Arctic Connectivity Working Group 2021

The Arctic Connectivity Sustainability Matrix is intended to assist policymakers, local leaders and other decision makers in understanding the benefits and considerations of the various types of investment based on the project, location, scientific knowledge, Indigenous and community inputs, and funding sources.

Welcome

The Arctic Economic Council (AEC) formed the Connectivity Working Group (CWG) in 2018 to emphasize the unique role that connectivity plays in the responsible development of the Arctic. From its inception, the group's intention has been to help facilitate improved connectivity and sustainable economic development for the people and businesses in the Arctic. As a former educator, I have seen the importance public schools and other community organizations have in expanding the focus of infrastructure investment beyond economic opportunities into community benefits.

In the investigative process for this report, we identified a further need for useful tools to help stakeholders understand the various investment and planning decisions that can impact the long-term technical and economic success of the project and the Arctic. This tool is presented as the Arctic Connectivity Sustainability Matrix and is aligned with previous efforts. The matrix's aim is to assist policymakers, local leaders, and other decisionmakers in understanding the community and economic benefits, as well as investment considerations arising from location, scientific knowledge, Indigenous and local community inputs, and funding sources associated with any given connectivity project and its impact on the Arctic.

With that goal, we present this report as a practical compendium to the previous work done by the **Arctic Investment Protocol (AIP)** endorsed by the AEC in 2017, the **Arctic Council's 2019 Task Force on Improved Connectivity in the Arctic (TFICA)**, and the AEC's 2017 report on Recommendations for an Interconnected Arctic.

Today, the members of the working group solely represent the North American Arctic, and, as such, the recommendations and place-based examples are focused there. It is our hope that, upon submission of this report, other Arctic States, Arctic Indigenous peoples, and relevant stakeholders will present additional context to expand our report's applicability. Further, the Arctic Council Connectivity Coordinator is serving as a liaison between the Arctic Council and AEC so that this report can be shared more broadly.

We present this report and decision matrix with the earnest desire to provide useful tools in helping create a sustainable and vibrant Arctic.

Pam Lloyd, PhD
Chair, AEC Connectivity Working Group

Executive Summary

We are in a time of unprecedented change in the Arctic. Ice is melting on sea and on land. A renewed focus on the Arctic by stakeholders, policymakers, and investors creates threats to and opportunities for development that over time could result in significant growth in the economies of Greenland, Russia, and the North American Arctic.

The drive to open previously impassable shipping routes, expand broadband connectivity, create new business opportunities, and otherwise expand economic development in the Arctic must be considered in the context of—and with the prior input and participation of—the people in Arctic communities most directly impacted by this development. Coordinating development efforts to support critical community institutions, including schools, healthcare facilities, and government services, is needed to prevent economic growth becoming dissociated from social well-being.

Sustainable economic development and the resilience of local Arctic communities are two sides of the same coin. Arctic investments, therefore, must consider Indigenous and community priorities with an eye toward cultural sustainability before delving into global economic development. When pursued mindfully, this economic development can foster and sustain cultures into the future. This report is targeted at providing government policymakers, local stakeholders, and other development agents with a broadened perspective on the unique economic conditions broader social considerations present in the Arctic.

PAN-ARCTIC CHALLENGES, PAN-ARCTIC COLLABORATION

As a coalition of leaders across the region, the AEC aims to coalesce industry efforts around fostering the Arctic's tremendous potential by supporting and promoting cooperation in responsible Arctic economic development. Given the broad agreement on the need for improved connectivity for the people of the Arctic, this working group's mission is to engender collaboration across Arctic stakeholders and build sustainable models for expanding investment in broadband connectivity infrastructure.

While warming conditions are opening new opportunities in the Arctic, those physical changes occur across decades, with impacts measurable in lifetimes. Meanwhile, the people of the Arctic need connectivity today. The exponential pace of technological change is rapidly widening the gap between communities that have fast internet service and those that do not. This gap results in differences in educational opportunities, access to government services, telemedicine, social and cultural participation, economic participation, and other indicators of well-being. Postponing deployment of Arctic broadband infrastructure until the economics justify a purely private business case for investment will strand an entire generation of Indigenous residents on the wrong side of the Digital Divide. The urgencies of the COVID-19 pandemic have brought new focus to the need for connectivity investments in remote northern communities.

Yet, the reality today is that unique challenges remain to investing in connectivity infrastructure in the Arctic, especially in the North American and Russian Arctic. These challenges include unrelentingly harsh weather, difficult terrain, sparse population, and a relative dearth of large businesses that could anchor the business case for private investment. In many Arctic communities, investment in connectivity infrastructure is not possible without some form of additional financial support or long-term commitments from large enterprise or public sector entities.

INTRODUCING THE ARCTIC CONNECTIVITY SUSTAINABILITY MATRIX

To provide support for overcoming these challenges and for balancing the drive toward economic development with the need for sustainability, we offer the Arctic Connectivity Sustainability Matrix on page 23. The matrix is organized around different types of funding models, with a focus on presenting the difference between initial support for upfront expenses and ongoing support. Each model is presented with current examples (based on North American Arctic programs), the type of support provided, the intention of each model, and additional elements to consider about each model.

The working group's objective is to illuminate the fundamental economic drivers that impact connectivity investment decision making in the Arctic. By understanding and applying an Arctic lens to project planning and funding, the social impact and economic viability of a project will be more thoroughly understood and considered. Although the principles set forth in the Arctic Connectivity Sustainability Matrix were developed based on this group's long experience deploying networks in remote Arctic environments, we believe the matrix has wider applicability to other challenging investment contexts.

This report examines various funding models and the types of local, economic, and other factors that warrant consideration of one model versus another for connectivity investment. We also survey the range of connectivity technologies already available or soon to be available. We outline certain benefits and considerations of each technology. In construction of this report and the matrix, we were inspired by the complexity principles of ecosystem consciousness, positive-sum game, and emergence. These principles, when combined with lessons learned from previous Arctic connectivity efforts, investment strategies, and funding models, provide the baseline approach to the Arctic Connectivity Sustainability Matrix.

EXISTING RESOURCES AND PROJECTS TO LEVERAGE

Our work has not been conducted in isolation. This report and the Arctic Connectivity Sustainability Matrix would not exist but for the prior work of an interconnected web of Arctic stakeholders. Our adherence to this prior body of work was intentional, though we acknowledge that we may have benefitted from important work in unintentional ways we may not recognize. Among other foundational influences, this report and decision matrix adhere to the guidelines laid forth in the **Arctic Investment Protocol** and referenced in the information curated by the **Wilson Center's Arctic Infrastructure Inventory**.

Moving forward, it will be critical to maintain a comprehensive, up-to-date inventory of connectivity infrastructure, as envisioned by the Wilson Center's database. Given the vast territories of the Arctic, the challenges of monitoring every industry and every private investment, the language barriers between nations, and the variations in tracking and storing data across the whole Arctic, any one organization will face challenges keeping its thumb on the pulse of every Arctic investment project, even aided by information gathering technology. We recommend that Arctic nations and stakeholders work with the Wilson Center directly to ensure the accuracy and completeness of its database.

HOW TO USE THIS TOOLKIT

By presenting a holistic approach to Arctic investment, our intention is that policymakers, government leaders, and other stakeholders will better understand what is required to overcome the challenges of investing in the Arctic environment and target scarce public resources where they will have the greatest impact for Arctic communities.

The Why, What, and How of Connectivity Infrastructure in the Arctic

Over the past decade, Arctic nations and stakeholders, through events like **Top of the World Summit** and entities like the Arctic Council, have recognized the importance of connecting the nearly one million Indigenous peoples of the Arctic to the world. **Working together, we have achieved greater understanding of the logistical and technological challenges before us.** The sparse populations, formidable climate, and extreme location both hinder and necessitate advanced communication capabilities. Without increased investment, the dearth of connectivity will continue to hamper sustainable economic development.

Previous efforts by this Working Group introduced six areas—**Investment, Arctic Datacentres, Game Changing Investments, Improvement, Competitiveness and Economic Opportunity, and Communication Industry Models**—as pillars for success to consider when working to overcome connectivity challenges in the Arctic. As we considered how to build on those pillars, we realized the larger need was to first identify foundational issues related to the reasons for investment, then determine how to make necessary investments sustainable.

UNIQUE ARCTIC CHARACTERISTICS

The Arctic is often misunderstood, underestimated, and assumed to operate under the same business conditions as other regions. When considering any project in the circumpolar region, a reasonable understanding of the landscape of the Arctic and how Arctic economics differs from traditional business economics must be obtained. It is useful to consult with a higher education institution specializing in the Arctic to conduct or understand research on how to effectively build and manage projects in the Arctic. Factors that influence this work include the following:

- **LANDSCAPE:** The Arctic is a vast expanse, much of which is defined as permafrost, an unstable and fragile terrain increasingly vulnerable to the effects of climate change. Permafrost is a less than ideal surface on which to construct communications infrastructure. Unique techniques must be employed to protect the landscape, build reliable infrastructure, and span great distances. In Russia, Canada, and Alaska, the Arctic landscape is especially vast, with communities often separated by hundreds of kilometres and inaccessible by roads most or all the year.

- **WEATHER:** Across the Arctic, weather conditions are extreme. High winds, sub-zero temperatures, and extended periods of darkness in winter contribute to an unforgiving environment to which humans and businesses must adapt. Due to this, infrastructure and construction equipment must be designed to operate well outside of standard operational specifications. Arctic-resilient equipment and business processes must take climate into account, especially where it involves travel and systems maintenance. In the Arctic, dispatching a technician to a site could mean chartering planes and traveling hundreds of kilometres over several days, as opposed to a few hours elsewhere in the world. Both capital and operating expenditures are higher in the Arctic, where building and maintaining the necessary equipment is more expensive.

- **DENSITY:** Over much of the Arctic, population density is extremely low, with communities often separated by great distances. This low density is characterized by clustered population centres of small communities often centred around ancestral villages or modern business ventures. In the Canadian territory of Nunavut, with a total population of 37,100, residences are spread over an area the same size as Greenland but with two-thirds the population, resulting in a population density far lower than Greenland's. Alaska's North Slope Borough has a population of less than 10,000 people over more than 150,000 square kilometres (or less than one person per 15 square kilometres on average).

- **ETHNOGRAPHIC DIVERSITY:** The Arctic is home to many Indigenous groups, from the Alaska Natives, First Nation peoples, and Inuit of North America to the Sámi people of Scandinavia and Indigenous peoples in Russia. In addition to being the stewards of the land, these peoples represent a significant portion of the population (over 1,000,000 or about one-fourth of the total Arctic population). Therefore, Indigenous input must be considered in all infrastructure and environmental decisions in the Arctic.

- **LACK OF INFRASTRUCTURE:** Due to the low population density and harsh environment, in addition to other factors, relatively little infrastructure exists in the Arctic today, especially outside of major urban centres. Consider rural Alaska, where over 300 communities are situated far from the contiguous road system and can be accessed only by boat, plane, or snowmobile. Consider also remote regions of Canada, Russia, and other Arctic nations, where some rural communities may not have running water or dependable and affordable electricity. This lack of underlying public infrastructure is further compounded by the lack of business infrastructure, which often relies on roads and utilities.

- **REGULATIONS AND PERMITTING:** Each Arctic nation has its own approach to regulating, protecting, and permitting work within lands owned by the government. Further, many of these nations also include a variety of indigenous and sovereign entities with their own land use rights and requirements. In Alaska, more than 60% of the more than one million square kilometres of land is owned by the federal government, 28% by the state, and 11% of land by Alaska Native regional corporations and their shareholders. As a result, the permitting process for large-scale projects that pass through a mix of public and private lands can be extensive, and this adds years and associated capital expenses (CapEx) and operating expenses (OpEx) to many buildout timelines.

- **PUBLIC INVESTMENT:** Due to the low population density and harsh environment, businesses have historically been unable to make strong business cases for infrastructure builds and normal operations in the Arctic without public investment through the programs and grants discussed in “The What” section of this report. As a result, the traditional idea of competition may make investments even more difficult to sustain. The role of public investment is not to pick winners or losers or to entrench any single provider but to deploy limited public investment resources widely and equitably. The presence of multiple competitors can create an imbalance due to the limited customer pool, making it extremely difficult to sustain ongoing operational expenses.

In combination, these factors equate to the need for Arctic projects to be evaluated on a different set of criteria. The pure performance and cost modelling used in most global projects are incomplete in their application in the Arctic. Conventional theories on economic return modelling and profit-sustainability equations break under these conditions.

Understanding What is Unique in the Arctic

It is the goal of this paper to use an Arctic economic lens to illuminate the differences in the Arctic for decisionmakers and influencers involved in connectivity and other infrastructure projects. This approach is built upon the valuable body of knowledge presented in previous Arctic initiatives. Specifically, the **Arctic Investment Protocol (AIP)** offers a broad set of standards to guide all Arctic investments, connectivity and otherwise. These standards apply to business practices, governance, and environmental stewardship:

- **Build resilient societies through economic development.**
- **Respect and include local communities and Indigenous peoples.**
- **Pursue measures to protect the environment of the Arctic.**
- **Practice responsible and transparent business methods.**
- **Consult and integrate science and traditional ecological knowledge.**
- **Strengthen pan-Arctic collaboration and sharing of best practices.**

By combining the AIP with an Arctic-adjusted understanding of project planning and funding, the social impact and economic viability of efforts will be more thoroughly understood. To that end, this report focuses on **three fundamental considerations** when exploring investments in connectivity in the Arctic and defining sufficient long-term support.

- **THE WHY: ECONOMIC AND SOCIAL PURPOSE FOR INVESTMENT**
  Consideration of both historical and contemporary drivers for investment in the Arctic and how that investment interacts with the Arctic's economy and cultures.

- **THE WHAT: TYPES OF INVESTMENTS AND ANCILLARY CONSIDERATIONS**
  An overview of the various types of technology and infrastructure investments, as well as physical and environmental considerations.

- **THE HOW: FINANCIAL FOUNDATIONS FOR INVESTING**
  A discussion of models for Arctic investment and recommendations for how and when to leverage them to build connectivity in the Arctic.

Viewed as a whole, these considerations combine to form a means of determining the best approach for investing in any project related to Arctic connectivity. Further, the following three factors offer additional insight:

1. **New economic opportunities typically require modern telecommunications infrastructure to be competitive.**
2. **Connectivity is necessary to support ongoing economic opportunity but is not sufficient to sustain it alone. New Infrastructure must be planned in support of other initiatives in the Arctic.**
3. **Coordination with other development projects can extend connectivity to communities near those efforts. By collaborating early and linking projects during the design and development phase, benefits can be maximized to surrounding areas.**

Significant challenges must be overcome to bring critical connectivity services to the Arctic. Progress will require continued cooperative efforts to provide creative solutions that improve the business case for telecommunications network infrastructure deployment.

The Why:
Social and Economic Purpose for Investment

Since the advent of the internet and modern telecommunications technology, connectivity has been powering key advancements and growth in every major industry. From government services to healthcare to transportation to resource extraction and beyond, the internet has enabled a wide range of capabilities and operational efficiencies that empower businesses to innovate and compete in increasingly complex global markets. In addition, the internet provides a means for people to take advantage of global resources while maintaining their local traditions and living in their communities.

As a region, much of the Arctic landmass is remote, with low population density and harsh climates making it one of the last areas to gain broadband connectivity. Yet, the Arctic, by all accounts, stands poised for the next phase of rapid economic development. With the business world and governments alike waking up to the potential of the Arctic, the region is primed to successfully execute unique, game-changing projects in a variety of sectors. From real-time virtual tracking of maritime shipping vessels to constructing datacentres, the Arctic has produced numerous economic developments and projects in multiple areas.

THE RIGHT REASONS TO INVEST

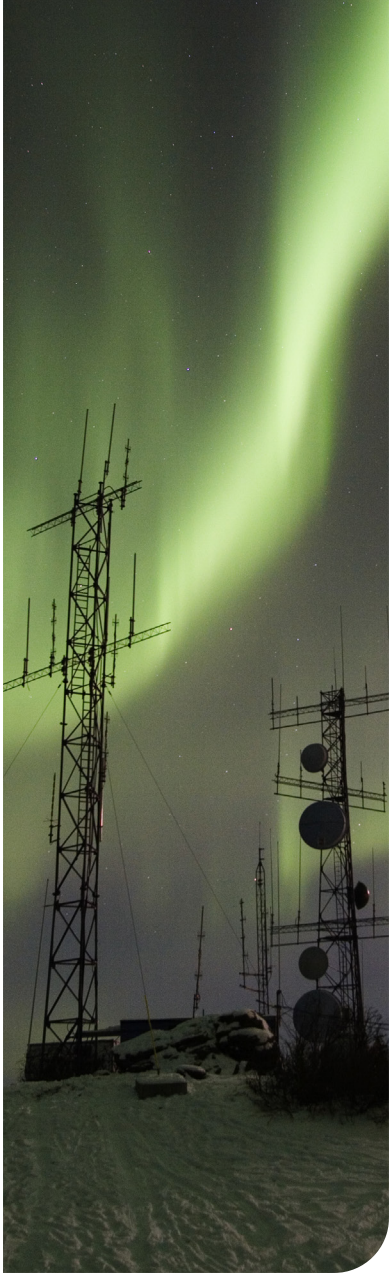
Simply recognizing the need for infrastructure is not enough. We must also understand the motivations for and against investment. Arctic economic development efforts need to balance building infrastructure that promotes economic drivers with respecting the environment and the culture. In the Arctic, new projects should begin with an evaluation of the conditions that made previous efforts successful. Effective solutions may be found in large public works projects and in small business entrepreneurship.

With the business world and governments alike waking up to the potential of the Arctic, the region is primed to successfully execute unique, game-changing projects in a variety of sectors.

By coordinating a cluster of geographically overlapping projects, costs may be reduced to individual investors with parties pooling construction costs. In Canada, this model has been used in a three-pronged initiative to build roads, fibre optic-cable, and hydroelectric power from Churchill to Baker Lake. These principles can be applied to a variety of Arctic projects:

1. **Leverage and upgrade infrastructure that is there**
2. **Strengthen and enter into partnerships with organization that have proven history of success in the Arctic**
3. **Invest in companies that have a roadmap for the future**
4. **Be serious about closing the digital divide**
5. **Products and services need to be financially and technically sustainable**

Further, investment in this area needs support from local communities and governments. The unique legal, environmental, and social requirements are often difficult to navigate for organizations without prior Arctic experience. Having resources available to understand the process and requirements can further de-risk the investments and increase opportunities.



The What:
Types of Investments and Ancillary Considerations

From a technological perspective, the future of connectivity in the Arctic is — and will continue to be — nonhomogeneous. Today, connectivity is achieved through a network made of networks that leverages satellites and subsea fibre for backbone connections and includes everything from wireless to fibre optics and copper for middle- and last-mile access in and to Arctic communities. Together, these mutually reinforcing technologies create an expansive network that provides coverage to many of the most remote regions in the world.

Broad support for rapid deployment of a variety of broadband technologies is a crucial requirement toward connecting the Arctic to the rest of the world. As the various broadband technologies are deployed, it is important to plan for future capacity requirements and to build redundancies into all systems so that businesses and residents can rely on the service, regardless of equipment failures or inclement weather. Of these technologies, the most reliable today is fibre. By building fibre as deep into networks and communities as possible, we strengthen those backbone connections and improve the total capability of all other networks.

In Norway, authorities have carried out an effort to increase system stability in its northernmost county of Troms and Finnmark. The area is more susceptible to outages than other parts of Norway, due to rough weather and the climatic conditions. Consequently, there has been a programme aimed at increasing the security and robustness of local mobile networks. This includes increased diversity for transmission, physical security measures for sub-sea fibre cables, and increased battery backup solutions (including 72 hours for a defined central location in municipalities). Further public funded initiatives are being planned to increase fibre network redundancy in the region.

OPPORTUNITY FROM TECHNOLOGY

The Task Force on Improved Connectivity in the Arctic (TFICA)'s report 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 CWG agrees with TFICA and believes that understanding the various communication technologies within the industry is critical to engendering cross-border collaboration on networks. Additionally, we support joint efforts on regulatory reform, standardization, and other attempts to find efficiencies that can lower barriers of network infrastructure deployment through cooperation. In the process, private and public sector participants must remain technologically agnostic, choosing the best available and most viable mode rather than a pre-determined one. Though this report highlights several technologies that could be used, there is no one solution. The Arctic Connectivity Sustainability Matrix is technology agnostic and may be used to support all technologies today and in the future.

The presence of multiple funding models and interested parties will create a framework for success. This has been demonstrated in both Canada and Alaska, where, through a combination of public subsidies, private investment, and public-private partnerships, the backbone network has expanded tremendously. In Canada, there are two redundancy initiatives advocating for construction of the Canada-North Fibre Loop and the Great Slave Lake Fibre Loop, which is still being contemplated. In Alaska, the existing fibre may soon be expanded by Nushagak Electric and Telephone Cooperative (Nushtel)'s proposed Nuyakuk River project, which will extend hydroelectricity and fibre to six communities in the southwest of the state.

Similar initiatives should be explored elsewhere in the Arctic. The recent attention garnered by Low Earth Orbit (LEO) satellite networks demonstrates the nuances of these initiatives and need for cooperation. Many of the LEO deployment models require on-the-ground wired infrastructure in communities and throughout a service region to distribute the connectivity, making cooperative deployments a priority.

Future public investments should be made with the goal of delivering broad public benefits in health and education. Priority should be given to new investments (versus the overbuilding of existing facilities) and delivering affordable service to consumers.

AVAILABLE TERRESTRIAL COMMUNICATIONS TECHNOLOGIES

Terrestrial technologies may be used to connect remote locations over long distances via middle-mile services or to connect households and business to the internet via last-mile services. The quality of last-mile services is also a critical factor affecting the performance available to a location.

- **OPTICAL FIBRE:** A "fibre" is a thin strand of glass or plastic roughly the width of a human hair. In communications, fibres are used to transmit data via light at various bandwidths. Fibres are threaded through cables, which can then be laid above-ground, underground, or on the ocean floor ("subsea") to create connections between disparate locations.
- **TWISTED-COPPER PAIR:** Often the underpinning of phone lines and DSL service, this is a cable comprised of two insulated copper wires twisted around each other.
- **COPPER COAXIAL CABLE:** A cable that uses an insulated copper conductor instead of optical fibre. This cable is said to be "coaxial" because the outer sheath and the inner conductor share an axis.
- **HYBRID FIBRE COAXIAL (HFC):** A network that leverages both optical fibre and coaxial cable.

AVAILABLE WIRELESS COMMUNICATIONS

- **MOBILE WIRELESS (4G/LTE, 5G):** A form of continuously evolving communications technology that connects mobile devices, such as smartphones. Each major milestone in the technological evolution is referred to as a "generation," where 5G stands for "fifth generation." While the North American Arctic still has substantial deployments of older 2G and 3G technologies, 4G is becoming increasingly available there and in the Scandinavian Arctic. 5G is currently being rolled out in some parts of Alaska, Canada, and Norway.
- **FIXED WIRELESS (MICROWAVE, 4G, 5G):** A type of wireless communications technology connecting two fixed locations, such as two buildings in remote villages several kilometres apart. For longer distances, such as between communities, this technology often uses microwave radio bandwidths to send and receive data. For shorter distance, within a community, the same technology used in Mobile wireless (i.e., 4G and 5G wireless) can be use with fixed wireless access (FWA) to provide local connectivity.

AVAILABLE SATELLITE COMMUNICATIONS TECHNOLOGIES

Satellite technologies are often described in terms of antenna size (i.e., earth station and very-small-aperture terminal or VSAT), frequency, and orbit. Each frequency band offers unique performance characteristics. Typical satellite communication bands include C-band, Ku-band, Ka-band, L-band, and X-band. More recently, satellite orbits have made news with the race to deploy new LEO satellite networks.

- **GEOSTATIONARY (GEO):** A satellite fixed in a specific location in the Earth's orbit so ground antennas can remain fixed in one location, with no need to track the satellite's motion. These satellites broadcast from an orbit of 36,000 kilometres above the equator and provide a broad swath of coverage.

- **LOW EARTH ORBIT (LEO):** A developing network of satellites that orbits less than 2,000 kilometres above Earth. Given the low orbit, these satellites are part of constellations that require tracking antenna to shift from one satellite to another. There are two models in deployment: direct to the premise with through an on-premises terminal and service to the community using local, wired, or wireless distribution. This technology is currently being deployed with manufacturers indicating performance characteristics will be like those of terrestrial communications technologies, although latency will not be fully on par with 5G or fibre.

- **MEDIUM EARTH ORBIT (MEO):** These non-geostationary satellites orbit at altitudes between LEO and GEO, commonly at 20,000 kilometres. Though this orbit is typically used for navigation network, like GPS and Glonass, it is also being used by communication companies for hybrid network deployments over the Arctic.

- **HIGHLY ELLIPTICAL ORBIT (HEO):** These satellites operate with an elliptic orbit that is elongated over polar regions, allowing ground stations to maintain connections for extended periods of time. There are two projects currently in development, the **Norwegian Arctic Satellite Broadband Mission (ASBM) commissioned for late 2022** and the **Russian Satellite Communications Company's proposed Express-RV HEO** satellite project.

The How:
Financial Foundations for Investing

The core challenges of building connectivity infrastructure in the Arctic are outlined in the **Kingdom of Denmark's Business Financing in the Arctic report,** "Improved access to finance for SMEs (small and medium enterprises) and start-ups is important with regard to promoting business growth in the Arctic … it will be especially important to improve access to venture capital in the early expansion and scale-up phases. This is where the need seems to be biggest, where Arctic conditions differ most significantly from elsewhere, and where the impact for promoting economic growth and jobs is the greatest."

The CWG stands in agreement with this report's analysis and conclusions, and we further emphasize the critical need for sustainable investment strategies tailored to the Arctic's unique business landscape and physical environment. Additionally, structuring early-stage investments that emphasize coordination of entrepreneurship with research and development efforts can offer new opportunities for innovation. In the United States, there are a number of federal grants that encourage this type of coordination, like **SBIR/STTR** and **I-Corps**, as well as startup accelerators, like **Launch Alaska**, **Arctic Innovation Competition (AIC)**, and the **University of Alaska's Center ICE**.

There is a critical need for sustainable investment strategies tailored to the Arctic's unique business landscape and physical environment.

THE MARKET FOR ARCTIC INVESTMENT

To understand Arctic investments models, we must first understand the Arctic development market. In ideal conditions, private funding would allow traditional market dynamics to succeed. However, the Arctic's extreme environment makes the conditions less than ideal. In areas that lack adequate middle-mile transport networks, there is often less incentive to invest in the modern last-mile infrastructure (e.g., fibre, 5G wireless, and hybrid fibre-coaxial) necessary to support advanced broadband services for consumers and businesses. Similarly, middle-mile networks that do not connect to last-mile networks are failing to realize their potential to bring widespread improvements in connectivity to all Arctic communities.

Throughout the Arctic, there needs to be better understanding amongst network providers, regulators, and organizations of the unique challenges faced when building middle-mile networks in the far North. In Canada, the federal government's national broadband plan and **Canadian Radio-television and Telecommunications Commission (CRTC)** have established a service objective of 50 megabits per second (Mbps) download and 10 Mbps upload speeds for all Canadians. However, with the high costs of building infrastructure in remote Arctic regions, this goal will be difficult to achieve without significant investments from network providers and other sources of funding. Further, even with initial support, the ongoing costs of maintenance, repair, and operations (specifically power costs), makes the long-term economic sustainability of investments challenging without meaningful government support.

Even in the more densely populated areas of the Arctic, where better connectivity options are available, network providers must continue to invest in communications infrastructure to keep up with exponential growth in business and consumer demand. For all communities and people in the Arctic to benefit from extensions or upgrades to communications networks, it will be necessary to link regional middle-mile and long-haul networks with local networks. However, these networks cannot be funded through traditional mechanisms because of the small and remote nature of these populations.

LESSONS FROM THE NORTH AMERICAN ARCTIC

In our analysis of recent investment projects in the North American Arctic, we found few communities in the region that can sustainably support a purely private business case for investing in broadband networks. For years, Canada and the United States have relied upon multiple public funding models to incentivize broadband deployment. While many of the programs have been successful, lessons have been learned along the way. By examining the principles that undergird these support programs and comparing successful and unsuccessful approaches, this working group has extracted guidelines for sustainable investment. Our best practice analysis feeds into the Arctic Investment Sustainability Matrix.

We found that public support programs in the Arctic should be open, transparent, and provide support for connectivity in a technologically neutral manner such that providers can select the best tool for the job. Policymakers should prioritize support in the areas with the greatest need. Though much of the justification for investment is focused on anchor tenants (e.g., government, healthcare, or education facilities), deploying facilities with high-capacity levels is important in allowing consumers to have access to affordable services.

Program rules should ensure that funded projects are economically and technically sustainable, which requires ensuring each project will generate sufficient ongoing revenues to cover operating expenses as they become due. Requiring private providers to have significant capital invested can prevent excessively optimistic financial forecasts. All funding agencies must coordinate their efforts to prevent working at cross-purposes and wasting resources.

Funding support should also be tailored to the situation, insofar as is feasible within an administrative organization. In communities that lack sufficient aggregate demand for business services or support for a private business case for broadband deployment, sustainability – and thus project success – depends on programs that provide ongoing support. In these cases, providing public support only for the initial capital expenditures necessary to build the broadband network and not for ongoing operational expenses is insufficient. Where once the mantra “build it and they will come” may have made sense, we now find that process to be a recipe for failure. Every project needs a sustainable business plan for the initial capital investment and for the ongoing operational expenses necessary to maintain, upgrade, and operate the network.

Here, it is worth noting that some Arctic communities have sufficient aggregate commercial demand to support ongoing broadband. For various reasons, these areas have less need for ongoing public support of operational expenses. These reasons include size, presence of large industrial or other business customers, or relative proximity to other communities that can aggregate demand to justify a larger project. In such communities, clearing the financial hurdle of upfront investment in a new network may be sufficient to jumpstart an independently sustainable project without significant public support over the long run. One example is the use of a long-term purchasing agreement by Quintillion to provide Atlas Space terrestrial connectivity in Utqiagvik where they downlink signals from polar orbit satellites.

All this evidence points to the fact there is no one-size-fits all investment solution in the Arctic. Wise public investment requires the cooperation of all stakeholders, each of which needs to contribute inputs in a wise and sustainable manner.

EXAMPLE PUBLIC FUNDING PROGRAMS IN THE UNITED STATES

Over 65% of rural Alaska schools in the Arctic have access to internet speeds of 25 Mbps or higher through the combination of the **Federal E-Rate** subsidy and the **Alaska Broadband Assistance Grant** program.

This two-step funding process provides students in communities as small as 20 residents with access to online education resources.

EXAMPLE PUBLIC FUNDING PROGRAMS IN CANADA

Over 46% of homes in the Canadian territories now have access to internet speeds of 50 Mbps or higher. The Nunavut territory in the eastern Arctic region of Canada is served by satellite technology and speeds are generally limited to 15 Mbps downloads. Nearly every community in northern Canada has access to 4G HSPA or LTE cellular service.

- **COMMUNITY CONNECT GRANTS:** The United States Department of Agriculture's Rural Utility Service created this grant program to provide funds for the construction of telecommunications facilities in rural areas that lack broadband speeds of 10 Mbps download by 1 Mbps upload. The program requires a 15% match and encourages partnerships between telecom providers, local governments, and federally recognized tribes.

- **RECONNECT:** The United States Department of Agriculture created this program offering a combination of financing options: loan, loan-grant, and grant. It subsidizes the construction of facilities in unserved areas and requires that funded service areas achieve 90% coverage. Though the program is a capital subsidy, it requires five-year business projections to ensure project sustainability.

- **CRTC BROADBAND FUND:** The Canadian Radio-television and Telecommunications Commission (CRTC) is the federal telecommunications regulator in Canada and has established a C$750 million fund over 5 years to close the digital divide. The target is to provide Canadians with 50 Mbps downloads, 10 Mbps upload speed, and an option for unlimited data transfer.

  In August 2020, the CRTC announced they would fund four new broadband projects in the Yukon and Northwest Territories. The project includes C$62.5m to Northwestel that will help expand fibre-to-the-home (FTTH) and construct Low Earth Orbit PoPs in nine communities to achieve 50/10 Mbps. **In March 2021, the CRTC announced two projects in Nunavik**. The projects include C$53.4 million to Kativik Regional Government that will build and upgrade transport infrastructure in five communities in northern Quebec.

- **UNIVERSAL BROADBAND FUND:** The C$1.75 billion Universal Broadband Fund (UBF) will support high-speed internet projects across the country. The UBF was designed to fund broadband infrastructure projects that will bring high-speed internet at 50/10 Mbps to rural and remote communities. Applications for the C$150 million rapid response stream were due January 15, 2021, and the core intake had an application deadline of March 15, 2021.

  The Government of Canada has also established a C$600 million contribution agreement with satellite operator Telesat Canada to improve connectivity in the north by leveraging Low Earth Orbit (LEO) satellites.

VIABLE ARCTIC INVESTMENT MODELS

Given the expansiveness and low population density of the Arctic, the use of the private-public funding model has seen the greatest success in translating projects into successful deployments and businesses. Public-private partnerships can leverage public interest to support the initial construction costs, ongoing fees for end-users, or both. “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” **(TFICA)**.

In surveying existing industry, academic, and public sector accounts of Arctic development projects, both successful and otherwise, it becomes clear that sustainable investment in the Arctic requires using a layered approach to funding. There exists significant evidence of success with public, private, and public-private and private-private (hybrid) investment models, particularly the models that leverage innovative solutions or partnerships to engender cross-collaboration between all interested parties, regardless of their sector.

Successful investments previously outlined in TFICA 2019 report:

- **PRIVATE INVESTMENT**
  - **Finnish Shared Network** (Finland): Rural cellular coverage
  - **Arctic Mobile** (Kingdom of Denmark): GSM hotspot in ships with satellite backhaul.
- **PUBLIC INVESTMENT**
  - **Maritime Broadband Radio** (Norway): Safety at sea.
  - **Digital Camp** (Russia): Satellite connection to communities.
- **PUBLIC-PRIVATE INVESTMENT**
  - **Connect to Innovation Program** (Nunavut, Canada): High-capacity satellite backbone to 25 communities, leveraging schools and health centres as anchor tenants.
  - **Terrestrial for Every Rural Region of Alaska – TERRA** (United States): Hybrid fibre-microwave backbone network to 84 rural and remote communities.

Arctic Connectivity Sustainability Matrix

By recognizing the types of projects that may occur in the Arctic, a framework can then be presented to evaluate the appropriate and sustainable response from a connectivity and infrastructure perspective. Given that many development projects lacked a suitable business case in isolation, consideration should be placed on how coordinating the activities of potential investors across different market segments could create game-changing synergies.

As referenced throughout the report, much of the Arctic requires an expanded view of economics. The intention of this matrix is to provide context to the multitude of funding vehicles available. It offers insight into ten funding models, offering descriptions of each approach, examples of the approach in use, and considerations to understand. These funding vehicles range from full public support of connectivity projects to coordinated private support.

Beyond the means of providing funding, it is important to consider the social ecosystem being served. Given the difficulty in funding, constructing, and operating these systems, a broad view should be considered for all such investments.

INDIGENOUS AND LOCAL IMPERATIVES

Given the historic differences in access to economic opportunities and modern infrastructure, Indigenous communities need targeted support to prevent disparities from continuing to grow. Tribal and Indigenous organizations occupy a unique and critical role in representing and advocating for all elements of their community: government, culture, economic, wellness, education, and social.

Due to prior displacement and settlement of many Indigenous peoples in remote areas, and given that those remote areas have downstream inequities, there is a societal obligation to ensure remoteness does not continue to create economic disadvantages due to difficulty of access to modern necessities. For any project that may impact tribal lands or peoples, active collaboration with representatives must be undertaken to ensure activities meet societal and legal obligations.

Further, sustainability is not solely defined in financial terms. It also incorporates the principles of the Arctic Investment Protocol, as well as technical survivability. Given the vastness of the region and difficulty in providing on-the-ground support, the need for local support is high. Each infrastructure project represents an opportunity to coordinate with local groups to provide training and jobs that support each community.

UNDERSTANDING THE MATRIX

Two categories of expenses are central to understanding the matrix: Capital Expenses (CapEx) and Operating Expenses (OpEx). CapEx is the upfront cost of building infrastructure to deliver services. Essentially, these are start-up costs necessary to offer a service. OpEx is the ongoing costs of supporting the infrastructure to provide ongoing service. It may range from the cost of electricity for powering fibre-optics to deploying field technicians to repair network damage to purchasing middle mile capacity. OpEx costs are often overlooked when considering the cost of delivering a service, but they are often significant and are critical in creating sustainable networks.

AEC Arctic Connectivity Sustainability Matrix 2021

FUNDING MODEL	CAPEX SUPPORT	OPEX SUPPORT	FUNDING EXAMPLES	WHAT	WHY	CONSIDERATIONS
Design-Build Grant	X		USDA ReConnect, RUS Distance Learning & Telemedicine Grants, Community Connect Grants	A program that pays for all or part of the capital expenses (CapEx) of the construction of telecommuications facilities.	To overcome economic barriers to capital investment in regions where there is insufficient private demand to create incentives for construction of advanced connectivity.	**Economic:** Given that grants support the economic case for CapEx, the sustainability of facilities must also be considered from a OpEx perspective. Do ongoing revenue sources cover operating and maintenance costs? **Community:** Does the funding provided via the grant make the business case for additional builds in surrounding communities more viable? Could the grantee invest additional CapEx or secure other forms of funding to build to more communities on the path of the original grant project?
Publicly Supported Loans and Bonds	X		RUS Distance Learning & Telemedicine, USDA ReConnect, RUS Telecommunications Infrastructure Loans & Loan Guarantees	Lending vehicles designed to offer more favorable terms (such as rates, qualifications, etc.) for entities seeking to build telecommunications facilities.	To offer reduced rates or extended terms more favorable than those offered by traditional commercial lending vehicles. This can enable borrowers to meet the prescribed financing requirements.	**Economic:** Targeting the level of due diligence rigor for granting loans is paramount. Insufficient review of borrower finances and project feasibility could result in stranded investment of failed projects, while market-style review may result in limited support and eliminate portential projects. By requiring recipient to pay back into the program, the program becomes more self-sustaining and can further leverage its own capital to finance more projects. Ongoing financial interest associated with the loan may increase regulatory oversight and compliance costs creating operational inefficiencies.
Tax Incentives	X	X	Opportunity Zones, Tax credit programs	Programs that can reduce tax burdens for and/or provide tax credits to entities engaging in a specific action (such as providing services in a qualified region). *Note: some tax incentives may be saleable.*	To drive investment in specified types of projects or locations by offsetting the CapEx and/or OpEx with tax credits.	**Economic:** If credits are sold, they become a CapEx offset that provides direct capital to construct facilities. If tax credits are not sold, they become an OpEx offset. However, unsold tax incentives may take time to realize benefits, as a profit must first be made before the tax incentive can offset the profit and provide value. Unless sold, the tax incentives provide no benefit to tax-exempt organizations.
Operation Subsidy		X	E-rate, Rural Health Care Program, Alaska Broadband Assistance Grant (BAG)	A program that provides direct or indirect subsidies to support ongoing operational expenses (OpEx) of delivering services.	To provide support in regions where a combination of total delivery costs and socioeconomic conditions make ongoing support prohibitive.	**Community:** Some subsidies limit the scope of coverage to the targets of the subsidy program (e.g. a specific sector or anchor tenant) and not the entire community; others may focus on all household in a geographic region. This can be mitigated if the subsidy also provides an opportunity to expand the program rules to extend program eligibility to services beyond initial subsidy targets.
Design-Build-Operate Support	X	X	Alaska Universal Service Fund, Connect America Fund	One program or a combination of programs that support the initial CapEx of construction, plus recurring OpEx of delivering services.	To overcome all economic barriers associated with construction and delivery of services.	**Economic:** By providing support at all levels via a single program, services are often delivered in high-cost areas where they would not have otherwise been provided. Ongoing OpEx must be fully understood up front in order to create a predictable commitment to the necessary long-term support. Both the entity offering the support and the provider receiving it would have to absorb the ongoing administrative and compliance burden of maintaining the program.
Public-Private Partnership Funding	X	X	NTIA Broadband Infrastructure Program, Tribal Broadband Connectivity Program, Connecting Minority Communities Pilot Program, Universal Broadband Fund	Shared funding provided in part by a private stakeholder and in part by a public entity.	To create shared opportunities and incentives for success between community stakeholders, anchor tenants, and communication providers.	**Economic:** This funding approach provides a substantial enough incentive to overcome insufficient rate of return calculation. However, ongoiung revenue must be enough to support the OpEx requirements. **Sustainability:** While Canada's Universal Broadband Fund does not fund operational expenses, applicants must submit a business case demonstrating sustainability for at least five years. The Universal Broadband Fund provides higher program contribution limits for projects supporting indigenous communities.
Centralized Purchasing		X	Buyer's Group, Consortium buying	The creation of a consolidated purchasing coalition of public and/or private entities who can collectively simulate the anchor tenant model and its economic leverage.	To aggregate buying power in areas where no individual customer could motivate capital investment through its own revenue.	**Community:** The aggregation of buying power can cause residences and organizations not in the buying group to be excluded from the benefits of investment.
Aid-to-Construction	X		Anchor tenants such as resource and tourism industries	Direct financial support from a stakeholder or customer who can offset non-recurring costs, such as construction.	To stimulate regional development by offsetting all or some of the CapEx of constructing facilities. Typically, this funding is provided by private customers of sufficient scale and access to capital.	**Economic:** Aid-to-Construction is typically provided in tandem with a Long-term Purchasing Agreement. In the absence of long-term revenue commitments, accounting for the ongoing operational costs is critical to avoid stranded investments.
Long-term Purchasing Agreement		X	Anchor tenants such as resource and tourism industries, native organizations, and public sector entities (governments, military, public safety)	An extended commitment from an anchor tenant to purchase services, thereby mitigating risk of investment by guaranteeing return on invested capital.	To drive private investment in capital construction by guaranteeing revenue that provides sufficient rate of return on investment.	**Community:** Similar to Centralized Purchasing, this vehicle depends on anchor tenants to make long-term commitments and may result in services bypassing communities, residents, and businesses to serve just the purchasing anchor tenants.
One-time Funding	X	X	American Rescue Plan	Block grants to localities which may be used to support broadband infrastructure.	To expand broadband access in response to a crisis, such as the COVID-19 pandemic	**Economic:** These are large, one-time infusions of capital, which can support construction of broadband infrastructure with aid to CapEx. As the need for universal access to broadband increases, this funding may become recurring and provide the opportunity to close gaps in broadband availability with OpEx support.

Conclusion

It is the goal of this Working Group to support the people and businesses in the Arctic with improved connectivity. Our intent with publishing this report is to connect the current body of knowledge on Arctic development to this paper's economic perspective. For broadband efforts to be impactful on social advancements and economic development, there must be coordination amongst stakeholders including local and Indigenous representatives, academics, researchers and scientists, telecommunication executives, state and local government officials, and business representatives. In combination this group can create models that consider the entire Arctic ecosystem and are based on sustainability.

These efforts extend beyond building for economic gain. Coordinated development also considers how to include critical community institutions, like schools, healthcare facilities, and government services—preventing economic growth from becoming dissociated from social well-being. Further, Arctic investment should incorporate Indigenous and community priorities with respect to cultural sustainability. By understanding and applying the Arctic lens through the planning and funding process, the social and economic viability of the effort will be more likely to last.

The benefits of a coordinated approach for Arctic projects are summarized well by **Gemma Jiang's presentation** of the following framework:

1. **ECOSYSTEM CONSCIOUSNESS:** A focus on the whole versus the individual—the inspiration behind the Arctic Sustainability Decision Matrix. For connectivity investment to be sustainable, anchor tenant customers must exist and be successful, but also operate in a positive relationship and with the interests of the residents of Arctic communities and other stakeholders in mind.
2. **POSITIVE-SUM GAME:** Individual projects that focus on a single goal often bypass potential opportunities to expand the network to nearby communities. In multidimensional systems like the Arctic, ancillary system benefits should be considered early in the planning process.
3. **EMERGENCE:** The positive downstream effects of applying ecosystem consciousness in the Arctic will appear in the near future. By working together and taking the needs of the whole Arctic into account as we engage in our individual pursuits, we create a better environment for sustainably deploying broadband infrastructure.

When this report and matrix are considered in the context of these three principles, we hope all stakeholders will have an expanded view of their prospective projects. Though the Arctic continues to change as it becomes more developed, Indigenous lifeways, unique economic conditions, and long-term sustainability of people and projects must be considered.

Though our analysis addressed several issues, from cultural preservation to economic sustainability, it was not able to adequately address issues associated with the changing climate. For future efforts on infrastructure development in the Arctic – whether connectivity or otherwise – a deep consideration of the interrelated nature of cultural, economic, and environmental sustainability should be a priority.

KEY TAKEAWAYS

- Indigenous organizations occupy a unique and critical role advocating for all elements of their communities.
- Conventional theories on economic returns and sustainable profit break under Arctic conditions.
- Private-public funding models have seen the greatest success in deploying projects given the expansiveness and low population density of the Arctic.
- Providing public support only for the initial capital expenditures necessary to build the broadband network and not for ongoing operational expenses is often insufficient. Each project needs a plan for both.
- Coordinating geographically overlapping projects can reduce costs to individual investors and expand development benefits.
- Maintaining a clear inventory of both the broadband infrastructure in operation and being constructed is critical to focusing investments and coordinating efforts.
- Government should provide liaisons and clear regulations to drive investment, lower barriers to network infrastructure development, and encourage cooperation.
- Public investments should be made with the goal of delivering broad public benefits in public safety, healthcare, and education.

Suggestions for Next Connectivity Working Group

- Consider how to further incorporate a focus on environmental change in the Arctic into the future of connectivity development.
- Continue collaborating with the Arctic Council to represent the importance of an Arctic economic lens.
- Extend the applicability of the paper to encompass the entire Arctic region by enlisting additional stakeholders in the European and Russian Arctic.
    - » Expand the Arctic Investment Sustainability Matrix to include funding models found in Europe and Russia.
    - » Include additional place-based examples from the European and Russian Arctic.

Thank you for reading the Arctic Economic Council Connectivity Working Group's report on Arctic Connectivity and Sustainability. We thank our contributors, advisory committee, and stakeholders for their important insights through the development of this report.

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