Airship Market Prospects: A Qualitative Forecast to 2015

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Introduction

Technological changes that lower transportation costs can create rapid trade growth because it is doubly stimulated (Kindleberger, 1962). Shippers want to use more of the new transportation alternative because lower freight costs translate into higher profits for their production. At the same time, consumers find that the costs of their purchases have decreased because of the lower cost transport, and they increase consumption. Consequently, innovation in transportation generates a double stimulus for trade that is the basis for an explosive demand for a new transportation service.

The rapid growth of the railway industry in the 19th Century is an example of the double stimulus of trade. As railway lines were extended into undeveloped locations, farming opportunities emerged that were previously uneconomic. This encouraged trade and settlement that made demand for the railways self-perpetuating. A similar experience has been occurring over the past three decades in ocean transport. Advances in ocean container ships, double-stack trains and faster port handling equipment have lowered unit costs. The cause and effect of trade can easily be confused. However, the economic stimulus of innovations in container shipping cannot be ignored in the rapid growth of trade between China, North America and Europe.

Similar advances in technology make airships one of the most promising modes of freight transport that has yet to experience an explosive growth of demand. Both technical and economic reasons lie behind the 70 year delay in the commercialization of large freight

carrying airships, but as we enter the new century no obvious technological barriers remain. Where transportation infrastructure is well established, profitable markets for airships have been hard to identify. Interest has been growing however, in the potential for airships to serve remote areas that have fewer transportation alternatives and scarce infrastructure.

In Canada, roads and railways reach less than 30 percent of the landmass. A new generation of airships could bring forward new markets in remote northern areas, like the railways did 150 years ago, that have latent demand and few economic transportation alternatives. The reduction in transportation cost that is possible with a new generation of airships is impressive. As larger airships become available, total freight costs could be similar to trucking. The new generation of airships has the potential to create the conditions for explosive economic development and growth of trade in the North.

The purpose of this paper is to present a qualitative forecast for a new generation of cargo carrying airships in Canada. This forecast is based on the extensive research that has been undertaken by the authors over the past four years, and the three successful *Airships to the Arctic* conferences that have been held since 2002. The paper begins with a description of the forecasting approach, and continues with an industry sector breakdown to substantiate the estimates.

Qualitative Forecast

Forecasting the potential market for cargo airships in Canada is difficult because no history exists that would permit a statistical analysis. In fact, no existing buoyancy aircraft is certified for operations in icing conditions. Consequently, the first assumption in formulating a qualitative forecast is that new airships can be engineered to operate safely in winter cold, precipitation and wind conditions. Historical precedence suggests that airships can operate safely in cold weather, but certification will involve the establishment of replicable testing conditions and safe tolerances, as well as the creation of other regulations. Even an optimistic assumption would envision three years before a certified airship could be available for

the North. Consequently, a ten-year forecast is really an estimate of the period from 2009 to 2015, which is the earliest that these new aircraft would be introduced.

Transportation innovations that could give businesses access to new areas can create their own market dynamic. It is impossible to envision all the possible uses for airships. Applications will depend on the peculiarities of design and performance. It seems clear that the airship market will have at least three variants. Work is advanced on the catamaran-shaped hybrid aircraft. The hybrid aircraft are about 30 percent heavier than air, and take advantage of a lifting body design to remain airborne. They operate at higher speeds than traditional airships, fly higher and can operate without the need to re-ballast when not carrying a load. The only infrastructure requirement is an unimproved runway or expanse of lake for takeoff and landing. These are significant advantages for moving general freight longer distances, and could have a particular advantage in the North where a return load may be difficult to find.

The second variant is a hybrid that combines the elements of a helicopter and an airship. In this case, the buoyancy of the airship can lift the dead-weight of the vehicle while the thrust wing of the helicopter lifts the cargo. Vertical delivery and precise placement is very desirable for some applications, like forestry, construction and the movement of indivisible, oversized freight. The Heli-stat that was developed by Peasecki (1979-1986) was an early attempt at a hybrid helicraft. Unfortunately, a fatal accident ended this experiment before it was ever properly explored. After 20 years, the limitations of helicopters are again providing impetus to explore the hybrid helicraft concept (Prentice and Thomson, 2005).

The third variant is the traditional dirigible that operates close to neutral buoyancy, including the cargo. Dirigibles need re-ballasting, which makes ground handling more complicated, but they do have advantages in endurance, low fuel consumption, low noise and altitude. Very high altitude dirigibles for telecommunications and defense purposes have received funding from the U.S. government,

while state agencies in Korea and Japan are undertaking this research. Small dirigibles have found a niche in tourism, advertising and general surveillance (Prentice and Turiff, 2002). It is unlikely that traditional dirigibles will have much role in the carriage of cargo, which is the focus of this analysis, and will not be considered further.

In order to develop a qualitative forecast a standardized unit is needed to estimate demand. Economics and the technical time-path of aerospace technology can provide some guidance on the market development. The first models can be expected to be sub-optimal in terms of size and performance. As the industry develops, a dominant size and design will emerge.

Size has a bearing on the scope of applications. Smaller hybrid aircraft can be used for short haul markets, but to be economic for long haul missions, larger hybrid aircraft are required. Hybrid helicraft are likely to have a longer range than helicopters, but in general these vehicles will serve short haul markets where precision placement is more important than speed of delivery. Economies of size are important because displacement vehicles experience increasing economies of scale. Consequently, larger hybrid aircraft and helicraft can offer much lower tonne-kilometre rates that will expand the boundaries of economic opportunity for their application.

Several resource industries could employ hybrid aircraft and hybrid helicraft that could lift 20 or 30 tonnes. Once the lift of hybrid technology exceeds 50 tonnes, however they will become the dominate mode of transport in Northern Canada and other circumpolar regions. For the purposes of this report, a 50 tonne equivalent airship (FEA) is used as a unit of measure. The scope of the forecast is limited to the Canadian market.

Hybrid Aircraft Demand Forecast

A qualitative demand forecast for hybrid aircraft is presented in the Table 1. The subsequent sections provide a brief commentary on the development of the market forecast. This followed by a discussion of

the market for hybrid helicraft. Only the low demand forecast is discussed in detail.

Table 1 Hybrid Aircraft Demand Forecast for Canada to 2015

Application		Low Demand	High Demand
Industry	Sub-sector	50 tonne equivalent airships	
		FEA	FEA
Mining:			
	Diamonds	10	20
	Gold	10	20
	Base metals	50	200
Northern re-supply:			
	Near north	20	30
	Far north	50	200
Emergency response:			
	Forest fires	10	30
	Other incidents	5	10
Energy industry:			
	Oil sands	20	100
	Pipelines	10	25
Total		195	635

Mining Demand

Diamond mining has joined gold mining as the principle economic driver of the Nunavut and the Northwest Territories. These mines are operated by a combination of winter roads and small aircraft. Winter roads are used to bring in the year's supply of diesel and heating oil to operate the mines. The fuel shipments are conducted during a narrow window that can approximate 10 to 12 weeks in length. During the same time, all other non-perishable and over-sized equipment is brought into the mine. Small airplanes are used to ferry

crews in and out from the mines along with perishables and the mine output.

Two diamond mines are operating in the Northwest Territories and several others are in various stages of development and environmental approval. Prentice and Thompson (2003) examined the use of hybrid airships to serve the Ekati diamond mine. An 82 tonne hybrid was projected to haul 40 percent of Ekati's 180 million litre fuel demand. Four fifty-tonne equivalent airships (FEAs) would be required to serve their 2003 demand. Since that time, the Divek mine that is similar in size to Ekati has opened. This mine would also require 4 FEAs. At least one more diamond mine is expected to open in the next three years that would require similar transportation services.

Rising gold prices is stimulating mine development in Nunavut and the Northwest Territories. Operations of gold and diamond mines are similar. If hybrids were available, 10 FEA are easy to envision. In 2002, the operator of the Meadowbank Mine in Nunavut indicated that he wanted a fleet of airships (Prentice and Turiff, 2002). Moreover, they have three or four more properties that they would like to develop as soon as possible.

Base metal mining demand is much larger in total, but remains a latent demand for lack of feasible transportation. Unlike diamonds and gold, base metals require lower cost transportation to move the large volumes of metal concentrates to market. In general, this means the construction of an all-weather road. The Isok Lake copper/zinc deposit is one of the richest in the world, but its development has been stymied by environmental issues and the cost of building an all-weather road.

The projected production of copper/zinc concentrates from the Isok Lake mine is 1,500 tonnes daily. Assuming that 100 tonne hybrids could be available at the tonne-mile costs of trucking and road construction, a total of 12 FEA hybrids would be required to serve this mine at three round trips per day. Although Isok Lake is an

exceptional mineral deposit, a dozen more base metal mining properties exist in a similar state of preparation, waiting only for the right transportation solution. The demand for 50 FEA would include mines in the northern parts of the major provinces as well as the territories.

Northern Re-supply

Remote communities in Canada depend on annual sealift, winter roads and small airplanes for transportation services. Annual services transport the heavy, indivisible, or bulky goods, but are inconvenient. For example, the diamond mines must purchase more expensive "winter diesel" even for summer operations, because transport is during the winter months. Annual re-supply imposes significant inventory financing costs on buyers and requires storage facilities. Airplanes provide year round service for perishable and higher value goods that they can accommodate (typically less than 7 tonnes payload), but they are expensive. Perishable food product prices can be easily double the cost of the same goods in the south.

A second problem is the growing unreliability of winter roads that are used to move supplies into remote communities. Road sections are being re-routed away from lake crossings and pre-fabricated wooden bridges are being installed over river crossings, to increase their season. Temperatures and snow cover however still affects reliability. Over the past ten years, the operations of winter roads have been reduced by 50 percent in about half the years.

The winter roads problem extends across all of northern Canada and into Alaska. Smaller hybrid aircraft (<50 tonnes) could serve most of the provincial markets, but larger vehicles would be necessary to provide service to the high Arctic because the distances[i]. Manitoba could employ two to three FEA, while Ontario and Quebec could use ten FEA. The remainder of the near North could use another seven vehicles. In the far North, the estimate is for 50 FEA, although most would be larger vehicles.

Emergency Response
Emergency response is an attractive role for hybrid aircraft because often the problem is to move staff and supplies the last 50 or 100 miles. Many types of emergency response can be envisioned, but oil spills and forest fires are the two most pressing problems in Northern Canada. The extent of the boreal forest in Canada means that virtually every province needs some equipment to contain wild fires. Hybrid aircraft are not an option for the delivery of water directly to an open fire, but they could be very effective in laying down a continuous line of fire suppressant[ii]. Also, hybrid aircraft could move in staff and equipment and set up a base camp at any lake large enough for landing and take-off.

Hybrid aircraft could provide communications and fire intelligence to manage the emergency response. The ability to hover and cruise slowly around the fire area would provide a floating command post for the direction of the fire response team. Finally, the hybrids could be used for mop-up activities to bring in large quantities of water to cool potential flare-ups.

At least 10 FEA could be employed in Canada for forest fire suppression. The demands for other emergency response could employ another 5 FEA, likely stationed on the Atlantic, Pacific and the Arctic Oceans. The need for better emergency response for oil spills in the Arctic is outlined in Prentice and Phillips (2002).

Energy Industry
Hybrid aircraft could be used for at least the following missions in the energy industry:

- Movement of larger industrial equipment from ports or inland manufacturing facilities to the project construction sites.
- Movement of large indivisible loads that have clearance that exceed the road and/or rail allowances.
- Movement of people and supplies from the rail head in Fort McMurray to oilsands sites.

The Alberta Government estimates that new and sustaining capital requirements to produce the Alberta Oilsands resource may reach $93.5 billion over its expected 30-year life. Every day 300 hundred bus loads of workers are transported from the city of Fort McMurray to the project sites. This is a time consuming and costly exercise given the limited road capacity and bridges in the area. The furthest site is 125 km, one-way, from Edmonton. A conservative estimate for the needs of the Oilsands and related energy developments is 20 FEA.

Support for the construction of pipelines is another potential market for hybrid aircraft. At least four major pipeline projects planned for Canada and the north:

- Mackenzie Valley Pipeline (gas) – $7 billion
- Alaska Pipeline (gas) - $13 billion
- Gateway Pipeline (oil) – $2.5 billion
- Keystone Pipeline (oil) - $2.0 billion

Soft and sensitive ground conditions limit construction to a short winter season where conditions of cold and darkness are at their harshest. This creates a massive logistics challenge because the entire requirements for pipe, construction material, camps, equipment and personnel must be mustered to the northern sites during the off-season for the short construction season. We estimate that 10 FEA could be employed in these construction projects. Additional vehicles would be necessary if more than one pipeline is built simultaneously.

Hybrid Helicraft Demand Forecast

Table 2 presents the demand forecast for the hybrid helicraft. Although these measures are also presented in FEA units, the helicraft could be smaller. Initially, these vehicles are likely to be in the 25 tonne lift capacity. Over time, larger vehicles are envisioned, but research is too sparse to go beyond the 25 tonne range at this time. Three general market areas are considered: forestry, construction and oversized loads.

Table 2 Hybrid Helicraft Demand Forecast for Canada to 2015

Application		Low Demand	High Demand
Industry	Sub-sector	50 tonne equivalent airships	
		FEA	FEA
Forestry:			
	Boreal logging	20	200
	B.C. logging	20	200
Energy construction:			
	Oil exploration	20	100
	Hydro-electrical	10	20
Oversized loads:			
	Indivisible pieces	20	200
Total		90	720

Forestry

Sustainable forest environments and the construction of logging roads are mutually incompatible. Ground disturbance and access to species invasion caused by roads have destroyed huge areas of the boreal forest. In the 1970s, the forestry industry became interested in aerial logging and made some investments in airship development. For various reasons these efforts were abandoned, but helicopter logging of standing stems has continued (Smith, as cited in Prentice et al, 2003). A new generation of hybrid helicraft presents an opportunity to obtain a lower cost method of aerial logging that can minimize ground disturbance and complement helicopter operations.

Helicopter logging is practiced for high value, standing stems in British Columbia, but the range of operations is limited to a few miles from the roads. The requirement is for a vertical take-off and landing vehicle that can carry bundles of logs weighing between 20 and 40 tonnes for a distance of 25 to 100 kilometers. This vehicle needs to operate with costs that are competitive with the costs of building

roads and operating tractor trailers. The market for hybrid helicraft that could meet these requirements is estimated at 20 FEA for the boreal forest and 20 FEA for the forests of British Columbia.

Forestry operations in the boreal forest would likely use traditional harvesting equipment that would be brought in by the hybrid helicraft to begin cutting and stacking logs. The size of this equipment is not greater than the weight capacity of the hybrid, but could easily be disassembled and brought in. The sustainable timber harvesting method would emulate the natural forest fire and re-growth cycle. Mature trees would be harvested where forest fires had occurred 40 years previously. After clearing, the forest can be returned to its natural condition through controlled burns. By avoiding the need for roads, the natural drainage and wild-life are unaffected. Subsequently, the equipment would be moved to the next oldest fire site.

Energy Exploration and Construction

The surge in energy prices has put further pressures on the energy industry to explore and produce new wells. New capacity is being sought in the more logistically challenging permafrost climate zones. In much of northern Canada and Alaska, local ground conditions severely inhibit oil and gas drilling activity. Oil drilling in areas with muskeg or marshy conditions requires the ground to be frozen before heavy drilling rig equipment can be transported. During the remainder of the year, impassable mud and environmental restrictions prohibit surface transport to these sites.

The economic impact of the transportation bottleneck created by the seasonality of oil drilling adds 30 to 40% to the total cost of oil drilling. Conservatively, this market is worth $300 to $400 million (Prentice and Thomson, 2005). The logistics of a rig move include transportation of all camp supplies, consumables and drilling equipment. A typical rig move could involve 40 loads of 40 tons each that would be moved over 15 to 20 miles. Camp supplies include the living quarters for the crews and consumables like food.

Other important consumables that need to be supplied are drilling mud and diesel fuel to operate generators and equipment[iii].

Hybrid helicraft could cost between three to five times as much as moving oil rigs using conventional means. At these rates, it is unlikely that airships would replace winter roads and trucks, but they could complement their operations. Trucks could move the oil rigs into place, while airships would move them out without concerns about the normal end of the winter road season. Moreover, the airships could bring in re-supplies of fuel and other consumables throughout the drilling season rather than requiring large initial inventories. The oil exploration market for helicraft is estimated at 20 FEA.

Other energy construction project could also benefit from the movement of indivisible pieces of equipment. In some cases this might mean ferrying equipment across rivers in place of bridges, or lightening the load so that lighter-weight bridges could be used. In addition to hydro electrical projects, the hybrid helicraft could also find employment in the construction of pipelines. The total market is estimated to be another 10 FEA.

Oversize Loads

The CargoLifter project was not able to generate sufficient capital to carry its development to conclusion, but they were able to document the demand for moving oversized, indivisible loads. Although they were aiming for much heavier pieces (>165 tonnes), they were able to identify a significant market for smaller loads, or where vertical lift would be desirable (Boyle, as cited in Prentice et al, 2003).

Clearly, the demand for oversized pieces would grow with the capability of the hybrid helicraft to lift greater weights. For the purposes of this forecast, the figure is set conservatively at 20 FEA. One example of the market potential is in the use of large trucks for open pit mining and oilsands projects. The limit to the size of the mine trucks is the largest tire that can be transported to the site. Most of the other truck parts can be disassembled, but a tire, by definition

is an indivisible load. Suncor operates 30 trucks, each has 6 tires and a tire lasts about 11 months. They need about 180 tires per year. An individual tire weights about 8,000 lbs. They spend about $8 million per year on tires alone. If hybrids could transport larger tires, trucks could be larger and the potential benefits to the mines would be very significant.

Concluding Comments

The transportation industry is dependent on the general economy and sizes itself to the available demand. Changes in transportation technology that lower freight costs can create its own demand because trade is doubly stimulated. Shippers want to use more of the new lower costs alternative and make higher profits. Consumers want to buy more because of the lower cost transport reduces the costs of their purchases. Consequently, innovation in transportation generates a double stimulus for trade that can be the basis for an explosive demand for a new transportation service.

Hybrid aircraft and hybrid helicraft have the potential to open up vast expanses of Canada that have neither roads, nor railways. Year round transport of heavy freight is a completely new capability that could stimulate many new natural resource investments and expand the scope for economic development in the North. As larger airships become available, total freight costs could be similar to trucking. At this point, the entire mineral, forestry and energy wealth of Canada will be economic to develop.

Statistical analysis is unavailable to forecast potential market demand for hybrid aircraft and helicraft in Canada. Only qualitative methods can be used. The qualitative forecast presented here is based on the authors' study of applications for airship transport in the North, and three successful *Airships to the Arctic* conferences that have been held since 2002. The division of the markets between hybrid aircraft and hybrid helicraft is artificial. Undoubtedly, both vehicles could find markets in many areas. Moreover, the hybrid aircraft could perform both functions if built with sufficient vertical thrust. In all

likelihood, more specialized vehicles will develop, but a general use hybrid should not be automatically ruled out.

Aircraft size has a bearing on the scope of applications. Smaller hybrids will be most economic in short haul markets, under say 500 miles. Canada has enough markets for small hybrid aircraft and helicraft to establish this industry. Once a foothold is gained, larger vehicles become inevitable. This forecast estimates the low demand in the Canadian market at 285 FEA. Even if this is too optimistic by a factor of three, the market is still sufficient to justify investment in hybrid aircraft and helicraft development. In the authors' opinion, this low demand is more akin to the early estimates of the computer industry: "I think there is a world market for about four or five electronic computers." -- *Thomas Watson, IBM, 1943*[iv]

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[i] It should be noted that this does not reflect the range of hybrid aircraft that could be four or five times longer. The problem is economic. Hybrids are faster than airships, but still are relatively slow compared to their capital cost. In order to generate enough paying round-trips, short haul missions will dominate the small hybrid aircraft market.

[ii] No air buoyancy vehicle could be used for direct attack on a fire. The heated air would remove the support for the vehicle and cause it to descend rapidly into the fire.

[iii] The largest indivisible piece would be less than the 25 tonne threshold envisioned for the hybrid helicraft.

[iv] Famous quotes (as collected by Steve Plimpton) http://www.swcp.com/~mccurley/humor/quotes.html