Section 1 - Executive Summary

This Nunavut Fibre Optic Feasibility Study report was commissioned by the Nunavut Broadband Development Corporation (NBDC) and subsequently executed by QINIQ INC (on behalf of NBDC) and Salter Global Consulting INC (SGC). In turn, SGC engaged Ledcor Infrastructure Services and Imaituk Inc. as sub contractors.

The principal requirements of the study were:

1. To review current and anticipated fibre optic technologies and make recommendations for suitable deployment in Nunavut.
2. Review the status of arctic fibre network infrastructure, including proposed expansion initiatives up to 2020.
3. Review a minimum of 3 possible landing points in Nunavut.
4. To review the possible impact of fibre systems on service parity in Nunavut. This review is also to include the socioeconomic impact of a mixed telecommunications network in Nunavut, including possible overland distribution alternatives.
5. Provide recommendations for initiating and financing a fibre network in Nunavut, including Private Public Partnership (PPP, P3) alternatives.

Review of Fibre Optic Technologies

From a strictly technical point of view, the report concludes that existing fibre optic technologies (with some modifications to adapt to northern environments and local conditions) would permit the installation and operation of a fibre optic network in Nunavut. However, this is not without risk, and the report has indentified key risk areas, possible risk mitigation strategies, and the need for further “on the ground” survey work before the detailed final configuration and scheduling aspects of a fibre network can be recommended. Key issues are:

- The need for accurate bathymetry information, up to date nautical charts, geological information, tidal information and local ice condition forecasts (including possible iceberg tracks) in order to determine optimum undersea cable routings and landing approaches.
- Environmental review processes and permitting information, both for marine aspects of any proposed fibre system, and also for landings and any proposed land crossings.
- The limited installation window and the unpredictability of changing ice conditions.
- The need for a long term maintenance and repair strategy that identifies alternative backup systems in the event of a prolonged system outage. This is particularly important given the potential inaccessibility of undersea cables for extended periods of time.

The installation of fibre optic cables in Nunavut could be accomplished using three existing technologies (these techniques may need to be modified to meet local conditions):

- Horizontal drilling from landing points to deeper water, to reduce the possibility of cable damage close to the shore.

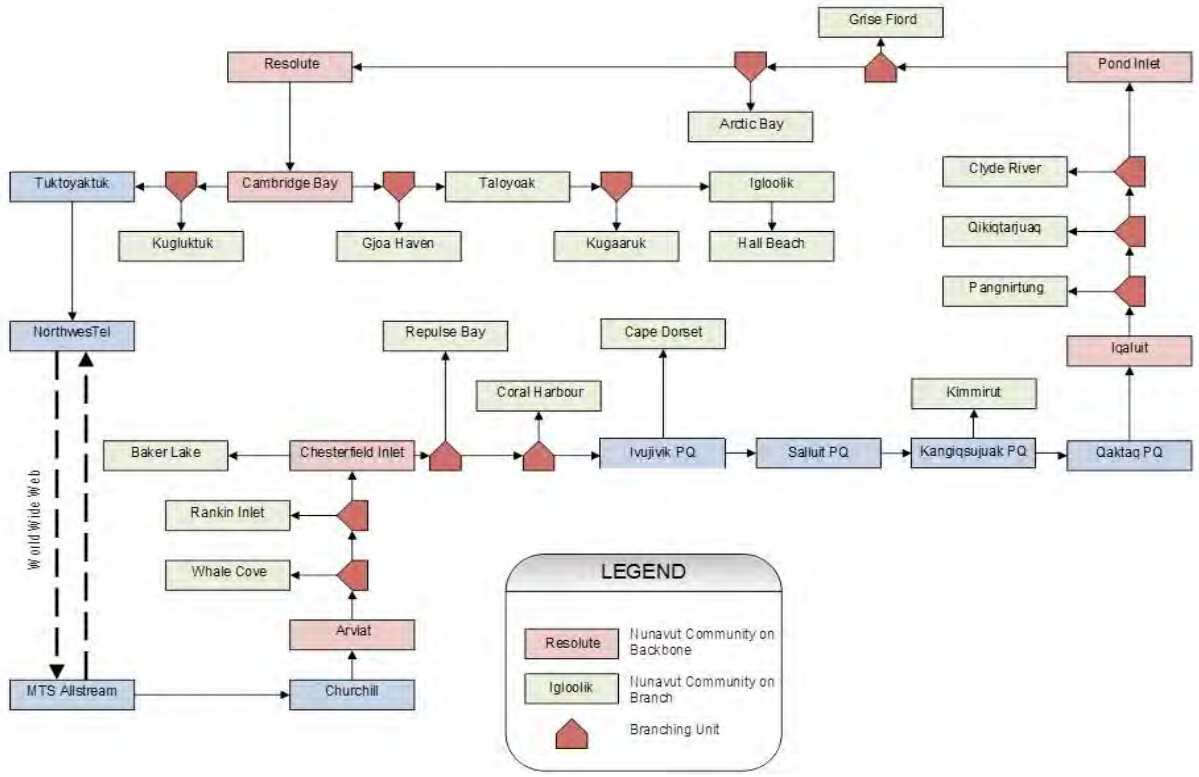
- Undersea plowing of the cable directly into the sea bed for the approaches to landing areas and in shallower water.
- Laying the cable directly on the sea bed in deep water.

Fibre Optic Network Considerations

Fibre optic systems are inherently reliable, but overall system reliability and availability can be significantly improved using three techniques:

- Network fibre "ring" architectures – traffic in these systems can flow in either direction, giving the system improved resilient to a single break. Overall reliability can be further improved by having a "ring within a ring" configuration and multiple ring entry points.
- Route diversity – this technique requires a parallel, but independent routing.
- Use of "branching units" – in this architecture, local feeds to communities along the route are provided by spurs off the main cable. This means that, in the event of a failure along the spur route, the mainline cable system is unaffected.
- Alternative technologies as backup (satellite and/or digital radio).

Proposed network to provide fibre service to communities in Nunavut (- in this model, it is assumed that Sanikiluak could be most economically served from a Nunavik network).



The cable distance for this architecture is 10, 782 km (this distance could be increased marginally following detailed marine and geological surveys).

The "Rough Order of Magnitude" (ROM) capital cost estimate to realize this network is $750M. If a typical Government of Canada style risk analysis is performed on the project, and recognizing that the ROM estimate is based on a desk top study without any physical surveys, the "risk premium" that could be then allocated to a project at this stage of consideration could increase the estimated project cost to $1,050M.

A second network alternative was considered, that provides fibre service to the Regional Centres of Iqaluit, Rankin Inlet and Cambridge Bay, with an extension to Resolute Bay.

The baseline ROM cost estimate for this alternative is $244M (this includes links from Cambridge Bay to Tuktoyaktuk, Iqaluit to Nuuk, Greenland, and Rankin Inlet to Churchill, Manitoba. Using the same "risk premium" analysis as in the first network model, the cost estimate would increase to $342M.

A long term expansion of the Nunavut fibre ring model is proposed that connects communities in Hudson's Bay (including communities in Nunavik). This long term network model is characterized by a two ring network model, with four entry points: Tuktoyaktuk (connecting to the southern NWT system); Churchill, Manitoba; Radisson (or Chisasibi) Quebec; and Iqaluit (connecting to Nuuk, Greenland or Milton, Newfoundland). This network architecture provides a potential long term template for a robust "pan arctic" fibre optic network.

Landing Point Analysis

The report provides a preliminary "desk top" analysis of four landing points using publicly available nautical charts. The locations are Iqaluit, Rankin Inlet, Cambridge Bay and Resolute Bay:

- For Iqaluit, two diverse cable routing paths are proposed. It is also proposed that cable be buried for a distance of at least 7 km to minimize the potential for damage by ice, fishing activities and anchorages.
- For Rankin Inlet, it is proposed to use a branching unit located in deeper water and have a spur feed to the community. From a technical point of view, we have proposed Chesterfield Inlet as a preferable regeneration point for the system, which could be equipped with two diverse shore landings.
- For Resolute Bay, two diverse cable paths are proposed, with separate feeds from Pond Inlet and Cambridge Bay.
- For Cambridge Bay, two diverse routings are proposed. The first, through the bay and into Dease Straight towards Kugluktuk, and the second into Queen Maud Gulf for the routing to Resolute Bay.

Arctic Fibre Optic Systems

Existing fibre optic systems are operating in:

- Northwest Territories and Yukon – NorthwesTel uses a ring fibre optic architecture for its backbone network. An extension of the existing system from Carmacks to Dawson City is planned for 2012.
- TELE Greenland has an undersea system operating from Milton, Newfoundland to Nuuk, Greenland, with a continuing connection to Iceland. A separate network operator is used for the continuation of the system to the Faroe Islands and the UK.
- Two US fibre "ring" systems are operating between Alaska and Washington, and Alaska and Oregon.
- Two 1,400 km marine fibre cables from the Svalbard archipelago, Norway to the Norwegian mainland, operated by Telenor.
- Manitoba Telephone System (MTS) and Manitoba Hydro have a fibre system extending to Churchill, Manitoba.
- A fibre system to Radisson, Quebec that has recently been extended to Chisasibi, Quebec (located on the eastern shore of James Bay).

The following arctic fibre optic systems have been proposed:

- A Mackenzie Valley Fibre Link from near Fort Simpson to Inuvik with an extension to Tuktoyaktuk. This has been identified as one of the top three infrastructure project by the Government of the Northwest Territories.
- Arctic Link has proposed a Europe to Asia system. Two routing options have been discussed; a northerly routing using the McClure Strait, and a southerly routing past Cambridge Bay and then routing north to serve Resolute Bay and communities on the eastern shore of Baffin Island.
- NorthwesTel has proposed a number of system architectures for serving Nunavut communities with marine fibre cable.
- TELE Greenland has proposed a northern domestic fibre route to connect communities on Greenland's western shore with the Nuuk fibre hub.
- Most recently, Arctic Fibre announced a Europe to Asia proposal using a routing via Tuktoyaktuk, Cambridge Bay, and Gjoa Haven and then using a land crossing across the Boothia Peninsula before continuing on a southerly routing to the south of Baffin Island. In this proposal, a separate fibre cable is proposed to connect Iqaluit with Milton, Newfoundland.
- A northeastern passage routing, connecting England, Japan, China and Russia through cable stations in the cities of Bude (England), Tokyo (Japan), and Russia's Murmansk, Vladivostok, and Anadyr has recently been tendered (January, 2012) by the Russian Optical Trans Arctic Submarine Cable System (ROTACS).

Alternative Telecommunications Technologies

At the same time that fibre optic technology has advanced, alternative telecommunications technologies have also been characterized by significant advances.

Satellite Technology

The report considered three satellite technologies:

- High throughput satellites.
- Low Earth Orbit (LEO) satellite constellations
- The Government of Canada's PolarSat mission proposal, based on a two satellite constellation in highly elliptical polar orbits (Tundra or Molniya orbits).

The report concludes that high throughput satellites provide the best alternative for enhanced satellite broadband coverage in Nunavut. Using the recently launched ViaSat 1 satellite as an example, future expanded high speed broadband coverage is technically possible for all communities in Nunavut.

Digital Microwave

Current digital microwave systems have the capacity to backhaul broadband data at speeds of between 500 Mbit/s and 1 Gbit/s. Typical capital ROM site cost estimates average at between $1M and $1.2M per location (assuming 40 m towers). A typical repeater "skip" distance of between 30km and 40 km has been assumed. In most cases, communities would need to be between 100 km and 140 km distance from a telecommunications fibre hub for a microwave system to be cost effective.

Mixed Telecommunications Network

The Nunavut telecommunications network could evolve in two ways:

- A satellite only configuration, using a combination of existing satellites and, potentially, high throughput satellites.
- A mixed network comprising a backbone fibre network with digital microwave backhaul systems for communities that are relatively close to fibre hubs, and satellite service for outlying communities.

The study indentifies four possible microwave candidates, in addition to a possible digital radio route diversity system from the existing terminal of a microwave system at the Ekati Mine site, NWT, to Cambridge Bay, Nunavut.

Socioeconomic Considerations

Nunavut demographics are unique in the north, with a population spread more evenly throughout the Territory, so it is important that all communities have the opportunity to benefit equally from the

provision of broadband services. It is also important in Nunavut to ensure that all communities have similar broadband speeds so that territory wide initiatives that are dependent on broadband will provide benefits to all 31,000 residents.

- The socioeconomic opportunities broadband brings will only be open to a portion of the population if some communities are connected and others are not, creating a political and cultural challenge in Nunavut.
- It is critical that concurrent investment in high throughput satellite will be required to serve non-fibre linked communities, and to provide effective back up in the event of a fibre failure.
- Any serious plan for fibre backbone investment must consider how to mix fibre and satellite so that any difference in service levels can be managed for the socioeconomic growth of the entire territory.

The report makes 4 socioeconomic recommendations:

- Investment in infrastructure must benefit Nunavummiut as it also seeks to benefit Canada.
- Reliability and system redundancy are paramount.
- Strategic concurrent backbone investment is required in satellite.
- Future revenue streams required to maintain and innovate.

Private Public Partnership (PPP or P3) Models

The report considers four types of P3 models:

1. Traditional P3 models, that have been employed by the Government of Canada's (GoC) Federal P3 Agency e.g. Design, Build, Operate Maintain. In this model, the asset has to ultimately be owned by a public body (Territorial Government, Provincial Government, Aboriginal Government, Municipality etc).

2. GoC P3 model that has been used by Industry Canada – In this alternative, the ownership of the asset can ultimately rest with the private sector.

3. "Condominium" Model – In this model, a project sponsor (e.g., a Territorial Government) would own and manage the overall framework infrastructure of the project, but would be able to "sell," "lease," or "rent" capacity to private sector clients at market rates, while maintaining a separate element for public good use (health care, education, social services etc.).

4. IRU (Indefeasible Right of Use) – this is a common form of arrangement within the fibre optic sector. IRUs are commonly used in long haul fibre systems as a way of sharing costs while retaining indefeasible control of an agreed communications channel.

Proposed "Next Steps"

The following next steps are proposed:

1. Local community consultations. Local knowledge with respect to landing approaches, ice conditions and scouring, etc. are important elements in any design.
2. Further assessment of risk mitigation options – this could significantly reduce the "risk premium." These could include:
    a. Completion of a detailed field and marine study, including bathymetry and geological surveys.
    b. Detailed assessment and projected schedule for environmental reviews and permitting.
    c. Sharing and transference of risk to private sector and/or other potential stakeholders.
    d. Business case analysis for the proposed project elements.
    e. Assessment of financing alternatives.
3. Review of long term pan arctic communications alternatives with interested Territorial, Provincial and Aboriginal Governments, together with the Federal Government. This report provides one alternative for a long term pan arctic fibre network infrastructure.
4. Proposed Northwest Passage Private Sector Initiatives – there have been two Europe-Asia fibre optic network proposals. Eventually, one of these proposals (or a similar proposal) could succeed, and it would be important to have the strategy in place to negotiate appropriate branching units and business arrangements, to protect the interests of Nunavut.