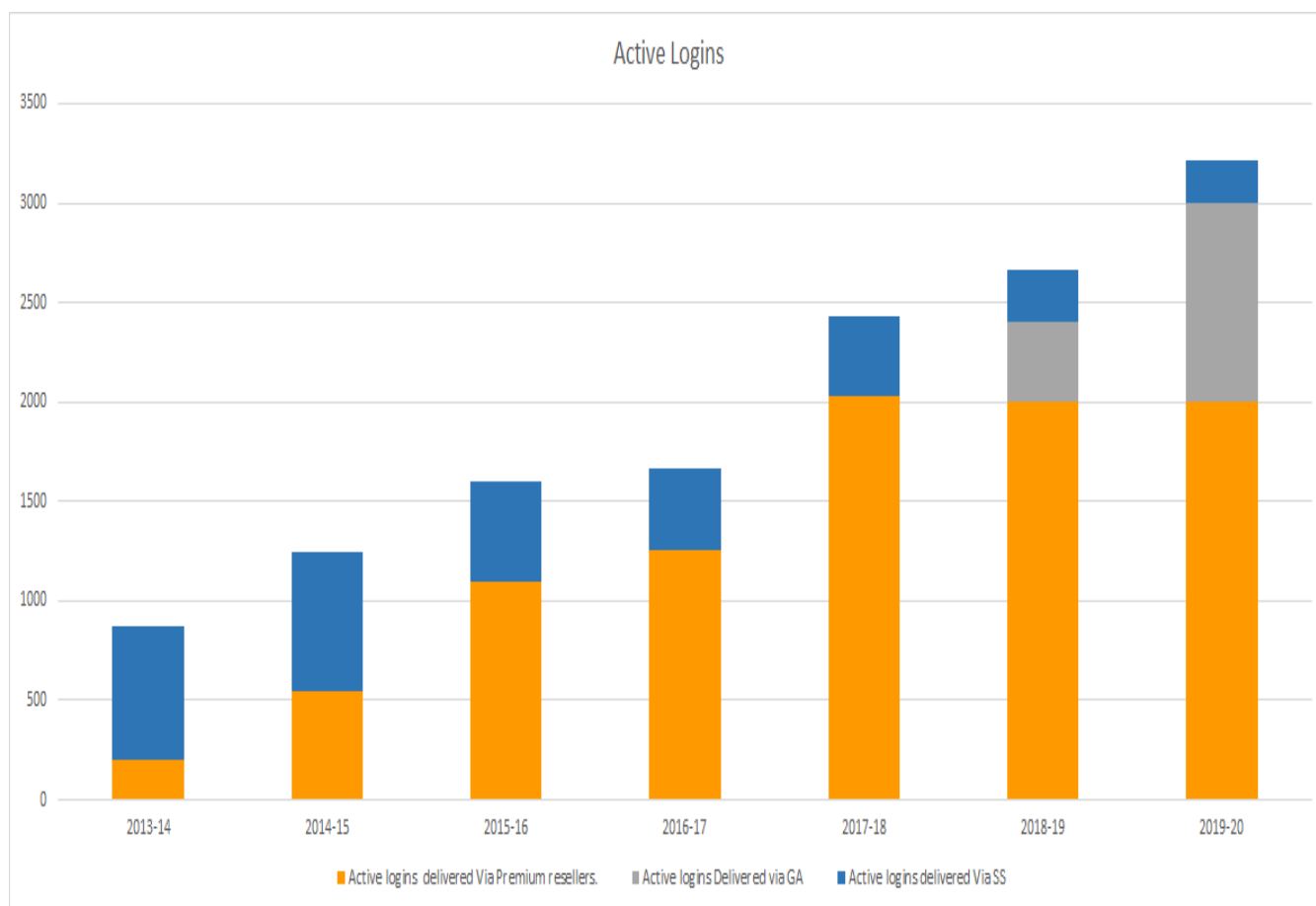
There were a number of questions in the customer satisfaction survey which were designed to measure how CORSnet-NSW is being used, why it is used, and the benefits derived from this usage. We can draw the following conclusions.

- Most respondents access their data via mobile rover RTK.

Respondents were asked about the main way they access their data.

Answer choices	Response n=	Response %
Mobile rover RTK	62	76%
Reference data shop	16	20%
Automatic software e.g. iGate, Catalyst etc.	4	4%
Total	82	100%

- All real-time was used more than some real-time and some RINEX.

Respondents were asked *"In relation to real-time RTK and post processing RINEX data, what describes your use of CORSnet-NSW data?"*

Answer choices	Response n=	Response %
All real-time	28	34%
Mostly real-time	18	22%
Some real-time and some RINEX	25	30%
Mostly RINEX	7	9%
All RINEX	4	5%
Total	82	100%

The table below provides evidence of the transition from data delivery direct to the customer then to Premium Resellers, and then finally wholesale. The slight rise from 2018-19 to 2019-20 shows an increase in market usage.

Figure 9. Data delivered to retail customers
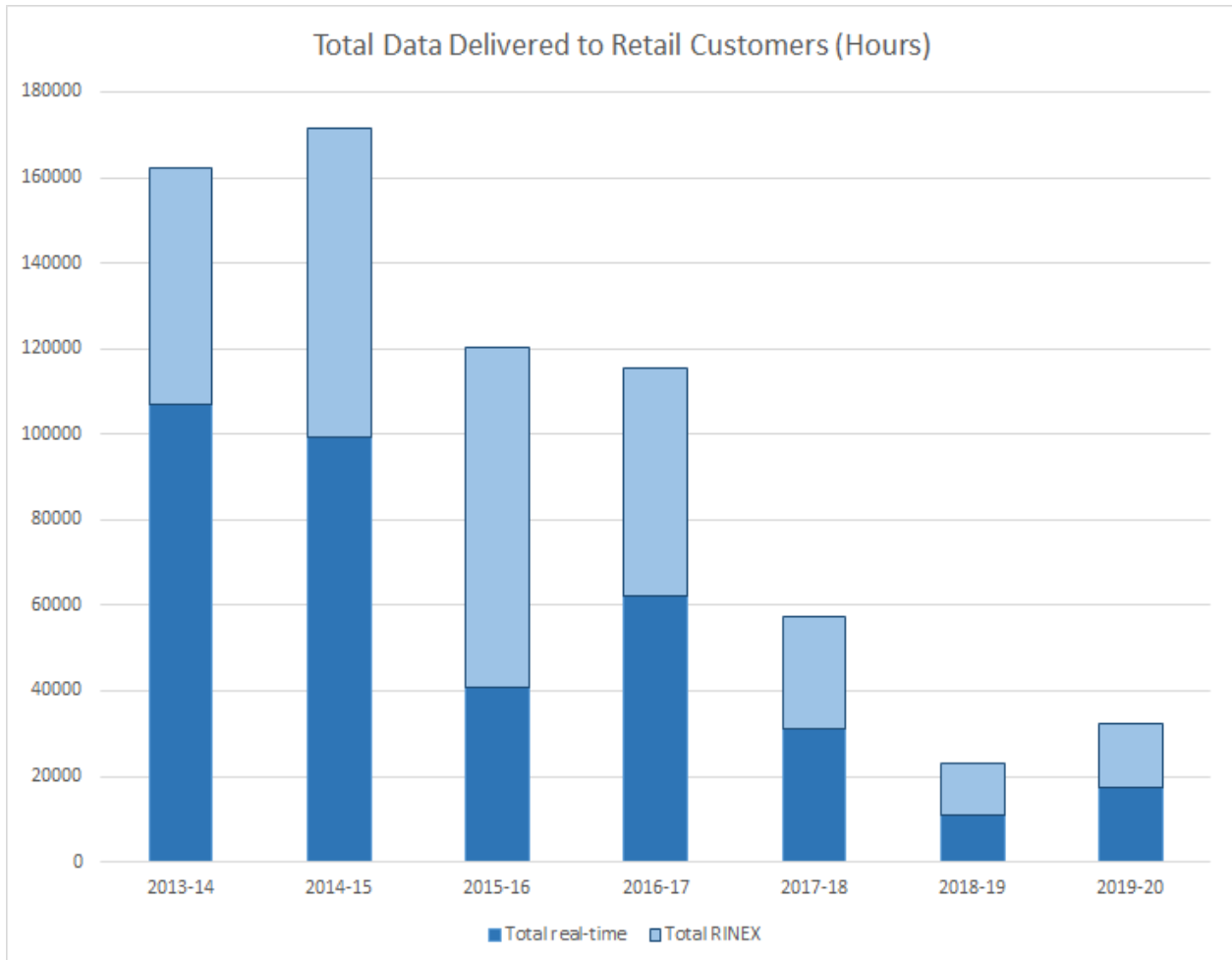
- Most respondents use CORSnet-NSW data for their 'Survey' needs.

Respondents were asked to choose the categories that best suit their use of CORSnet-NSW data.

Answer choices	Response n=	Response %
Survey	71	86%
Mapping/GIS/Asset Management	31	37%
Construction	19	23%
Testing and evaluation	15	18%
Research	15	18%
Education	12	14%
Machine control	11	13%
Agriculture	2	2%

Note – multiple choice question so Response % is higher than 100%.

- The top five benefits gained from using CORSnet-NSW are;
    1. Fast
    2. Reliable
    3. Easy
    4. Station location/coverage
    5. Direct connection to datum

Respondents were asked *"What benefits do you see in using CORSnet-NSW services? (Please select all that apply)"*

Answer choices	Response n=	Response %
Fast	64	77%
Reliable	62	75%
Easy	61	73%
Station location/coverage	59	71%
Direct connection to datum	56	67%
Economical	40	48%
Scientifically valid	38	46%
Legally traceable	31	37%
My organisation is a CORSnet-NSW host	26	31%
Other (please specify)	9	11%

Note – multiple choice question so Response % is higher than 100%.

A few of the 'Other' responses to the question above included:

- Educational use/purposes
- Authoritative
- Saves on UHF radio set up/frequency interference
- Post processing is always available

Interviewees were asked:

"Can you please share your thoughts on the CORSnet-NSW network and its capabilities according to your/your organisation's needs?

Overall, stakeholders interviewed confirmed their high level of satisfaction with the quality of the network provided. One interviewee referred to CORSnet-NSW as 'world class'.

- "It's undoubtedly world class, if not one of the better networks in the world. The level of expertise in building and maintaining sites is again world class. All the sites were built to ICSM standards, so that is very impressive. On the downside of that NSW is reliant on proprietary software to operate it." (VAR)

3.2 Value Added Resellers (VARs) are satisfied with the availability (uptime) of CORSnet-NSW servers

The CORS-net NSW team continuously monitors and maintains two server systems. VARs have direct access to streams from both the primary production system in Gov DC, Silverwater and a backup server in Bathurst. External monitoring shows the availability of each server between June 2019 and June 2020 was in excess of 99.4%, including downtime for routine maintenance. On close inspection of the data, none of the outages were simultaneous across both production and backup, meaning a system availability of 100%.
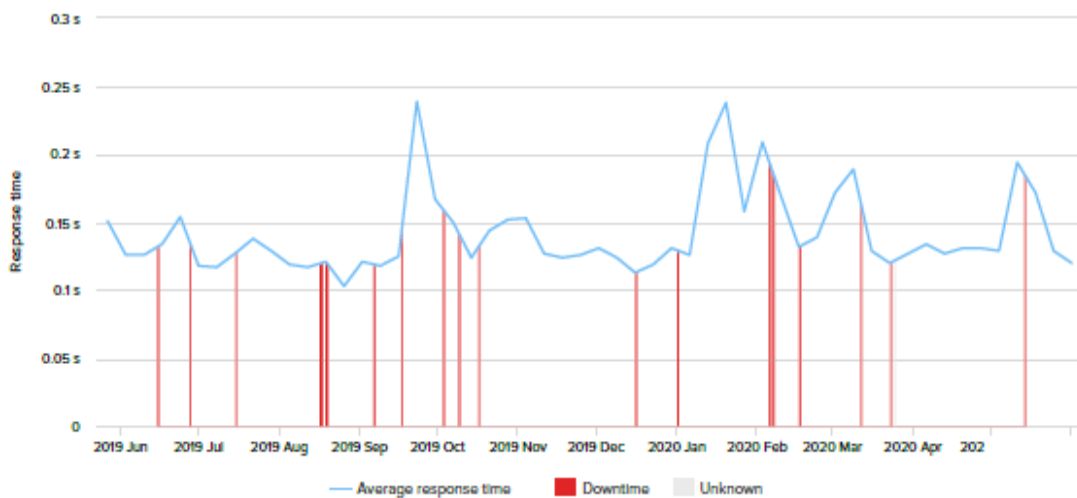
The graph below illustrates server availability for Bathurst (backup), from Pingdom uptime report.

Figure 10. Pingdom uptime report for Bathurst (backup)
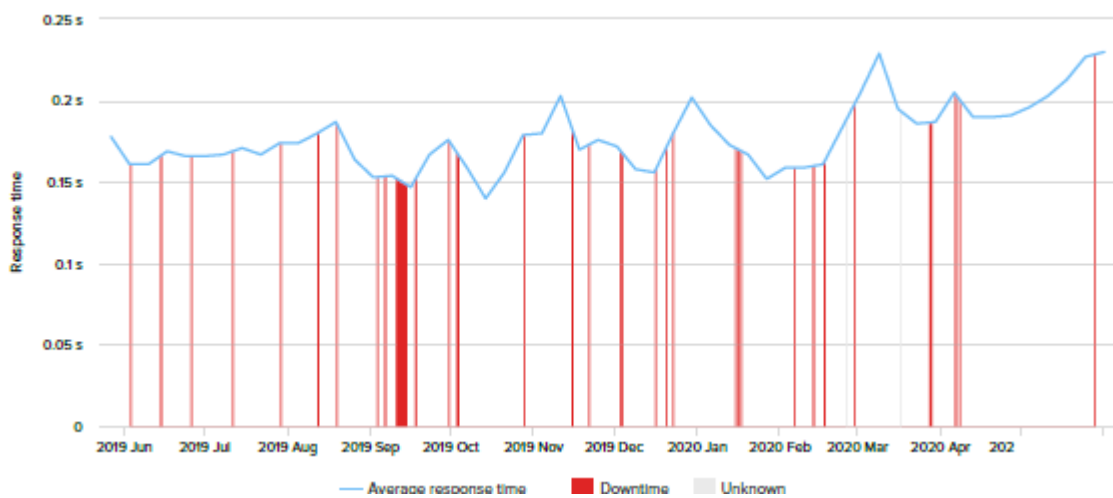
The graph below illustrates server availability for Gov DC (production), from Pingdom uptime report.

Figure 11. Pingdom uptime report for Gov DC (production)

VARs were asked about their satisfaction with the availability (uptime) of CORSnet-NSW servers. Almost all respondents who answered this question were either 'Very satisfied' or 'Extremely satisfied' with the availability (uptime) of CORSnet-NSW servers.

| Answer choices	Response n=	Response %
Not satisfied at all	0	0%
Not so satisfied	0	0%
Neither satisfied nor dissatisfied	1	4%
Very satisfied	15	58%
Extremely satisfied	10	38%
Total	26	100%

3.3 CORSnet-NSW stations are performing well, whilst there are opportunities to improve the station locations and network software

Two further findings from the customer satisfaction survey concluded that:

- There is general satisfaction with the performance (uptime, latency, reliability) of CORSnet-NSW stations.
- Opportunities exist to improve the locations of CORSnet-NSW stations and network software.

CORSnet-NSW CORS are designed with reliability as a primary focus, which extends to multiple telecommunications carriers, redundant modems, battery backup and the highest quality industrial equipment. This resulted in excellent reliability, exceeding 99% on average. Even during the height of COVID-19 restrictions, with extra strain on telecommunications systems and travel bans for maintenance staff, the total number of sites online still averaged above 99% for the month. Similar reliability was recorded during the bushfire crisis in December 2019-January 2020, with only two to three stations offline due to telecommunications outages in the south coast. Outages lasted from a few hours to a couple of days (Mogo CORS was the worst affected). No CORS were damaged as a result of fire. The following graph shows the station reliability for April-May 2020, which also includes state border CORS supplied by the Queensland and Victorian Governments (not operated by CORSnet-NSW).

Figure 12. Total CORS uptime
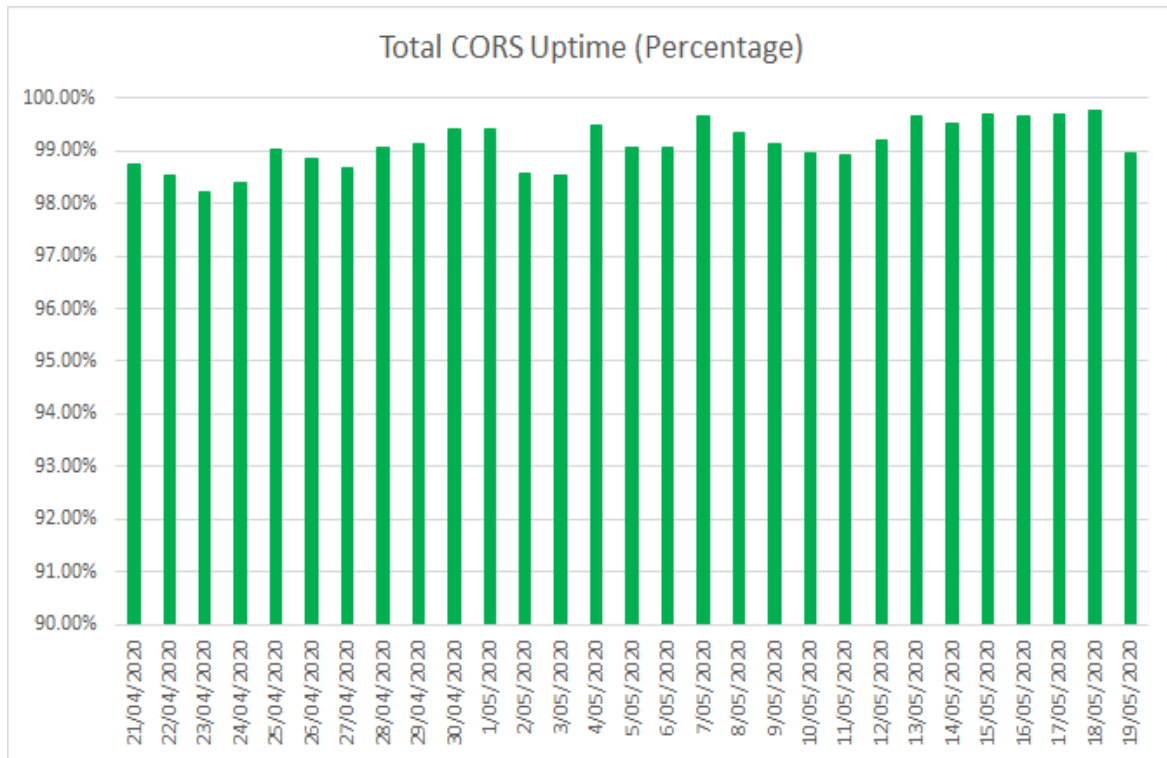
CORSnet-NSW construction rollout began in 2004 and has been through various program stages to provide state survey and infrastructure coverage for the industry in NSW. Refer to the graph below which illustrates this construction progression.

Figure 13. CORSnet-NSW construction progression

CORSnet-NSW Construction
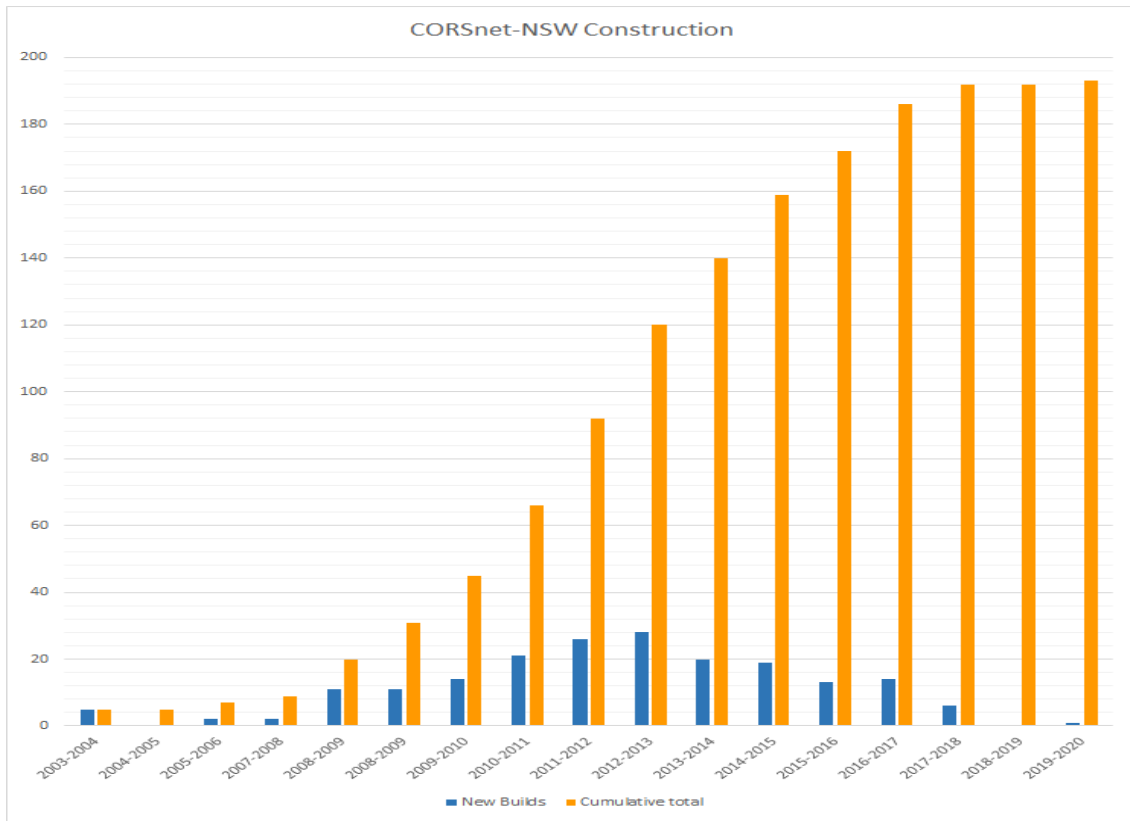
As a result of the construction that has occurred since 2003, as at May 2020 more than 99% of NSW residents live within the coverage area of at least one CORS. This coverage area extends over almost every major construction and subdivision project in NSW.

Figure 14. CORSnet-NSW coverage statistics

CORSnet-NSW Coverage Statistics
May 2020

Legend

▲ Operational Sites

☐ NSW

Coverage

■ 50km Radius

☐ 150km Radius

Population (Per Statistical Local Area)

· 1 Dot = 2,000 Residents

150 km radius   total area 796392 square km (99.4%)
                 99.9% of the total population
50 km radius   total area 645743 square km (80.6%)
                 99.8% of the total population
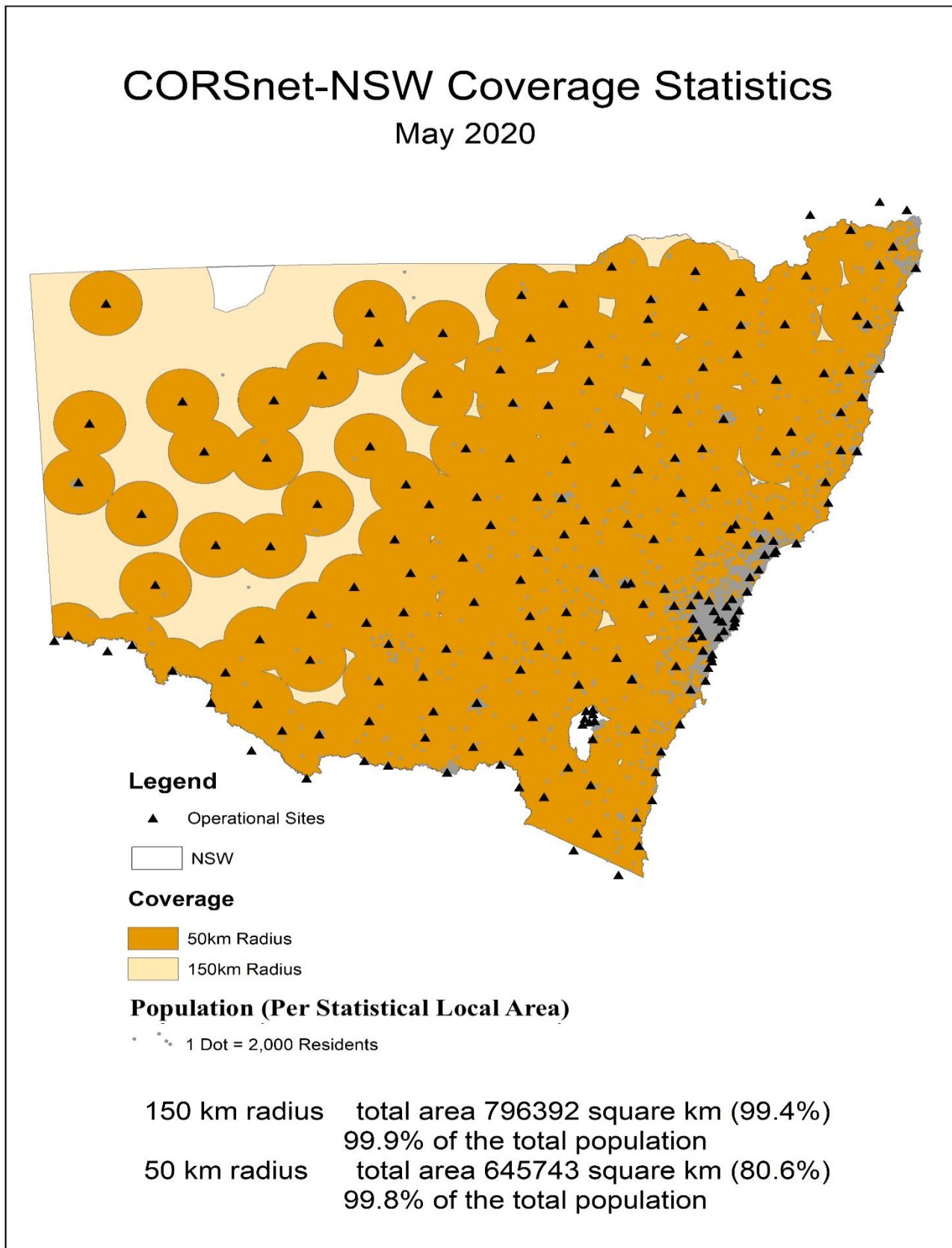
Respondents to the customer satisfaction survey were asked *"How satisfied are you with the performance (uptime, latency, reliability) of CORSnet-NSW stations?"*

Most respondents who answered this question were either 'Very satisfied' or 'Extremely satisfied' with the performance of CORSnet-NSW stations.

Answer choices	Response n=	Response %
Not satisfied at all (e.g. my local station is always down)	0	0%
Not so satisfied	0	0%
Neither satisfied nor dissatisfied	4	5%
Very satisfied	50	58%
Extremely satisfied (e.g. my local station always functions well)	32	37%
Total	86	100%

Whilst there was general satisfaction overall when respondents were asked *"How satisfied are you with the location of CORSnet-NSW stations"*, n=40 respondents then answered the following optional open-ended response question:
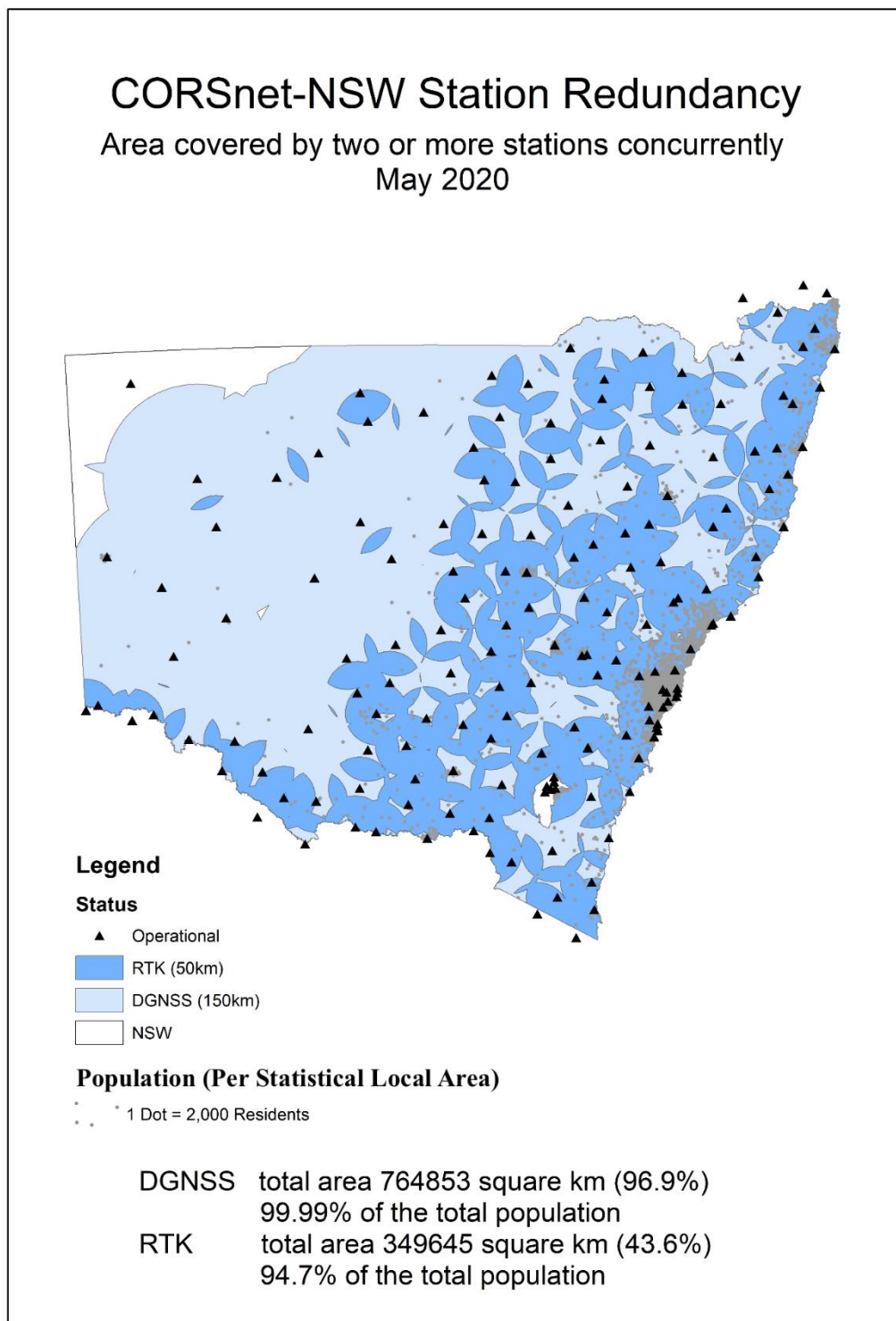
"How do you feel locations of the CORSnet-NSW stations can be improved?"

Some of the comments are below, with a general theme around densification of the network.

- *"More stations required west of Hay and Hillston." (External user)*
- *"Maybe another CORS north of Mildura and somewhere near Ingebyra. VIC and NSW can go halves as NSW have a better pillar design for more CORS." (External user)*
- *"Higher concentration of base stations in areas currently, or proposed, development areas e.g. NW Sydney and future airport may provide greater robustness and accuracy." (External user)*
- *"More co-location of CORSnet with tide gauge locations for sea level research like Fort Denison and Newcastle." (Internal user – other NSW Government department)*

When considering potential locations of new stations, it is important to refer to station redundancy figures such as those illustrated below. CORSnet-NSW designed the station rollout and infill process using a risk reduction principle. In high use areas and identified high risk areas, stations were installed to provide overlapping redundancy i.e. area covered by two or more stations concurrently. If a single CORS fails in any of the area shown as dark blue on the map below, users can still expect to get the same or very similar performance from the next nearest station. It is important to note that when using Network RTK the user will not notice an outage and approximately 95% of the NSW population live in an area serviced by two or more CORSnet-NSW stations.

Figure 15. CORSnet-NSW station redundancy

CORSnet-NSW Station Redundancy
Area covered by two or more stations concurrently
May 2020

Legend

Status
▲ Operational
RTK (50km)
DGNSS (150km)
NSW

Population (Per Statistical Local Area)
1 Dot = 2,000 Residents

DGNSS total area 764853 square km (96.9%)
99.99% of the total population
RTK total area 349645 square km (43.6%)
94.7% of the total population

In the in-depth interviews, interviewees provided feedback about their experiences with station performance and equipment.

There was general satisfaction overall, with some interviewees making the point of the importance of maintaining performance in high use areas.

- "We usually don't like any of the high use sites in metro areas going down, so we had some concern about Fort Denison getting offline a couple of weeks ago. Apart from that, customers are really happy." (VAR)

4. Industry impact

This chapters examines the impact of the project on the spatial services industry. It answers the following evaluation questions:

- To what extent does CORSnet-NSW supply the Office of the Surveyor General (OSG) and other organisations with real-time and post process products to support operations and research into the future?
- How well does the project provide guidance and leadership (e.g. through positioning infrastructure) within the industry?

4.1 The data being provided is up-to-date, however the supply of CORSnet-NSW data can be further improved

Three important findings from the customer satisfaction survey concluded that:

- CORSnet-NSW data is as up-to-date as users need it to be, for example it provides all the top up-to-date constellations, formats and frequencies that are required.
- High satisfaction rating with the overall availability of CORSnet-NSW real-time services.
- A minority of users identified a few opportunities to improve the supply of CORSnet-NSW data.

Users were asked the following question *"Is the data provided by CORSnet-NSW as up-to-date as you need it to be? E.g. does it provide all the top up-to-date constellations, formats and frequencies which you/your software/equipment (and customers) require?"*

93% of respondents who answered this question responded with 'Yes' to indicate that the data being provided is as up-to-date as they need it to be. Of those who answered 'No' two were External users, two were Equipment suppliers/resellers, one an Internal user – Other NSW Government department and one a VAR.

Answer choices	Response n=	Response %
Yes	81	93%
No	6	7%
Total	87	100%

Comments in the in-depth interviews also supported this finding above. Interviewees were asked:

"Does CORSnet-NSW fulfil the technical needs of your type of usage? For example, are you able to utilise the available data formats, satellites, constellations etc."

Users were generally satisfied with the availability of data and the formats were meeting needs.

- "We're very happy that the sites that we share have been updated to the latest models of receivers." (External user)
- "On a couple of levels, in terms of the constellations it exceeds our requirements. From that respect yes. In terms of coverage, for the static post processing model, the coverage is excellent." (Internal user – other NSW Government department)

Respondents were also asked about their satisfaction with real-time services. The question posed was *"How satisfied are you (and your customers) with the overall availability of CORSnet-NSW real-time services in your area?"*

Most respondents who answered this question were either 'Very satisfied' or 'Extremely satisfied' with the overall availability of CORSnet-NSW real-time services in their area.

Answer choices	Response n=	Response %
Not satisfied at all	1	1%
Not so satisfied	3	3%
Neither satisfied nor dissatisfied	2	2%
Very satisfied	45	52%
Extremely satisfied	36	41%
Total	**87**	**100%**

Results indicated that there are opportunities to improve the supply of CORSnet-NSW data. Respondents were asked *"Do you think the way CORSnet-NSW data is supplied could be improved?"*

Just over 1/3 of respondents who answered this question felt that there was room for improvement.

Answer choices	Response n=	Response %
Yes	32	37%
No	55	63%
Total	**87**	**100%**

Those that answered 'Yes' to the question above were then asked the following optional open-ended response question *"How do you feel the supplying of CORSnet-NSW data can be improved?"*

Some of the common suggestions included higher levels of accuracy, flexibility and reliability, improvements relating to RINEX data and better connectivity and availability from mobile phone networks. A few of these are below.

- "More constellations made available." (Internal user – other NSW Government department)
- "With regard to RINEX data, more flexibility with time zones and simultaneous downloading or multiple sites with varying duration." (External user)
- "A combination of mobile and satellite data would eliminate areas of no mobile coverage." (Equipment supplier/reseller)

Most respondents (72%) would also use CORSnet-NSW real-time services more if mobile phone coverage was better.

Answer choices	Response n=	Response %
Yes	63	72%
No	7	8%
Not sure	17	20%
Total	87	100%

4.2   CORSnet-NSW is beneficial to industry and the economy in NSW

Results from the customer satisfaction survey (with supporting comments in the in-depth interviews) concluded that:

- CORSnet-NSW data is seen as beneficial to industry and the economy in NSW.
- CORSnet-NSW has a solid reputation in the industry.

Respondents were asked *"Do you see CORSnet-NSW as beneficial to industry and the economy in NSW?"*

There was a unanimous response to this question, with all respondents answering 'Yes'.

CORSnet-NSW 'Host' users were also asked *"Do you believe hosting a CORSnet-NSW station as beneficial to the region/industry?"*

The majority of respondents responded 'Yes'. Of those who answered 'No' one was an External user, one Education/research user and one an Equipment supplier/reseller.

Answer choices	Response n=	Response %
Yes	44	94%
No	3	6%
Total	47	100%

Responses provided by interviewees in the in-depth interviewees support the conclusions reached as a result of the customer satisfaction survey, which had 100% of respondents indicate that CORSnet-NSW is beneficial to industry and the economy in NSW. Interviewees were asked:

"Do you see CORSnet-NSW as an authoritative source of CORS data in the industry? And if so, how? And if not, please explain why you don't see CORSnet-NSW as an authoritative source?"

- "Absolutely. One it's a government organisation. Two it's got fairly extensive technical capabilities and resources to maintain the system with multiple users. It's always seen as being an industry leader that's got significant technical resources and capability, and the products are quality."
(Internal user – other NSW Government department)

- "Yeh again that's world class. The stability of the sites, the monitoring of the sites, the regulation 13 certificates… they are setting a standard that is tremendous. Yes, I'd call it authoritative and best of class, yes." (VAR)

Interviewees were also asked:

"From your perspective, what kind of reputation do you feel CORSnet-NSW has in the industry? And how can this reputation be improved?"

- "Firstly, I think yes you have a world class network and team. A lot of time was spent documenting to technical documents and case studies in the early days. That's exactly what governments should do and have done. When you are getting 10 out of 10, it's hard to get 11 out of 10. Don't know how they can beat that. The bar is set pretty high." (VAR)
- "I think it has a solid reputation based on the service it provides to end customers directly and public sector surveyors. Apart from some reliability issues in the not so distant past, the system is improving as we go so we are not seeing as many interruptions as we used to 2-3 years ago and intermittent disturbance on sites is being investigated quickly. Minimising response time on the intermittent response time on the stream going out can help improve the reputation." (VAR)

5. Conclusion

5.1 Overview of key findings

The evaluation of the CORSnet-NSW project was delivered as intended.

The evaluation found a general satisfaction of users and resellers with CORSnet-NSW, and that CORSnet-NSW has been successful in its transition from a build project to an ongoing operational program. Current needs are being met as intended, with 97% of respondents to the customer satisfaction survey indicating that CORSnet-NSW is fit for purpose for their current needs. Also, there is belief in the CORSnet-NSW data supporting their future needs, with 98% of respondents trusting CORSnet-NSW data to support their foreseeable future needs.

Evidence from the research conducted amongst stakeholders also concluded that CORSnet-NSW is beneficial to industry and the economy in NSW. All respondents answered in the positive when asked whether they see CORSnet-NSW as beneficial to industry and the economy in NSW.

Relating to this, interviewed stakeholders commented on CORSnet-NSW being an authoritative source of CORS data in the industry. Stakeholders were complimentary when asked about the reputation that CORSnet-NSW has in the industry.

There are a number of lessons to be learnt for not only the CORSnet-NSW program in future, but also for other for other similar infrastructure programs or projects across DCS Spatial Services and the NSW Government in future (see below in 5.2 Recommendations).

CORSnet-NSW stations are performing well in regard to availability, latency and reliability. 95% of respondents were satisfied with the performance of CORSnet-NSW stations. However, there is an opportunity for improvement when it comes to the location of CORSnet-NSW stations. Generally, densification of the network is an area that was identified by stakeholders on how CORSnet-NSW stations can be improved, ensuring stations are built in the appropriate areas. When considering potential locations of new stations, it is important to refer to station redundancy figures that were used in the analysis for this evaluation. CORSnet-NSW designed the station rollout and infill process using a risk reduction principle. Should the closest station be non-operational, there is another close enough to continue to deliver either single base or network RTK products. In key high use areas and identified high risk areas, stations were installed to provide overlapping redundancy. Future station locations will continue to take this into consideration along with economic need in the surrounding area, and to support infrastructure projects.

Feedback was also given on the derived network software and its importance in providing better coverage, which provides an area for potential investigation and improvement.

5.2   Recommendations

The recommendations and areas for improvement as identified through this evaluation are outlined below. These can contribute to the future success of not only the CORSnet-NSW program, but also other similar infrastructure programs or projects across DCS Spatial Services and the NSW Government in future.

Table 2.   Recommendations

Area	Recommendation
Communication and consultation	• Effective communication to industry on new CORSnet-NSW products, services and developments. • Consultation on important new changes prior to commissioning, for example the location of any new CORS sites.
Testing and development	• Further testing and development on applications, software and development. Consider market opportunities and feedback from users.
Infrastructure and maintenance	• Infrastructure, maintenance and development of individual stations to improve product delivery across NSW. For example, continue to investigate emerging battery technology. • Infrastructure, maintenance and development of the IT architecture for risk mitigation and to aim for a system that provides 100% uptime. For example, cloud-based data centres. • Investigation into locations for new CORSnet-NSW stations to densify the network.
Supply of data	• Continued focus on the supply of CORSnet-NSW data, including improving accuracy, flexibility and reliability, and improvements relating to RINEX data. • Continued collaboration with industry for better connectivity and advocating for better availability from phone networks.

Appendix 1.   CORSnet-NSW Customer Satisfaction Survey

You are invited to participate in this **CORSnet-NSW Customer Satisfaction Survey** conducted by Spatial Services, Department of Customer Service. It is designed to measure your experiences with CORSnet-NSW and assist management in making improvements to the program in future. Your responses will be strictly confidential, and data will be analysed and reported in aggregate. Please complete the survey by **Friday April 24**. The survey will take approximately 10 minutes to complete. Please complete in one sitting and DO NOT hit the back button.
Thank you in advance for your feedback.

1.   Which of the following CORSnet-NSW groups do you belong to? *(Please select the option that is most applicable to you)*
a)   Internal user – Spatial Services *(Skip to Q.4)*
b)   Internal user – other NSW Government department *(Skip to Q.4)*
c)   Host *(Skip to Q.4)*
d)   Education/research *(Skip to Q.4)*
e)   External *(Skip to Q.4)*
f)   Value Added Reseller (VAR) *(Skip to Q.8)*
g)   Equipment supplier/reseller *(Skip to Q.4)*
h)   I am not a current user in any of the above groups

2.   Have you been a CORSnet-NSW user in the past?
a)   Yes
b)   No *(Skip to end of survey)*

3.   What was the main reason/s you stopped using CORSnet-NSW? *(Please select all that apply) (Randomised)*
a)   Cost was too high
b)   Accuracy
c)   Not reliable enough
d)   No mobile internet available
e)   No longer have a CORS-enabled rover
f)   Have my own base station
g)   Switched to another CORS provider
h)   CORS was not suitable for the type of work I do
i)   It was too difficult to use
j)   Other (please specify)

4.   What benefits do you see in using CORSnet-NSW services? *(Please select all that apply) (Randomised)*
a)   Easy
b)   Reliable
c)   Economical

d) Fast
e) Station location/coverage
f) My organisation is a CORSnet-NSW host
g) Scientifically valid
h) Legally traceable
i) Direct connection to datum
j) Other (please specify)

5. Please choose the categories that best suit your use of CORSnet-NSW data? *(Please select all that apply) (Randomised)*
a) Education
b) Research
c) Agricultural
d) Survey
e) Mapping/GIS/Asset management
f) Construction
g) Machine control
h) Testing and evaluation

6. In relation to real-time RTK and post processing RINEX data, what describes your use of CORSnet-NSW data?
a) All real-time
b) Mostly real-time
c) Some real-time and some RINEX
d) Mostly RINEX
e) All RINEX

7. What is the main way you access your data?
a) Mobile rover RTK
b) Reference data shop
c) Automatic software e.g. iGate, Catalyst etc.

8. Do you see CORSnet-NSW as fit for purpose for your current needs? I.e. meeting the needs for you/your customers as you had originally intended.
a) Yes
b) No

9. In your opinion, do you think CORSnet-NSW data will support your foreseeable future needs?
a) Yes *(Skip to Q.11)*
b) No
c) Unsure

10. Please explain why you don't think CORSnet-NSW data will support your foreseeable future needs?
Comment box

11. Do you currently pay a fee for access to CORSnet-NSW?
a) Yes
b) No *(Skip to Q.14)*

12. Do you believe the CORSnet-NSW offering you receive provides value for money?
a) Yes *(Skip to Q.14)*
b) No

13. What changes would you make to the offering for it to provide you more value? *(Optional)*
Comment box

14. Do you see hosting a CORSnet-NSW station as beneficial to your organisation?
a) Yes
b) No
c) N/A as I am not a 'Host' *(Skip to Q.17)*

15. Do you believe hosting a CORSnet-NSW station as beneficial to the region/industry?
a) Yes
b) No

16. Are you satisfied with how much it costs to host a CORS?
(Satisfaction rating scale 1-5 with 1 = 'Not satisfied at all' and 5 = 'Extremely satisfied')
- 1 - Not satisfied at all (it costs too much)
- 2 - Not so satisfied
- 3 - Neither satisfied nor dissatisfied
- 4 - Very satisfied
- 5 - Extremely satisfied (the cost is very little)

17. How satisfied are you (and your customers) with the OVERALL availability of CORSnet-NSW real-time services in your area?
(Satisfaction rating scale 1-5 with 1 = 'Not satisfied at all' and 5 = 'Extremely satisfied')
- 1 - Not satisfied at all
- 2 - Not so satisfied
- 3 - Neither satisfied nor dissatisfied
- 4 - Very satisfied
- 5 - Extremely satisfied

18. Would you (and your customers) use CORSnet-NSW real-time services more if mobile phone coverage was better?
a) Yes
b) No
c) Not sure

19. Do you see CORSnet-NSW as beneficial to Industry and the economy in NSW?
a) Yes
b) No

20.   Do you think the way CORSnet-NSW data is supplied could be improved?
a)   Yes
b)   No *(Skip to Q.22)*

21.   How do you feel the supplying of CORSnet-NSW data can be improved? *(Optional)*
        Comment box

22.   Is the data provided by CORSnet-NSW as up-to-date as you need it to be? E.g. does it provide all the top up-to-date constellations, formats and frequencies which you/your software/equipment (and customers) require?
a)   Yes
b)   No

23.   Are you satisfied with the current business model where CORSnet-NSW supplies wholesale data to Value Added Resellers (VARs)?
a)   N/A as I am not a 'VAR' *(Skip to Q.27)*
b)   Yes
c)   No

24.   Please indicate the estimated % that your organisation services for each of the CORS user segments below:
-       Survey
-       Mapping/GIS
-       Construction and machine control
-       Education/research

25.   How satisfied are you with the availability (uptime) of CORSnet-NSW servers?
        (Satisfaction rating scale 1-5 with 1 = 'Not satisfied at all' and 5 = 'Extremely satisfied')
-       1 - Not satisfied at all
-       2 - Not so satisfied
-       3 - Neither satisfied nor dissatisfied
-       4 - Very satisfied
-       5 - Extremely satisfied

26.   Please indicate the level of support you provide your customers for the CORS products you sell for each of the options below.
        Yes   No
-       24 hour support
-       Extended business hours support
-       9am-5pm office hours support
-       On-site support
-       Phone support

27.   How satisfied are you with the performance (uptime, latency, reliability) of CORSnet-NSW stations?
        (Satisfaction rating scale 1-5 with 1 = 'Not satisfied at all' and 5 = 'Extremely satisfied')
-       1 - Not satisfied at all (e.g. my local station is always down)

-     2 - Not so satisfied
-     3 - Neither satisfied nor dissatisfied
-     4 - Very satisfied
-     5 - Extremely satisfied (e.g. my local station always functions well)

28.   How satisfied are you with the location of CORSnet-NSW stations?
    (Satisfaction rating scale 1-5 with 1 = 'Not satisfied at all' and 5 = 'Extremely satisfied')
-     1 - Not satisfied at all
-     2 - Not so satisfied
-     3 - Neither satisfied nor dissatisfied
-     4 - Very satisfied
-     5 - Extremely satisfied

29.   How do you feel locations of the CORSnet-NSW stations can be improved? *(Optional)*
    Comment box

30.   We would potentially be interested in following up with some respondents who have completed this survey. This would involve a phone interview to address some questions not addressed in this survey. Would you be interested in participating in a phone interview at a mutually convenient time in the next month?
a)   Yes
b)   No *(Skip to Q.31)*

31.   Please provide the following details to allow us to get in contact with you if we decide to proceed with a phone interview with you.
    Full name:
    Phone:
    Email:

32.   Do you have any other comments, feedback or suggestions in relation to your experience with CORSnet-NSW? *(Optional)*
    Comment box

Thank you for your time and contributions.

Appendix 2. CORSnet-NSW Qualitative in-depth interview guide

Good morning/afternoon [INSERT INTERVIEWEE NAME], firstly thank you for completing our recent **CORSnet-NSW Customer Satisfaction Survey**. We appreciate your time today in delving deeper into some issues that were either unable to be addressed via the survey or require more comments from CORSnet-NSW users like yourself.

The insights from responses you provide may be used in our CORSnet-NSW evaluation report and you will be de-identified. May I please request your permission to record this interview solely for the purpose of analysis and reporting for this evaluation?

USER/INTERNAL
- Now to get things started, thinking about the way you use and access CORSnet-NSW data, can you please tell us about some of the tasks/projects you use CORSnet-NSW for?
- What are your thoughts on the current CORSnet-NSW subscription model? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?
- Does CORSnet-NSW fulfil the technical needs of your type of usage? For example, are you able to utilise the available data formats, satellites/constellations etc.
- Do you believe that CORSnet-NSW helps Spatial Services maintain its capability as an industry leader? And if so, how? And if not, why not?
- Do you see CORSnet-NSW as an authoritative source of CORS data in the industry? And if so, how? And if not, please explain why you don't see CORSnet-NSW as an authoritative source?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?
- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

USER/HOST
- Now to get things started, thinking about the way you use and access CORSnet-NSW data, can you please tell us about some of the tasks/projects you use CORSnet-NSW for?
- What are your thoughts on the current CORSnet-NSW subscription model? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?
- Does CORSnet-NSW fulfil the technical needs of your type of usage? For example, are you able to utilise the available data formats, satellites/constellations etc.
- Do you believe that CORSnet-NSW helps Spatial Services maintain its capability as an industry leader? And if so, how? And if not, why not?
- Do you see CORSnet-NSW as an authoritative source of CORS data in the industry? And if so, how? And if not, please explain why you don't see CORSnet-NSW as an authoritative source?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?

- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

USER/EDUCATION/RESEARCH
- Now to get things started, thinking about the way you use and access CORSnet-NSW data, can you please tell us about some of the tasks/projects you use CORSnet-NSW for?
- What are your thoughts on the current CORSnet-NSW subscription model? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?
- Does CORSnet-NSW fulfil the technical needs of your type of usage? For example, are you able to utilise the available data formats, satellites/constellations etc.
- Do you feel that CORSnet-NSW is able to provide you with the data you need for research and development into future or novel applications of GNSS? And if so, how? And if not, why not?
- Do you see CORSnet-NSW as an authoritative source of CORS data in the industry?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?
- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

USER/EXTERNAL
- Now to get things started, thinking about the way you use and access CORSnet-NSW data, can you please tell us about some of the tasks/projects you use CORSnet-NSW for?
- What are your thoughts on the current CORSnet-NSW subscription model? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?
- Does CORSnet-NSW fulfil the technical needs of your type of usage? For example, are you able to utilise the available data formats, satellites/constellations etc.
- Do you see CORSnet-NSW as an authoritative source of CORS data in the industry?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?
- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

WHOLESALERS/VAR
- Now to get things started, thinking about the way your customers use and access CORSnet-NSW data, can you please tell us about some of the tasks/projects your customers use CORSnet-NSW for?
- Is CORSnet-NSW your preferred supplier? If yes, why is it your preferred supplier? If not, why not?
- What are your thoughts on the current CORSnet-NSW licensing arrangements? Does your current arrangement suit your/your organisation's needs? Do you have any suggestions on how it can be improved?
- Can you please share your thoughts on the CORSnet-NSW network and its capabilities according to your/your organisation's needs?
- And how about your/your customers experiences with station performance and equipment in terms of reliability, effectiveness etc?

- Do you see CORSnet-NSW as an authoritative source of CORS data in the industry?
- From your perspective, what kind of reputation do you feel CORSnet-NSW has in the industry? And how can this reputation be improved?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?
- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

WHOLESALERS/EQUIPMENT SUPPLIER
- Now to get things started, thinking about the way your customers use and access CORSnet-NSW data, can you please tell us about some of the more significant tasks/projects your customers use CORSnet-NSW for?
- Do you feel you are able to meet the demands of your customers by supplying them with a range of CORS-based products to suit their needs? If yes, why? If not, why not?
- If you had one thing to change in the way the program is conducted, what would it be?
- Is there anything that you would NOT change?
- Now for some blue sky thinking to finish, please share any new, unusual, interesting or exciting applications for CORS data?

Appendix 3.   Document review

Papers written documenting the rollout of CORSnet-NSW including:
1. Kinlyside D, Yan T (2005) SydnNET.? First Results, *Proceedings of Association of Public Authority Surveyors Conference 2005,* Batemans Bay, Australia, 10pp.
2. Roberts C, McElroy S, Kinlyside D, Yan T, Jones G, Allison S, Hendro F, Hoffman S (2007) Centimetres across Sydney: First results from the SydNET CORS network, *Proceedings of SSC2007,* Hobart, Australia, 152-161.
3. CORSnet-NSW: Delivering a state-of-the-art CORS network for New South Wales (PDF 345.1 KB) White A., Yan T., Janssen V. and Yates K. (2009), Proceedings of IGNSS Symposium 2009 (IGNSS2009), 1-3 December, Surfers Paradise, Australia, 7pp.

Briefings and project planning documents including:
1. CORSnet-NSW rollout and upgrade Project Status report Dec 2016.
2. Business Case – CORSnet-NSW Operating Unit v1.0 2016.
3. DFSI_Report_Business_Model for CORSnet_NSW_November 2016.
4. SydNET Capital Budget (draft May 2003).
5. Internal budget projections and spending spreadsheet records.

Planning and evaluation documents for the benefits of precision positioning including:
1. Frontier SI (2019), SBAS Test-bed Demonstrator Trial Economic Benefits Report, June 2019, https://frontiersi.com.au/wp-content/uploads/2018/08/SBAS-Economic-Benefits-Report.pdf
2. The Allen Consulting Group (2008), Economic benefits of high resolution positioning services. https://www.crcsi.com.au/assets/Resources/ffa927a7-55d1-400a-b7d6-9234f4fe4ad2.pdf

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