Transport Airships for Northern Logistics: Technology for the 21st Century

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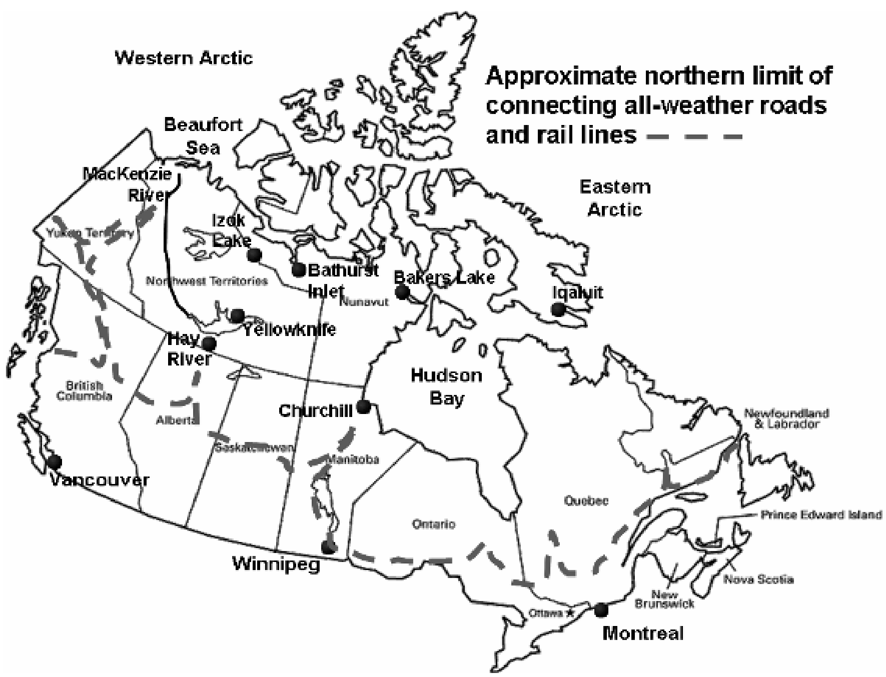
Introduction

Northern Canada has an abundance of natural resources that could meet world demands for metals and energy. The primary challenge is the cost of extraction. If a development frontier can be defined as an area without railway or road access, 70 percent of Canada's landmass and much of Alaska would be classed as disconnected from the modern North American economy. This access denied territory is where an emerging generation of transport airships could fill gaps in the existing transportation networks.

The northern frontier is characterized by vast distances, thin markets and harsh weather conditions. The map below denotes the northern extent of road and rail infrastructure in Canada. The land area north of the all-weather roads and rail lines encompasses approximately 4 million square miles.

Sparse traffic density, few back-haul opportunities, seasonal shutdowns and unreliable transportation services lead to expensive logistics. The price of virtually everything in remote communities is two and a half to three times more expensive than in Southern Canada. These are the characteristics of under-developed hinterland that impede private investment and job creation.



The solution for the future of northern transportation could lie in an older technology that is gaining renewed interest. Eighty years ago, large passenger airships were able to carry 70 tons at 80 miles per hour, and cross the Atlantic Ocean on regularly scheduled flights. Investment in airships was curtailed by the rapid development of airplane technology during World War 2 and the subsequent Cold War. Transport airships could have been built anytime during the past 50 years but oil was cheap, everyone wanted to go fast and airplanes had a solid safety record. There was simply no demand for any airships, except for a few advertising blimps.

Canada is not the only country considering the use of transport airships. Interest in airship technology for freight transportation use has three drivers: fuel prices, environmental concerns, the need to serve locations without established infrastructure and technological advances. Modern transport airships are under various stages of development in Europe, South America, North America and Russia.

This submission sets out the economic opportunity for a new generation of transport airships for Arctic logistics. Its purpose is to point out the policy barriers that impede transport airship development. The paper begins with an overview of the logistical options available in the North and the roles that transport airships could play. Next, the supply of airships is considered with respect to the product life-cycle theory and the observation of tipping points. Four distinct periods of development are examined. The penultimate section identifies weaknesses in infrastructure and regulations, and the need for institution building to encourage airship development in Canada.

Overview of Traditional Northern Logistics

The means of Arctic freight transportation are saltwater ships, barges, airplanes, helicopters, all-weather roads, cat-trains and ice road trucks. Each mode of transport is described briefly with some thoughts on how airships could be used to support or replace them.

Marine Transport

Sealift is the least expensive form of transport available to communities with seasonal access to open water. Ships and ocean going barges are capable of delivering 5,000 to 25,000 tonnes of fuel and other cargo[1] out of Montreal and Churchill to serve the eastern Arctic. The western Arctic can be served by fuel tankers from overseas and 12,000-tonne ocean barges out of Vancouver or Prince Rupert, BC that can connect to smaller barges in Tuktoyaktuk, North West Territories (NWT).

Saltwater transport permits two or three deliveries per year. Seasonal service means that if cargo misses the sailing date, a construction project or other development can be held up for a full year, or forced to use much more expensive air transport. Lack of investment in port infrastructure adds to the problem. Where the ports lack docking facilities, ships lower lighters[2] over the side to take goods to the shore. Lost utilization due to long dwell times adds to the cost of marine service.

It is generally the case that intermodal combinations are more economic than a single mode of transport. Adaman et al (2015) determine that an airship in combination with marine is the least expensive method of delivering food and household supplies to southern Nunavut. It could also be more efficient in northern Nunavut to combine airships and marine transport. If port facilities were developed at, say Iqaluit, all goods could unloaded efficiently and delivered by airships to the smaller communities, or ones that are frozen-in some years. Faster unloading of the ships

[1] Goods destined for Iqaluit and other Nunavut and Nunavik communities are assembled in warehouses at Montreal during the spring, then shipped on the Umiavut, Anna Desgagnes, Arctic Viking, Lady Franklin and Aivik. The first ships arrive in Nunavut about mid-July, with another in mid-August and the last trip in late September.

[2] Usually, the lighters are barges.

could enable them to complete an additional voyage each year, or be redeployed for other commercial operations.

Communities located on the coasts of Hudson Bay, the western Arctic and the Mackenzie River valley can take advantage of barge shipment. Barge service is more frequent, but can be more expensive than ships because of the extra handling and smaller shipment size. Communities on Hudson Bay are served with barges that connect with the railhead at Churchill, Manitoba.

The western and central Arctic communities are served out of Hay River, NWT that is located on the south side of Great Slave Lake. An all-weather road and rail line connect Hay River to Alberta and southern Canada. Barge cargo is trans-loaded at Hay River and taken north down the Mackenzie River. These barges serve oil and gas development and communities along the Mackenzie River valley and the Arctic coast.

Mackenzie River barges suffer a lack of feeder traffic for the backhaul to Hay River. Resource development along the Mackenzie River is sparse and roads are few. Transport airships could provide feeder services to the barges. They could lift pipe, equipment, fuel and supplies from the barges to extraction sites, and haul mineral concentrates from base metals/rare earth mines back to the barges. Transport airships would complement barge transport in the Mackenzie delta and Beaufort Sea, and make the existing service more economically viable.

All-weather Roads

The construction of all-weather gravel roads is prohibitively expensive in areas of muskeg, permafrost and many water crossings. Two on-going road developments in the North are the 100-km road from Inuvik to Tuktoyaktuk that is expected to be completed in 2017, and an 872-km road network on the east side of Lake Manitoba that is expected to take 30 years at the current rate of funding. On average these roads cost about $ 3 million per km depending on the number of bridges required, rock outcrops to blast and swamps to fill in. At $3 million per km, the frontier region is unlikely to receive much all-weather road infrastructure anytime soon. It would cost $15 billion just to convert the 5,000 km ice-road networks of Ontario and Manitoba into one lane gravel roads[3]. Compared to the cost of converting ice roads to gravel, airships would be an inexpensive means to expand service to remote communities and resource developments.

Annual road maintenance and snow clearing would cost millions more; especially as climate change progresses. Soil conditions are a critical factor. About 40 percent of Canada's geography has one of four types of permafrost. From south to north, permafrost is classified as isolated, sporadic, discontinuous and continuous. Roads built on all but continuous permafrost are threatened. Sections of paved roads have had to be abandoned because of thawing permafrost causing soil slump and/or bank erosion.

The utilization of the road infrastructure is another important consideration. Prentice, et al. (2013) conclude that transport airships are more economic than all-weather roads, the lower the traffic volume, the longer the distances and the shorter the road's useful life (in the case of a mine). For the cost of building about 300 km of gravel roads, a transport airship industry could be established that would serve the entire north of Canada.

[3] If stretched out and linked together, this would be the equivalent of building a gravel road from Montreal to Vancouver.

Ice Roads

Cat-trains and tractor-trailers operate on temporary roads that are built over frozen lakes and cleared bush. Typically, it costs $3,500 to $6,000 per km to build an ice road over proven routes that do not require clearing. Pioneering a new route is much more expensive and requires a land use permit. In general, ice road construction costs increase with distance and the proportion of the ice road that is routed over land (Johnson, 2008).

Added to the annual cost of building and maintaining the ice roads, truck shipments are 65 to 70 percent more expensive than the equivalent truck transport over all-weather roads[4]. Trucks have to travel more slowly crossing frozen lakes, suffer greater damage to suspension and tires on the land portions, experience longer delays and face more risk associated with pressure ridges and thin ice.

Ice roads usually open in January and close in March. The length of the ice road season depends on location and weather. Prior to the mid-1990s, ice roads east of Lake Winnipeg were able to operate 50 to 60 days every year. In the years since 1996, barely 30 days of operation has been possible. In a severe year, like the El Niño of 1998, ice roads can fail completely and air transport is the only option[5].

An El Niño year in 2006 caused the premature closing of the ice road serving the diamond mines out of Yellowknife, NWT. Out of the 10,000 truckloads planned to move over the ice road that winter, approximately 3,500 truckloads of fuel and materials were undelivered when it closed. The expense to fly in fuel and supplies added $100 million to cost of the mines' operations.

The ice roads problem extends across all of northern Canada and into Alaska even where all-weather roads are available. At major rivers, like those on the Dempster Highway on the route to Inuvik, NWT 6-week gaps occur during the spring break up and the fall freeze up. Trucks have no ferry service and it is unsafe to cross on the ice road. As the climate becomes milder, the transition periods can be expected to grow.

Warming temperatures are a mixed blessing for transportation. Greater melting of the Polar Cap is extending the marine shipping season, but has also increased the active layer above the permafrost. Damage to existing roads, landing strips and other infrastructure is a growing concern. As the winters warm, the ice roads are also becoming less reliable. The end of the economic use of ice roads is already visible in the central provinces[6].

Air Transport

Air transport is the only year-round transportation service in the northern frontier. However, airplanes and helicopters are expensive and shipments can be limited by cargo size and dimensions. Air freight rates in the north and the airstrip requirements are presented in Table 1 for a comparable 300 km airplane flight. Assuming full loads, the larger the aircraft the lower the unit costs of air shipment. The disadvantage of airplane size is the greater cost of providing

[4] Personal communication, Big Freight Systems, Inc. This freight rate differential applies to Manitoba. Further north, in the Territories, the costs are likely to be higher

[5] In 1998, the Government of Canada had to spend an additional $12 million to fly in fuel and supplies to First Nations communities in Manitoba.

[6] Manitoba, Ontario and Quebec.

longer and better quality landing strips. Only specially kitted jet aircraft can operate from gravel runways[7]. In the spring gravel landing strips may be too soft to permit safe use.

Table 1 Aircraft Cost Comparison for a 300 km Flight

Aircraft Type	Cargo (kg)	Cost ($/km)	Cost ($/kg)	Airstrip (m)
Twin Otter	955	$6.50	$4.09	310
DC3	2500	$10.60	$2.46	925
Curtis C-46	6800	$17.95	$1.58	1075
DHC Buffalo	7500	$17.00	$1.37	925
Boeing 737C	13500	$20.99	$0.97	1700
Hercules	20000	$35.78	$1.12	1700

Sources: (Petrie; Johnson, 2008)

In addition to the high freight rates, smaller airplanes are restricted by cargo weight and dimensions. Airplanes can easily "cube-out" before they "weigh-out" if the cargo is low density, e.g. bread, corn flakes, diapers, paper towels, etc. Adaman (2013) determined that transport airships could reduce the transportation costs of food and general merchandise to remote communities by one-third.

Cargo size is also a problem. Indivisible freight can only be shipped if it can fit through the airplane's cargo door. Airships would be able to complement existing airplane fleets for the movement of oversized cargo or oddly shaped pieces.

One of the diamond mining companies affected by the 2006 El Niño had an 80 tonne piece of equipment that had to be delivered in order to continue the operations of the mine. Premature closure of the ice road stranded this critical piece of mining equipment 400 kilometers from the site in Yellowknife, NWT. Airborne Energy Solutions brought the Russian made *MI-26* helicopter to Yellowknife to carry this equipment to the mine.

The mining equipment had to be cut into four 20-tonne pieces to be ferried in by the MI-26. The total costs of the move are unavailable but the helicopter's fuel consumption is 3,000 liters of fuel per hour, and several stops were made along the way for refueling. The MI-26 charges out at more than C$20,000 an hour (Siku News, 2006).

<u>Summary</u>

Arctic logistics is a case of doing the best we can with what we have (Prentice and Russell, 2009). Whether it is effective is another matter. By any measure, consistent delivery success is limited and transport cost is expensive. Greater financial and human risks are taken than would be considered in the developed parts of Canada. Indirect costs are also high because of the need to store large quantities of goods for a whole season, requiring larger warehouses and bigger fuel storage tanks. Finally, the opportunity costs are immense. Resource development opportunities

[7] The Boeing 737-200 can be gravel kitted, but not the new versions of this aircraft.

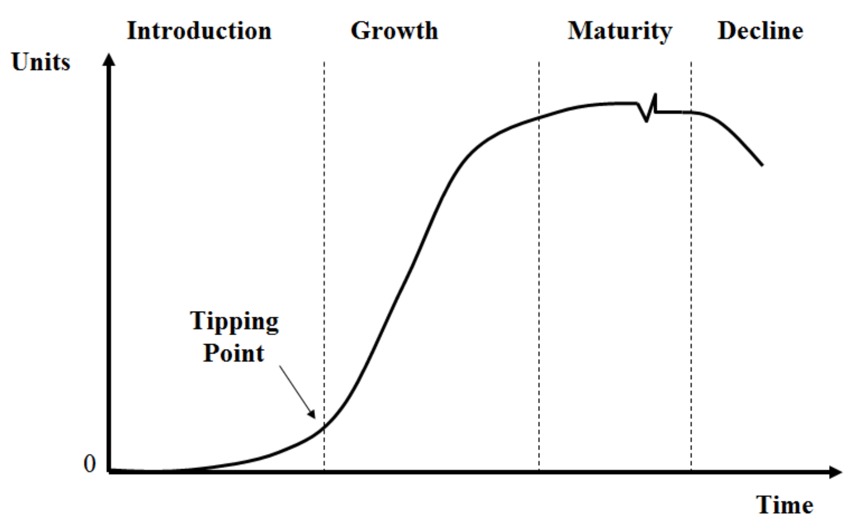
languish for decades in the Arctic, assets are stranded for long periods and local people suffer chronic illnesses because of unbalanced diets and substandard shelter.

A new generation of transport airships would have a revolutionary impact on the northern economy. Transportation and logistics costs would fall, and problems of environmental regulations and aboriginal land ownership would greatly diminish. The airship may be the only means of transport that can adapt to the negative consequences of climate change on northern transportation. The question is no longer whether transport airships will be used, only when. This is the topic of the next section.

Technological Advance and Tipping Pointes

The concept of a tipping point is derived from the biological sciences, but it also applies to many economic phenomena. The success of new innovation is said to be ensured after it passes a tipping point. This can be observed in the product life cycle that is illustrated in Figure 1. The tipping point occurs at the border of the introduction and growth phases.

Figure 1 Theoretical Product Life-Cycle



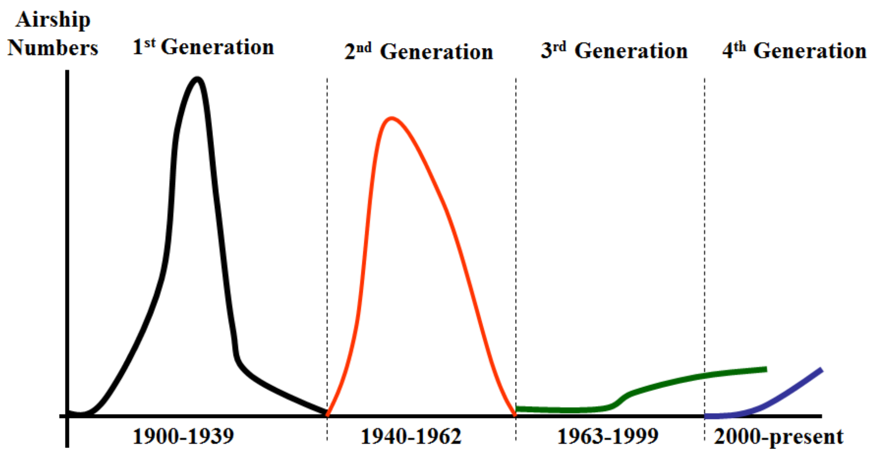
During the introductory stage, few units of the new innovation are produced. As technological barriers are overcome, markets may develop. Most new ideas die before the product ever reaches this stage. If the tipping point is passed however, the industry then enters a period of sustained, rapid sales growth. Sales finally level off as the technology matures. Subsequently, the sales growth is similar to the growth rate of general economy. The maturity period can be quite extended. Eventually the technology enters a period of decline, or re-invents itself and returns to a growth path and extended maturity[8].

It is arguable whether airship technology has ever reached a tipping point. An approximate histogram of the airship industry since 1900 is presented in Figure 2. The histogram divides the

[8] The railways were in a period of decline from the 1950s through to the 1980s. The advent of double-stacked container trains permitted the railways to re-invent themselves and return to a growth path, that still continues.

development of airships into four generations of technology. A brief description of the accomplishments in each period is discussed together with the reasons for its decline.

Figure 2 Development of Airship Product Life-cycle 1900-present



<u>1900 – 1939</u>

In the early decades of the 20th century giant airships were built in Britain, France, Italy, Germany, Russia and the United States. The majority of these airships were built for military purposes, but in Britain and Germany airships were also built for civilian use. In 1910 the giant Zeppelins entered regular civilian passenger service (Delag) in Germany. During the First World War (WW1), the Zeppelins were also used extensively, although not very effectively, to bomb England.

Airship developers established a number of world records. In 1919, a British airship (*R34*) was the first aircraft to cross the Atlantic Ocean in both directions. An Italian airship (*Norge*) was the first aircraft to cross the North Pole in 1926. The German LZ127 (*Graf Zeppelin*) became the first aircraft to circumnavigate the world in 1929.

The greater development of German airship technology during WW1 enabled the Zeppelin Company to build durable airships that could enter trans-Atlantic passenger services in 1928. This era proved that dirigibles could operate scheduled passenger services, providing 65 to 80 tons of useful lift and be safely moored and hangared.

During the first 40 years of airship development, virtually all airships were filled with hydrogen. The U.S. banned hydrogen after the *Roma* accident in 1922.[9] This was a painless change for the U.S. because they had a near monopoly on world helium supplies. Of course, helium did not prevent the accidents of the *Shenandoah*, *Akron* or *Macon* (all U.S. Navy airships). These airships were lost due to structural failures during storms.[10]

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[9] According to the National Museum of the US Airforce, the accident occurred because of a structural failure. New Liberty engines were being tested that proved to be too powerful. The control box at the rear of the airship broke. The *Roma* was forced the downward, the nose buckled, the disabled airship hit some high-voltage wires. The airship burned and thirty-four men died in the crash." http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=747

[10] It is worth noting that weather forecasting in this era was very imperfect, and that the strain gauge that could enable engineers to identify stress concentrations was not invented until after 1938.

Rigid airships were covered with painted canvas that served only to streamline the exterior and offer some protection from rain. The canvas deteriorated within four years of exposure to ultraviolet light and proved to be very flammable. Although airship technology appeared ready to expand rapidly before the *Hindenburg* accident (1937), the Second World War (WW2) prevented the industry from reaching a tipping point. The outbreak of WW2 ended further development of rigid airships because the rapid advance of fixed-wing aircraft replaced their need in of the passenger market.

<u>1940 – 1962</u>

The war effort from 1939 to 1945, and subsequent Cold War, focused investment mostly on fixed-wing aircraft technology. The combined combatants of WW2 built a total of 500,000 airplanes and advanced the technology to high altitude heavy bombers and jet engines. All these technological advances were quickly applied to civilian aircraft planes after the war. With the ability to offer faster, safer and less expensive passenger services, the airlines experienced accelerated growth for the next 30 years.

The achievements of airship technology during WW2 are less known, but this conflict also introduced a new generation of non-rigid airship designs, or Navy K-ships as they are often called. The largest US Navy blimps (N-class) could lift about 10 tons of crew, supplies, accommodations, fuel and water. They were used to spot submarines along the coast and escort convoys on the North Atlantic.

The Navy blimps proved the reliability of large non-rigid structures, safety and endurance. They withstood hurricanes and winter weather on the north seas. Endurance records set during this period still stand.

The rubberized envelopes of the Navy blimps were made of multi-ply cotton-neoprene fabric and painted to reduce permeability. They were robust and provided structural support, but were high maintenance. Damage to the envelopes occurred from stretching, flexing, scraping, scrubbing and unintended contact with hard surfaces. In service, all envelopes required overhaul and repair every two years[11].

The end for the Navy blimp program came with the introduction of nuclear submarines. Although the blimp crews had been very successful in spotting diesel-electric submarines, the nuclear submarine's lack of bubble trace made them invisible. Some efforts were made to use the blimps as floating radar platforms, but in 1962, the last two blimps were retired.

<u>1963 – 1999</u>

When the US Navy terminated airship operations in 1962, the world supply of airships shrank to three small advertising blimps operated by Goodyear. This changed in the mid-1970s when the dramatic rise in oil prices re-awakened interest in lighter-than-air technology.

Although the period of high oil prices ended before commercial airship developments could hit a tipping point, a number of technological changes were introduced – especially in materials. During the 1980s new composite envelope materials were developed that could last over 15 years in direct sunshine.

[11] The authors acknowledge helpful information on the US Navy Blimps from Albert Robbins and Richard Van Treuren.

Gases pass through membranes in both directions; the rate increases with increasing pressure differential. The Navy blimps lost 100 percent of their helium each year in part because they had to maintain relatively high pressures. With less permeable materials and lower pressures, the advertising blimps lose only 10 percent of the helium annually. The other significant advances in the third generation airships were FAA air worthiness certification, fly-by-light avionics and vectoring engines.

Despite the many technical advances, advertising blimps still need a crew of 12 or more holding ropes for ground-handling. The large labour requirement makes these airships costly to operate and limits their size. But the main economic problems for the advertising blimps are security worries (terrorism) that restrict operations at sporting activities and the change in advertising strategies. Like the newspapers, the demand for aerial advertising had been replaced by the Internet.

<u>2000 – Present</u>

A fourth generation of airships is characterized by their ability to land and take off without a ground crew of rope-holders. On the 100th anniversary of the first Zeppelin flight, the ZF Company introduced the Zeppelin NT. Technically the *NT07* is a semi-rigid airship, rather than a blimp. An internal frame carries half the stresses, while the pressurized envelope carries the remaining loads. The *NT07* can land and takeoff unassisted. Two side propellers swivel 120 degrees to push the airship up or down for landing. A third aft engine drives a pusher propeller that can rotate down 90 degrees to assist with takeoffs and slow speed control[12].

Seven Zeppelin *NT07*s have been constructed since 2000, but the tipping point for commercial success is not evident. High capital and operating costs to provide a relatively small passenger load (12 people) limits their market appeal. Nonetheless, the Goodyear Company has retired its fleet of blimps and purchased three Zeppelins to replace them. Incremental improvements and refinements can be expected as this model evolves, but the ZF Company has announced no plans for any cargo version.

One hundred years of technological advance has created the knowledge base and materials to build large, robust airships that could deliver cargo to the most inhospitable corners of the earth. At the current time, 10 teams are working in 6 different countries with airships at various stages of design and testing. More airship designs exist on the drawing boards and await only sufficient investment to explore their ideas. The race is on to establish the dominant design for a transport airship.

The current transport airship designs include a broad spectrum of innovations in ballasting, structure and shape Prentice and Knotts (2014). Rigid, semi-rigid and non-rigid transport airships are being proposed and tested. Figure 3 presents the range of international competition. Pictures of the various transport airships are presented in Figure 4.

[12] A second side propeller on the aft assembly revolves in a neutral pitch during flight, but can act as a helicopter tail rotor in takeoff and landing situations and in hover mode. All this is controlled by computers that connected to the pilot's side stick.

The catamaran shapes are being proposed by Lockheed-Martin, HAV, Aeros and AeroVehicles. These are hybrid designs are non-rigid and about 20 to 40 percent heavier than air. They obtain extra lift with their aerodynamic hull shape and engine thrust. When on the ground the catamaran airships move around on modified hovercraft pads. These pads are designed to operate as "suction cups" to hold the airship in position for loading and unloading. The advantage of this design is their ability to unload cargo and return empty. The disadvantage is the higher fuel burn required to carry the same payload as a traditional cigar-shaped airship.

Figure 3 Current Status of Transport Airship Development Worldwide

Location and Company	Structure	Shape	Status	Payload
U.S.: Lockheed-Martin	non-rigid	catamaran	scaled prototype	21 T
Aeros	rigid	catamaran	scaled prototype	66 T
Ohio Airships	semi-rigid	cigar	scaled prototype	TBD
Brazil: Airship do Brasil	semi-rigid	cigar	engineered design	30 T
Arg.: AeroVehicles Inc.	semi-rigid	catamaran	concept design	20-40 T
U.K.: HAV	non-rigid	catamaran	scaled prototype	10-50 T
Varialifter	rigid	cigar	concept design	50-250 T
Canada: LTA Aerostructures	rigid	round top	concept design	10-70 T
BASI	rigid	cigar	concept design	10 T
Russia: RosAeroSystems	rigid	round top	engineered design	16-60 T

The cigar shape is a traditional design, and it can be rigid or semi-rigid. Typically, these airships are lighter-than-air and use a system of ballast control to adjust for weight changes in loading and unloading. Airship do Brazil, Varialifter and BASI are examples of the cigar-shape design. The Ohio airship is an exception. It is cigar-shaped but has wings, and is heavier than air.

The round-top design is a compromise between the cigar and catamaran shapes. They can take advantage of their more aerodynamic shape, but usually rely on the lifting gas to carry the loads. These airships have rigid outer shells and internal gas cells to hold the lifting gas.

The majority of the current transport airships are being designed to start out with a 10 to 20 tonne payload size. Inevitably, this will get much bigger because of the economies of size inherent in airships, and the need for larger airships in order to travel longer distances economically.

Figure 4 Designs of Rigid, Semi-rigid and Non-rigid Transport Airships

Only a few transport airships are at the stage of physical construction. Scaled prototypes have been built and flown, but the only full-scale vehicle is the HAV AirLander which is scheduled to fly in the summer of 2016[13]. Most concept designs are at the stage where a prototype could be flown within two years, while the engineered designs could be flown in one year if finance were available. Certification is likely to take one or two years beyond this, but HAV and Lockheed-Martin are well advanced on the certification of their crafts.

Policy Perspective

Transportation infrastructure underpins the economic and social development of a modern economy in southern Canada. In northern areas of Canada transportation challenges discourage investment in resource industries, limit employment prospects, and increase the cost of living. Moreover, the socio-economic conditions in Canada's remote First Nations communities are deplorable. While some communities are better off than others, 60-80 percent unemployment, food prices two to three times higher than urban centres, high incidence of diabetes, boiled water restrictions and lack of indoor plumbing are commonly found. High food prices have given rise to citizen activism (Strapagiel, 2012) and concerns about food security have been the subject of in-depth analysis (Council of Canadian Academies, 2014).

Few transportation options exist because of cost, distance and demand. The North is served best by air transport, but the increasing cost of aviation is causing spiraling increases in food and fuel prices in northern communities and resource extraction sites. Land transportation is limited in many places to ice roads that are becoming increasingly vulnerable to climate change. Governments have neither the financial capacity, nor the political will, to undertake the expense of road infrastructure in northern Canada. A new approach is needed to northern logistics.

Aside from economic and social policy, Canada has another pressing need for better transportation in the North – sovereignty and defence of the realm. Climate change is opening up the Arctic to navigation, while the actions of other nations are giving cause to reconsider the control Canada exerts in its northern landmass. The Canadian military has already identified the logistical problems they face in the Arctic and prepared a concept paper that considers the potential for transport airships (RCAF, 2014)

The Arctic frontier has much to gain from airship development, but the impediments to transport airship use in Canada are significant. The remainder of this paper is devoted to the three important barriers to the development of an airship industry in Canada: 1) an inadequate regulatory framework, 2) the absence of airship hangars (airdocks) to build and maintain airships in Canada and 3) the lack of institutions to provide the knowledge and management of airship services.

An inadequate regulatory framework contributes to the lack of business confidence in the development of transport airships. At this time, the Canadian Air Regulations (CARs) is confused on the issue of airship pilot licencing[14]. The CARs requires an airship pilot to hold a

[13] This was formerly the U.S. Army LEMV airship that was built too late for deployment in the Afghanistan war. It is now being retrofitted and certified as a transport airship.

[14] Airship – is defined under subsection 101.01 of the CARs. The CARs state that an airship type rating is endorsed on the balloon pilot licence. Under section 541.3, definitions are provided for a captive-gas airship (an airship that

hot air balloon licence, but is vague or silent on how a rating is obtained on a captive gas airship. Regardless, a hot air balloon licence inappropriate for airships and unsafe. Hot air balloons have no route planning, engines, control systems, landing gear, seat belts, pressure gauges or ballast systems. In short, a hot air balloonist is completely unqualified to pilot a modern captive gas airship.

Canada is out of step with the U.S., EU and Australian regulations that give pilots an airship rating on a fixed-wing pilot licence. Similarly, Canada has no Aircraft Mechanical Engineers (AME) that hold the qualifications to provide an annual inspection. While these changes could be made fairly quickly, Transport Canada has known of these problems for over four years without any indication of interest in updating the CARs.

Another regulatory problem area is the Canadian ban on the use of hydrogen gas in airships[15]. This prohibition was initiated in the U.S. following the *Roma* accident in 1922 without any scientific basis or justification. Subsequently, the U.S. FAA regulation was adopted into the CARs and most other air regulations around the world. Given that Canada has no helium supplies, and that hydrogen gas is allowed as fuel in buses, forklifts and cars, the continuation of this ban is irrational. In fact, hydrogen could be used as a fuel for an airship (the CARs is silent on this), but not for lift. Either a material is used safely or it is not. Clearly, hydrogen requires proper procedures and engineering, but a blanket prohibition for one specific use of hydrogen gas is unreasonable, and should be negated.

Unlike most sectors of the economy, transportation is a partnership between the public and private sectors. In general, the private sector provides the mobile, short-lived assets, such as trucks, ships and airplanes. The public sector provides the long-lived, multi-user, fixed cost infrastructure like roads, airports and harbours. In the case of airships, the critical public infrastructure is airship hangars (airdocks). Not to be confused with airplane hangars, airdocks operate more like drydocks. An airship only requires access to an airdock for 10 to 14 days per year. The main need is for annual inspections and major overhauls. Otherwise the airship operates like ocean-shipping, moving from port to port.

There are about 10 airdocks in the world. Most were built by the U.S. military or as public works.[16] Without airdocks an airship industry cannot function in Canada.

While it is possible for private companies to build their own airdocks, it is in the public interest to encourage competition by providing common use infrastructure. Any firm that owns an airdock would have immense market power. An airship monopoly could slow innovation and restrict the service offerings that would be enhanced by competition. Ultimately, the government faces a choice between encouraging competition or regulating a monopoly. Clearly, the best way forward is a network of public airdocks that could stimulate multiple transport airship suppliers to enter the industry[17].

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derives its lift from a captive lighter-than-air gas) and a hot-air airship (an airship that derives its lift from heated air). But, under CARs 421.25 the pilot requirements for either type of airship are silent.

[15] “Hydrogen is not an acceptable lifting gas for use in airships.” CARs Part V - Airworthiness Manual Chapter 541 – Airships - 541.7 Lifting Gas

[16] The exceptions are the Goodyear airdock (1929) and the CargoLifter airdock (1999) that were constructed by the companies for airship fabrication.

[17] It would not be a precedent to operated publically-owned airdocks. Historically, the Government of Canada operated public drydocks for the marine industry.

Creating a transport airship industry in Canada can be done with either organic growth of Canadian industry, or the importation of airships designed and built elsewhere. Regardless, the government has an institution building role that is important to its success. Canada relies on colleges and universities to provide technical experts and managers. Internationally only five universities have undergraduate engineering programs in airship technology and none of these are Canadian. Commercial airships also need qualified AMEs and pilots. Efforts must be made to expand the curriculum at colleges and flight schools to include airships.

Risk sharing is another role for government in the development of new industries. Whether this is done through pilot projects, research contributions or other means, government has a role in initiating new transportation networks. The transcontinental railways would never have been constructed if government had simply waited on the sidelines and hoped for private investors to bear the full burden of their development. Northern Canada needs a proactive effort of a similar kind to bring forward transportation services that end its remoteness. A first step in this direction could be a white paper directed to the establishment of a policy statement on the public interest in transport airships for Canada.

Conclusion

The aerospace industry in Canada is well established. The new generation of transport airships can be built in these recognized centres. The actual size of airship manufacture and operations in Canada make it an appealing industry to encourage for its own sake, but the payoff to northern development will be nothing less than revolutionary.

Governments are responsible for creating a business environment that is conducive to technological developments and emergent industries. In the case of transportation, this role requires a more proactive policy because governments are not just passive regulators; they are also directly involved in providing infrastructure and ensuring national security.

For too long people in northern Canada have had to make the best of whatever transport they could with limited infrastructure and a sparse population. This is no longer necessary. Sufficient demand exists in northern Canada to produce transport airships and no technological barriers remain. Transport airships present an opportunity to open up the North in the 21st century, like the railways opened up the west in the 20th century. The commercial tipping point is in sight, it just needs a final push to make it happen.

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