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State of Alberta Digital Infrastructure Report 2021

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Revision History

DATE	REVISED BY	VERSION	REVISIONS
Oct 10, 2014	Cybera	0.9	Development of the first draft.
Oct 20, 2014	Cybera	1.0	Revisions to all sections. Additions of the Executive Summary, Introduction and Data section.
Oct 31, 2014	Cybera	1.1	Revisions to all sections.
Sept 13, 2016	Cybera	2.0	Updated network section & acknowledgements. Updated hyperlinks and citations.
July 15, 2021	Cybera	3.0	Updated all sections and added new content.

Executive Summary

Digital infrastructure has become the foundation for innovation, economic growth and market diversification in Canada. Our network infrastructure, in particular, drives productivity, growth and competitiveness, and serves as an integral component of how individuals connect and interact with each other.

As governments around the world plan for the future, digital infrastructure investments are being recognized as the bedrock upon which innovation in science and technology can be harnessed for the public good. In Alberta, digital infrastructure is critical in revolutionizing traditional industries, while creating entirely new ones. Understanding the current digital infrastructure landscape in the province will help create a strong strategic foundation to leverage these resources to maximize our potential.

As Alberta's not-for-profit organization responsible for driving economic growth through the use of digital technology, Cybera recognizes the importance of having a strong overview of the province's digital resources. The first draft of the State of Alberta Digital Infrastructure Report was produced in 2014, and highlighted what was needed at that time to carry out advanced research and innovation in the province. Since that time, the digital infrastructure landscape in Alberta has constantly evolved, both at a technical and regulatory level.

This updated State of Alberta Digital Infrastructure Report provides a more focused review of Alberta's current network connectivity. This includes an overview of opportunities for investing in Alberta's internet infrastructure in a way that responds to multiple immediate needs, while laying the foundation for future research and innovation.

This 2021 update is intended to be part of a continually evolving review, as feedback from partner organizations and external stakeholders is received and incorporated. Cybera is committed to collaborating with invested stakeholders and key contacts to gather the full scope of information in an iterative and coordinated approach.

Readers of this report should bear in mind that while Cybera is the province's expert technical agency, we do not have all the answers, and as such, rely heavily on our colleagues within our member institutions. As such, the facts and figures reported here may change as more of our colleagues have a chance to read and comment on the material. If readers are making critical decisions based on data in this report, we encourage them to contact the authors to ensure the very latest information is available.

Networking in Alberta – At a Glance

Globally, the demand for bandwidth is increasing exponentially. Alberta is also seeing an increased demand for bandwidth, as more education and work activities are carried out online, and as high-bandwidth mobile platforms become more ubiquitous.

Currently, Alberta has two high-speed public fibre networks: the research and education network, CyberaNet, and the province-wide fibre optic network, the Alberta SuperNet. Both are available to a select portion of the population. Commercially, services are provided by the big three telecommunications providers — TELUS, Bell and Rogers — in addition to a number of regional competitors, most notably the Calgary-based Shaw Communications (although on March 15, 2021, Rogers announced a plan to acquire Shaw in a $26B merger, a deal which would eliminate Shaw as a regional competitor. As of the publication of this report, the deal is pending regulatory approval).

The reach, bandwidth, and prices these providers offer can vary, and rural areas continue to struggle to obtain internet connections at a cost and speed comparable to the province's urban areas.

By the Numbers...

- Percentage of Canadians in the lowest income quintile with a home internet subscription (as of 2019): 65%[1]
- Percentage of Canadian households without access to at least 50 Mbps download and 1 Mbps upload (as of 2019): 16%
- Median download speed in Canadian cities in 2021: 51.09 Mbps
- Median rural download speeds in 2019: 9.74 Mbps[2]
- Availability of internet service of 50 Mbps download and 10 Mbps upload with unlimited data in rural Alberta : 33.2%

[1] Canadian Radio-Television and Telecommunications Commission (CRTC) . Communications Monitoring Report 2020, pg. 28

[2] Canadian Internet Registration Authority (CIRA). Canada's Internet Equity Gap: Rural residents suffer with inferior service during pandemic. Accessed 08 July 2021.

Recommendations for Improving Networking in Alberta

Short-term recommendations (1-3 years)

- ***Alberta needs a provincial broadband strategy.***
  A comprehensive framework linking all connectivity technologies and opportunities across the province.

- ***Alberta needs coordinated leadership for the development of rural broadband solutions.***
  A *community of communities* should be created to act as an aggregator and facilitator of resources (from across diverse sectors) to determine options for broadband adoption in Alberta. This could form part of the provincial broadband strategy.

- ***Unfair regulatory loopholes must be closed.***
  The CRTC should ensure its appeals process and costing proceedings cannot be used by larger telecommunications players to delay decisions — such as wholesale pricing and support structure access — in order to negatively impact non-incumbent ISPs.

- ***Government and industry should further develop and promote Internet Exchange Points (IXPs).***
  Calgary and Edmonton should grow their IXPs to improve internet resiliency, minimize long range data transport costs, and increase competition within the carrier market.

- ***Alberta should develop a coordinated approach to accessing the federal Universal Broadband Fund, either under the provincial broadband strategy, and/or under the coordinated leadership of the "community of communities".***
  Enabling piecemeal solutions for different providers or communities through grant submission programs should be phased out. Instead, the provincial government should offer a coordinated strategy, with cookie cutter solutions that can be rolled out across Alberta, optimizing grant funding through economies of scale.

- ***The Canadian Government should modify its National Broadband Access Map to be more granular and accurate, using additional testing and/or accessing CIRA's Internet Performance Test data.***
  Counties and other municipalities are being denied access to broadband grant funding due to inaccurate maps that falsely show them as being adequately served. This is most notable in shoulder communities around larger urban municipalities.

- ***The provincial government should leverage the Alberta SuperNet to make the province a national leader in broadband deployment.***
  The Government of Alberta should ensure the implementation of the 2018 SuperNet agreement is better leveraged for rural broadband distribution.

- ***The provincial government should leverage the Research & Education Network to make Alberta a national leader in equal access to online education tools.***
  This should include continued investment in CyberaNet, the provincial R&E network, with a target of >1 Tbps capacity in the next five years to support modern learning applications and student success, as well as post-secondary big data research, and campus-to-commerce innovation.

Long-term recommendations (3-10 years)

- ***Equal access to telecommunications infrastructure should be available to all service providers.***
  Telecommunications carriers should be just that — carriers — and not be given preferential treatment for their own competing retail services. More needs to be done by the CRTC to regulate these resources.

- ***Alberta's broadband strategy should set a target of at least 100 Mbps symmetric internet bandwidth for all citizens.***
  This would place Alberta among the top 20 countries for average internet access speeds.

- ***Government regulations should require all trenching of public land to include the installation of conduits that can carry public access fibre.***
  This will greatly reduce the cost of building out infrastructure for future expansion.

- ***Government should work to ensure that next generation technologies — including Low Earth Orbit (LEO) Satellites, 5G, mesh networking, and the Internet of Things (IoT) — are utilized equitably in Alberta.***
  Next generation technologies promise higher bandwidth access in geographic regions that have proven difficult to reach using legacy technologies. Provincial and federal governments should ensure they are deployed equitably.

- ***Antenna tower and site sharing should be encouraged and facilitated by rural municipalities and land-use authorities in a way that supports the deployment of fixed area wireless.***

Introduction

One of Cybera's core mandates is to monitor and document the changes in Alberta's digital infrastructure that is used for research, innovation and the economic benefit of the province. In this State of Alberta Digital Infrastructure Report, Cybera is setting the benchmark for future digital utilization in the province. Within the next ten years, the majority of digital infrastructure solutions will need significant investments. Success will require an organizational shift in the way this infrastructure is planned for, built, operated, used, and maintained. Digital infrastructure needs to be flexible and adaptable to meet the needs of future generations and disruptive technologies.

High-speed connectivity and access to bandwidth remain the largest barriers to digital advancement in the province. Connectivity is key to making computational resources available. The Research and Education (R&E) Network operated by Cybera fills this need for most academic users when they are on site at school or other locations where R&E access exists, but the commercial internet is the backbone for everyone else.

This is a major weakness in Alberta, where problems exist with access and affordability, particularly for those in rural areas. Due to the high cost of digging and laying fibre, and the low rate of return in communities with a low population density, market forces alone cannot bring connectivity to all users. Because of this, regulation and government funding programs are needed to ensure equitable, non-prejudicial access.

Currently, multiple federal government departments — including Innovation, Science and Economic Development Canada (ISED) and the CRTC — have funding initiatives aimed at building networks in rural communities. However, several communities have expressed concerns that these programs are underfunded, and their eligibility requirements are too restrictive to achieve universal connectivity.

Concurrently, new commercial relationships between Internet Service Providers in Alberta have formed, and the potential of new technologies such as Low Earth Orbit (LEO) satellites, 5G and the Internet of Things (IoT) have created new connectivity opportunities. However, observers differ in their assessment of how transformative these technologies will be in achieving universal connectivity.

The following sections will cover the current state of digital infrastructure in Alberta, as well as its ongoing technological, regulatory and commercial development. In addition, we will review a number of municipal broadband initiatives to contextualize the scope of the rural connectivity problem in Alberta. In doing so, these sections will document — with the best available data — which communities in Alberta continue to be underserved, and how best to close these gaps.

Networking in Alberta

Background

Broadband internet is generally defined as any high-speed internet access that is always on (as compared to dial-up access). The key word is "high-speed." In Canada, the definition of high-speed changes over time, as the technologies and nature of the internet changes. For the context of this report, as of 2021, we will follow the CRTC's speed benchmark of 50 Mbps for downloads and 10 Mbps for uploads[3].

Service Providers Overview

Global internet infrastructure comprises many independent but interconnected networks. Consumers connect to local or regional Internet Service Providers (ISPs) through access networks (called the 'first or last mile') that can be wireline (fibre optic or copper cables) or wireless (satellite or tower-based). Fibre-to-the-home or fibre-to-the-premise supports the highest internet bandwidth speeds (> 1 Gbps), as shown in Figure 1. Consumers purchase internet access from regional ISPs, who in turn acquire internet access from larger upstream ISPs (e.g. a Tier 1 network).

[3] CRTC. What you should know about Internet speeds. Accessed 14 December 2020.

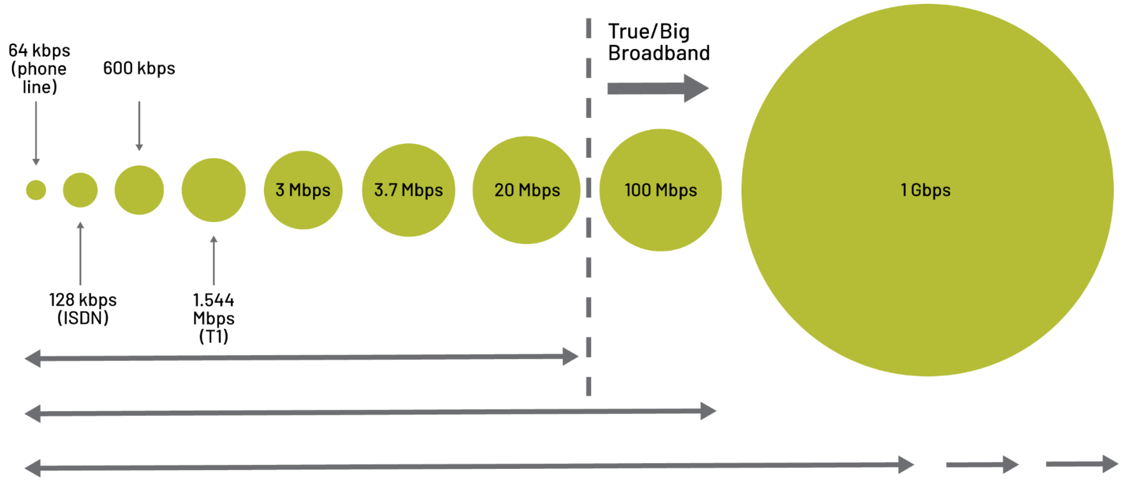


Figure 1. Carrying Capacities of Broadband Access Solutions *(Adapted from Broadband Communities Magazine[4])*

Connections from a local access network to the global internet take place via a middle mile network. In the context of rural communities, the "middle mile" usually means the connection to a larger metropolitan centre. The Alberta SuperNet is one example of middle mile infrastructure. Backhaul networks then connect the middle mile to a major internet exchange or the core portion of a provider's network. Middle mile and backhaul connections are almost always fibre-based, due to the large bandwidth requirements these connections must support.

The physical network infrastructure can provide broadband services according to a number of access models, based on who controls these various network layers:

- Physical Infrastructure Layer — copper, fibre optics, wireless radio (terrestrial or satellite)
- Network Provider Layer — active equipment such as routers and switches
- Service Provider Layer — internet services

Depending on whether one or more organizations control the above layers, different access models are used to deliver broadband services, leading to either infrastructure- or services-based competition.

Infrastructure-based competition means each service provider has to own and operate all layers of the network. In order to enter this market, a new service provider has to build its own network infrastructure.

[4] Broadband Communities Magazine. The FTTH Primer. Accessed 27 July 2016.

In services-based competition, service providers leverage common physical infrastructure in order to deliver broadband services. This is predicated on open access networks that provide fair and non-discriminatory access to the underlying layer(s) for all service providers. This access would either be at the network provider or physical infrastructure layer (Figure 2).

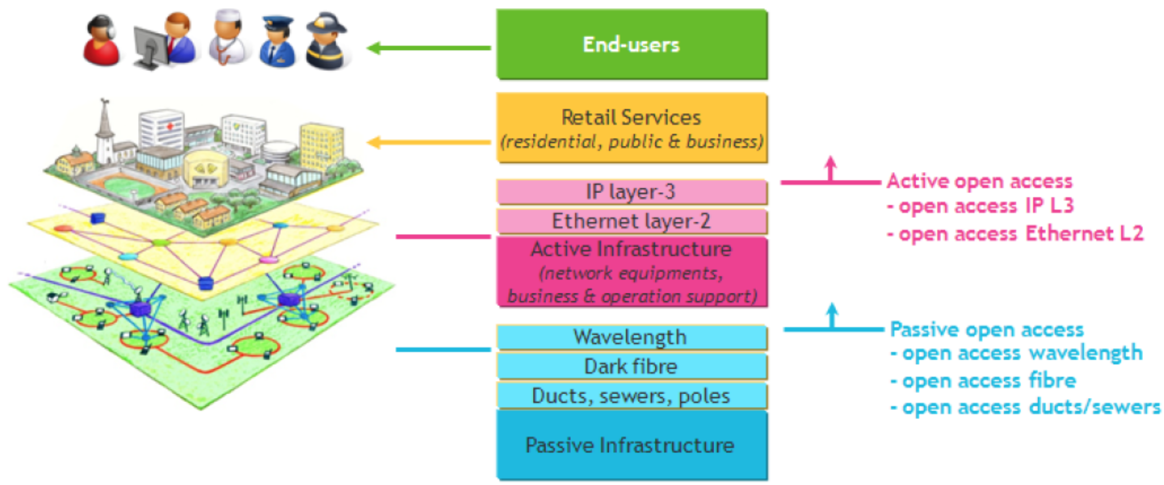


Figure 2. Network layers and types of open access networks. Source: Fibre to the Home Council [5].

Downloads vs Symmetric Bandwidth Speeds

While download speeds are the most commonly cited attribute reflecting broadband quality, access to symmetric bandwidth is becoming increasingly important. Symmetric bandwidth means the upload speed is as fast as the download speed.

Currently in Alberta, symmetric bandwidth is not the norm, as most commercial internet packages provide upload:download ratios ranging between 1:30 and 1:5. A number of newer fibre to the home (FTTH) services have symmetrical, or 1:1 ratio internet packages.

Significant changes in the data environment of individuals are putting more emphasis on upload speeds. These changes include the rapid increase of home videoconferencing services for both work and pleasure, especially after the start of the COVID-19 pandemic in 2020. The need for cloud storage of data, much of it higher quality image and video data created by mobile phones, is also pressuring upload speed requirements.

[5] Fibre to the Home Council Europe. FTTH Handbook - Edition 7. 16 February 2016.

Current Landscape: Broadband Availability in Alberta

Alberta's broadband availability as of 2019 is shown in Table 1. As the table demonstrates, practically the entire province (99.7%) has access, at least minimally, to 5 Mbps download speed. The percentage of Albertans able to access the current acceptable standard for high-speed internet — 50 Mbps download and 10 Mbps upload — is 87.8%. This is slightly higher than the Canadian average of 87.4%.

Table 1[6]. Broadband Availability in Alberta by Download Speed, 2019 per CRTC Communications Monitoring Report 2020

Download Speed (Megabits per second)	Availability (Percentage of Households)
5.0 - 24.9	99.7
25.0-49.9	98.6
50.0-99.9	94.7
50/10 & Unlimited Data Transfer	87.8
100.0 – 999.9 +	83.6
1,000 (Gigabit)	33.5

Source: Prepared by Cybera using data from 2020 CRTC Communications Monitoring Report. These figures exclude satellite technologies.

However, accurately assessing the current state of broadband services in Alberta is difficult, not least because it is a constantly moving target. Internet Service Providers are often reluctant to give out accurate figures of actual service delivery throughout their service area. Using their advertised services gives an idea of service availability, but in rural areas, this ideal scenario rarely plays out in reality.

[6]CRTC. Communications Monitoring Report - 2020, Table 4.2, p. 107. Accessed 01 January 2021.

Determining accurate broadband speeds for Alberta: the Sturgeon County case study

Canada's federal ministries, along with the Canadian Radio and Television Commission (CRTC), have devised a National Broadband internet Service Availability Map (ISAM)[7] to show the level of broadband services available in any part of Canada. This map uses a combination of data sources. The data is collected in partnership between the CRTC and the Ministry of Innovation, Science and Economic Development through annual surveys and ongoing consultation with key stakeholders, including ISPs, federal partners, industry associations, provinces and others[8]. This is now used as a standard map of services for many internet bandwidth improvement projects and grant funding programs.

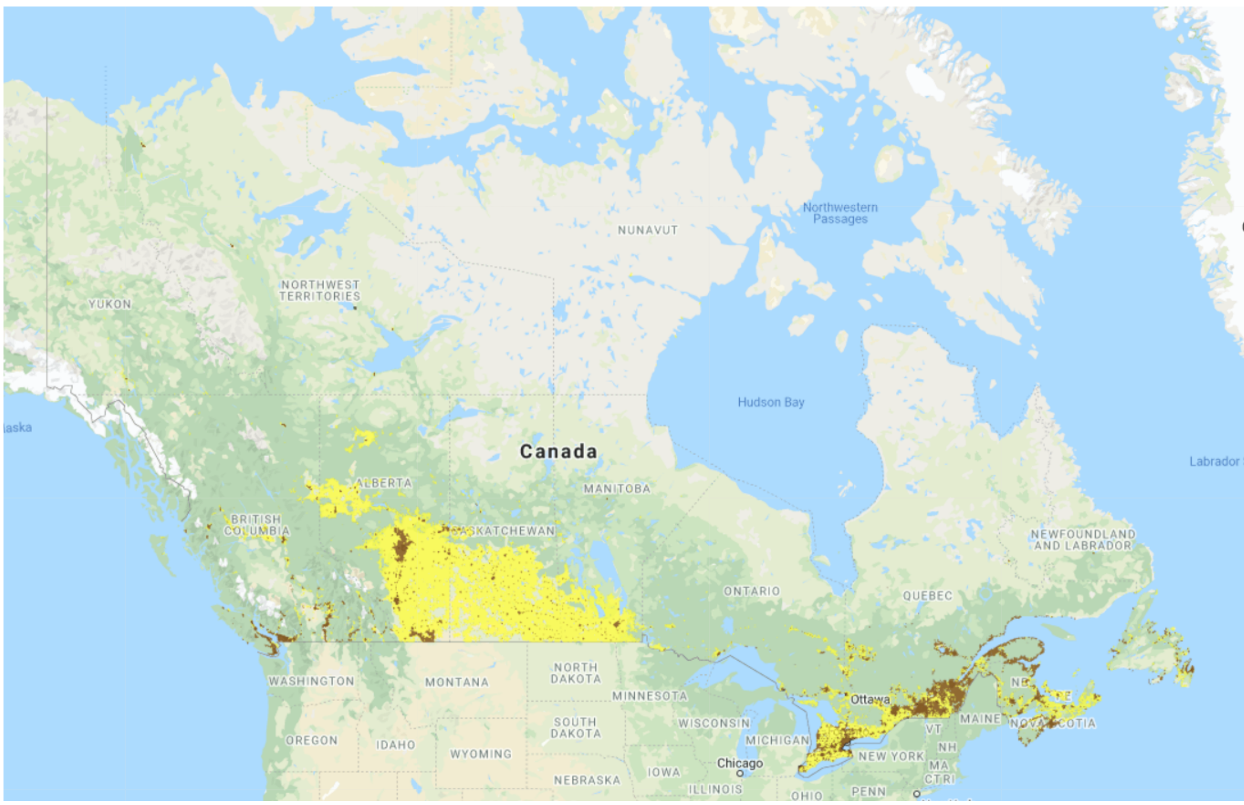


Figure 3. National Broadband Internet Service Availability Map of Canada. Source: Innovation, Science and Economic Development Canada[9] Orange to brown regions indicate increasing percentages of 50/10 Mbps availability. Yellow regions have at least 5/1 Mbps available, as per the legend in Figure 4.

[7] Innovation, Science and Economic Development (ISED) Canada. National Broadband Internet Service Availability Map.
[8] ISED. National Broadband Data Information - Get connected (ic.gc.ca).
[9] ISED. National Broadband Internet Service Availability Map. Accessed 15 June 2021.

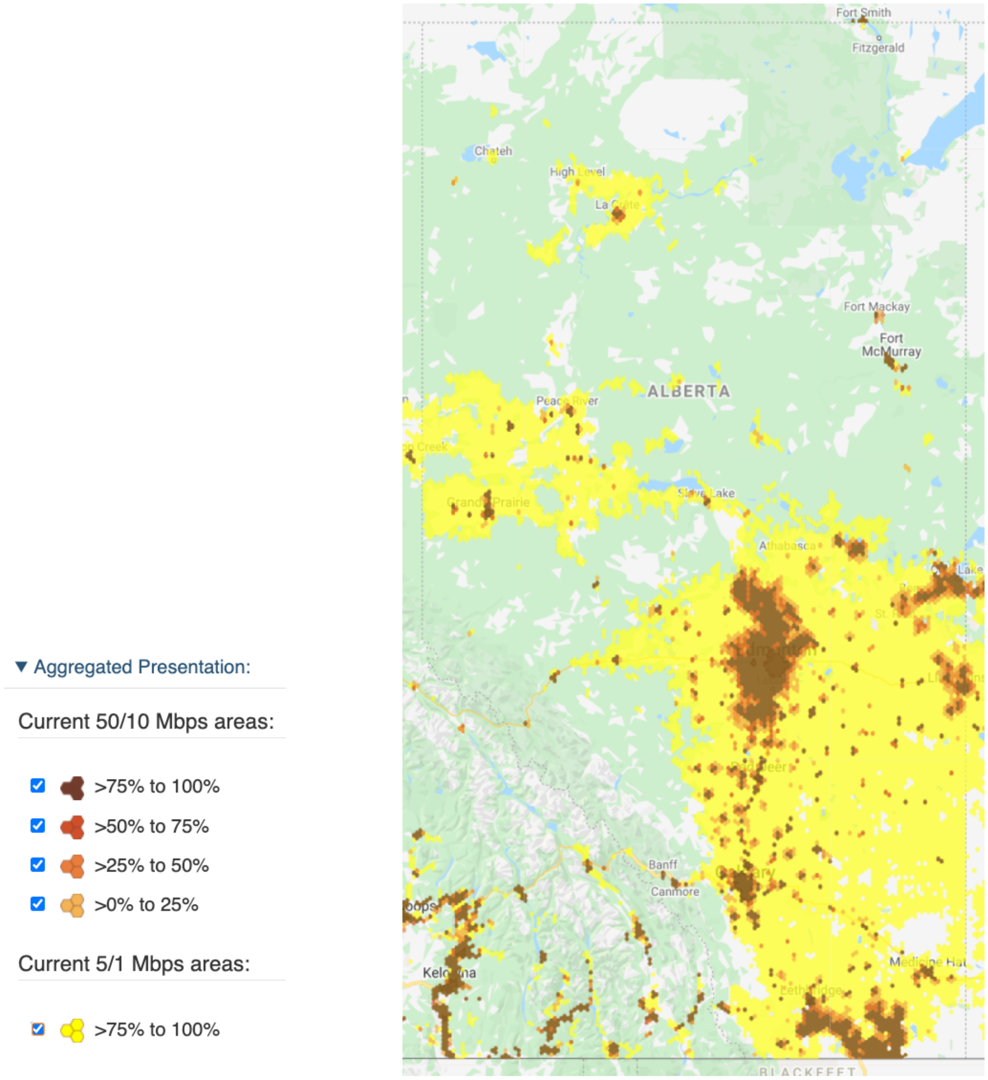


Figure 4. National Broadband Internet Service Availability Map of Alberta. Source: Innovation, Science and Economic Development Canada[10].

Despite the best efforts of the creators behind ISAM, it is unable to achieve a level of granularity to detail the actual levels of service available in a given geographic region, particularly rural areas. For example, in Sturgeon County, immediately north of Edmonton, the national map shows the majority of the county as being fully served at 50/10 Mbps or better, and the remainder at a minimum of 25/5 Mbps (see Figure 5). And yet, many farmers and acreage owners in the county are significantly

[10] ISED. National Broadband Internet Service Availability Map. Accessed 15 June 2021.

underserved. This can be shown from data captured by the Canadian Internet Registration Authority (CIRA) using its Internet Performance Test (IPT)[11].

CIRA is a non-profit organization tasked with maintaining internet domains in Canada, along with a host of other related services. Its IPT service allows internet subscribers to test the actual bandwidth performance of their internet. It is independent of any other data, such as those used by ISAM, and provides real-time data capture. The speed test data CIRA produces comes from hundreds of thousands of data points from around the country.

Cybera acquired CIRA's IPT data for Alberta for the years 2019 and 2020, and has used samples of this data to determine the accuracy of the ISAM information. It should be noted that individual network tests are not always a good indicator of a given network's performance. This is because bandwidth and other network performance indicators — such latency and jitter (lag in data packet delivery and consistent flow of data) — can be dependent on many factors. Nevertheless, the volume of results in a given area from the IPT data can produce averages based on different locations on different connection types and different times of the day and the season. This data then is very telling.

Below is a section of Sturgeon County captured from the ISAM website. When zooming in from the large-scale maps, you get what ISAM calls "Rural Road Coverage", as shown in Figure 5. This shows expected service levels available along these roads, which means the entire area is identified as having service levels at a minimum of at least 25/5 Mbps, if not 50/10 Mbps.

[11] Canadian Internet Registration Authority (CIRA). Internet Performance Test | CIRA.

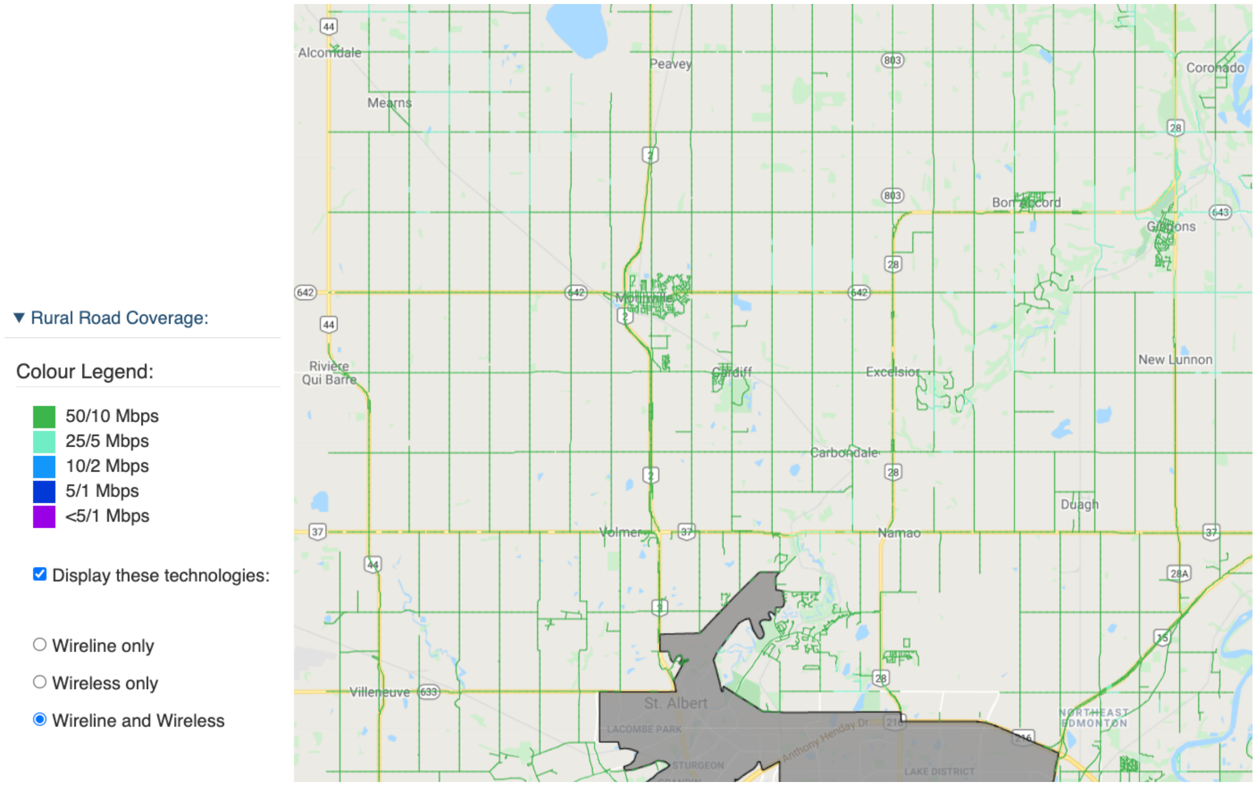


Figure 5. Zoomed-in area of the National Broadband Internet Service Availability Map (ISAM). This shows a portion of Sturgeon County immediately north of Edmonton and St. Albert (grey areas). The Rural Road Coverage shows green lines along the roads indicating full coverage of 50/10 Mbps in the county. Source: Innovation, Science and Economic Development Canada[12].

Compare that view of the area with the data provided by CIRA's IPT data, shown in Figure 6. Using the same legend as ISAM, the results show a much more diverse level of service availability, with a number of locations getting results at less than 5/1 Mbps service availability.

[12] ISED. National Broadband Internet Service Availability Map. Accessed 15 June 2021.

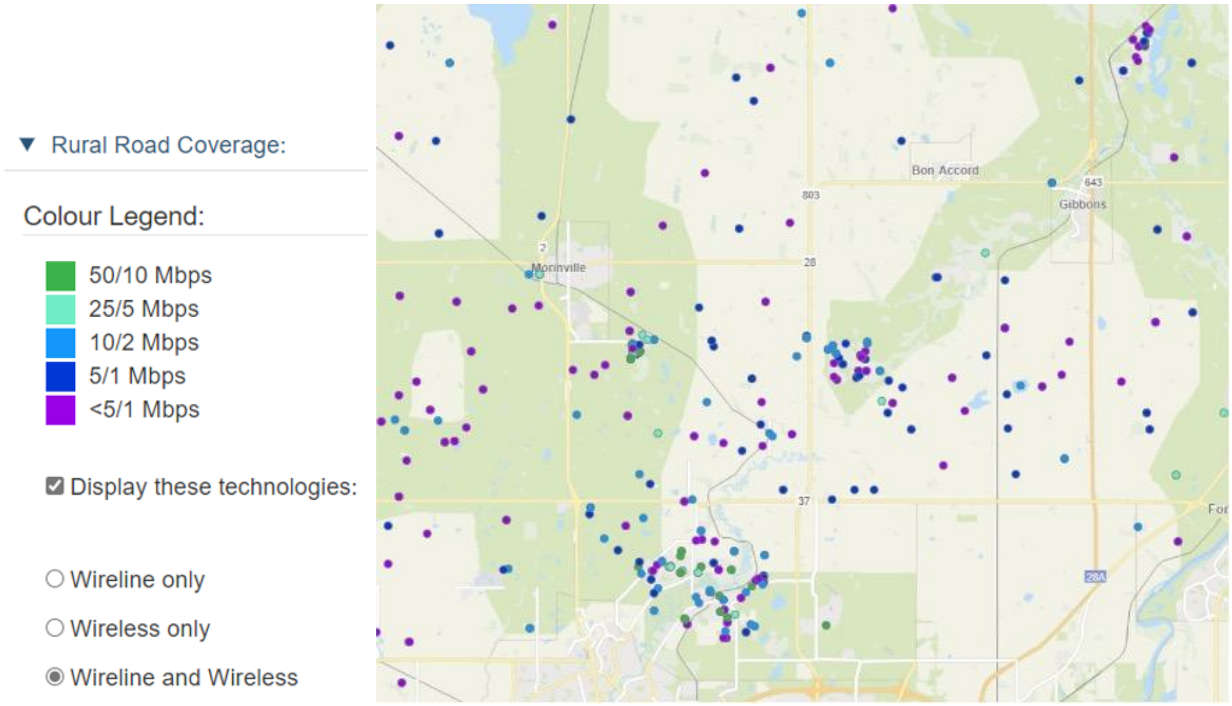


Figure 6. CIRA's Internet Performance Test (IPT) data shows the same section of Sturgeon County as Figure 5, with test results from individual source locations. There are many data points showing less than 50/10 Mbps and even well below 25/5 Mbps as shown in the ISAM image. Source: Canadian Internet Registration Authority IPT data[13].

The CRTC Communications Monitoring Report (Table 1) shows broadband availability percentages for Alberta based on the ISAM data, which gives a broad strokes picture of broadband coverage. CIRA's IPT data can help improve the granularity of the actual broadband service availability in any specific geographic region. Using both of these tools to analyze broadband service availability for a given region, say, to apply for grant funding opportunities, should greatly improve the understanding of the actual availability in any region. This will be further discussed in the Future Needs and Opportunities section of this report.

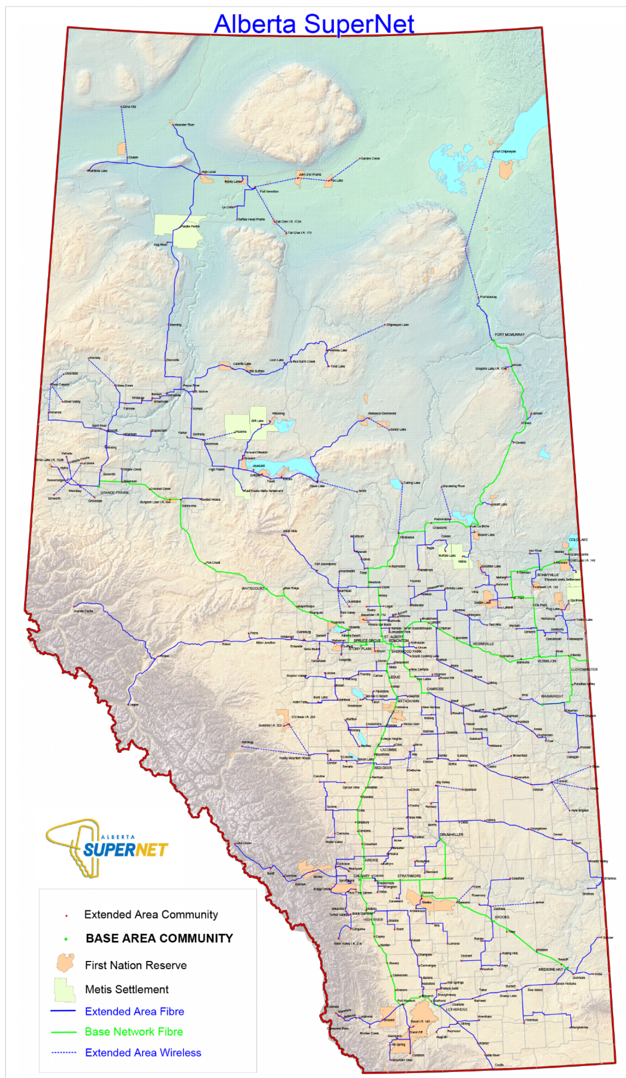
Alberta SuperNet: Vision and History

The Alberta SuperNet is a network of fibre-optic cables and wireless connections across Alberta in over 400 communities. It consists of more than 13,000 km of fibre and 2,000 km of high-speed wireless links. The SuperNet connects more than 3,300 government services and public

[13] CIRA Performance Test data from 2019 and 2020.

institutions, including over 1,950 learning centres, 650 government locations, 300 healthcare facilities, 300 libraries, and 90 Alberta municipalities, with more schools being built and connected each year. Currently, 43 First Nations communities in the Treaty 6, 7 and 8 regions, and eight Métis settlements, have SuperNet connectivity within or adjacent to their communities.

In operation since 2005, SuperNet was built to provide broadband network connectivity to Alberta public organizations and business users. The network is also leveraged by dozens of private service providers to deliver internet and other services directly to customers throughout the province[14].



[14] Bell Canada. Bell awarded SuperNet contract by the Government of Alberta. Newswire, 03 July 2019.

Figure 7. Map of the Alberta SuperNet backbone as it was originally deployed to 429 Alberta communities. Some network pathways have been modified since, but this map shows the scope of provincial coverage by the network[15]. Of note: there is no longer a Base Area Network and Extended Area Network, as Bell manages the entire network.

The SuperNet was a $295 million strategic infrastructure investment by the Government of Alberta ($193 million) and Bell Canada ($102 million). When construction was completed in 2005[16], the final cost, including subsequent extensions, was approximately $330 million[17]. At the time of completion, the SuperNet was the first jurisdiction-wide fibre optic network in North America.

The SuperNet was originally divided into two networks: a primary backbone made up of 27 Base Area Network (BAN) locations, and an additional 402 Extended Area Network (EAN) locations. The operation and management of the SuperNet was originally contracted to Axia SuperNet Ltd (a wholly owned subsidiary of Axia NetMedia Corporation) on the Extended Area Network (EAN), and to Bell Canada on the Base Area Network (BAN). All public sector customers, whether on the BAN or the EAN, were managed by Axia. The initial contract agreement spanned 2005-2015, and was extended from its initial 10-year term for an additional three-year period until June 30, 2018[18].

Governed by Service Alberta, a ministry of the Government of Alberta, the SuperNet now entered a second contract phase. In early 2016, Service Alberta issued a Pre-Qualification Request (PQR) for provincial broadband services in order to identify potential service providers, review business and technical requirements, and gather current information on industry trends[19]. In May 2016, telecommunications operators Axia, Bell, TELUS, and Zayo were pre-qualified to participate through the PQR process[20].

After the PQR process concluded, in late 2017, Service Alberta issued a Request For Proposals (RFP) to replace the initial, extended SuperNet contract from the shortlist of Bell and Axia, as by this time TELUS and Zayo had withdrawn from the competition. The RFP was awarded to Bell Canada, who became the sole contract holder for the SuperNet as of July 1, 2018. To ease the transition process,

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[15] Service Alberta. Layout:4 (servicealberta.ca).
[16] Government of Alberta release.cfm (alberta.ca). Accessed 10 February 2021.
[17] Middleton, C. and Given, J. (2010) Open Access Broadband Networks in Alberta, Singapore, Australia and New Zealand. The 38th Research Conference on Communication, Information and Internet Policy, 1 October 2010. Accessed 10 February 2021.
[18] Axia NetMedia. Continuity of Services Assured for Axia's Alberta Customers. Newswire, 29 August 2013. Accessed 10 February 2021.
[19] Service Alberta. Procurement Services. Pre-Qualification Request (PQR) For Provincial Broadband Services PQR 288-PA-PBS, Reference number: AB-2016-01170, 16 February 2016.
[20] Alberta Purchasing Connection. Opportunity Notice: Provincial Broadband Services, Awarded Vendors, 05 May 2016.

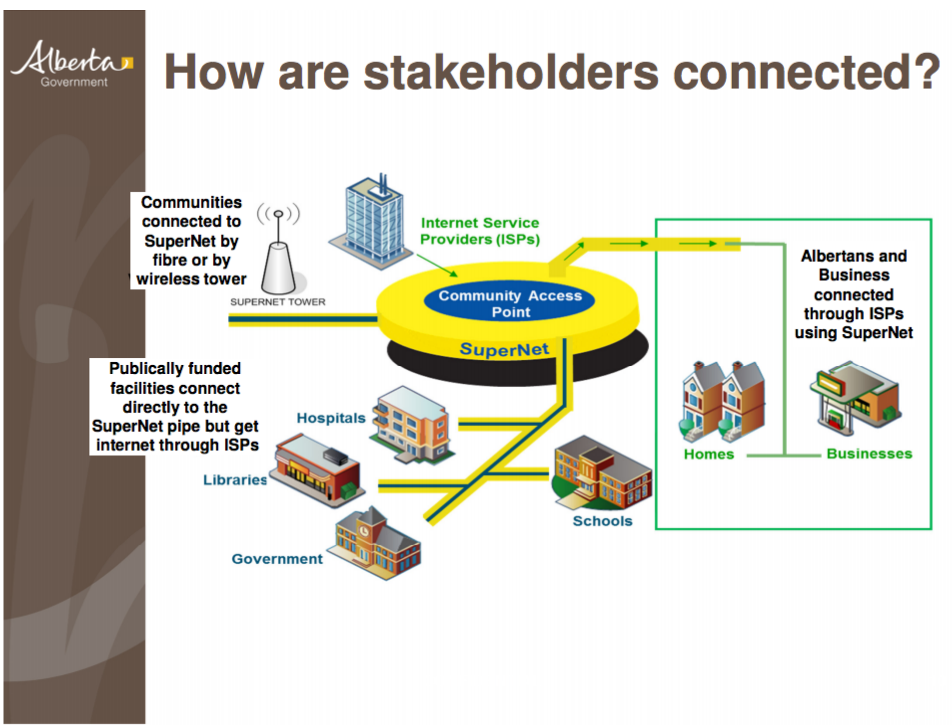
Bell purchased Axia Netmedia Corporation and began integrating SuperNet into its national network[21].

SuperNet Operating Model

The Alberta SuperNet is a backhaul (or 'middle-mile') network that connects on one end to local access networks ('first-' or 'last-mile' connections), and on the other end to separate networks that connect to the internet. Today, the SuperNet serves both public sector customers through a unique suite of services (see Table 2), as well as business and wholesale customers.

For public sector customers, the Government of Alberta set a universal fee structure across the province for monthly flat-rate services, irrespective of a subscriber's physical location. This model contradicts conventional private sector telecommunications billing practices, where rates tend to be lowest in urban centres and highest in rural communities.

The SuperNet does not directly serve residential subscribers. It is intended to provide affordable wholesale fibre access to local ISPs. The ISPs can then provide last-mile connectivity and internet service to residents of SuperNet communities. For a partial list of ISPs providing services through the Alberta SuperNet, please see Appendix A3.



[21] Interview with Bell SuperNet Contract Manager, 08 February 2021.

Figure 8. SuperNet - How are stakeholders connected? Source: June 8, 2016 Service Alberta IM Aware presentation[22].

Public sector organizations that utilize the SuperNet include Government of Alberta ministries, schools, health facilities, libraries and municipalities. School districts receive subsidies of $800 per month for each school site, which may only be spent on connecting to the Alberta SuperNet[23]. Alberta Libraries, through the provincial Ministry of Municipal Affairs, subsidizes SuperNet annual costs for libraries participating in the Public Library Network by $1.85 million per year[24].

Table 2. SuperNet Services for Government Ministries[25].

SuperNet NGN SERVICE	
Base package of 100 Mbps: $898/month ● 90 Mbps Basic ● 5 Mbps Interactive ● 5 Mbps Real Time Includes up to 10 Layer 2 or Layer 3 VPNs, with additional VPNs available upon request at no additional cost.	Additional megabits available in increments of 1 Mbps ● Basic - $0.75/Mbps ● Standard - $2.50/Mbps ● Interactive - $4.00/Mbps ● Real Time - $11.00/Mbps
SuperNet LINE RATE SERVICE	
100 Mbps Line Rate Service: $798/month 1,000 Mbps Line Rate Service: $1098/month ● Includes up to 10 Layer 2 or Layer 3 VPNs, with additional VPNs available upon request at no additional cost. ● Up to 4 physical 1 Gbps Ethernet Ports.	● For customers with large bandwidth requirements, but who don't need multiple classes of service. ● Service can be leveraged by customers with a sophisticated network and IT team, who would like more control over their network.
SuperNet 10 Gbps SERVICE	

[22] Service Alberta Artifact. Accessed 5 July 2016.
[23] Funding Manual for School Authorities 2020/21 School Year, C3.3 SuperNet Service Funding and H1.1 Funding Rates for School Jurisdictions - School Based Grants.
[24] Government of Alberta. Public library statistics | Alberta.ca.
[25] Axia. E-mail communication: Service Alberta and Axia announce newly available suite of SuperNet services for all government ministries, 18 September 2015.

10 Gbps Service: $5,098/month ● Includes up to 10 Layer 2 or Layer 3 VPNs, with additional VPNs available upon request. ● Includes 1 Physical 10 Gbps Ethernet Port.	● For customers with very large bandwidth requirements, but who don't need multiple classes of service. ● Service can be leveraged by customers with a sophisticated network and IT team, who would like more control over their network.

New SuperNet Services since July 1, 2018

Most of the legacy services (re: from the initial contract) on SuperNet were based on using Multiprotocol Label Switching (MPLS) based Internet Protocol Virtual Private Networks (IP VPNs). These were retained in the new contract, but several other services and network requirements were added. These included ethernet (WAN based optical ethernet) and wavelength services[26].

As the latter two services require upgraded network devices to implement, they are not immediately available across the entire SuperNet network. Specifically, the wavelength service was initially available in Edmonton and Calgary, and outside of these two cities, was considered on a case-by-case basis[27].

Additionally, SuperNet was required to connect to all Internet Exchanges located in Alberta. Bell has fibre feeds and electronics located at both the Calgary (YYCIX) and Edmonton (YEGIX) exchanges. No peering requests from SuperNet customers have been made as of the writing of this report[28].

SuperNet and Rural Last Mile

Section 13 (page 187) of the 2018 SuperNet contract refers to support for broadband throughout Alberta, particularly in rural and remote areas of the province, that is required by the SuperNet contractor, Bell.

It specifically states that "Any utilization of [Government of Alberta] Network Infrastructure by the Contractor for providing products and services to Commercial Clients or for any other purposes not specified in the Contract must support the provision of broadband in Alberta."

[26] SuperNet Network Services Contract (#288PA-22559) Schedule 02B.
[27] Interview with Bell SuperNet Contract Manager, 08 February 2021.
[28] Interview with Bell SuperNet Contract Manager, 12 February 2021.

Further clauses spell out that the SuperNet is to be utilized for wholesale commercial services in the same way as other carrier class infrastructure. This clarifies that the SuperNet is to be utilized in a manner that gives a fair and competitive advantage to all ISPs in the province.

In addition, at the time of signing the 2018 contract, Bell was required to submit a "Plan for Alberta" document that outlined its commitments to supporting rural broadband. Bell's rural broadband plan had to include:

- Investments for expanding internet access at targets that meet or exceed 50/10 Mbps
- A community-based plan for expanding internet access – 1 year horizon
- A province-based plan for expanding internet access – 3 year horizon

Bell is required to provide annual updates to the government on the progress it is making on this plan.

At the time of signing the contract, Bell was also required to create a Contractor Contribution Fund, made up of a redacted percentage of its annual revenue, to support rural broadband in Alberta. Currently, there are no publicly available plans on how the Contractor Contribution Fund will be spent, allocated or accessed.

Additional broadband support involved provisions for wholesale services in SuperNet facilities and at other locations to facilitate lower installation costs. Additional required supports include:

- Bell is contractually obligated to support the provincial government's priorities for broadband deployment in Alberta, with an emphasis on rural communities.
    - According to the contract these priorities include:
        - transport, middle mile, and final mile infrastructure
        - unserved communities, and indigenous communities
        - creating partnerships with existing ISPs and municipalities
        - creation and support of new ISPs
        - other opportunities (e.g. free Wi-Fi hotspots at community gathering places, sponsoring training, and other learning supports)

CyberaNet

CyberaNet is Alberta's publicly-funded, high-speed research and education (R&E) network. CyberaNet, which is operated by Cybera, connects the province's education and entrepreneurial institutions to provincial, national and international R&E networks, as well as to the commercial internet (Figure 9).

Created in 1993, CyberaNet serves post-secondary institutions (PSIs), K-12 school districts, provincial and municipal agencies, not-for-profit organizations, and high-tech incubators. (The company operated as WURCNet between 1993-1999, and Netera between 1999-2007). The Government of Alberta supports CyberaNet as a strategic investment to deliver CyberaNet and other services in support of technological advancement.

CyberaNet consists of CANARIE's national R&E network and leased fibre optic infrastructure services, through which local network connections are configured to reach the Alberta SuperNet and municipal fibre networks in Calgary, Edmonton, and Lethbridge. As well as operating the province's R&E network, Cybera offers an Internet Buying Group and Peering service to its members. For the Internet Buying Group, Cybera aggregates members' internet traffic and purchases bulk internet from contracted ISPs on their behalf, thereby obtaining lower cost bandwidth. In order to utilize this service, members must be connected to CyberaNet either through the SuperNet or via another network provider.

For Peering, Cybera leverages direct connections to the Calgary and Edmonton Internet Exchanges (IX) and has access to several more through its NREN connections via CANARIE. These IX connections provide a transit exchange service with major internet content providers such as Google, YouTube and Facebook, thereby reducing overall bandwidth usage by connected CyberaNet members.

As of February 2021, CyberaNet is connected to 27 post-secondary institutions, 54 public and private K-12 school districts, 24 municipality, public or non-profit members, and 1 private member, representing 74% and nearly 100% of all K-12 and PSI Alberta students, respectively. (For a current list of Cybera members, see cybera.ca/membership).

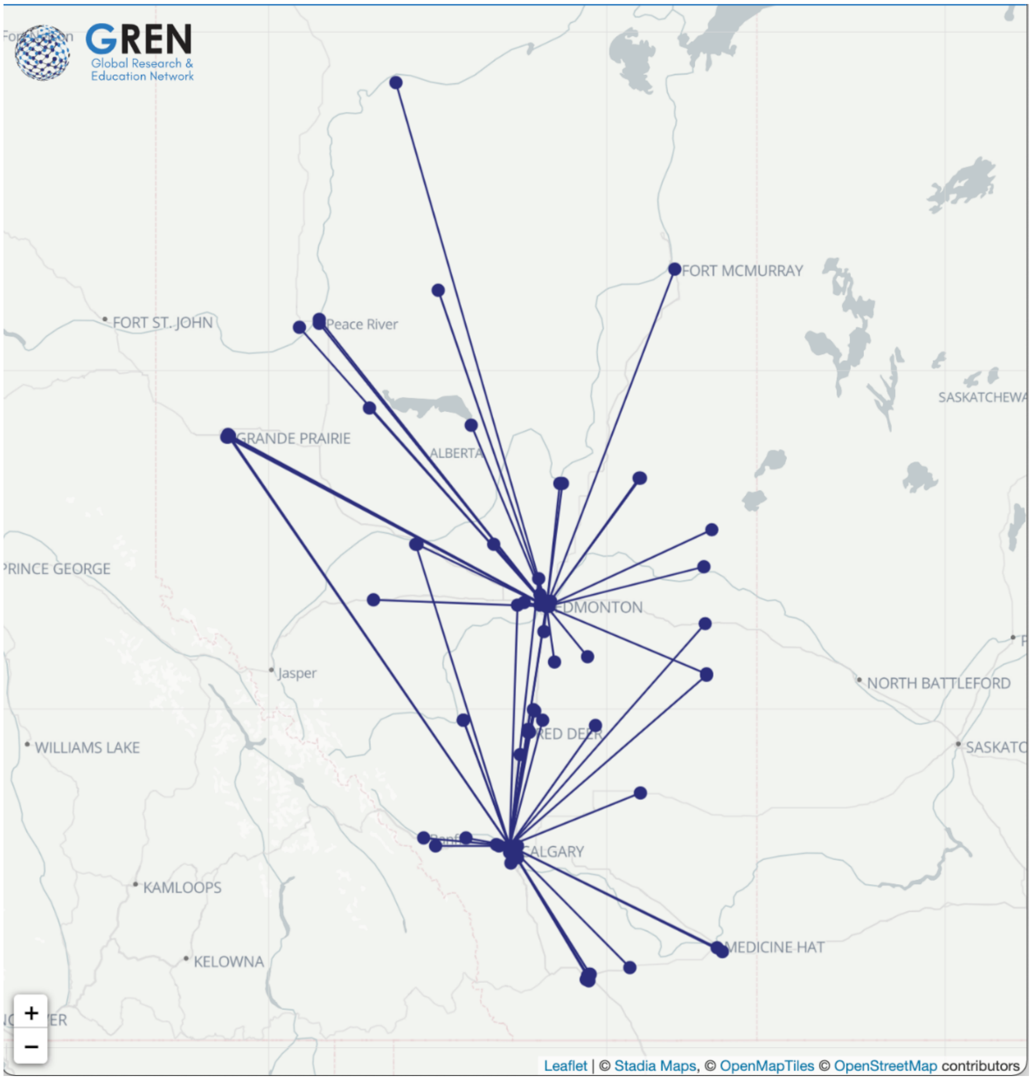


Figure 9. Network map of CyberaNet. The network lines are representative and do not reflect the actual path of the network connections[29].

Research Networks

CyberaNet provides value to its members through its internet buying power and IX connections, but largely through its link to global research networks. Cybera is one of 13 provincial and territorial partners that, together with CANARIE, form Canada's National Research and Education Network (NREN). The high-capacity, high-speed connections made possible through the NREN have been leveraged by Alberta post-secondaries and the Government of Alberta for many global research projects.

[29] Provided by Cybera, 17 February 2021.

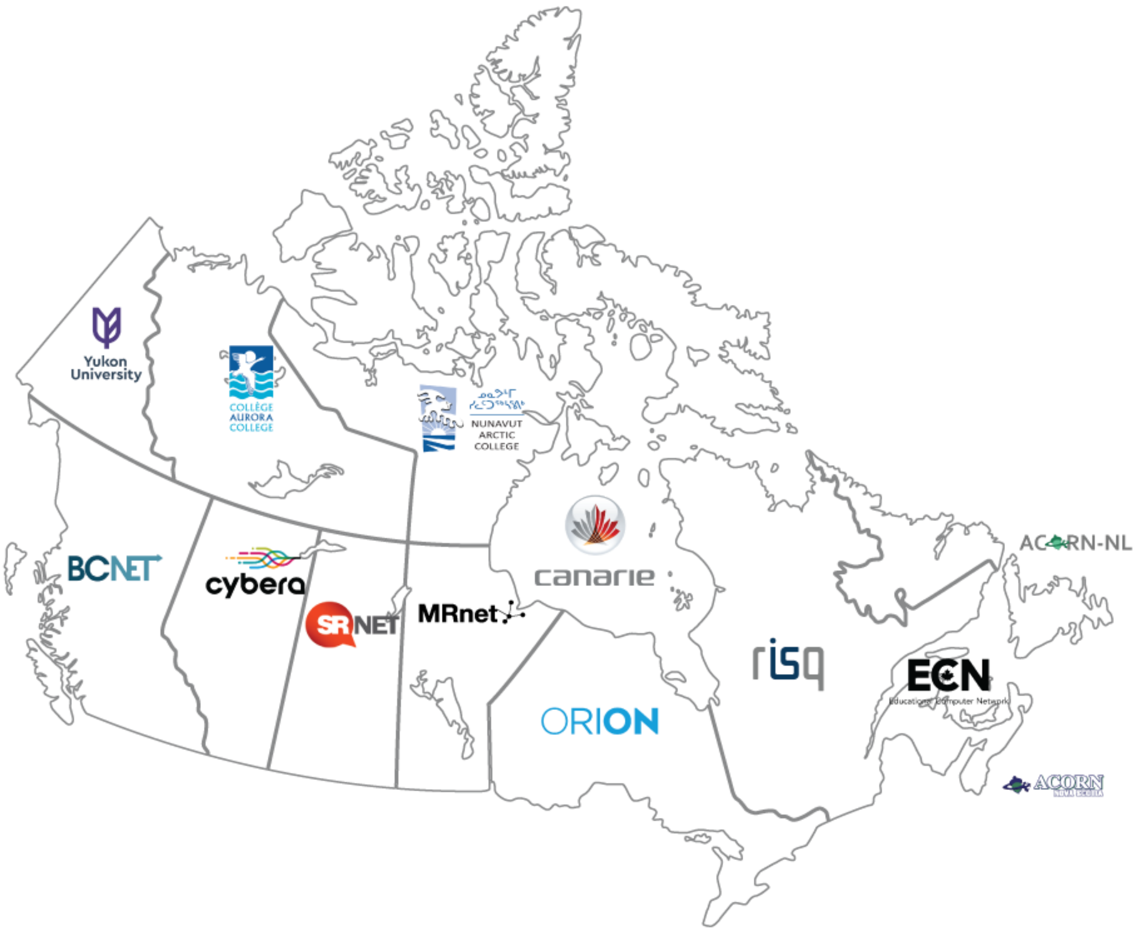


Figure 10. Network map of Canada's National Research and Education Network (NREN). Source: CANARIE Media Kit[30]*.*

Large Internet Service Providers (ISPs)

Access to broadband internet in urban jurisdictions in Alberta is primarily provided by large telecommunications and cable companies.

In Alberta, the largest ISPs are Shaw Communications and TELUS Corporation, both of which offer residential and business internet services. As of February 2021, Shaw offers residential packages of up to 1 Gbps download speed, 100 Mbps upload speed, and unlimited data for $125/month[31]. This package is available wherever Shaw has cable-based services.

[30] CANARIE.Network-Map-NREN-Logos-September2020. Accessed 10 June 2021.
[31] Shaw. Fibre+ Internet Plans & Packages | Shaw. Accessed 21 February 2021.

NOTE: On March 15, 2021, Rogers announced a plan to acquire Shaw in a $26B merger, a deal which would eliminate Shaw as a regional competitor. As of the publication of this report, the deal is pending regulatory approval.

TELUS offers a download speed of 940 Mbps, with symmetrical upload speed of 940 Mbps, for $160/month[32]. TELUS has a data cap of 1 Terabyte. They also advertise 1.5 Gbps download with 940 Mbps upload options, but do not publicize the price[33]. These packages from TELUS are only available to fibre-to-the-home communities (currently 25 communities listed in Alberta)[34].

It is worth noting that commercial providers do not guarantee a customer will attain the stated maximum connection speed. Most provide an 'up to' speed commitment.

As well, business WAN network solutions are provided across Alberta, with symmetrical speeds up to 100 Gbps[35]. Again, these speeds are limited to fibre-only solutions, in specific locations.

Municipal / Community Networks

A 2020 report published by the Edmonton Metropolitan Region Board estimated that improved broadband connectivity across the Edmonton region could increase its GDP by up to $1 billion — approximately a 1% increase — per year. It also argued that closing the connectivity divide would bring significant socioeconomic benefits in areas such as healthcare, education, skills, and general community wellbeing[36].

For many rural communities in Alberta, the internet gap has contributed to serious structural harms to social and economic resilience. Because of this, a number of communities have invested in municipally owned infrastructure for broadband delivery in Alberta.

For rural communities pursuing municipally owned infrastructure initiatives, access to high-speed internet is often cited as one of the most important factors in retaining the local business and population base. Caroline McAuley, Mayor of Vermilion, has said "the lack of broadband and connectivity levels have been a deterring factor for inquiring new businesses, despite all of the advantages we have[37]." The Town of Vermilion registered as an internet service provider with the

[32] TELUS: https://www.telus.com/en/shop/home-services/internet/plans?linktype=ge-meganav. Accessed 21 February 2021.
[33] TELUS PureFibre 1.5 Gigabit Internet | TELUS. Accessed 21 February 2021.
[34] TELUS Fibre Optic Internet Service Areas - PureFibre | TELUS Accessed 21 February 2021.
[35] TELUS Wavelength - Data Centre Interconnect | TELUS Accessed 21 February 2021.
[36] Edmonton Metropolitan Region Board. Broadband Situation Analysis: Final Report August 2020. Pg. 4, Accessed 08 June 2021
[37] Angela Mouly. Vermilion ventures to test broadband internet in pilot project. Lakeland Connect, 20 July 2020.

CRTC in 2019, to test the feasibility of a community broadband project. This came after they failed to attract investment from incumbent providers.

Alanna Hnatiw, Mayor of Sturgeon County (another rural municipality testing a community broadband initiative), testified before the Standing Committee on Finance that "not only does the lack of internet service drive workers and employers to cities, thereby reducing productivity in rural areas, but improved rural internet service can play an integral role in Alberta's economic recovery[38]."

Several municipal governments and local economic development authorities in Alberta are either actively exploring community broadband options, or undertaking broadband projects that follow several different models, including leveraging existing unused infrastructure for broadband. The City of Calgary, for example, has made its dark fibre available for lease[39], and the Lethbridge Electric Utility has provided dark fibre services to public oriented organizations within the City of Lethbridge[40].

In early 2016, the Alberta Ministry of Economic Development and Trade, in conjunction with University of Alberta professors Dr. Michael McNally and Dr. Rob McMahon, conducted eight consultations with Regional Economic Development Authorities (REDA) across the province on the topic of network infrastructure. Using the information they gathered, they spearheaded the creation of the Understanding Community Broadband: The Alberta Broadband Toolkit[41]. This guide is available to assist local governments in determining what solution might best fit their need for improved broadband services for residents and businesses.

Olds

O-NET is Canada's first example of a community owned and operated fibre-to-the-premise (FTTP) deployment. It was conceptualized in 2004 by the Technology Committee of the Olds Institute for Community and Regional Development. Community leaders originally conceived of an "open telecommunications network" that would directly connect every home and business to fibre optic cable. Internet Service Providers could then use this fibre link to offer services to customers.

When those ISPs did not come forward, O-NET was established separately as an ISP to supply services, using the community infrastructure. Construction began in 2011[42]. O-NET now operates

[38] Standing Committee on Finance. Testimony : Second Session, Meeting 46. 18 May 2021.
[39] City of Calgary. Access The City of Calgary's dark fibre. Accessed 18 February 2021.
[40] Energyrates.ca. Lethbridge Electric Utility Rates & Plans - Energyrates.ca, Accessed 21 February 2021.
[41] Dr. Michael McNally. E-mail correspondence, 4 July 2016 and Understanding Community Broadband: The... | ERA (ualberta.ca). Accessed 16 February 2021.
[42] O-NET. About O-NET | O-NET (o-net.ca) Accessed 21 February 2021.

as a “triple play” service provider, with internet, telephone, and television services available to all residents of Olds.

The Olds example has demonstrated the importance of having strong local support in order for a community broadband project to be successful. At a 2015 broadband information session with the Calgary Regional Partnership, Mitch Thomson, executive director of the Olds Institute, remarked: “The Olds Institute has over 150 volunteers and 11 standing committees. [We] have tried to tally what value those volunteers brought to the process. At a $10.00/hour rate, it would reflect millions of dollars of dedicated expertise and effort from volunteers in many corners of our community[43].”

O-NET offers internet packages at speeds of 250 Mbps, 500 Mbps, and 1 Gbps at $90/month, $105/month, and $125/month, respectively[44]. O-NET also offers wholesale service to communities interested in developing their own FTTP networks. O-NET connects to the Calgary Internet Exchange (YYCIX) through fibre leased from Shaw[45]. As a result, O-NET can serve as the ISP over any network that also has a fibre connection to Calgary. At present, O-NET provides service to the village of Waterton in Waterton National Park.[46]

Waterton

In 2014, Waterton began construction of a fibre network, leveraging funds from a Parks Canada initiative that required all Parks Canada offices to have a fibre connection. TELUS fibre optic cables run to the entrance of the park, and access was extended to near the town by Parks Canada during the construction of the Kootenai Brown Trail[47]. Waterton has since procured a fibre connection to Calgary through TELUS, and utilizes O-NET as its ISP.

Waterton offers a wireless network that covers the town and its townsite campground. According to Improvement District chairman, Brian Reeves, wireless internet access is “the number one thing people ask for, no matter whether they’re staying: in a hotel or in the campground in a motorhome[48].”

[43] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015, p.4. Accessed 22 May 2016.
[44] O-NET. Products. http://o-net.ca/internet/ Accessed 21 February 2021.
[45] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015, p.6. Accessed 22 May 2016.
[46] Town of Olds. Notice of Public Hearing: Regarding Olds Fibre Limited. Accessed 21 July 2021.
[47] Pincher Creek Echo. Fibre optic speeds in Waterton, 25 February 2015, p.5.
[48] Pincher Creek Echo. Fibre optic speeds in Waterton, 25 February 2015, p.5.

Parkland

Parkland County has utilized provincial and federal grants to construct a wireless communications network. This network is comprised of 20 towers for service providers to collocate on, thereby extending wireless broadband and mobility coverage. The towers are designed to serve a full range of rural communications service providers, including broadband (internet), mobility (cell), public safety (fire, police, ambulance), and enterprise customers.

This tower use model is intended to accommodate providers that offer different wireless services to residents and businesses, otherwise known as an Open Access Network (OAN). The county is not a Wireless Internet Service Provider (WISP), but instead provides infrastructure for the use of WISPs in return for rent (which covers the operating costs of the towers)[49]. Parkland is the first county in Canada to pioneer this model. Parkland now faces the challenge of improving network capacity at each tower using fibre, and encouraging a competitive service environment for ISPs[50] .

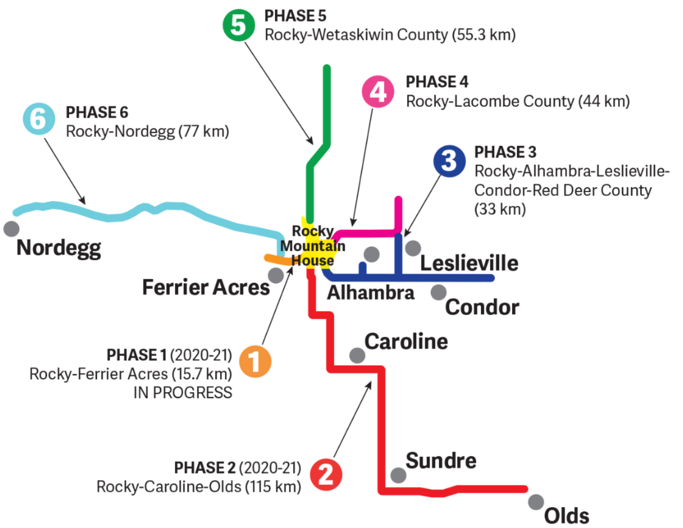
Clearwater County

Clearwater County's Broadband Internet Project is a multi-year initiative that aims to deliver high-speed connectivity to a majority of residents and businesses in the county. A vast majority of county residents and businesses are underserved by available connectivity options, most of which fall below the CRTC standards for broadband speeds[51].

Clearwater County is building an Open Access Network (OAN), similar to Parkland, but primarily using fibre infrastructure, with some fixed wireless. Using a fibre-to-the-node (FTTN) model, the county will provide points from which ISPs can connect, and then provide last-mile connections to customers. As with Parkland, this model significantly reduces infrastructure costs for ISPs in low population density areas, allowing for broadband internet at a more competitive price.

Proposed services over the OAN could include Voice over IP, internet TV, prepaid tourist internet, and connectivity to support agri-tech services. The project started in 2020 and is expected to be completed in 2025.

[49] Parkland County. SMART Parkland Intelligent Community. Accessed 8 July 2016.
[50] Parkland County. Phone conversation with Barb Scully, Connected Communities Coordinator, 12 July 2016.
[51] Clearwater County. Clearwater County - Broadband Project. Accessed 29 January 2021.



Implementation Phase		Estimated Cost	Distance
1	Rocky-Ferrier Acres (2020-2021) IN PROGRESS	$998,000	15.7 km
2	Rocky-Caroline-Olds (2020-2021) IN PROGRESS	$6,900,000	115 km
3	Rocky-Alhambra-Leslieville-Condor-Red Deer County	$2,707,000	55.8 km
4	Rocky-Lacombe County	$1,782,000	44 km
5	Rocky-Wetaskiwin County	$2,376,000	55.3 km
6	Rocky-Nordegg	$4,308,000	77 km
	Wireless Fixed Broadband Access Costs	$1,100,000	
TOTAL	Broadband, Equipment, Infrastructure	$20,600,000	362.8 km (estimated)

Figure 11. Clearwater County Broadband Internet Project. Construction began in 2020. Source: Clearwater County[52].

Other Initiatives

There are other projects in various states of evolution in Alberta. Big Lakes County is undertaking a fibre-to-the-home initiative called Project Aurora[53]. Service download speeds are projected to be between 100 Mbps and 10 Gbps.

The Town of Vermilion is undertaking a project called V-Net, which uses a combination of fibre (fibre-to-the-node) and Wi-Fi for last mile distribution. The town hopes to complete a six-month pilot program with 10 businesses in 2021 and, with positive results, will consider expanding the service to the residents of the town[54].

More small, quick-win solutions are also starting to emerge in the province. The Town of Viking is using its grain elevator to offer a point-to-multipoint wireless internet service. Anyone who is able to establish a clear line of sight path to the elevator is able to access internet services. A three-year contract covers the cost of the internet, plus the customer radio equipment[55].

[52] Clearwater County. Clearwater County - Broadband Project. Accessed 15 June 2021.
[53] Big Lakes County. Communications | Big Lakes County. Accessed 22 February 2021.
[54] Angela Mouly. Vermilion ventures to test broadband internet in pilot project - Lakeland Connect. 20 July 2020. Accessed 25 February 2021.
[55] Nutec Electro Tel sales agent: phone conversation 26 February 2021.

These numerous municipal and county services that are currently operating, or under construction, are likely to be joined by more projects over the next few years. The significant grant funding dollars available for rural internet projects by various government agencies are providing more opportunities for rural and remote parts of Alberta that are still underserved. These opportunities are further discussed in the Future Needs and Opportunities section.

Internet Service Provider Wi-Fi Hotspots

Wi-Fi hotspots are an important service that ISPs offer in order to differentiate themselves and extend their brands. Hotspots are locations where internet access is offered to the public via 802.11 Wi-Fi technology (a specification for implementing wireless local area networks [WLANs]).

By 2019, the CRTC reported over 51,000 hotspots available in Canada, with +12,000 of those in Alberta[56]. However, this number is disputed by the largest provider of Wi-Fi hotspots in Canada (based on the number of access points available), the Shaw Go Wi-Fi network, which says it has more than 100,000 hotspots across Western Canada at the writing of this report in 2021[57]. This is an increase from the 75,000 hotspots Shaw reported in Canada in 2016.

Regardless, there are many places to get free Wi-Fi access in Alberta. The full Shaw Go Wi-Fi network is open to Shaw customers, and is available for "Guest Access" in select locations[58]. TELUS established its own Wi-Fi hotspots in 2015. By 2021, they had reported over 20,000 free hotspots across Western Canada. Bell also offers Wi-Fi access points across Alberta, with almost 500 partner retail outlet locations[59].

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[56] CRTC. Communications Monitoring Report 2020, page 98.
[57] Shaw. Shaw Go Wi-Fi - Over 100,000 hotspots across Canada | Shaw. Accessed 22 February 2021.
[58] Shaw. How to set up Guest Access for Shaw Go Wi-Fi. Accessed 22 February 2021.
[59] Bell. Bell Wi-Fi locations. Accessed 22 February 2021.

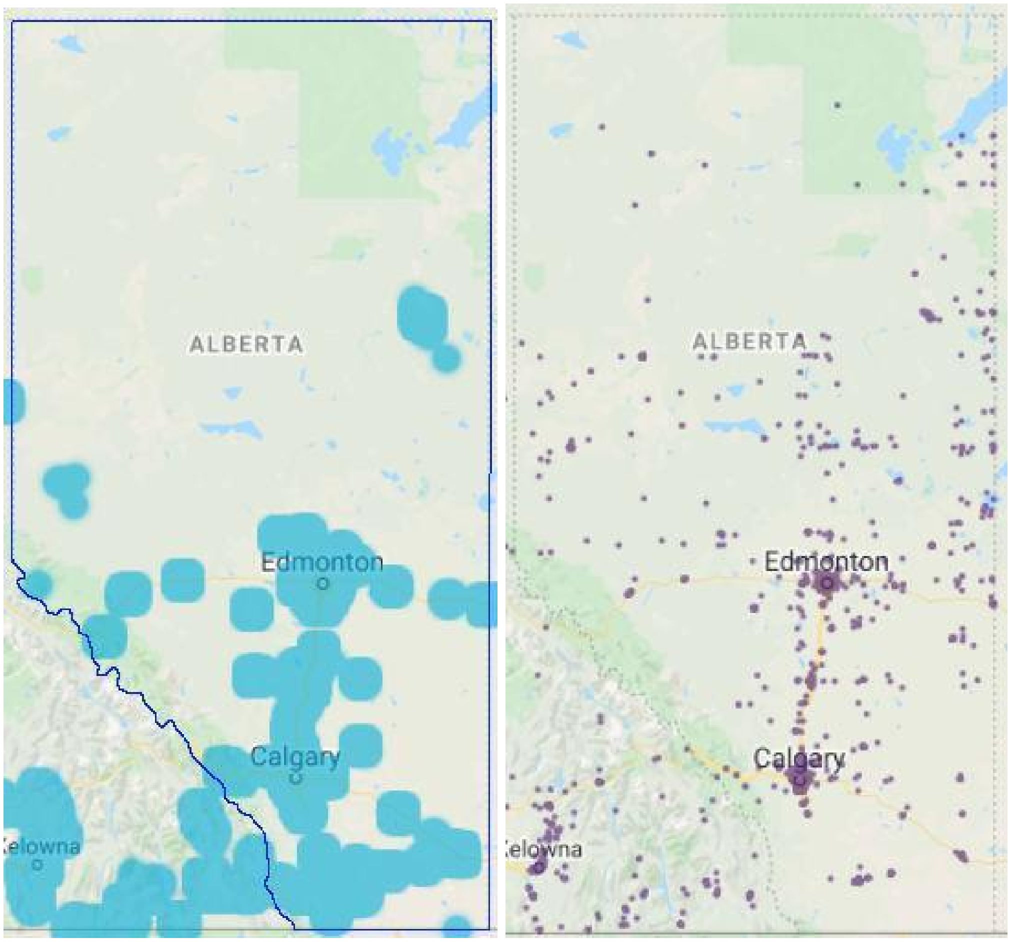

Figure 12. A comparison of "heat maps" between Shaw Go Wi-Fi (left) and TELUS's free Wi-Fi (right) in Alberta, as of February 2021. TELUS's map does have some inaccuracies outside of towns and cities, but shows more distribution than Shaw's. Shaw has more sites in larger municipalities. Sources: Shaw Go Wi-Fi and TELUS Free Wi-Fi[60].

Municipally driven Wi-Fi Hotspots

In 2015, the Olds Institute directed funds from its social enterprises, Mountain View Power and O-NET, to the development of a free public Wi-Fi network in Olds. There are currently more than 80 hotspot locations in and around businesses, and another 19 outdoor access points in parks, campgrounds, exhibition grounds, schools and commercial areas within the community[61]. Approximately 11,000 people connect to this network every month, on average. Another 2,600

[60] Shaw & TELUS. Shaw Go Wi-Fi - Over 100,000 hotspots across Canada | Shaw & Free Internet & Free Wifi - Public Wifi Hotspots | TELUS. Accessed 22 February 2021.
[61] Olds Institute. E-mail communication with Mitch Thomson, 08 July 2016.

devices connect monthly to the network developed within the Olds Hospital and Care Centre (patients have access to free Wi-Fi and can receive their O-NET services while in care)[62].

The City of Edmonton is offering a program called Open City Wi-Fi that provides free public Wi-Fi in some of the city's publicly accessible facilities. More than 14,000 devices connect to Open City Wi-Fi every week, utilizing more than 2TB of data traffic. The service routinely accepts over 4,500 concurrent sessions during peak periods[63].

The City of Calgary has also launched public Wi-Fi access in many of its facilities, such as recreation centres, golf courses, and C-Train stations. The city awarded a contract to Shaw Communications to provide public Wi-Fi through the Shaw Go Wi-Fi service. The contract allows anyone to use the service without having to be a Shaw customer[64].

On a much smaller scale, the town of Hanna provides Wi-Fi to residents and visitors in and near most municipal buildings[65].

Retail Wi-Fi

Offering open access Wi-Fi points in retail and other businesses has been common since the mid-2010s. Many have seen economic returns from offering free Wi-Fi, including longer loiter times by customers that have led to increased sales, and attracting return customers, especially for coffee shops, restaurants, and bookstores. It has also increased customer satisfaction in businesses that see longer wait times for customers, such as auto repair shops or dentist offices[66].

However, in the latter half of the 2010s, more cellular service providers have improved their data plans, offering high limit or unlimited data. This has mitigated the effectiveness of free Wi-Fi, and many customers say they are less likely to connect to an available Wi-Fi service if they're still able to get good cellular coverage. Places of weak or zero cellular coverage are where businesses can still use free Wi-Fi as a draw[67].

Nevertheless there are many business sites in Alberta that have deployed free Wi-Fi and improved internet access in their communities. A number of them are using telco-based solutions like Shaw Go Wi-Fi and TELUS Free Wi-Fi, thereby eliminating network management of the service.

[62] O-NET. Community Wi-Fi Hotspot Map. 22 April 2016. Accessed 20 May 2016.
[63] City of Edmonton. Open City Wi-Fi. Accessed 23 February 2021.
[64] City of Calgary. Public Wi-Fi (calgary.ca). Accessed 28 February 2021.
[65] Town of Hanna Wi-Fi - Hanna, Alberta. Accessed 03 March 2021.
[66] InCorp. Should Your Business Offer Free Wi-Fi? (incorp.com). Accessed 03 March 2021.
[67] Business 2 Community. Is Wi-Fi Even Necessary for Modern Business? Here's What You Need to Know - Business 2 Community. Accessed 03 March 2021.

Provincial and National Parks

There are 11 provincial parks in Alberta, as of March 2021, that offer Wi-Fi access at their visitor centres, such as Peter Lougheed and Lesser Slave Lake[68]. These are primarily connected to the Alberta SuperNet for backhaul.

Parks Canada announced in 2014 it would start installing Wi-Fi hotspots in up to 150 locations across Canada[69]. The Jasper and Banff townsites offer free commercial Wi-Fi services, including Shaw Go Wi-Fi. In Waterton National Park, free Wi-Fi is offered in the town of Waterton as part of its community broadband network, a mix of fibre and wireless services.

Mobile Broadband Service

Wireless Technologies

Mobile broadband services refers to technologies and standards that enable internet access on a portable/mobile device via mobile or cellular networks.

The mobile telecommunications standards that enable modern mobile broadband internet access are commonly known by their "generational" numbers, i.e. 3G means third generation. Most of Alberta's coverage, using the TELUS map in Figure 11, has surpassed 3G and moved into 4G and now 5G coverage. There are still a few Evolved High Speed Packet Access (HSPA+), a later 3G technology, in a few remote areas. These standards are based on evolving wireless networking technologies, and are briefly compared and described in Table 3.

The peak download speeds described in Table 3 represent test results in ideal conditions, whereas real-world results are usually lower, often significantly so. For example, Ookla's speed test data shows that, in the fourth quarter of 2020, the mean download speed of mobile data in Alberta was 101.4 Mbps. This is despite the fact that most of the province is covered by 4G LTE — much of it LTE-A — which is capable of up to 3 Gbps download speeds[70].

The evolution of each mobile technology generation is meant to improve performance and increase the practical use of mobile data for more applications. For example, moving from 3G to 4G allowed for the addition of higher bandwidth apps, such as streaming video services to mobile devices[71].

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[68] Alberta Parks. By Amenities | Alberta Parks. Accessed 03 March 2021.
[69] The Canadian Press. Wi-Fi hotspots coming to Canadian parks. CBC 29 April 2014.
[70] Ookla. Canada's Mobile and Broadband Internet Speeds - Speedtest Global Index. Accessed 06 March 2021.
[71] Thales Group. 5G and the IoT (What is IoT in 5G?) - Thales (thalesgroup.com). Accessed 07 March 2021.

In order to achieve improvements in speed, latency, coverage and availability, service providers have had to make significant investments in infrastructure to both deploy new radios for newer generation services, and beef up their backhaul networks to manage the significantly increased data transmissions. Between 2013 and 2016, TELUS invested $3.6 billion in infrastructure upgrades in Alberta, most of which went to enhancing their 4G LTE rollout[72].

Table 3. Cellular service generations through to 2020. Source: Commsbrief[73].

Commsbrief	1G				2G			3G		4G	5G
Technology standard	AMPS	NMT	TACS	C-Netz	GSM	D-AMPS	IS-95 A	UMTS	CDMA2000	LTE	NR
Digital or not?	Analogue				Digital			Digital		Digital	Digital
Launch year (approx.)	~1980				~1990			~2000		~2010	~2020
Enhancements					GPRS		IS-95 B	HSPA	EVDO Rev. 0	LTE-Advanced	
					EDGE			HSPA+	EVDO Rev. A	LTE-Pro	
									EVDO Rev. B		
Services	Voice only				Voice + SMS + Data (Mobile Internet)						
Peak download speeds	-				GPRS	171.2 kbps		UMTS	2 Mbps	LTE 300 Mbps	10 Gbps
								HSPA	14.4 Mbps		
					EDGE	384 kbps		HSPA+	42 Mbps	LTE-A 1 Gbps	
					IS-95 A	14.4 kbps		CDMA2000	153 kbps		
					IS-95 B	115 kbps		EVDO 0	2.4 Mbps	LTE-Pro 3Gbps	
								EVDO A	3.1 Mbps		
								EVDO B	14.7 Mbps		

Mobile or cellular networks are essentially radio communication networks, but where the last link to the end-user device is wireless. These networks are composed of fixed location transceivers (base stations) that provide wireless coverage over a defined land area, known as a “cell”. The signal strength is higher when the cell is closer in distance to the base station[74]. As an end-user moves locations, there should be a seamless hand-off in coverage from one base station to another, ensuring continuous mobile access.

[72] Newswire and MarketScreener. TELUS investing $2 billion in Alberta over next three years (newswire.ca) and TELUS : to Invest $2.6 billion Across Alberta Through 2016 | MarketScreener. Both accessed 06 March 2021.
[73] Commsbrief. What do the terms 1G, 2G, 3G, 4G and 5G really mean? - Commsbrief. 03 March 2021. Accessed 06 March 2021.
[74] Wikipedia. Cellular Network. Accessed 03 March 2021.

In urban or hot-spot areas (e.g. shopping centres, stadiums, airports) where population concentrations tend to be higher, there is typically a higher density of base stations compared to rural areas, to satisfy traffic demands[75].

Mobile phones — almost ubiquitously of the smartphone variety, combining cellular and mobile computing functions into a single unit — are becoming an indispensable tool for everyone. Current estimates are that over 3.8 billion smartphones are in use around the world, as of March 2021[76]. That is over 48% of the world's population.

In 2019, LTE mobile broadband service was available to 99.5% of Canadians[77]. By 2018 in Alberta, 92% of households owned one or more smartphones[78]. This represents the highest level of mobile device penetration in the country (see Figure 13).

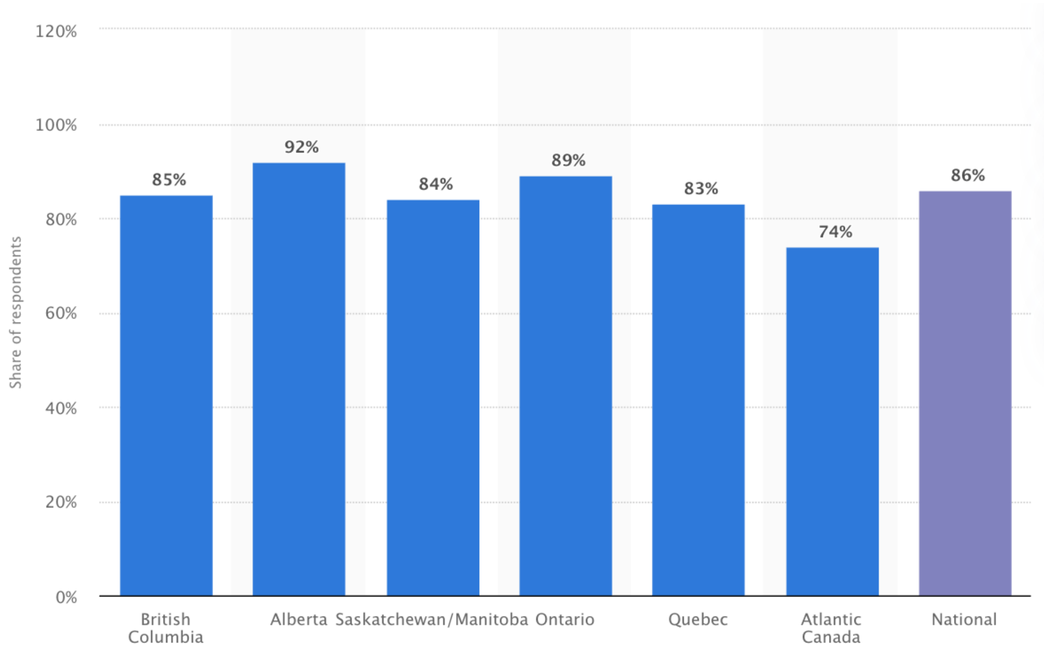

Figure 13. Canadian smartphone household penetration rate in Canada in 2018, by province. Source: Statista.com[79].

A key reason for the popularity of smartphones is the significant service coverage that connects them to voice and data. In Canada as of 2019, over 99.7% of the population lived in areas covered by

[75] Chiaraviglio, L. et al. What is the best spatial distribution to model base station density? A deep dive into two European mobile networks. April 2016.
[76] Statista.com. • Smartphone users 2020 | Statista. Accessed 04 March 2021.
[77] CRTC. Communications Monitoring Report 2020. Accessed 21 July 2021.
[78] Statista.com. • Smartphone penetration rate in Canada 2018 | Statista. Accessed 05 March 2021.
[79] Statista.com. • Smartphone penetration rate in Canada 2018 | Statista. Accessed 4 March 2021.

some form of mobile coverage[80]. Higher speeds of data transmission enhance the smartphone user experience, especially for those using data-intensive applications. Alberta reported the highest percentage of the highest speed (as of 2019) coverage, offering LTE-A to 97.9% of its population. In comparison, the lowest coverage province with LTE-A was Newfoundland and Labrador, at 76.8%.

Figure 14 shows a coverage map of TELUS cellular service in Alberta. TELUS has by far the most comprehensive coverage area in the province, and so represents the most complete coverage map for Alberta. Bell has some of its own towers in the province, but it also has a shared infrastructure agreement with TELUS. As such, both TELUS and Bell have the same national coverage map for services[81]. Rogers has towers in a subset of locations in Alberta, along with Shaw and other cellular service providers.

Figure 14 also shows a map of cell towers distribution in Alberta. Edmonton and Calgary are shown to have a high density of towers (over 1,000), and Red Deer and Sherwood Park have 100+ towers. Outside of those regions, the number of towers is significantly smaller. Parts of Alberta's grasslands to the southeast, and much of the northern half of the province, are populated with just a few towers. This is because the devices that connect to each tower must share the same backhaul bandwidth on the network. Too many devices on the network would overwhelm and significantly slow down the connection.

Unfortunately for more sparsely populated areas, this can also mean there are zones with no cellular coverage.

[80] CRTC. Communications Monitoring Report | CRTC, page 96.
[81] CompareCellular. Compare Canadian Mobile Network Coverage. Accessed 03 March 2021.

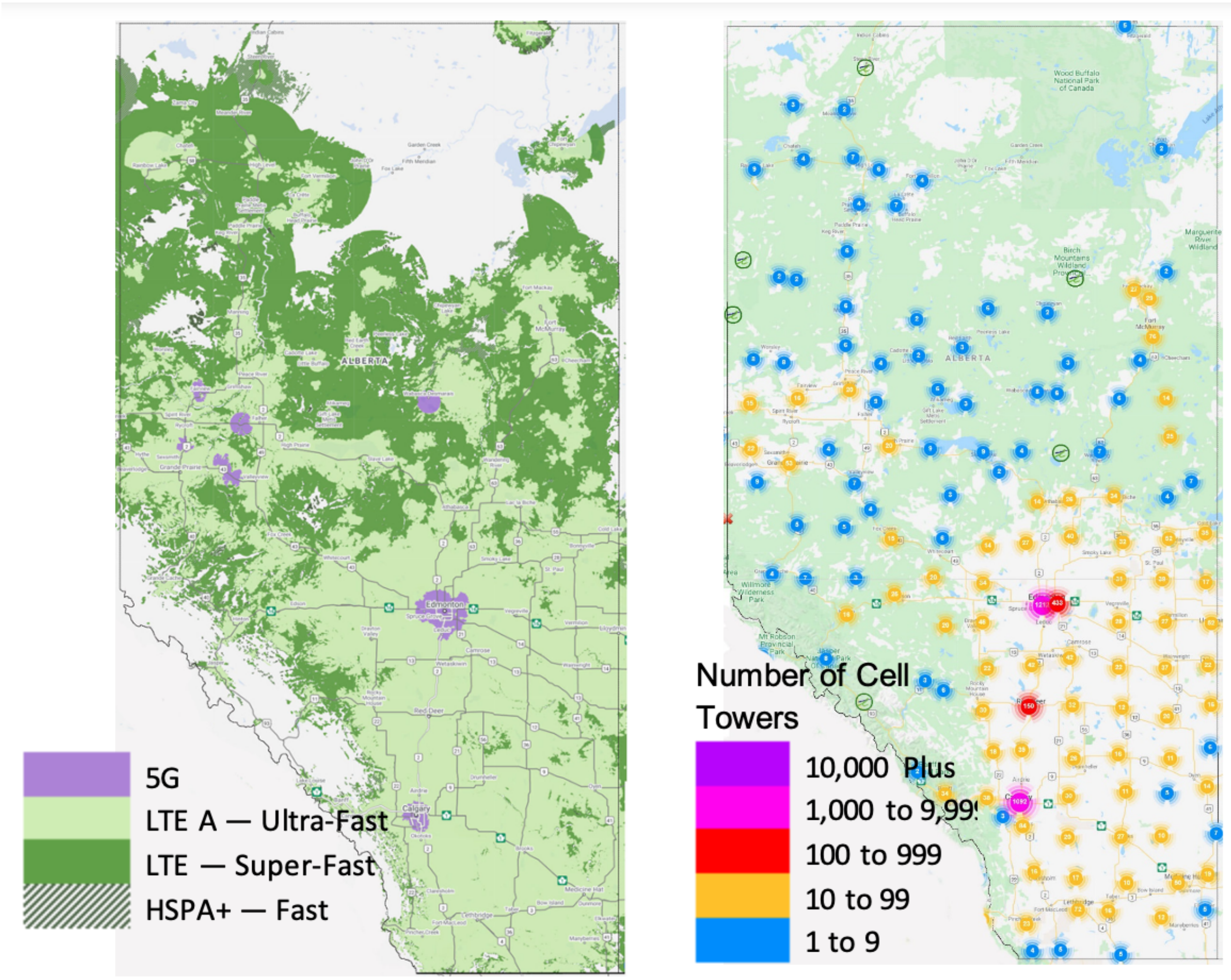

Figure 14. Left: TELUS cellular coverage map of Alberta. Source: TELUS[82]. Right: Cell tower coverage map of Alberta. Source: SCADACore[83].

5G

As discussed in the Wireless Technologies section above, "generational" shifts in network standards allow for newer and better services to be offered, primarily through the increased bandwidth provided. The fifth-generation (5G) standard of broadband cellular networks is currently enabling a vastly increased number of wireless devices in our world, with smartphones being only

[82] TELUS. 5G and 4G LTE, HSPA+ & LPWA network coverage map | TELUS. Accessed 04 March 2021.
[83] SCADACore: Canadian Cell Tower Map - SCADACore. Accessed 02 March 2021.

one type of device to connect to these networks. Telecommunications providers started rolling out 5G in 2019, and by 2020, most major cities in the world, including Edmonton and Calgary, had 5G services available[84]. Figure 15 shows the deployment of 5G enabled cell towers in Alberta, as of March 2021[85].

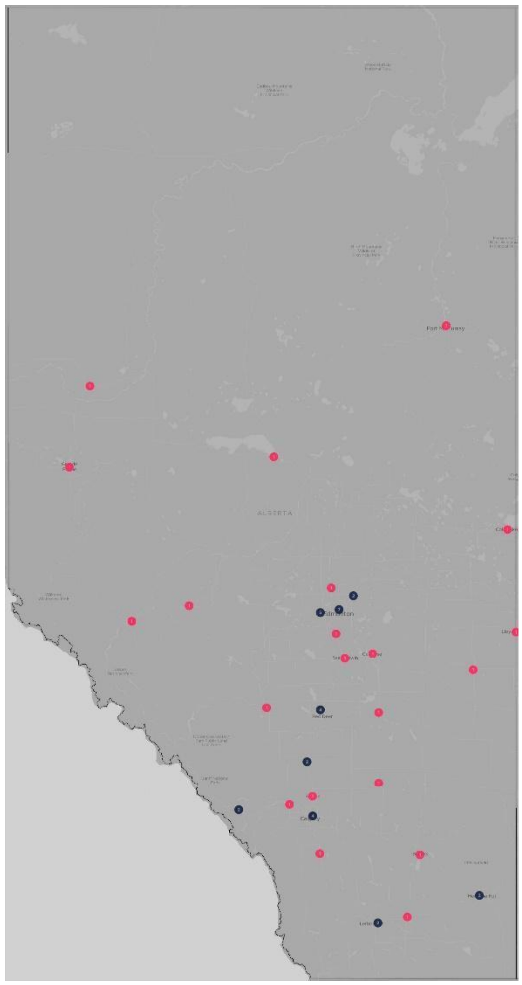

Figure 15. 5G enabled cell tower deployments in Alberta in March 2021. The blue dots represent multiple tower locations and are mostly found in higher population centres. Source: Ookla Speedtest.

5G, like its predecessors, will not achieve its highest expected performance levels immediately. Its rollout began with lower frequency radios, similar to those used by 4G, before ramping up to higher frequencies in the years ahead.

[84] Wikipedia. 5G - Wikipedia. Accessed 07 March 2021.
[85] Ookla Speedtest. Ookla 5G Map - Tracking 5G Network Rollouts Around the World (speedtest.net). Accessed 02 March 2021.

Different levels of radio frequencies offer advantages and disadvantages. The lower the frequency, the farther it will reach and the more easily it can pass through objects. The higher the frequency, the more data it can transmit per second, but its range is limited and it is more easily blocked by walls and windows. The 600-800 Megahertz (MHz) frequency, considered the low-band solution, gives 5G download speeds slightly better than 4G, allowing 30-250 Mbps.

Mid-band 5G, at 2.5 – 3.7 Gigahertz (GHz), can achieve download speeds from 100-900 Mbps. This is the level of service most widely deployed now, and some service providers are bypassing low-band entirely to start deploying at this level. High-band 5G solutions are in the 25-39GHz range, also known as millimeter wave frequencies, and can provide up to 10 Gbps download speeds.

All of these ranges and speeds are based on tests done in 2020. It is likely that, as the standard evolves over the next several years, combined with the use of higher band frequencies and/or improved technologies, even greater bandwidth speeds will be achieved.

Since high frequency, high bandwidth 5G solutions require more radios spaced closer together, it is much more expensive for service providers to deploy this solution. It is therefore more likely that the highest levels of service solutions will only be deployed in densely populated urban areas and where crowds of people congregate, such as sports stadiums and convention centres.

5G and The Internet of Things (IoT)

As mentioned, the capacity of 5G networks will allow them to support many more devices than are connected today. Many see 5G as providing the foundation for the future development of the Internet of Things (IoT). The Internet of Things is a network or series of networks of interconnected objects that have the ability to transfer data autonomously with each other or to other computers. These objects can be sensors, software, or other technologies.

Examples of these connected objects can include sensors used to provide SCADA (supervisory control and data acquisition) systems information on utilities, oil and gas production, agricultural use, and many more areas. Those related to home appliances and other residential items are not likely to utilize 5G connectivity, as they will most likely connect through the LAN/WLAN networks within the residence.

The Internet of Things presents significant challenges for IT management. The number of objects that will need to be on a ubiquitous network can be in the thousands or millions (for example, traffic management sensors embedded in roads or utility meters across Alberta alone could number in the thousands).

This is where 5G networking can play a role. It can connect to at least 10 times more devices than 4G, in fact up to 1 million devices within 1 km^2 [86]. The network speed of 5G will also greatly improve upon 4G, allowing it to handle the significantly increased number of devices transmitting and receiving information on the network. 5G will also significantly reduce network latency (with later implementations in particular). This allows for more refined control of the many devices connected. This could be important, especially for safety purposes, in many areas such as on the factory floor or in monitoring road traffic.

However, the significantly increased bandwidth requirements of 5G brings its own issues. 5G wireless is, essentially, a last mile connection to devices. All the data transmitted still needs to be hauled, in most cases, through middle and primary networks.

This means upgrades to all networks are necessary to manage the implementation of 5G. Once again, this could impact rural Alberta as telecommunications providers look to a return on their investment of pushing expensive technology upgrades into sparsely populated areas.

The next few years will need to see significant improvements in broadband deployment to rural Alberta, but these required upgrades must be planned to not only overcome today's bandwidth shortfalls, but future needs and opportunities as well.

Rural

Rural access networks provide connectivity between transport networks and individual premises, enabling service providers to deliver residential and business services. Transport networks are comprised of optical fibre, while most rural and remote access networks often use wireless technologies to reach subscribers. In Alberta, digital subscriber lines and cables are also used, where available.

Virtually all premises in rural Alberta are served by at least one wireline or wireless access network, but service levels and the quality of service vary greatly[87]. Differences in network operating environments, and in the media and architectures of access networks, account for considerable variations in the performance and cost of service provision.

Fixed and mobile wireless are currently the most common solutions for broadband internet access in rural Alberta. Satellite wireless is often used in more remote or sparsely populated areas. Several

[86] Statista.com. • 4G, 5G and 6G connection density | Statista. Accessed 08 May 2021.
[87] Government of Alberta. Alberta leads in access to high speed internet, 06 December 2013. Accessed 01 June 2016.

communities and regional economic development authorities are also in the process of exploring or deploying various models of fibre-to-the-premise (FTTP) solutions (see below).

Regardless of the access technology, there is widespread agreement that improved rural broadband access is necessary for bridging the digital divide, as well as supporting economic and social growth. In rural communities, available data shows significant drops in access for higher-speed broadband service compared to urban counterparts.

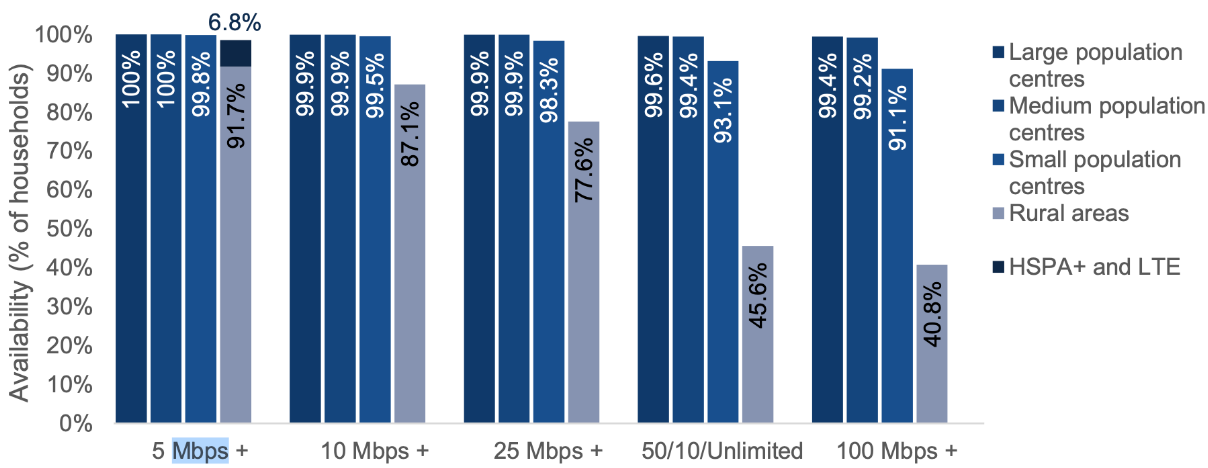

Figure 16. Rural communities experience a significant drop-off in availability at progressively higher speeds[88].

Rural Fibre

TELUS has deployed FTTP networks in 25 municipalities in Alberta, including 20 with a population of less than 10,000. Internet, voice and television are available over their PureFibre service in a number of rural communities, as laid out in TELUS' map[89]. Advertised internet speeds available in rural fibre communities are the same as in urban centres.

During the latter days of the first SuperNet contract, Axia Netmedia Ltd created a retail internet service subsidiary called Axia Connect. This company offered FTTP solutions to rural communities, and established services in 11 municipalities. After Bell won the second SuperNet contract and acquired Axia Netmedia, it subsequently sold the Axia Connect company to TELUS in 2019[90]. As of March 2021, Bell and TELUS continue to work on the transition process to add these 11 locations to TELUS' PureFibre services, which will increase that service to 36 municipalities served in Alberta.

[88] CRTC. Communications Monitoring Report 2020, pg. 108.
[89] TELUS. TELUS Fibre. Accessed 23 February 2021.
[90] Axia. Transition | Axia. Accessed 03 March 2021.

Xplornet is a national ISP that caters exclusively to rural and remote communities in Canada. In Alberta, it offers fixed wireless (up to 5G services now) and satellite solutions. The company has also begun rolling out FTTP solutions in other parts of Canada, and is planning to do the same in Alberta in more densely populated communities. Xplornet expects to offer FTTP in some areas by 2022[91].

Please see the *Municipal/Community Networks* section for more information about rural fibre in Olds and Waterton.

DSL and Cable

As per incumbent telephone company obligations, "twisted pair copper connections" were deployed by TELUS to virtually all residential and business premises in rural Alberta. However, the physical limitations of twisted pair copper loops are such that, in rural areas, only dial-up internet connection speeds are possible over this infrastructure.

Digital subscriber line (DSL) refers to a technology that can be used to transmit digital data over telephone lines. The DSL connections available in urban regions are not widely available to rural customers because DSL performance degrades as the distance from the digital subscriber line access multiplexer (DSLAM) increases, making connectivity in remote sites utilizing copper difficult and expensive. For example, 5 Mbps download speeds on ADSL and ADSL2/2+ technologies are only possible at line distances of less than 4 km from the DSLAM exchange point[92].

Advanced DSL technologies are still being developed, although it's not known how much it could be used in Alberta, as most landline solutions appear to be moving to fibre. G.fast is a DSL technology that can offer speeds in excess of 100 Mbps. It has been deployed in parts of the United States and Europe, but there are no known deployments in Canada. Emerging DSL technologies like G.mgfast (XG-fast/NG-fast) and Terabit DSL (Waveguide over Copper) promise speeds of 5 Gbps, all the way up to 1,000 Gbps (1 Tbps)[93].

Shaw is a major provider of wireline coaxial cable connections in rural parts of the province. Broadband internet access over coaxial cables leverages the data transmitted over a cable service interface specification (DOCSIS) standard. This requires two components: a cable modem termination system, usually located at the head-end of the network, and an end-user cable modem

[91] Xplornet. Email from Vice-President Business Development – Western Canada.
[92] Increase Broadband Speed. Chart of ADSL and ADSL2+ Speed Versus Distance. 25 October 2019. Accessed 03 March 2021.
[93] Wikipedia. G.fast - Wikipedia. 19 February 2021. Accessed 03 March 2021.

device located at the customer's premise. Shaw's top residential service offering of 1 Gbps download is achieved using a FTTN architecture made up of fibre to the nodes in its service communities, and copper cable to each home[94]. Shaw's Gig service is available wherever Shaw is offered in Alberta, meaning that all of its middle-mile services must be fibre.

Fixed Wireless Access/Wireless Internet Service Providers

In rural or remote regions of Alberta where wired cable, DSL, or fibre infrastructure is unavailable, fixed wireless broadband has become a common solution for internet connectivity. Companies operating fixed wireless networks are known as Wireless Internet Service Providers (WISPs) and there are a number of WISP options throughout Alberta (see Appendix A4).

While wireless solutions are cost effective and cover a larger geographic area, there are concerns about the scalability and robustness of the technology. For example, it is not clear how the technology will be able to accommodate ever growing symmetric bandwidth needs as more devices and services come online.

Wireless Internet Service Providers in Alberta purchase backhaul internet bandwidth via a major ISP that connects to a location in the WISP's service territory — usually Axia, TELUS, Bell, or Shaw. From there, the WISP builds additional backhaul connections — either fibre or microwave links — between the public internet connection point and the WISP's towers (See Figure 16).

A small dish or antenna that is mounted to the roof of the subscriber's premise is directed at the WISP's nearest access point. This means remote customers can be added to the network without trenching or hanging physical cables, or modifying existing infrastructure. Subscribers to a fixed wireless service usually pay an installation fee to cover the cost of installing antenna equipment on their premises.

A WISP may also construct its own towers for signal transmission or co-locate equipment on existing radio towers or other points of high elevation, such as water towers or grain silos (see Town of Viking in Municipal/County - Other Initiatives). Co-locating transmission equipment on existing radio towers, however, has proven difficult for WISPs in Alberta. In 2008, during the Advanced Wireless Services (AWS) auction, Industry Canada mandated antenna tower and site sharing[95]. But despite the mandated tower sharing policy, the WISPs that Cybera spoke to reported difficulty and delays with co-locating equipment on incumbents' towers.

[94] Shaw. Lightning Fast Fibre+ Internet (shaw.ca). Accessed 21 February 2021.
[95] Industry Canada. CPC-2-0-17 — Conditions of Licence for Mandatory Roaming and Antenna Tower and Site Sharing and to Prohibit Exclusive Site Arrangements. Accessed 17 May, 2016.

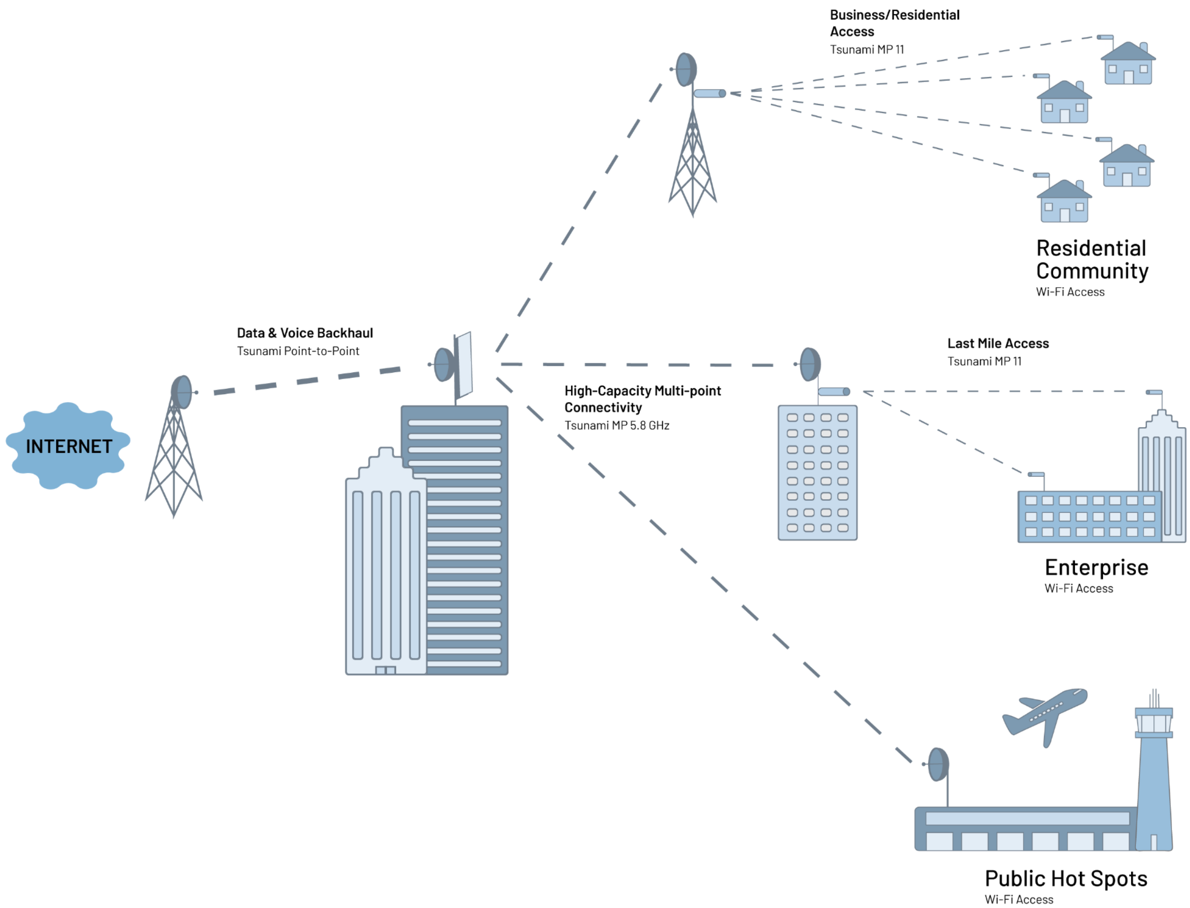

Figure 17. High-level overview of the network architecture for delivery of internet services by WISPs.

Spectrum

Radio frequency spectrum characteristics, and its associated policies, impact all forms of wireless internet service delivery, including satellite and Wi-Fi based technologies. Radio frequency spectrum in Canada is managed by the Ministry of Innovation, Science, and Economic Development (ISED). Spectrum is a finite public resource utilized by various bodies, including commercial private sector entities and their consumers, as well as public sector entities including defence, police, emergency responders, and researchers.

Spectrum is periodically divided into frequency bands, which are allocated for one or more specific uses by international voting decisions at the World Radiocommunication Conference (WRC), which is supported by the International Telecommunications Union (ITU), an agency of the United Nations.

Countries usually adapt global policies developed by the WRC and ITU, and allocate frequency bands on a domestic basis. While the ITU coordinates frequency for different services (broadcasting, mobile, radio, etc.), individual countries determine how those frequencies are subdivided geographically and in terms of channel size.

In Canada, these are set out in The Canadian Table of Frequency Allocations (CTFA). Canadian spectrum allocations tend to align with those of the United States, allowing network operators to take advantage of economies of scale achieved by US telecommunications equipment ecosystems specific to each band.

Only a fraction of the complete electromagnetic spectrum can support radio communication, which is why it is important to use the resource as efficiently as possible. As radio communication technology advances, spectrum utilization becomes more efficient. This "spectral efficiency" allows a single block of spectrum to deliver a greater capacity to service more subscribers.

The Spectrum Management System (formerly Spectrum Direct) is a public database that allows users to view data collected and managed by the Canadian Spectrum Program, and search for spectrum used for communications and broadcasting purposes according to geographic area, frequency, licensee name, and other parameters.

Table 4. A curated and summarized list of radio frequency spectrum assigned for broadband technologies

RADIO FREQUENCY BANDS (MHZ)	INTENDED USAGE	COMMENTS
512 - 608,	• For Remote Rural Broadband Systems (RRBS)[96].	• RRBS service providers can operate on a secondary basis (i.e. no-interference, no-protection), with broadcasters getting priority. • The frequency range 614-698 MHz was permanently removed from this category in 2019, and was reallocated for mobile broadband services[97].
614-698 MHz	• For Mobile Broadband Services. Was	• These spectrum licenses were auctioned off in 2019.

[96] ISED. RSS-196. February 2019. Accessed 10 March 2021.
[97] ISED. Consultation on Repurposing the 600 MHz Band. Accessed 10 March 2021.

	formerly for RBBS and over the air television	● In Alberta, blocks are owned by Rogers, TELUS, and Freedom (now Shaw)[98].
763 - 768, 793 - 798	● Public Safety Broadband Block (PSBB). ● For public safety broadband use.	● The 700 MHz band was formerly used for over-the-air television[99]. ● This frequency band is favoured for delivering next-generation wireless services, as it carries well over long distances and is able to penetrate structures[100].
2500 - 2690	● For broadband radio services (BRS).	● These spectrum licenses were auctioned off in 2015. ● In Alberta, blocks are owned by TELUS, Bell, Rogers, Corridor Communications Inc., Videotron, and Bragg Communications[101]. ● This spectrum is best suited for expanding the capacity of mobile systems in urban areas. ● Not ideally suited for mobile systems covering expansive rural and remote areas.
902 - 928, 2400 -2483.5, 5150 - 5350, 5470 - 5600, 5650 - 5850, 24050 - 24250	● For wireless broadband services (no spectrum license required).	● License exempt spectrum.[102] ● Devices must adhere to specific Radio Standard Specifications. ● Services operate under a secondary allocation basis (i.e. no protection and no-interference).
3475 - 3650	● For fixed wireless access (spectrum license required).	● Spectrum in some Tier 4 localized service areas has been made available for licensing. ● Annual spectrum licence fees apply[103]. ● Devices must adhere to specific Radio Standard Specifications[104,105].

[98] ISED. 600 MHz Auction — Final Results. 10 April 2019. Accessed 10 March 2021.
[99] ISED. Policy and Technical Framework. 12 March 2014. Accessed 10 March 2021.
[100] ISED. 700 MHz Spectrum Auction FAQs. 19 February 2014. Accessed 10 March 2021.
[101] ISED. 2500 MHz Auction - Final Results, 25 June 2015. Accessed 10 March 2021.
[102] ISED. Consolidated Radiocommunication Regulations. Accessed 21 July 2021.
[103] Industry Canada. Notice No. DGRB-008-99. 2011. Accessed 12 June 2016.
[104] Industry Canada. Gazette Notice DGSO-007-14. 03 January 2015. Accessed 12 June 2016.
[105] Industry Canada. SRSP-303.4. December 2008. Accessed 12 June 2016.

3500[106]	• 200 MHz of spectrum available for "flexible use" such as mobile 5G or fixed wireless.	• To be auctioned off in June 2021. • There will be 50 MHz "set aside" spectrum in markets where enough spectrum is available for smaller and regional competitors.
3650 - 3700	• For wireless broadband services (spectrum license required).	• Licensing is shared wherein all licensees have equal access to the spectrum[107]. • Currently no annual spectrum licence fees.
4940 - 4990	• For fixed and mobile services in support of public safety.	• The primary uses of this band are designated for broadband mobile services for public safety, and fixed systems that support these broadband mobile systems[108]. • Additional spectrum in the 8 GHz range for public safety is being planned for auction in the ISED Spectrum Outlook 2018 to 2022.

In evolving rules around the future uses of spectrum, Innovation, Science and Economic Development works to ensure that Canadian spectrum users have enough for next generation technologies, and are also in step with the United States. The federal ministry's most recent strategic outlook for spectrum was published in 2018, and is called Spectrum Outlook 2018 to 2022. It includes plans for supplying next generation 5G technologies, among other purposes.

Remote Rural Broadband Systems (RRBS)

The previous version of the *State of Alberta Digital Infrastructure Report* talked of one promising wireless technology, of limited scope, but that could offer some potential in rural and remote areas of Canada: television spectrum. Over-the-air television signals greatly decreased in value as more viewers switched to wired solutions via cable television or internet streaming services. This, combined with Canada's transition from analogue signals to digital signals for television broadcasts, made a good portion of the country's UHF reserved frequencies of little use, particularly in rural areas.

[106] ISED. 3500 MHz band spectrum auction - Canada.ca. 05 June 2020. Accessed 10 March 2021.
[107] Industry Canada. CPC-2-1-26. 06 June 2016. Accessed 10 March 2021.
[108] Industry Canada. CPC-2-0-19. 01 November 2008. Accessed 12 June 2016.

In the mid-2000s, Industry Canada began looking at re-allocating spectrum in the 512-608 MHz and 614-698 MHz range (TV channels 21 to 51) to be used for Remote Rural Broadband Systems (RRBS). The ministry did not remove the spectrum's use for over-the-air television broadcasting, but wherever there was no conflict with such use, the spectrum was made available for fixed wireless data transmission.

Industry Canada (now Innovation, Science and Economic Development Canada, or ISED) considered licenses on a case-by-case basis. Essentially, an operator of RRBS could only use the spectrum far enough away from major urban centres where the frequencies may be in use by over the air television broadcasters. If at any time a television broadcaster wanted to use the allocated spectrum in an area where the RRBS operator was offering services, the operator had to defer its use of the spectrum to the broadcaster.

Despite all these constraints, there was still plenty of room for the deployment of RRBS, specifically in Alberta. Dr. Gregory Taylor, a spectrum policy researcher and professor at the University of Calgary, did a study on RRBS adoption across Canada, which was published in February 2018. He determined that RRBS deployments were highest in Alberta: mainly in sparsely populated areas, and deployed largely by passionate, self-taught individuals. Nevertheless, issues arose that may lead to the demise of RRBS at some point in the future.

The most significant issue was that ISED was keen to consider repurposing the 600 MHz spectrum for mobile broadband services (and then did so), to follow similar models elsewhere in the world, notably in the United States. This had the potential to cripple some operations.

While a decision to repurpose the 600 MHz spectrum was made in 2015[109], it was not until 2019 that the spectrum was finally auctioned off[110]. Innovation, Science and Economic Development's website shows several places in Alberta that are still licensed to use spectrum in the 512-608 MHz range, located in rural areas that would not conflict with major urban centres or are near the U.S. border. So it appears possible that some RRBS operators are still utilizing this technology solution to deliver services in rural Alberta.

[109] ISED. Decision on Repurposing the 600 MHz Band. Accessed 10 March 2021.
[110] ISED. 600 MHz Auction – Final Results. 10 April 2019. Accessed 10 March 2021.

First Nations

Current Status

First Nations communities in Alberta offer varying degrees of broadband internet access to their residents. Different broadband strategies are being implemented to resolve this issue. While the Alberta SuperNet did roll out to all (or nearly all) schools in First Nations communities, the infrastructure was not always readily available for ISPs to use as backhaul. Several projects around the province have provided other solutions.

Despite this, Alberta's First Nations communities have some of the lowest 50/10 Mbps accessibility numbers in the country, with only 19.6% of communities achieving speeds at that level (only four other provinces have less access to 50/10 Mbps speeds in First Nations communities).

Table 5. Prepared by Cybera using data from the 2020 CRTC Communications Monitoring Report[111]*.*

PROVINCE	FIRST NATIONS ACCESS TO 50/10 MBPS + UNLIMITED
New Brunswick	92.9
British Columbia	68.3
Quebec	62.8
Nova Scotia	44.1
Prince Edward Island	30.4
Alberta	19.6
Ontario	16.1
Manitoba	2.0
Saskatchewan	1.7
Newfoundland and Labrador	0.0
Canada	**34.8**

[111] CRTC. Communications Monitoring Report 2020, page 113.

Overall availability of broadband to Canadian First Nations communities is shown in Figure 18. Alberta communities place high for availability of up to 25 Mbps, but are lower than average for faster bandwidth speeds. Last mile connectivity technologies are likely to be the issue for many of them, given backhaul availability issues via SuperNet or other providers.

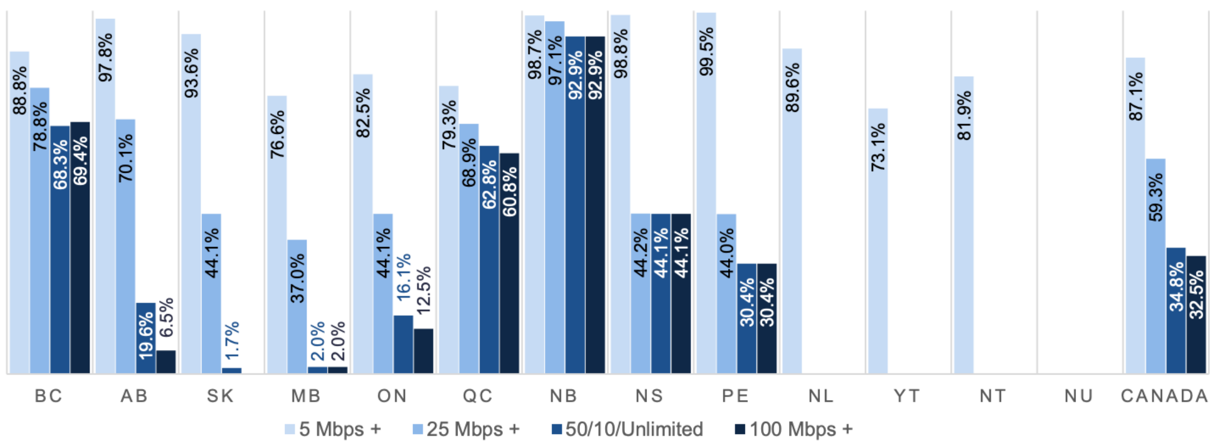

Figure 18. First Nations reserve broadband service availability, by speed and province/territory (% of households), 2019[112].

Remarkably, five out of the 80 First Nations communities in Alberta have less than 50% LTE mobile data service coverage, and 10 out of 80 are less than 100% covered[113].

Federal Initiatives

There are two federal grants for broadband initiatives available in Canada as of the writing of this report. More about these can be found in the Future Needs and Opportunities section on page xx. Both grants have provisions specifically for First Nations or Indigenous people in Canada.

The Universal Broadband Fund (UBF) is an Innovation, Science and Economic Development Canada (ISED) managed, $1.75 billion fund aimed at improving rural broadband services across the country. Within the categories of eligible projects is a stipulation for mobile projects:

[112] CRTC. Communications Monitoring Report 2020, page 110.
[113] CRTC. https://crtc.gc.ca/cartovista/BroadbandInReservesYE2019_EN/index.html. Accessed 11 March 2021.

Up to $50 million has been set aside to fund mobile projects that primarily benefit Indigenous peoples. These mobile projects are expected to extend 4G LTE coverage or better mobile services to unserved areas. Projects must target Indigenous communities, roads within or leading to Indigenous communities, or highways and roads where the deployment of mobile network coverage would benefit Indigenous peoples. Unserved sections of roads that would be deemed strategic for the socio-economic development or public safety of Indigenous peoples could also be eligible[114].

The first intake for applications to the fund ended on March 15, 2021, however, ISED has stated that additional intake processes may be announced in the future[115].

Another federal fund managed by Infrastructure Canada is the Investing in Canada Infrastructure Program. This $33 billion program is designed to stimulate Canada's economy through new infrastructure projects. There are four streams, including Rural and Northern Communities Infrastructure. One sub-category within this stream is "Improve Broadband Connectivity[116]."

In an agreement with the province of Alberta[117], the federal government has committed to providing $159 million toward the Rural and Northern Communities Infrastructure stream between 2018-2028. The agreement states that this stream "Will support projects that improve the quality of life in rural and northern communities by responding to rural- and northern-specific needs." Some of this funding may be eligible for broadband projects that support Indigenous people.

The First Nations Technical Services Advisory Group

The First Nations Technical Services Advisory Group (TSAG) is a not-for-profit First Nations organization that provides technical support and training to Indigenous people in the Treaty 6,7, and 8 regions. The TSAG Information Technology program delivers IT services, including high speed internet, helpdesk, telehealth videoconferencing, and GIS capture and management[118]. The Advisory Group owns 51% of Arrow Technology Group, a service provider with a presence in 50 First Nations communities[119]. Arrow offers residential and business wireless services in the 10 Mbps to 20 Mbps download speed range.

[114] ISED. Universal Broadband Fund - Get connected (ic.gc.ca). 05 March 2021. Accessed 11 March 2021.
[115] ISED. Universal Broadband Fund: For applicants - Get connected. 10 February 2021. Accessed 11 March 2021
[116] Infrastructure Canada. Infrastructure Canada - Investing in Canada Infrastructure Program. 22 December 2020. Accessed 11 March 2021.
[117] Infrastructure Canada. Infrastructure Canada - Integrated Bilateral Agreement Canada - Alberta. 20 June 2018. Accessed 20 Jan 2021.
[118] TSAG. First Nations Technical Services Advisory Group Inc. (tsag.net). Accessed 11 March 2021.
[119] Arrow Technology Group. Arrow High Speed Internet Locations. Accessed 11 March 2021.

Emergency Communication System

An Emergency Communication System (ECS) supports one-way and two-way communication of emergency messages between individuals and groups of individuals[120].

Typically, first responders to emergency situations will use a two-way (push to talk) radio communication systems. There are multiple problems that can affect the use, let alone efficient use, of this technology, including:

- Fire, police, and ambulance services are on different radio systems, preventing easy coordination in major emergencies.
- Radio towers that enable these radio systems can become disabled in disaster scenarios, rendering the systems useless.

Solutions to these problems have been enabled or are in the process of being enabled. They are outlined in the following sections.

Alberta First Responder Communication Systems

Traditionally, first responders operate in silos, with each department responsible for running its own network. This can hinder the interoperability needed in times of significant emergency situations or disasters.

On July 1, 2016, the Alberta First Responder Radio Communications System (AFRRCS) was fully activated. This is a province wide APCO Project 25 (P25) trunked two-way radio network for first responders in municipal, provincial and First Nations agencies. The AFRRCS system also carries all the radio traffic of the various government agencies that currently use wireless/radio communications, including Alberta Environment and Sustainable Resource Development, sheriffs, Alberta Health Services, as well as the Royal Canadian Mounted Police (RCMP).

The system uses a mix of 700 MHz (digital trunking), and, in some areas such as mountainous terrains and similar regions, a "VHF overlay" involving non-trunked-conventional- P25 VHF-hi (136-174) frequencies. The system, which cost $438 million[121], not only enables a fully coordinated joint response among first responders from different agencies, it also reduces the cost of radio system infrastructure. Participation in AFRRCS by first responder agencies is voluntary and costs the province an additional $17 million yearly in upkeep and rental cost for the towers. Municipalities

[120] Wikipedia. Emergency Communication System. Accessed 11 March 2021.
[121] Alberta Government. New first responder radio system launching July 1 will better protect Albertans, 23 June 2016. Accessed 11 March 2021.

and their agencies (and wireless providers) have access to the towers for free, but have to pay for the radios and equipment needed to access the network[122].

Low Earth Orbit Satellite (LEOS) Emergency Services

While AFRRCS has Alberta emergency services covered, there can still be issues if the local towers are disabled due to a disaster situation (forest fires, ice storms, etc.), or if an emergency occurs in remote locations without AFRRCS coverage.

Low Earth Orbit (LEO) satellite internet services are starting to serve customers in southern Alberta, beginning with SpaceX's Starlink service. More information is found in the LEO section of this report. One service that LEOs can offer first responders is ubiquitous, unhindered internet, in any location. Already, Starlink has proved useful in the US state of Washington, where it provided communications in areas affected by forest fires[123]. Canada's own satellite service provider, Telesat, is deploying LEOs, and is also offering specific services for first responders[124].

Public Emergency Alerts

An emergency notification system refers to a collection of methods that allow the one-way dissemination or broadcast of messages to people during an emergency. An important function for such public alerts is the ability to broadcast on more than one forum. Public alerts traditionally make use of radio and television, and have incorporated social media, texting, email, and other cellular notifications.

Communications failures often occur during major disasters. In 2014, the CRTC required all FM and AM radio, and over-the-air television stations, as well as subscription-based broadcasters, to participate in the National Public Alerting System (NPAS). Four years later, on April 6, 2018, the CRTC also required all wireless service providers to participate in NPAS and begin distributing wireless public emergency broadcasts on their LTE networks[125].

In Alberta, as a result of the July 31, 1987, tornado that struck Edmonton and the surrounding area, the government developed an Emergency Public Warning System (EPWS) in 1992. The EPWS was the first rapid warning system of its kind to use media outlets to broadcast critical life-saving information directly to the public.

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[122] CBC. New radio system that played 'lifesaving role' in Fort McMurray launched across Alberta, 24 June 2016. Accessed 11 March 2021.
[123] CNBC. Washington emergency responders use SpaceX Starlink. 29 September 2020. Accessed 11 March 2021.
[124] Telesat. First Responders | Telesat. Accessed 11 March 2021.
[125] CRTC. Emergency Alert Messages and NPAS. 15 October 2020. Accessed 11 March 2021.

In October 2011, the EPWS was upgraded and renamed the Alberta Emergency Alert to address the changes in technology, as radio and television moved from analogue to digital. Alerts are disseminated through various media outlets including television, radio, and social media. In 2014, an app was created for both iOS and Android devices to help with the dissemination of this information to the public[126].

Internet Exchange Points

Internet Exchange Points (IXPs) are "interchanges" where networks can connect to other networks without having to go through a third-party provider. Technically, they are the physical infrastructure through which ISPs and content delivery networks (CDNs) exchange internet traffic[127].

The key advantages of an IXP include[128]:

- Improving performance: shorter network distance, better latency
- Increasing resiliency: reduced congestion, stopping cyberattacks
- Accessing global content: improved performance to major content providers
- Reduced costs: transit costs to third-party providers is lower
- Domain Name System (DNS) resolution resilience: offers multiple paths to top level domain DNSs

Many IXPs are operated by non-profit organizations or by a consortium of ISPs, to provide a neutral site where all participants and the network traffic can be treated equally. In Canada, as of March 2021, there are 12 IXPs in operation, including two in Alberta[129].

Table 6. CIRA List of IXPs in Canada in 2021[130].

CITY	IXP	METRO POPULATION	WEBSITE
Toronto	TORIX	5,928,040	torix.ca
Montreal	QIX	4,098,927	qix.ca

[126] Alberta Government. Alberta Emergency Alert History. Accessed 11 March 2021.
[127] Wikipedia. Internet exchange point - Wikipedia. 18 February 2021. Accessed 11 March 2021.
[128] CIRA. Canada's Internet Exchange Points | CIRA. Accessed 11 March 2021.
[129] CIRA. Canada's Internet Exchange Points | CIRA. Accessed 11 March 2021.
[130] CIRA. Canada's Internet Exchange Points | CIRA. Accessed 11 March 2021.

Vancouver	VANIX	2,463,431	vanix.ca
Calgary	YYCIX	1,392,609	yycix.ca
Ottawa-Gatineau	OGIX	1,323,783	ogix.ca
Edmonton	YEGIX	1,321,426	yegix.ca
Winnipeg	MBIX	778,489	mbix.ca
Halifax	AIXP / HFXIX	403,390	aixp.ca
Saskatoon	YXEIX	295,095	yxeix.ca
Moncton	AIXP / MonctonIX	144,810	aixp.ca
Saint John	AIXP / SJIX	126,202	aixp.ca
Charlottetown	AIXP / PEIX	69,325	aixp.ca

Alberta's Internet Exchange Points (IXPs) are the YYCIX in Calgary and the YEGIX in Edmonton. The YYCIX was introduced in 2013 and has 71 peers, transferring 35.5 Gbps, on average (Figure 19). The YEGIX was created in 2015 and currently has 10 peers, transferring 537 Mbps, on average (Figure 20).

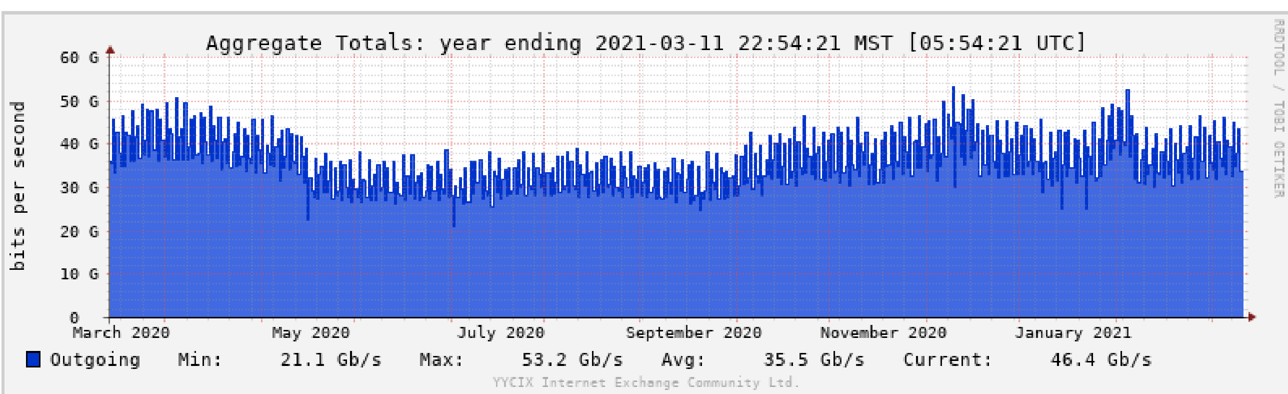


Figure 19. Aggregate total traffic of YYCIX in the year ending March 11, 2021[131].

[131] YYCIX. Graphs, 11 March 2021. Accessed 11 March 2021.

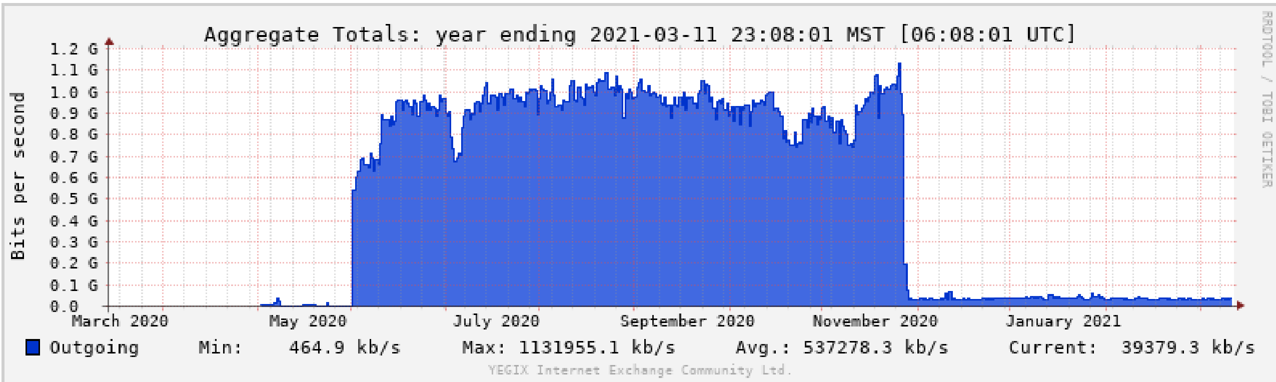
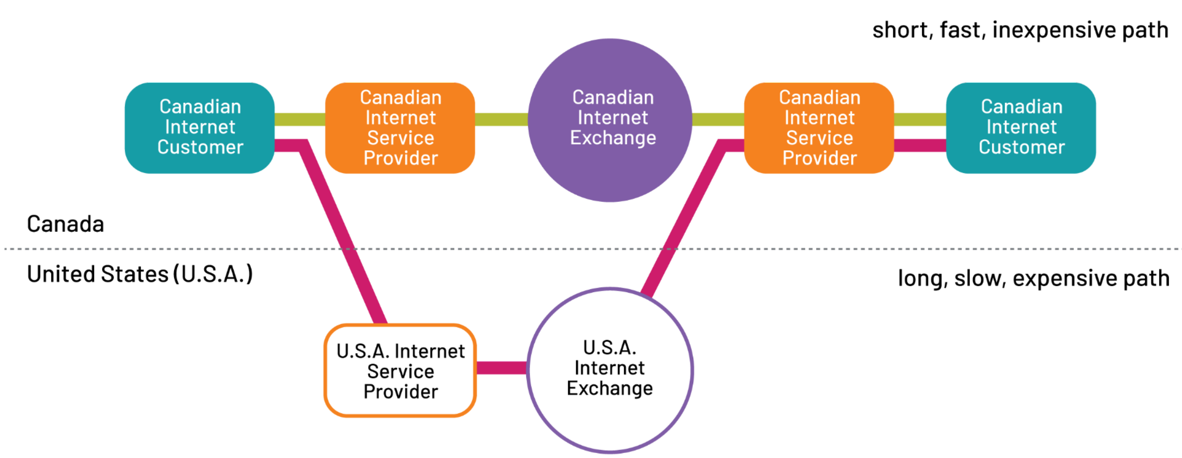


Figure 20. Aggregate total traffic of YEGIX in the week ending March 11, 2021[132].

The YEGIX traffic load over the 2020-21 year is quite disproportionate, with loads over 1 Gbps from June to December. This is not unusual, as the YEGIX Network Manager explained to this report author: "a simple change of route metric at a peer can steer a lot of traffic toward or away from the IX." This underscores the robustness to which IXPs must be scaled.

A connection to a local IXP may allow regional ISPs to transfer data without limit or cost, vastly improving the connection speed between customers of two adjacent ISPs. A direct interconnection also avoids the need for data to travel through other cities or continents in order to move from one network to another, thus reducing latency and keeping local traffic local (Figure 21).



[132] YEGIX. Graphs, 11 March 2021. Accessed 11 March 2021.

Figure 21. The network paths to connect two Canadian internet customers through a Canadian IX (green) and an American IX (pink).

According to Packet Clearing House, "a strong domestic Internet Exchange Point is the first and most critical component of a cyberwarfare defense[133]." This is because countries without an IX are heavily dependent on international data circuits for their domestic connectivity. In the case of the 2007 cyberattacks on Estonia, denial-of-service attacks were halted at the country's IX, which meant they had minimal impact on domestic internet traffic.

In 2014, the Internet Society created a Mutually Agreed Norms for Routing Security (MANRS) initiative to bring basic security to internet routing. There were three primary issues to resolve: route hijacking, IP address spoofing, and route leaks. In 2017 alone, there were 14,000 internet routing issues. In 2018, the Internet Society expanded MANRS to include IXPs, to further strengthen security for global routes[134].

The benefits of peering to an IX for governments include network resiliency. If a government's ISP is taken offline by a denial-of-service attack, the government can lose contact with its citizenry. However, if its ISP peers at an IXP, its services will remain available by virtue of the connections to other ISPs.

The Government of Alberta required Bell to enable a peering point at Alberta's IXPs for the use of SuperNet customers, should they request it, within the most recent SuperNet contract (signed in July 2018).

Low Earth Orbit satellites (LEOs)

Globally, a majority of the Earth's population still lives further than 25 km from fibre optic network infrastructure[135]. This physical isolation from wireline network infrastructure, combined with low population density and topographical remoteness, all contribute to the unique challenges of connecting rural and remote communities.

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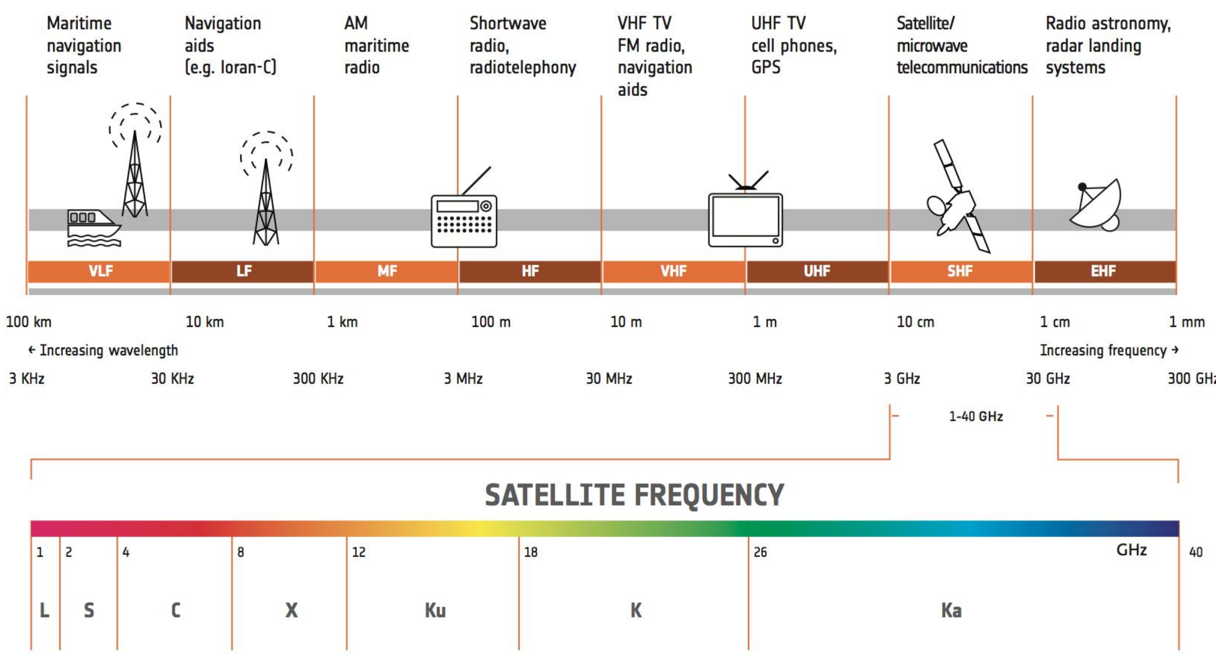
[133] Stapleton-Gray, R. and Woodcock, B (Packet Clearing House). ACM Queue. National Internet Defense—Small States on the Skirmish Line, 19 January 2011. Accessed 11 March 2021.
[134] Security Week. Internet Society Calls on IXPs to Help Solve Internet Routing Problems. 23 April 2018. Accessed 11 March 2021.
[135] ITU/UNESCO Broadband Commission for Sustainable Development. The State of Broadband 2019. Pg. 7. Accessed 10 June 2021.

In Canada, roughly 20% of the population lives in census-defined rural areas[136]. Over the last few decades, these communities have experienced significant economic diversification. Many rural residents no longer make their livelihood from agricultural or natural-resource production, and now require access to modern high-speed internet for educational and employment opportunities. Because of this, broadband advocates have looked to emerging technologies, such as Low Earth Orbit (LEO) satellites, as a solution to the last mile problem for people in rural and remote regions.

Background

Communications satellites that provide internet services can be deployed in one of three orbit ranges above the Earth's surface — as measured from the equator — and in one of three satellite spectrum bands: C(4-8 GHz)-, Ku(12-18 GHz)- and Ka(26.5-40 GHz)-band[137] (Figure 22).



[136] Hambly, H. and Rajabiun, R, (Telematics and Informatics), Rural broadband: Gaps, maps and challenges. June 2021.
[137] CRTC. Satellite Inquiry Report (2014). Accessed 18 May 2016.

Figure 22. A Comparison of frequency bands and their corresponding applications[138].

Geostationary or geosynchronous orbit satellites

Geostationary or geosynchronous orbit (GSO) satellites are positioned > ~35,000 km above the surface of the Earth, as measured from the equator. These satellites include the Anik series launched by Telesat between 1972-2013[139]. Currently, GSO communications satellites provide the majority of satellite internet services to Canadian users, through service providers such as Xplornet. These satellites typically provide long-term coverage over a large area by moving at the same angular velocity as the rotation of the Earth.

The costs associated with sending a satellite into GSO are high (> $100 million). As one example, the estimated costs for ViaSat's ViaSat2 Ka-band satellite system were $625 million[140], when factoring in the build, launch, insurance, and ground infrastructure.

In general, GSO satellite launches have a smaller payload capacity and require more propellant (leading to more mass) to reach orbit. This leads to higher costs per satellite, per launch, compared to lower Earth orbit destinations. The GSO satellites are typically large (> 1,000 kg in mass, e.g. ViaSat-2 is 6,400 kg)[141], and have long (planned) life spans (e.g. > 10 years). For communications purposes, they carry technologies that enable large coverage areas and bandwidth (ViaSat-2's bandwidth capabilities are estimated at 350 Gbps[142]).

This technology allows satellite-based internet providers to serve a large number of consumers at higher bandwidth, with a single satellite. However, due to their high orbit, data transmission times from GSO satellites experience a path latency in excess of ~230 milliseconds. Although the data packets are being transmitted at a relatively fast rate, because they are transmitted over time, the larger latency often leads to a delayed distribution of network data, which can impact webpage load times.

Low Earth Orbit satellites

Low Earth orbit (LEO) satellites are deployed between ~400 and 2,000 km above the surface of the Earth. At this altitude, LEO satellites deployed for broadband communications purposes experience a significant advantage with respect to round-trip (~3 milliseconds) and inter-satellite

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[138] European Space Agency. Satellite Frequency Bands. Accessed 24 June 2021.
[139] Telesat. Our Fleet (2016). Accessed 18 May 2016.
[140] Peter B. de Selding. ViaSat-2's 'First of its Kind' Design Will Enable Broad Geographic Reach. Space News. 17 May 2013. Accessed 10 June 2016.
[141] Gunter Krebs. ViaSat2. Gunter's Space Page. 17 April 2016. Accessed 10 June 2016.
[142] Space News. ViaSat-2's 'First of its Kind' Design Will Enable Broad Geographic Reach, 17 May 2013. Accessed 10 June, 2016.

latency, compared to GSO satellites. The LEO satellite constellations also offer increased performance due to advanced modulation schemes, multi-beam antennas, and more sophisticated frequency reuse schemes[143].

The primary disadvantages of being deployed in LEO include experiencing some atmospheric drag leading to loss of orbit, and shorter life spans of the satellites. Also, due to their high apparent angular velocity, LEO satellites have a smaller "dwell" time (in which the object is visible to one part of the Earth). In order to overcome these challenges, satellite operators are required to use a constellation of satellites (with multiple orbits that differ with respect to location and time) to provide global coverage and visibility.

Modern LEO satellite internet proposals were first publicly discussed in 2014. Earlier LEO projects from companies such as Iridium and Globalstar had previously been proposed in the 1990's[144]. These earlier projects failed largely due to the prohibitive manufacturing and launch costs of satellite technology at the time.

Over the past three decades, advances in satellite technology (e.g. smaller size and mass, antennae technology, and configurable radio-frequency payload systems) and practices (i.e. mass production, multiple-payload launches and reusability) have significantly reduced satellite production and launch costs. This has resulted in an increased interest in the possibility of LEO satellites to provide affordable, high-speed and low-latency internet to the Earth's most remote and unconnected regions. The throughput promised also far exceeds that which can be provided by any realistically deployable network infrastructure.

Due to this, the period from 2018-2021 saw an explosion of satellite broadband providers launching satellites into low Earth orbit, with the most advanced of these moving shortly afterwards to beta testing.

At the time of writing, the three LEO constellations at the most advanced stage of development are SpaceX's proposed 4,425 Starlink constellation in the Ku-Ka band, OneWeb's 720 satellite system in the Ku-Ka band and Telesat's 298 satellite Lightspeed constellation in the Ka band[145]. Of these three companies, SpaceX moved to the beta testing stage in October 2020, while Canadian provider Telesat has set the second half of 2023 as its target for launching commercial services[146, 147]. After a

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[143] De Portillo, et al. Technical Comparison of Three Low Earth Orbit Satellite Constellation Systems to Provide Global Broadband, MIT (2019).
[144] Mckinsey. Large LEO Constellations: Will it be different this time?
[145] De Portillo, et al. Technical Comparison of Three Low Earth Orbit Satellite Constellation Systems to Provide Global Broadband, MIT (2019).
[146] Michael Sheetz. Space Starlink service priced at $99 a month. CNBC, 27 October 2020.
[147] Caleb Henry. Telesat preparing for mid-2020 constellation manufacturer selection, Space News, 01 May 2020.

period of difficulties in securing financing, including a bankruptcy filing in March 2020, OneWeb (now owned by a consortium that includes the UK government) has operated a consistent launch schedule, launching its 200th satellite in May 2021. OneWeb expects to launch global commercial services by 2022[148].

Currently, LEO broadband services are advertised to provide significantly higher download and upload speeds relative to comparably priced wireline plans. In a filing with the US Federal Communications Commission, SpaceX claimed it can currently deliver 100 Mbps download speeds and 20 Mbps upload speed on its existing LEO network, at a cost of $129 CAD per month (in addition to a one-time $649 CAD hardware and installation cost)[149]. Once fully deployed, its goal is to offer download speeds of up to 10 Gbps.

While LEO providers all operate on the same basic hardware, business strategies and orbital arrangements vary widely between them. OneWeb plans to partner with telecommunications providers to offer its services, while Telesat's initial focus has been on the non-consumer market, including the government and defense sectors, as well as providers of specialized services[150].

In March 2019, Telesat signed its first major contract to provide LEO satellite capacity to OmniAccess, a connectivity solutions provider for specialty maritime vessels[151]. Conversely, SpaceX has thus far focused largely on serving residential end-users, shipping its own user terminals to subscribers on a direct-to-consumer model.

These differences in business models and technologies mean different ground systems arrangements are required to aggregate and relay the satellite signals at the community level. The location and number of ground stations and gateway antennas will play a significant role in total system throughput and geographic service area.

It is estimated that SpaceX's Starlink constellation will require 123 ground stations and 3,500 gateway antennas to reach maximum throughput globally[152]. It is important to note that, currently, the geographic reach of SpaceX's Starlink service is limited to below the Earth's 55th parallel, above which the company has little ground segment infrastructure and has yet to deploy polar orbiting satellites. The figure below shows a segment of Starlink's physical infrastructure on and above North America (the white dots represent orbiting satellites, while the orange icons show the

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[148] Jonathan Amos. OneWeb sends up 36 broadband internet satellites, BBC, 25 March 2021.
[149] Federal Communications Commission. Petition Of Starlink Services, LLC For Designation as an Eligible Telecommunications Carrier, 04 January 2021.
[150] Jonathan Amos. OneWeb satellite internet company is officially reborn. BBC, 20 November 2020.
[151] Telesat. OmniAccess Signs Major Contract for Broadband Service on Telesat's New LEO Satellite Constellation, 13 March 2019.
[152] Mckinsey. Large LEO Constellations: Will it be different this time? 04 May 2020.

location of ground-based gateway antennas). This demonstrates the interrelation of ground and terrestrial infrastructure in determining service area.

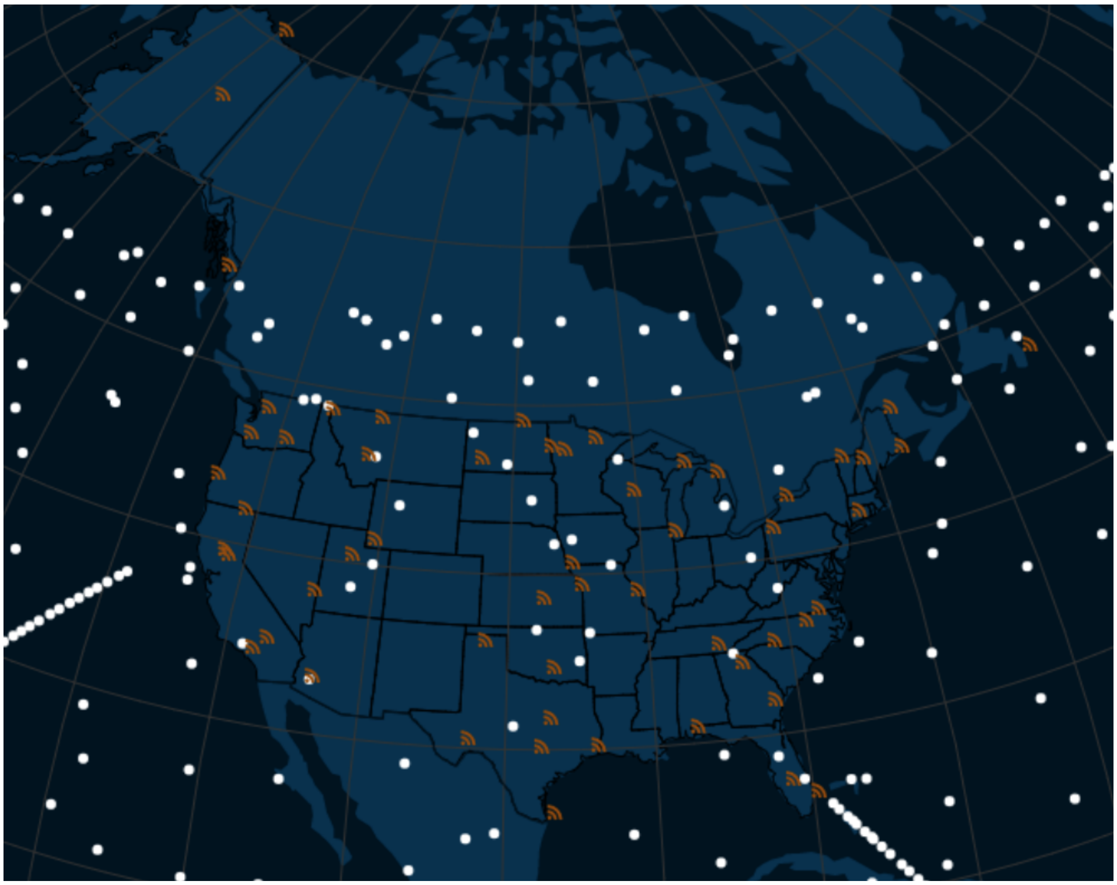

Figure 23. A user-generated map using public satellite data shows a segment of the Starlink network. The white dots represent orbiting satellites, while the orange icons show the location of gateway antennas[153].

Telesat will make use of optical intersatellite linking, whereby satellites within a constellation are able to relay data to each other and not solely to individual points on the ground. This system, which is in effect a terrestrial mesh network, will allow any user to connect to Telesat's constellation from anywhere on Earth without needing a direct line of sight. This significantly reduces the need for ground systems infrastructure. Telesat plans to build 30 ground stations worldwide to service its network[154].

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[153] Live Starlink Satellite Map. Accessed 15 June 2021.
[154] MIchael Sheetz. Telesat to build a $5 billion global satellite network to bring fiber-like internet to businesses. CNBC. 09 February 2021.

Because OneWeb will not utilize optical intersatellite linking, subscribers will need to have direct line of sight to both a ground station and an orbiting satellite. In contrast to both Telesat and SpaceX, OneWeb's constellation will comprise 18 orbital planes, each made up of up to 40 satellites orbiting longitudinally, or "pole-to-pole", across the globe[155].The orientation of these planes and the footprint of each of the constellation's satellites will ensure that users are always within the field of view of at least one satellite at any given time[156]. The segment of OneWeb's existing partial constellation is shown below, with the white dots representing orbiting satellites.

Figure 24. A segment of OneWeb's existing network showing its longitudinal orbit planes[157].

There is significant interest and potential to provide affordable and reliable internet service to remote and rural communities via satellite technologies. In Alberta, the SuperNet could play a key role in supporting satellite internet by giving ISPs wholesale access to middle-mile infrastructure

[155] De Portillo, et al. Technical Comparison of Three Low Earth Orbit Satellite Constellation Systems to Provide Global Broadband, MIT (2019).
[156] Federal Communications Commission. ONEWEB NON-GEOSTATIONARY SATELLITE SYSTEM (LEO). 26 May 2020.
[157] Live Starlink Satellite Map. Accessed 09 June 2021.

to link upstream internet sources with terrestrial-based satellite gateways. Similarly, throughout the rest of Canada, affordable wholesale access to long-range backhaul fibre networks that are fed by satellite technologies will be critical to providing economical high-speed broadband services to consumers in rural and remote communities.

Changes in the policy and regulatory landscape

Universal Broadband Fund

In its 2019 Budget, the federal government committed to the creation of a national connectivity strategy, in conjunction with additional funding for broadband projects in Canada. As well as topping up a number of existing broadband funding initiatives, including the Connect to Innovate program and the CRTC's Broadband Fund, the *High-Speed Access for All: Canada's Connectivity Strategy* also created the Universal Broadband Fund, with an initial investment of $1.75 billion over six years[158]. In subsequent federal budgets, investments in the Universal Broadband Fund were increased to $2.75 billion. The strategy also set the goal of achieving 98% access to 50 Mbps download / 10 Mbps upload in Canada by 2026, and 100% by 2030.

Eligibility for the Universal Broadband Fund is determined using the National Broadband Internet Service Availability Map[159]. Any project existing within a 250 m road segment that does not have access to 50/10 Mbps internet is deemed eligible for UBF funding — provided the project delivers a minimum 50/10 Mbps connection speed and provides open access to Points of Presence. As of June 2021, Alberta has received $5,303,762 in funding for broadband projects from the Universal Broadband Fund, serving a total of 12,259 households[160].

CRTC Broadband Fund

In Telecom Regulatory Policy CRTC 2016-496, the CRTC first expressed its intention to create a funding mechanism to support broadband infrastructure projects in Canada[161]. Through a number of subsequent public proceedings, the CRTC established parameters around its Broadband Fund — an investment of $750 million over five years in broadband infrastructure projects throughout Canada.

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[158] Government of Canada. High-Speed Access for All: Canada's Connectivity Strategy. Accessed 15 June 2021.
[159] ISED. National Broadband Internet Service Availability Map. Accessed 15 June 2021.
[160] Government of Canada. Selected Universal Broadband Fund Projects. Accessed 16 June 2021.
[161] CRTC. Telecom Regulatory Policy CRTC 2016-496. Accessed 15 June 2021.

Money for the fund is not drawn from general tax revenue, but is redirected from funds previously collected from incumbent projects by the CRTC to subsidize telephone services in remote and rural areas. Eligible projects include Transport, Access or Mobile Wireless initiatives existing in an area deemed "underserved" by ISED's National Broadband Internet Service Availability Map, which uses a hexagon system. Underserved, in this context, means any 25 km^2 hexagon that does not have access to 50/10 Mbps for any household.

The first call for applications to the CRTC Broadband Fund was announced in June 2019 for eligible projects in Canada's North, with eligibility opened up to all areas of Canada in March 2020. As of June 2021, no projects in Alberta have received funding through the CRTC Broadband Fund[162].

CRTC Wholesale Rates Regulations

From 2015-2021, the CRTC initiated a number of impactful proceedings with respect to wholesale rate regulation in Canada. Historically, the CRTC has applied an "essentiality test" to infrastructure owned by facilities-based carriers. Where telecommunications firms own "bottleneck facilities" that are not easily or practically duplicable by competitors, but are otherwise required as an input to provide telecommunications services, the CRTC mandates that wholesale providers be given access to these networks in order to deliver internet services, thereby fostering competition in the telecommunications market[163].

Whereas large DSL and cable providers have been required to share their copper and coaxial cable networks through wholesale and Third Party ISP Access (TPIA) arrangements since the 1990s, incumbents have been required to do the same with fibre optic access networks or "fibre-to-the-home" networks since 2015[164].

Between 2016-2019, the CRTC undertook an extensive proceeding to investigate the reasonableness of its costing framework with respect to wholesale rates. The proceeding was spurred by filings by wholesale providers claiming the existing pricing framework allowed incumbent carriers to unjustly overcharge them for network access, thereby significantly increasing the fees they had to charge their customers.

The CRTC accepted this reasoning in 2019 and significantly lowered wholesale access rates (by as much as 89% in some cases) and mandated incumbent carriers to repay wholesale providers all overcharged rates retroactive to 2016[165]. In response, incumbent carriers Bell and Rogers filed an

[162] CRTC. Broadband Fund Projects Selected for Funding. Accessed 15 June 2021.
[163] CRTC. Telecom Decision CRTC 2008-17. 03 March 2008.
[164] CRTC. Telecom Regulatory Policy CRTC 2015-326. 22 July 2015.
[165] CRTC. Telecom Order CRTC 2019-288. 15 August 2019.

appeal with the CRTC, in conjunction with initiating court proceedings to appeal the rate-setting decision[166].

Following a stay order of its 2019 decision while it investigated Bell's appeal, in May 2021, the CRTC reversed its previous determination on overcharged wholesale rates and significantly raised rates on wholesalers. Met with widespread derision by wholesale providers and broadband advocates, the decision led to immediate price increases and suspensions of services by a number of wholesale providers.

At the time of writing, wholesale provider Teksavvy had petitioned the federal Minister of Innovation, Science and Industry to have the CRTC's May 2021 rate increase overturned[167].

CRTC Regulatory Policy 2016-496: Universal Service Objective

On December 14, 2016, the CRTC released *CRTC Regulatory Policy 2016-496* establishing the Universal Service Objective, which set an internet connection of at least 50 mbps download speed and 10 mbps upload speed, with unlimited data allowance, as a target for both residences and businesses across Canada[168]. In addition, the decision set fixed and mobile wireless broadband internet and fixed mobile wireless voice services as "basic telecommunications services." The regulatory policy has been significant in formalizing the CRTC's shift in focus towards high-speed internet access.

In addition, the Universal Service Objective of "50/10" has served as the eligibility basis for all significant broadband infrastructure funding initiatives since 2016, including the Universal Broadband Fund and the CRTC's Broadband Fund, and for the federal government's long term innovation agenda more broadly.

Other infrastructure owners

Starting in the 2010s, rural communities began looking for less traditional, more cost-effective ways to get broadband services to their communities. Several of their ideas are outline below,

[166] The Canadian Press. Bell petitions Trudeau government to overrule CRTC on wholesale network rates. 13 November 2019.
[167] TekSavvy. TekSavvy Petitions Federal Cabinet to Overrule CRTC's Arbitrary Rate Decision. 28 May 2021.
[168] CRTC. Telecom Regulatory Policy CRTC 2016-496. 21 December 2016.

including opportunities to coordinate connectivity projects utilizing transportation and infrastructure corridors in Alberta:

Electricity transmission towers

Transmission tower fibre optics, or optical ground wire (OPGW), is located at the topmost position in the high-voltage power transmission structures that are distributed throughout Alberta. This wire is positioned to take advantage of an electric utility's transmission right-of-way to transport large amounts of data.

Optical ground wire generally serves two main purposes:

1. Protects electrical infrastructure by grounding lightning strikes and fault currents, and
2. Carries optical signals for the protection and management of the transmission line.

The data capacity of the OPGW in almost all cases greatly exceeds the needs of the transmission facility operators, leaving room for others to make use of the utility as a high-speed fibre connection.

Canadian Pacific Railway and Canadian National Railway

Fibre optic cables traverse existing rail rights-of-way. Rail lines are well suited for housing fibre backbones, as the corridors and associated rights of way are owned by a single entity.

Petroleum and natural gas pipelines

Modern pipelines often employ fibre-optic monitoring systems along the length of the pipeline corridor. Like rail lines, pipeline corridors are well suited to hosting fibre backbones, as the long-range rights-of-way are already negotiated.

Community & Volunteer Initiatives

In the UK, several rural communities have championed broadband initiatives by leveraging support from a collective of volunteers, landowners, farmers, private investors, and government funding sources. These projects include Tove Valley Broadband, Broadband for the Rural North Ltd (B4RN) and Fibre for Rural Nottinghamshire (F4RN). The initiatives are dependent on wayleave agreements between the broadband organization and the farmer/landowner to enable work to be carried out on their privately owned land. This includes access approval for network installation, maintenance and repair.

Volunteers from the community help with the administration of the project, recruitment of landowners, and even the physical labour involved (including digging trenches and laying duct work on the properties). Investor funding for the projects is raised by selling shares in the company (e.g. B4RN, F4RN). Shares are also offered as compensation to landowners[169].

This innovative use of community and funding resources has considerably reduced the cost of fibre deployments in these areas. For example, B4RN was able to complete its network for a total of £2.7 million through a mixture of purchased shares (£1.4 M), loans (£1.3 M) and volunteer effort. This represents savings of £800,000 compared to the estimated commercial cost to deploy the fibre network.

A similar strategy of leveraging local volunteer capacity and farmer / landowner involvement could be considered for rural Alberta, to reduce the costs of deploying rural broadband networks.

Progress to date

Many of the opportunities outlined above looked promising in the early 2010s as lower cost solutions, but none have yet been acted on in Alberta. There are several factors that have hindered this progress:

1. **New SuperNet contract.**
   The Alberta SuperNet contract was initially due to expire in 2015, and a new contract may have been able to include new opportunities for rural broadband. The contract was subsequently extended to 2018. With the 2018 Bell contract for SuperNet, there are new opportunities that need to be explored for rural solutions.

2. **Government of Alberta Provincial Broadband Strategy.**
   In line with a new SuperNet contract, there have, for years, been hints of a broadband strategy being developed by the provincial government that could assist rural Alberta with new opportunities, possibly aligned with the SuperNet. This strategy has yet to be rolled out.

3. **Low Earth Orbit satellite internet service solutions.**
   A promising solution that was first discussed in the mid-2010s, it is only now (2021) starting to provide services to Albertans.

4. **Other government initiatives.**
   As described in the Municipal/Community Networks section of this report, some local and regional governments have implemented more traditional solutions by paying for their own

[169] B4RN. Broadband for Rural North Ltd. Accessed 14 March 2021.

infrastructure for new network builds: either fibre, fixed wireless, or both. Several federal grant programs have helped to fund some of these initiatives.

5. **Additional rural fibre capacity.**
   New mobility services have required service providers to roll out vast quantities of new fibre-optic builds throughout Alberta to enable LTE and now 5G mobile services. These may have helped enable new municipal FTTH solutions, such as those being provided by TELUS (and formerly Axia) to numerous smaller municipalities.

IPv6

An Internet Protocol (IP) is the communications protocol system used to identify and locate computers or devices on networks, and thereby route traffic across the internet. When the global internet was first designed in 1973, IPv4 (Internet Protocol version 4) became the underlying protocol. However, the internet's founders did not anticipate the explosion of users and devices connected to the world wide web. The address space allocation of IPv4 — similar to telephone numbers — is sufficient for only 4.3 billion termination points on the internet. Its store of 32-bit addresses was never intended to facilitate the formation of the global commercial internet as it exists today.

As a result of the expansion of the global internet, and the increase in connected computers and devices, the IPv4 address pool was essentially depleted by November 2019, with only Africa's Regional Internet Registry (RIR) having a few /22 address spaces left. This has resulted in an IPv4 address transfer market, where organizations with an excess of IPv4 resources can either return them to the RIR or sell them to another organization that qualifies for resources under an RIR policy. When ISPs run out of viable IPv4 addresses, an ISP may not be able to give individual subscribers their own IPv4 address. Instead, to conserve resources, they may opt to put customers behind Carrier Grade Network Address Translation (CGN, NAT).

Engineers began to recognize that IPv4 depletion would become a problem in the early 1990s, and developed the next generation protocol, IPv6, which supports 340,000,000,000,000,000,000,000,000,000,000,000,000 or 340 trillion trillion trillion addresses. IPv6 was formally adopted by the Internet Engineering Task Force in 1998. This new protocol is comprised of unique, 128-bit addresses (as opposed to IPv4's 32-bit addresses), and can therefore accommodate an exponential growth of connected computers.

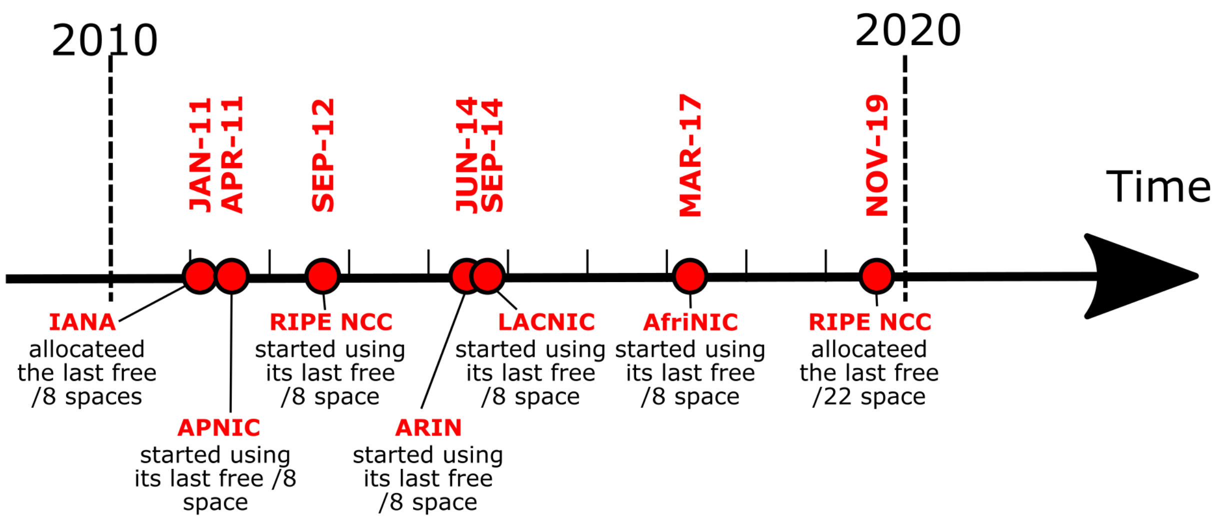

Figure 25. IPv4 Exhaustion in IANA and the RIRs. Source:Michel Bakni - IANA, APNIC, RIPE-1 RIPE-2 LACNIC, ARIN and AfriNIC., CC BY-SA 4.0[170].

While IPv6 has existed as a protocol for more than 20 years, uptake has been slow. Because the majority of the internet continues to be accessible via IPv4 only, IPv6 must coexist side-by-side with the fully functional IPv4 public internet. This "dual stack" architecture will continue to be necessary into the foreseeable future, until such a time that IPv6 becomes the default standard.

"Tunneling" is one method that allows IPv4 and IPv6 to coexist. When two systems on the edge of a network support IPv6, but the routers on the public internet between them do not, IPv6 packets can be put inside IPv4 packets, and "tunneled." Additionally, IPv6 packets can be translated into IPv4 packets utilizing NAT64 — a Network Address Translation technique.

Without the expansion of IPv6, and eventual replacement of IPv4, the evolution of the internet — including the expansion of the Internet of Things (IoT), the "industrial internet" and sensor networks — will be limited by the resource and network management constraints of IPv4. The sheer quantity of devices projected to come online cannot be supported by IPv4. The future of internet connected devices and sensor networks relies on the transition to IPv6.

Google collects and publishes statistics on IPv6 adoption rates based on the percentage of users accessing Google with an IPv6 connection. According to its statistics, Canada has adopted IPv6 at a rate of 30.13%, whereas the United States has adopted IPv6 at a rate of 44.87%[171].

[170] Wikimedia. IPv4 IANA and RIR exhaustion time line - Wikimedia Commons. Accessed 13 March 2021.
[171] Google. IPv6 Statistics, North America. Accessed 13 March 2021.

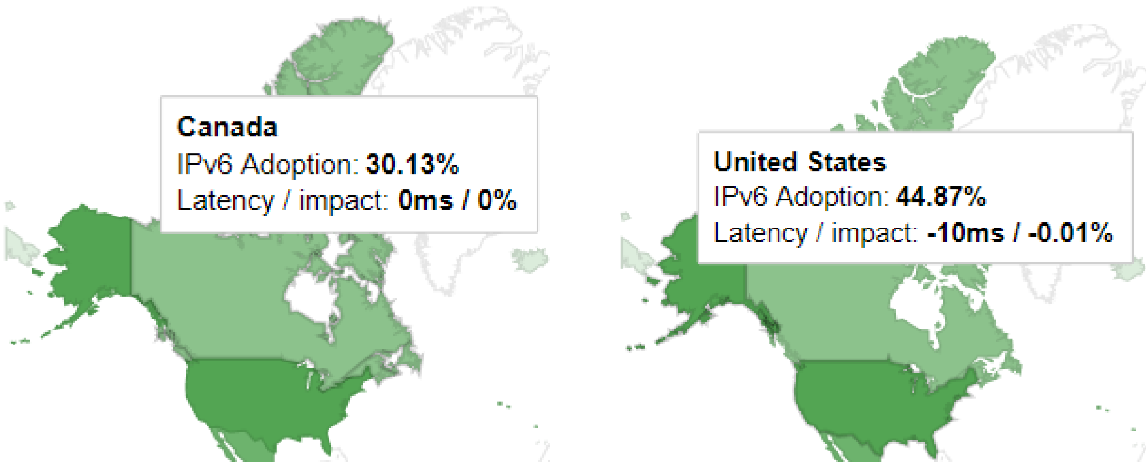

Figure 26. IPv6 adoption in Canada and the US based on accessing Google via an IPv6 connection, as of March 13, 2021[172].

Akamai shows Canada at 27.3%, but also shows significant growth in the country since 2015. It ranks Canada as 25th in the world in terms of IPv6 adoption.

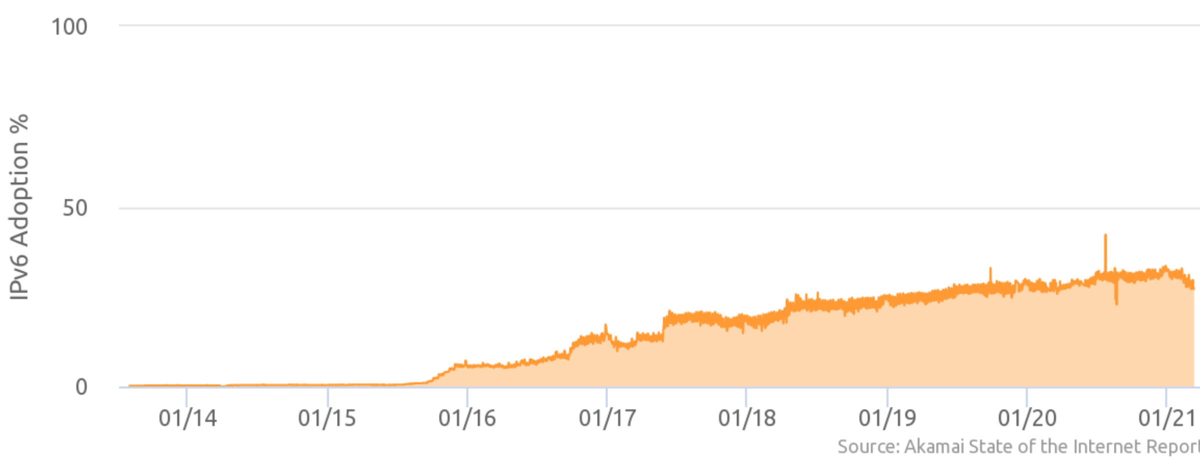

Figure 27. IPv6 adoption in Canada based on Akamai (a content delivery network and edge server provider), as of March 13, 2021[173].

The incredible proliferation of mobile IP devices, including IoT devices, has likely forced ISPs into IPv6. An example of the movement to IPv6 when working with massive IoT type devices took place

[172] Google. IPv6 Adoption Statistics. Accessed 13 July 2016.
[173] Akamai. State of the Internet IPv6 Adoption Visualization | Akamai. Accessed 13 March 2021.

in British Columbia in 2014. B.C. Hydro implemented a network with nearly 2 million gas meters. Using an IPv6 based network seriously reduced the complexity in rolling out that solution[174].

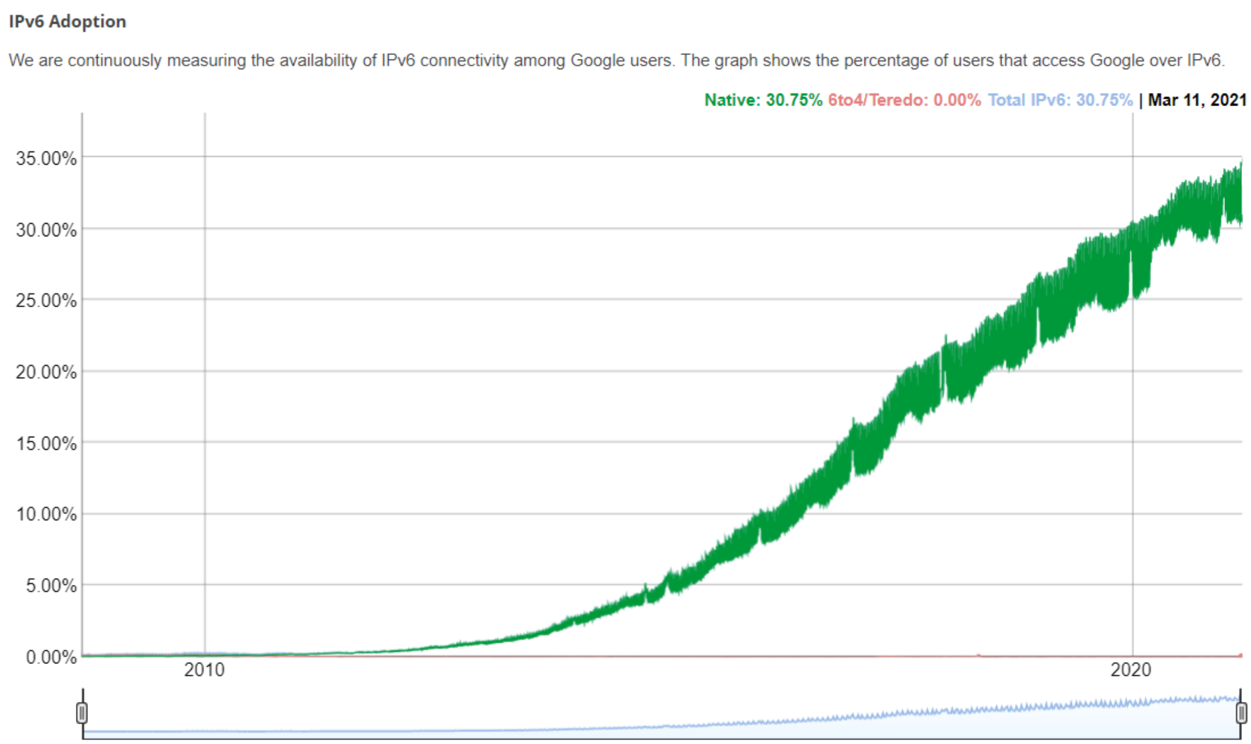

Figure 28. Global IPv6 adoption over time based on accessing Google via an IPv6 connection, as of March 11, 2021[175].

The Internet Society measures and reports elements of global IPv6 deployment via the World IPv6 Launch website. Of the 255 networks monitored, Rogers Communications is ranked 19th overall in IPv6 traffic, with over 75% IPv6 deployment on its network. TELUS is close behind at 22nd overall and over 59% deployment on its network. Bell, the operator of SuperNet, is well behind at 65th overall and a mere 9.73% IPv6 deployment on its network[176].

As stated earlier, the implementation of NAT significantly decreased the pressure to move to IPv6. As such, there has been a gradual but steady increase in IPv6 implementation in Alberta and across Canada. Of note, the Government of Alberta did require Bell to enable IPv6 on SuperNet so that public sector organizations can make the move when they are ready.

[174] Cisco. BC Hydro, Cisco and Itron - a Powerhouse in Canada - Cisco Blogs. 24 June 2014.
[175] Google. IPv6 Adoption Statistics. Accessed 13 March 2021.
[176] Internet Society. World IPv6 Launch Measurements. Accessed 13 March 2021.

Future Needs and Opportunities

In 2016, the CRTC declared broadband internet to be a basic telecommunications service in Canada[177]. This is analogous to other countries that declared the internet a basic human right, starting with Estonia in 2000. Indeed, Alberta began development of the Alberta SuperNet that same year, in part to improve internet access for all Albertans. Twenty years later, the need for ubiquitous broadband internet was amplified by the global lockdowns imposed by the COVID-19 pandemic[178].

According to Cloudflare, countries like the U.S., Canada, Australia, and Brazil experienced jumps in network usage of 40-50% after the rise of the pandemic in 2020. As we move towards a post-pandemic world, it is likely that recent shifts in internet use for work and education will become permanent[179]. This puts those without adequate broadband services (as well as without adequate access to computing technologies) at a serious social and economic disadvantage.

[177] CBC. CRTC declares broadband internet access a basic service | CBC News. 22 December 2016.
[178] CBC. If a crisis like COVID-19 hasn't pushed government to take action to improve broadband access, what can? | CBC News. 23 August 2020.
[179] Forbes. Internet Service Providers Need To Prepare For The Post-Pandemic Era. 15 July 2020.

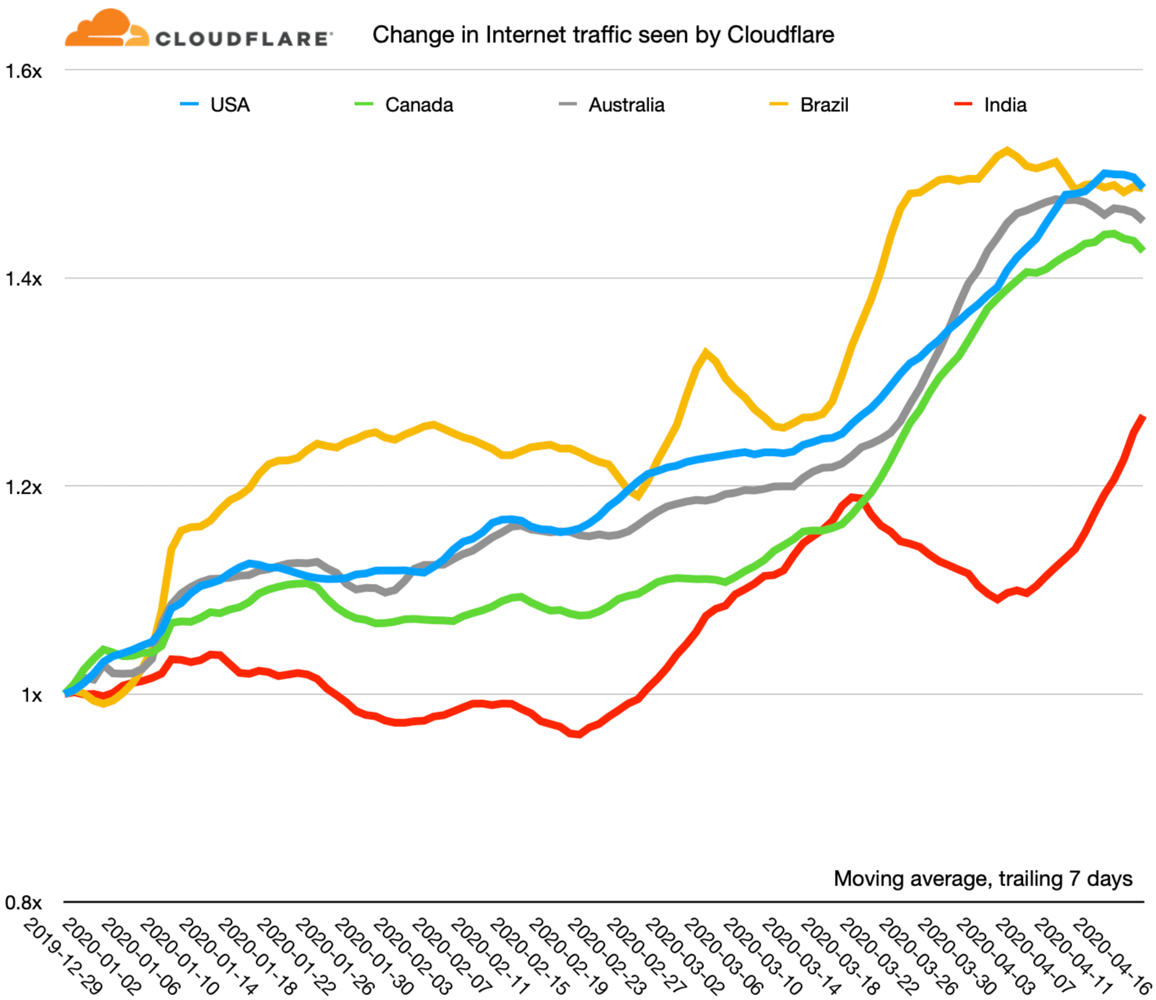

Figure 29. Change in internet traffic levels in the early days of the COVID-19 pandemic lockdown in 2020[180].

Conclusion

The future of Alberta's economy is data. And to grow this economy, Alberta needs to invest more strategically in its foundational infrastructure, specifically networking.To grow the economy, Alberta needs to start investing more strategically in its foundational networking infrastructure.

[180] Cloudflare. [Internet performance during the COVID-19 emergency (cloudflare.com)](). 23 April 2020.

There is an opportunity for Alberta to build a coordinated approach and framework to grow its digital infrastructure. We all share the responsibility in this effort, particularly if we hope to develop a knowledge-based economy supported by a comprehensive and sustainable digital infrastructure system. The information presented in this report provides a starting point. Strong leadership is required by all sectors to build and move forward with a clear and organized digital infrastructure agenda.

This report was developed by Cybera, Alberta's not-for-profit technology accelerator, with support from Erwin Loewen.

Appendix 1. Networking - SuperNet BAN Communities

List of the 27 Alberta SuperNet Base Area Network (BAN) communities. These communities all have access to internet download speeds of ≥ 5 Mbps.

SuperNet BAN Communities	Connection Type
Airdrie	Fibre Optic
Bonnyville	Fibre Optic
Brooks	Fibre Optic
Calgary	Fibre Optic
Camrose	Fibre Optic
Cold Lake	Fibre Optic
Drumheller	Fibre Optic
Edmonton	Fibre Optic
Fort McMurray	Fibre Optic
Grande Prairie	Fibre Optic
High River	Fibre Optic
Lacombe	Fibre Optic
Leduc	Fibre Optic
Lethbridge	Fibre Optic
Lloydminster	Fibre Optic
Medicine Hat	Fibre Optic
Red Deer	Fibre Optic
Sherwood Park	Fibre Optic
Spruce Grove	Fibre Optic
St. Albert	Fibre Optic
Stony Plain	Fibre Optic
Strathmore	Fibre Optic
Vegreville	Fibre Optic
Vermilion	Fibre Optic
Wainwright	Fibre Optic
Wetaskiwin	Fibre Optic
Whitecourt	Fibre Optic

Appendix 2. Networking - SuperNet EAN and EAWN Communities

List of the 402 Alberta SuperNet Extended Area (EAN) and Extended Wireless Area Network (EAWN) communities[181].

SuperNet EAN and EAWN Communities	Connection Type	SuperNet EAN and EAWN Communities	Connection Type
Acadia Valley	Fibre Optic	Jasper	Fibre Optic
Acme	Fibre Optic	Jenner	Wireless
Alberta Beach	Fibre Optic	John D'Or Prairie	Wireless
Alder Flats	Fibre Optic	Joussard	Fibre Optic
Alexander I.R. 134 (special areas 2, 3, 4)	Fibre Optic	Kathyrn	Fibre Optic
Alix	Fibre Optic	Keephills	Fibre Optic
Alliance	Fibre Optic	Keg River	Fibre Optic
Altario	Wireless	Kehewin I.R. 123	Fibre Optic
Amisk	Fibre Optic	Kikino	Wireless
Andrew	Fibre Optic	Killam	Fibre Optic
Anzac	Fibre Optic	Kingman	Fibre Optic
Ardmore	Fibre Optic	Kinuso	Fibre Optic
Ardrossan	Fibre Optic	Kitscoty	Fibre Optic
Arrowwood	Fibre Optic	La Crete	Fibre Optic
Ashmont	Fibre Optic	La Glace	Wireless
Athabasca	Fibre Optic	Lac La Biche	Fibre Optic
Atikameg	Fibre Optic	Lafond	Fibre Optic
Banff	Fibre Optic	Lake Louise	Fibre Optic
Barnwell	Fibre Optic	Lamont	Fibre Optic
Barons	Fibre Optic	Lancaster Park	Fibre Optic
Barrhead	Fibre Optic	Langdon	Fibre Optic
Bashaw	Fibre Optic	Legal	Fibre Optic
Bassano	Fibre Optic	Leslieville	Fibre Optic
Bawlf	Fibre Optic	Lindale	Fibre Optic
Bear Canyon	Wireless	Linden	Fibre Optic
Bearspaw	Fibre Optic	Little Buffalo	Fibre Optic
Beaumont	Fibre Optic	Lomond	Fibre Optic
Beaver Lake	Fibre Optic	Longview	Fibre Optic
Beaverlodge	Fibre Optic	Loon Lake	Fibre Optic
Beiseker	Fibre Optic	Lougheed	Fibre Optic
Bellevue	Fibre Optic	Lundbreck	Fibre Optic

[181] Industry Canada. Comments received on Telecom Decision CRTC 2008-01, 19 September 2008. Accessed 13 June 2016.

Bena lto	Fibre Optic	Magrath	Fibre Optic
Bentley	Fibre Optic	Mallaig	Fibre Optic
Berwyn	Fibre Optic	Ma-Me-O Beach	Fibre Optic
Bezanson	Fibre Optic	Manning	Fibre Optic
Big Valley	Fibre Optic	Mannville	Fibre Optic
Bind loss	Fibre Optic	Manyberries	Fibre Optic
Black Diamond	Fibre Optic	Marwayne	Fibre Optic
Blackfalds	Fibre Optic	Mayerthorpe	Fibre Optic
Blackie	Fibre Optic	Mclennan	Fibre Optic
Blairmore	Fibre Optic	Meander River	Fibre Optic
Blood I.R. 148	Fibre Optic	Mecca Glen	Fibre Optic
Blue Ridge	Fibre Optic	Medley	Fibre Optic
Bluffton	Fibre Optic	Milk River	Fibre Optic
Bodo	Wireless	Millarville	Fibre Optic
Bon Accord	Fibre Optic	Millet	Fibre Optic
Bonanza	Fibre Optic	Milo	Fibre Optic
Botha	Fibre Optic	Mirror	Fibre Optic
Bow Island	Fibre Optic	Monarch	Fibre Optic
Bowden	Fibre Optic	Morinville	Fibre Optic
Boyle	Fibre Optic	Morley	Fibre Optic
Bragg Creek	Fibre Optic	Morrin	Fibre Optic
Brant	Fibre Optic	Mountain View	Fibre Optic
Breton	Fibre Optic	Mundare	Fibre Optic
Brocket	Fibre Optic	Myrnam	Fibre Optic
Brownfield	Wireless	Namao	Fibre Optic
Brownvale	Fibre Optic	Nampa	Fibre Optic
Bruce	Fibre Optic	Nanton	Fibre Optic
Bruderheim	Fibre Optic	Neerlandia	Wireless
Buck Lake	Fibre Optic	New Brigden	Wireless
Buffalo Head Prairie	Fibre Optic	New Norway	Fibre Optic
Buffalo Lake	Fibre Optic	New Sarepta	Fibre Optic
Burdett	Fibre Optic	Newbrook	Fibre Optic
Busby	Fibre Optic	Nisku	Fibre Optic
Byemoor	Wireless	Niton Junction	Fibre Optic
Cadogan	Fibre Optic	Nobleford	Fibre Optic
Cadotte Lake	Fibre Optic	Nordegg	Wireless
Calling Lake	Wireless	O'Chiese I.R. 203	Wireless
Calmar	Fibre Optic	Okotoks	Fibre Optic
Canmore	Fibre Optic	Olds	Fibre Optic
Carbon	Fibre Optic	Onoway	Fibre Optic

Cardston	Fibre Optic	Oyen	Fibre Optic
Carmangay	Fibre Optic	Paddle Prairie	Fibre Optic
Caroline	Fibre Optic	Paradise Valley	Fibre Optic
Carse land	Fibre Optic	Peace River	Fibre Optic
Carstairs	Fibre Optic	Peavine	Wireless
Casian	Fibre Optic	Peerless Lake	Fibre Optic
Castor	Fibre Optic	Peers	Fibre Optic
Cayley	Fibre Optic	Pen hold	Fibre Optic
Cereal	Fibre Optic	Picture Butte	Fibre Optic
Gessford	Fibre Optic	Pincher Creek	Fibre Optic
Champion	Fibre Optic	Pipestone	Fibre Optic
Chard	Fibre Optic	Plamondon	Fibre Optic
Chateh	Fibre Optic	Ponoka	Fibre Optic
Chauvin	Fibre Optic	Provost	Fibre Optic
Chestermere	Fibre Optic	Radway	Fibre Optic
Chipewyan Lake	Wireless	Rainbow Lake	Fibre Optic
Chipman	Fibre Optic	Rainier	Fibre Optic
Clandonald	Fibre Optic	Ralston	Fibre Optic
Claresholm	Fibre Optic	Raymond	Fibre Optic
Cleardale	Wireless	Red Deer	Fibre Optic
Clive	Fibre Optic	Red Earth Creek	Fibre Optic
Clyde	Fibre Optic	Redcliff	Fibre Optic
Coaldale	Fibre Optic	Rich Valley	Wireless
Coalhurst	Fibre Optic	Rimbey	Fibre Optic
Cochrane	Fibre Optic	Riviere Qui Barre	Fibre Optic
Cold Lake I.R. 149	Fibre Optic	Rochester	Fibre Optic
Coleman	Fibre Optic	Rocky Lane	Fibre Optic
College Heights	Fibre Optic	Rocky Mountain House	Fibre Optic
Condor	Fibre Optic	Rockyford	Fibre Optic
Conklin	Fibre Optic	Rolling Hills	Fibre Optic
Conrich	Fibre Optic	Rosalind	Fibre Optic
Consort	Fibre Optic	Rosemary	Fibre Optic
Coronation	Fibre Optic	Round Hill	Fibre Optic
Coutts	Fibre Optic	Rumsey	Fibre Optic
Cremona	Fibre Optic	Rycroft	Fibre Optic
Crestomere	Fibre Optic	Ryley	Fibre Optic
Crooked Creek	Fibre Optic	Saddle Lake	Fibre Optic
Crossfield	Fibre Optic	Sandy Lake	Wireless
Crowsnest Pass	Fibre Optic	Sangudo	Fibre Optic
Czar	Fibre Optic	Schuler	Fibre Optic

Dapp	Fibre Optic	Seba Beach	Fibre Optic
Darwell	Fibre Optic	Sedgewick	Fibre Optic
Daysland	Fibre Optic	Seven Persons	Fibre Optic
Delburne	Wireless	Sexsmith	Fibre Optic
Delia	Fibre Optic	Shaughnessy	Fibre Optic
Derwent	Fibre Optic	Siksika	Fibre Optic
Devon	Fibre Optic	Silver Valley	Wireless
Dewberry	Fibre Optic	Slave Lake	Fibre Optic
Didsbury	Fibre Optic	Smith	Wireless
Dixonville	Fibre Optic	Smoky Lake	Fibre Optic
Donalda	Fibre Optic	South Cooking Lake	Fibre Optic
Donnelly	Fibre Optic	Spirit River	Fibre Optic
Drayton Valley	Fibre Optic	Springbank	Fibre Optic
Driftpile	Fibre Optic	Spruce View	Fibre Optic
Duchess	Fibre Optic	Sputinow	Fibre Optic
Duffield	Fibre Optic	St. Isidore	Fibre Optic
Dunmore	Fibre Optic	St. Paul	Fibre Optic
Dunstable	Wireless	Stand Off	Fibre Optic
Eaglesham	Fibre Optic	Standard	Fibre Optic
East Prairie Metis Settlement	Fibre Optic	Stavely	Fibre Optic
Eckville	Fibre Optic	Stettler	Fibre Optic
Edberg	Fibre Optic	Stirling	Fibre Optic
Eden Valley I.R. 216	Fibre Optic	Strome	Fibre Optic
Edgerton	Fibre Optic	Sturgeon Lake I.R. 154	Fibre Optic
Edson	Fibre optic	Sunchild I.R. 202	Wireless
Elizabeth Metis Settlement	Fibre Optic	Sundre	Fibre Optic
Elk Point	Fibre Optic	Sunset House	Fibre Optic
Elmworth	Wireless	Swan Hills	Fibre Optic
Elnora	Fibre Optic	Sylvan Lake	Fibre Optic
Empress	Fibre Optic	Taber	Fibre Optic
Enchant	Fibre Optic	Tall Cree I.R. 173	Wireless
Enoch	Fibre Optic	Tall Cree I.R. 173A	Wireless
Entwistle	Fibre Optic	Teepee Creek	Fibre Optic
Erskine	Fibre Optic	Thorhild	Fibre Optic
Evansburg	Fibre Optic	Thorsby	Fibre Optic
Exshaw	Fibre Optic	Three Hills	Fibre Optic
Fairview	Fibre Optic	Tilley	Fibre Optic
Falher	Fibre Optic	Tofield	Fibre Optic
Falun	Fibre Optic	Tomahawk	Fibre Optic
Faust	Fibre Optic	Trochu	Fibre Optic

Fawcett	Fibre Optic	Trout Lake	Fibre Optic
Flatbush	Fibre Optic	Tsuu Tina Sarcee	Fibre Optic
Foremost	Fibre optic	Tulliby Lake	Fibre Optic
Forestburg	Fibre Optic	Turner Valley	Fibre Optic
Fort Assiniboine	Fibre optic	Two Hills	Fibre Optic
Fort Chipewyan	Wireless	Uncas	Fibre Optic
Fort Mackay	Fibre Optic	Valhalla	Wireless
Fort Macleod	Fibre Optic	Valhalla Centre	Wireless
Fort Saskatchewan	Fibre optic	Valleyview	Fibre Optic
Fort Vermilion	Fibre Optic	Vauxhall	Fibre Optic
Fox Creek	Fibre Optic	Veteran	Fibre Optic
Fox Lake	Wireless	Viking	Fibre Optic
Frog Lake	Fibre Optic	Vilna	Fibre Optic
Gadsby	Fibre Optic	Vimy	Fibre Optic
Galahad	Fibre Optic	Vulcan	Fibre Optic
Garden Creek	Wireless	Wabamun	Fibre Optic
Gem	Wireless	Wabasca Desmarais	Fibre Optic
Gibbons	Fibre Optic	Wandering River	Wireless
Gift Lake	Fibre Optic	Wanham	Fibre Optic
Gleichen	Fibre Optic	Warburg	Fibre Optic
Glendon	Fibre Optic	Warner	Fibre Optic
Glenevis	Fibre Optic	Waskatenau	Fibre Optic
Glenwood	Fibre Optic	Water Valley	Fibre Optic
Goodfish Lake	Fibre Optic	Wembley	Fibre Optic
Grand Centre	Fibre Optic	Westerose	Fibre Optic
Grande Cache	Fibre Optic	Westlock	Fibre Optic
Granum	Fibre Optic	Whitelaw	Fibre Optic
Grassland	Fibre Optic	Wildwood	Fibre Optic
Grassy Lake	Fibre Optic	Willingdon	Fibre Optic
Gregoire Lake I.R. 176	Fibre Optic	Winfield	Fibre Optic
Grimshaw	Fibre Optic	Woking	Fibre Optic
Grouard	Fibre Optic	Worsley	Wireless
Grouard Mission	Fibre Optic	Wrentham	Fibre Optic
Grovedale	Wireless	Youngstown	Fibre Optic
Gwynne	Fibre Optic	Zama City	Wireless
Halkirk	Fibre Optic		
Hanna	Fibre Optic		
Hardisty	Fibre Optic		
Hay Lakes	Fibre Optic		
Hays	Fibre Optic		

Heart Lake	Fibre Optic		
Heinsburg	Fibre Optic		
Heisler	Fibre Optic		
High Level	Fibre Optic		
High Prairie	Fibre Optic		
Hill Spring	Fibre Optic		
Hines Creek	Fibre Optic		
Hinton	Fibre Optic		
Hobbema	Fibre Optic		
Holden	Fibre Optic		
Horse Lake I.R. 1528	Fibre Optic		
Hughenden	Fibre Optic		
Hussar	Fibre Optic		
Hythe	Fibre Optic		
Indus	Fibre Optic		
Innisfail	Fibre Optic		
Innisfree	Fibre Optic		
Irma	Fibre Optic		
Iron River	Fibre Optic		
Iron Springs	Fibre Optic		
Irricana	Fibre Optic		
Irvine	Fibre Optic		
Islay	Fibre Optic		
Janvier	Fibre Optic		
Jarvie	Fibre Optic		

Appendix 3. Networking - Retail Service Providers providing services through the Alberta SuperNet

A list of retail service providers that connect consumers to the Alberta SuperNet using wireless or wireline services. [Please note, this is only a partial list provided by Axia.]

360 Business Solutions	O-Net
3C Information Solutions Inc	Optic-Lynx
Aaxess Satellite Communications Inc.	Pathcom Wireless Inc
Abnorth.com	Persona Communications Inc.
Alberta Communication Cable Services Inc	PetroBand Networks Inc.
Arrow Technology Group	Platinum Communications Corporation (Xplornet)
Binary Solutions Ltd.	Prairiewireless
CampTek	Rainbow Lake Cable TV
Care Radio Broadcasting Association	Rigstar Communications Inc.
Communications Cold Lake	Serbernet
Comtech (Telecom Solutions) Ltd	Slave Lake Communications Ltd.
Corridor Communications, Inc	Tera-byte Dot Com Inc
DataDrill Communications Inc	The Rural Link Inc.
Davinci Broadband Inc	Tough Country Communications Ltd.
DigitalWeb Internet Services	True Solutions
Galaxy Broadband Communications Inc	Westcan Wireless
Harewaves Wireless	Wiband Communications Corp
Hybrid Wireless Inc.	Wispernet.ca
I Want Wireless. Ca Ltd.	*Wolfpaw Services Inc*
Iristel Inc.	Xplornet
KBS Cable	Optic-Lynx
MCSNet	Pathcom Wireless Inc
Milk River Cable Club	Persona Communications Inc.
NETAGO	PetroBand Networks Inc.
NEXXCOM Technologies Ltd.	
Noralta Technologies Inc.	
Northwestel Cable Inc	

Appendix 4. Networking - Wireless Internet Service Providers in Alberta

This list represents a best-effort search by the report author for available providers, and may not be exhaustive.

Name	Head office	Source	Service territory map or list, where available
North			
CCI Wireless	Calgary	cciwireless.ca	Map
I Want Wireless	Debolt	iwantwireless.ca	List
Slave Lake Communications	Slave Lake	slavelakecommunication.com/	List
First Broadband	Grand Prairie	firstbroadband.ca	Map
GPNetworks	Grand Prairie	gpnetworks.ca	List
Wild Rose Internet	Calgary	wildroseinternet.ca	Map
Central			
NETAGO	Hanna	netago.ca	
CCI Wireless	Calgary	cciwireless.ca	Map
Clearwave	Edmonton	clearwave.ca	Map
MCSNet	St. Paul	mcsnet.ca	Map
Airsurfer	Edmonton	airsurfer.ca	Map
Arrow Technology Group	Edmonton	sis.net	List
Broadband Surfer	Spruce Grove	canadasurfs.ca	Map
TeraByte Wireless	Edmonton	tbwifi.ca	Map
Harewaves	Eckville	harewaves.net	Map

TeraGo (business services only)	Calgary	terago.ca	n/a
Wild Rose Internet	Calgary	wildroseinternet.ca	Map
South			
CCI Wireless	Calgary	cciwireless.ca	Map
Tough Country Communications	Pincher Creek	toughcountryinternet.ca	Map
Wild Rose Internet	Calgary	wildroseinternet.ca	Map
Satellite			
Xplornet		www.xplornet.com	Coverage

Non-residential

Rigstar Communications	Calgary	rigstar.ca	Energy, mining, financial services, healthcare, construction, remote camps, public & private sector
TeraGo	Calgary	terago.ca	n/a
WiBand	Calgary/Edmonton	wiband.com	n/a

About Cybera

Cybera is Alberta's not-for-profit organization responsible for driving economic growth through the use of digital technology.

Our core role is to oversee the development and operations of Alberta's cyberinfrastructure – the advanced system of networks and computers that keep government, educators, not-for-profits, and entrepreneurs at the forefront of technological change.

We work with our members to ensure a connected future for all Albertans.

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- Tim Olsen (Innovation and Advanced Education)
- Randy Goebel (Alberta Innovates - Technology Futures)
- Paul Nelson (Crystal Downs Inc.)
- Jim Ghadbane (CANARIE)
- Lindsay Sill (WestGrid, Compute Canada)
- Dugan O'Neil (Compute Canada)
- Rob Myatt (Shaw)
- Walter Stewart (Research Data Canada)
- Craig Dobson (University of Alberta)
- Chris Thompson (Alberta Health Services)
- Rand Ayres (Southern Alberta Institute of Technology)
- Dr. Michael McNally (University of Alberta)

- Dr. Rob McMahon (University of Alberta)
- David Basto (City of Calgary)
- Dr. Gregory Taylor (University of Calgary)
- James van Leeuwen (Ventus)
- Don R. Mcleod (Town of Viking)
- Rob Schneider (Sturgeon County)
- Holly Saulou (Government of Alberta)
- Grant Street (CIRA)