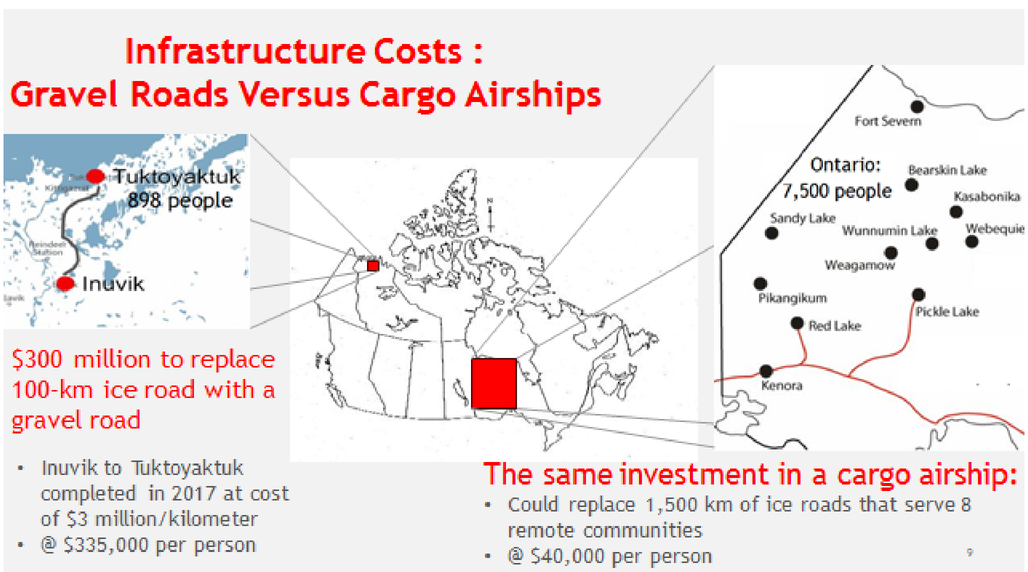
Aviation Innovations Conference: 2019 *Cargo Airships*

March 14-15, 2019, Toronto, ON Canada

This is the first airship conference in Canada, since the Remote No More Conference at Winnipeg in 2014. During the past five years, the acceptance of a Climate Crisis has broadened and with this, the interest in cargo airships as a solution to the increasing logistical problems of Northern Canada. The organization of the program follows a familiar format. The first day sets out the Demand for transportations in remote areas of the Canadian Shield and Arctic regions. The second day is designed to establish the Supply of transport airships to meet the identified needs for freight movements. This report is set out in the order of the invited experts' presentations for the first day of the Conference. A summary of the second day will be prepared for a subsequent edition.

The morning program began with a presentation on the economic case for cargo airships in remote areas, "Transportation Innovations and Transformational Change" by **Dr. Barry E. Prentice**, University of Manitoba. His framing remarks were based on Dr. Prentice's submission that won the People's Choice Award, of the national CanInfra Challenge 2018.[1] The slide presented in Figure 1 summarizes the case for cargo airships versus building gravel roads in the North.

Figure 1 Economic comparison of serving remote communities by gravel roads versus cargo airships



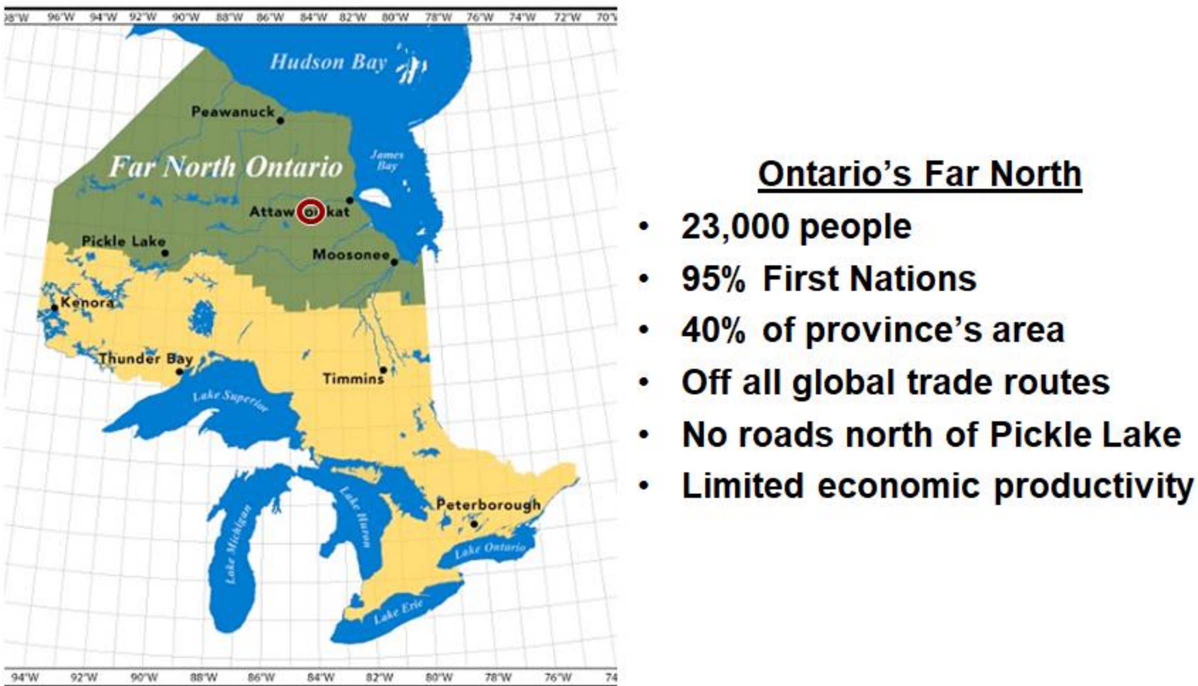
Source: Barry Prentice

Over a three-year period, the Government of Canada spent $300 million to replace a 100-kilometer ice road in the Arctic with a gravel road. This all-season road serves 898 people in the Northwest Territories for an average cost of $335,000 per person. For the same money, airships could replace 2,000 kilometers of ice roads in Northwestern Ontario serving over 7,500 people at 12 percent of the per capita cost. Gravel roads cost approximately $3 million per kilometer to build and over 70 percent of Canada's land mass has no roads. The economics are obvious.

[1] "Electric Airship Transportation System" www.caninfra.ca #caninfra

This point was extended by **Dr. David Robinson,** Associate Professor, Laurentian University, in his presentation on the "Opportunities for Economic Development in the North". He notes that in practical terms the "Far North" begins a lot further south than the Arctic. As illustrated in Figure 2, all the land north of the TransCanada highway in Ontario is considered "Far North" because without roads it is not part of the global economic system. The only options are seasonally-available low cost trucks over ice roads and year-round, but very expensive airplanes. The middle-cost year-round transportation service is missing.

Figure *2 Far North of Ontario: Market for Cargo Airships*



Source: David Robinson

Cargo airships could serve many potential general freight markets in the "Far North" and some special needs like fly-in courts and health clinics. Airships would also greatly assist the creation of a new mining system. Over the next 40 years global mineral production is expected to double. Airships could carry in all loads necessary for mining operations in Northern Ontario and bring prosperity to a chronically impoverished area.

The other crucial need in the northern communities is for more and better housing. **Mr. Jeff Armstrong**, Managing Director, Cold Climate Building, provided a first-hand account of the challenges and costs in his presentation on "Transporting Building Materials to Remote Communities". The statistics are sobering. Over-crowded housing is chronic in Nunavut with a median number of 6 people per house. Over 53% of all houses have someone sleeping in their living room, and a floating population that surfs from one couch to another. As a result of over-crowding tuberculosis is coming back and social ills multiply. Over 3,000 new units needed immediately, but the cost is high. The average construction cost of dwellings in Nunavut is $500,000.

The cost of building housing on-site is high because of a lack of skilled labour, no lifting equipment and weather susceptibility in the short construction season. Many options have been tried to reduce construction costs. The use of modular housing reduces the labour component and speeds up construction, but requires lifting equipment that makes the "last-kilometer" logistics awkward and expensive. Panelized housing, with crated components, can improve housing quality and reduce skilled-labour requirements. Of course, this is not always an advantage because building construction creates activity in a high-unemployment area. The lack of local involvement creates resentment.

Figure 3 presents the cost of shipping crated house kits to Nunavut. The maximum size and weight of the crates are set by the ocean carriers. The costs to move one crated house costs $54,580, the largest part of which is the sealift. However, the cost of moving these crates the last kilometer from the beach to the community is three times the cost of trucking the 200 kilometers from the factory at Ottawa to the Port of Montreal.

Figure 3 Crated houses and transportation costs to Nunavut, 2018.

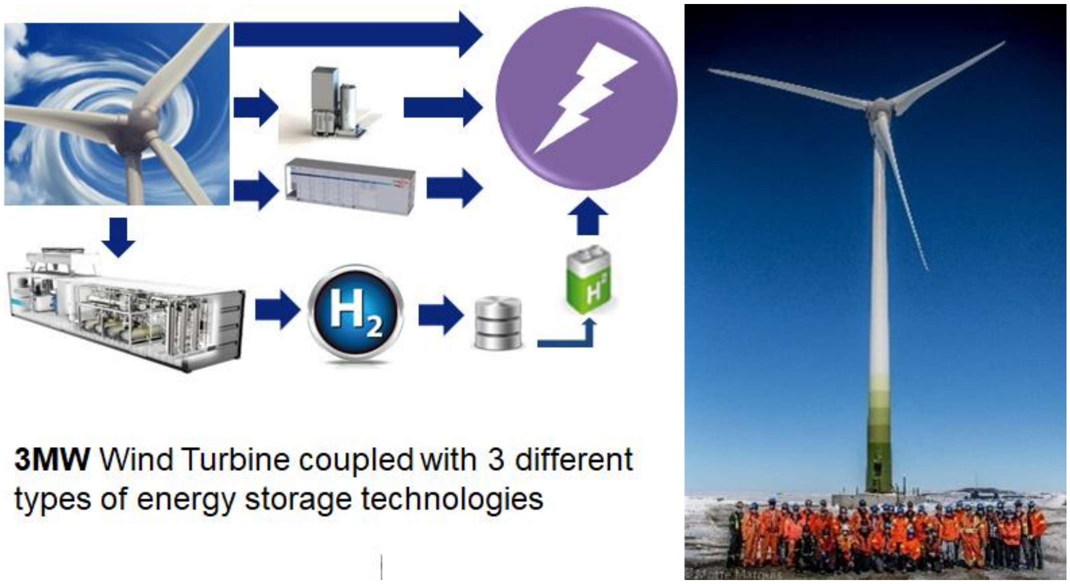
Source: Jeff Armstrong

The conference then turned to the logistics of remote energy and mining operations. The first presenter, **Mr. Pierre Rivard,** Executive Chairman, TUGLIQ Energy Company described their recent wind turbine installation in the Arctic in "Off-Grid Power Service". The need to replace the use of diesel fuel to produce electricity in the North has turned interest to wind power. The logistics to establish the first wind turbine at the Raglan mine, operated by Glencore in Nunavut, presented a number of challenges. The components were brought in by sea and moved by road to the mine site. Normally, a large concrete base is poured, but in this case, the wind turbine was pinned directly to the bedrock. The arrival of the crane to assemble the wind turbine was critical because of the short season of navigation.

The TUGLIQ installation comprises three energy storage systems to maintain power when the wind dies. Hydrogen is created and stored to power a fuel cell system. In addition, batteries are charged to create storable power. The third system is a fly-wheel that can sustain power until one of the storage systems is brought on-line.

The system is estimated to save 2.2M liters diesel that is equivalent to 6,700 tons GHG avoidance per year. A second wind turbine has now joined the installation. As a specialist in bringing clean energy to off-grid remote industrials, communities and islands, TUGLIQ is very interested in the potential of cargo airships. Many locations have adequate wind resources, but not easy access by sea or roads connecting the coast. Figure 4 illustrates the energy storage system and a photo of the first such wind turbine in the Arctic. The inbound logistics for materials and supplies for mining operations is only half the battle, transporting outbound ore, or mineral concentrates, to market can be just as challenging, or more so.

Figure 4 TUGLIQ wind turbine and schematic storage system at the Glencore Mine, Nunavut, Quebec.



Source: Pierre Rivard

"Getting Minerals from Remote Areas to the Market" was the topic of the presentation by **Dr. Dirk Naumann**, President, Torngat Metals Ltd. Torngat has a large deposit of rare earth minerals located at Strange Lake on the border of Quebec and the Province of Labrador and Newfoundland. The increasing demand for rare earths to make magnets for cars and electronics makes this particular deposit rich enough to develop despite its remote landlocked location in Northern Quebec. This deposit is over 300 kilometers from the closest railway line, through rough terrain, river crossings, muskeg and permafrost soils. Other routes have been considered to the north and east, but they are as expensive and dependent on seasonal sea transport.

As illustrated in Figure 5, the preferred logistics is for Torngat Metals to use an airship to fly the rare earth concentrate from Strange Lake to Schefferville. They hope to use airships to move these concentrates to the Schefferville railhead. Planning is at an advanced state for the loading, landing and transshipment sites. From Schefferville, the concentrate is to be moved by rail to Sept-Iles where it will be transhipped to barges for transport to Becancour for further refining. Finally, the output will be transported to Norway for final production.

Torngat Metals cites a number of benefits associated with using airships to develop their mine. Cargo airship logistics significantly shortens mine development timeline. In addition to the cost of building a new road, significant resources are needed to complete the environmental studies and deal with native land claims. By their calculation, the cost per tonne shipped with the 20 tonne-lift airship is comparable to cost of constructing a new road, and with 100 tonne-lift airship, the costs will be substantially lower. Shipping year-round versus only 5 months by road and ship reduces inventory holding costs and improves cash flow.

Environmentally, cargo airship transport has a much smaller environmental footprint. Only a small landing site is required, and no new infrastructure needs to be built (no new road, no new port). And, the airship has lower CO^2 emissions. The local people also support the project because it will create jobs for the local communities in Northern Québec, and lower the cost of inbound supplies. The volume of outbound mineral concentrates is much greater than inbound supplies which enable some return missions to stop at the local communities with supplies before returning to the mine.

Figure 6 Torngat mineral deposit in Quebec landscape and map of transport system

Source: Dirk Naumann

During the lunch break, international greetings were provided by **Mr. Krill S. Mikhaylov**, Consul General, Russia and **Mr. John Hill**, Energy and Environment Counselor, of the United States Embassy in Canada. They recognized the role of American and Russian airship companies in this international competition to introduce cargo airships to the world. Greetings were also extended by representatives of the Canadian Government who were in attendance.

Northern Canada is not the only country that has difficulty accessing its remote areas. **Prof. Ely Carneiro de Paiva,** School of Mechanical Engineering, University of Campinas - Unicamp, Brazil gave a presentation on "Unmanned Airships for Monitoring/Surveillance in Amazon". Brazil has a long history of interest in airships and a need for better transportation. Their work has focused on the use of UAV technology for airships. Three RC airships have been used for mapping and vision control. The *Noamay*, which is pictured in Figure 7, is their most recent. It has four electric vectoring motors to assist its maneuverability.

Although their main interest has been agriculture, attention has turned to monitoring the Amazon rainforest that accounts for 60% of Brazil's landmass. The Amazon is an incredible biosphere. It has 2 million insect species and is estimated to hold 70% of the plants with anti-cancer properties. There are also estimated to be 50 tribes that have no regular contact with the outside world.

Airships are highly suited for environmental and biodiversity applications. Their hovering capability allow for intensive examination of the flora and fauna. The long endurance (for medium-large airships) enables researchers to undertake studies that are not possible with other modes of transport. The low noise and stability of the platform (if wind is not too strong) allows for studies of nature in their natural habitat.

Figure 7 The *Noamay* remotely-controlled electric airship

Source: Ely Carneiro de Paiva

From the tropics, the attention of the conference returned to the realities of transportation in northern Canada. **Ms. Nancy Wood**, President, First Logistics presented a comprehensive analysis of “Building the Western James Bay Winter Road”. This is a 312-kilometer ice road that is built each year by 4 First Nation to connect their communities and the DeBeers’ Victor diamond mine, is illustrated in Figure 8. The route from Moosonee to Attawapiskat, Ontario follows the old pioneer road built by the missionaries. The ice road west from Attawapiskat to the Victor Mine is built to serve DeBeers’ diamond production.

Figure 8 Ice Road to Attawapiskat and Victor Mine

Source: Guy Ginter

Since the DeBeers mine opened, they have provided assistance with capacity development for the management of the road and paid all costs not covered by government funding – between $5 and $9 million per year depending on traffic loads which impacts road specifications. The over 200 seasonal jobs on the road are important because the area experiences 70 to 85% unemployment. Winter road construction begins with initial compacting of snow for frost penetration. Once ice capping is complete (flooding and finishing with a smooth surface), the corners are scarified (ice roads are slippery). The road is 10 m wide, 15 M at curves. The prices for everything in the communities drops when the ice road opens. Food insecurity is a reality for those that live in remote communities because food costs 2.5 to 3 times more than city prices. Diabetes rates are very high.

Water crossings are generally built to an ice thickness of 43” which will support GVW 55,000 kg (106,000) pounds, or a fuel tanker truck. Creek and stream crossings are filled with snow and flooded, creating a ramp between land and water. Ground penetrating radar is used to test and measure ice thickness during construction and maintenance phases of the winter road.

Climate change is resulting in unstable weather and more frequent storms. This changes the snow texture. Natural ice is thinner with more slush and air pockets, river freeze-thaw patterns are earlier, and the muskeg no longer freezes well. Wild-life changes are also evident: Orca whales have been seen for the first time in Hudson's Bay. Woodland caribou populations are plummeting and are listed as a threatened species at risk. Ptarmigan are no longer seen and the snow geese are changing their migration pattern, which affect the hunting season.

A feasibility study regarding an all-season road is underway. Cost estimates have been pegged between $500 million to over a billion dollars, so it is unlikely that a permanent road will be built anytime soon. Figure 9 presents a picture of the ice road and some distances.

Figure 9 Western James Bay Winter Road

Source: Clara Wheesk and Nancy Wood

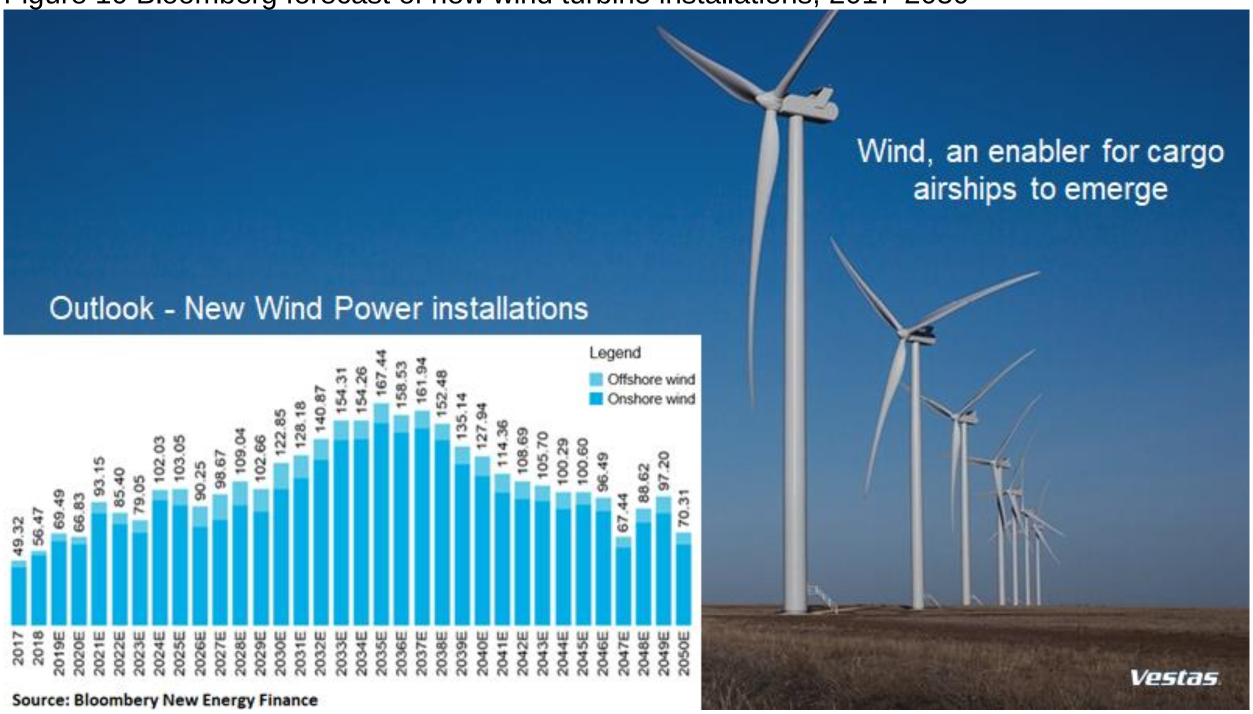
The next session examined the demand for the transport of oversized, indivisible loads. Airships have been on the radar of the wind industry for over 10 years, but now the demand for airships to move wind turbine blades has come into the centre of the picture. The case for using “Cargo

Airships for Wind Power” was made by **Klaus Lynge Petersen,** Director, Ideation & Cluster Technologies, Vestas Wind System A/S. Vestas is not alone in their interest and joined with Seimens Gamesa (a direct competitor) to help encourage development and reduce risk.

Blade transportation could be the best first application for cargo airship technology. Blades are the most troublesome part of a wind turbine to move over land and the lightest large component. There is a cost/volume trade-off, and the first airships are expected to be expensive, but with development of the airship industry these costs will become increasingly competitive with overland trucking.

As per the Bloomberg forecast in Figure 10, new installations of wind turbines are expected to continue rising until at least 2036. These installations are divided into offshore and onshore winds. The onshore winds are going to remain the dominant source of energy. The cost of wind turbine installations varies with location and are no longer subsidized, but can compete directly with other forms of energy.

Figure 10 Bloomberg forecast of new wind turbine installations, 2017-2050



Source: Petersen

The biggest challenge is transportation because the blades are getting every longer with some reaching 70 meters in length. The road and rail infrastructure limits the ability to carry such long pieces. This is aggravated by the market demand for energy that is growing in Africa and Asia where the infrastructure is less mature. Studies that have been done on various approaches (e.g. manufacturing on site, multi-part blades, etc.) are more expensive than the airship solution, but airship technology is considered to be at a low level of readiness.

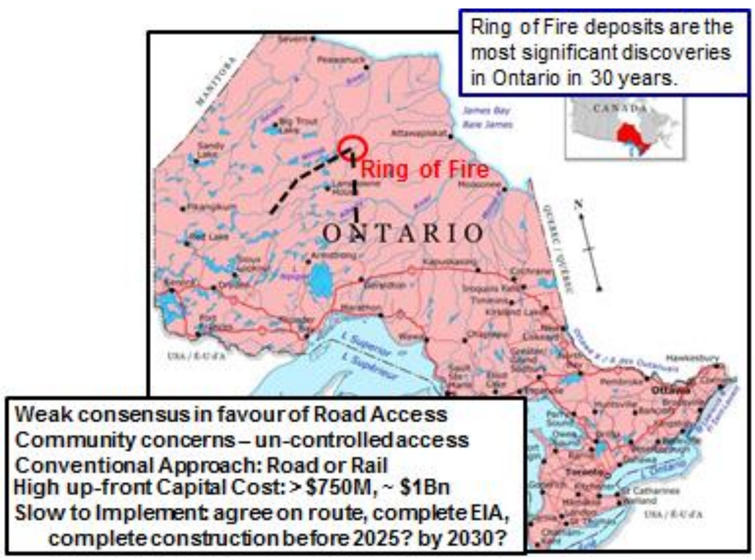
The wind energy industry can be an enabler of the cargo airship industry. While it would be wonderful to have an airship that could also serve as a crane, just to have a transport airship would be a major improvement. The need is to get everyone around the table - OEMs, operators and customers - to work together to develop a viable business case. The wind turbine industry is ready to participate in the risk with other members of the supply chain to help bring airship technology forward. Costs will decline as the technology matures, but even at one Euro per tonne-kilometer some volume is likely possible. One blade would be 15 to 20 tonnes in weight. The wind industry could easily occupy a handful of cargo airships in North America.

In the mining industry there is a constant search for better ways to do things, too. **Doug Morrison**, who is the President and CEO, the Centre for Excellence in Mining Innovation (CEMI), gave a presentation on “Moving Over-Dimensional Freight. The work of CEMI is to take ideas through to where they can be commercialized. They look for significant change, like technologies that can halve-cost. One of the most important issues, managing waste from mines, is critical because the ore only represents about 3% of what is extracted from the earth.

The value-density of the product is critical. Gold and diamonds can be mined using ice roads because the product can be brought out in a small airplane, but base metals require large volumes that can be in the order of 10,000 to 20,000 tons per day. However, many of the First Nations communities do not want roads because of the “bad things” that can come in too. They are also very expensive.

Northern Ontario has the largest deposit of chromium in North America. For over 12 years efforts have been made to develop this mine, but the sticking point is an access road. Figure 11 illustrates the location of the Ring of Fire mining area and the two proposed routes that are about 300 kilometers distance.

Figure 11 Location of the Ring of Fire mining area and proposed land routes



Source: Morrison

The government has shown no interest in the $750+ million investment, so CEMI is looking at other alternatives. One alternative is a hoverbarge, and CEMI has put in a lot of analysis to determine whether or not they are economic and also the best routing. What is clear is that transportation solutions from the temperate agricultural regions are not going to work in the Canadian Shield and zone. Hoverbarges can be appropriate for large heavy loads, but for the lighter and more perishable goods, a cargo airship is likely more appropriate.

Prepared by:

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