AIRSHIP APPLICATIONS IN THE ARCTIC: PRELIMINARY ECONOMIC ASSESSMENT

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ABSTRACT

Northern Canada represents a large potential market for a new generation of cargo airships. The needs of resource developers and native people are not well served by the ice roads and annual sealifts. The North needs better transportation, but the economic case for airships remains unproven. This paper presents a financial simulation model for the use of an 84 tonne airship to deliver fuel to a diamond mine in the Northwest Territories. The model results are only as strong as its assumptions, but if an airship company can match or better the specifications used in this model, the fuel haul represents a real and growing market for their utilization.

INTRODUCTION

Harsh Arctic conditions and the lack of transportation infrastructure frustrate northern development. Without an effective means of getting to market, rich mineral deposits that lay buried beneath the tundra will likely stay there.

Ground based transportation in the north, if available, costs ten to 20 times the equivalent of southern transportation. Even at these high prices, the construction of all weather roads for mining may be economically infeasible.

While the climate is harsh, the physical environment is fragile. Moreover, aboriginal leaders are apprehensive about the social impacts of connecting their isolated communities to the south by road.

In terms of economic development, the Arctic is similar to the condition of Western Canada at the time of Confederation. Very few people lived on the Prairies at that time, and furs were the only trade good that could justify the cost of transportation to an outside market.

Once the railways were extended to Western Canada, the costs of imported goods fell. Lower value commodities became profitable to export. Development capital flowed in with the waves of settlers. The transportation revolution created by railway technology gave the Prairies the breakout opportunity they needed to grow beyond the frontier economy.

Technological advances that are leading to a new generation of cargo airships could do for the Arctic what the railways did for Western Canada.

Giant airships were a proven technology when people were still driving Model-A Fords, and nylon stocking were advanced materials[i]. Moreover, they were demonstrated to work reliably by the Zeppelin Company. This is not a lost art. With the advent of ultra lightweight composite materials, modern avionics, vectored engines and computerized design capability, no technical impediments block the development of a new generation of safe and efficient cargo airships.

Airships offer a breakout opportunity to cut the cost of Arctic transportation and stimulate economic development in a manner that is respectful to both the environment and culture of the people.

The purpose of this paper is to set forth the economic case for using a new generation of cargo carrying airships to support northern mining operations. The first section provides a brief sketch of the logistical requirements for a cluster of mines located in the North West Territories (NWT). Subsequently, a financial simulation is presented for an airship that could carry 84 tonnes of fuel or general freight.

The model is general, rather than specific to any of the numerous designs that are proposed for cargo airships. The intention is to provide a target for airship builders, and a realistic option for northern mining companies to consider. We hope that this paper helps to initiate a series of in-depth studies on the economic case for cargo airships.

THE CHALLENGE

Canada has a long history in the use of air transport in mining development. Bush planes, like the Beaver aircraft, were crucial to the early development of gold, silver and nickel mining in northern Quebec, Ontario and Manitoba.

Air transport enabled people and equipment to undertake resource exploration and development in areas that are virtually inaccessible. Roads and railway lines were eventually built to the richest of these deposits. But even today, Canada has the renown of being the largest single market for helicopter services.

Despite their success, bush planes and helicopters have limitations in both payload and flight distance. Development of large-scale mines or energy exploitation was only possible in the southern fringes of the north where rail lines or road links could be built economically.

Many types of cargoes are required for mine development and operations. The main categories include construction materials, fuel, equipment, machinery, cement, explosives, camp supplies, food, etc.

Fuel is the largest single input requirement that limits northern development. Supply shortages of some mining provisions may be a nuisance, but a fuel shortage can be a catastrophe. A mine that is forced to shutdown its concentrator for lack of fuel may never get re-opened. The camp can also face some very significant safety issues without heat and electricity.

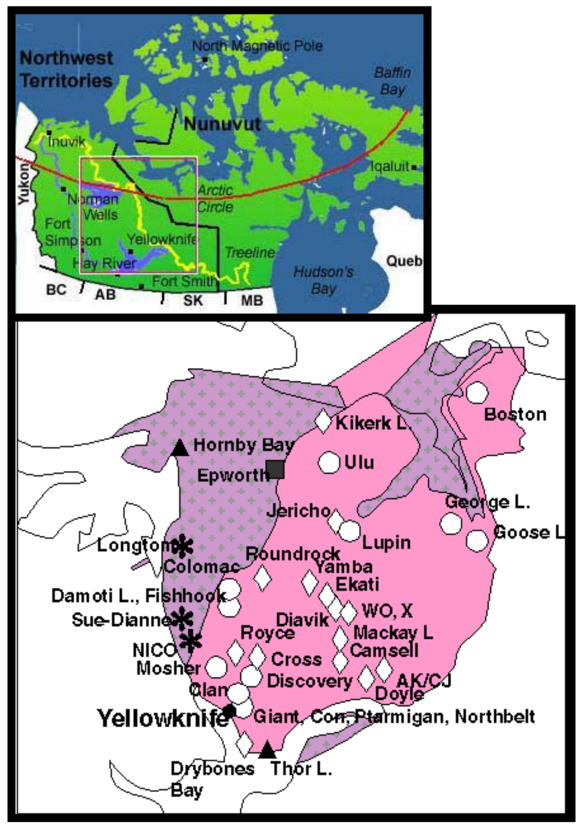
Transporting fuel is costly and environmentally risky. Typically fuel is transported in bulk using rail, truck or barges. Mines that have no railway, all weather roads or marine access must operate using ice roads during a short winter season[ii].

Known mineral deposits and operating mines near Yellowknife, NWT are identified on Map 1. A seasonal ice road serves two operating mines and a third mine under construction. Two of the properties are diamond mines (Ekati and Diavik) and the third is a gold property (Lupin).

All three mines require one-way hauling over the ice road with little requirement for back hauls. Combined, these mines require approximately 200 million litres of fuel.

The year's supply of fuel is trucked over an ice road that operates for a 12–16 week period. In addition to the fuel, a whole year's supply of grinding balls, explosives, plant supplies, non-perishable camp supplies, etc. must be moved over the 400-kilometer ice road. The transportation cost for fuel is about $40 million. The total cost for all freight, including building and maintaining the ice road, would be much higher.

The capacity of the ice roads out of Yellowknife could easily be reached if the season shortens, one of the mines expands (which is a realistic possibility for Lupin), or another property tries to connect to the existing road. Adding more lanes over the lakes could extend capacity, but ultimately, safety concerns would impose an upper limit on traffic.



Map 1 Mine Locations outside Yellowknife, NWT

Ice roads are not viable in all cases. Several known mineral deposits could be developed in the NWT/Nunavut if all-weather roads could be built. For example, Izok Lake, which is located in central Nunavut, is one of the largest undeveloped zinc-copper deposits in North America. It is estimated that the mine could produce 400,000 tonnes of concentrate annually and employ 250 persons. A pre-feasibility study suggests that the mine would have a minimum life of 13 years based on known reserves.

Several major mining companies have considered developing the Izok Lake reserve but all have failed to overcome the transportation challenges associated with economically moving mining supplies, principally fuel, into the mine site and concentrates back out.

Unlike a diamond or gold mine where the finished product can be brought out by air on a weekly basis, base-metal mines have to stockpile their inventories for a year. In addition to the direct costs of ice roads, the indirect costs of financing inventories contribute to the total logistics costs of the mines.

Mining companies have examined many creative solutions to the Izok Lake transportation dilemma. Considerable study was made of building a deep-water port on the north shore of the continent at Bathurst Inlet. This port would be the terminus for a 265-kilometer all-weather road to the mine. The cost of constructing a deep-water port and building the road is estimated to be $250 million.

Part of the study also looked at connecting other properties to this main road/port system. While adding other movements would increase the utility of the road, it would still be an expensive, low traffic volume operation. Further, if metal commodity prices collapse, this road becomes a stranded asset. Thus far, this project remains uneconomic, not to mention the invasiveness that such a road would have to this pristine northern landscape.

THE POTENTIAL FOR CARGO AIRSHIPS

Interest in airship technology is being stimulated by the need for a means of transport that will open up Earth's last remaining frontiers to commercial exploitation. The significant barrier that remains to the production of a new generation of airships is the investment capital required to finance the research, development and air-worthiness certification. Prior to raising such capital, airship developers have to overcome the skepticism of potential customers.

Northern mining operations are searching for a better means of transport than the ice roads, and could be an inviting market for the first cargo airships to test their commercial viability. To get the attention of these shippers, the airship must be able to deliver cargo in a way that is safer, more reliable and/or at a cost that is lower than the current system.

The model is based on the northern fuel haul from

Figure 1 Economic Model Assumptions Annual Basis

Total fuel requirements (litres)	180,000,000
Total landed cost of fuel	$150,000,000
Total transport cost (25 percent)	$ 37,500,000
Airship capital cost	$ 60,400,000
Payload	100,000 litres/84 tonnes
Flying distance	380 kilometers
Average flight speed	161 kph
Loading/Unloading time	1 hour each
Roundtrip travel time	7 hours
Loads per year (260 days operation)	780 loads
Flight crew (3 members, 4 crews)	$ 1,032,000
Maintenance & Administration	$ 704,000
Insurance costs	$ 1,750,000
Fuel burn (2,400 litres per hour)	$ 5,400,000
Depreciation charge	$ 3,655,000
Trucking costs (Edmonton-Hay River)	$ 1,541,000
Return on Invested Capital (10 percent)	$ 6,070,000
Reduced Inventory Carrying Cost	$ 5,010,000

Edmonton to Hay River by truck, and then by airship to the three mines near Yellowknife that now are being served by an ice road. The model assumptions are summarized in Figure 1. These parameters are used to build a financial simulation of 24/7 operations on a service dedicated to the fuel haul.

Airships enjoy significant economies of size, but the mines are unlikely to risk their fate to an unproven technology. Consequently, the model assumes that a smaller airship of 84 tonnes capacity would be the starting point. This is equal to two Super B tanker trucks and would provide a convenient unit of transport.

Operating 260 days per year, an 84 tonne airship could carry 78 million litres, or approximately 40 percent of the mines' requirements. The airship is assumed to have a purchase price of $60 million and to be fully depreciated over 20 years, with a skin replacement at 10 years. This is very pessimistic given that the skins would likely last longer, and no salvage value is assumed at the end of 20 years. Also, the insurance at $1.750 million annually might be reduced in later years as more experience is gained.

The model is based on a single vehicle. A fleet of airships would permit the land based infrastructure costs to be amortized over a larger base that would reduce the unit costs. Also, the maintenance personnel and administration costs per load would decline with a larger fleet.

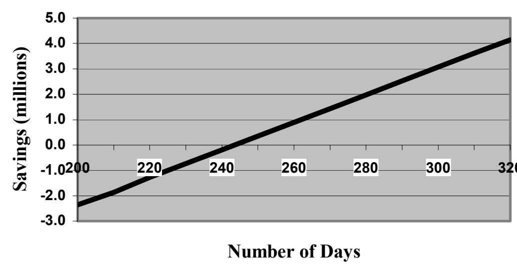
Airships would reduce the indirect costs of holding inventories. Storage tanks are required to be large enough to hold a year's supply, plus some buffer safety stock. Losses due to shrinkage or theft are unlikely, but the carrying cost can be high. Compensation for holding the landed value of a year's supply of fuel is estimated to be $12 million. The savings of using an airship to provide daily deliveries of 40 percent of requirements is assumed to be $5 million.[iii]

Airships have very interesting trade offs between flight speed, fuel burn, operating distance, capital costs and cargo carriage. At higher speeds, more fuel is burned, and more fuel replaces cargo, but vehicle utilization is higher. For short legs, operators would likely try to maximize vehicle speed, in order to reduce capital cost. This model assumes a higher speed and greater fuel consumption than might normally be associated with airships.

The optimal speed issue is really a subject of empirical study that is beyond the scope of this paper. Ground handling and turn around times are other topics that deserve attention, but will be unique to each airship design.

Figure 2 presents the summarized results of the economic model in the form of a breakeven analysis. The airship could satisfy the 10 percent return on investment with approximately 245 days of utilization. As utilization rises the savings to the mine/returns to the airship operator increase. With 320 days of operation the airship would produce $ 4million in extra savings for the mines.

Figure 2 Airship Utilization Breakeven Analysis
(3 flights/day)



If a base operation serving the Ekati requirements were established, it's likely that other customers could be added without having to make significant investments in additional ground based infrastructure.

Beyond the Hay River to Ekati scenario many more fuel haul requirements exist today, or could become a requirement if 84-tonne airships were available. Eight to ten more known mineral deposits could be developed in NWT/Nunavut. Additionally, several millions of litres of fuel oil must be transported to remote communities that are only accessible by barge or sealift for short periods during the year.

An element of reality that needs to be injected into this analysis is the demand for general freight movements over the course of the year. The mines rely on small cargo aircraft to move perishables and equipment that was not included in the ice road re-supply, or whose need (e.g.

parts) became apparent later. No doubt this freight would be loaded on the airship first, and the fuel would be used to top off the load. If an airship were viable for a "fuel only" operation, it would be very profitable if general freight were included in its cargo mix.

WHY AIRSHIPS FOR ARCTIC FUEL HAUL MAKE SENSE

The business case for employing airships to haul fuel must make economic sense. However, several other qualitative reasons make this mode of transportation attractive.

As stated initially, the challenge of northern development is the absence of existing transportation infrastructure. Paradoxically, this lack of transportation infrastructure is what makes airships attractive. Airship hauling cannot compete against conventional surface modes of transportation in the south. However in the north, where the costs of transportation are several times greater than conventional southern transportation, airships should become the dominant means of transport.

Second, the building of all-weather or ice roads is very invasive to the landscape. There are many possible negative consequences relating to road construction. These unnatural structures create barriers for migratory animals. Roads also provide access to areas that would otherwise be unreachable. Hunters, adventures and the curious would all have access if roads were built. Effectively, roads foster "human contamination" of wilderness environs.

Conversely, isolated communities may suffer an exodus of their youth and culture if ready access to the south becomes available. Many aboriginal communities have expressed grave concern over the prospects of the cultural threat that roads represent and have been unequivocal in their wish to keep their communities intact at any price. The good news about airships is that only small pockets of disruption to the environment need to take place in developing northern mines. Being able to fly cargo into sites negates the need to create fixed road links.

Third, airships are a safe means of transporting fuel. Even if an airship is forced down, it can do so in a controlled fashion thus reducing the risk of a fuel spill in a sensitive and difficult to reach area. By comparison, significant risks are associated with hauling fuel over ice roads. An accident involving a fuel tanker on a frozen lake means a spill on the ice surface, which can be difficult and expensive to clean up. Worse still, a tanker breaking through the ice and ending up on a lake bottom risks seepage and contamination of the lake, plus the cost of retrieval (Prentice and Phillips, 2002).

Fourth, airships have a relatively benign impact on the environment. They are not as noisy as a jet so they can fly overhead without disturbing the local fauna. Airships do not require bridges or other land based disturbances that would negatively impact these fragile northern environs. Further, airships are relatively low producers of air pollution because most of the lift comes from the lighter-than-air gases rather than propulsion.

Airship experts generally agree that hydrogen could be an acceptable fuel to power cargo vehicles. As the fuel cell technology advances, it is a very realistic belief that the airships of the future may be powered by fuel cell. This could be augmented by photoelectric arrays placed on the massive skin of the airship to feed the electrical motors during the long summer days of the Arctic.

Fifth, almost all inland cargo must be transported in the winter, during relatively hazardous weather conditions. An entire year's supply must be moved during a compressed window. There are two financial consequences associated with this required practice; first, the mine cannot avail itself of pricing efficiencies during the course of the year but rather they must buy all their supply at the prevailing prices; and second, a significant inventory carrying cost adds to the operation's overall energy cost. Environmentally, storing a year's supply of fuel increases the risk and consequences should a storage tank fail or some other catastrophe occur.

CALL TO ACTION

Recently airship manufacturers, potential customers (mining, energy and northern re-supply companies), government, aboriginal, military, ecotourism, research and business interests gathered at the "Airships to the Arctic Symposium" held in Winnipeg, Manitoba. Over the course of the three-day session, it became clear that the technology and expertise necessary to build large cargo carrying airships was well defined and available (Prentice and Turriff, 2003). Potential customers were keenly interested in what they see as an elegant and effective solution to their transportation concerns. However, the common refrain heard from the manufacturing community was, “Tell us what you want us build and we will gladly deliver. But we need a customer who will pay money today to finance the building of the first commercial airship”. The customers, on the other hand, were saying, “We don’t want to own and operate airships. This is not our core business. But we will sign a transportation contract today if the airships can do what they claim to”.

Traditionally, carriers fill this void between shippers who want transportation services and manufactures that build transportation equipment. Carriers operate the equipment and contract with the shipper. For example, in the trucking industry, a carrier who successfully bids a transportation contract can then acquire the equipment and drivers to serve the requirement.

The financial risk of equipment ownership is underpinned by the transportation contract. The carrier, knowing that there is sufficient cash flow to justify the equipment purchase, is comfortable issuing a purchase order to the equipment manufacturer. The end result of this commercial transaction is that each party’s business needs are met and the risks of ownership and operations are properly managed.

Airships face the proverbial “chicken and egg” dichotomy that often limits the implementation of new technologies. Before an airship industry in the north can be birthed, a carrier must step forward to connect the shipper, who has the transportation need, with the manufacturer, who has the ability to provide the equipment to fulfill that need. The carrier who wishes to avail himself of this business opportunity may come from the ranks of carriers in other industries who can adjust their business model to develop that airship industry. Alternatively, a new class of carrier may be formed from business interests who are prepared to seize this opportunity. Either way, until the carrier role is filled, this fledgling industry will struggle to become a legitimate northern transportation option.

Other potential players could be the catalyst to entice a carrier to come forward. Most commercial interests are accountable to their shareholders and must mange their investments subject to their own perceptions of risk and reward. On the surface, the potential prize for the carrier who becomes the provider of northern transportation services is great. However, so too are the risks associated with this endeavor. Generally, most of the high-risk areas relate to the operational capabilities of airships that are both unproven and uncertain for the conditions in which the airships will have to operate. Until an airship manufacturer builds and flies an airship in the north, carriers and their investors will likely remain skeptical. Therein lays the impasse.

How then can these operational risks be mitigated so that the carriers can be attracted to this opportunity? Here is where other parties who do not necessarily have commercial interests have an important role to play. Incubating such a groundbreaking industry is a legitimate role for government. This is not to say that government needs to get into the airship industry and actually own and operate the first airships. The role of government is to help finance the operations and business research that can answer some of the important questions that create risk.

Given that the Federal and Territorial governments are obligated to their constituents to provide for economic development, it may be worthwhile for these respective governments to provide some of the risk capital. Demands from the north are increasing for infrastructure like the $250 million all-weather road from Bathurst Inlet. Governments should consider supporting the airship industry as a less expensive transportation alternative for the north.

OTHER OPPORTUNITIES

Most people who have taken the time to get an understanding of airships and their potential uses can easily understand why there is such excitement in seeing the first modern cargo airships built. The versatility and applicability of airships, coupled with the capability of building an airship with the technology and materials that actually exist is both compelling and achievable, if only the first airship could be built.

The focus of this discussion has been oriented towards bulk fuel hauling. However, there are many other transportation requirements that would be well suited for airships. Airships are a realistic transportation option and, once established, many more uses for airships will be found. Figure 3 presents a list of commercial and public applications for new generation airships.

Figure 3 Commercial and Public Sector Applications for Airships

		Commercial Uses	Public Uses
Mining and Energy Development		✦	
Hydro-electric and Pipeline Construction		✦	✦
Forestry		✦	
Research:	Environmental Studies		✦
	Resource Exploration	✦	
Emergencies:	Accidents	✦	✦
	Search and Rescue		✦
Defence:	Surveillance		✦
	Heavy lift		✦
Eco-tourism		✦	
Advertising		✦	
Essential Goods and Services Supply			✦
Communications		✦	✦

Hydroelectric projects and pipeline construction represent enormous transportation challenges and opportunities not to mention profit potentials. Over dimensional loads can be more easily accommodated using airships, and for the north, equipment can be re-located with out the cost and damage associated with disassembly. Moving oil drilling rig and supplies (e.g. oil drilling mud) is a similar application. Existing transport is expensive and operations are limited to a very short season that inflates production costs.

Airships could have valuable public roles in search and rescue, and in emergency response to pollution spills or other national disasters. The military could also find uses for airships in surveillance and to provide airlift for the armed forces. Forestry, ecotourism and advertising are other commercial markets that have received attention, while airships have been shown to be ideal platforms for the study of wildlife and to monitor the environment.

Northern re-supply of essential goods and services is an exceptionally costly role for government. The transportation costs of sustaining northern communities is destined to grow ever larger, as their population expands, and demands for equivalent “Southern” services become louder. Airships could lower these costs. Finally, airship technology is being developed for use as a high altitude communications platform. This is a role with both civilian and public applications that has generated a great deal of interest.

CONCLUSION

Commercial necessity is the usual foundation for developing transportation infrastructure in a frontier region. For example, on the Canadian Prairies, railways were built to connect grain producers to export markets. Communities grew up around the grain elevators, as these centers became re-supply points for surrounding farms. Roads were then needed to move goods and people between communities and the larger centers. Over time a reliable transportation network evolved that served these needs. So what began as a commercial justification for the building of transportation system, gradually migrated to become a societal imperative.

It is unlikely that development of northern transportation infrastructure will follow the same pattern. The harsh climate, aboriginal land claim issues and the fragility of the environment preclude development of the large population centers that exist in the south. Without the social imperative, the justification for transport infrastructure development rests squarely with the commercial needs.

The north has many stakeholders with competing and conflicting needs. For some, like the aboriginal communities, a strong desire exists to leave the land intact and discourage exploitative commercial activities. For others, like the mining companies, the north represents vast mineral reserves that cannot be economically developed because of prohibitively expensive access costs. Both the Federal and Territorial Governments have land stewardship and social development obligations. Airships represent a transportation option that could potentially align many of these conflicting needs and offer a very credible option to responsible northern development.

This paper has identified a commercial market where a heavy lift airship could be economically viable, based on reasonable performance assumptions. It is by no means the only application for airships, but it is a realistic starting point. The ball is now in the airship manufacturer's court. If they can match or better the cost and performance specifications assumed in this study, the world will beat a path to their door.

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[i] In 1929, the Graf Zeppelin completed a 20,500-mile circumnavigation of the world. In total this airship made 144 Atlantic crossings and without any major incidents.

[ii] Airplanes could be used to transport fuel, but they are too expensive for the qualities needed to be transported to be a viable option.

[iii] The inventories cost savings are very complicated. The rate of interest used can vary between the savings rate to the opportunity cost of capital. If a new mine were built, smaller storage tanks could be used. Finally, buying all fuel requirements at one time increases price risk. Being able to spread acquisition out over the course of the year would facilitate hedging and purchasing on dips in the market price.