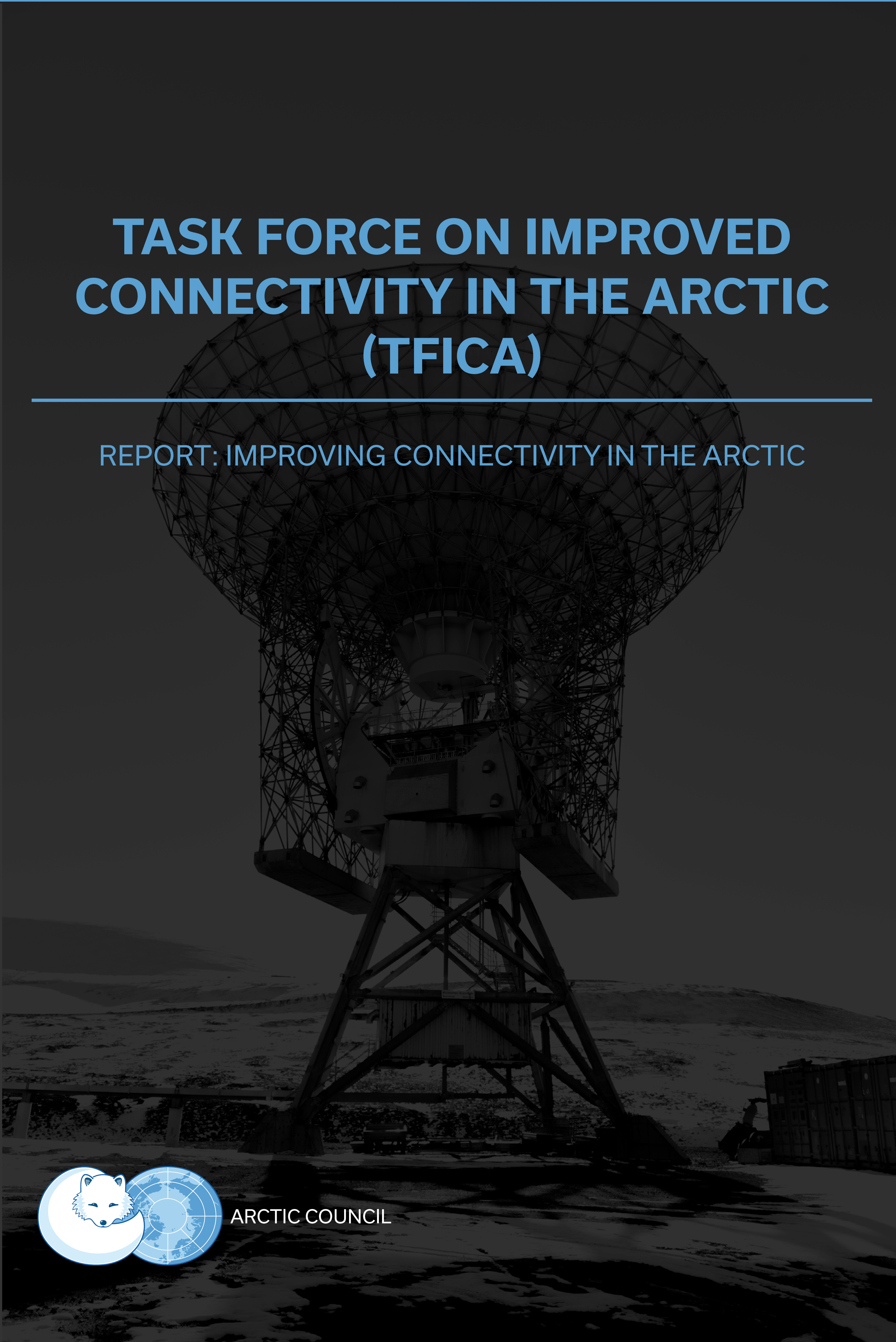
TASK FORCE ON IMPROVED CONNECTIVITY IN THE ARCTIC (TFICA)

REPORT: IMPROVING CONNECTIVITY IN THE ARCTIC



ARCTIC COUNCIL

Improving Connectivity in the Arctic
Final report: Rovaniemi Ministerial meeting - 7 May 2019
Improving Connectivity in the Arctic

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Terms and abbreviations used in this report

AEC	Arctic Economic Council
AIS	Automatic Identification System
ACGF	Arctic Coast Guard Forum
ADS-B	Automatic Dependent Surveillance-Broadcast
AIA	Aleut International Association
ANSP	Air Navigation Service Providers
ASBM	Arctic Satellite Broadband Mission
ASTAC	Arctic Slope Telephone Association Cooperative
CAF	Connect America Fund
CAFF	Conservation of Arctic Flora and Fauna
CLEO	Circumpolar Local Environment Observer Network
CONAS	Community Observation Network for Adaptation and Security
CPWG	Cross Polar Work Group
CSF	Competitive State Funds (Iceland)
CTI	Connect to Innovate Program (Canada)
EAFRD	European Agricultural Fund for Region al Development
EPPR	Emergency Prevention, Preparedness and Response
ETCs	Eligible Telecommunications Carriers (United States)
FCC	Federal Communications Commission (United States)
FSN	Finnish Shared Network
GCI	General Communications Inc.
GEO	Geostationary Earth orbit
GNSS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety Service
GSM	Global System For Mobile Communica tion Services
GPS	Global Positioning System
HEO	Highly Elliptical Orbit
HF	High Frequency, 3-30 MHz radio waves
ICAO	International Civil Aviation Organization
ICT / ICTs	Information and Communications Technology (or technologies)
IMO	International Maritime Organization
ICO	Intermediate Circular Orbit
IOT	Internet of Things
IP	Internet Protocol
IT	Information technology
KMAO	Khanty-Mansi Autonomous Okrug-Yugra
KRG	Kativik Regional Government
LEO	Low-Earth Orbit
LF	Low Frequency, 30 kHz – 300 kHz radio waves
LTE	Long-Term Evolution
MF	Medium-Frequency, 300 kHz to 3 mHz radio waves
MBR	Maritime Broadband Radio
NCA	Norwegian Coastal Administration
NCG	Norwegian Coast Guard
NGSO	Non-Geostationary Orbit
NORUT	Northern Research Institute (Norway)
NPS	National Park Service (United States)
NWT	Northwest Territories
PPs	Permanent Participants (Arctic Council)
PPDR	Public Protection and Disaster Relief
PPP	Public Private Partnership

PPRSC	Prevention, Preparedness and Response in Small Communities
PTS	Swedish Post and Telecom Agency
PNT	Positioning, Navigation, Timing
RSCC	Russian Satellite Communications Company
SAR	Search and Rescue operations
SDGs	Sustainable Development Goals (United Nations)
SDWG	Sustainable Development Working Group
SMS	Short Message Service
TFICA	Task Force on Improved Connectivity in the Arctic
TFTIA	Task Force on Telecommunications Infrastructure in the Arctic
TIF	Telecom Infrastructure Fund
TN	Thematic Network of the University of the Arctic
VHF	Very High Frequency, 30-300 mHz radio waves
UArctic	University of the Arctic
UHF	Ultra-High Frequency, 300 mHz- gHz radio waves
USFWS	US Fish and Wildlife Service
VDES	VHF Data Exchange Systems
VSAT	Very Small Aperture Terminal

Foreword

The Task Force on Improved Connectivity in the Arctic (Task Force) started its work in Helsinki in November 2017, where it held its first meeting. Since then, the Task Force had three other meetings:, one in Washington D.C in May 2018, the next in Copenhagen in September 2018, and the last in Reykjavik in December 2018. The participants of the meetings were the delegates from the Arctic states, Permanent Participants (PPs), Arctic Council Working Groups (WGs) and Observers.

Since the first meeting, the group focused on understanding user needs while it explored new technological solutions, commercial opportunities and industry best practices. The Task Force developed a clear vision where the aim was to engage with the telecommunications industry to deepen the analyses of the different user needs versus the available technologies and services in and for the Arctic. During the work of the past 14 months, the group invited a number of representatives from business entities, different authorities, stakeholders and various organizations to present their perspectives on the challenges of connectivity in the Arctic. In particular, a number of companies and organizations representing a wide variety of innovative technological solutions were invited to participate in the second meeting of the Task Force in Washington DC. At that meeting, the Task Force gained a better understanding of the technologies that exist today as well as those expected to develop in coming years. It also discussed user needs and explored ways to accelerate network deployment in the Arctic.

The Task Force continued its work in the third meeting in Copenhagen, where it had focused discussions on clarifying who are the different users of telecommunications services and what they need. Special attention was paid, in particular, to maritime and aeronautical safety and search and rescue issues from the perspectives of professional users.

The human dimension of connectivity (*i.e.*, user needs, and questions of resilience related to the people living in the Arctic) played a pivotal role in the discussions during all the Task Force meetings. This was also highlighted in the Levi Senior Arctic Officials' meeting held in March 2018, where the discussions concentrated on the needs of the different user groups and ways to solve everyday challenges to improve connectivity.

The Task Force continued to look for synergies with the Arctic Economic Council (AEC), exchanged views with the representatives of the Telecommunications Working Group of the AEC, and participated in the 3rd *Arctic Broadband Summit* in Sapporo, Japan, in June 2018. One of the main conclusions of the Task Force's work was that the Arctic Council would benefit from closer cooperation with the AEC to improve the outcome of this work.

Natural Resources Canada's antenna I-CAN. This artwork was done by the Inuvialuit artist Sheree McLeod // Photo by Peter Clarkson

1. Executive Summary

1. Executive summary

At the Arctic Council 2017 Ministerial meeting in Fairbanks, Alaska, the Ministers established the Task Force on Improved Connectivity in the Arctic (Task Force) and gave it a mandate to compare the needs of those who live, operate, and work in the Arctic with available infrastructure, and to work with the telecommunications industry and the Arctic Economic Council (AEC) to encourage the creation of the required infrastructure with an eye toward pan-Arctic solutions and to report to Ministers in 2019.[1]

As the Arctic is opening up, modern connectivity will underpin economic growth, and allow for the delivery of better services to Arctic peoples. By commissioning this report, Arctic states have delivered a strong message that further improvements to connectivity are needed. This work builds upon member states' commitments under the United Nations Sustainable Development Goals (UN-SDGs) to strive towards providing "universal and affordable access," in order to help achieve sustainable development and to empower communities.

1 See *Fairbanks Declaration (2017)*. Arctic Council Open Access Repository. Available from: https://oaarchive.arctic-council.org/handle/11374/1910.

1a. Key Findings

Close the digital connectivity gap. Arctic peoples require access to affordable connectivity of sufficient quality in order to participate in today's digital economy.

Opportunities for improved connectivity in the Arctic are on the horizon. Over the next few years, existing and emerging connectivity technologies are expected to become more widely available which, if successfully coordinated with industry, could improve service in the circumpolar regions.

The digital economy is taking shape in the Arctic. There is a new trend of data centers emerging in some Arctic states due to economic advantages related to lower cooling energy costs and a safe operating environment. Additional connectivity will help to support this growing industry.

Multiple solutions for connectivity. The telecommunications industry expressed its desire to provide connectivity solutions in the Arctic using a variety of platforms and technologies so that all tools can be utilized to improve connectivity.

Importance of redundancy. Network reliability is important for all users, but especially for health clinics, schools, public safety and emergency service institutions and businesses. The use of public-private financing models. Public investment often supplements private investment to increase deployment of connectivity solutions in remote and less densely populated areas. This will also be true in the Arctic.

Enable industry innovation through regulatory flexibility. The telecommunications industry expressed an interest for a regulatory environment that allows for piloting new technologies to facilitate earlier commercial deployment in the Arctic.

Need for regulatory clarity. The telecommunications industry cited challenges in understanding the regulatory requirements for infrastructure development unique to the Arctic region.

Windows of opportunities for infrastructure installation are short. Regulatory delays of a few weeks can result in postponing the implementation of projects for a year, due to a short construction season in the Arctic.

Gaps remain in Positioning, Navigation and Timing (PNT) services available across the Arctic. Improved coverage of augmentation systems for Global Navigation Satellite System (GNSS) in Arctic areas is desirable.

Information gaps concerning Arctic connectivity remain. The ongoing dissemination of statistics on connectivity, penetration and access across the circumpolar Arctic would enhance knowledge in this area. Future academic research on connectivity in the Arctic may require funding.

The AEC seeks to be a resource body for the Arctic Council's future work on connectivity. Building on their work with the Task Force, the AEC sees a need for future collaboration with the Arctic Council in order to maintain focus on improving connectivity in the region and addressing outstanding issues.

1b. Recommendations

The Task Force recommends that the Arctic Council:

- Work with the telecommunications industry to:
  - engage with indigenous groups during the design and implementation phases of network technology infrastructure;
  - demonstrate that new technology can withstand Arctic climatic and environmental conditions; and
  - develop connectivity that supports maritime and aeronautical users and, in particular, search and rescue efforts.
- Support the AEC's engagement with the telecommunications industry and other experts to expand and accelerate network deployment across the Arctic.
- Engage with the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), as well as other external bodies, to raise awareness for the need for improved connectivity in these industries when operating across the Arctic region.
- Support continued collaboration among the Arctic Council Working Groups to further the goal of improving connectivity for Arctic users.
- Facilitate the collection of statistics in order to measure connectivity, penetration and access across the Arctic region on an ongoing basis.

The Task Force encourages Arctic Council states to:

- Provide regulatory clarity that can support increased investment to accelerate network deployment in the Arctic.
- Consider ways to accommodate emerging technologies that may not yet have relevant rules and regulations.
- Consider ways to incentivize investment by reducing regulatory burdens while still respecting environmental assessments and other public policy objectives.
- Develop regulatory policies that reward and recognize a mix of technologies and service providers (technology neutrality). Considering there is no one-size-fits-all approach, encourage national incentive schemes to be results-oriented and outcome-focused to improve innovation and allow for new technological possibilities in the Arctic.

2. The Arctic Council and connectivity

2. The Arctic Council and connectivity

This report by the Task Force is part two of the Arctic Council's recent work on improved connectivity in the Arctic. The first report was written by the Task Force on Telecommunications Infrastructure in the Arctic (TFTIA) and can be found on the Arctic Council's Open Access Repository web page.[2] The TFTIA recommendations, conclusions on infrastructure, and discussions on user needs stand on their own, and the TFICA used the TFTIA information as the basis for its work. Therefore, to the maximum extent possible, the outcomes of the TFTIA Report are not repeated in the TFICA Report.

The TFICA report builds on the work of the TFTIA to focus more specifically on: 1) the evolutions in the industry that can or will serve users in the Arctic; 2) financial and other models that may help stimulate investment in Arctic telecommunications infrastructure; and 3) relationships that may lead to further collaboration and cooperation on Arctic telecommunications.

In preparing this report, the Task Force engaged with the telecommunications industry, the AEC, and other interested stakeholders to identify possible connectivity solutions for the Arctic – both technological developments of special interest to the Arctic and various financial models that have been used to improve connectivity to hard-to-serve locations.

It was understood in the Task Force that the users in the Arctic are not unique in why they need improved connectivity, but rather that the conditions of serving those users (climate, distance, lack of related infrastructure) present the commercial providers with difficult challenges to overcome. Moreover, industry representatives noted that lack of power supply, difficulties in maintaining facilities and significant hurdles to achieving financial profitability represented additional challenges for connectivity in the Arctic.

2 The report of the Task Force on Telecommunications Infrastructure in the Arctic (TFTIA) is available here: https://oaarchive.arctic-council.org/handle/11374/1661.

3. Highlights from what we heard from the telecommunications industry

3. Highlights from what we heard from the telecommunications industry

The Task Force engaged with several telecommunications companies who serve the Arctic today, who will serve the Arctic in the next few years, or who have technologies available that could help improve connectivity in the Arctic. Participating companies included satellite providers, undersea cable providers, domestic telecommunications providers, radio communications equipment providers, and technology service integrators. In addition, the Task Force considered the input from the AEC. The companies mentioned below are a few examples of providers of different technologies and services.

Natural Resources of Canada's antenna I-CAN. This artwork was done by the Inuvialuit artist Sheree McLeod // Photo by Jiri Raska

3a. Available and emerging technologies and services

This section provides a brief overview of selected available or emerging connectivity technologies with applicability in the circumpolar Arctic. It also explores the types of services that may be commercially offered today or in the near future leading to improved connectivity in the Arctic.

Low Earth Orbit (LEO) Satellites

There are multiple types of LEO systems, which serve different purposes and provide different capabilities. These include: broadband services (including internet access), narrowband services (including short message delivery), telecommunications services, remote sensing, as well as scientific usage.

Broadband services

A number of companies are currently competing to be first-to-market with a fully functioning constellation of next generation, high-throughput LEO satellites to provide broadband and other data services. Some of these companies plan to connect satellites by (optical) high speed inter satellite links used to route data between satellites before transmission down to ground stations. While the number of satellites in each company's constellation differs from as low as approximately 100 satellites to as high as 4,500 satellites, most share similar commercial objectives.

These constellations are being built to serve the entire surface of the Earth. As a result, Arctic areas should be able to capitalize on the high-level private sector investments in this new technology. If and when they materialize, Arctic users are expected to benefit from lower access costs and higher connectivity speeds than they receive today. It is important to realize that there are differences in how Arctic users will be able to take advantage of these new offerings – with some companies preferring to remain wholesalers, working with other retail service providers, while others are preparing to enter into the consumer market.

COMPANY NAME: OneWeb
LOCATION: United Kingdom and United States

TECHNOLOGY: LEO constellation of 600 satellites that will provide data and broadband direct to end users and telecommunication service providers (*i.e.*, whole sale operations).

ARCTIC COVERAGE:

Current: Not available

Planned: Full Pan-Arctic (and global) coverage. Service offerings are expected to begin in 2019 with initial and full Arctic coverage expected in service by 2020-2021.

COMPANY NAME: SpaceX (Starlink)
LOCATION: United States

TECHNOLOGY: LEO constellation of 4,500 satellites that will provide data and broadband direct to end users as well as to service providers. SpaceX is applying its manufacturing expertise and space operations skillset toward developing its constellation.

ARCTIC COVERAGE:

Current: Not available

Planned: Full Pan-Arctic (and global) coverage. Service offerings are expected to begin in 2019 with full Arctic coverage to follow.

Narrow-band communications

Narrow-band LEO or Medium Earth Orbit (MEO) systems usually have direct end user access. These systems could transport short messages and voice that require limited bandwidth. They are meant to offer services for users of ship and air traffic tracking system (*e.g.,* AIS and ADS-B transponder signals), for safety and rescue services, for sensor systems (Internet of Things) as well as for individuals and business.

COMPANY NAME: Gomspace
LOCATION: Denmark and Sweden

TECHNOLOGY: Nanosatellites, the size of a toaster, that provides a variety of data and scientific services (*e.g.,* for ship and aircraft tracking).

ARCTIC COVERAGE:

Current: Launched a demonstration for surveillance in the Arctic.

Planned: Nanosat for Arctic surveillance.

COMPANY NAME: Omnispace
LOCATION: United States

TECHNOLOGY: Operates in the S-band, with about 60 megahertz globally. As a result, it is more focused on narrowband connectivity, rather than broadband. It is an emerging provider of hybrid connectivity solutions globally that seeks to leverage its past satellite infrastructure (*i.e.*, ICO F2 satellite) alongside a new Non-Geostationary Orbit (NGSO) constellation.

ARCTIC COVERAGE:

Current: Limited pole-to-pole global coverage.

Planned: Omnispace intends to provide 24/7 coverage at the poles, and in the future, the company will be focused on mobile satellite services.

COMPANY NAME: Iridium
LOCATION: United States

TECHNOLOGY: Global LEO constellation of 66 satellites that provides voice and data connections for a range of applications (*e.g.*, maritime, aviation, and search and rescue). Iridium has completed the replacement of its current satellite system with a new system, Iridium NEXT.

ARCTIC COVERAGE:

Current: Pole-to-pole global coverage.

Planned: Iridium foresees that the Internet of Things (IOT) will be an important area of growth driven by the increasing need for global tracking capability.

Highly Elliptical Orbit (HEO) Satellites

Currently, Norway and Russia are planning to launch high speed HEO satellite systems having two or four satellites, respectively. These HEO satellites are meant to serve the needs of these countries and are capable of serving the circumpolar Arctic. In addition to governmental services, they have a commercial capacity as well. These are state-initiated systems that will combine both public and private financing.

Antenna and satellites in Iqaluit, Canada // Michael Delaunay

COMPANY NAME: Russian Satellite Communications Company (RSCC)
LOCATION: Russian Federation

TECHNOLOGY: Operates 12 geostationary satellites, with 11 of them located from 40 degrees West to 145 degrees East, providing close to global coverage. RSCC is planning a HEO system of four satellites providing full circumpolar coverage.

ARCTIC COVERAGE:

Current: Provides connectivity and communications services throughout Russia, including to communities in the Russian Arctic and to vessels operating above the Arctic Circle.

Planned: Provide connectivity services outside the Russian market, particularly through their new HEO constellation system that is expected to be available by 2023.

COMPANY NAME: Space Norway
LOCATION: Norway

TECHNOLOGY: Space Norway plans to operate in the Arctic Satellite Broadband Mission (ASBM), which is a cooperative effort aimed at providing broadband connectivity north of 65 degrees North latitude (*e.g.,* terrestrial, maritime and airspace). The ASBM is based on the HEO system composed of two satellites. This capacity is critical to perform effective Search and Rescue in northern areas. Space Norway is working with private satellite operators to also provide satellite-based coverage on a commercial basis.

ARCTIC COVERAGE:

Current: Unavailable.

Planned: Pan-Arctic coverage. Contracts are expected to be signed in spring 2019. Full operational capacity will be in place 2023.

Other wireless technologies

4G Long-Term Evolution (LTE) technology is a mature technology that can be used as a mobile wireless solution in communities and other sites (*e.g.,* mining camps; ships; research stations). However, this may not always be sufficient because public safety authorities, mining companies, etc. often require direct phone-to-phone connections as well as transportable systems that can be installed where needed. In marine areas, high frequency (HF) communication is a common wireless solution. Recent developments in HF radio and networking technology are increasing reliability and availability that have overcome HF bottlenecks in the past. Finally, especially in the public safety sector, there are systems that combine various technologies to achieve multiple tasks simultaneously.

COMPANY NAME: Motorola Solutions
LOCATION: United States

TECHNOLOGY: Mix of technologies and hybrid wireless solutions focusing on the user needs of groups and customers through public-private research initiatives. It is a developer of “mission-critical” and “business-critical” solutions across a variety of sectors, such as defense and public safety, industrial solutions (*e.g.,* oil, gas, and mining), and hospitality.

ARCTIC COVERAGE:

Offers transportable system that requires a backhaul connection (*e.g.,* internet access).

COMPANY NAME: KNL Networks
LOCATION: Finland

TECHNOLOGY: High Frequency (HF) radio technology with cognitive networking combined with mobile radio technology. It focuses on offering connectivity and communications used by the maritime industry, as well as information security providers.

ARCTIC COVERAGE:

Current: Global coverage, including the circumpolar Arctic.

Planned: As the number of radios in use increases in the future, the reliability and services could be expected to increase.

COMPANY NAME: COSPAS – SARSAT PROGRAMME
LOCATION: International Organization (44 governments and agencies) with headquarters in Canada

TECHNOLOGY: Search and rescue beacon network connecting end users via satellites to ground stations. It provides accurate, timely and reliable distress alert and location data in 228 countries and territories to help search and rescue (SAR) authorities assist persons and vessels in distress.

ARCTIC COVERAGE:

Current: Global coverage using various satellites systems (*e.g.,* GALILEO).

Planned: Exploring ways to add two-way communications co-located with radio messenger devices and improving the payload (*i.e.,* data).

Fibre optic cables – terrestrial and undersea

The Arctic will hopefully benefit from investments in new fibre optic infrastructure, both terrestrial and submarine cables, which are largely driven by global demand. There are several pending projects that seek to significantly expand fibre deployment in the Arctic. The installation and operation of these cables should benefit from experiences gained by recent deployments of undersea cables in the Arctic.

COMPANY NAME: Cinia
LOCATION: Finland

TECHNOLOGY: Provides network and software services. From 2014 to 2016, it developed and invested in an undersea cable system in the Baltic Sea (called C-Lion1).

ARCTIC COVERAGE:

Current: Connecting Finland directly to Germany.

Planned: In line with Finland's strategic plan to increase Arctic connectivity and enhance the development of an Arctic data route, Finland has requested Cinia to facilitate the government's "Arctic Connect" initiative, which aims to connect Europe, Asia, and North America via the shortest distance across the Arctic.

COMPANY NAME: Quintillion
LOCATION: United States

TECHNOLOGY: Undersea fibre optic cable network that seeks to provide high-speed internet access to the North American Arctic and connect this region to Asia and Europe.

ARCTIC COVERAGE:

Current: Privately-owned fibre wholesaler serving five northern Alaskan Communities (Phase 1).

Planned: Phase 2 will aim to connect Alaska to Japan by 2020. Phase 3 is expected toconnect Alaska to the United Kingdom with possible landing sites in the Canadian Arctic.

Airport communications installation in Iqaluit, Canada // Michael Delaunay

3b. Challenges to accelerating network deployment

Building and maintaining infrastructure in many areas of the Arctic is challenging due to the terrain, harsh climate, vast distances, and dispersed populations. Cold temperatures and large amounts of snow and ice can impact the reliability of communications equipment and may require special measures to mitigate risks.

In addition to these factors, service providers identified a higher cost environment and challenges with staffing as affecting the deployment of network infrastructure within some areas of the Arctic. Specific issues cited were the costs of deploying and maintaining connectivity infrastructure in areas that lack road access and are not connected to an electrical grid. In these cases, companies have had to employ alternative measures such as constructing supplementary infrastructure (*e.g.,* power generation). In addition, staffing can sometimes be challenging due to an insufficient availability of specialized contractors to install and maintain network infrastructure necessary for full deployment. The process of recruiting, training, and retaining local workers is also often difficult in Arctic locations. Overall redundancy issues (*e.g.,* reliance on single network systems) also generate ongoing operating issues.

COMPANY NAME: NorthwesTel
LOCATION: Canada

TECHNOLOGY: Hybrid with fibre, microwave, and satellite networks.

ARCTIC COVERAGE:

Current: Available in 96 communities (*i.e.,* Yukon, Northwest Territories, Nunavut, and northern British Columbia). However, the level of service provided varies depending on technologies used.

Planned: Tamarmik Nunalitt project is expected to bring 15 Mbps internet and 4G wireless to every Nunavut community by 2019. NorthwesTel is a partner in the Canada North Fibre Loop, which will be a fully redundant fibre loop when the last leg is completed.

COMPANY NAME: GCI
LOCATION: United States

TECHNOLOGY: Largest Arctic network in the United States based in Alaska using various technologies (*e.g.,* satellite, fibre, mobile and microwave). GCI has invested close to $1.4 billion USD in its expansion over the last decade.

ARCTIC COVERAGE:

Current: Coverage across 100 communities in Alaska.

Planned: Lay undersea fibre along the coastline of the Aleutian Islands in Alaska.

COMPANY NAME: TELE GREENLAND
LOCATION: Kingdom of Denmark

TECHNOLOGY: Multiple telecommunications infrastructure technologies (*e.g.,* submarine fibre network, radio links, satellites, satellite connections).

ARCTIC COVERAGE:

Current: The submarine cable was extended in 2018 with Greenland Connect North, to provide broadband internet connections to the most populous towns on the Greenlandic west coast.

Planned: With the extended submarine cable, upgraded radio links and local connections, Tele Greenland aims to provide high-speed internet to 92% of the population. The remaining 8% will, for the foreseeable future, be served by satellite connections.

COMPANY NAME: FAROESE TELECOM
LOCATION: Kingdom of Denmark

TECHNOLOGY: A full portfolio of telecommunications services and products over multiple technologies, including fibre backbone in the islands that drives the availability of fixed broadband connectivity to all people in the Faroe Islands.

ARCTIC COVERAGE:

Current: Faroese Telecom Mobile provides broadband over 4G LTE, which has been deployed and is made available everywhere on the islands. Faroese Telecom is also servicing the maritime community with long range mobile connections up to 120 km from shore. In addition, Faroese Telecom provides mobile coverage to ships in the Arctic via 'Arctic Mobile'.

Planned: 5G mobile broadband is expected to be implemented in 2019.

3c. Regulatory barriers

In addition to these operational and technical challenges, some industry stakeholders have found regulatory barriers difficult to overcome. Regulatory challenges cited include regulatory uncertainty, a lack of transparency, and the duration of the process to obtain licenses and permits. For example, a cable installer reported that there were no precedents about the applicable regulatory processes, resulting in the company having to follow various processes for regulatory permits generally applicable to other industries, such as oil pipelines or utility cables. This created significant uncertainty related to timeframes, fees and processes. In the Arctic, clarity over the process and timelines is critical because, due to weather patterns, installation often needs to take place during narrow windows of opportunity. Delays of the permitting process by weeks or a month can delay a project an additional year — when access is again available.

Various stakeholders also suggested that it would be helpful if governments created opportunities for companies to undertake small pilot or proof-of-concept projects involving new technologies. These projects can help identify lessons learned and best practices, as well as relevant regulatory issues, for potential larger scale projects. Various stakeholders observed that having good regulatory practices, especially for cross-border projects, can also be particularly helpful. Companies also advocated that regulators provide opportunities for access to unlicensed spectrum, which in some circumstances may allow deployments at lower cost and quicker speed-to-market than exclusive-use licensed spectrum. It was also proposed that governments consider having a lead agency when multiple governmental agencies are involved in the review of a project, citing Norway as a good example.

Juneau, Alaska, U.S.A. // Linnea Nordström

4. Facilitating access to technologies

4. Facilitating access to technologies

A number of existing technologies are already providing connectivity in the Arctic or will be able to do so in the near future. The focus of this chapter is to identify examples of financial models applicable for supporting the development, implementation and operation of systems and services for improved Arctic connectivity. This discussion is based on case studies submitted by the Arctic states, which provided insights into how concrete Arctic connectivity challenges are currently addressed – from both technological and financial perspectives.

4a. A picture of financial models relevant for connectivity in the Arctic

Some general trends for financial models used for projects related to improving connectivity in the Arctic can be identified. An important trend is that large infrastructure projects (*e.g.,* electricity, roads, telecommunication cables, satellite systems, etc.) may involve a substantial amount of public funding.

Even though financing schemes vary, the overall concept of substantial public contributions is based on the realization that large infrastructure projects, with a limited number of users, represent an insufficient business case for pure private/commercial financing – at least in the development and implementation phase. Therefore, to help improve connectivity in the Arctic, other sources of funds may need to be sought to spur initial investment.[3] Smaller projects exploiting existing infrastructure can, however, often be developed and implemented on a purely private/commercial basis.

Table 1 shows a summary of examples with a brief outline and funding principles.

Table 1. Summary of examples including their funding scheme

Cases	Solution outline	Funding principle: private, public, hybrid
Canada: **Connect to Innovate Program**	High-capacity backbone in rural and remote areas, last-mile infrastructure to households and businesses	Hybrid
Finland: **Finnish Shared Network**	Cellular rural coverage	Private
Iceland: **Iceland Broadband Coverage**	Broadband to remaining households	Hybrid
Kingdom of Denmark: **Arctic Mobile**	GSM hot spot in ships with satellite back-haul	Private
Norway: **VDE-SAT; Maritime Broadband Radio**	Safety at sea via satellite; from AIS base stations to internet/mesh network for datacom	Public; public
Russia: **Digital Camp**	Satellite connection to communities	Public
Sweden: **High-speed broadband in Sweden**	Rural broadband where there is market failure	Hybrid (state aid)
United States: **Alaska Plan**	Rural and remote broadband connection	Hybrid

3 See examples from the "Business Financing in the Arctic Report" (2018): http://um.dk/en/foreign-policy/the-arctic/business-financng-in-the-arctic.

4b. Concrete examples of challenges

Case studies provided by the Arctic Council states illustrate various approaches to the implementation of telecommunications technologies and their applications to provide connectivity across the Arctic region. The provided examples cover most of the existing technologies such as fibre cables, satellites and land-based radio systems.

Canada

Connect to Innovate Program

In Canada, investment in telecommunications networks is primarily led by the private sector. Broadband speeds of 50 Mpbs or above are available to 98% of Canadian households in urban areas; however only 41% of rural Canadian households have access. To help close this gap, the Government of Canada launched the Connect to Innovate (CTI) program to expand high-capacity backbone in rural and remote areas. By 2021, CTI will improve connectivity in more than 900 communities, including 190 indigenous communities. In total, CTI contributions as well as leveraged funds from other levels of government and private sector partners will provide more than CAD 1 billion towards improved connectivity. Below are examples of northern CTI projects.

Dempster Fibre Link

The Dempster Fibre Link will run approximately 777 km from Dawson City, Yukon to Inuvik, Northwest Territories (NWT). By closing the 4,000 km long Canada North Fibre Loop, it will significantly reduce the risk of internet service interruptions in more than 70 communities. The project is being funded through a public-private partnership: Government of Canada (CAD 59 million), Government of Yukon (CAD 5 million) and NorthwesTel (CAD 15 million).

Currently, communities in Yukon as well as parts of the NWT and northern British Columbia are reliant on a single fibre link. As a result, network outages are common due to mechanical damage to cables caused by flooding, forest fires, construction work and other operations in the right-of-way. By creating a loop, this new fibre link will provide an alternative pathway in which traffic can be temporarily re-routed. Furthermore, it will also offer protection to voice, data and wireless satellite services as satellite traffic from Nunavut and NWT is routed through a ground station in Whitehorse. Lastly, two communities will be upgraded to fibre optic.

Tamaani Internet Phase 5 Project

The Tamaani Internet Phase 5 Project will help reduce the digital gap in Nunavik, Québec, by improving internet service to all 14 communities. Led by the Kativik Regional Government (KRG), the proposed solution involves a mix of technologies: a new subsea fibre link to Puvirnituq; a microwave backbone to serve Kuujjuaq; the reallocation of satellite capacity to the remaining communities; and the deployment of fibre-to-the-home in 10 communities. The financial model involved a federal-provincial-indigenous partnership. The Governments of Canada and Québec will each invest CAD 62,6 million in the project, with KRG contributing CAD 500,000.

This subsea fibre link is intended to enable residents in the four connected communities to have access to Internet service packages on par with those available to Canadians in major cities. By increasing overall capacity and speeds, this project seeks to generate new educational and economic opportunities, and to also improve videoconferencing, bringing residents in these fly-in-only communities closer together. In the future, the subsea link could serve as a stepping-stone to bringing high-speed broadband to other communities in the region.

Finland

Finnish Shared Network Ltd.

In 2014, two of the three major mobile operators (DNA and Telia Finland) established a shared network company to provide 2G, 3G and 4G coverage in rural areas in Northern and Eastern Finland. Networks cover half of Finland's total geographical area and serve approximately 15% of the population.

Finnish Shared Network Ltd. is not a telecommunications operator, but it provides coverage directly to DNA and Telia. It does not sell mobile subscriptions directly to consumers or corporate customers.

DNA and Telia are using the Finnish Shared Network (FSN) mobile network to provide services to their customers in rural and remote areas. FSN offers a number of benefits such as improved coverage for mobile broadband and calls, improved mobile broadband throughput speeds and connection quality for rural and remote areas.

With the shared network, the two operators can increase the number of base stations in rural and remote areas and double connection speeds utilizing combined DNA and Telia spectrum resources. Sharing the network in rural areas brings cost effectiveness and reduces the CAPEX compared to the situation in which both operators would invest in separate networks. This lowers the barrier to invest in coverage in rural areas.

Iceland

Connectivity in Iceland is relatively well secured regarding both fixed line and mobile service. 99% of homes have high speed (> 30 Mbps) broadband connections. 99.7% of the population has access to high speed mobile service, 90% of the landmass is covered and most of the ocean around Iceland (up to 100 km) have high speed mobile service.

Mobile connectivity

Allocation of frequencies for mobile communication is done by auction process. The mobile systems are financed by private initiative where there are market demands in place. This has shown to be approximately 99% of the population where access to service can be secured by market means. This is secured by coverage requirements in the frequency licenses for lower frequencies. State aid may be used to fill the remaining 1% gap as well as to secure service access for Public Protection and Disaster Relief (PPDR) services and remote tourist areas. The state aid can be either through the Telecom Infrastructure Fund (TIF) (*e.g.*, for PPDR connectivity) or as a rebate from the auction price of frequencies in return for a commitment to secure service access in dedicated remote areas.

Fixed line connectivity

The Government of Iceland has a five-year program to facilitate access by 99.9% of homes and business locations to 100 Mbps fixed line connection by year-end 2020. The program initiative involves public-private partnerships and is solely aimed at making fibre economically available for around 4% of homes and businesses in rural areas where market failure exists. By the end of 2018 over 70% of this goal will be achieved.

This will help improve socio-economic opportunities so that end users will be able to access education or to develop a professional activity that requires high-speed broadband connections. The program will also strengthen the core fibre network of Iceland.

Eligible entities for state aid are approximately 60 municipalities, which are obliged to add a complementary contribution. The total program scope is around 6000 buildings.

The program is based on a regulatory framework in accordance with EU-regulations. Competitive State Funds (CSF) are made available annually for every part of the country for specific projects under the supervision of the national telecom infrastructure fund.

The original budget (estimate) is ISK 5 to 6.7 billion with state aid accounting for around ISK 3.1 billion and the remainder coming from municipalities, telecom operators and users.

Kingdom of Denmark

Arctic Mobile

The goal of this project is to deliver global system for mobile (GSM) communication services to crews of fishing vessels in Arctic waters. Developed by telecom operators in Iceland, Greenland and the Faroe Islands, a GSM base-station is installed on the vessel by the operator to provide the crew with voice and SMS services. The crew pays the normal GSM subscription, which includes the use on the ship as if they were at home. Operations commenced in early 2016.

With this solution, crews on fishing vessels can communicate with their GSM handsets, as if they were on shore with normal GSM coverage. This service is a clear benefit for the many sailors working on-board fishing vessels. They are able to maintain contact with friends and family, with no extra cost. It also supports the way of life, where a portion of the population is away from home fishing for extended periods. Good communications are essential for attracting young people to these jobs, and thereby contributing to the viability of local communities.

Norway

VDE-SAT

VDE-SAT is the satellite component of a Data Exchange System using radio frequencies in the VHF-band for communications (VHF Date Exchange Service or VDES). It aims to become fully operational in the 2020-2024 timeframe. VDE-SAT is under development by international maritime and telecommunications organizations. The overall goal for VDES is to improve the safety of life at sea, the safety and efficiency of navigation, the protection of the marine environment, as well as to enhance maritime safety and security. The terrestrial component of the VDES (VDE-TER) provides service coverage in coastal waters, while VDE-SAT extends the system to global coverage using LEO satellites. The first VDE-SAT test satellite (NorSat-2) was launched by Norway in 2017 and has demonstrated broadcasting of graphical ice charts to vessels and reception and relay of vessel position reporting.

There is currently a lack of affordable communications systems that are widely deployed on vessels in Arctic waters. Weather and hydrological forecasts cannot be received as broadcasts. VDES supports most of the 16 e-Navigation digital services defined by IMO (such as broadcasting of weather maps, SAR coordination with digital transfer of search patterns, harbor reporting and Vessel Traffic Services (VTS)).

As described above, the primary services intended for VDES and VDE-SAT are for improvement of the safety of life at sea etc. VDE-SAT can also support other, more commercial services, but these service opportunities will only be exploited when there is a large installed base of user equipment. The financial model is expected to be based on public funding by maritime authorities and administrations. However, deployment of the VDE-SAT could be organized as a private-public partnership (PPP), where the private part could be expanded as commercial services are rolled out. The total system cost for Arctic coverage depends on message latency requirements and the number of satellites needed to provide the intended service quality. Combined AIS and VDES satellites such as NorSat-2 have an approximate cost of less than EUR 4 million in orbit.

The potential user group for VDE-SAT services include all vessels operating outside shore-based VHF coverage (50 nautical miles from VHF coast stations). The next generation AIS ship terminals are expected to include VDES functionality in the same box, using one common VHF antenna.

VDES is an extension of the successful AIS and has been developed as an open global standard. As most ships will carry AIS, the incremental equipment and installation cost is expected to be low, thereby facilitating deployment of a large number of satellite communications terminals. Thus, VDES is expected to be fitted on-board all ships, ranging from small fishing vessels to large tankers and cruise liners.

Maritime Broadband Radio (MBR)

A radio device called Maritime Broadband Radio (MBR) has been developed by Kongsberg Seatex AS to transfer data from AIS base stations to the Internet. Furthermore, MBR units within communications' reach of each other form a mesh network for data communications, establishing a local wireless network between assets with MBR installed. The first 5 units were installed in 2017 and are in operation. Each MBR unit costs NOK 300,000 (including installation). The wireless range is approximately 50 km from vessel to vessel and base station to vessel. The range is approximately 200-250 km between vessel/base station and aircraft.

MBR provides a broadband communications solution with a data rate of 15 Mbit/s between MBR installations, enabling the possibility of data exchange in Arctic areas where satellite communication is not available. The implementation cost is relatively low as, for instance, land-based MBR installations make use of existing infrastructure (*e.g.,* Telenor Svalbard and Avinor installations).

The MBR installations have been financed through the investment budget of the Norwegian Coastal Administration (NCA). A financial model allowing third party users into the network is not established yet. NCA will consider connecting further users after evaluating their needs based upon applications. Telenor Svalbard AS, Northern Research Institute (NORUT), the Norwegian Coast Guard and the Governor of Svalbard are users of the network. There are at present no costs for the end users.

Russian Federation

Project "Digital Camp" ("IT camp")

For indigenous peoples of the North living in remote areas, access to communications and the Internet are of fundamental importance.

A "Digital Camp" project has been launched in the Khanty-Mansi Autonomous Okrug - Yugra (KMAO), which is designed to provide broadband internet through satellite communication technologies across traditional territories of Russian indigenous peoples. The project is aimed at ensuring information accessibility for indigenous peoples of the North and facilitating their integration into the modern digital society.

The technical component of the "Digital Camp" project includes the installation of a satellite dish and equipment for providing access to WIFI, as well as connecting subscriber devices. Within this project, local residents will be introduced to the state and municipal service portal "Gosuslugi" (www.gosuslugi.ru).

The estimated project cost for the first year is 210,000 rubles (including: the cost of satellite equipment - 160 000 rubles, the cost of equipment for providing wireless access - 10 000 rubles, the cost of a laptop - 40 000 rubles). The estimated annual cost of project support is 230 000 rubles per year (including: a 70 GB traffic package per month with the Internet speed of up to 4 Mbit/s - 15 000 rubles per month, maintenance service twice a year - 50 000 rubles).

In 2019, the installation and connection of equipment for broadband satellite Internet are planned for 7-8 camps of reindeer herders in the Russian Arctic. In the future, this new technology will provide reindeer herders with the possibility of organizing video calls. Internet users will therefore have an opportunity to see the life of reindeer herders, which is expected to contribute to the development of ethno-tourism in the Khanty-Mansi Autonomous Okrug.

Sweden

State aid for deployment of high-speed broadband

Overall, Sweden has good broadband coverage, but areas outside towns and small villages lack a high degree of access to high-speed broadband. According to the latest survey made by the Swedish Post and Telecom Agency (PTS), 95% of the population has access to 30 Mbps, 79% to 100 Mbps and almost 100% to broadband via LTE (4G).

The Government's main national state aid program for the period 2014-2020 aims to increase deployment of high-speed broadband in rural and remote areas where no commercial deployment is planned within three years (in accordance with the state aid rules of the EU). The state aid funding of SEK 4,25 billion is expected to provide about 361,000 people with access to high speed broadband. The aid is channeled through the European Agricultural Fund for Regional Development (EAFRD).

The national managing authority for the aid program distributes the aid to the regional level (county-level) in accordance with a distribution key based on access rate to 100 Mbps and population density in the particular region.

Individual projects apply for support with aid levels that can vary between 40% and 90% of the eligible costs. The projects are obliged to add the additional funding required, depending on aid level, to reach 100%. Entities eligible for aid are authorities, municipalities, regional actors and other organizations or companies that are legal entities. The aid-scheme is technology neutral and wireless solutions can also be used as long as they provide high-speed broadband in line with certain criteria.

The Government recently assigned the PTS to develop a potential future model for state aid funding. Since the remaining households lacking access to high-speed broadband are increasingly scattered geographically and are expensive to reach, PTS concluded that a more centralized top-down approach would likely be a more efficient model for future aid schemes.

United States

Federal Communications Commission (FCC) Programs Funding Universal Service in Alaska

In the United States, the FCC administers a Connect America Fund (CAF) program targeted to making fixed and mobile broadband available in locations unlikely to receive broadband on a private commercial basis. The goal is to have broadband service available everywhere people live, work, and travel, even in the most remote high-cost areas of the nation. The CAF program is funded by assessments on telecommunication carriers, which must contribute based on a carrier's interstate and international end-user telecommunications revenues. Support is distributed to Eligible Telecommunications Carriers (ETCs), which are defined by statute, with further details established by the FCC.

Given the unique challenges posed by the state, the FCC has adopted an "Alaska Plan" that provides USD 1.5 billion in dedicated funding over ten years solely to smaller carriers serving remote areas of Alaska. The Plan's goals are to maintain, extend, and upgrade wireline and mobile broadband service across the remote areas of Alaska, including areas located within the Arctic Circle. Alaska's large size, varied terrain, harsh climate, isolated populations, shortened construction season, and lack of access to infrastructure make it challenging to deploy voice and broadband-capable networks.

In return for Alaska Plan support, recipients are required to meet individually targeted initial performance levels, and to make enhanced commitments if upgraded middle-mile infrastructure becomes available. For fixed broadband, the carrier's commitments are generally set in terms of the number of locations that receive broadband service with at least 10 Mbps downstream and 1 Mbps upstream, subject to requirements for network latency and any usage caps. Many of the initial commitments were limited by insufficient middle-mile facilities. For instance, General Communications Inc. (GCI)'s wireline affiliates committed in their areas to provide 1 Mbps/256 kbps with at least a 7GB cap where only satellite is available; 10/1 Mbps with at least a 40GB cap where microwave backhaul is available; and 25/3 Mbps with at least a 150 GB cap where fibre backhaul is available.

In addition, as new terrestrial or new-generation-satellite backhaul becomes commercially available, support recipients will be subject to revised heightened commitments. For instance, now that Quintillion's fibre line running along the north and west coasts of Alaska is operational, the Arctic Slope Telephone Association Co-operative (ASTAC), which was providing 1 Mpbs/256kbps fixed service in areas with satellite backhaul, is providing many locations in the Arctic towns of Wainwright, Point Hope, Nuiqsut, and Utqiaġvik with 10/1 Mbps fixed broadband, and has publicly committed that new fibre drops in its villages will allow it to provide by the end of 2021 4G mobile wireless service with 5/1 Mbps in all eight of its villages north of the Arctic Circle as well as to Prudhoe Bay.4

4 Additional, more targeted Universal Service support is provided for Alaskan connectivity by the FCC through its CAF Phase II, CAF Alternative Connect America Cost Model (A-CAM), Lifeline Program, its Schools and Libraries Program, and its Rural Healthcare Program. Connect America Proceedings at the FCC: WC Docket Nos. 10-90, 10-208, 16-271. Lifeline Proceedings at the FCC: WC Docket Nos. 17-287; 11-42; 09-197. Schools and Libraries (E-rate) Proceedings at the FCC: CC Docket No. 02-6; 13-184. Rural Health Care Proceeding at the FCC: WC Docket No. 02-60.

Fairbanks, Alaska // Photo by Arctic Council Secretariat / Linnea Nordstrom

5. Establishing relationships with other parties to collaborate on ways to improve connectivity in the Arctic

5. Establishing relationships with other parties to collaborate on ways to improve connectivity in the Arctic

The Task Force recognizes that improvements in Arctic connectivity are a long-term effort that will require continued and expanded cooperation and collaborations among the users in the Arctic and with the industry. Established relationships among the Arctic Council states, Working Groups, users in the Arctic and industry will allow for continued discussion on the unmet needs in the Arctic so that industry can adjust to meet the evolving needs.

To begin this process, the Task Force sought input from Arctic Council WGs, the AEC, the Arctic Coast Guard Forum (ACGF) and academia through a questionnaire. The questions were meant to help identify how the activities of various users in the Arctic would specifically benefit from improved connectivity and how a lack of connectivity negatively affects those users. With these responses in mind, the Task Force then investigated communications industry models of cooperation to help address the lack of connectivity. It benefitted from receiving concrete examples (e.g. projects, scenarios, etc.), that highlighted needs, solutions or forward looking "wishes" relevant to the groups the AEC represents.

5a. Arctic Council Working Groups

Arctic Council Working Groups (WGs) are at the core of the Arctic Council. The Task Force reached out to all the WGs to solicit their expertise on how connectivity challenges impact their work. The Task Force benefited from the active participation of the EPPR, SDWG and CAFF.

Emergency Prevention, Preparedness and Response (EPPR)

EPPR noted that increased connectivity can be beneficial for the emergency responder community (SAR, Oil spill, response, etc.). With the increase of commercial activity and tourism in the Arctic region, planning preparedness and response to potential emergencies requires reliable communication. The development of next generation satellite services (e.g. LEO) and mobile coverage is encouraging. However, EPPR expects that redundancy in the system via more traditional radio/VHF – with inherited limited capabilities – is likely to be the norm for some time to come.

EPPR recently experienced how a lack of connectivity can negatively impact raising awareness and contingency planning. The EPPR project Prevention, Preparedness and Response in Small Communities (PPRSC) revealed some challenges related to how to communicate with remote Arctic communities. As a part of this project, EPPR developed videos to be distributed in remote less connected areas. To make sure that lack of connectivity would not be a barrier for the success of the project, EPPR had to consider that high density or long videos may not be able to stream smoothly in some communities due to limited bandwidth. To solve these restrictions, the length and size needed to be minimized, ensuring that it would be possible to watch the videos in those communities. In addition, some communities requested offline versions as they could not access the internet.

Continuous improvements in this field could be facilitated by innovation in the private sector. To that end, ongoing cooperation between the Arctic Council and the AEC could provide an important link to private sector work in this domain.

Sustainable Development Working Group (SDWG)

SDWG noted that that their work is significantly challenged by a wide geographic variation in connectivity across the circumpolar Arctic. For example, SDWG continues to experience challenges in connecting to remote areas when distributing the results of their work in a digital format to communities, which have limited bandwidth and/or high costs of services. Virtually all working communications between representatives, among project teams, and by the SDWG Secretariat, rely on connectivity. As a result, reliability, 24/7 connectivity, bandwidth, latency, and mobility are highly important.

Furthermore, SDWG finds that improved connectivity can strengthen resilience and support sustainable development for indigenous peoples and local communities, and a lack of connectivity in some parts of the Arctic can be a barrier to delivering results that support resilience and sustainable development. In a region like Nunavut in Canada, where there is no road system connecting communities, where air and marine transportation is expensive, and in some cases limited, and where government ministries and administrations are decentralized, broadband connectivity is essential to efficiently delivering services. In the work of the SDWG, sharing best practices and building the Arctic knowledge base inside and outside the Arctic are dependent on affordable and reliable connectivity.

Conservation of Arctic Flora and Fauna (CAFF)

CAFF found that the work of the Task Force could help find solutions for community-based monitoring. Improved connectivity could potentially facilitate the gathering and transfer of information, to and from local communities, regarding environmental changes by broadening the ability of people to connect from remote locations and more easily report and/or access information. As examples where better connectivity would benefit the efforts to preserve biodiversity in the Arctic, CAFF mentioned support for early warning systems to detect and report invasive alien species and for increased use of community-based monitoring technologies/tools, such as the Circumpolar Local Environment Observer Network (CLEO), a project led by the Arctic Council's Arctic Contaminants Action Program (ACAP) WG.

Cormorant photographed at Kvaløya outside of Tromsø, Norway // Photo by Arctic Council Secretariat / Linnea Nordstrom

5b. Indigenous communities

The Task Force sought to underline the importance of user needs, in particular those of indigenous peoples. Arctic states are striving to ensure that all of their citizens have access to modern connectivity. In this regard, the Task Force welcomed the regular participation of the Aleut International Association (AIA), one of the six Permanent Participants (PPs) in the Arctic Council. In addition, members of the Task Force attended the 2018 'Indigenous Connectivity Summit' to gain a better understanding of Arctic indigenous communities' challenges, needs, current capabilities and future plans on this issue.

Aleut International Association (AIA) and the Aleut People

Improved connectivity is very important for AIA and the Aleut people who live in this region of the Alaskan Arctic and the Commander Islands in Russia. This region currently does not have a terrestrial infrastructure and is limited to satellite backhaul for connectivity needs. Access to new satellite technologies and undersea fibre projects that are in progress will serve these people and fulfill the mission to "promote the continuity of culture and protecting the resources needed to sustain it." Furthermore, improved connectivity is essential for business development opportunities, improved health care and education services, and improved search and rescue capabilities that are especially important with an increase in maritime traffic.

AIA, their research partners and organizations will use the improved connectivity to continue to preserve culture and language in new ways. Language revitalization efforts would advance greatly with the ability to connect speakers and teachers remotely to students. This will allow speakers to reach more students in more communities. Currently teachers need to travel by air to spend weeks in a village to conduct classes. With communities stretching thousands of miles across the Bering Sea, these improvements will provide the opportunity to have more reliable cultural exchanges with Aleut people in Russia and between villages where travel costs are upwards of USD 1500 to travel between them. There are no direct flights between many places. On the Alaska side, travel between Akutan and King Cove for example, require a helicopter ride, three flights and an overnight stay in Anchorage. Connectivity is essential for communication, planning and sharing information about the remote environment.

Currently AIA has the lead on several projects that will be enhanced with access to better connectivity. The Community Observation Network for Adaptation and Security (CONAS) is a partnership project focused on community-led subsistence mapping efforts between AIA, interested communities, the US National Park Service (NPS), the US Fish and Wildlife Service (USFWS), the Aleutian and Bering Sea Islands Landscape Conservation Cooperative (ABSI LCC) and local Aleut tribes. The CONAS project is also partnering with Bering Sea Watch program that has been collecting data for almost 20 years. These data are collected by community members and document changes or abnormalities in the environment. This information will be combined with other data sets that can then be used by policy makers and community members alike to make informed decisions about natural resources. Improved connectivity will allow for faster and more reliable information transfer and the ability for more communication for trouble shooting in the CONAS project.

Indigenous Connectivity Summit 2018

The 2018 Indigenous Connectivity Summit was held in Inuvik, Northwest Territories, Canada to find solutions to ensure indigenous communities, including those in the Canadian and US Arctic, have access to fast, affordable and reliable internet. Members from both the Canadian and American Task Force delegations attended the Summit to hear indigenous perspectives about the significant challenge to connectivity in rural and remote northern communities. Summit participants identified that it was critical that governments and internet service providers consult with indigenous communities and stakeholders as they develop and implement their network deployment plans and that strategic partnerships can be formed with indigenous communities based on shared common values and connectivity goals.

5c. Arctic Economic Council (AEC)

The Task Force collaborated with the AEC as part of its efforts to "further explore the possibility of public-private partnerships as tools for the development of telecommunications infrastructure in the Arctic." This collaboration took the form of participation by the AEC in two of the Task Force's meetings, as well as the completion of a questionnaire. The Co-Chair of the Task Force also participated in the third Top of the World Arctic Broadband Summit, organized by the AEC.

Meeting user needs

The AEC noted that private telecommunications companies are working to meet the needs of different users. Increased bandwidth is required for the smooth transmission of large datasets and bandwidth-intensive applications such as those rich in video content. Low latency is also needed for a high-quality user experience for many applications, especially real-time and interactive services such as video chat. Mobility is required for services in non-fixed locations such as people on snow mobiles, boats, or airplanes. 24/7 connectivity is required for services involving public safety, such as telemedicine and emergency response, including SAR. The need for reliability is proportional to the value of the service and the sensitivity of that value to time. For instance, while telemedicine requires a high degree of reliability, certain remote monitoring services that have the ability to cache data locally might not.

Addressing regional gaps

Connectivity continues to improve across the Arctic region, with some regions being better connected than others. Similarly, within regions, certain communities are better connected than others. These advancements for the most part have taken place at the national and sub-national level as individual providers continue to deploy new or upgraded infrastructure under the regulatory framework of that member state. Accordingly, notwithstanding that national providers often partner with international equipment manufacturers, and that providers sometimes cooperate to build or connect networks that cross international boundaries for the delivery of international services, the advancement of fixed and mobile terrestrial services to date have more often resulted from national and local effort rather than pan-Arctic cooperation.

Enhancing regional cooperation

Certain cases could perhaps be advanced through pan-Arctic cooperation. For example, aviation in the Arctic is growing very quickly. Asian-European routes along with the transatlantic route are growing in excess of 10% per year. Air traffic controllers in the area today use multiple communication and surveillance systems. An Arctic standard would potentially increase aviation security throughout the region. An added benefit would be better communications for SAR and the possibility of using the network for the marine sector in the area. In this regard, the Arctic Council may wish to consult with the Cross Polar Work Group (CPWG), which is made up of representatives of air navigation service providers from Russia, Canada, Iceland and the United States, as well as international organizations representing airspace operator groups to see if the Council's involvement could help foster those efforts.

Enabling economic development

Connectivity is essential for the development of Arctic societies and businesses. Without connectivity, the Arctic risks falling even further behind in economic development, which is moving more and more towards digitalization. From the socio-economic point of view, it is in the AEC's interest to make sure that none of the (already) remote communities are left even further behind.

Connectivity also serves as an enabler for sustainable Arctic business development. This is especially true within the maritime sector. As the AEC broadband report states,[5] due to the great variations across the Arctic, the ideal solution for Arctic connectivity comprises a mixture of different solutions. There is no "one-size-fits-all" solution for the needs of Arctic users.

As new public or private enterprises expand in the Arctic, economic growth could stimulate demand for communications services, which in turn gives network providers increased economic incentives to deploy new or upgraded broadband networks. This could then help facilitate additional economic development.

New economic opportunities in the Arctic could include hosting modern data-centers that require economical cooling, clean energy and a safe environment. Looking into the future, the AEC noted that the Arctic would be a "fantastic" area to build new data-centers. The AEC expects that data-center industry will experience robust growth in the Arctic, particularly in Scandinavia.

Addressing regulatory challenges

One of the major feedbacks from the industry representatives gathered at the third Top of the World Arctic Broadband Summit in 2018 was related to the regulatory challenges. Promoting a stable and predictable regulatory framework is one of the overarching themes of the AEC. The telecommunications industry active in the Arctic is seeking a unified regulatory framework. Simultaneously, access to dialogue with regulatory bodies is challenging. The AEC therefore encourages Arctic states to work together to facilitate further telecommunications deployment.

5 Arctic Economic Council (2016). *Arctic Broadband. Recommendations for an Interconnected* Arctic. Available online: https://arcticeconomiccouncil.com/our-work/.

Increasing Arctic Council – AEC future collaborations

The AEC acknowledges the contributions of the dedicated Arctic Council task forces on connectivity (TFTIA, TFICA), as they have brought wider recognition to the need for improved connectivity and have provided useful information about what network infrastructure is currently deployed in the Arctic and making recommendations for the future.

The AEC Connectivity Working Group seeks to be a resource for the Arctic Council by working collaboratively to advance connectivity and economic development in the Arctic. The Working Group desires to foster better collaborations amongst telecommunication network providers. For example, network providers that do not regularly work in the Arctic may not understand the challenges of operating in harsh environmental conditions; yet still may have valuable insights. Working together, the AEC and the Arctic Council could encourage industry participation in Arctic-focused collaborations to increase deployment of new technologies in this region.

5d. Arctic Coast Guard Forum (ACGF)

The Task Force reached out to the ACGF as part of its efforts to better understand the needs of the maritime sector and SAR authorities faced with connectivity gaps. Representatives of the ACGF presented the following observations to the Task Force.

Maximizing situational awareness and response

Coast Guard authorities must react to the changing Arctic environment and utilize the potential of new technology in order to maximize their situational awareness and improve response. Automation, together with an intelligent shipping infrastructure, as well as with up-to-date and accurate data on situational awareness systems and environmental conditions will increase the safety of shipping in Arctic waters. To achieve this, fast and reliable ship-to-ship and ship-to-shore communication is needed. The amount of connectivity necessary for each response can vary greatly and may include requirements for large amounts of data transfer, such as videos and photos, while also utilizing voice communications.

Providing reliable and accurate coverage

Currently there are gaps in satellite coverage of the Arctic. Reliable and accurate satellite connection at high latitudes would create a safer and more predictable Arctic area. It is equally important to ensure that programs provide good satellite navigation in the Arctic. Commercial vessels require up-to-date ice charts, navigational services, weather information and oceanographic information. The IMO recently recognized the Iridium satellite network for expansion of the Global Maritime Distress and Safety Service (GMDSS), which may help provide many of these critical services.

The ACGF encourages the Arctic Council to keep connectivity issues on its agenda. It will be important to include service providers and end users in future discussions and work programs. To assist future connectivity developments, the ACGF often performs live exercises that could provide a platform for testing new technology in the Arctic, particularly for SAR operations.

5e. Academia

The Chair of the UArctic Telecommunications Thematic Network (TN) has been a regular participant in this Task Force, including by providing his expertise to the drafting of this report. Future work of the Arctic Council on connectivity would benefit from the continued involvement of this TN, including by drawing-in other telecommunications academics as well as by reaching out to other UArctic networks whose users might benefit from improved connectivity. Academia outside the UArctic network should also be welcomed to these Arctic Council discussions.

This collaboration could be strengthened by the funding of specific projects and/or studies, where the Arctic Council is seeking to close information gaps. Arctic states are encouraged to publicize their research needs to foster new Arctic-related studies on connectivity. The researchers could then be invited to speak about their findings at various events where Arctic connectivity-related issues are discussed.

6. Findings and recommendations

6. Findings and recommendations

6a. Key findings

Close the digital connectivity gap. Arctic peoples require access to affordable connectivity of sufficient quality in order to participate in today's digital economy. Allowing the gap to continue to exist would not be in the interest of the Arctic states.

Opportunities for improved connectivity in the Arctic are on the horizon. Over the next few years, existing and emerging connectivity technologies are expected to become more widely available in the circumpolar regions. Consequently, interested stakeholders will need to consider how to best leverage these technologies to connect local communities in a way that is accessible, and responsive to the diversity of user needs.

The digital economy is taking shape in the Arctic. There is a new trend of data centers emerging in some Arctic states due to economic advantages related to lower cooling energy costs and a safe operating environment. Additional connectivity will help support this growing industry.

Multiple solutions for connectivity. The telecommunications industry expressed its desire to have the opportunity to provide connectivity solutions in the Arctic using a variety of platforms and technologies so that all tools can be utilized to improve connectivity.

Importance of redundancy. Network reliability is important for all users, but especially for health clinics, schools, public safety and emergency service institutions, and business. In a harsh Arctic environment, network outages can impact any connectivity technology despite a provider's best efforts to harden its network. Providers can minimize the risk of network downtime by constructing redundant transmission lines, including through a ringed network architecture, and/or employing a variety of networking technologies.

The use of public-private financing models. Public investment often supplements private investment to increase deployment of connectivity solutions in remote and less densely populated areas. In these types of areas in the Arctic, a profitable business case relying exclusively on private investment is difficult to achieve. Public private partnerships can leverage public support to drive private investment to build new connectivity networks; thereby delivering the benefits of modern connectivity to communities that otherwise would remain unserved or underserved. It is important that any funding be based on principles of neutrality and utilize an open, transparent, and competitive process so as to not disrupt basic market forces.

Enable industry innovation through regulatory flexibility. The telecommunications industry expressed an interest for a regulatory environment that allows for piloting new technologies to facilitate earlier commercial deployment in the Arctic. Recognizing that the connectivity of the future will not be homogenous but rather "a network of networks," governments are encouraged to develop regulatory policies that reward and recognize a mix of technologies and service providers (technology neutrality).

Need for regulatory clarity. The telecommunications industry cited challenges in understanding the regulatory requirements for infrastructure development unique to the Arctic region. This is particularly the case for multi-year projects with long lifetimes, like satellites, fibre and undersea cables.

Windows of opportunities for infrastructure installation are short. Regulatory delays of a few weeks can result in postponing the implementation of projects for a year, due to a short construction season in the Arctic.

Gaps remain in Positioning, Navigation and Timing (PNT) services available across the Arctic. Improved coverage of augmentation systems for Global Navigation Satellite System (GNSS) in Arctic areas is important for the aviation industry and will in general improve navigation on land and sea, not at least to the benefit of Search and Rescue (SAR) operations.

Information gaps concerning Arctic connectivity remain. The ongoing dissemination of statistics on connectivity, penetration and access across the circumpolar Arctic would enhance knowledge in this area. Future academic research on connectivity in the Arctic may require adequate funding.

The AEC seeks to be a resource body for the Arctic Council's future work on connectivity. Building on their work with the Task Force, the AEC sees a need for future collaboration with the Arctic Council in order to maintain focus on improving connectivity in the region and addressing outstanding issues.

6b. Recommendations

The Task Force recommends that the Arctic Council:

- Work with the telecommunications industry to:
  - engage with indigenous groups during the design and implementation phases of network technology infrastructure;
  - demonstrate that new technology can withstand Arctic climatic and environmental conditions; and
  - develop connectivity that supports maritime and aeronautical users and, in particular, search and rescue efforts.
- Support the AEC's engagement with the telecommunications industry and other experts to expand and accelerate network deployment across the Arctic.
- Engage with the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), as well as other external bodies, to raise awareness for the need for improved connectivity in these industries operating across the Arctic region.
- Support continued collaboration among the Arctic Council Working Groups to further the goal of improving telecommunications services for Arctic users.
- Facilitate the collection of statistics in order to measure connectivity, penetration and access across the Arctic region on an ongoing basis.

The Task Force encourages Arctic Council states to:

- Provide regulatory clarity that can support increased investment to accelerate network deployment in the Arctic.
- Consider ways to accommodate emerging technologies that may not yet have relevant rules and regulations.
- Consider ways to incentivize investment by reducing regulatory burdens, while still respecting environmental assessments and other public policy objectives.
- Develop regulatory policies that reward and recognize a mix of technologies and service providers (technology neutrality). Considering there is no "one-size-fits-all" approach, encourage national incentive schemes to be results-oriented and outcome-focused to improve innovation and allow for new technological possibilities in the Arctic.

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