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EXISTING AND PENDING INFRASTRUCTURE PROJECTS: POTENTIAL COMPATIBILITY WITH THE CANADIAN NORTHERN CORRIDOR

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FOREWORD

THE CANADIAN NORTHERN CORRIDOR RESEARCH PROGRAM PAPER SERIES

This paper is part of a special series in *The School of Public Policy Publications*, investigating a concept that would connect the nation's southern infrastructure to a new series of corridors across middle and northern Canada. This paper is an output of the Canadian Northern Corridor Research Program.

The Canadian Northern Corridor Research Program at The School of Public Policy, University of Calgary, is the leading platform for information and analysis on the feasibility, desirability, and acceptability of a connected series of infrastructure corridors throughout Canada. Endorsed by the Senate of Canada, this work responds to the Council of the Federation's July 2019 call for informed discussion of pan-Canadian economic corridors as a key input to strengthening growth across Canada and "a strong, sustainable and environmentally responsible economy." This Research Program will benefit all Canadians, providing recommendations to advance the infrastructure planning and development process in Canada.

This paper, "Existing and Pending Infrastructure Projects: Potential Compatibility with the Canadian Northern Corridor", falls under theme Organization and Governance of the program's eight research themes:

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Dr. Jennifer Winter
Program Director, Canadian Northern Corridor Research Program

EXISTING AND PENDING INFRASTRUCTURE PROJECTS: POTENTIAL COMPATIBILITY WITH THE CANADIAN NORTHERN CORRIDOR

Alaz Munzur

KEY MESSAGES

- Rigorous planning of a multi-modal corridor at a national scale requires identifying current and future infrastructure needs and determining opportunities for co-location of linear infrastructure.
- Ensuring compatibility of such a major and complex infrastructure expansion with existing and pending infrastructure projects is necessary to avoid potential redundancies, minimize environmental impact, optimize resource allocation and enable long-term, sustainable economic growth.
- Determining the regions, cities and communities to be served by the corridor requires a comprehensive investigation of the existing and pending infrastructure projects serving an area in addition to determining the needs and priorities of the stakeholders and the area's economic potential. Successful integration of existing infrastructure primarily depends on the design principles and priorities determined and agreed upon by the stakeholders in the early stages of infrastructure development.
- Developing a systematic approach for measuring compatibility first requires an overview of the existing and pending infrastructure projects. To provide input for future research on the compatibility of infrastructure projects and its potential implementation to the CNC, this paper provides a comprehensive overview of the major components of Canada's infrastructure network, organized by mode and complements an accompanying database of Canada's linear infrastructure network.

SUMMARY

Rigorous planning of a multi-modal corridor at a national scale involves identifying current and future infrastructure needs and determining opportunities for co-location of linear infrastructure. Ensuring compatibility of such a major and complex infrastructure expansion with existing and planned projects is necessary to avoid potential redundancies, minimize environmental impact, optimize resource allocation and enable long-term, sustainable economic growth.

For this purpose, this paper reviews linear infrastructure projects in Canada's North and near-North that could potentially constitute a segment of the Canadian Northern Corridor (CNC). The CNC concept connects Canada's Atlantic, Pacific and Arctic coasts and Hudson Bay through a linear infrastructure corridor. In accordance with the aims and scope of the CNC, this assessment covers linear infrastructure modes such as rail, road, pipeline, electrical transmission and communications infrastructure and ports and airports as supporting inter-modal infrastructure hubs and gateways to the rest of the world. The assessment reviews infrastructure projects in two categories: existing and pending.

Corridor development is a lengthy, costly and complex process. Planning stages often involve a risky assessment of possible changes in economic activity, regional priorities, land use and environmental conditions (such as changing needs for climate adaptation strategies). However, there is no universal methodology for the design and development phases of corridors. On the basic requirements of planning a corridor route, Srivastava (2011) states that, "Corridor development does not create economic strength so much as it channels, focuses, and amplifies the potential for economic growth. Thus, a corridor from nowhere to nowhere through nowhere would not be very meaningful. Similarly, a corridor linking two substantive nodes but with no potential for growth in between (because of adverse geography) is also of limited interest." Therefore, determining the regions to be served by the CNC requires a comprehensive investigation of the stakeholders' needs and priorities and the economic potential of the areas to be served.

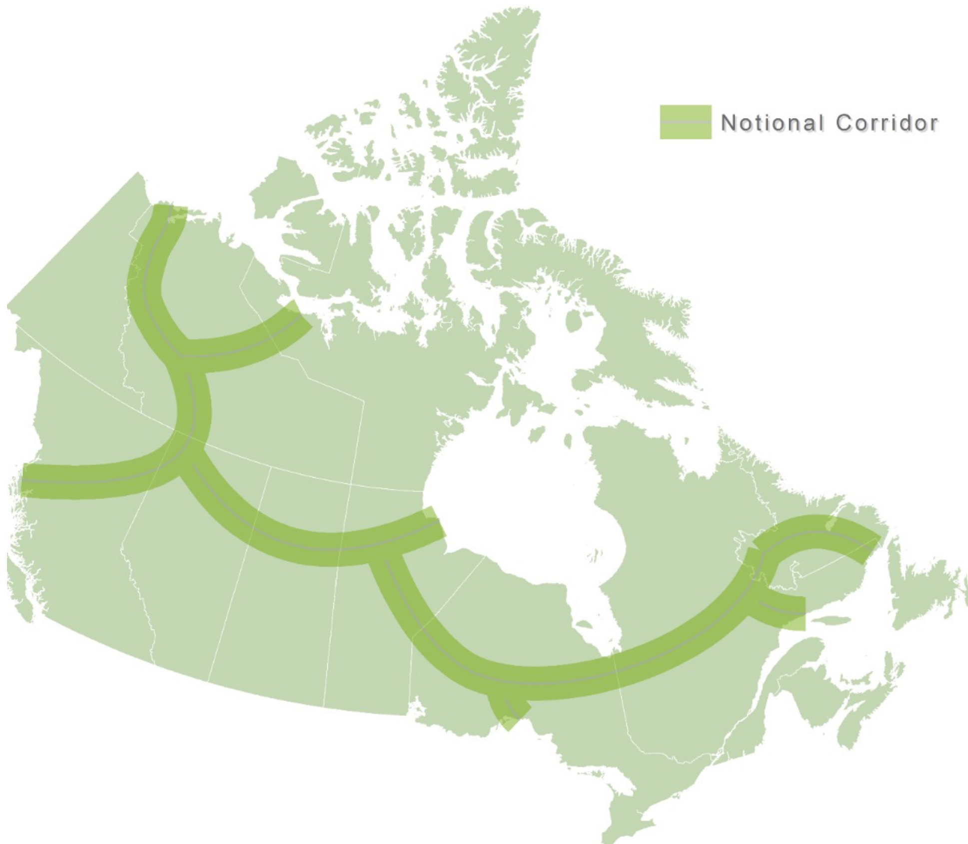
However, there is no single rule for determining the level of compatibility of an existing piece of infrastructure with a planned corridor project. Although integrating previously independent sets of infrastructure potentially eliminates redundancies, saves time and resources and reduces habitat fragmentation, aiming for achieving full integration can also result in inefficient outcomes by creating bottlenecks and delays in the movement of goods and services.

The assessment in this paper serves as a step towards determining a compatibility of the CNC with Canada's existing and pending infrastructure network. The assessment suggests developing a compatibility index as a multi-criteria appraisal framework for Canada as an avenue for further research. The compatibility index would be simple, including only quantifiable factors as decision criteria, which can be measured using the dataset developed accompanying this assessment and the outcomes of other CNC research. This would represent a concrete step toward developing the multi-modal route for Canada with a northern focus that efficiently and purposefully integrates Canada's existing and pending infrastructure network.

1. INTRODUCTION

The Canadian Northern Corridor (CNC) concept is a network of pre-approved and administered rights-of-way through Canada's North and near-North together with a regulatory and governance structure (Fellows et al. 2020). It is intended to be multi-modal, capable of accommodating roads, rail, power lines, communication cables, commodity pipelines and other linear infrastructure modes. The notional route of the envisioned multi-modal CNC connects Canada's Atlantic, Pacific and Arctic coasts and Hudson Bay through a linear infrastructure corridor. Figure 1 shows the notional route of the CNC.

Figure 1: The Notional Route of the Canadian Northern Corridor



Note: Map prepared by the author based on Fellows et al. 2020. Routing is for illustrative purposes only; exact path is to be determined.

Corridor development at this scale is a lengthy, costly and complex process. While determining the optimal route starts simply by asking whether a given route is in the public interest by weighing its positive and negative consequences, there is no universal methodology for this due to the problem's complexity. Rigorous planning of the route of a multi-modal corridor at a national scale involves identifying current and future infrastructure needs and determining opportunities for co-location of linear infrastructure. While co-location of infrastructure is advantageous for many reasons, such as avoiding habitat fragmentation, it also makes the protection of critical infrastructure a bigger challenge for risk and emergency management. Co-location of critical infrastructure may raise national security risks by creating geographic hotspots that may be targeted for malicious attacks, resulting in disruptions to critical infrastructure (Thacker et al. 2017).

Planning stages involve determining the optimal route among many alternatives as a result of a risky assessment of possible changes in economic and social activity, regional and national priorities, land use and environmental conditions (such as changing needs for climate adaptation strategies). Ideally, determining the precise locations the CNC would serve requires a comprehensive impact assessment of the needs and priorities of the stake- and rights holders, the economic potential of the areas to be served, the potential for expansion, national security, available technologies and environmental considerations. Decision-makers would assess these impacts thoroughly and accurately for both the short and long term.

One option decision-makers have is incorporating existing infrastructure into the corridor and eliminating redundant systems with limited or no interconnectivity with the rest of the network. This allows authorities to simplify planning, operations and maintenance of the corridor without necessarily replacing existing infrastructure and brings sustainability at a lower cost. Prioritizing complementarity rather than competition among infrastructure modes is also important while choosing whether and which pieces of the existing infrastructure assets to incorporate along the corridor route. Although integrating previously independent sets of infrastructure into a corridor potentially eliminates redundancies, saves time and resources and reduces habitat fragmentation, aiming for achieving full integration can also result in inefficient outcomes by creating bottlenecks and delays in the movement of goods and services.

Infrastructure is essential for improving the resilience of communities, especially in Canada's remote North. While bringing road, rail or transmission lines to these communities can be important to lower the cost of living or enhance investment opportunities in the resource sector, such investments are costly and technically complex due to geography and may take years to integrate with the existing infrastructure network. Therefore, in addition to partial integration, policy-makers should also consider alternatives to linear infrastructure in certain locations and for certain infrastructure modes along the CNC. The quality of life and resilience of the isolated communities can improve faster and at a lower cost by harnessing new technologies. For example, decentralized approaches towards energy management, such as distributed energy systems, can offer significant opportunities to enhance quality of life by lowering costs, improving reliability and reducing dependency to fuel barged or flown north to communities for resupply.

On the basic requirements of planning a corridor route, Srivastava (2011) states that, "Corridor development does not create economic strength so much as it channels, focuses, and amplifies the potential for economic growth. Thus, a corridor from nowhere to nowhere through nowhere would not be very meaningful. Similarly, a corridor linking two substantive nodes but with no potential for growth in between (because of adverse geography) is also of limited interest." Therefore, linear infrastructure corridors are very location- and time-specific endeavours. Policy-makers involved in designing a corridor should consider the current needs of particular communities and supply chains a corridor intends to serve, and plan and prepare for changes in these local needs and priorities.

Rodrigue (2021) states that an important step in planning a corridor is assessing the latent demand that it could reveal. Additional latent demand the CNC could unlock would be limited due to existing corridors in southern Canada and low population and economic density in northern communities. With limited commercial incentives, the core drivers of the CNC in the near future would be improving quality of life in these communities, strengthening Canada's Arctic and northern security and improving access to resources in certain segments along the notional corridor.

In accordance with the CNC's aims and scope, this assessment tracks linear infrastructure modes like rail, road, commodity pipelines, power lines and communications infrastructure and supporting inter-modal infrastructure in Canada. The assessment reviews active infrastructure projects in two sub-categories: existing and pending. While operational infrastructure is included in the existing projects category, the pending infrastructure category captures projects that are not yet operational, i.e., in the planning stage, pending approval or under construction. For infrastructure projects reviewed under these categories, this assessment provides brief information about the purpose, geographical characteristics, funding sources and active environmental and regulatory review processes.

The main purpose of this project is to develop a geo-located database of existing and pending infrastructure projects in Canada. Drawing on data from official sources, the accompanying database is organized by type and mode of infrastructure. The infrastructure database developed as part of this project provides a comprehensive range of information on the status of the existing and pending linear infrastructure assets. Combined with additional data on, for example, use, geography, housing, population, economic activity, etc., the accompanying database can inform long-term planning of infrastructure investments in Canada.

The projects included in this assessment are selected from the accompanying database. The selection is based on factors such as proximity to the CNC's notional corridor; inter-modal hubs such as ports and airports and/or the rest of the Canadian linear infrastructure network; availability of information on status for pending projects; and the significance of the project to a community/region it serves. However, inclusion in this assessment does not imply compatibility with the CNC since the sample is not built based on an evaluation of projects according to a list of pre-determined criteria backed up by research. Developing a systematic approach for measuring compatibility first requires an overview of the existing and pending infrastructure projects. To provide input for future research on compatibility of infrastructure projects and its potential implementation to the CNC, this paper provides a comprehensive overview of the major components of Canada's infrastructure network, organized by mode.

1.1. A RENEWED FOCUS ON CANADA'S CORRIDOR AND GATEWAY STRATEGY

Although Canada's history is punctuated with big and bold national projects, such as the Trans-Canada Highway and the Canadian Pacific Railway, a long list of stalled or cancelled stand-alone infrastructure projects can create frustration and lead to an erosion of public confidence in established processes among certain groups of stakeholders and members of the public. Lengthy and fragmented regulatory and review processes that assess the feasibility of major infrastructure projects are often viewed as a source of conflict between economic objectives and environmental conservation and culture and heritage preservation. The challenges that project proponents face include long delays between project proposal and approval; lack of opportunities for sharing additional costs of sorting out broader legal and regulatory issues and risks that proponents of each individual project must bear; and uncertainty arising from political cycles. While attending to these, policy-makers also need to strengthen public trust by improving communication channels between different levels of government, non-governmental organizations, local communities, Indigenous communities and industry; and strengthening policy, regulation and monitoring efforts (Colton et al. 2016; Gattinger 2016, 9–13). Pre-established corridors can streamline infrastructure development and help overcome some of these challenges by allowing for centralized monitoring of multiple infrastructure modes located along a single right-of-way and decreasing land disturbance and fragmentation.

Discussion of multi-modal corridors is relatively recent in Canada. Federal efforts to address the corridor concept with its possible applications in Canada and to develop a framework structure started in the early 2000s. The first example of this at a major scale, the Asia-Pacific Gateways and Corridors Initiative (APGCI), was launched in 2006 to facilitate and support trade between Canada and the Asia-Pacific region. APGCI was designed to encompass a set of policy and research initiatives and a network of integrated infrastructure assets in British Columbia, Western Canada and the Prairies (Figure 2). In 2007, the federal government released the National Policy Framework for Strategic Gateways and Trade Corridors (Transport Canada 2009). The framework was developed based on the federal government's experience with the APGCI, establishing an overarching policy approach to long-term infrastructure planning. Following the APGCI, two additional regional multi-modal corridor strategies were developed as part of the National Gateway Framework to advance the Canadian economy's competitiveness in international markets: the Ontario-Quebec Continental Gateway and Trade Corridor and the Atlantic Gateway.

Figure 2: The Gateway and Corridor Initiatives

Source: Map prepared by the author (2021) using data from NRCan 2006; NRCan 2020a; Statistics Canada 2019; Statistics Canada 2020b; U.S. Census Bureau 2018. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

These gateways and corridors and Canada's overall trade and transportation strategy were based on the five considerations below (Transport Canada 2009). These five policy lenses may still provide an analytical framework to assess the value of future transportation initiatives:

i. **International Commerce Strategy**: Develop strategic gateways and corridors that help align Canada's major infrastructure network with Canada's most important opportunities and challenges in international trade.

ii. **Volumes and Values of National Significance:** Develop effective gateways and corridors that target where volumes and values are most significant for Canada's economy overall.

iii. **Future Patterns in Global Trade and Transportation:** Develop forward-looking gateways and corridors that address major trends in international trade and transportation.

iv. **Potential Scope of Capacity and Policy Measures:** Develop integrated gateways and corridors that go beyond existing infrastructure systems and address integration on several levels such as modes of transportation, and between investment and policy, public and private sectors and among levels of government.

v. **Federal Role and Effective Partnerships:** Develop collaborative gateways and corridors that ground federal action in concrete responsibilities and effective partnerships with other governments and the private sector.

About C$6 billion from public and private sources had been committed to developing these three gateways and trade corridors. The available funds supported about 60 infrastructure projects across Canada, including the Roberts Bank Rail Corridor in B.C., the modernization of the Port of Sept-Îles in Quebec and the building of CentrePort Canada, an inland port and multi-modal transportation hub in Winnipeg. These funds also supported development of infrastructure-related metrics such as port use and supply chain fluidity indicators (Transport Canada 2011, 121–124).

Under Budget 2017, an investment of C$10.1 billion over 11 years was earmarked for trade and transportation projects (Government of Canada 2016, 23). As part of this announcement, and building on the corridors and gateways framework developed by Transport Canada, a new federal funding program, the Trade and Transportation Corridors Initiative (TTCI), was announced (Government of Canada 2017, 138). The TTCI's purpose is to support Canada's trade corridors and resolve trade-related transportation issues through multiple funding streams. For this purpose, the C$50 million Transportation Data and Information Hub was created in partnership with Statistics Canada to gather accurate and timely transportation data (Government of Canada 2017, 139). As part of the TTCI, the federal government also created the National Trade Corridors Fund (NTCF) in 2017 with an initial allocation of C$1.9 billion over 11 years. The NTCF provides funding for projects that can potentially address capacity constraints and bottlenecks along the existing corridors and contribute to enhancing and diversifying Canada's international trade (Government of Canada 2017, 139). The NTCF recently received additional funding of C$1.9 billion with a renewed focus on supporting economic recovery and building long-term resilience for the Canadian economy through enhancing internal trade, alleviating bottlenecks in the transportation network and reducing greenhouse gas emissions in Canada (Government of Canada 2021, 143).

Important for the purposes of the CNC is a NTCF funding stream that specifically targets projects which address the transportation-related infrastructure needs of Canada's North. Under the current funding scheme, 15 per cent of the total funding of the NTCF is dedicated to building and improving transportation networks in the Arctic and northern regions (Government of Canada 2021, 143).[1] One substantial investment in the North made through the NTCF is the C$1.1 billion Slave Geological Province Corridor Project in the Northwest Territories. In 2019, the NTCF provided C$30 million to support the construction of a 413-kilometre year-round access corridor into the mineral-rich areas around Yellowknife and in western Nunavut. The corridor will also facilitate the development of linear infrastructure in the region, including an all-weather road, hydroelectric transmission and communication lines.

Under the funding stream for Arctic and northern transportation projects, five other projects in Nunavut have also received federal funding. Among the supported projects is the initial phase of the construction of the 227-kilometre Grays Bay Road and Port Project, which will be part of an all-weather road connecting Nunavut to the Northwest Territories and the rest of Canada. To improve accessibility to Nunavut, the NTCF also provided C$45 million to expand the Rankin Inlet airport and C$22.5 million to modernize five airport terminals across the territory. In 2019, the NTCF partially funded the Kivalliq trade corridor, another major transportation project in Nunavut. This corridor, linking Rankin Inlet with Kivalliq communities, is a step towards a highway system connecting Nunavut to Manitoba (Nishi-Khon and SNC-Lavalin 2010, 3).

Following the development of the National Policy Framework for Strategic Gateways and Trade Corridors, the federal government has tried to improve the fluidity of supply chains across the country by identifying and addressing major bottlenecks and capacity issues. In recent years, Ottawa has similarly focused on the infrastructure-related challenges in Canada's Arctic and northern regions. The Arctic and Northern Policy Framework was released in 2019, replacing Canada's Northern Strategy (Government of Canada 2009 and 2019a). The framework highlights the issues and challenges in Canada's Arctic and northern regions and sets priorities for federal policy. To achieve the overarching goal of resilience in the region, the framework emphasizes the need for strengthened transportation, energy and communications infrastructure (Government of Canada 2019a). Regarding corridors and gateways as a means to closing infrastructure gaps with other regions of Canada, the framework proposes developing multi-purpose corridors for transportation infrastructure, broadband internet and energy, including connections to existing hydroelectricity grids. Accompanying the framework are the partner chapters, which offer the respective priorities of the federal government's co-development partners in preparation of this framework. As of September 2021, the Inuit Nunangat, Northwest Territories, Nunavut and pan-territorial chapters are available alongside the federal framework.[2] In all of these documents, the partners state eliminating the infrastructure deficit and improving connectivity with other regions of Canada as the main priorities (Inuit Tapiriit Kanatami 2019, 9; GNWT 2019a, 16; Government of Nunavut 2019, 22; Government of Yukon, Northwest Territories and Nunavut 2019, 5).

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1 This funding stream's geographic scope includes Yukon, the Northwest Territories, Nunavut, the northern extent of Labrador containing the Nunatsiavut region; the Nunavik region in Quebec; and the town of Churchill, Port of Churchill and related infrastructure assets in northern Manitoba. For more information on this program and the funded projects, see Transport Canada (2021a).

2 The Arctic and Northern Policy Framework website notes: "Additional partner chapters will be posted once available for release" (Northern Affairs 2019).

1.2. ORGANIZATION OF THE PAPER

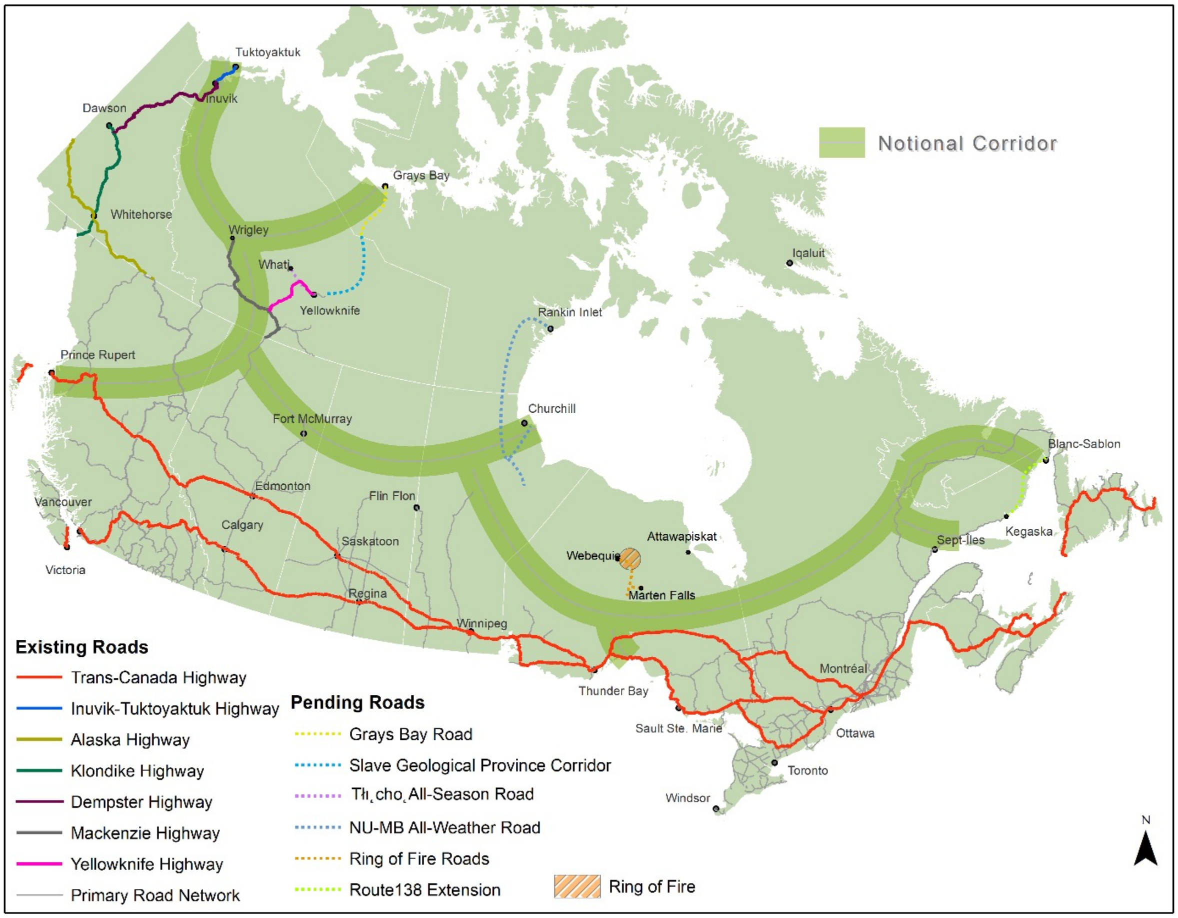
The remainder of the paper proceeds in Section 2 with a selected set of existing and pending road infrastructure projects relevant to the scope of the CNC. Section 3 provides details on the railway corridors in Canada and an overview of the pending railway projects. Sections 4 and 5 follow with existing and pending electricity, communication and pipeline corridors. Existing and pending multi-modal corridors are presented in Section 6. The last section concludes with information on the developed database of existing and pending infrastructure projects in Canada and avenues for future research.

2. HIGHWAY CORRIDORS

2.1. OVERVIEW

Canada is the second largest country in the world by area with a substantially urbanized population. About 82 per cent of the population lives in urban centres and 60 per cent lives in urban centres with a population of more than 100,000 (Statistics Canada 2016a). Due to these geographic and demographic attributes, reliable and efficient transportation networks and services are important. Canada's transportation network is primarily based on roads for both freight and passenger traffic (Transport Canada 2021b). Although the three northern territories cover about 3.5 million square kilometres, equivalent to 40 per cent of Canada's total land mass, the national road network mainly connects the country's population centres across the southern parts of the provinces, along an east-west axis anchored around Canada's longest national road, the Trans-Canada Highway (Figure 3).

Figure 3: Primary Highway Corridors and Pending Highway Projects

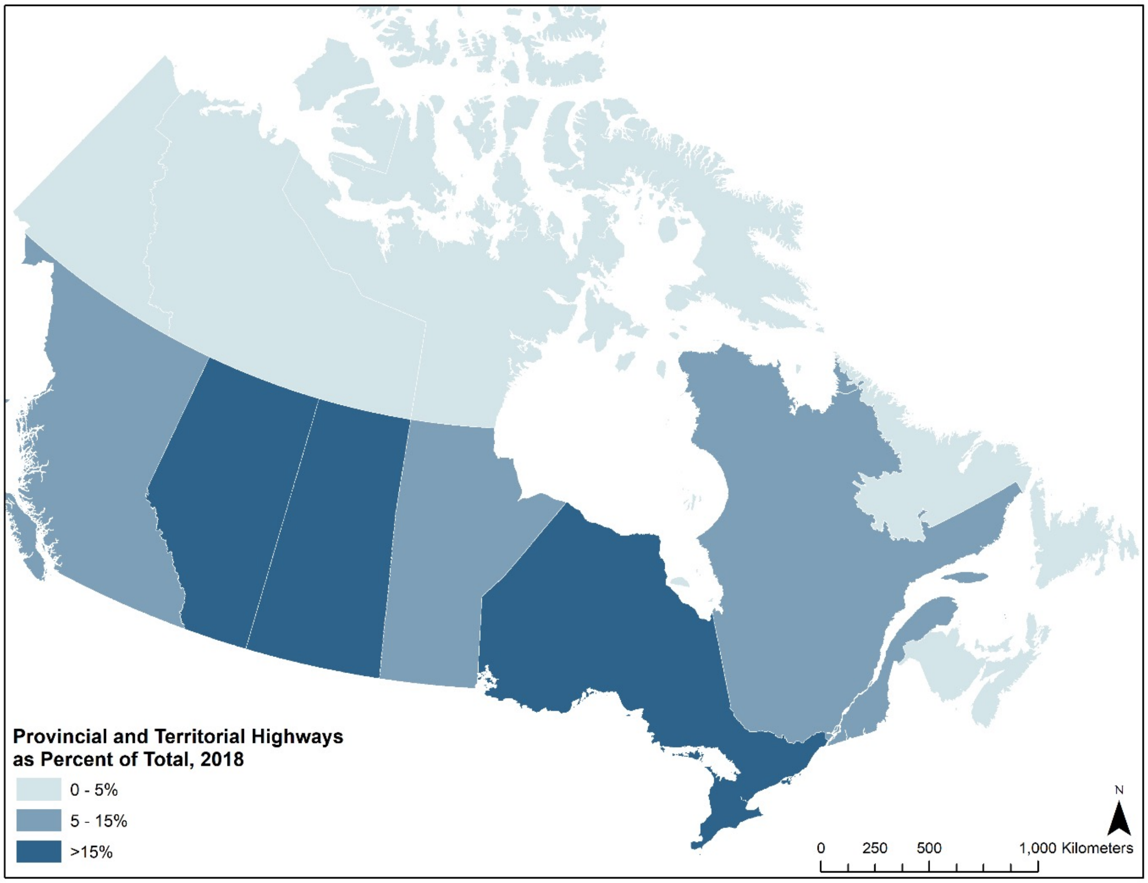


Source: Map prepared by the author (2021) using NRCan 2020a; Statistics Canada 2019; Statistics Canada 2020b; GBEEC 2017; GNWT 1999; GNWT 2015; Nishi-Khon & SNC-Lavalin 2010; Government of Quebec 2019; City of Thunder Bay 2020. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

According to the results of Statistics Canada's "Canada's Core Public Infrastructure" survey, there are 1,066,181 kilometres of publicly owned roads in Canada (Statistics Canada 2020a). Alberta, Ontario and Saskatchewan lead the country in terms of total road length; 63 per cent of Canada's publicly owned roads are in these three provinces (Figure 4). While Saskatchewan accounts for the largest share of Canada's roads (24 per cent), only 1.3 per cent of Saskatchewan's road network is comprised of highways, while 68 per cent is local roads connecting rural municipalities (Statistics Canada 2020a). Overall, local roads are the most prevalent type in Canada. While local roads account for about 60 per cent of the total Canadian road network, highways comprise about five per cent of all roads (Statistics Canada 2020a). The majority of the new roads constructed in recent years are also local roads. For example in 2017 and 2018, 62 per cent of new construction was local roads and 12 per cent was highways (including rural highways).

In the northern territories, where about 0.32 per cent of Canada's population lives (Statistics Canada 2016a), communities mainly rely on air and marine transportation and a network of ice roads in winter to move both people and goods. This is why the share of highways in the short road networks of the Northwest Territories and Yukon is high (69 and 75 per cent respectively). Nunavut is the most isolated territory, with no connection to the rest of Canada's road network. Forty kilometres of mostly unpaved roads provide access to residents in Nunavut's communities.

Figure 4: Provincial and Territorial Highways as a Per Cent of Canada's Total Highways, 2018



Source: Map prepared by the author (2021) using data from Statistics Canada 2019 and Statistics Canada 2020a. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

In 1988, the Council of Ministers Responsible for Transportation and Highway Safety established Canada's national highway system (NHS). As of 2017, the NHS encompasses about 38,000 kilometres or 3.7 per cent of Canada's roads. The NHS includes only the routes that support international and interregional trade and travel by connecting Canada's major population and commercial centres, major ports of entry and exit with the United States and inter-modal connectors and hubs such as ports, airports and railway terminals. Thus, the NHS is a federal designation for strategic routes in Canada's road network, such as the Trans-Canada Highway, that are important from a provincial, territorial and national perspective. The NHS has three categories: the core international and interregional corridor routes, the feeder routes that link core routes to population and economic centres and northern and remote routes that link core and feeder routes to northern and remote areas.

Figure 5: The National Highway System

Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; NRCan 2006; NRCan 2020a; Transport Canada 2015a; Transport Canada 2015b. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

The NHS's largest expansion happened in 2005 when about 4,500 kilometres of feeder routes and 5,900 kilometres of northern and remote routes were included in it, following the recommendation of the NHS task force established by the Council of Ministers. From 2005 to 2017, there was no significant change in the length of the NHS. An additional 77 kilometres were added as a result of minor adjustments made in the system for route alignments and bypasses (Council of Ministers Responsible for Transportation and Highway Safety 2019, 7). Table 1 shows the NHS length by provinces and territories. Ontario has the largest share of the core NHS network, followed by British Columbia and Alberta. Compared to their respective populations, both have a large share of the NHS, since it extends to the North through these two provinces. Quebec has the largest share of northern and remote routes. Two main roads connect southern Quebec to the northern regions: Route 109 runs along a north-south direction and connects southwest regions to Nord-du-Québec and Route 389 links the north shore of the St. Lawrence River to the Quebec-Labrador border. Since its expansion in 2005, travel on the northern and remote network of the NHS increased by 81 per cent (Transport Canada 2018). Among the sparsely populated northern territories, Nunavut is the only one still unconnected to the national highway system.

Table 1: Summary of NHS Routes by Jurisdiction (as of December 2017)

Province/Territory	NHS Length in 2017 (km)		
	Core Network	Feeder Network	Northern & Remote Network
British Columbia	5869.3	446.7	724
Alberta	4088.5	215.5	196.5
Saskatchewan	2451.2	0	236.3
Manitoba	985.2	740.6	368.2
Ontario	6134.8	682	0
Quebec	3436.9	770.9	1435.6
Newfoundland and Labrador	1007.6	298	1161
New Brunswick	994.6	818.4	0
Prince Edward Island	208.7	189.5	0
Nova Scotia	904.7	294.3	0
Yukon	1068.6	0	947.9
Northwest Territories	575.6	0	847.2
Nunavut	0	0	0
Canada	27725.7	4455.9	5916.7

Source: Council of Ministers Responsible for Transportation and Highway Safety (2019)

Although the NHS established an interconnected corridor of strategically important roads and inter-modal transport hubs, it has been criticized over the years for lacking a co-ordinated national strategy for maintenance and expansion (Government of Canada 1997) and a comprehensive effort to harmonize regulations between provinces and territories to reduce interregional trade costs (Government of Canada 2019b). There is no single, ongoing program for funding and planning the NHS; rather, governments have financed improvements along the NHS route through a variety of federal infrastructure funding programs such as the National Trade Corridors Fund (Transport Canada 2021c).

An updated road transport strategy would be a strategic component of a multi-modal national trade infrastructure policy for Canada. An integrated national road network as part of this corridor could serve as the strategic link between the urban, rural, remote and northern communities, enhance international and interregional trade and travel and strengthen Canada's northern and Arctic security and sovereignty (Lackenbauer and Koch 2021). To develop an integrated road network, one approach could be upgrading the NHS by correcting the deficiencies along the existing system and incorporating certain existing and pending road infrastructure projects along the north-south corridors. The following sections provide detailed descriptions of the existing and pending road infrastructure projects that could be included in an integrated network.

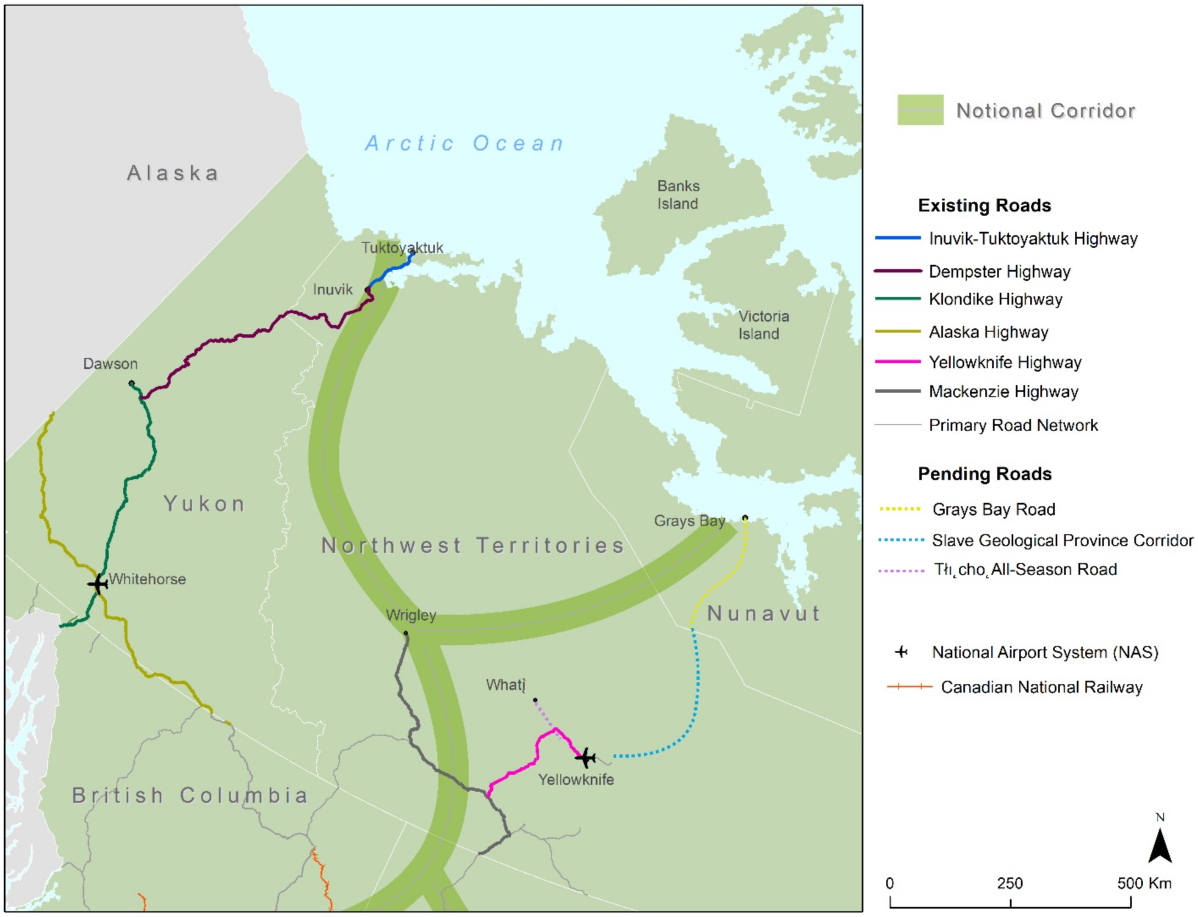
2.2. THE INUVIK–TUKTOYAKTUK HIGHWAY

The hamlet of Tuktoyaktuk is in Canada's western Arctic, off the coast of the Beaufort Sea and near the Mackenzie River Delta; it is one of the six communities in the Inuvialuit Settlement Region of the Northwest Territories. The Inuvik to Tuktoyaktuk Highway (also known as Highway 10) is the first all-weather road to Canada's Arctic coast, replacing the seasonal winter road that was built every year along the Mackenzie River Delta and the Arctic Ocean (Figure 5). Before the highway's completion, Tuktoyaktuk was only accessible by air during warmer months. Consistent observations of the climate in Tuktoyaktuk indicate warmer and shorter winters, hotter summers and earlier break-up and later freeze-up of river ice, plus increased erosion mostly due to melting permafrost (Environmental Impact Review Board, 2013, 52). The shortening of the winter-road season due to these changes in climate is a concern across remote communities in northern Canada that rely on winter roads about four months of the year for supplies.

The highway is located entirely within the zone of continuous permafrost. Following the recommendations of the Inuvik-Tuktoyaktuk Highway Review Panel, the raw resources required for the highway construction were sourced from select locations near the established route, the majority of the construction activities took place during the winter months to preserve the permafrost terrain and additional engineering design options like higher embankments were adopted to mitigate impact on the permafrost (Environmental Impact Review Board, 2013). The highway was officially opened on November 15, 2017, three years after construction started. The Inuvik-Tuktoyaktuk Highway is a two-lane, raised, gravel roadway that runs approximately 120 kilometres between the two communities in the Northwest Territories. The Dempster Highway connects Inuvik to the NHS, so with the completion of Highway 10, Canada was connected for the first time from coast to coast to coast.

Both communities had demanded an all-weather road from Inuvik to Tuktoyaktuk since the 1960s when oil and gas explorations began in the Beaufort Sea and Mackenzie River Delta. Public Works Canada completed an initial survey of a route between the two communities in 1974 during the peak period of resource exploration activities in the region. Ten years later, in 1984, the Inuvialuit and the governments of Canada, the Northwest Territories and Yukon (INAC 1984) signed the final land claims settlement, which established the procedures for appropriating lands for a public road right-of-way in the region (INAC 1984, 10). In 1998, information on the design, routing and environmental and socio-economic impacts of the highway were gathered and released in a comprehensive report carried out for the government of the Northwest Territories (Rescan 1999). Based on this report, the government of the Northwest Territories conducted a detailed benefit-cost analysis and identified the highway's completion as a strategic priority (GNWT 2000). In 2009, the hamlet of Tuktoyaktuk, the town of Inuvik and the government of the Northwest Territories, Department of Transportation, signed a memorandum of understanding. Construction started in early 2014 and was completed on budget in 2017.

Figure 6: Inuvik to Tuktoyaktuk Highway



Source: Map prepared by the author (2021) using Statistics Canada 2016b; Statistics Canada 2019; Statistics Canada 2020b; GBEEC 2017; GNWT 1999; GNWT 2015; Transport Canada 2015a; NRCan 2020a; NRCan 2021; US Census Bureau 2018. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

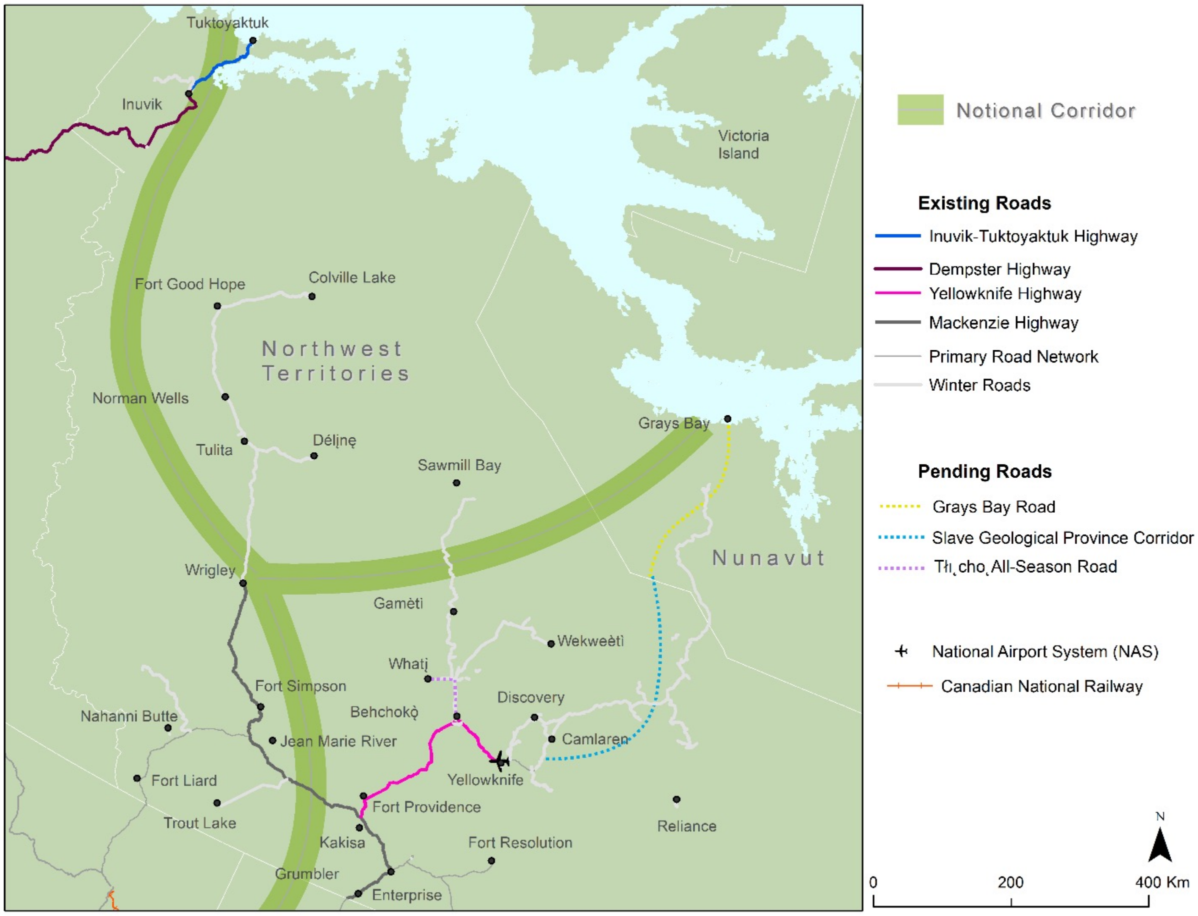
The highway improved access to the remote community of Tuktoyaktuk and as goods have been shipped year-round since its completion, it has resulted in savings of more than C$1.5 million for residents through a reduced cost of living (GNWT 2018). Besides improving the quality of life in the North, the highway represents the final piece in the territorial highway network that connects Canada's Arctic coast to the rest of the world through the Dempster, Klondike and Alaska highways. The system connects to the Canada-U.S. borders through the Alaska Highway and in the south through Highway 97. With the highway's completion, Canada's Arctic coast is also connected to the national railway network and inter-modal transportation hubs such as the Port of Prince Rupert, the Port of Vancouver and the Erik Nielsen Whitehorse International Airport in Yukon.

2.3. Tłı̨chǫ ALL-SEASON ROAD

The Tłı̨chǫ all-season road (TASR) involves the construction of a 97-kilometre, two-lane gravel road providing all-weather access from Highway 3 west of Yellowknife to the community of Whatì in the Northwest Territories (Figure 7). The government of the Northwest Territories initiated the formal procurement process in 2017 by releasing the request for qualifications to design, build, finance, operate and maintain an all-season road to Whatì. Following the completion of the environmental assessment and the regulatory and permitting phases in late 2018, construction began in 2019. In November 2020, the government of the Northwest Territories and the Tłı̨chǫ government announced the TASR's official name as Highway 9 (Tłı̨chǫ Government 2020). The TASR was set to open to traffic in 2021. Prior to the project, Whatì was a fly-in community except for the months it was accessible through the Tłı̨chǫ winter road. Figure 7 shows the extent of the winter road network in the region. Once completed, TASR will replace the southern section of the Tłı̨chǫ winter road and increase the winter road window-of-access to the communities of Gamètì and Wekweètì north of Whatì by about a month.

The TASR is one of three priority corridors — the Mackenzie Valley Highway, Tłı̨chǫ all-season road and Slave Geological Province access corridor — that Wally Schumann, the NWT's former infrastructure minister, committed to securing funding for and to the advance planning and construction of, in the 2017 mandate letter (GNWT 2017). The project's funding comes from the territorial and federal governments, as well as the private sector, using a public-private partnership (P3) model. The government of the Northwest Territories and the Tłı̨chǫ government had been studying options for an all-season road to Whatì since the 1980s and the TASR is the first major infrastructure project in the Northwest Territories in which an Indigenous government has taken an equity role. The Tłı̨chǫ government has a 20 per cent equity stake in the project (GNWT 2019b, 18). According to the project agreement signed by the government of the Northwest Territories and the Tłı̨chǫ government, the project had a northern-hiring target of 35 per cent during the construction phase and out of 227 workers employed as of October 2020, 93 were Tłı̨chǫ territory or Northwest Territories residents (GNWT 2020a).

Figure 7: Tłı̨chǫ All-season Road



Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; GBEEC 2017; GNWT 1999; GNWT 2015; Transport Canada 2015a; NRCan 2020a; NRCan 2021. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

By improving the transportation infrastructure to the Tłı̨chǫ territory, the TASR is expected to reduce the cost of living and attract further interest from industry in exploration and development of natural resources in the region. The road will improve access to a proposed mining operation (NICO Project) 50 kilometres north of Whatì and to three small hydro facilities (Nailii, Rae-Taka and Kaa Two Tii De'a Hydro projects) which would reduce the Tłı̨chǫ territory's dependency on diesel-generated power.

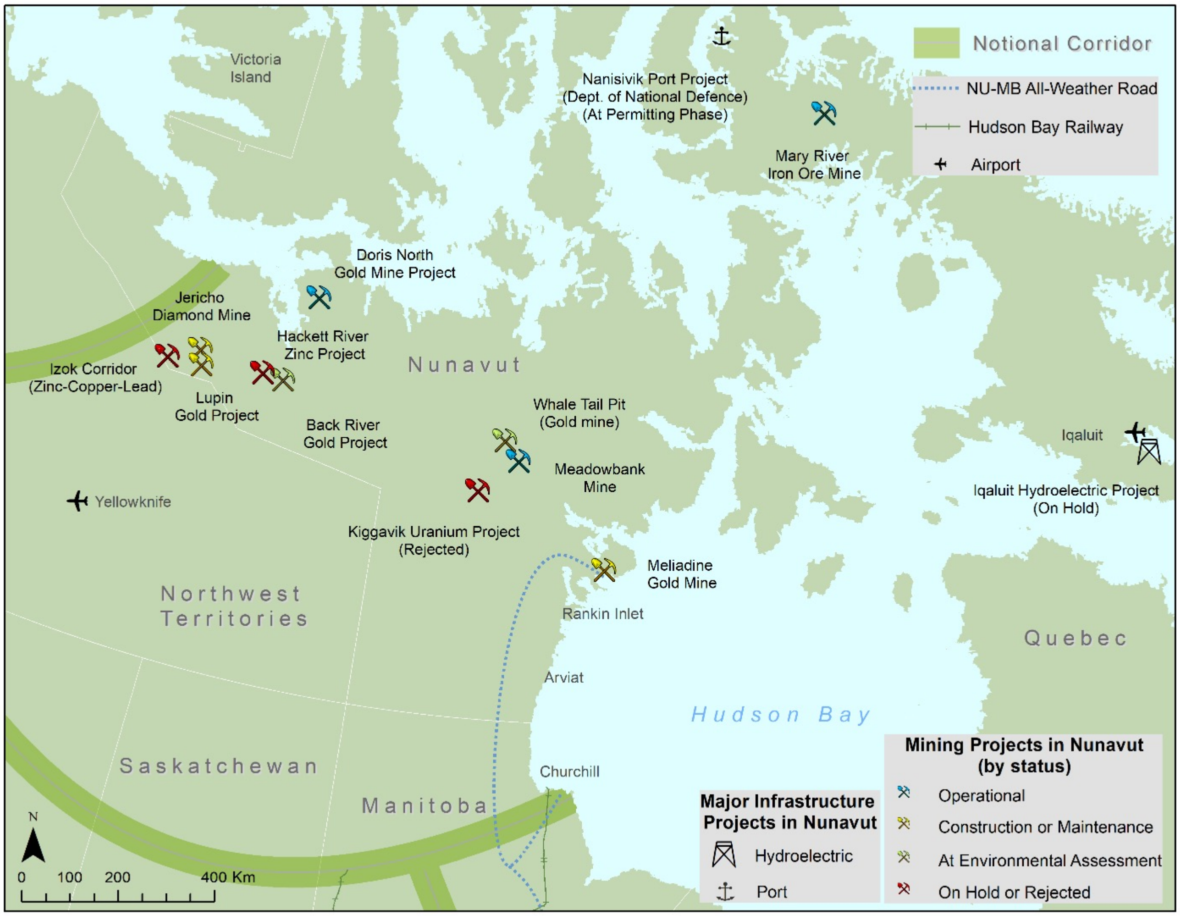
2.4. THE NUNAVUT-MANITOBA ALL-WEATHER ROAD

Nunavut remains entirely isolated from Canada's national road network. The territory's road infrastructure is comprised of 40 kilometre-long unconnected roads within communities. Surface transportation options outside of communities are mainly limited to all-terrain vehicles and snowmobiles. Lack of inter-community and territorial roads means Nunavut relies solely on air and marine infrastructure to travel and resupply remote communities (Governments of Yukon, Northwest Territories and Nunavut 2008, 12). Connecting the territory to the rest of the country through road transportation could improve the quality of life by reducing isolation and the cost of living, promoting employment by encouraging resource development and tourism and increasing access to public services.

The government of Nunavut developed its first transportation strategy in 2001, right after the territory was created in 1999. Over the years, several inland and inter-community projects have been developed to improve road transportation (Government of Nunavut 2003). In 2001, the governments of Nunavut and Manitoba signed a Memorandum of Understanding on Transportation to explore the potential for one of these projects, an approximately 450-kilometre all-weather road connecting Nunavut to Manitoba (Government of Manitoba 2001).

This all-weather route linking Rankin Inlet — the population centre of the Kivalliq region — to Churchill and from there to the road network in Manitoba could connect Nunavut to Canada's NHS. There is no rail infrastructure in Nunavut; however, an all-weather road access to the rail service to the Port of Churchill would be an important multi-modal link for the Nunavut supply chain. This would improve access to goods in communities and mineral resources of the Kivalliq region. Multiple routes are being considered for the Nunavut-Manitoba all-weather road. Figure 8 illustrates the notional route and the range of infrastructure and mining projects currently at different phases in Nunavut.

Figure 8: Nunavut-Manitoba All-Weather Road



Source: Map prepared by the author (2021) using Statistics Canada 2016b; Statistics Canada 2019; Statistics Canada 2020b; Transport Canada 2015a; NRCan 2020a; NRCan 2021; Canadian Northern Economic Development Agency 2021. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

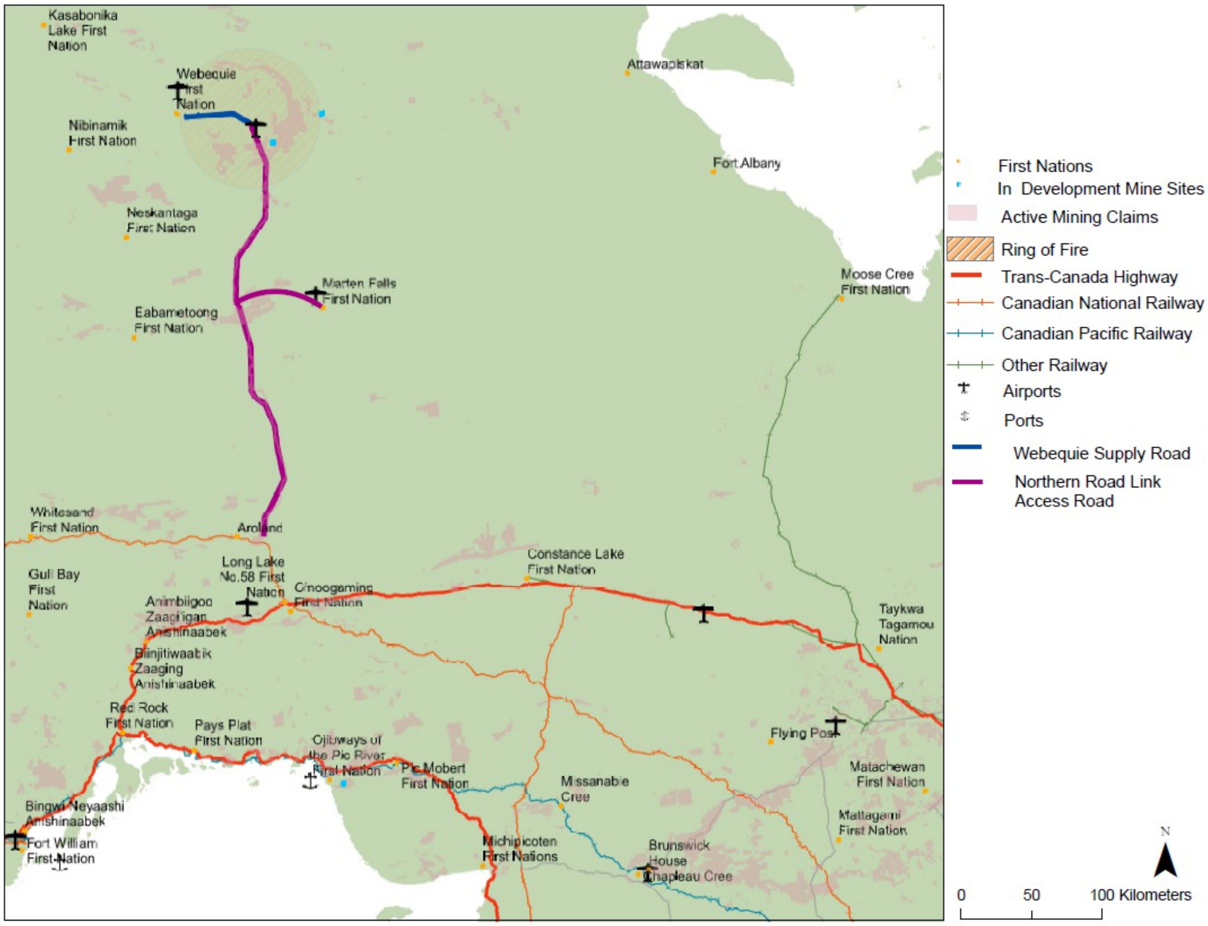
The cost-benefit analysis of the Nunavut-Manitoba all-weather road prepared for the governments of Manitoba and Nunavut finds that whether the project makes economic sense in terms of the benefit/cost ratio depends highly on the parameters (i.e., the discount rate) used in calculation (Nishi-Khon and SNC-Lavalin. 2010, 8). However, although the project may not be justified based on the cost-benefit analysis, decision-makers would need to consider some unquantifiable but probable benefits an all-weather road could provide to the communities along the route. The results of the engagement sessions with project stakeholders and the public (Nishi-Khon and SNC-Lavalin 2007) identify impacts on the environment and traditional knowledge as main concerns. The study (Nishi-Khon and SNC-Lavalin 2007) also indicates strong support in the affected communities for improved access to essential public services and hydroelectric generation sites; participation in economic activities like tourism, exploration for minerals or construction and maintenance of the road. The potential road would also help connect communities along the coast like Arviat, Chesterfield Inlet, Rankin Inlet, Whale Cove and Naujaat and improve access for inland communities and mining activities, which rely mostly on air transportation. Considering the challenges in Nunavut attributable to the lack of transportation access, such as the high cost of living, limited labour mobility and limited all-season access to Nunavut's rich mineral resources, connecting Nunavut to the rest of Canada, although costly, could benefit the region if carefully planned and designed. To advance the planning, design and environmental assessment of the project, the government of Nunavut received C$4.5 million in funding from the National Trade Corridors Fund in 2019.

2.5. RING OF FIRE ROADS

The Ring of Fire is a resource-rich area of approximately 5,120 square kilometres in the James Bay Lowlands region of northern Ontario with significant potential for mineral development (Ontario Chamber of Commerce 2014, 5). Since the early 2000s, mining companies have found large deposits of chromite, nickel, copper, zinc, gold and platinum in the region. The first of these discoveries was in 2002 when miners from the De Beers open-pit Victor mine discovered large sources of copper, nickel, palladium and platinum (Gorrie 2010, 23). The discovery of an estimated 220 million tonnes of high-quality chromite was particularly important. Chromite is a key mineral used in the production of stainless steel. This deposit propels Canada into fourth place in the world in terms of proven reserves and represents the first commercial chromite deposit in North America (Cliffs Natural Resources 2013).

Activities in the Ring of Fire region are mainly in the exploration stage. The main challenge with development in the area is its remoteness and lack of access to the rest of the infrastructure network. The Ring of Fire area is located about 500 kilometres northeast of Thunder Bay, approximately 300 kilometres from the nearest paved highway and 350 kilometres from the nearest rail line in Nakina (Figure 9). To encourage development of the deposits, in its 2014 party platform, the Ontario Liberal Party pledged C$1 billion toward infrastructure, mainly in the form of a paved road to the area (Rogers 2014). In its 2018 budget (Government of Ontario 2018, 91), the next provincial government formed by the Progressive Conservative Party, also committed $1 billion toward strategic transportation infrastructure development in the region. However, the proponents have not moved forward with the project for more than a decade.

Figure 9: Ring of Fire Roads



Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; NRCan 2020a; NRCan 2021; City of Thunder Bay 2020. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

Infrastructure investment to support mining development in the form of roads, rail, communication and power lines may also service other stakeholders in the region. The closest communities to the Ring of Fire are Webequie First Nation, 80 kilometres to the west, and Marten Falls First Nation, 120 kilometres to the south (Figure 9). An all-weather north-south road would connect the communities to Nakina. The proposed route, the Northern Road Link, is a 120-kilometre road that would provide access to the Ring of Fire and connect two other proposed all-weather road projects, the Webequie supply road and the Marten Falls community access road to Canada's transportation system. In 2020, the two communities entered into an agreement with the provincial government to make the proposed road link subject to the *Environmental Assessment Act* (Government of Ontario 2020). And, in May 2021, Webequie and Marten Falls First Nations (Northern Road Link 2021) announced that the northern road link environmental assessment process would start with the release of the official Notice of Commencement for the terms of reference. On October 8, 2021, the provincial environmental assessment process for the Webequie supply road also commenced with the approval of the terms of reference for the project (Government of Ontario 2021).

3. RAILWAY CORRIDORS

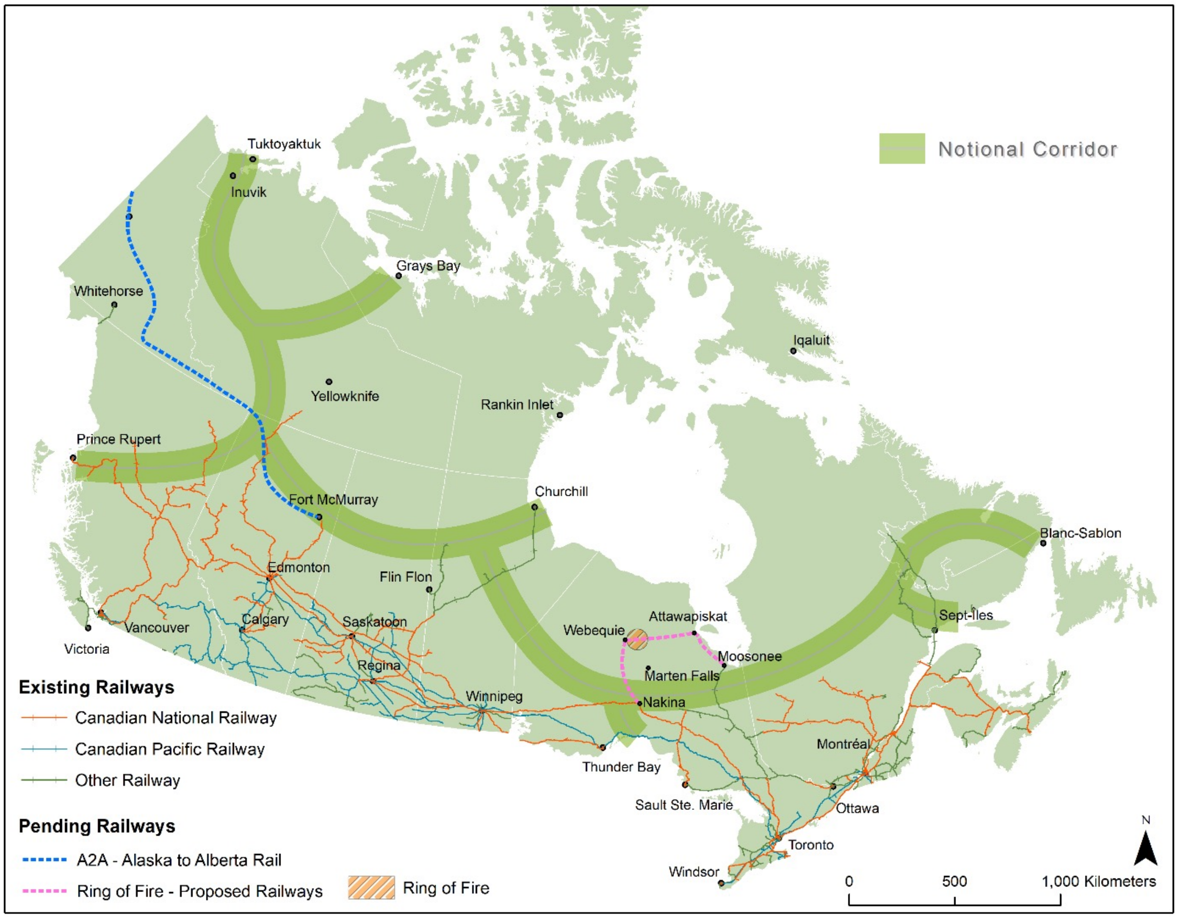
3.1. OVERVIEW

Canada has a long railway network running about 42,000 kilometres of track mainly in the east-west direction (Figure 10). The ports on the East and West Coasts, as inter-modal transportation hubs, provide extensive accessibility to the provinces through this railway network. Two large companies operating the mainlines between coasts — the Canadian National Railway (CN) and Canadian Pacific Railway (CP) — dominate the sector and there are a few other railway companies that operate short branches off these two mainlines.

The rail infrastructure is especially important to the Canadian economy due to the amount of freight tonnage moved by rail, which has been steadily increasing in the last decade (Statistics Canada 2021). In 2019, Canada's railways transported 330.2 million tonnes of freight. About two-thirds of the shipments from Canada originated from Alberta, followed by British Columbia and Saskatchewan. Canadian railways mainly carry raw materials and natural resources to export markets. For example, fuel oils and crude petroleum were the leading commodities originating in Alberta in 2019 with more than 80 per cent destined for the United States (Statistics Canada 2021). In British Columbia, coal and wood were the main exports carried by rail, while potash and wheat were the dominant commodities in Saskatchewan (Statistics Canada 2021).

Despite their significance to the provincial economies, railways are almost non-existent in the territories. The system is limited to an isolated line in Yukon between Skagway, Alaska and Whitehorse and a line between Hay River in the Northwest Territories and northern Alberta. (Figure 10). In northern Manitoba, the Hudson Bay Railway serves Canada's only deep-water Arctic port, the Port of Churchill. Recently, there have been two proposals to connect remote communities in the North and Arctic to the rest of Canada's railway network: the A2A railroad and a rail route to Ontario to facilitate transport of ore from the Ring of Fire deposits (Figure 10).

Figure 10: Existing and Pending Railway Projects

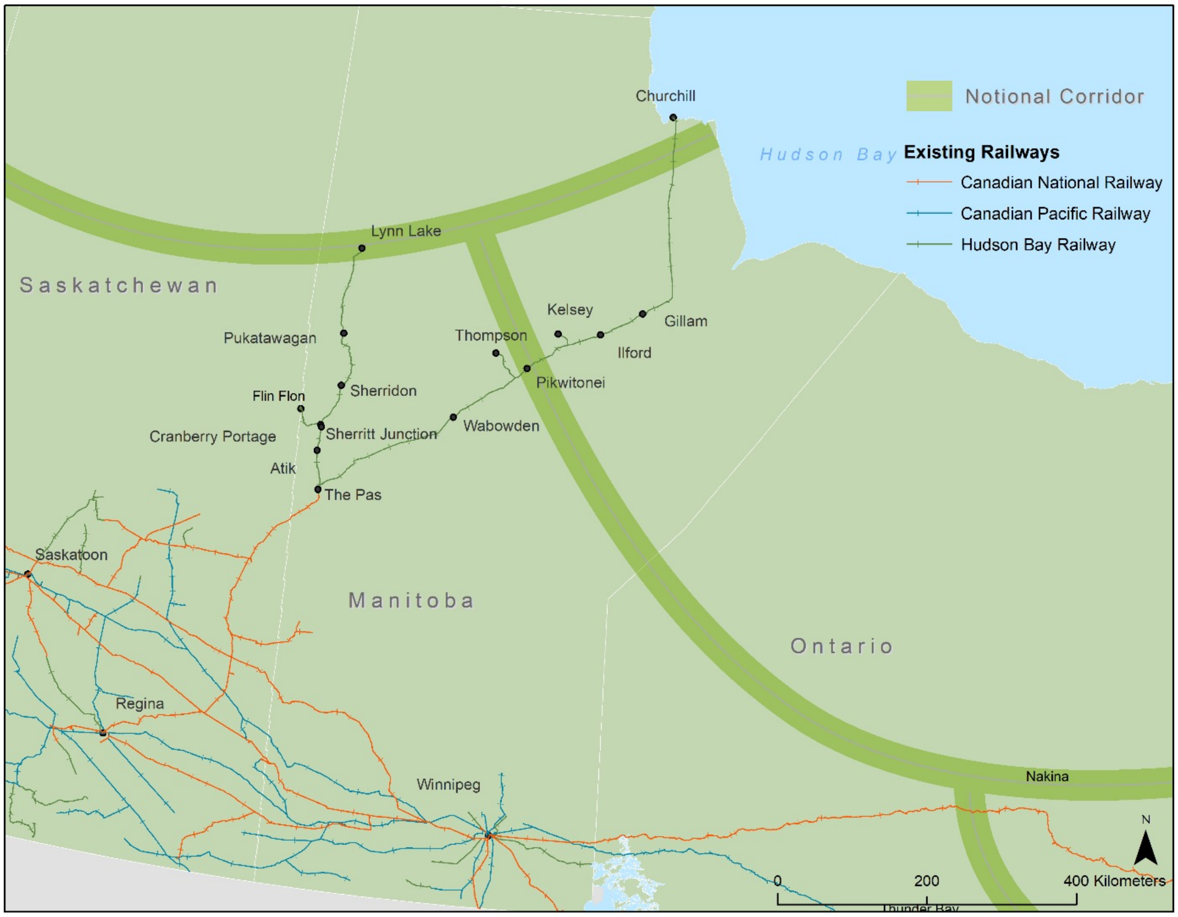


Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; NRCan 2020a; NRCan 2021; City of Thunder Bay 2020; Alberta Railway Development Corp. 2020. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

3.2. HUDSON BAY RAILWAY

Hudson Bay Railway represents an important transportation link for carrying passengers, natural resources and grain between the Port of Churchill and The Pas on the western border of Manitoba (Figure 11). The line starts at The Pas and ends in Churchill, Canada's only Arctic port. A branch originating in Lynn Lake connects to the railway in The Pas. The Hudson Bay Railway is an important corridor for shipping goods to communities in northern Manitoba and Nunavut from the rest of the southern transportation network and the Port of Churchill.

Figure 11: Hudson Bay Railway



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The Port of Churchill is at the eastern end of the Hudson Bay Railway. It is Canada's only operating deep-water port, located 1,697 kilometres by rail from the provincial capital of Winnipeg and provides marine access to communities in the eastern and central Arctic. Because of its role in the resupply of northern communities, it is an important inter-modal hub linking Canada's Arctic waters to its railway system. The distance from the Port of Churchill to Europe through Hudson Bay is shorter than the distance to Europe from the ports in Quebec and Ontario. Therefore, as climate change gradually opens up shipping routes in the Hudson Bay and the Arctic, the Port of Churchill's economic and strategic importance may increase.

3.3. A2A RAILROAD

The Alaska to Alberta Railway (A2A Rail) is a private, 2,570-kilometre railway project that pledges to connect northern Alberta to Alaska's tidewater (Figure 12). According to the officials of the Alaska to Alberta Railway Development Corporation, once completed, the $22 billion-dollar rail project would link Fort McMurray in Alberta to the Delta Junction in Alaska and transport commodities, natural resources and people (Alberta Railway Development Corp. 2020). The exact route of the A2A has yet to be determined but the most recent route that acquired a presidential permit in the U.S. in September 2020 for construction in the U.S. territories, passes through Alberta, Yukon and the Northwest Territories before reaching Alaska. The project is currently inactive since the Alberta-based Alaska to Alberta Railway Development Corporation obtained creditor protection in 2021 after the Ontario Securities Commission placed its main lender in receivership (Alberta Railway Development Corp. 2021).

Figure 12: A2A Railway

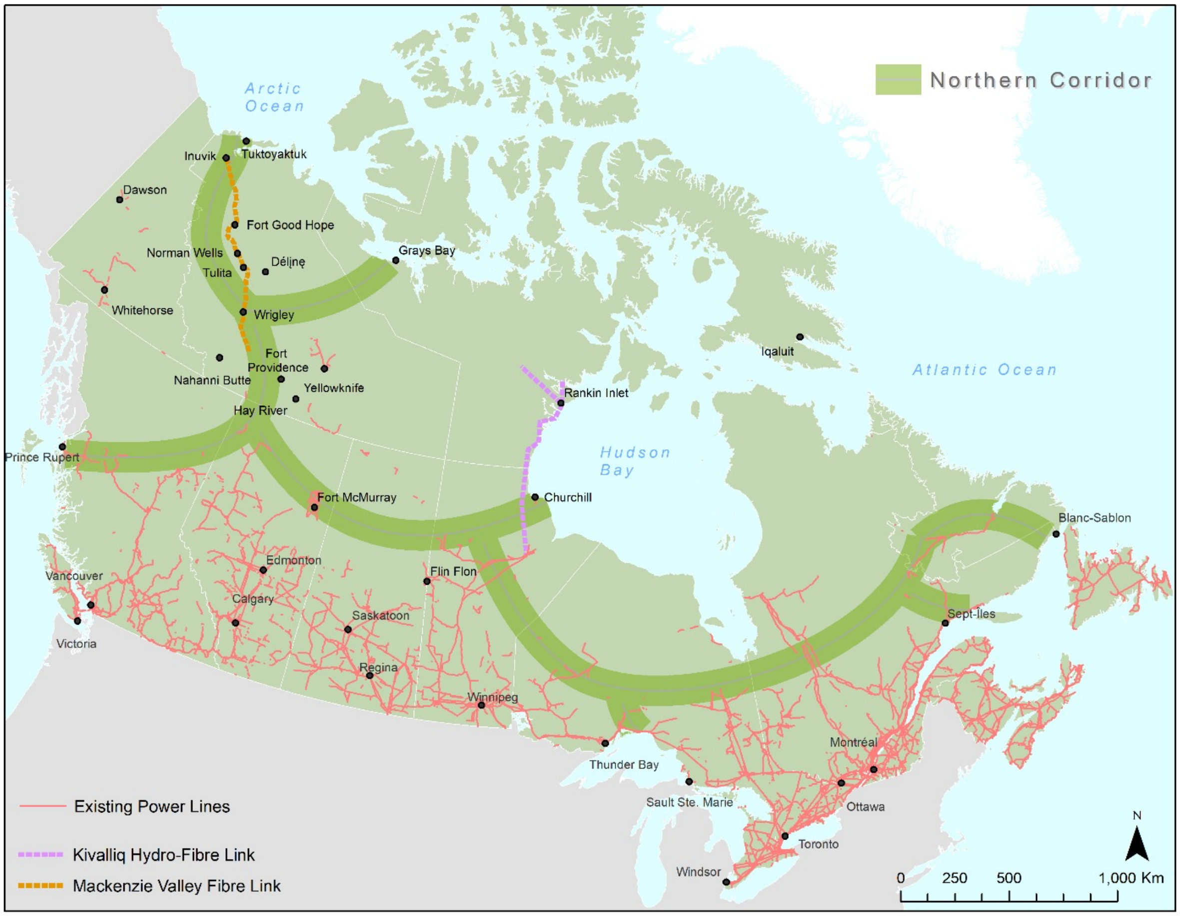
Source: Map prepared by the author (2021) using Statistics Canada 2019; NRCan 2020a; NRCan 2021; Alaska to Alberta Railway Development Corp. 2020; US Census Bureau 2018. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

4. ELECTRICITY AND TELECOMMUNICATION CORRIDORS

4.1. OVERVIEW

The majority of Canada's Arctic and northern communities are not connected to the electricity grid (Figure 13). For the most part, the electricity infrastructure in the northern territories is a mixture of diesel generation and hydroelectric facilities. However, there are differences across territories. For example, while hydroelectricity accounts for more than 90 per cent of total generation in Yukon and about 70 per cent in Northwest Territories, almost all of Nunavut's electricity is generated by diesel (CER 2019).

Figure 13: Existing and Pending Electricity and Telecommunication Infrastructure



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Electricity generation and distribution in Nunavut is unique among the territories: There are no regional or territorial electricity grids in Nunavut, meaning, for energy generation and distribution, each one of Nunavut's 25 communities relies on its own diesel plants. For generation, Nunavut depends almost only on diesel imported during summer and stored over the winter. According to a Senate committee report (Government of Canada 2015, 38), as of 2014, 14 of 25 diesel plants had reached the end of their designed service life and were posing risks to public safety. Since the publication of the Senate report, Nunavut's sole energy generator and distributor, Qulliq Energy Corporation (QEC), has decommissioned and replaced several of these aging community power plants. In 2021, the 58-year-old Grise Fiord plant, one of the oldest in Nunavut, was decommissioned and replaced with a new diesel power plant. Recently, with funding from federal programs, QEC conducted studies to assess the feasibility, viability and reliability of alternative renewable energy sources in Nunavut like geothermal, solar and wind (QEC 2021, 8). In 2016, QEC installed solar panels in

Iqaluit as part of a demonstration project. Following the success of this project, in 2019, the company announced that it would install a 500 KW solar panel with storage capacity in a hybrid diesel-solar power plant in Kugluktuk, a first for Nunavut (QEC 2021, 8). This project is expected to finish in 2024 (Infrastructure Canada 2021).

Another challenge in Canada's North is connectivity and very limited access to communications infrastructure. Northern communities depend on stable telecommunications infrastructure to access public services and maintain business. Although reliable high-speed internet service has become a necessity in the 21st century, internet access in northern communities remains slow, unreliable and expensive. Slow bandwidth and, in some cases, complete service outages to internet services were common in 2020.

The infrastructure is insufficient to provide access to reliable, fast and affordable broadband internet, particularly in rural, northern and Indigenous communities. While about 98 per cent of all Canadian households have access to broadband coverage at 5/1 Mbps or greater, availability greatly varies by province and territory. More than 90 per cent of households in every area have access to broadband coverage at 5/1 Mbps or greater with the exception of Nunavut. In 2018, only about 50 per cent of households in Nunavut had access to speeds of at least 5/1 Mbps and none had access to the Canadian Radio-television and Telecommunications Commission's target speed of 50/10 Mbps (CRTC 2019). Widespread access to this target speed is typically limited to urban areas with high population density.

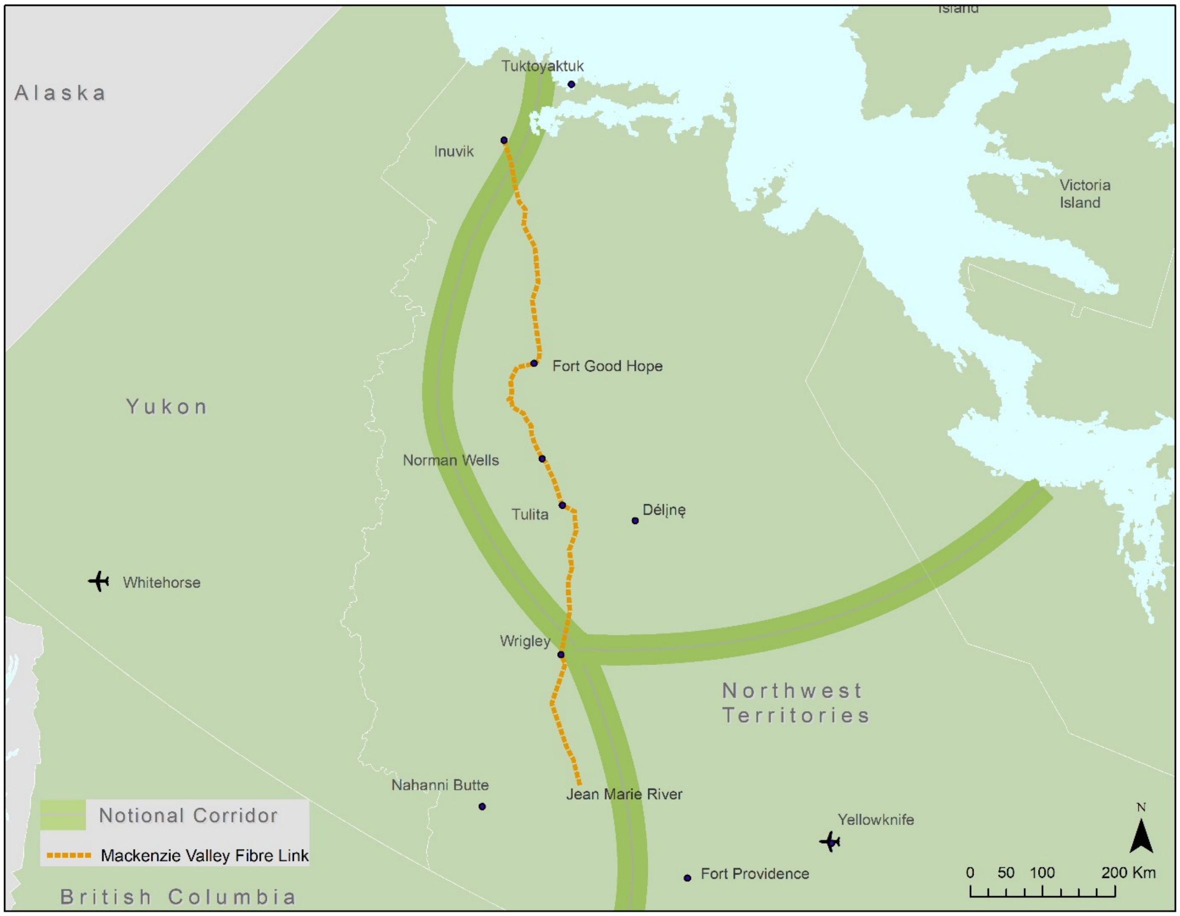
Considering the need for broadband access for delivery of information, goods and services, excluding rural and Indigenous communities from the best available broadband service creates technological and economic barriers among these communities and the rest of the country and amplifies isolation. Providing access to reliable, fast and affordable terrestrial telecommunications connections and eliminating this digital divide among Canadians can enhance productivity and improve access to health, education and financial services.

Therefore, a successful infrastructure corridor strategy should include considerations regarding improving access to power and communications infrastructure in Canada's North and near-North. This section presents two recent projects carried out in the North to improve communications infrastructure and access to reliable electricity in the region's isolated communities.

4.2. MACKENZIE VALLEY FIBRE LINK

The Mackenzie Valley fibre link (MVFL) is long-haul transport fibre-optic link financed and owned by the government of Northwest Territories. The project involved the installation of approximately 1,150 kilometres of high-speed fibre-optic cable from McGill Lake (80 kilometres south of Fort Simpson) to Inuvik in the north (Figure 14). From McGill Lake, the fibre-optic line connects to the existing infrastructure.

Figure 14: Mackenzie Valley Fibre Link



Source: Map prepared by the author (2021) using Statistics Canada 2019; NRCan 2020a; NRCan 2020b; Transport Canada 2015a; US Census Bureau 2018. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

The feasibility study for a high-speed fibre-optic link in the Northwest Territories was completed in 2011 (GNWT 2011). The study highlighted the technical and environmental complexity of the undertaking due to the permafrost conditions along the proposed route and suggested the government consider the Dempster Highway route as a lower cost alternative (GNWT 2011, 4). The MVFL's purpose is to improve delivery of health, education and social services to remote communities. The project would directly serve six communities (Fort Simpson, Wrigley, Tulita, Norman Wells, Fort of Good Hope and Inuvik) with potential future access via microwave radio to two others (Colville Lake and Deline). An extension of the link to Tuktoyaktuk was also planned following the completion of the all-weather highway between Inuvik and Tuktoyaktuk. The GNWT opted for the Mackenzie Valley route since the extent of benefits to these communities would not be as high with the Dempster Highway route, which would serve two remote communities (Tsiigehtchic and Fort McPherson).

The MVFL was completed in 2017 after three years of construction.[3] The GNWT owns the infrastructure but bringing internet to the consumers across the Northwest Territories falls on the local internet service providers. Therefore, although the link's construction is completed, setting up the connection has been left to the service providers. A recent report from the GNWT's standing committee on government operations on long-term post-pandemic recovery in the Northwest Territories highlights this issue and notes that the GNWT's position on the fibre link project has made it unclear which communities are still waiting for local service providers to set up internet connection (GNWT 2020b, 6). The report also recommends developing a digital communications plan for the Northwest Territories, especially for the outlying communities that are not located directly in the MVFL's path (GNWT 2020b, 7).

4.3. KIVALLIQ HYDRO-FIBRE LINK

A collaboration between the Kivalliq Inuit Association and Sakku Investments Corporation aims to get the Kivalliq region of Nunavut off diesel and satellite internet. The goal is to complete Nunavut's first land-based connection to the rest of Canada's infrastructure network with a 1,200-kilometre multi-modal corridor consisting of a 230-kilovolt, alternating current hydroelectric transmission line and a fibre-optic cable. The project will connect five Kivalliq communities and the region's mineral-rich areas to northern Manitoba. The proposed corridor starts in Gillam, Manitoba, and crosses Manitoba to Arviat, Whale Cove, Rankin Inlet and Baker Lake in Nunavut (Figure 15). This route also connects two major gold mining operations close to Baker Lake to the transmission line.

The Canadian Infrastructure Bank (CIB) is a project partner of the Kivalliq Hydro-Fibre Link (CIB 2020). The residents of the region hold a 51 per cent share in the project through the Kivalliq Inuit Association, whose purpose is to pay out the investments of other institutions and make the project 100 per cent Inuit-owned.

With an objective to introduce clean and reliable energy and broadband internet to Nunavut, and with potential to expand into other modes of infrastructure as well, the Kivalliq hydro-fibre link may represent a branch towards Nunavut that complements an infrastructure corridor in the region.

[3] Work on a Tuktoyaktuk extension of the MVFL has not started.

Figure 15: Kivalliq Hydro-Fibre Link

Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2016b; NRCan 2020a; NRCan 2020b. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

5. COMMODITY PIPELINES

5.1. OVERVIEW

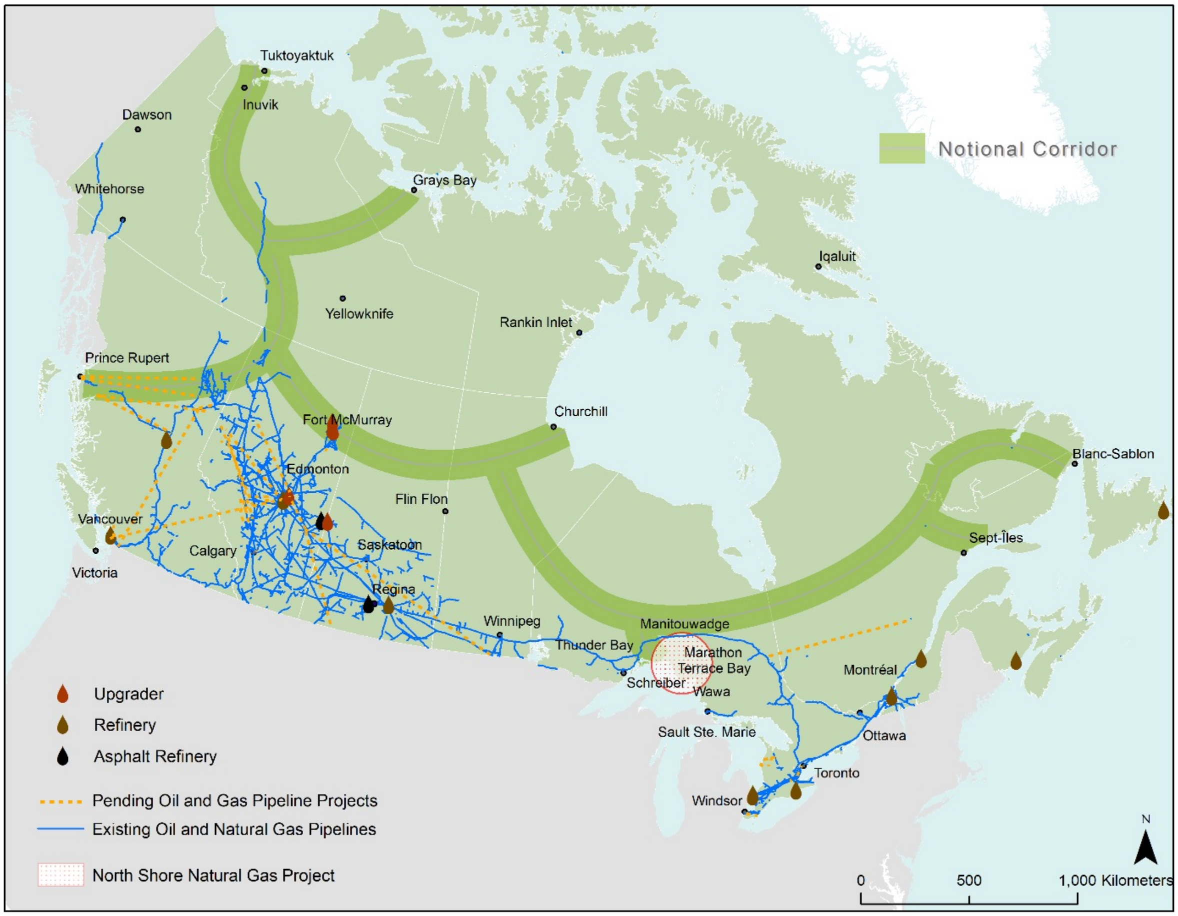
Canada has approximately 840,000 kilometres of pipelines made up of four main types: 117,000 kilometres of transmission pipelines moving crude oil and natural gas cross-border and within Canada; 25,000 kilometres of feeder pipelines transporting oil and gas from processing facilities to transmission pipelines; 250,000 kilometres of gathering pipelines moving crude oil and natural gas between producing areas; and 450,000 kilometres of distribution pipelines delivering natural gas to final consumers (NRCan 2020c). The system is mainly distributed across provinces in the south and connects major producing areas to refineries, upgraders, final consumers and border crossings (Figure 16).

The only petroleum-producing region north of the 60th parallel in Canada is the Northwest Territories. The region's output is transported south to Alberta via the Enbridge Norman Wells Pipeline. This is the only major commodity pipeline connection any of the territories has with the rest of Canada.

Several pending oil and natural gas pipeline projects are in various stages of development that may be of interest for a linear infrastructure corridor with a northern focus like the CNC. For example, the proposed Gazoduq project is a 780-kilometre natural gas pipeline, which would connect the existing mainline in northeast Ontario to a proposed natural gas liquefaction facility in Saguenay, Quebec (Figure 16). The Impact Assessment Agency of Canada (2020) commenced assessing the project in July. Multiple natural gas and LNG pipeline proposals to Prince Rupert from the northeastern border of British Columbia are other examples.

One project underway in Ontario stands out among these pending projects. The North Shore natural gas project is a community-led initiative and represents an alternative for delivering resources to communities in the North where it might be too costly to construct a lateral pipeline. The following section provides further details on the North Shore natural gas project.

Figure 16: Major Oil and Natural Gas Pipelines (Existing and Pending)



Source: Map prepared by the author (2021) using Statistics Canada 2019; NRCan 2019; NRCan 2020a; NRCan 2020c; Marathon 2018; US Census Bureau 2018. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

5.2. NORTH SHORE NATURAL GAS PROJECT

The North Shore natural gas project is a collaboration of five communities, Manitouwadge, Marathon, Schreiber, Terrace Bay and Wawa, located on the north shore of Lake Superior between Thunder Bay and Sault Ste. Marie in northwestern Ontario (Figure 16). The C$55 million project aims to provide the region with a cleaner and more affordable source of energy. The project would expand natural gas service to the residents and businesses in these municipalities. The region's population is approximately 11,000 people. There is no natural gas supply or distribution within any of these municipalities and residents mainly rely on fuel oil and propane systems for space heating and electricity for water heating (Marathon 2018, 44–46).

Initially, the proponents proposed a new liquefied natural gas (LNG) plant in Nipigon, Ontario. According to this proposal, LNG would be stored and converted into natural gas locally, transported from Nipigon to small depots in each community by trucks and distributed into homes and businesses by local pipelines (Marathon 2018, 20). The distances between the Nipigon plant and the municipalities range from 110 to 385 kilometres one way. In 2018, the proponents partnered with the Northern Ontario Heritage Fund Corporation and Northeast Midstream to assess the project's engineering, environmental and economic feasibility. Trucking LNG to communities was chosen as the most economic option over lateral pipelines from the mainline as a result of feasibility studies ordered by the municipalities. The construction of the Nipigon plant was the first phase of the project and in 2019, the provincial government announced a C$27 million investment toward its construction. However, in 2020, the Ontario Energy Board issued a decision on the application and directed the applicant municipalities to provide a more detailed assessment of a compressed natural gas (CNG) option as a lower cost alternative to LNG (Ontario Energy Board 2020). Later, the LNG option was ruled out and the municipalities signed an agreement with an Alberta-based company, Certarus, as their supplier of choice for the transportation, storage and supply of CNG for the five municipalities.

Like several others mentioned in this paper, the North Shore natural gas project is a community-led and community-endorsed initiative. Since the project does not require the construction of new transmission pipeline connection to the region, it represents an alternative to commodity pipelines for communities where the upfront capital investment to create connections with the existing mainline would be high due to geography or remoteness.

6. MULTI-MODAL CORRIDORS

6.1. OVERVIEW

Multi-modal corridors include linear transportation infrastructure like utilities, road and rail access and inter-modal transportation hubs along a route, but with accompanying policy, regulatory and operational measures, they may also extend beyond infrastructure. One such example is the Quebec government's Northern Action Plan. The project is a long-term economic and social plan to improve accessibility in the isolated northern regions of the province. In addition to linear infrastructure projects like the extension of Route 138, the plan also includes regulatory initiatives such as management and removal of hazardous and residual materials in the region. Other examples of multi-modal corridors with a northern Canada focus are the Slave Geological Province Corridor in the Northwest Territories and the Grays Bay and Bathurst Inlet Road and Port projects in Nunavut. These multi-modal projects are significant and relevant for any infrastructure development in Canada's Arctic and North for various reasons. The Slave Geological Province Corridor would create the first all-season link for the Northwest Territories' eastern communities to the rest of Canada's transportation network. A road and port corridor to the Arctic coast has been envisioned for decades. The Grays Bay and Bathurst Inlet Road and Port projects would connect Nunavut to the rest of Canada through surface transportation and create an Arctic gateway for Canada.

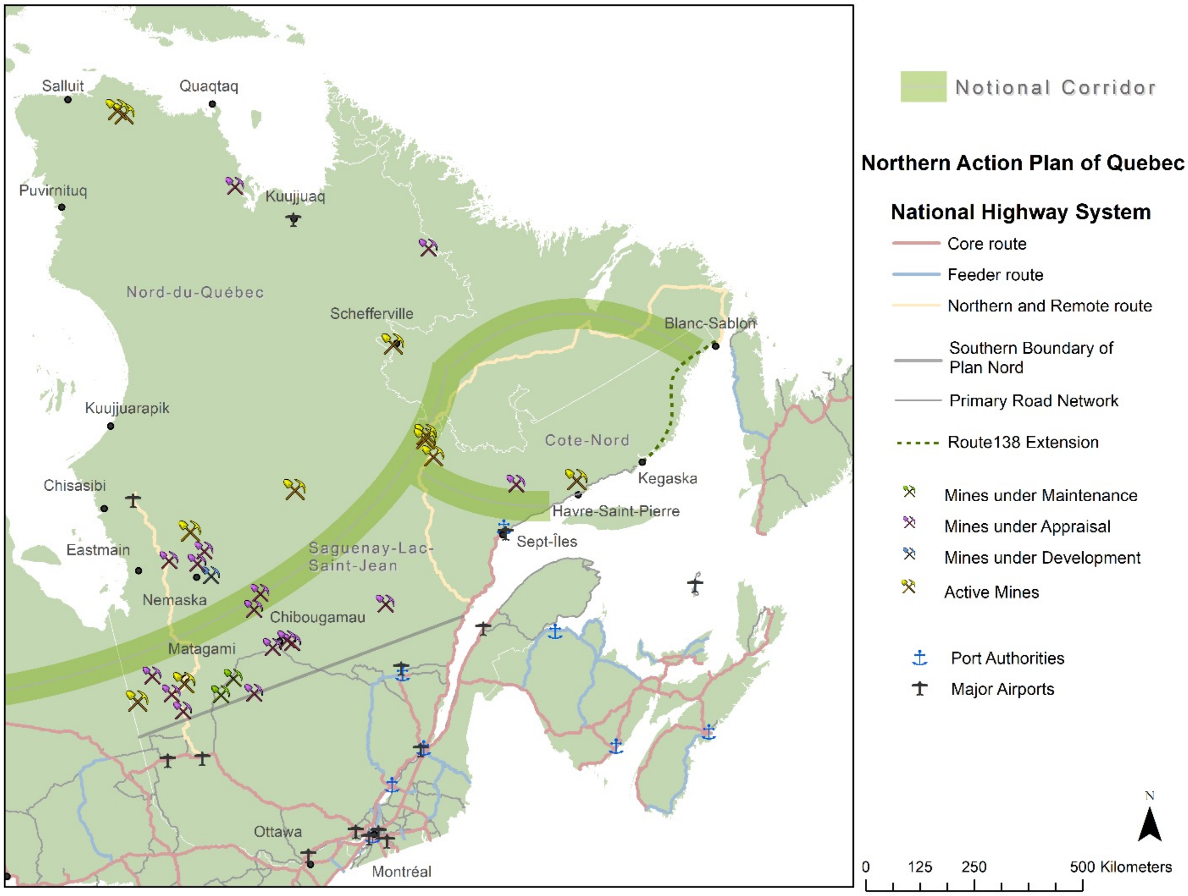
6.2. NORTHERN ACTION PLAN OF QUEBEC

The Quebec government's Plan d'Action Nordique is an economic and social development plan to improve the accessibility of the province's three regions north of the 49th parallel: the Côte-Nord, Nord-du-Québec and northern Saguenay–Lac-Saint-Jean (Figure 16). Former Quebec premier Jean Charest launched the Northern Action Plan in 2011 as "Plan Nord." The plan projected $80 billion in transportation, energy, mining and forestry investments until 2035. Over the following years, subsequent governments first shelved then relaunched the plan in modified forms. The most recent plan, announced in 2020, the 2020-2023 Northern Action Plan, lists 49 initiatives to be completed over the three years (Government of Quebec 2020).

Northern Quebec is nearly three-quarters of the province's geographic area but limited access to infrastructure poses challenges for further economic development in the region. From the total $1.422 billion estimated investment over the next three years, the province plans to invest $1.033 billion to improving the multi-modal infrastructure network in the North (Government of Quebec 2020). Highlights of the planned infrastructure projects include enhanced access to the Labrador Trough, development of port facilities at Pointe-Noire in Sept-Îles, and construction of new roads and upgrading existing ones to improve access to communities and mineral resources.

Quebec's three northern regions are rich in mineral deposits and account for a significant portion of Quebec's production of critical and strategic minerals like nickel, cobalt, platinum, iron, zinc and gold. Figure 17 shows the locations of major mineral activities together with the main infrastructure assets in northern Quebec. While the three regions' road network is about 3,000 kilometres long, these are mainly located in the southern parts or were built to provide access to mineral development projects rather than prioritizing the communities' needs. Therefore, communities mostly rely on sea or air for transportation and supply of goods. To support opportunities for economic development, the plan pledges to extend major highways like Route 138, which follows the north shore of the St. Lawrence River towards the Côte-Nord (Figure 17), and reconstruction of road links between northern communities like the 15-kilometre link between Schefferville and Kawawachikamach, close to the northwestern border of Labrador. Among the plan's 2023 goals is also the completion of geophysical surveys to acquire knowledge on the mineral development potential in the region (Government of Quebec 2020).

Figure 17: The Northern Action Plan of Quebec



Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; NRCan 2006; NRCan 2020a; Transport Canada 2015b; Government of Quebec 2019; Government of Quebec 2021. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

6.3. GRAYS BAY ROAD AND PORT PROJECT

The Grays Bay Road and Port (GBRP) Project is a multi-modal trade, transportation and energy corridor that includes the construction of a 230-kilometre all-weather gravel road running from the Jericho mine site close to the northern end of the Tibbitt-Contwoyto winter road to a deep-water port at Grays Bay in Coronation Gulf (GBEEC 2017, 25).

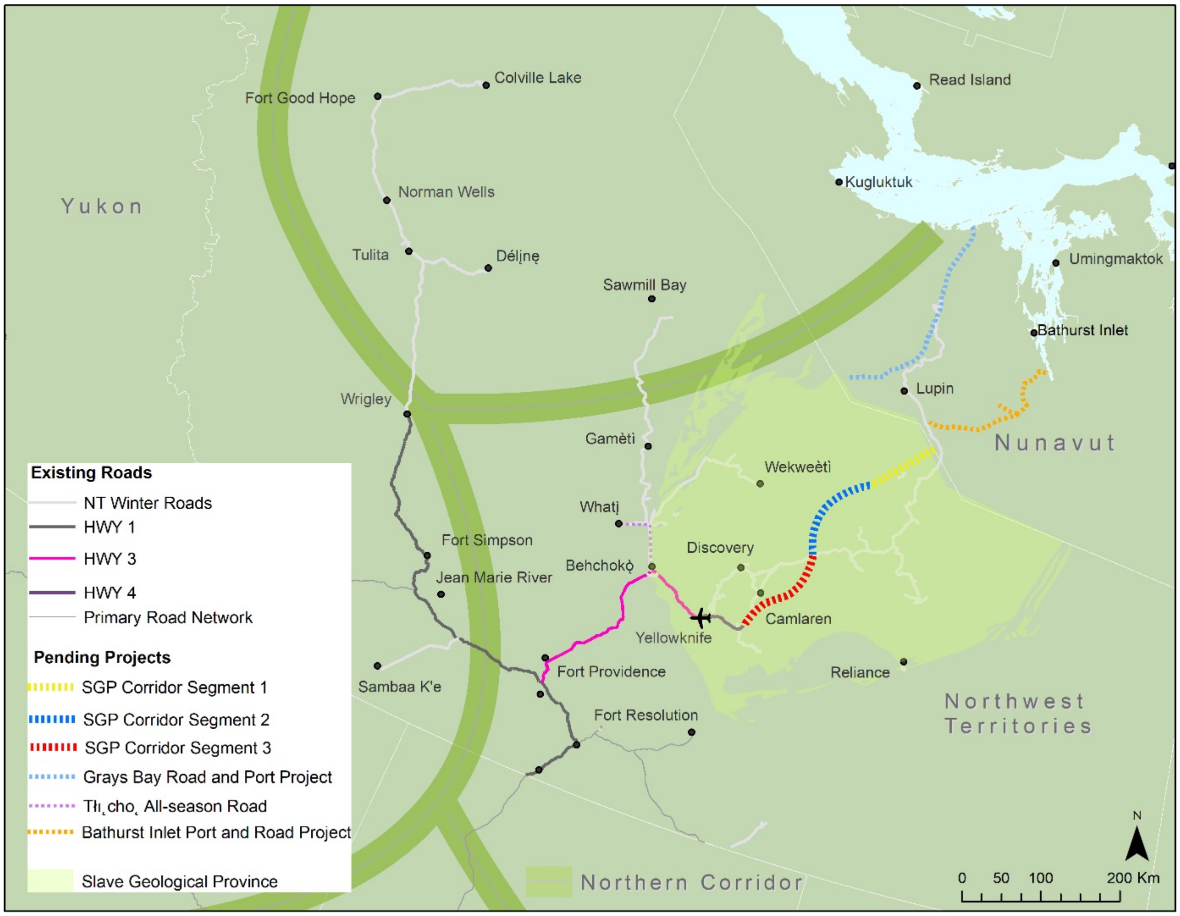
The project proponents are the Kitikmeot Inuit Association and the government of Nunavut.[4] Once completed, the GBRP project would create a land connection between Nunavut and the rest of Canada through the Northwest Territories winter roads that connect to the primary road network in Yellowknife (Figure 18). The purpose of the project is to create all-season access to the mineral-rich interiors of Nunavut and stimulate exploration activity. The project would also potentially connect the mineral resources of Canada's Slave Geological Province to Arctic shipping routes.

In addition to its impact on the region's economy, the project is also expected to provide a number of benefits to the local population through improved overland and marine access. For example, it would enable an inter-community barge service for the movement of people and supplies between Kitikmeot communities along the coast. To enhance the project's benefits, the proponents suggest additional land connections with the south via a multi-modal corridor of other linear infrastructure such as fibre-optic cables, natural gas pipelines and power transmission lines (GBEEC 2017, 30).

In 2019, the C$550 million GBRP project received C$21.5 million in funding from Transport Canada's National Trade Corridor Fund to carry out pre-construction work such as geotechnical investigations and detailed route design (Transport Canada 2019). However, the project is currently stalled due to lack of funding and the COVID-19 pandemic (George 2020).

4 Three regional Inuit associations were established under the Nunavut Land Claims Agreement: Kitikmeot Inuit Association, Kivalliq Inuit Association and Qikiqtani Inuit Association. Kitikmeot Inuit Association represents 6,000 residents who live in five communities: Cambridge Bay, Kugluktuk, Gjoa Haven, Kugaaruk and Taloyoak. (GBEEC 2017, 22)

Figure 18: Grays Bay Road and Port Project and Slave Geological Province



Source: Map prepared by the author (2021) using Statistics Canada 2019; Statistics Canada 2020b; NRCan 2020a; GBEEC 2017; GNWT 1999; GNWT 2015; Government of Quebec 2019; Transport Canada 2015a; Canadian Northern Economic Development Agency 2021. For illustrative purposes only. The following software was used: Esri, ArcGIS Desktop, version 10.7.1. Contains information licensed under Open Government Licence – Canada.

6.4. SLAVE GEOLOGICAL PROVINCE CORRIDOR

The Northwest Territories is connected to Canada's road network through Yukon, British Columbia and Alberta. However, many of the all-season roads in the Northwest Territories are in the south and western parts of the territory. There is no all-season road connection to the neighbouring jurisdiction, Nunavut, or to the communities in the mineral-rich region, the Slave Geological Province (SGP). A network of winter roads provides access to the communities and mines to the region north of Yellowknife. The region mainly relies on air transportation for year-round mobility. The Northwest Territories has a fairly developed air transportation system with community-based and privately operated airstrips used for travel and resupply of communities and the resource development sector.

The government of the Northwest Territories developed the SGP corridor in the 1990s to improve the region's accessibility. The corridor is as a 413-kilometre multi-modal transportation, energy and communications route into the SGP that runs in a southwest to northeast direction. The corridor would connect the communities and the vast mineral resources to the transportation networks in the south and a deep-water Arctic port in Nunavut (Figure 18). This way, the SGP corridor would connect Canada's southern transportation network to the Arctic Ocean in Nunavut. The project's proponents consider a future connection to the Grays Bay Road and Port Project as well. The project received C$40 million in funding from the National Trade Corridors Fund and C$3.4 million from the Canadian Northern Economic Development Agency for environmental and regulatory reviews and planning.

Considering the shortening winter-road season due to climate change, the SGP corridor would provide more reliable access to the region. The corridor would also mean enhanced tourism opportunities and improved access and lower transportation costs for mines. It would also facilitate exploration and development in the SGP. However, potential environmental disturbances, such as the corridor's impact on the Bathurst caribou herd, might be a concern that would have to be addressed for the project's successful implementation.

6.5. BATHURST INLET ROAD AND PORT PROJECT

The Bathurst Inlet Road and Port project consists of a port at Bathurst Inlet, Nunavut, connected to the mineral deposits in the south by a 211-kilometre all-weather road to Contwoyto Lake (Figure 18). The project was initially proposed in the late 1990s by a group of proponents from the region's mining industry, including Inuit-owned companies, as a way to improve access to mines in Nunavut's interior. The government of Nunavut, the Kitikmeot Inuit Association and some Kitikmeot communities, such as Cambridge Bay, backed the project. The port at Bathurst Inlet was completed in 2018 with additional facilities, such as an all-weather airstrip, storage, diesel fuel tanks and accommodations. The proposed all-season road project failed the environmental review in 2016 and passed with modifications in 2017. Eventually, the corridor would connect mining projects and communities along Nunavut's territorial border with the Northwest Territories to the Arctic shipping routes. However, the road project is stalled.

7. CONCLUSION AND FURTHER RESEARCH

This paper is part of a project building a spatial database of existing and pending linear infrastructure projects in Canada. The purpose of this paper is to present overviews of Canada's linear infrastructure networks and inter-modal hubs, and provide details on a subset of projects from each mode. However, inclusion of a project in this assessment does not imply compatibility with the CNC since the sample is not built based on an evaluation of projects according to a list of pre-determined criteria backed up by research.

To assess whether an existing or pending infrastructure project should be subsumed into a planned corridor, the level of compatibility of all existing and pending projects should be systematically evaluated based on common criteria, including economic, social and technical aspects. If the criteria used are subjective or not pre-determined, the users' perception could bias the evaluation process and result in suboptimal outcomes. Therefore, further research could develop a multi-criteria appraisal framework to build a compatibility index. This index could be very simple, including only quantifiable factors as decision criteria, such as:

- Physical proximity to the CNC
    - In terms of location, alignment and intersection
- Connectivity to strategic nodes
    - Proximity to existing and planned infrastructure assets such as ports, airports, railway terminals and border crossings, etc.
    - Proximity to communities, logistic centres, resources, industry, fishing, forestry, agriculture, tourist destinations and/or heritage places, etc.
- Expansion potential
    - Depending on the type of infrastructure: use (volume-to-capacity ratio), seasonality of use, share of commercial vs. personal use, potential for co-location of multiple modes of infrastructure, proximity to environmentally sensitive zone, etc.
- Current regulatory stage for pending projects (potential for achieving necessary approvals)

This would lower data needs and require minimal exercise of judgment by the users. The approach could also be customized to reflect local or regional conditions accurately and developed with further research. This assessment and the accompanying database could be a step towards developing a methodology to evaluate compatibility of linear infrastructure projects with Canada's existing infrastructure network. The corresponding database will be available as an online resource for interested stakeholders.

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