ARCTIC BROADBAND

Recommendations for an Interconnected Arctic

Telecommunications Infrastructure Working Group

ARCTIC ECONOMIC COUNCIL

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Message from AEC chair, Tara Sweeney

I am incredibly proud of the hard work and dedication demonstrated by the members of the Telecommunications Infrastructure Working group. The pan-Arctic engagement evident throughout this document exhibits the strong commitment of the Arctic business community to support the Arctic Economic Council's four core principles of partnership, collaboration, innovation and peace.

Being raised in rural Alaska, I have a deep understanding for the importance of connectivity and the challenges that come with a lack of reliable communications. Expanding broadband access and adoption will be vital for the economic, social and political growth of local Arctic communities. It is my hope that these recommendations add value to the ongoing discussion of broadband deployment in the Arctic, and serve as a tool for policy makers, investors, researchers and communities to come together for sustainable polar growth.

Message from AEC Telecommunications Infrastructure Working Group chair, Robert McDowell

The recommendations provided in this report are the result of a true collaborative effort among the business community within the eight Arctic states. Together, local Arctic residents and expert broadband advisors have combined their knowledge to establish a comprehensive strategy for the deployment and adoption of broadband in the far north – a first of its kind. To the members of the Telecommunications Infrastructure Working group, I thank you for your unwavering commitment and invaluable input contributed throughout this process.

May this document mark the beginning of increased broadband access in the Arctic, and encourage continued work in the field of broadband deployment throughout the circumpolar north.

Executive Summary

With its beautiful scenery, harsh climate, significant indigenous population and increasing geopolitical importance, the Arctic is unique. The challenges posed by the Arctic to broadband deployment and adoption are also unlike any on the planet. With this in mind, the dual purposes of the *Recommendations for an Interconnected Arctic* are to take stock of the current state of broadband in the Arctic, and to make recommendations as to how to facilitate broadband deployment and adoption.

This document begins by exploring how each Arctic state (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and United States of America) defines broadband and the goals each has established for broadband deployment. Typically, Arctic states define broadband in terms of data transmission speed or have established transmission speed goals. Several Arctic states have established speed goals of 100 Mbit/s by the year 2020.

Next, this document lays out some of the overarching societal benefits of broadband. From the economy and healthcare to scientific research and public safety – broadband has the potential to positively affect nearly every sector of society. It facilitates and enhances our daily lives in ways once unimaginable. Indeed, broadband has the power to transform society and enable new and more robust ways of interacting with one another.

At the same time, the Arctic poses extreme challenges. The region is characterized by a dispersed population, harsh climate and lower rates of broadband adoption than non-Arctic regions. This document discusses these and other challenges that must be considered and surmounted in order to expand broadband in the Arctic.

These *Recommendations for an Interconnected Arctic* note that a comprehensive strategy for the Arctic requires a multi-pronged approach focused on ways to promote deployment while encouraging broadband demand.

Understanding current broadband usage by country is a necessary first step in realizing the ultimate goal of making the technology universally available in the region. As such, this document looks at current broadband deployment in each Arctic state. All but one Arctic state have overall broadband coverage rates of 90 percent or higher.

The following assessment then provides an overview of some of the existing technologies that may facilitate Arctic broadband deployment. Technologies such as optical fiber, mobile wireless and satellite each have positive and negative aspects that should be considered and evaluated. No single technology is appropriate for all situations. Rather, broadband deployment in the Arctic likely requires a combination of various technologies.

Next, funding options are explored. Private investment may be difficult to attract to Arctic broadband projects given the high cost of deployment and often small clusters of customers. Nevertheless, expanded oil and gas exploration and other business activities may facilitate improved access to private finance. This document identifies numerous policy initiatives, such as those that adopt market mechanisms to promote more efficient spectrum use that may attract private investment in broadband. Public-private partnerships (PPPs) can also be an effective tool to promote delivery of broadband services to Arctic populations, and this document enumerates concrete steps governments and regulators can take to foster PPPs. Lastly, government support of Arctic broadband deployment is an option and can take a number of forms, including subsidies, tax incentives and the creation of universal service funds.

Past, current and proposed broadband deployment projects are the next topic addressed. Among these are the Quintillion project that will build and operate a privately-funded, 1,850 km long subsea fiber optic system that will initially run along the north and west coast of Alaska; and a project funded by Nornickel, a privately-owned Russian mining and metallurgical company that will construct a 957 km long fiber optic cable laid through the Yamal-Nenets Autonomous Region and Krasnoyarsk Territory. Numerous other projects are also described.

This document concludes by identifying goals and recommendations for Arctic broadband deployment and adoption. Included among these are examples of potential legal, regulatory, and business practice reforms and strategies that the private sector, NGOs and local, indigenous, provincial, and national governments could undertake to facilitate deployment. For example, governments could modernize tax structures to incentivize private investment in broadband and make more spectrum available.

As to adoption, this document encourages the private and public sectors to work together to address barriers to entry, including cost, and to further promote digital literacy.

I. Introduction

The interconnectivity of people, communities, governments, businesses and beyond is one of the hallmarks of these opening decades of the 21st century. Reliable broadband is necessary to promote and advance interconnectivity, which in turn facilitates improvements in national economies, education, health, and many other sectors of society. Despite these benefits, broadband deployment and adoption across the globe have not been uniform. One region in danger of being left behind is the Arctic.

Recognizing this, private sector representatives from each nation state with territory in the Arctic – Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the United States of America – have come together to take stock of the current state of broadband in the Arctic and consider how to promote greater interconnectivity. This document is the result of this unprecedented collaboration. However, it is not the end point. Given the constant progression of technology generally, and broadband specifically, strategies designed to advance broadband deployment and adoption must necessarily be iterative.

This document proceeds in five substantive sections. Section II provides a snapshot of broadband in the Arctic, including the current state of broadband coverage and adoption, challenges to expanding broadband and technologies available to facilitate broadband deployment. Section III summarizes broadband usage in each Arctic state and the technologies available to effectuate broadband connectivity. Section IV discusses the funding options available for the further development of broadband infrastructure. Section V provides an overview of various broadband projects in and adjacent to the Arctic. Section VI lays out goals and recommendations for a regional strategy to promote broadband deployment and adoption throughout the Arctic.

II. Key Issues

A. BROADBAND PERSPECTIVES

In general terms, broadband refers to telecommunications services that provide multiple channels of data over a single communications medium, typically using some form of frequency or wave division multiplexing.[1] More specific definitions vary, with no international consensus as to how broadband should be defined.[2] As discussed below, the majority of Arctic states define broadband in terms of data transmission speed or have set transmission speed goals.[3]

1. Country Definitions/Goals

Canada

Two regulatory agencies – the Innovation, Science and Economic Development (ISED) agency and the Canadian Radio-Television and Telecommunications Commission (CRTC) – have jurisdiction over broadband-related issues in Canada. The ISED defines broadband as an "Internet service that is always on (as opposed to dial-up, where a connection must be made each time) and offers higher speeds than dial-up service."[4] The agency further specifies that "In Canada, broadband service refers to download speeds of 1.5 [Mbit/s] or greater."[5] The CRTC takes a slightly different view. In 2011, the CRTC set a broadband speed goal of 5 Mbit/s download and 1 Mbit/s upload for all Canadians.[6]

Denmark

In 2013, the Kingdom of Denmark's Ministry of Business and Growth established a broadband speed goal of at least 100 Mbit/s for all households and businesses by 2020.[7]

Finland

The Republic of Finland considers broadband access to be a basic legal right.[8] In 2008, Finland promulgated a national broadband plan that called for construction of fiber middle-mile networks such that at least one fiber access point is located no further than 2 km from virtually all permanent residences and businesses.[9] These networks are intended to cover 99 percent of the Finnish population.[10] In November 2015, Finland's Ministry of Transport and Communications (MTC) established a minimum speed rate of 2 Mbit/s for universal broadband service with a goal of increasing the speed to 10 Mbit/s by 2021.[11] In 2016, the MTC promulgated a broadband implementation plan designed to facilitate build-out of the fiber networks contemplated in the 2008 national broadband plan.[12] The plan proposes a number of measures to promote network construction by increasing market-driven supply and demand without distorting competition and while utilizing a technology-neutral approach.[13]

Additionally, telecom operators defined as "universal service providers" must be able to provide every permanent residence and business office with access to a reasonably priced and high-quality connection with a downstream rate of at least 1 Mbit/s.[14]

Iceland

The Republic of Iceland broadly defines broadband as "high-speed Internet connections over fibre optic cables."[15] Currently, Internet service providers in Iceland provide fiber speeds ranging from 40 Mbit/s to 500 Mbit/s.[16]

Norway

The Kingdom of Norway's National Communications Authority ("NCOM," previously the National Post and Telecommunications Authority) defines broadband as having a minimum service capacity greater than 4 Mbit/s.[17] In 2013, NCOM established a goal of access to high-speed broadband at 100 Mbit/s throughout the country.[18] In 2016, the Ministry of Transport reiterated this goal, further specifying that 100 Mbit/s broadband should be available to at least 90 percent of Norwegian households by 2020 and to all households in the long-term.[19]

Russia

In 2012, the Ministry of Communications and Mass Media of the Russian Federation announced national broadband targets.[20] The Ministry plans to make 100 Mbit/s ultra-fast broadband (UFB) available to 80 percent of Russian residents by 2018, with the ultimate goal of providing affordable and accessible broadband to 95 percent of households by 2020.[21]

Sweden

In 2004, a working group within the Kingdom of Sweden's Ministry of Enterprise and Innovation defined broadband both as "IT infrastructure with high capacity" and as "an 'always on' Internet connection with relatively high capacity."[22] The working group noted, however, that "there are market solutions in which a broadband connection does not necessarily automatically mean a connection to the Internet."[23]

In 2011, the Ministry of Enterprise, Energy and Communications established a broadband speed goal of 100 Mbit/s by 2020 for 90 percent of permanent Swedish households and businesses.[24] Sweden believes that Internet access "makes it possible for people to fully exercise their rights to freedom of expression and opinion," and thus "States have a responsibility to ensure that Internet access is broadly available."[25]

United States of America

The United States of America's Federal Communications Commission (FCC) defines broadband as "high-speed Internet access [that] allows users to access the Internet and Internet-related services at significantly higher speeds than those available through 'dial-up' services."[26]

Although the FCC does not generally define broadband in terms of data throughput,[27] it has adopted various broadband speed thresholds for specific regulatory purposes. For example, the FCC is required to evaluate annually whether "advanced telecommunications capability"[28] is being deployed to all Americans in a "reasonable and timely" fashion.[29] In 2016, the FCC conducted this analysis using actual download speeds of 25 Mbit/s and actual upload speeds of 3 Mbit/s.[30]

In March 2010, the FCC released a comprehensive plan for broadband deployment in the United States.[31] That plan, referred to as "The National Broadband Plan," recommends that the government establish a goal of at least 100 million U.S. homes with affordable access to actual download speeds of at least 100 Mbit/s and actual upload speeds of at least 50 Mbit/s "over the next decade."[32] In Alaska,[33] the state's Statewide Broadband Task Force[34] established a similar goal of 100 Mbit/s connectivity (up and down) for every Alaska household by 2020.[35]

B. BENEFITS OF BROADBAND

Broadband is a transformative platform that affects nearly every sector of society, including, but not limited to, the economic, educational, governmental, health, scientific and public safety sectors. In addition to the macro-level benefits discussed below, broadband also enhances individual's lives on a micro-level, allowing them to interact and prosper (whether economically, educationally, politically or culturally) in ways not possible before the advent of broadband.

1. Economy

In terms of economic benefits, a 2009 study by the World Bank found that for every 10 percent increase in broadband penetration, there is a corresponding 1.21 percent increase in per capita GDP in high-income economies.[36] The rate of per capita GDP increase is even more significant in developing countries— 1.38 percent.[37] Other studies by the World Bank show that the deployment of broadband facilitates the adoption of more efficient business processes, cuts transaction costs, and provides better access to labor pools, materials and consumers.[38] Companies adopting broadband-based processes improve labor productivity by five percent in the manufacturing sector and by 10 percent in the services sector.[39] Studies also suggest that 10 percent higher broadband penetration in a specific year correlates to 1.5 percent greater labor productivity over the following five years.[40] In addition, the deployment of broadband accelerates innovation by introducing new technologies, services and business models.[41] It enhances human capital by facilitating knowledge and technical skill acquisition."[42]

2. E-Commerce

Broadband allows for new business models and ways of doing business. Perhaps one of the most widespread and important applications of broadband Internet is e-commerce, which includes business-to-business transactions (e.g. digital advertising, invoices, recruitment, financing) and customer-to-business exchanges (e.g. "e-tailing," bill payments, electronic reservations and ticket purchases, and web-based banking).[43] Indeed, broadband Internet access may offer the best mechanism for advertising Arctic goods and services to the rest of the world. Substantial increases in demand are possible for Arctic businesses able to take advantage of broadband to advertise their goods and services to a broader base of consumers. Broadband also offers a means to accept payments from far-flung individuals as well as purchase supplies and equipment for Arctic businesses themselves.

3. Education

Broadband has the potential to transform education by giving teachers and students access to learning resources and technologies that will allow them to gain the knowledge and skills necessary to live and work in the 21st Century.[44] For example, broadband facilitates distance learning by connecting teachers to students and allows greater access to a wide range of educational materials not available locally. With reliable broadband access, educators can create diverse virtual learning environments as well as more personalized and interactive curricula. Broadband enables students to communicate with, and learn from, their counterparts and instructors around the world.

4. E-Government

Broadband enables e-government, which refers to the use of information and communication technology to enhance the range and quality of public services to citizens and businesses while making government more efficient, accountable and transparent.[45] E-government expands access to government services and information. For example, e-government may allow citizens to find information about identification documents and allows them to apply for those documents online. In addition, e-government redefines the relationship between citizens, businesses and governments by creating innovative platforms to prioritize and craft policy, reform public services and reduce regulatory burdens.[46]

5. Government Participation and Community Involvement

Broadband helps to prevent political isolation and to enable political engagement and participation. Broadband improves access to information and allows individuals to take part in the political process regardless of one's physical location. Broadband also improves community involvement by allowing stakeholders to exchange ideas, meet, and collaborate in order to work through issues confronting the community. Moreover, broadband facilitates programs designed to foster increased public, social, and economic participation of individuals with physical and cognitive disabilities, unemployed youth, the economically inactive, immigrants and the elderly.[47]

6. Medicine/Public Health

Broadband enables the development of telemedicine, which can have a transformative effect on otherwise remote regions. The expansion of robust broadband services creates the foundational infrastructure that allows health care providers to improve the health of their patients regardless of where they live. Telemedicine allows for long-distance consults and diagnoses, real time medical monitoring, and secure electronic health information exchange. In addition, given the shortage of some medical specialties in rural and remote parts of the Arctic, telemedicine can play an important role in ensuring patients in rural communities get access to the specialty care they need.[48]

7. National Interests

Access to secure broadband is critical to national interests such as state security and defense. Climate change combined with estimates suggesting that the Arctic seabed may hold substantial oil and natural gas reserves may lead to increased economic and military operations in the Arctic.[49] Given the likelihood of increased communications support requirements arising from such operations, expanded broadband deployment should be a priority.

More generally, the ability to easily locate and quickly exchange data, including videos and other large files, is essential to ensuring the security of the nation-state as well as the safety of citizens at home and abroad. Allowing key stakeholders to rapidly engage and respond to developing situations or threats quickly is a significant benefit of broadband. Broadband also provides a window into the activities of anti-government groups or individuals and supports numerous technologies critical to national defense.

8. Scientific Research

Broadband enables new and more robust ways of conducting scientific research. Researchers rely on connectivity to access information, share scientific resources and instruments, and virtually collaborate with colleagues around the world.[50] For example, scientists conducting field research in the Arctic require broadband connectivity to access remote computing facilities and transmit field data. Particularly as scientific endeavors increasingly rely on data, simulation and models, e-infrastructures enable new ways of scientific collaboration and resource sharing, as well as wider availability of repositories of scientific data.[51] Broadband may also facilitate knowledge exchange between indigenous and local populations, industry and researchers.

9. Trade and Transportation

Broadband is essential to trade and transportation in the Arctic. Approximately 80 percent of the world's industrial production takes place north of the 30th parallel north, making the Arctic Ocean a shortcut between the world's most advanced and productive regions.[52] Compared to traditional routes between the North Pacific and North Atlantic Oceans, advantages of trade and transportation routes through the Arctic Ocean include shorter distances, reduced fuel consumption and carbon emissions, faster deliveries of goods and higher profits.[53] As the Arctic becomes increasingly important to the global economy, access to real-time information regarding weather and ice conditions is critical for navigation safety, efficiency of travel and regulatory compliance.

Broadband is already helping to shape the future of the maritime and aeronautical industries. Broadband-driven connectivity in the maritime industry is improving telematics, telemetry, efficiency, safety, and crew welfare and training.[54] Broadband technology is beginning to expand to leisure ships as well, enhancing the passenger experience. In the aeronautical industry, broadband-based software and communications systems are making it easier for pilots, flight engineers and air traffic controllers to monitor flight operations, safety and security.[55] Broadband is also emerging in the passenger airline industry as a high value customer service that allows passengers to access live television and high-speed Internet while in flight.

10. Public Safety

Broadband is critical to the public safety community in any region.[56] Access to high-speed Internet facilitates communication and allows for more precise disaster planning and response. It also reduces the cost of operations and allows public safety officials to allocate scarce resources more effectively. In addition, reliable broadband can assist in organizing and analyzing data in a meaningful way so that officials can make real-time decisions in "life and death" situations. Similarly, broadband plays an important role is search and rescue ("SAR") operations. Depending upon the particular circumstances, SAR operations involve a number of communications technologies, including voice radios to guide first responders, satellite phones to expand the reach of voice communications, and GPS signals to help navigate.

C. UNIQUE CHALLENGES TO EXPANDING BROADBAND IN THE ARCTIC

The Arctic Council (AC) is the leading inter-governmental organization promoting pan-Arctic cooperation. Each of the AC's[57] eight member states has developed a national broadband plan tailored to its specific needs and goals.[58] However, many of the challenges posed by the Arctic's unique characteristics are common among all AC member states.[59] By focusing on these shared challenges, a regional broadband strategy can be developed to complement efforts already underway in individual AC member states.

The following are some of the challenges posed by the Arctic:

- Dispersed population: Much of the Arctic is characterized by small, rural settlements separated from one another by large distances. For example, approximately 120 Alaskan villages have fewer than 1,000 residents, and many have fewer than 100 residents.[60] Communities such as these are highly dispersed and are often not connected to any road system, limiting ingress and egress to air and, depending on the season, waterways or temporary ice roads.[61]
- Geography: The geographic breadth and challenging terrain of the Arctic make much of the region difficult to service from an economic perspective and also make building, maintaining and providing affordable communication services to end users challenging.[62]
- Harsh climate: Arctic temperatures are some of the coldest in the world. In Svalbard, Norway, for example, temperatures can drop as low as -46°C in the winter.[63] Among other challenges, these temperatures contribute to a short construction season for deploying the physical infrastructure necessary for other broadband technologies. Large amounts of snow and ice also make the maintenance and evolution of broadband technologies more difficult.
- Higher costs: Energy in some parts of the Arctic is expensive,[64] thus increasing costs associated with building the physical infrastructure necessary for broadband deployment. In addition, the components of the broadband infrastructure may themselves be more expensive. For example, fiber optic cables must be heavily armored in order to withstand the freeze and thaw cycles of the harsh Arctic climate.
- Human resource gap: The Arctic has an insufficient network of specialized contractors to install equipment necessary for broadband deployment. Similarly, the number of IT professionals qualified to maintain technology and deal with equipment failures in the Arctic is small.[65] Even in locations where an adequate number of professionals may exist, the training necessary to keep pace with recent technological advances is lacking.[66]

- Inadequate satellite coverage: Current communications satellites operating in geostationary Earth orbit do not fully cover the Arctic region.[67] Satellite-based broadband in the Arctic can also experience latency issues.[68]
- Lack of a comprehensive strategy: There is currently no comprehensive strategy for connecting all Arctic communities to one another and the rest of the world.[69] AC member states tend to work in isolation from one another when attempting to address their internal user needs.[70]
- Lack of transportation infrastructure: Due, in part, to the harsh climate and dispersed population of the Arctic, road and railway infrastructure development has been limited. Many Arctic communities receive supplies primarily via sea or air.[71] However, due to the lack of natural harbors in many parts of the Arctic and the short summer season, even sea routes can be limited. Without adequate roads and railways, transporting the heavy equipment necessary to lay terrestrial cable or build towers or other facilities necessary for broadband deployment is challenging.
- Lower adoption rates/demand: Bandwidth tends to be limited and expensive throughout the Arctic. For example, individuals living in Nunavut, Canada pay 45 percent more for broadband than their counterparts in the lower Canadian provinces.[72] The broadband available in Nunavut is also considerably slower than that available in other parts of Canada.[73] The high cost for slow speeds contributes to lower broadband adoption rates in the Arctic. Also contributing to lower adoption rates is the lack of awareness of the Internet in some isolated Arctic communities or the belief that the Internet does not facilitate access to relevant (that is, local or localized) content and services.[74]
- Undeveloped or underdeveloped investment models: The existing investment infrastructure in the Arctic is not meeting the rapid pace of change and convergence of communication services available in other non-Arctic regions.[75]

As these challenges demonstrate, a broadband strategy for the Arctic requires a multi-pronged approach focused on ways to promote broadband deployment while encouraging demand to ensure that the benefits of connectivity are fully realized.

III. The Current State of Broadband in the Arctic

Realizing the ultimate goal of universal broadband in the Arctic requires a dual focus on deploying infrastructure and ensuring adoption across all segments of society, from consumers and businesses to government and civil society institutions. A necessary initial step in the process is assessing the current state of broadband coverage and adoption throughout the various Arctic communities.

A. BROADBAND USAGE BY COUNTRY

Canada

According to the Government of Canada, over 99 percent of Canadian households currently have access to broadband with speeds of at least 1.5 Mbit/s.[76] However, only 27 percent of households in the rural Nunavut region have access to broadband.[77] The Connecting Canadians program, part of Digital Canada 150, will invest up to $305 million to extend broadband access throughout the country with the goal of bringing speeds of at least 5 Mbit/s to an additional 280,000 homes in rural and northern regions of the country.[78]

Denmark

In 2014, the European Commission estimated that overall broadband coverage in the Kingdom of Denmark stood at 99.5 percent of Danish households.[79] Between 2012 and 2014, Denmark increased its rural DSL coverage by six percent, rural VDSL coverage by over 20 percent, rural LTE coverage by 96.8 percent, and overall rural broadband coverage by 1.3 percent.[80] Networks capable of providing at least 30 Mbit/s were available to 91.7 percent of homes overall and 53.7 percent of rural households.[81]

Regular Internet users account for 93 percent of Denmark's population; 75 percent of those users have basic digital skills that enable them to interact online and consume digital goods and services.[82]

Finland

According to the European Commission, some form of broadband was available to 99.8 percent of Finnish homes as of 2014.[83] Between 2012 and 2014, Finland increased its rural DSL coverage by 7.9 percent and rural LTE coverage by 54 percent.[84] Overall rural broadband coverage stayed the same between 2012 and 2014. Networks capable of providing at least 30 Mbit/s were available to 75.1 percent of homes overall and 7.5 percent of rural households.[85]

Ninety-one percent of the Finnish population uses the Internet regularly, and 75 percent have basic digital skills that enable them to interact online and consume digital goods and services.[86]

Iceland

In 2014, the European Commission estimated that overall broadband coverage stood at 98.7 percent of Icelandic homes.[87] Between 2012 and 2014, Iceland increased its rural DSL coverage by over seven percent, rural VDSL coverage by 69.1 percent, rural LTE coverage by 46.9 percent, and overall rural broadband coverage by 2.6 percent.[88] Networks capable of providing at least 30 Mbit/s were available to 89.6 percent of homes and 70.2 percent of rural households.[89]

Overall, 97 percent of Icelandic people use the Internet and 83 percent of them have basic digital skills that enable them to interact online and consume digital goods and services.[90]

Norway

As of 2014, 99.3 percent of Norwegian homes had access to some form of broadband coverage according to the European Commission.[91] Between 2012 and 2014, Norway increased its rural VDSL coverage by 7.9 percent, rural LTE coverage by 28 percent, and overall rural broadband coverage by 6.1 percent.[92] Networks capable of providing at least 30 Mbit/s were available to 78 percent of homes overall and 31.2 percent of rural households.[93] In the Arctic regions of Troms and Finnmark, broadband is available via fiber networks as well as mobile wireless. Wireless providers TeliaSonera and Telenor are expanding 4G coverage in the region and full 4G coverage is expected by end of 2017.[94] In addition, a study is underway to map the opportunities for broadband in Norway´s maritime Arctic territories.[95]

Overall, 96 percent of the Norwegians use the Internet and 80 percent of them have basic digital skills that enable them to interact online and consume digital goods and services.[96]

Russia

A 2015 study by the World Bank indicates that fixed broadband service is available to 56.5 percent of all Russian households.[97] In the second quarter of 2013, 21 percent of broadband connections were at speeds above 10 Mbit/s.[98] More than 56 percent of Russian households overall, and 33.3 percent of rural Russian households, had broadband access at speeds of 256 Kbit/s or higher in October 2013.[99] As of the third quarter of 2015, about 87 percent of Russian Internet users enjoyed connection speeds above 4 Mbit/s.[100]

Sweden

In 2014, the European Commission calculated that 99.5 percent of Swedish households had access to some form of broadband.[101] Between 2012 and 2014, Sweden increased its rural DSL coverage by 0.6 percent, VDSL coverage by 0.3 percent and rural LTE coverage by 27.4 percent.[102] Networks capable of providing at least 30 Mbit/s were available to 76.4 percent of homes overall and 13.9 percent of rural households.[103]

Overall, 89 percent of Swedish people use the Internet and 72 percent have the basic digital skills that enable them to interact online and consume digital goods and services.[104]

United States of America

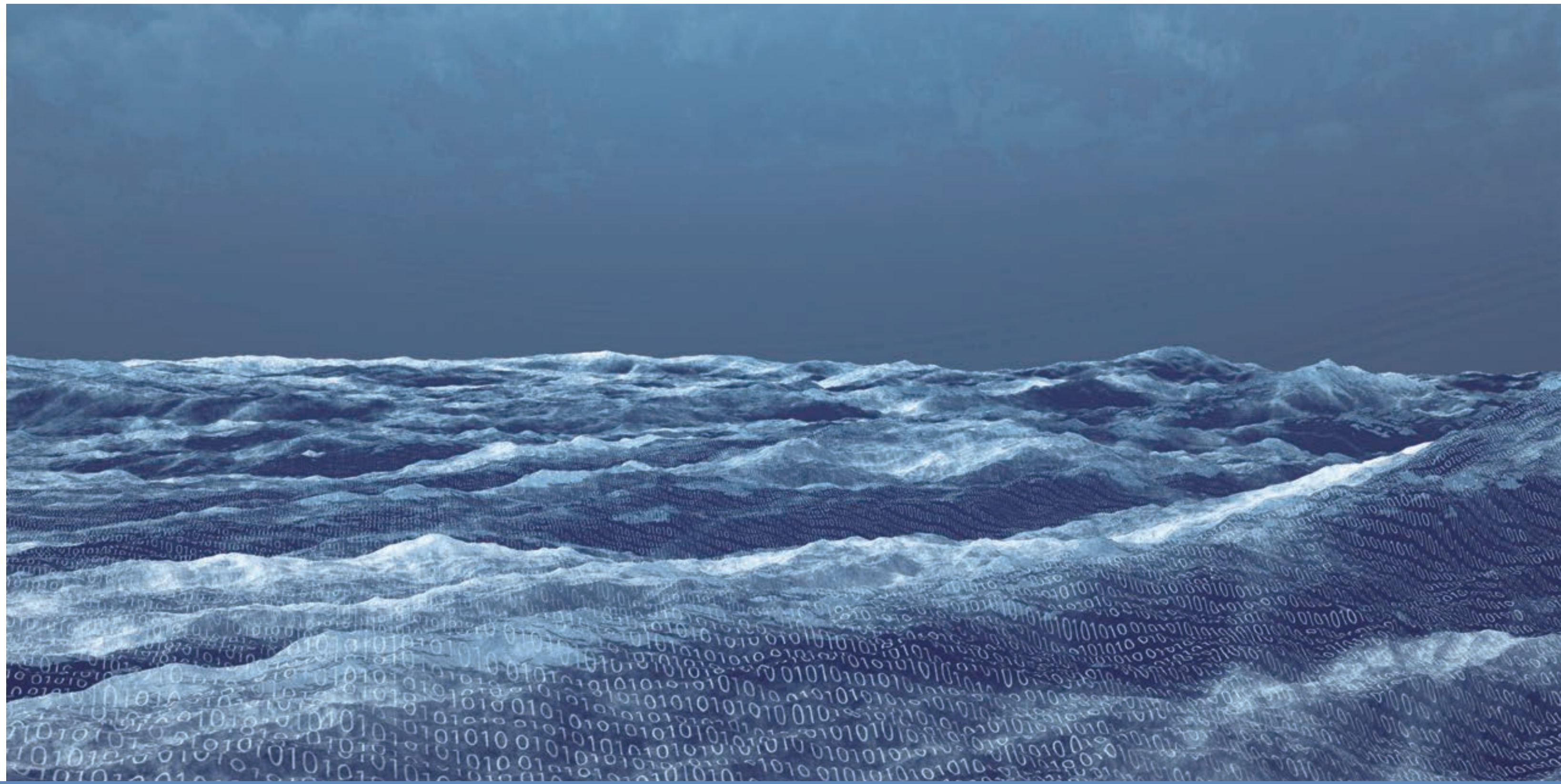
As of 2016, the Federal Communications Commission estimated that 90 percent of Americans have access to broadband with 25 Mbit/s of upload speed and 3 Mbit/s of download speed.[105] Sixty one percent of Americans living in rural areas have access to 25 Mbps/3 Mbps broadband.[106]

Currently, 126 Alaskan communities have broadband access via technologies ranging from fiber to fixed wireless service.[107] According to the State of Alaska Department of Commerce, 70 percent of rural Alaskans and 87 percent of non-rural Alaskans subscribe to Internet service.[108] As of October 2014, 91 percent of Alaskan households have broadband access at 3 Mbit/s download and 768 Kbit/s upload.[109] Since 2011, the availability of broadband service at speeds of 50 Mbit/s download and 1.5 Mbit/s upload has increased by 61 percent and service at 100 Mbit/s download/1.5 Mbit/s upload has increased by approximately 60 percent.[110]

B. AVAILABLE TECHNOLOGIES

Deploying broadband in the Arctic does not necessarily require the invention of new technologies. Indeed, numerous technologies already exist that could facilitate Arctic broadband deployment. These technologies, along with some of their technical advantages and disadvantages, include:

- **Optical fiber**
  - **Pros**: Very fast and efficient with less signal degradation; highly resistant to electromagnetic interference and low rate of bit error; scalable (wavelengths can be turned on or off on demand); longevity once deployed and relatively easy to replace or repair.
  - **Cons**: High investment costs; time consuming, lengthy deployment; susceptible to physical damage, such as accidental cutting; unidirectional light propagation requires concurrent cables to be laid to achieve bidirectional propagation of information.
- **Mobile Wireless** (3G, 4G, 4G/LTE, 5G)
  - **Pros**: More easily deployed than fix broadband; provides the convenience of mobile broadband access.
  - **Cons**: Signals are shared and thus can be degraded at peak usage times; signal strength impacted by distance, weather, line-of-sight, and other external factors. In addition, with regard to 5G specifically, the technology is not yet ready for deployment. The ITU aims to finalize 5G standards and protocols by 2020.[111] 5G also requires high-speed terrestrial backhaul.
- **Microwave** (Fixed Wireless)
  - **Pros**: Wireless backhaul alternative to copper or fiber connections (less expensive, easier deployment); lower installation costs compared to buried cable systems; can transfer data at speeds of 1 Gbit/s.
  - **Cons**: Limited range compared to satellite; requires line of sight; may be subject to rain fade; bandwidth is shared.
- **Satellite**
  - **Pros**: Terrestrial backbone and area networks are not needed; ability to connect users across large regions; heavily utilized by the maritime industry; LEO and other satellites with non-geostationary orbits that are currently being developed and deployed could provide the Arctic with broadband speeds of 50 Mbit/s.
  - **Cons**: Many existing satellites are geostationary (positioned over the equator) and service degrades substantially at latitudes above 75 degrees north; expensive initial investment and maintenance; expensive end-user devices; signal degraded by weather and line-of-sight problems.
- **Copper** (e.g., Digital Subscriber Line (DSL))
  - **Pros**: Rely on existing copper wires that are already present in many locations (though potentially less so in the Arctic region).
  - **Cons**: Speed depends on the length of the copper line; upload speeds generally substantially lower than download speeds; slower than fiber (though VDSL and other developments increasing DSL speeds).
- **Coaxial cable** (via cable TV networks)
  - **Pros**: Rely on existing cable TV networks (lower deployment costs where networks already exist); generally more capable/efficient than traditional copper telephone networks.
  - **Cons**: Internet use by multiple users simultaneously can degrade service and slow speeds during peak hours; often not available in remote areas.



IV. Funding Options

A number of obstacles exist with respect to obtaining adequate funding for infrastructure development in the Arctic. These include the region's dispersed population, expansive geography, extreme weather conditions and difficult terrain, all of which undermine business cases focused on high investment returns. As a result, an effective strategy should focus on a variety of funding options.

A. PRIVATE INVESTMENT

Concerns over return on investment—due to the high cost of deployment in challenging and expansive terrain combined with a small and sparsely populated customer base—often deter private investment in broadband deployment in the Arctic. However, increasing reliance on Arctic shipping routes, expanded oil and gas exploration, and other business activities in the region—as well as the addition of new anchor institutions—may provide increased incentives for improved access to private finance.

In addition to profitability and return on investment, private investment depends heavily on the regulatory climate.[112] The Organization for Economic Co-operation and Development identified particular policy initiatives that may promote private investment in broadband, including policies to undertake the following:

- Improve access to passive infrastructure (conduit, poles, and ducts) and coordinate civil works as an effective means to encourage investment.
- Encourage and promote the installation of open access to passive infrastructure when public works are undertaken.
- Ensure access to rights-of-way in a fair and nondiscriminatory manner.
- Allow municipalities and/or utilities to enter telecommunications markets. Where market distortion is a concern, policy makers could limit municipal participation to basic investments (such as the provision of dark fiber networks under open-access rules).
- Provide greater access to spectrum and adopt more market mechanisms to promote more efficient spectrum use.[113]

B. PUBLIC-PRIVATE PARTNERSHIPS

Recognizing that both the public and private sectors can benefit from pooling their financial resources, know-how and expertise, public-private partnerships (PPPs) can be an effective tool to promote delivery of services (including broadband) to all citizens.

PPPs are a widely used and flexible funding mechanism, embracing a range of different cost and risk-sharing arrangements.[114] For example, PPPs for broadband development and deployment may be private-sector lead, whereby a commercial operator builds, owns and operates the network; government-sector lead, whereby a public entity or municipality owns the network and private partners construct, operate and/or maintain the network in exchange for financial and in-kind support; or follow a joint-ownership model whereby a commercial operator and the public enterprise jointly invest in the network and share capacity.[115]

PPPs can also take the form of a regulated monopoly. Mexico, for example, has authorized a wholesale "carrier's carrier" network for the deployment of a new fixed and wireless national broadband network. The entity selected to build out the network will be awarded a 20-year public-private partnership to build an LTE network that must cover a minimum of 85 percent of the population.[116] Once complete, the entity awarded the exclusive right to build out the network will then have the exclusive right to sell capacity at fixed rates to any requesting service provider.[117] The network could potentially be used by hundreds of mobile-service providers, but its operator would be barred from providing service directly to consumers.[118]

Regardless of the form of the PPP, governments and regulators committed to broadband deployment can take several concrete steps to encourage private investment. These include:

- "Hard-wiring" various aspects of broadband policy and regulation in legislation. For example, the law could include specific rules for setting service rates.
- Delegating implementation of more general legal provisions to an independent regulatory body.
- Using legally binding license conditions that set out the rights and responsibilities of providers as well as mechanisms under which they can be changed.[119]
- Identify and address regulatory barriers, such as permitting requirements and rights-of-way rules that may unduly impede broadband deployment.
- Create tax incentives, such as tax credits, tax certificates and accelerated depreciation schedules to promote private investment.

Several key issues should be considered before initiating PPPs to expand broadband deployment, however.

First, after careful examination, governments should determine whether private sector investment alone is unlikely without government support.

Second, governments should recognize that deployment does not equal adoption. Providing individuals and businesses with broadband access does not mean that they will subscribe. Thus, to help ensure the success of the PPP, programs encouraging broadband adoption should accompany broadband deployment.

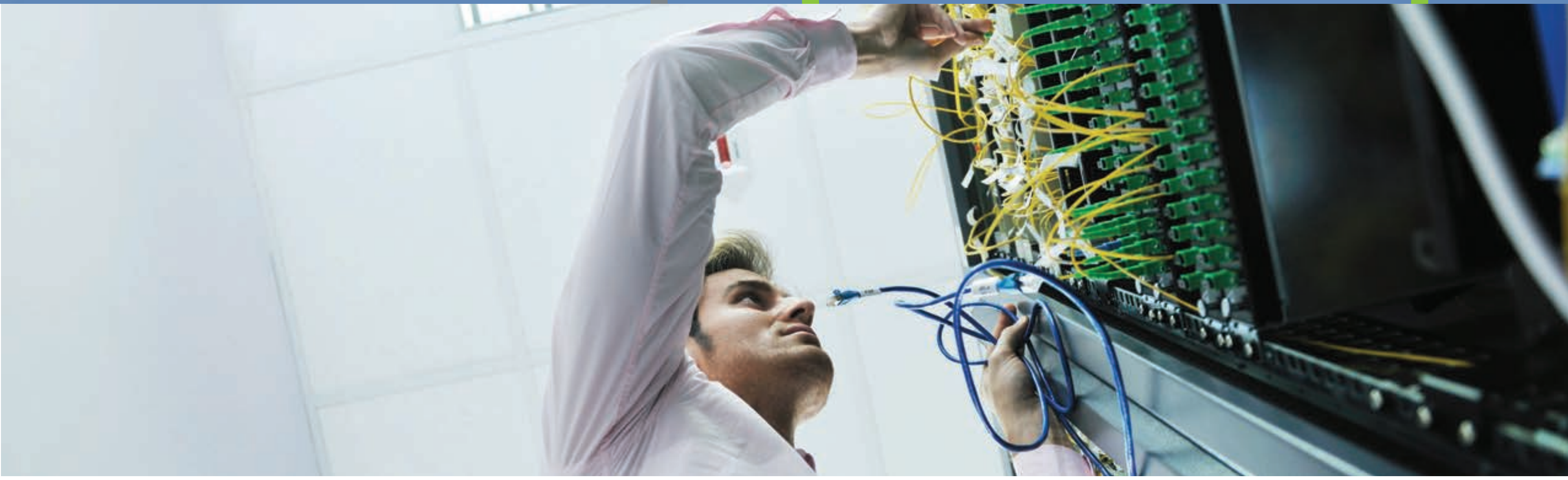
Third, governments should understand that private companies expect a reasonable return on their investment in broadband infrastructure and that private companies will assess the regulatory and other costs placed by governments on broadband deployment projects. Projects expected to have low rates of return will have trouble attracting private capital on favorable financial terms.

Fourth, careful consideration should be given to developing technology-neutral PPPs. Many PPPs fail because they assume that one technology is the only solution.[120] For example, assuming that fiber is the only solution ignores the fact that remote areas may be more effectively served by microwave technologies that have a lower CAPEX per subscriber than wired technologies.[121] PPPs for broadband deployment should incorporate, or at the very least consider and evaluate, a range of technologies suitable to the goal at hand.[122]

C. GOVERNMENT INVESTMENT

Relying upon government support alone to fund Arctic broadband deployment may present a challenge. Because each of the AC member states has developed a national broadband plan (in one form or another), government funding contributions are likely to be largely dictated by the strategies, preferences and politics of the various member states.[123]

Nevertheless, government support of Arctic broadband deployment could take a number of forms, including: subsidies for use in deploying infrastructure (loan guarantees, grants, etc.); subsidies for consumers to promote demand; tax incentives to encourage broadband deployment; and creation/expansion of universal service funds. Government support for Arctic broadband deployment could also come from sovereign wealth funds, which are investment funds owned by the governments of sovereign states and funded mainly by foreign exchange and reserve assets.[124]



V. Past, Current, and Proposed Projects

A. FAR EAST FIBER

In 2014, state-owned Russian telecom corporation Rostelecom began construction of an 1,855 km fiber optic cable line that will link the regions of Kamchatka, Sakhalin and Magadan in Far-Eastern Russia. The project is a part of a Russian federal program designed to bridge the digital divide by providing broadband access points to settlements with populations between 250 and 500 people. The network will have a maximum capacity of 400 Gbit/s in each direction, with the ability to expand up to 8 Tbit/s.

Phase one of the project was completed in 2015 and connects Sakhalin with Magadan via a terrestrial fiber network. Phase two will connect Okha, Sakhalin to Ust-Bosheretzk, Kamchatka via a submarine cable in the Okhotsk Sea. Rostelecom contracted with Huawei Marine to construct the 900 km submarine fiber cable connecting Sakhalin and Kamchatka. Phase 2 is scheduled for completion in the first quarter of 2017.

Additionally, Rostelecom is considering constructing a submarine fiber optic cable connecting Sakhalin with the Kuril Islands of Iturup, Kunashir and Shikotan. The cable would be 940 km long with a bandwidth of 40 Gbit/s. The scheduled in-service date would be in 2018.

B. GREENLAND CONNECT

Greenland Connect is a 4,500 km submarine cable that connects Canada, Greenland and Iceland. The cable was put into operation in March of 2009 and expanded in the summer of 2010.[125] Greenland Connect contains two fiber pairs specified for 128*10 Gbit/s each and two additional fiber pairs specified for 10 Gbit/s each.[126]

TELE Greenland A/S ("Tele-Post"), which is Greenland's sole telecommunications provider and which is wholly-owned by Greenland's government, carried out the project and owns and operates Greenland Connect.[127] The project was funded via a €20 million grant from the Nordic Investment Bank.[128]

Today, Greenland Connect serves as a vital part of Greenland's telecommunications infrastructure. Tele-Post provides fixed broadband to Greenland's population using a three zone pricing model; people living in more populated areas pay higher prices for service in order to subsidize the cost of providing fixed broadband to more rural areas. Tele-Post offers mobile broadband based on a "solidarity pricing" model – prices are uniform throughout the island so that citizens share the burden of paying for the infrastructure necessary to provide service to remote areas. Over 99 percent of Greenland's population has access to mobile broadband. Greenland's home rule government views the island as a "natural monopoly" and rejected proposals to liberalize the telecommunications market.

C. MACKENZIE VALLEY AND DEMPSTER HIGHWAY FIBER

The Mackenzie Valley Fiber Link (MVFL) project is a Government of the Northwest Territories, Canada (GNWT) initiative to provide a state-of-the-art high-speed fiber optic telecommunications link along the Mackenzie Valley and Beaufort Delta.[129] The MVFL project consists of the installation of 1,154 km of high-speed fiber optic telecommunications cable from McGill Lake to Inuvik, connecting communities along the Mackenzie Valley with Canada's high- speed fibre optic backbone network.[130] The fiber route will be extended from Inuvik to Tuktoyaktuk following the completion of the Inuvik-Tuktoyaktuk Highway.[131]

In October 2014, the GNWT entered into a 20-year Project Agreement with Northern Lights General Partnership (NLGP) to deliver the project.[132] NLGP is a consortium comprised of Ledcor as the construction partner and NorthwesTel as the service provider.[133] The project is expected to cost approximately $84 million.[134]

Relatedly, the Yukon government is planning a fiber optic line along the Dempster Highway to Inuvik, Northwest Territories.[135] The $32 million cable will connect to the Mackenzie Valley Fiber Link and will end frequent Internet service disruptions in the territory by providing it with a backup link to Southern Canada.[136]

D. MIDGARDSORMEN

Midgardsormen is a Norwegian-lead project seeking to design, build and operate a Norway-centric trans-Atlantic cable system to connect Norway and Sweden to the East Coast of the United States. Specifically, Midgardsormen will connect Virginia Beach, Virginia to Blaabjerget, Denmark, with a possible connection to Mo i Rana, Norway. Currently, the basic network architecture is in place, and backhaul and vendor negotiations are ongoing. Vendor selection was scheduled for June 2016, with a service goal of August 2018.

E. NORILSK FIBER OPTIC BROADBAND

Norilsk is one of the biggest cities in the Arctic and the only Russian city above the Arctic Circle with a permanent population of more than 175,000. The city currently lacks fiber optic broadband; Internet communications are handled by satellite with a general throughput of 1 Gbit/s. Nornickel, a privately-owned Russian mining and metallurgical company, has committed to constructing a 957 km long fiber optic cable that will provide Norilsk with broadband at speeds up to 40 Gbit/s. The cable will be laid through the Yamal-Nenets Autonomous Region and Krasnoyarsk Territory. Residents living along the line will be able to connect to it, as will inhabitants of Igarka, Snezhnogorsk and employees of the Vankor oil and gas field. Future infrastructure development could extend the cable to Yamal.

Although the project will not be profitable, Nornickel has agreed to construct the network as a social benefit to its many employees in Norilsk and as a means to develop its own IT infrastructure. Once construction is finished, Nornickel may be able to offset some of its cost by selling or leasing access to the cable to fiber optic operators. The cable is currently scheduled to be complete in 2017.

F. NXTVN´S OULU NORDIC EXPRESS

This will be a cross-border, Nordic-centric, Gulf of Bothnia bridge connecting cities in the Nordic regions of Finland and Sweden to Norway with onward connections to mainland Europe via submarine and terrestrial networks. NxtVn´s Oulu Nordic Express is estimated to cost approximately $80 million dollars (depending upon the number of landings). NxtVn may seek funding for the project from the European Commission.

G. NUVITIK

Nuvitik Communications, based in Ottawa, Ontario, specializes in submarine fiber optic cable operations. Its mission is to bring a telecommunications infrastructure to Canada's North.[137] The company is working on a proposed submarine cable[138] network that will provide fast, reliable cable Internet for hospitals, schools, government, authorities, businesses and homes in Canada's North.[139] The Ivaluk Network project was announced in January 2014, and the proposed network would provide 10 Gbit/s wavelengths per fiber pair with a design capacity of up to 64 waves per fiber pair.[140]

The Ivaluk Network project involves three sections—Nunavik, Southeast Nunavut, and Northwest Nunavut—with each section connecting every coastal community on its path.[141] Installation includes two phases, with the Nunavik and Southeast Nunavut network routes operational by fall of 2016 and the Northwest installation planned for 2017.[142]

H. QUINTILLION PROJECT

Quintillion is an Anchorage, Alaska-based company that will build and operate a privately-funded subsea fiber optic system that will initially run 1,850 km along the north and west coast of Alaska.[143] The project has three phases: (1) the Alaska segment; (2) the Pacific segment; and (3) a segment connecting Alaska to Europe via the Canadian Arctic. The Alaska segment, which includes the installation of a 1,850 km subsea fiber optic cable from Prudhoe Bay to Nome, is underway and expected to be completed in early to mid-2017.[144] The Pacific segment will connect Alaska to Japan, with options for additional spurs in Alaska.[145] Phase three will extend the subsea system from Alaska through the Northwest Passage to the United Kingdom, with spurs into select communities in the Canadian Arctic.[146]

Once all three phases are complete, the cable route will enable Internet data to flow between Europe and Asia at speeds as fast as 30 terabits per second.[147]

I. RUSSIAN OPTICAL TRANS-ARCTIC SUBMARINE CABLE SYSTEM (R.O.T.A.C.S.)

The Russian Optical Trans-Arctic Submarine Cable System ("R.O.T.A.C.S.") is a Russian-led project that began in the year 2000 but that has been delayed for economic reasons. R.O.T.A.C.S. was developed by the Russian company Polarnet with an estimated cost of $750 million. The planned 14,700 km long cable would link Japan and London through the Northeast Passage (Northern Sea Route) and provide a capacity of 100 Gbit/s.

J. SVALBARD UNDERSEA CABLE SYSTEM

The Svalbard Undersea Cable System provides a broadband connection between Svalbard and mainland Norway. The system consists of twin undersea fiber optic cables—one 1,375 km long, and the other 1,339 km long. In 2010, all houses and apartments in Longyearbyen received a fiber connection, including telephony, Internet, and Internet protocol television ("IPTV"), with Internet access speeds up to 500 Mbit/s. Businesses were connected to fiber-based services in 2013. In addition, 4G wireless broadband is available in Longyearbyen.

The Svalbard undersea cable system was financed and built by Norsk Romsenter Eiendom, the predecessor of Space Norway. Between 2009 and 2014, Telenor invested 12.1 million krone in the project. The system itself is owned by Space Norway AS but operated by Telenor Svalbard.

K. TERRESTRIAL FOR EVERY RURAL REGION IN ALASKA ("TERRA")

Terrestrial for Every Rural Region in Alaska ("TERRA") is a hybrid fiber optic-fixed microwave network that has brought broadband services to more than 70 communities in western Alaska for the first time. The network was built by GCI Communication Inc. ("GCI").

In 2010, GCI affiliate United Utilities, Inc. was awarded a $44.2 million loan and a $44 million grant from the federal Broadband Initiatives Program[148] and a smaller grant through the State of Alaska. GCI leveraged this public support with its own private investment and since 2010 has been steadily expanding and upgrading the network. In 2011, the TERRA network served 9,089 households and 748 businesses. In 2012, GCI completed the first phase of TERRA to connect southwest Alaska to the fiber backbone in Anchorage. In November 2014, GCI extended the service to Nome and Kotzebue, north of the Arctic Circle. The next phase, which will "ring" the existing network to increase resiliency and capacity, is currently underway.

VI. Goals And Recommendations

A regional broadband strategy encompassing eight countries with varying needs and degrees of development requires ambitious but flexible objectives. The following recommendations seek to establish long-term, comprehensive, and aspirational goals for the Arctic region, while also allowing for flexible short-term benchmarks for individual member states in order to strike an effective balance between pragmatic development considerations and the desire to advance a comprehensive strategy for the Arctic region as a whole. At the same time, technology continues to evolve and progress. As such, the process of developing and tailoring broadband strategies for the Arctic should be on-going and iterative. As technology and needs change, so should these goals and recommendations.

The private sector, NGOs, and local, indigenous, provincial and national governments should work together to spur more private sector investment in broadband deployment and facilities. To do so, these entities should conduct comprehensive reviews of laws, regulations, and business practices that could inhibit or frustrate private sector investment in, and deployment of, broadband technologies. Examples of potential legal, regulatory, and business practice reforms and strategies include:

- Modernize tax structures to incentivize private entities to put forth risk capital in the remote and insular areas of the Arctic. Specifically, governments could offer tax incentives tailored to stimulate Arctic broadband investment such as: accelerated depreciation schedules for enumerated technologies; allowing some capital expenditures to be treated as expenses; exempting specific technologies and expenditures from sales and use taxes; tax credits; and others.[149] Other incentives, such as grant programs or reduced regulation in exchange for a commitment to broadband deployment in remote areas, could also be offered.
- Streamline local zoning and permitting laws to allow for faster and easier construction of new broadband facilities.
- Collaborate with international partners (government, private sector, and NGOs) to facilitate cross-border deployment and data flow.
- Partner with environmental protection and land management agencies and NGOs to work together on best practices to allow for the most rapid broadband deployment possible while protecting the environment and archaeological, historic and cultural sites.
- Coordinate with government-owned and influenced assets and anchor institutions such as military installations, research centers, schools, libraries, health care clinics and community centers to leverage their presence to spur additional broadband deployment to outlying communities. Furthermore, make more readily available government controlled assets, including the following: rights-of-way, subsea cable landing rights on government lands, poles, conduits, roof rights and other assets where practicable.
- Make available more usable and appropriate spectrum in Arctic regions, whether on a licensed, unlicensed and/or shared basis. Additionally, streamline spectrum allocation processes to speed the rollout of new wireless services in the region.

When and where a realistic business case cannot be made for purely private risk capital ventures,[150] governments should work in collaboration with the private sector to identify and implement policies to support efficient and mutually beneficial public-private partnerships designed to support broadband deployment and adoption efforts. Solutions could involve subsidies, loans, grants, and other mechanisms to foster the construction of new broadband facilities and broadband adoption educational efforts.

Furthermore, if public-private partnerships are not practicable, governments should use public resources to finance and operate broadband facilities to offer services on a carrier-neutral and cost-based wholesale basis to help spur adoption. As part of such efforts, governments and private entities should work collaboratively to examine whether a transition path to privately owned and operated network facilities and services can be found.

Supporting the rapid deployment of a variety of broadband technologies is the crucial first step in getting the Arctic connected to the rest of the world. Deployment without adequate adoption rates will be meaningless, however. Accordingly, the private sector, NGOs and governments alike should work collaboratively to create innovative programs to spur rapid adoption of broadband technologies. Among many ideas to be considered are:

- Address barriers to adoption, such as costs. For instance, broadband Internet access providers should be encouraged to offer, publicize and actively market several tiers of service at various price points that are affordable to the populations being served. Governments should explore new methods of subsidizing broadband access on a means-tested basis for residential subscribers.
- Tackle digital literacy barriers to broadband adoption. Private sector players, NGOs and governments at all levels should be encouraged to work together to promote digital literacy programs, especially in communities that will gain broadband access for the first time.
- Coordinate with schools, libraries, community centers and other anchor institutions to leverage their presence to spur digital literacy and broadband adoption.
- Form special task forces of governments, NGOs, private enterprises, and indigenous governments and councils to work together to address deployment, adoption, and cultural issues relative to the presence of broadband technologies vis-à-vis the unique attributes of indigenous peoples.

VII. Conclusion

The Arctic is unique. It offers dramatic beauty, abundant natural resources and a robust indigenous population with valued traditions. The Arctic will also undergo more changes in the 21st century due to increased human activity than perhaps any other region on Earth. The deployment and adoption of a variety of broadband technologies can enable the expanding Arctic population to grow and prosper economically and socially while also protecting the environment and indigenous traditions.

Broadband technologies will continue to advance and change rapidly. These Recommendations are intended to serve as a thought provoking guide to help spur more broadband deployment and adoption in the Arctic region. It is our hope that the Arctic Economic Council will continually work on this endeavor because the goal of making available cutting-edge broadband technologies in the region will always be a work in progress. We encourage others to pick up where this document ends.

AEC Telecommunications Infrastructure Working Group

The Arctic Economic Council established the Telecommunications Infrastructure Working Group (TIWG) in 2016. The TIWG's mission is to draft, from a business perspective, a transnational broadband strategy for the Arctic region that will help to influence the political, social, and economic decisions made regarding telecommunications and information and communications technology (ICT).

The TIWG consists of telecommunications and ICT expert advisors with diverse backgrounds in industry and Arctic affairs. TIWG advisors hail from each nation state with territory above the Arctic Circle, understand the challenges of broadband deployment in the Arctic and have specific knowledge of broadband technologies.

Robert McDowell, *Cooley LLP / United States of America*

McDowell chairs the TIWG and is co-leader of the global communications practice of the international law firm of Cooley, LLP, a partner in the telecommunications, media and technology practice in Washington, DC. Rob is a former commissioner and senior member of the Federal Communications Commission, where he helped steer two of the then-largest wireless auctions in U.S. history and sparked the creation of an international coalition to combat multilateral Internet regulation. He has been an industry and government leader on a multitude of complex issues in the communications field throughout his career. McDowell provides strategic legal, business and public policy advice to clients on important domestic and international matters in the telecommunications, media, technology and digital media industries. He is also a senior fellow at the Hudson Institute, a nonprofit, nonpartisan policy research organization.

George Hungerford, *Gwich'in / Canada*

Hungerford is senior legal counsel, corporate finance at a Canadian government securities regulator. Previously, he was in private practice at a major international law firm as corporate/commercial counsel for a variety of clients, including First Nations, which he represented in negotiating impact benefit agreements. George was also formerly an investment banker and consultant, focusing on telecommunications and IT, in Silicon Valley, California and East Asia. He is Gwich'in and sits on the Gwich'in Development Corporation Board (Inuvik). Hungerford holds degrees in law from the University of British Columbia, business from Stanford University, and electrical and computer engineering from Queen's University. He also holds a Chartered Financial Analyst charter.

Viet Nguyen, *Ericsson Canada Inc. / Canada*

Nguyen is director, regulatory and government relations for Ericsson Canada Inc. In that role, he is responsible for the company's interaction with government and associations on technical, regulatory and policy issues. Viet was promoted to the director level in 2006, having held the position of manager, director, regulatory affairs and government relations since 2000. Viet began his career at Ericsson in 1988 at the Research & Development and Services Center in Montreal, where he held various positions including system design, project manager and technical project manager. He relocated to Ericsson's Mississauga office in 1998 assuming the role of manager, business strategy as part of a team responsible for short and long-term corporate strategies in Canada. Currently, Nguyen holds the chair position of the Canadian Electronics and Communications Association (CECA) and is also a member of the Radio Advisory Board of Canada's (RABC) executive committee.

Oana Spinu, *Nunavut Broadband / Canada*

Spinu manages the overall operations of the not-for-profit corporation Nunavut Broadband Development Corporation and its operating subsidiaries. In that role, she performs a variety of functions including strategic planning oversight, policy research and development, management, communications and outreach, funding development, and reporting. Oana regularly liaises with a variety of stakeholders including federal and territorial governments, Inuit organizations, telecommunication service providers, media, civil society and the general public.

Morten Glamsø, *Danish Shipowners Association / Denmark*

Glamsø is currently senior advisor to the Danish Shipowners' Association, a trade organization that represents 40 ship owners and two offshore companies. In that capacity, he is responsible for representing and promoting the interests of the Danish shipping industry in the Arctic. Such interests include navigational safety, improvements to the telecommunications infrastructure, and ensuring the physical security of ships and personnel. His work puts him in close contact with member companies, shipping authorities and decisions makers. Before joining the Danish Shipowners' Association, Glamsø was a naval officer in the Royal Danish Navy.

Peter Bay Kirkegaard, *Confederation of Danish Industries / Denmark*

Kirkegaard is senior advisor at the Confederation of Danish Industry, which is Denmark's largest business organization. The organization is funded, owned and managed entirely by 10,000 companies within the manufacturing, trade and service industries. He works in the trade policy department, where he focuses on advocacy for multi- and bilateral trade policy. He also works on export controls and Arctic affairs.

John Strand, *Strand Consult / Denmark*

Strand's background is in sales and marketing in the IT and publishing sectors. In 1994, he founded Strand Consult, which today focuses on the mobile sector. As founder and principle of Strand Consult, John, along with his team of analysts, evaluates markets and market trends, publishes reports, and holds executive workshops that enable mobile operators and service providers, device manufacturers, and media companies all over the world to maximize investment returns in the mobile sector.

Suvi Lindén, *Pearlcon Consulting / Finland*

Lindén is chairperson of the board of NxtVn Finland and vice chair for NxtVn Group. From 2007 to 2011, Suvi was Finland's Minister of Communications responsible for media and telecommunications. She previously served as Minister of Culture, Youth and Sport from 1999 to 2002 and as a member of Parliament from 1995 to 2011. Lindén acted as ITU´s special envoy to the Broadband Commission for Digital Development and was also a member of the Broadband Commission from 2010 to 2015. She is a member of the Advisory Board of SocialEco Ltd and an advisor for the Broadband Innovation Fund. In 2011, the Intelligent Community Forum, a New York-based think tank, named her as its "Visionary of the Year" for her commitment to ensuring affordable broadband access to every citizen in Finland.

Heidar Gudjonsson, *Vodafone Iceland / Iceland*

Gudjonsson is managing director of Ursus and chairman of the board of Vodafone Iceland. Heider founded Eykon Energy, an oil exploration company and is the chairman of the board. He also founded the first infrastructure investment fund in the Arctic. Among other accomplishments, Heidar built hydropower plants in Iceland, organized the largest acquisition of Icelandic fisheries in history, and founded a Norwegian-Icelandic oil exploration company. He is a board member of the Icelandic Arctic Chamber of Commerce, is on the advisory board of the Arctic Circle, and is the author of the "Arctic Push: Iceland and the Opportunities" (2013), a bestseller in Iceland.

Dag Ivar Brekke, *Innovation Norway / Norway*

Brekke has over 20 years of experience in engineering and infrastructure development and is currently serving as special advisor, Invest in Norway at Innovation Norway. Dag previously served as commercial counsellor at the Royal Norwegian Embassy in Moscow, Russia and as deputy managing director and temporary acting CEO and COO at Store Norske Spitsbergen Grubekompani AS, a government-owned company specializing in Arctic mining and logistics, property development and mineral resources.

Willy Jensen, *Retired / Norway*

Prior to his retirement in 2012, Jensen served as councillor of electronic communication to the Norwegian Embassy for the European Union. Willy served for 11 years as the director general for the Norwegian Post and Telecommunications Authority, and for two years as the director general to the Norway 2000 Cultural Program. Earlier in his career, he held key positions at the European Space Agency and Spacetec Ltd., and was also a professor at the University of Tromsø. Jensen has served in a number of different capacities on various national and international committees, including as a board member of the University of Tromsø and the Norwegian delegate to the IFIP.

Stanislav Dimukhametov, *Pro-Arctic / Russia*

Dimukhametov is the founder of Pro-Arctic, an organization dedicated to the management, promotion, and responsible and sustainable development of the Russian Arctic. Pro-Arctic also serves as a portal for Arctic professionals to connect to one another and share ideas and resources. In addition, he is responsible for the development of an online geo intelligence platform for the Arctic utilizing GIS applications, geospatial data cloud management, satellite AIS and remote sensing, and scientific data. Stanislav served as director of CreoProm from 2003 to 2012, where he lead the development and implementation of business-to-business, business-to-government, and business-to-community marketing campaigns for leading domestic and international energy, IT, telecom and automotive companies.

Yury Grin, *Intervale Group / Russia*

Grin is the deputy director general of Intervale, a group of companies focused on the e-commerce and mobile payment fields. He also serves as vice chairman of the ITU-T focus group on digital financial services. Previously, Yury worked for the ITU as chief of the conference and publication department and deputy to the director & chief of the administration and operations coordination department of the Telecommunication Development Bureau. While at the ITU, Grin assisted developing countries with various telecommunications-related issues including migrating from analog to digital broadcasting, radio frequency management and cybersecurity. Yury has also served in various positions within the Russian Federation's Ministry for Information Technologies and Communications. Yury is the recipient of numerous awards, including the Medal of the Soviet Peace Fund, and is a member of the International Academy of Communications and the Moscow Scientific Society.

Marianne Treschow, *TreschowConsulting / Sweden*

Treschow is the former director general and member of the board of the Swedish Post and Telecom Authority (PTS). She was appointed as the Commonwealth Telecommunications Organisation's ambassador for Scandinavia in 2010-2015. She is also senior advisor to Ericsson Group; advisor-Europe to VoIPSolutions; founder and CEO of TreschowConsulting; senior advisor to EcoDataCenter; expert for the Global Network Women in ICT; and a member of the Royal Academy of Engineering Sciences, the Swedish Institute of International Affairs, and i-CANADA´s Governors Council. In addition to a long career in PTS, Marianne has also held a number of important positions in Sweden including director of the Swedish Space Agency, director of the Swedish Natural Sciences Research Council and assistant professor in structural chemistry at Stockholm University.

Lori Davey, *Alaska Communications / United States of America*

Davey is director sales and service at Alaska Communications. She previously served as director business development and general manager at Fairweather LLC, which offers medical, aviation, weather forecasting, and logistics services to the oil and gas industries. Lori also serves as a trustee on the Alaska Nature Conservancy.

Karl Kowalski, *University of Alaska Fairbanks / United States of America*

Kowalski is chief information technology officer for the Alaska State University system, which consists of 16 campuses spread across 600,000 miles. Karl advises the University president, other university officers and the Board of Regents in matters related to information technology systems and services, and is responsible for the University's core information systems and services infrastructure, as well as for the coordination, development and implementation of system-wide information technology standards.

Drue Pearce, *Crowell and Moring LLC / United States of America*

Pearce joined Crowell & Moring in 2010 as a senior policy advisor with their environment, energy and resources, and public policy groups. Drue served in the Alaska State Legislature for 17 years, presiding as Senate President for two terms. She left the Legislature to serve as senior advisor to Secretaries Gale Norton and Dirk Kempthorne at the Department of the Interior. In 2006, she was nominated by President George W. Bush and confirmed by Congress as the first federal coordinator in the Office of the Federal Coordinator for Alaska Natural Gas Transportation Projects, an independent federal agency created by Congress in 2004. Governor Sean Parnell has appointed her to the boards of both the Alaska Gasline Development Corporation and the Alaska Aerospace Corporation. She serves as vice chair of both boards. Pearce also serves on the board of the Marine Exchange Alaska and is the chairman of the board of the Institute of the North.

Robert Walsh, *General Communications, Inc. / United States of America*

Walsh is director of rural broadband development for General Communications, Inc. (GCI). In that role, he is responsible for community relations in rural Alaska, solving sometimes delicate problems and bringing rural perspectives to senior managers. Robert's typical activities include conducting community meetings, following up on complaints and suggestions from the community, supporting GCI's work with the Arctic Council's Task Force on Telecommunications Infrastructure in the Arctic (TFTIA), conducting monthly rural advocacy committee meetings addressing service and transport issues, and creating innovative solutions to improve customers' communications service in the Arctic.

Kristina Woolston, *Quintillion / United States of America*

Kristina is vice president external affairs for Quintillion and is responsible for overseeing the company's external affairs. Kristina is also board chair of the Native American Contractors Association (NACA). Kristina was raised in the rural Alaska community of Naknek and is an Athabaskan shareholder of the Bristol Bay Native Corporation, the regional Alaska Native Corporation for southwest Alaska. Kristina worked for the World Trade Center Alaska where she advocated for Alaska businesses in their efforts to break into global markets. She has also worked for a private firm that represented oil and gas developers on the Sakhalin Island projects and for NovaGold Resources on the Donlin Gold project in western Alaska.

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