Undersea Fibre Optic Cable Installation

Linking Greenland, Nunavut and Quebec

Project Description

By Government of Nunavut

Table of Contents

List of Figures

List of Tables

Glossary of Terms

Digital Line Segment (DLS) - means the entire set of elements necessary to transmit a digital signal between two Client Interfaces.

Dry Plant - all Terminal Equipment and other components installed in the Cable Landing Station and between the Cable Landing Station and the demarcation point with the Submerged Plant in the Beach Manhole, including all terminals, line monitoring, power equipment and land cable.

Extended Digital Line Segment - means a Digital Line Section in which one or both SLTEs is placed at a location other than a Cable Landing Station and connected to the Cable Landing Station by means of terrestrial fibre and In-Line Amplifier (ILA) sites.

Good Industry Practice - The exercise of the degree of skill, expertise, diligence and foresight which would be expected of skilled and experienced professional contractors engaged in work of a similar nature to the Work.

Optical Transport Network (OTN) - means any system, link, interface or collection thereof which is generally compliant with the suite of Recommendations indicated in ITU-T G.872.

Segment - means a section of cable and all associated Submerged Plant between two designated end points.

Submerged Plant - All cable, joints, terminations, cable end seals, housings, repeaters, BUs, equalization units, wavelength filters and associated components capable of being deployed on the seabed as part of the System, up to the demarcation point with the Dry Plant in the Beach Manhole.

Synchronous Digital Hierarchy (SDH) - means any system, link, interface or collection thereof which is generally compliant with ITU-T G.780 series of recommendations.

Terminal Equipment - The collective term for any and all equipment that is required in a Cable Landing Station to terminate the submarine fibre optic System, including, but not limited to Submarine Line Terminal Equipment; Network Management System; Local Craft Terminals and Line Monitoring Equipment.

Unrepeatered Segment - means a segment which does not contain powered underwater repeaters.

Executive Summary

Project Identifier

To be confirmed

Project Title

Undersea Fibre Optic Cable Installation Linking Greenland, Nunavut and Quebec

Investment Stream

Rural and Northern Communities

Project Description

The *Undersea Fibre Optic Cable Installation Linking Greenland, Nunavut and Quebec* Project will construct a state-of-the-art submarine fiber optic system connecting Iqaluit, Kimmirut and Cape Dorset with an international connection to Nuuk, Greenland and Milton, Newfoundland. The installation will include the capability to connect to northern Baffin Island and western Hudson Bay in the future. An additional component of the project is proposed to install fibre optic cable from Sanikiluaq to the system being installed by the Kativik Regional Government.

Approximately 2,400km of fibre optic cable will be installed including all submarine and cable landing infrastructure including the fibre optical cable, powered repeaters, line terminating equipment, power-feeding equipment, and monitoring equipment.

Internet providers in Nunavut will then have access to high speed connectivity for distribution to their customers.

The fibre backbone is expected to potentially reduce the cost of bandwidth relative to the current satellite service by 85% and improve the connectivity at the residential customer of between 3 Mbps and 15 Mbps, with access at the distribution point of 100Mbps.

Project Proponent

Government of Nunavut, Department of Community and Government Services (CGS) is a territorial government

Location

The main trunk of the *Undersea Fibre Optic Cable Installation* project will cross the Davis Strait from Nuuk, Greenland, and proceed through the Hudson Strait to connect Iqaluit, Kimmirut and Cape Dorset with branching units installed to allow for additional connections.

To the south, and independent from the main trunk mentioned above, a separate branch of the fibre optic cable will be installed to connect Sanikiluaq to the Kativik Regional Government portion of the EAUFON system with terminals at Chisasibi, Quebec.

NOTE: KML file of the system locations submitted in the online form.

Key Metrics

Total cost	$126,491,811
Forecasted construction start	July 2019
Forecasted construction end	December 2021
Key Risks	- Late funding approval - Missing Weather Window - Permitting Delays

Project Background and Investment Rationale

Project Background

Nunavut has been exploring alternate broadband connectivity solutions for the territory including researching recent advances and potential service offerings in the Pan Arctic Marketplace. The fiber backbone available in Greenland is the closest active high throughput fibre connection available to Nunavut.

In 2014, Arctic Fibre proposed that an undersea fibre cable could be installed to interconnect some communities in Nunavut to other terrestrial high-speed systems in Canada. At the same time, the Kativik Regional Government in Quebec commissioned a pre-feasibility study to examine the potential of undersea fibre optic cable projects for northern Quebec and the Nunavik region.

In 2014, Industry Canada launched the Connecting Canadians Program, however, the funding of $50 million included in the Northern component was insufficient to address the eastern Canadian Arctic's telecommunications problem. Nunavut's $35 million share of the allocation fell short of providing a sustainable solution for the telecommunication infrastructure deficit in the territory. The funds were used to augment local distribution networks and to purchase additional satellite capacity. These improvements resulted in an increase of speed available to community residents from approximately 1.5 Mbps to 3 to 5 Mbps.

In 2016-2017, the Governments of Nunavut, Nunavik and Nunatsiavut undertook a comprehensive desktop feasibility study to examine the potential for an undersea fibre optic network for the entire eastern Canadian Arctic. The study provided in-depth information on the potential of bringing fibre optic service to 4 communities in Nunavut, 14 in Nunavik and 3 in Nunatsiavut. This network became known as the Eastern Arctic Undersea Fibre Optic Network (EAUFON).

The EAUFON is a complex initiative involving multiple partners, Nunavut, the Kativik Regional Government, and national and international jurisdictions. The long term objective is the development of a 4,200km fibre optic network which will link 12 communities in Nunavik and Nunavut with connectivity to existing telecommunications infrastructure in Quebec, and Greenland. The network will build in options to connect to Manitoba and northern Baffin Island.

The study was used by the Kativik Regional Government and the Government of Nunavut to apply for funding to Innovation Science & Economic Development Canada (ISED) under the *Connect to Innovate* Program in 2017.

The Kativik Regional Government was successful in receiving funding from the *Connect to Innovate* program for construction of undersea fibre optic network linking communities along the eastern Hudson Bay coast.

The Government of Nunavut secured separate funding to complete the marine survey in preparation for the development of a business case and the application for funding for the *Undersea Fibre Optic Cable* project.

Mobilization cost-efficiencies were recognized when GN and KRG proceeded with the marine survey in the summer of 2018. The survey will determine the optimum undersea cable routings and landing approaches, clarified the environmental review and permitting process and provided detailed information to ensure accurate project design and construction estimates. The marine survey is scheduled to be completed by late-November and the report expected to be available by mid-December.

In 2018, Telesat launched a new satellite which is targeted directly over Nunavut rather than the signal being diffused across North America. Northwestel secured $49.9M funding provided by the ISED *Connect to Innovate* program and $73 M contribution by Northwestel. The speed target is 15 Mbps, which is three times the maximum speed previously available in Iqaluit.[1]

The faster service will be available to residents in Iqaluit, Cambridge Bay, Arviat and Rankin Inlet by the end of 2018 and in all 25 of Nunavut's communities by 2019.[2] This initiative supports 'backbone' infrastructure as other internet service providers will be able to access the additional capacity.

However, the increased capacity through the satellite deployment is not enough to bridge the broadband deficit. Fibre optic technology is recognized as the technology of choice for more than 98% of intercontinental telecommunications traffic because of the enormous capacity, low latency, and reliability.

The *Undersea Fibre Optic Cable Installation Linking Greenland, Nunavut and Quebec Project* will construct a broadband backbone which will permit the internet providers to provide expanded services to the customers.

This application is requesting support to construct the Nunavut portion of the network. Once completed, the *undersea fibre optic cable* system will be an international system with redundancy and future planning incorporated into the network as well as providing state of the art technology to the most remote communities in Canada.

---

[1] CBC – Sept 15, 2017 – Ottawa commits $50M to get all 25 Nunavut communities faster internet by 2019
[2] CBC – Sept 17 2018 - Iqaluit residents to get 3 times faster internet access in October

Rationale

Nunavut is the only territory or province in Canada that does not have a fibre optic backbone. The territory is 100% satellite dependent. Connectivity and bandwidth issues continue to negatively affect the delivery of services within GN departments and in communities across the territory. Nunavut is lagging well behind its southern counterparts and the 'digital divide' has been growing.

The current landscape of telecommunications in Nunavut means that network capacity is costly, service quality is low and the GN has little influence on pricing and availability. To a large degree, this situation is a result of limited competition for satellite services and the limitations of the technology. For consumers, pricing is high, even by northern standards.

Access speeds and data plans are restrictive and can become price prohibitive when excess usage pricing is applied. The satellite service has vulnerabilities such as maximum capacity available, impact of weather and sun transits activity as well as the normal and expected delay in relaying voice and data.

Currently, Nunavut has download speeds of between three and fifteen megabits per second (Mbps), a number far below the CRTC 10-15 year target of 50 Mbps. Further, CRTC has ruled internet access as an essential service[3] which confirms the critical importance of broadband in the world of today.

Nunavut has the lowest penetration rate in Canada for internet services at about 20% below the national rate, and pays some of the highest fees for telecoms services in Canada. The high costs are believed to directly influence the penetration rate.

The Government of Nunavut currently operates on less than 200 Mbps to support its service delivery for the entire territory. The 200 Mbps supports delivery of healthcare across 25 remote arctic communities, provides services to 10,000 students in schools, and enables the day-to-day work of 4,000 staff. For a context, this speed can be compared to available residential cell phone packages in the south which offer speeds of 1 Gbps. This represents 5 times more bandwidth than the entire Government of Nunavut currently shares.

Broadband capacity is critically significant in geographically isolated locations for the deployment of modern health initiatives, educational opportunities and community-based responsive justice and social services and programming.

---

[3] CBC Dec 22, 2016 - CRTC declares broadband internet access a basic service

Without adequate capacity, advances in the delivery of telehealth services, remote diagnosis and support for clinicians in remote locations are not accessible. Broadband capacity also plays a key role in supporting innovative educational initiatives to provide quality learning opportunities to students in isolated communities. This impacts the potential of these students and limits the development of a highly skilled and self-reliant workforce.

Without access to reliable and functional video conferencing, travel to the locations is necessitated with the resulting high costs, business interruptions caused by weather and flight issues and delays in providing service. Further, the lack of high speed broadband has serious implications for the delivery of basic services such as banking, air traffic control and weather monitoring.

Improved broadband will support the delivery of telehealth, which will allow for funding to be directed into other essential health areas such as prevention and treatment.

CRTC Ruling

CRTC has declared that access to broadband speeds of 50Mbps is an essential service. This essential service is not being provided across Nunavut where 66% of the customers have speeds of 1.5-4.9 Mbps and 33% of the broadband customers have speeds of 5 – 9.9 Mbps. Speeds above 9.9 Mbps are not available.[4] This will be improved once the new satellite service is fully deployed, however, it will not address the essential service standards.

[4] (https://crtc.gc.ca/eng/publications/reports/policymonitoring/2015/cmr.htm, Table 5.3.13)

Fibre Optic Technology

Fibre optic technology has existed for over 50 years and is proven technology for transmitting large amounts of information quickly. Undersea fiber optic cables are interlaced across the global oceans as shown in Figure 1.

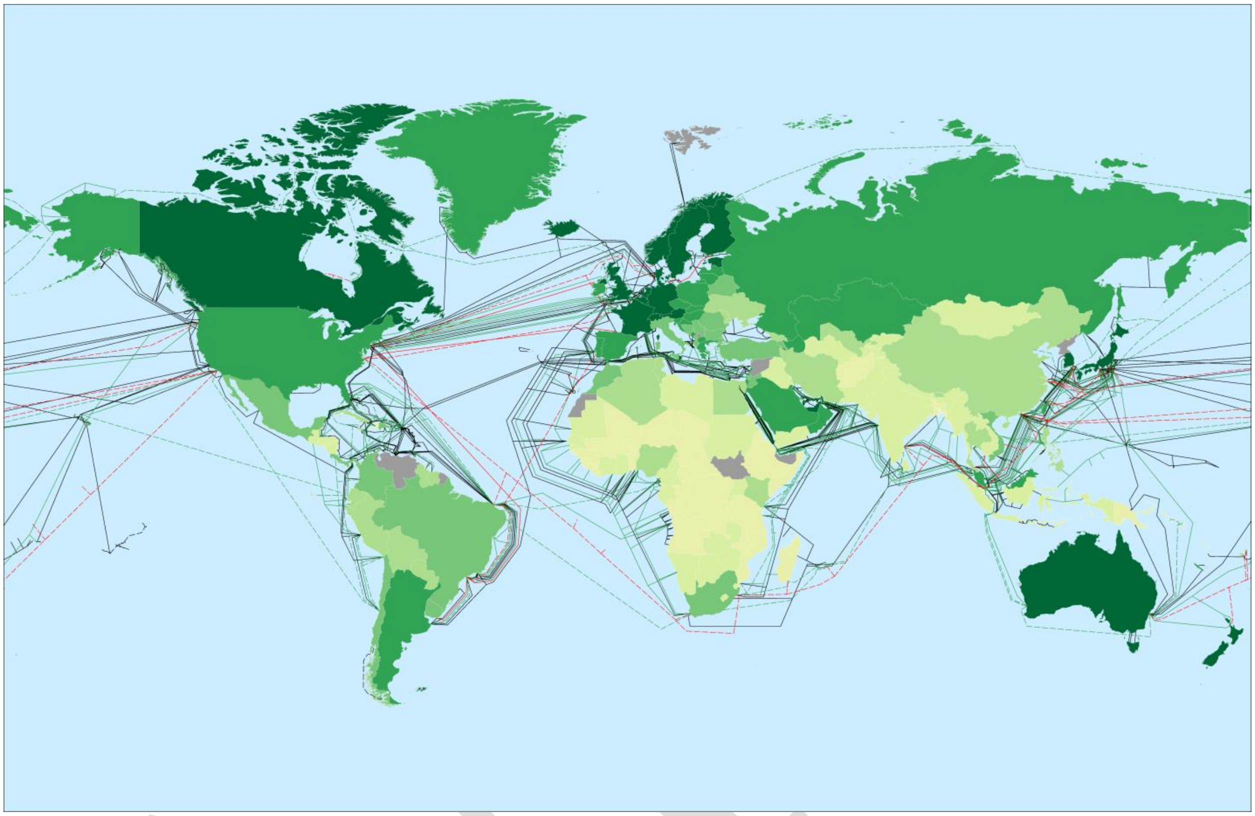


FIGURE 1 – DIAGRAM OF UNDERSEA FIBRE OPTIC CABLE INSTALLATIONS WORLD-WIDE

At one time it would have not been feasible to install fibre optic cables across the Arctic, however, the demonstrated success of the undersea cable connecting Europe, Iceland, Greenland and Canada proves the viability of this option.

Alternative approaches

The number of alternatives is very restricted; however, these have been invested thoroughly. The only current alternative is to continue with the satellite service with all the limitations currently being experienced. The Nuuk, Greenland to Milton, Newfoundland undersea fiber optic cable is the only available fibre cable line as the cost and routing required to connect to any other undersea cable is not reasonable. Refer to Figure 1.

The EAUFON model with government partners each responsible for a component of the entire service is the most cost efficient and functional approach and provides the best opportunity to enhance connectivity to all communities around Hudson Bay and Nunavut.

Benefits

- The undersea fibre optic network will provide tremendous amounts of bandwidth for a fraction of the cost of satellite services. This will enable local internet service providers to provide very stable and faster digital telecommunications services with more bandwidth available for transmitting data.
- The fibre optic cable installation will replace the costly and sometimes unreliable satellite service to 4 communities which will expand amount of bandwidth available to the other communities thereby bridging the digital divide between the Canadian Arctic and the rest of Canada.
- Iqaluit currently draws 70% of the territory's available satellite broadband capacity. By deploying fibre in Iqaluit, the available satellite bandwidth could be re-assigned to other communities enhancing the overall telecommunication picture for the territory
- Provide opportunities to reduce governmental cost of providing distance healthcare, education, national security and justice administration in the territory
- Expand ability to deploy modern health initiatives in geographically isolated locations, such as digital x-rays diagnosing TB and other conditions in real-time, and remote support for chemotherapy and respirology.
- Improved opportunities to introduce and expand educational initiatives critical to ensuring a highly skilled and self-reliant workforce
- Reduce delays in work productivity for employees and their clients when uploading/downloading data from the Internet. Government, non-governmental organizations (NGOs) and businesses operating in Nunavut lack the ability to send and/or receive large digital files or information. Enhanced broadband Internet services should greatly improve this ability.
- Improve economic development and expanded e-commerce opportunities, between communities of Nunavut and Nunavut and the world.
- Support expanded internal and external communications within communities, within territory, and with the rest of Canada and the world.
- Improved access to the same kinds of internet services enjoyed by customers in southern Canada without delays or interruptions which has the potential to reduce isolation and improve wellbeing among Nunavummiut.
- Reduce the cost of bandwidth relative to C-Band satellite by 85%. The Government of Nunavut pays $16M annually for the GN access to broadband and phone service. Cost savings can then be redirected into other critical telecommunications deficit areas.
- Additional savings from increased economies of scale being passed through to carriers and customers will help to stimulate increased telecommunications market entry by new carriers and extend cellular coverage.
- Provide for redundant systems by create physically diverse routes to avoid physical cable breaks afflicting other carriers and eliminating economic, social paralysis when satellite is off-line.
- Improve the ability to control the operating systems in municipal and GN buildings. These are managed remotely from southern control centres and improved broadband will increase the efficiency and reduce the occurrences of down time for building management.
- Increased opportunity to support recruitment of skilled workers who have an expectation of access to broadband and the services and social networking it supports
- Improved retention of skilled workers by increasing opportunities for professional development and improved functionality in the workplace.

Project Description

The Undersea Fibre Optic Cable Installation project will significantly increase telecommunications connectivity in Nunavut. New services can be provided, and existing services can be upgraded. This will allow for higher levels of productivity and collaboration and position Nunavut strongly with the rest of Canadian telecommunications services.

Project Scope

The scope of the *Undersea Fibre Optic Cable Installation* project includes all aspects of the construction, and includes plans for decommissioning and any future abandonment of the optical cable system.

The basic fibre optic cable system is a main trunk fibre cable with branching units (BUs) which provide for connecting cable spurs to Iqaluit, Cape Dorset and Kimmirut. There will be eight fibre pairs (sixteen fibres) in the trunk cable. One pair will be for traffic to each site. Other pair is for backup and the others are for future expansions or business opportunities. Two additional BUs are included for future expansions to northern Baffin Island and western Hudson Bay.

The system will be based upon current submarine fibre systems. Each fibre pair will carry multiple optical wavelengths (λs lambdas), e.g. 100 λs x 100Gbps or 50 λs x 200Gbps. Each of the four communities will be provided with two redundant wavelengths of at least 100Gbps per wavelength.

The cable and connections for Sanikiluaq will be funded by this project, but installed under the KRG EAUFON project. The two points of connection for the KRG EAUFON and the fibre optic network installed under this project are in the Hudson Strait and the Sanikiluaq extension connected to Chisasibi, Quebec.

The target is to have the *Undersea Fibre Optic Cable Installation* project in service at the end of 2021.

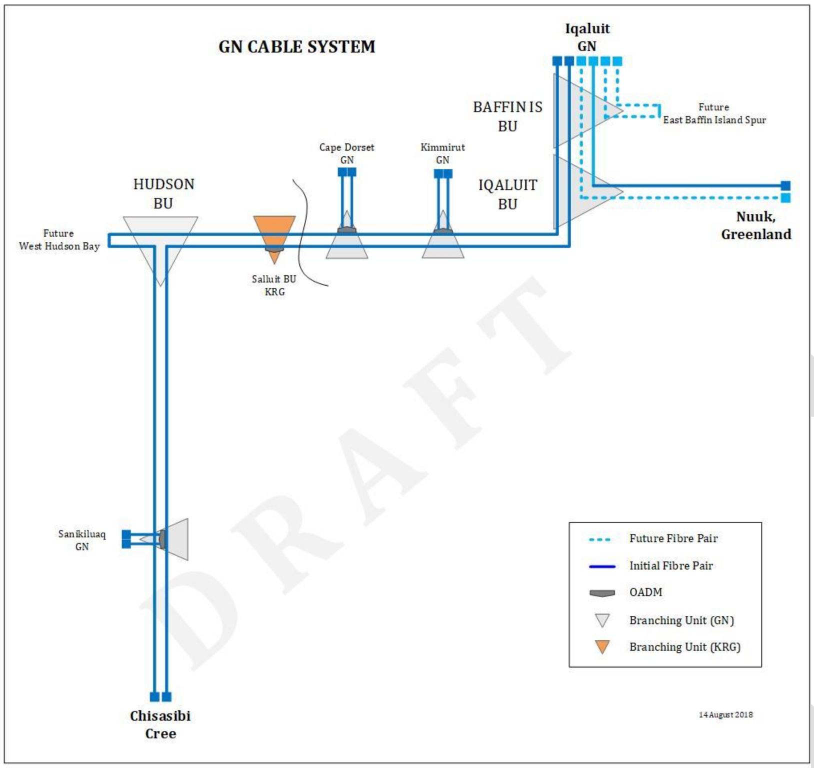


FIGURE 2 – NUNAVUT UNDERSEA FIBRE OPTIC NETWORK CONFIGURATION DIAGRAM

Targets

At full capacity, Iqaluit will have extremely high speed interface to Greenland and Newfoundland through TELE-Greenland facilities. When the *Nunavut Undersea Fibre Optic Cable* is connected to the KRG system, Iqaluit will have backup to Chisasibi, Quebec.

System Description

Iqaluit to Nuuk

The core system will consist of two fibre pairs (four fibres) between Iqaluit and Nuuk. Initially, only one fibre pair will be equipped for traffic (2 x 100Gbps) with one of the 100Gbps wavelengths being reserved for KRG backup. There will be a Baffin Island BU off the mouth of Frobisher Bay for a future expansion to communities in North Baffin. This requires a six-fibre pair cable between Iqaluit and the Baffin Island BU.

There will also be a BU for the extension to Kimmirut. This requires a four-fibre pair cable between the Baffin Island BU and the Iqaluit BU. The core system will have the Network Management System (NMS) and the Network Operations Centre (NOC) that will support all future expansions. System spares will be included with the core system.

Kimmirut

The first expansion will be from the Iqaluit BU to the Kimmirut BU with a spur to Kimmirut. One fibre pair will be equipped with 1 x 100Gbps between Iqaluit and Kimmirut. The second fibre pair will wait until the GN and KRG systems are connected. Once the GN and KRG systems are connected, the second fibre pair will be equipped (potentially up to 2 x 100Gbps) and will be a backup for both the Nunavut cable and KRG. Backup traffic grooming (patching) which ensures the ability to adjust and respond to future distribution will be done in Iqaluit and Chisasibi.

Cape Dorset

The second expansion will be from the Kimmirut BU to half way between the Cape Dorset BU (GN) and the Salluit BU (KRG). There will be a spur from the Cape Dorset BU to Cape Dorset. One fibre pair will be equipped with 1 x 100Gbps between Iqaluit and Cape Dorset. Once the GN and KRG systems are connected, the second fibre pair can be equipped (potentially 2 x 100Gbps) and will be a backup for both GN and KRG. Backup traffic grooming (patching) will be done in Iqaluit and Chisasibi.

Sanikiluaq

Due to its location, this spur will be engineered and installed as part of the KRG system. The cable will host two fibre pairs equipped for 1 x 100Gbps circuits with one serving as a backup.

Future Expansion

Baffin Island

The initial project will install a Baffin Island BU off the mouth of Frobisher Bay for a future 1,300km expansion to North Baffin. The future expansion will be a two-fibre pair cable system similar to the Iqaluit – Nuuk segment. The BU will have a three-kilometer stub cable for future attachment to the Baffin Island cable. This BU will be dormant until the system is expanded. The future expansion can be implemented without affecting traffic on the rest of the GN Cable system.

[Note: If the Baffin Island BU is not installed with the initial system, all traffic in/out of Iqaluit would be affected in the future when the BU would be installed, one to two weeks of traffic outage, with increased risk of damage to the Iqaluit cable.]

Hudson Bay

The initial project will install a Hudson Bay BU off the mouth of the Hudson Bay for a future 1,300km expansion to communities along the western coast of the Hudson Bay. The future expansion will be a two-fibre pair cable system with Optical Add/Drop Multiplex (OADM) for intermediate Nunavut communities. The BU will have a three kilometers stub cable for future attachment to the Western Hudson Bay cable. This BU will be dormant until the system is expanded. The future expansion can be implemented without affecting traffic on the rest of the GN Cable and KRG systems.

[Note: If the Hudson Bay BU is not installed with the initial system, all traffic east of the BU would have to be routed through Nuuk when the BU would be installed, i.e., one – two weeks of traffic rerouting. All traffic south of the BU would have to be routed through Chisasibi.]

Route Description

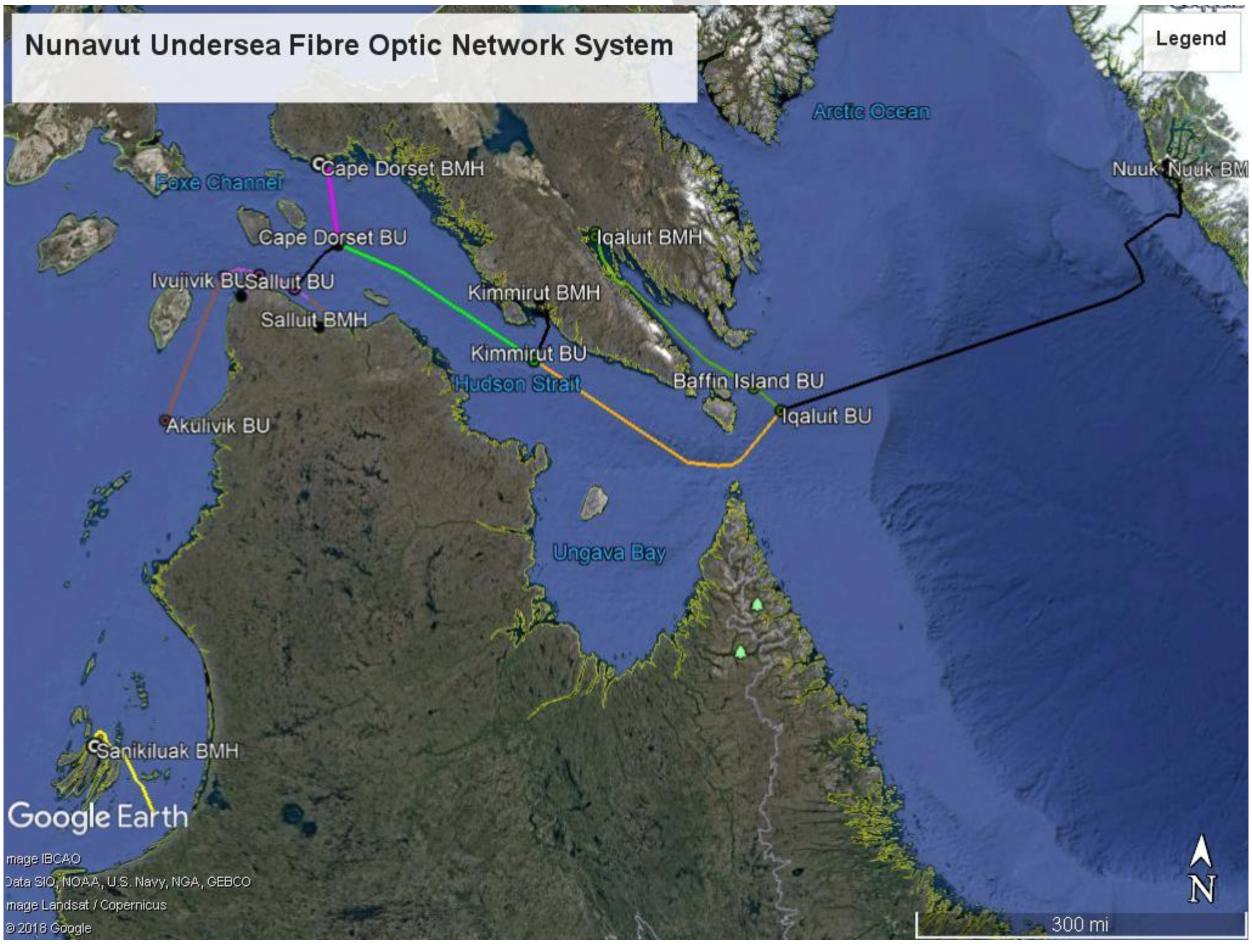
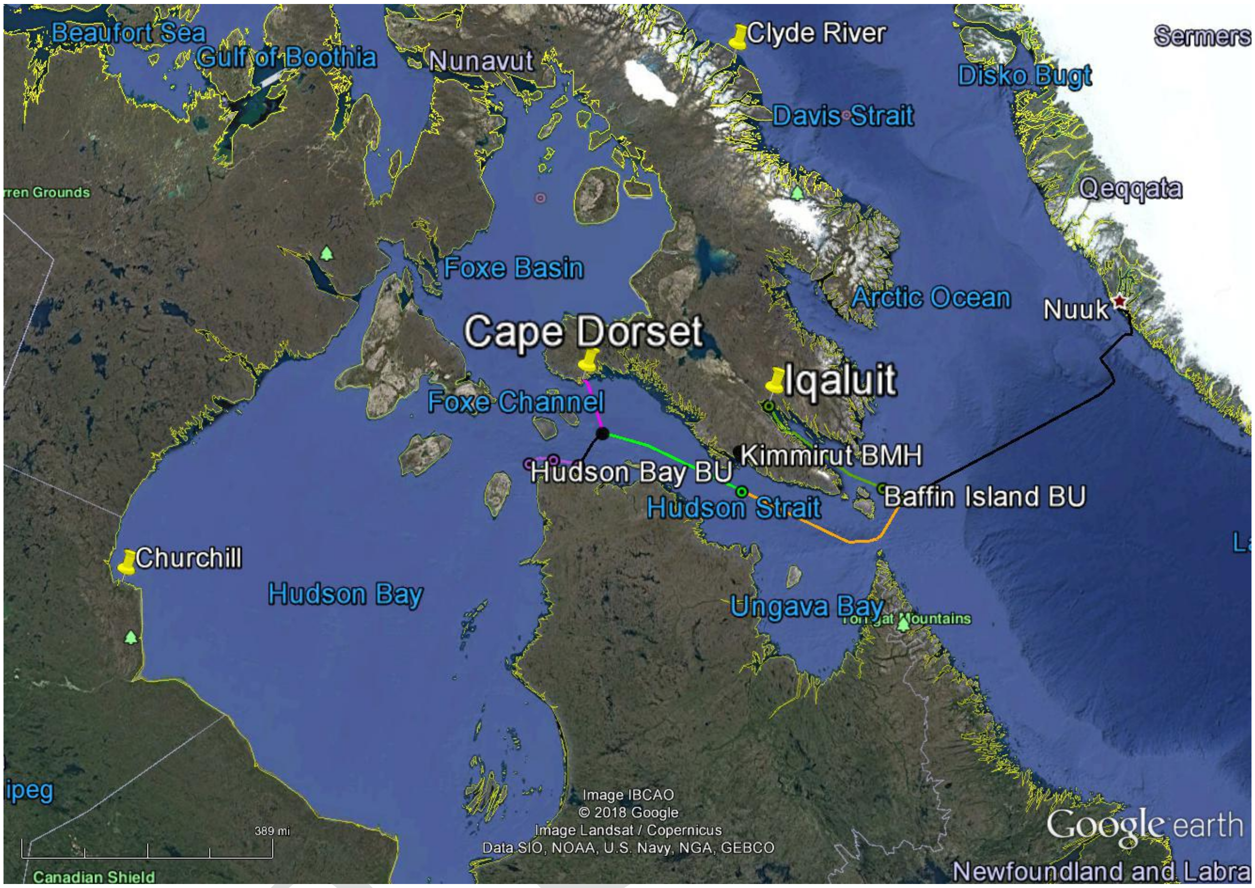


FIGURE 3 – NUNAVUT UNDERSEA FIBRE OPTIC NETWORK SYSTEM

The landing sites presented represent the latest pre-survey chosen locations based on IT International Telecom Canada's route engineering and the 2016 EAUFON Desktop Study (DTS).



Landing Sites

Reference	Community	BMH Coordinates
2	Iqaluit	63° 43.926'N, 68° 27.581'W
3	Kimmirut	62° 50.733'N, 69°52.068'W
4	Cape Dorset	64° 13.915'N, 76° 30.285'W
5	Sanikiluaq	56° 32.609'N, 79° 17.185'W

Iqaluit Landing

The Iqaluit site visit was conducted on September 23, 2016. Four landing site options were visited and three were ultimately ruled out. Site B was located southwest of the town, near the proposed port development where anchor threats would be high and where sealift vessels and barges operate. Site C was ruled out because it is situated next to a cemetery, and Site D was ruled out due to residential housing density. Site A at Apex is the preferred site.

Ice impacts are worse onto the shore and in the bay, but better seawards of where the new port development will be located (see below).

FIGURE 4 – IQALUIT LANDING

A deep-water port is currently being constructed with expected completion by spring, 2019. This will be an anchorage for large vessels, as opposed to alongside berthing. The anchorage is being dredged, with disposal of dredge spoils at sea.

Improvements to the existing jetty near the airport are also planned, which will double its length and add floating docks for smaller vessels. Again, dredging is planned.

Site A is located at Apex and is the preferred landing point in Iqaluit. It is southeast of the main town, along reasonable gravel/old paved roads. The landing at Apex will avoid sealift and other vessel anchorages.

The landing site has an extensive tidal flat, comprised of coarse sand and cobbles. Granite rock outcrops are seen either side of the beach, indicating that rock might sit under the sediment, within the burial depth. Permafrost sits at about 2m depth.

- Beach Manhole (BMH) locations will be finalized once HDD and/or conventional landing methods have been confirmedHDD - The main issue affecting an HDD operation here is the length of the drill, due to the extensive tide flat. A drill might not get the conduit out to into adequately deep water to protect the cable from shore ice effects.
- Direct Landing - It might be worth considering whether a rock-cutter can be used to create a slot in the granite, which is likely to sit below a thin layer of sand, into which the cable can be laid. This would allow a more conventional cable landing, with subsequent remedial protection of some kind, such as cementing the cable in place with compound.

The final decision on the option(s) adopted will be based upon the results of the marine survey.

Kimmirut Landing

Kimmirut is located south of Iqaluit on Baffin Island. See Figure 6: Kimmirut Approach. The site visits were conducted on September 23, 2016.

The proposed landing site is on a beach situated in Glasmow Bay, which has restricted access at its entrance, approximately 3.5km to the south of the community. The entrance to the Bay is 350m wide and this narrow width combined with the offshore islands might constrain cable vessel operations. A separate shore-end might need to be considered. The beach has extensive rock outcrop (granite), with a thin cobbly/gravelly sediment cover in places. There is a shoal off the beach, which then drops off quite quickly. The final decision on the option(s) adopted will be based upon the results of the marine survey.

FIGURE 5 – KIMMIRUT APPROACH

The site itself is somewhat limited from a landing perspective, due to the short nature of low water to the road (~50m). It is believed there could be room for an HDD drill site, on a clear area measuring approximately 10m x 14.5m.

FIGURE 6 – KIMMIRUT LANDING SITE

Cape Dorset Landing

Cape Dorset is located on the southwest side of Baffin Island. The site visits were conducted on September 24, 2016. Three sites had been identified prior to the landing site visits. See Figure 8: Cape Dorset Landing Options for an overview of the locations. Site C is in the town, and Sites A & B are to the east of the town.

Sealift vessels and barges come in near the town, and many other small vessels anchor diffusely and moor to buoys in the bay. Several vessels are hauled out onto the beach in town, east of Site C. Fuel barges anchor closer to the tank farm, which is east of the main town. Fishing and harvesting are subsistence only, with no bottom trawling. There are no icebergs here, due to the protected nature of the area, but sea ice will affect the landing.

FIGURE 7 – CAPE DORSET LANDING OPTIONS

Site B (preferred) is located east of the town. It is the site furthest from the town, with the longest backhaul. It is preferred as a landing point, however, because it has the best potential for a conventional burial operation. The beach has a low gradient, and is comprised of coarse sand and cobbles, with rock outcrop either side of the beach. There appears to be good sediment cover, which is likely a result of the protected nature of the small cove in which it sits. The approaches are somewhat constrained, with a visible rocky shoal about half to two thirds of the way across its entrance. The cable route will need to come in on the south side of the cove, to avoid this shoal. There is a small children's playground above the beach and a picnic area. There is open, flat ground near the playground for a BMH or HDD drill location. Backhaul would require ~1.5km of new aerial build along reasonable gravel roads.

Sanikiluaq Landing

Sanikiluaq is an island, located in Hudson Bay, about 160km off the west coast of the Quebec peninsula. There is a small marina/harbor area.

The Sanikiluaq sites visits were conducted on October 1, 2016. Two potential sites were identified from satellite imagery, in consultation with the team, once on the ground in Sanikiluaq. The site visits were limited to the west portion of the island but had to be relatively close to town due to the hostile terrain for backhaul.

Sealift and other vessels anchor inside the enclosed bay north of the town, and so selecting options on the east side is not viable. Also, scallop fishing occurs on the northeast portion of the island, to an estimated water depth of 50m.

The west coast is considered the safest area from a cable protection standpoint due to these fishing and shipping activities. It should be noted that clam digging does occur on the west coast beaches

FIGURE 8 – SANIKILUAQ SURROUNDINGS

Both the sites visited were close to town. They are separated only by 1.2km along the coast, but each is at the end of a different All Terrain Vehicle (ATV) trail. Sites further south or north were ruled out due to backhaul issues.

The recommended landing is at Site A, which is the site closest to the town. Site B is located to the north, a little further from town. Fishing occurs to the northeast tip of the island. Sealift, fuel and other vessels come right into the enclosed bay.

There is no dredging or dumping. No erosion is reported on the beaches. Currents can be strong, but the Council seemed to think they were tied to tides; there are no eddies reported near the west coast landing points, even though this area is a long embayment between two finger islands. No icebergs are seen, but there is ice rafting during the winter, and sometimes during the fall during winds. 150kg rocks have been seen to be moved by the ice. The Council thought 1m burial was too shallow to protect against the nearshore ice risks and 3m was suggested.

The rock types in this area are basalt (igneous), greywacke (sedimentary) and veins of quartz and iron rich material. Fishermen have not reported offshore rock, but then they fish on the northeast side, so this might not be true of the area off the landings. Underwater cliffs are reported, though, related to the general rock structure, which is basically a series of north-south aligned ridges.

Additional Characteristics

Digital Line Segment Description

The following table is a summary of possible Digital Line Segments (DLSs) on the Nunavut Undersea Fibre Optic Cable Installation. A DLS identifies the endpoints of the traffic and consists of all the traffic carrying system equipment between optical terminals, i.e., Submarine Line Terminating Equipment (SLTE), couplers, optical land cable, optical submarine cable, repeaters, branching units, shape and gain equalizers.

TABLE 1 – SUMMARY OF POSSIBLE DIGITAL LINE SEGMENTS

DLS	Length (Km)	End 1	End 2	Design Capacity
1	1,190	Iqaluit	Nuuk	100 X 100Gbps
2 (future)	1,190	Iqaluit	Nuuk	100 X 100Gbps
3	890	Iqaluit	Kimmirut	2 X 100Gbps
4	2,120	Kimmirut	Chisasibi	2 X 100Gbps
5	1,240	Iqaluit	Cape Dorset	2 X 100Gbps
6	1,830	Cape Dorset	Chisasibi	2 X 100Gbps
7	2,450	Iqaluit	Sanikiluaq	2 X 100Gbps
8	740	Sanikiluaq	Chisasibi	2 X 100Gbps
9	2,800	Iqaluit	Chisasibi	80 X 100Gbps
10	1,400 (future)	Iqaluit	Clyde River	2 X 100Gbps
11	1,400 (future)	Iqaluit	Clyde River	2 X 100Gbps
12	2,600 (future)	Iqaluit	Churchill	80 X 100Gbps

The above table is based upon a fibre pair carrying 100 x 100Gbps. When there is OADM on a fibre pair, it will not be able to carry the maximum wavelengths due to guard bands between the wavelengths. For example, the pair between Iqaluit and Chisasibi will support 2 x 100Gbps at four sites but will only support 80 additional wavelengths (8Tbps). The System Supplier will engineer the capacity of each DLS during system design.

Technology

The Nunavut Undersea Fibre Optic Cable Installation system will be designed for an expected life of 25 years. The 'wet plant' portion of the system will be an Open Cable Interface, meaning that the cable will be terminated with the common equipment needed for powering, line monitoring, and management of the undersea network elements, i.e., the wet plant. The Undersea Fibre Optic Cable Installation will be interoperable with other manufacturers' terminal equipment, i.e., the dry plant. The dry plant may or may not be supplied by the same vendor as the wet plant.

The system will be designed to have 10Tbps capacity on each of the trunk fibre pairs. The 10Tbps can be broken up into 100 channels (wavelengths) of 100Gbps each. The initial system loading can be as low as one 100Gbps channel. As demand increases, additional 100Gbps channels can be added. These channels can be added while the system is in-service, i.e., capacity additions are not service affecting. It is possible to mix and match different suppliers' terminal equipment (SLTE) on the cable, owever, for effective operations, only one supplier on each fibre pair is recommended.

Each community BU will be equipped with OADM to manage the Add/Drop traffic spectrum. The Baffin Island BU and Hudson Bay BU will be stubbed for future installation. The system will be designed to have an availability of better than 99.995%, or less than 26 minutes of outage per year.

Key Features

The dry plant is based on repeatered technology using Dense Wavelength Division Multiplexing (DWDM) in the 1550nm optical window. All the technology proposed for the system is proven and has been demonstrated to be reliable.

The system will have the following key technology features:

Wet Plant

The design capacity is primarily based on the wet plant and is determined by a combination of:

- Fibre selection – Coherent Submarine Fibre (CSF) [large effective area, ultra-low loss, nondispersion shifted fibre per ITU-T G654]
- System length – the longest Digital Line Segment is approximately 2,800km
- Repeater span – spans are approximately 80km
- Wet Plant Bandwidth – depends upon fibre, repeaters, BUs, shape and tilt equalizers.

The System Supplier will use different tools to validate the maximum design capacity, namely:

- Mathematical models and lab experiments

- Experience on similar systems
- Internal lab resources
- Representative test beds (including field trial results).

To achieve a design life of 25-years, rigorous qualification programs are carried out on critical components to insure high reliability. For each qualified component, there is a report that demonstrates that it meets the fit, form, and function needed for the overall system to operate as designed. For example, a repeater is designed to carry direct current at high voltages, relative to earth to amplify optical signals, while withstanding the tensions and torsions involved in deployment and recovery and to operate at oceanic depths up to 8000m. As all subsystem equipment and fiber cable are manufactured for the specific project, the process includes the development of prototype based on specific system design After the prototype is built, it is subjected to quality control testing, including sea trials, to verify that it meets all the necessary specifications. Once the prototype exceeds the pass/fail criteria of the qualification program and the design functionality and performance is validated, the equipment is then placed into production.

The submarine cable is a proven design with more than 500,000 km deployed in the last ten years. Coherent Submarine Fibre is the second generation of ultra-low loss, large effective area fibre for enhanced performance. The repeater for wideband Wave Division Multiplexing (WDM) applications is designed from highly reliable components. The Erbium-doped fibre amplifier (EDFA) repeaters will allow future higher bit rate upgrades. The BUs provide optical node functionality and segment power reconfiguration. Reconfigurable OADM BUs feature maintaining the traffic in case of trunk or branch cable failures. The BUs include an OADM feature to keep the traffic confidential. The system is monitored and controlled by the NMS for preventive maintenance and external fault localization.

Dry Plant

The dry plant will include the equipment needed to provide an operational system, namely:

- Terminal technology – state-of-the-art SLTEs that can be upgraded in the future.
- SLTEs that will have access to a defined bandwidth on the fibre pair.
- Power Feed Equipment (PFE) to supply DC power to the submerged repeaters and BUs. The PFEs are duplicated, and the system is designed to have double-ended power feed for greater reliability. Appropriately sized PFEs are installed at both ends of a segment. In case of a PFE failure or shunt fault, the entire segment can be fed from either end.
- An NMS for supervisory and control of the system. It has northbound interfaces to the Network Operations Centre (NOC) network management systems. The NMS provides functions like fault management, performance management, security management, and configuration management. It also performs periodic tasks including fault detection and location.

- Ancillary equipment such as Data Communications Network (DCN) routers and Private Automatic Branch Exchange (PABX) for Operations & Maintenance. The DCN and PABX can be carried over the network or off-network.

All these components will be integrated to meet the technical specifications of the system.

Beach Manhole (BMH)

The main cable-landing infrastructure consists of a concrete vault designated as the Beach Manhole (BMH). The BMH provides an anchor point that connects the marine cable to the seaward side, and the land cable to the landward side. The typical BMH is approximately 2 m x 2 m x 2 m (W x D x H). It will have adequate grounding (earthing) and be sealed from water / soil intrusion.

Cable

Route engineering

Cable Route Engineering (CRE) is defined as the process to ensure the physical security of the Subsea Cable System from natural and man-made hazards through route selection, slack allocation, cable type (including armor) choice, and the use of industry-standard cable burial and protection practices. Further, it includes the use of trawl-resistant design practices for all seafloor systems installed in waters that may reasonably be expected to be fished over the lifetime of the Subsea Cable System. In addition, CRE considers the viability of areas identified for the placement of seabed plant components such as nodes, repeaters and BUs.

CRE will be the responsibility of the chosen supplier of the Subsea Cable System. However, it is recognized that, the final CRE plan will be subject to the permits obtained from territorial and Federal agencies.

As part of the study, a preliminary level of CRE has been accomplished; however, this has been necessarily limited to the data available. It will be the responsibility of the chosen supplier of the Subsea System to independently research available data to verify or modify the information contained in the Marine Survey.

Cable Types

Cable types are selected to provide appropriate mechanical protection to the system noting that there are physical limitations to the installation of, for example, heavy cable in deep water. The table below outlines the general cable types by water depth recommended for the system but may be substituted by the Supplier based on product offerings, allowances for Arctic conditions, and results of the marine survey. Note that the cable has been generally "up armoured" to account for ice.

TABLE 2 – TYPE OF CABLE PER SEGMENT

Cable Type (km)	Nuuk to Iqaluit (km)	Iqaluit BU to Kimmirut (km)	Kimmirut to Cape Dorset (km)	Hudson Bay BU (km)	Sanikiluaq BU to Sanikiluaq (km)
Light Weight (LW)					
Light Weight Protected (LWP)	515			3	
Single Armoured (SA)	501	456	462		
Double Armoured (DA)	168	54	28		191
Pre-Laid Shore End (PLSE)					
Land Cable	3	2	2		2
Total	1,187	512	492	3	193

Procurement Strategy and Implementation Plan

Asset Ownership and Operation

Government of Nunavut (GN) Community and Government Services (CGS) will own and manage the operation of the asset.

Network Operation Center

Each system requires a NOC to operate and control the system. Some operators have two NOCs (NOCA and NOC-B) in case the primary NOC suffers a failure.

Marine Maintenance

Ultimately, the GN will be responsible to maintain and operate the subsea cable system. But a service contract will be considered.

As a rule, the approach to running a long-haul subsea system is one of self-insurance. This self-insurance is achieved by entering the system into one or more marine maintenance agreements; holding sufficient spare submerged plant in strategic locations; and investing in third party liaison programs. It is typical for systems to be self-insured. Most system owners enter their systems into a maintenance agreement(s) and then build up reserves from income to cover repair costs, typically based on one repair every two to three years.

Decommissioning

The cable's design life is 25 years. However, industry experience is suggesting that the actual lifespan often extends to 30+ years. It is current industry practice to abandon the cable in-place, with the existing cable being left on the seabed to minimize environmental impacts.

Project Schedule

Start and end Dates for the Project's Key Activities. Note that schedule is high-level and may vary slightly as the design is completed and the implementation of the system is executed.

Activity	Start Date	End Date
Project Planning	Mar. 2017	Oct. 2017
Stakeholder Meetings	Jan. 2018	Feb. 2018
Marine Survey Contract	Jul. 2018	Oct. 2018
Nuuk Transit Assessment	Jul. 2018	Aug. 2018
Environmental Assessments	Sep. 2018	Dec. 2018
Preliminary Engineering	Jun. 2018	Sept. 2018
Permitting	Aug. 2018	Jan. 2019
Land Acquisition	Aug. 2018	Nov. 2018
Request For Proposals System	Nov. Dec. 2018	Jan. 2019
Detail System Design	Jan. 2019	Mar. 2019
Mobilization	May 2019	
Land Construction Component	Jul. 2019	Aug. 2019
Marine Deployment Component	Aug. 2019	Nov. 2019
Demobilization	Nov. 2019	
System Commissioning	Jan. 2020	Feb. 2020

Current State - Activities underway

Marine Survey

The marine survey is route survey is in progress and planned to be completed before system installation This is proposed to be August 2019, pending funding decisions.

The marine route survey is an essential part of the project. It validates that the pre-engineering path selected is clear and suitable for the installation of the submarine fibre optic network. This survey is used to confirm or amend the preliminary cable route proposed, and to determine the optimum route for the cable and the cable design. The marine route survey is typically undertaken using a variety of techniques. Remote surveys are undertaken in deep waters and in the nearshore, using side scan sonar equipment. This equipment searches and detects objects on the ocean floor. A separate Burial Assessment (BA) may be necessary to assess the possibility of burial (i.e., how deep can or should the cable be buried), equipment type to be used, the ware-rate of the plough share and to determine the type of cable required. The BA survey is undertaken during the marine route survey.

Nuuk Transit Assessment

Assessment completed 100%

A site survey and bandwidth viability and capacity assessment has been completed and confirmed the capacity of TelePost to transport Nunavut network traffic back to Newfoundland.

Land Acquisition

The process of resolving land lease and acquisition is currently ongoing and is estimated to be at 10% completion at the time of writing. Negotiations are underway with Nuuk for land lease.

The landing sites are located on Commissioners Land; however, the municipalities will have oversight and management responsibilities. Once the leasing process has been completed, a land lease is typically issued for 100 years duration.

Targeted Date for Federal Funding

For construction to begin in 2019, the funding must be approved at the latest in May 2019. This timing requires that the Government of Nunavut be authorized to proceed with a Request for Proposal ahead of project approval, however build in a limitation on the ability for the GN to enter into contractual obligation by May. Otherwise the whole project will need to be moved to the following navigable weather season.

Procurement

The Government of Nunavut through the Department of Community and Government Services will proceed to procurement using a Request for Proposals (RFP) methodology for this project. The RFP will most likely be for a full system based on the pre-engineering design. Due to the nature of the systems to be installed the successful proponent will be responsible for the final design and deployment of the system. (turn-key fashion)

The Department of Community and Government Services will be responsible to prepare, document and publish the RFP. A review committee formed of experts and representatives of CGS - Procurement Division will evaluate the proposals based on criteria established by the RFP process. The GN may call up additional resources to prepare the RFP and evaluate bidders from available current standing offers assets. The process will be public, fair, transparent and competitive.

Project Governance and Recipient Capacity

The Government of Nunavut – Department of Community and Government Services (CGS) is responsible for this project with several divisions having specific responsibilities:

- Information Management / Information Technology (IMIT) Division is the technical lead for the design, procurement, construction and operation of the completed asset
- Procurement – responsible for the tendering and procurement process
- CGS Finance – responsible for all financial management and audit reporting

- CGS – Community Support and Infrastructure Division (CSID) – coordination of reporting, development of narratives and communications

Community and Government Services is responsible for the delivery of IT services to Nunavut and has all resources and experience required to successfully implement this project.

Stakeholder Engagement

Extensive government and public engagement sessions regarding the potential of fibre optic installation for Nunavut were undertaken over the last 5 years. Consistently, business, governments, and other stakeholders expressed the need for a fibre backbone to be built in the eastern Arctic.

When conducting the desktop study, the GN and KRG undertook visits to landing site communities in Nunavut and met with representatives, including Hamlet and government officials, Inuit organizations, Hunters and Trappers organizations, community leaders, business operators and community members. The various suggestions, community and traditional knowledge shared with the surveyors were included in the study results.

Additionally, prior to the GN commissioning the Marine Survey, the GN sent out letters to telecommunication service providers, Inuit organizations, federal government departments and agencies and neighbouring provincial governments to inform them and invite contributions to the scope of work proposed.

The permitting process involving Nunavut Planning Commission and the Nunavut Impact Review Board will consult with a wide range of stakeholders, many of whom were engaged in the work prior to the desktop study.

Innovation

While fibre optic cable is not a new technology, laying the cable under the sea in the Arctic raises additional challenges. Managing situations with the sea ice, icebergs, very high tides and extreme weather will require innovative responses. These situations and responses cannot be predicted

The marine survey was funded under the Building Canada Fund, a cost-shared legacy federal fund. The GN contribution was confirmed

Future Operations

The expected design life of this system is 25 years with standard submarine system maintenance. Once the landing site surveys and marine surveys are completed, the system will be engineered to minimize all identified hazards and risks. This could include such features as additional backup power for the cable landing station, additional armoring, and/or increased burial for the submarine cable.

It is common practice for telecommunication system owners to enter into a maintenance agreement and set up a reserve from income to cover repair costs. Typically, repairs are based on one repair every two to three years. Current experience of other telecommunication systems, such as the Southern Cross Cable System in the Pacific has had two repairs in 15 years. The risk of a cable fault can be assessed from fault data bases, and the cost of a typical repair can be calculated from the running cost of the maintenance agreement concerned.

System Operation

The O&M costs for a submarine cable system include:

1. Operation of the cable landing stations
2. Operation of the Network Operation Center (NOC)
3. Marine maintenance contracts – standby cost plus at-sea repair cost
4. Management overhead.

The cable station, Network Operation Center, and company overhead costs are well identified. Once the system is operational, these costs are stable, allowing for cost-of-living increases in each operational area. Marine maintenance costs consist of the fixed yearly standby charge plus any at-sea charges (usually day rates for transit and for onsite charges). There also may be yearly storage charges for customer spares kept at the marine contractor's facilities.

Climate Lens and GHG Mitigation Assessment

According to an initial scan of the project by the staff at INFC that is responsible for climate lens and GHG projects considerations, the only GHG consideration is the use of the ship to lay the cable and there are no other options for the installation. CGS was encouraged to seek an exemption from this assessment.

Climate Change Resilience Assessment

The cable infrastructure is designed to be operating underwater for over 25 years. No identifiable hazards associated with climate change and extreme weather were identified at this time.

Community Employment Benefits

The human resources required for the project construction are highly skilled and specialized. For the most part, workers will be existing employees of the contractors retained for project construction. The cable installation will be done mostly at sea.

Contracting opportunities exist for the supply of various materials and equipment, fuel, materials storage and inspection services. Local contractors and residents would be hired to build and install the BMHs and community tie-ins. During operations, the GN may choose to hire locally to support its technical functions or to outsource to a third party. It is anticipated that the fibre project will create 3 to 5 full-time positions. Contracting opportunities exist for materials storage and inspection services. GN is required to follow the NNI policy.

Risk and Mitigation Strategies

Various high-level project risks and potential mitigation strategies were identified, and key aspects have been included in the preliminary project schedule. The GN considered a detailed assessment of commercial, environmental, legislative, and technical risks of the proposed fibre system. The evaluation of these risks has formed a part of the final project initiative.

A comprehensive risk assessment will be prepared based on the upcoming results of the marine route surveys. It is understood that a risk registry will be maintained for the duration of the project.

Risk Assessment

System Provision Cost	
Probability	Low
Impact	High
Risk	Results of marine survey and Route Working Group may be different than estimates
Mitigation	A “factor” has been identified during the budgeting exercise to allow for additional cable lengths. A nominal value of 1% of total length is appropriate.
Ice Scouring	
Probability	Medium
Impact	High
Risk	Ice and associated scouring are a significant risk to a future submarine cable. System burial, icebergs and ice at every landing, tide and tidal currents, seabed exposure, and unburied cable segments are all factors that may impact the security of the submarine cable.
Mitigation	Protection methods will need to be identified during the marine survey and suitable cable burial accomplished during the installation of the system to minimize risk to the submarine cable.
Installation Window	
Probability	Medium
Impact	Medium
Risk	Must have sufficient time in the summer weather window to allow marine operations during implementation.
Mitigation	Recent experience in Arctic submarine cable system installation suggests that sufficient weather windows exist to install a submarine cable system. Considerable planning is required beforehand in order to minimize risk in the field, as any delays in fieldwork will cause further delays in the installation effort. Contract must be allocated early enough to allow for a 2019 installation, if not then the effort will be moved on to the following year’s summer window.