AN X-PRIZE FOR TRANSPORT AIRSHIPS

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Introduction

What if it were possible to pick up almost anything and transport it almost anywhere? What if goods could be flown over land or sea at the lowest energy costs and the least environmental impact? How would that change the world? Domestic and international commerce would no longer be constrained by geography or ground transport infrastructures. The impoverished and land locked regions of the world could be directly linked with the most advanced economies. Conventional transportation infrastructures could be supplemented or even by passed in favor of this new transportation system.

The Problem

The pace of the global economy requires fast, low-cost, reliable, point-to-point transports. The FAA estimates that the demand for US domestic airfreight will increase by at least 3% every year for the next ten years, and international demand will increase at twice that rate. Existing transportation systems face growing congestion. The scope for additional fixed-wing air traffic is constrained by cost and infrastructure. Capacity can be added by building new airports, but it is very expensive, and can take many years to complete.[2] Moreover, air transport is responsible for high elevation Greenhouse Gas (GHG) emissions that are more damaging[3], and has difficulty shifting to alternative fuels (Wentz, Myose and Mohamed, 2005). In short, air

transport has immense challenges to meet the increasing requirements of a growing society.

About once every 40 years since the Industrial Revolution, a new innovation in transportation technology has emerged to change the world economy. Steam ships and railways characterized the 19th Century; trucks, airplanes and intermodal containers characterized the 20th Century. The most promising technological advance for the 21st Century is a new generation of transport airships. The challenge for airship builders is no longer technical. The materials exist to construct reliable, robust airships. New aero-engineering designs and advanced weather forecasting models are able to eliminate earlier safety concerns. Vectorable engines and computer avionics are available to provide superior control of large airships. The principal hurtle today is the lack of business confidence and policy direction to support investment in a technology that outmoded thinking holds as being dangerous and uneconomic.

Shippers are eager to explore the utility of heavy lift airships, however, they are reluctant to commit the initial development funds needed to construct operational prototypes for test and evaluation. A conclusive demonstration is necessary to prove that a practical heavy lift airship vehicle can be constructed and operated.

The purpose of this paper is to set out the case for a challenge to stimulate the development of a transport airship capable of year round operations. An X-prize competition could energize the LTA community and the potential lead users to work together to bring this most unique and useful transportation system into being. The discussion begins with a review of the literature and a brief market assessment. This is followed by a note on the technology and a proposed criterion for an airship X-prize.

Literature Review

Congestion in built up areas and the demand for transport in remote areas has encouraged innovative planners to look for alternatives to

the existing legacy transportation systems. This has stimulated a resurgence of market interest in the potential value of lighter-than-air (LTA) vehicles for transport. Several investigations have been conducted on the potential offered by the airship.

In 2004 SAIC was contracted to conduct a “Transport Airship” study for the US Center for Army Analysis (CAA). The study created an analytical baseline of airship and hybrid air vehicle performance based on a synthesis of previous airship studies as well as new analysis. The most logical combinations of key performance factors, and effects of performance trade-offs were examined. The necessary R&D investments were identified and prioritized, and a recommended path for developing the most practical airship types was provided. This extensive analysis provided the U.S. DoD with a rigorous and in-depth assessment of the value transport airships could provide for the movement of resources into infrastructure poor regions.

In 2005 SAIC concluded studies on heavy lift airship technologies for two major petroleum companies. These studies were in response to interest in heavy lift airships for use in the construction of oil and gas pipelines in remote regions. Subsequent to these studies airships were endorsed by the International Pipeline & Offshore Pipeline Contractor and Construction Association (IPLOCA).

> IPLOCA is cooperating with BP and other oil companies on Research and Development projects aimed at reducing the cost of implementing major gas pipeline projects in remote regions of the world. This will not be achieved by reducing contractors' margins! On the contrary, the development of new techniques will make some of these major schemes economically viable, and therefore more work will be generated for our members! One of these R&D projects has the objective of facilitating the creation of a capability to address logistics problems by the use of Airship Technology. (IPLOCA, 2005)

IPLOCA is currently planning a workshop that will consider the technical requirements of a heavy lift airship suitable for the transport of pipe and supplies for pipeline construction projects to further pursue the application of airships in remote regions.

The University of Manitoba Transport Institute has held three *Airships to the Arctic* conferences. These international meetings have been well attended by high level representatives from resource extraction companies, airship developers and the Canadian government[4]. Following these conferences, a market forecast for transport airships in Canada was developed by Prentice (2006). The demand for cargo airships in Canada alone could range between 185 and 635 fifty-tonne equivalent units by 2015.

The Dutch also have a particular interest in Transport Airships and have conducted several studies. In 2002 a report was published on the "Sustainable Airship"[5]. The abstract reads in part:

> "The project examines the possible markets of the airships that are in operation now or will be in operation within 5 to 10 years. In particular, the project has to find out to which degree energy use and pollution will be decreased when current modes on promising markets are replaced by airships. …

> Markets where the airship is cleaner than the alternatives are the relevant markets where the airships can contribute to decrease pollution."

In addition to air pollution, the Dutch have to be concerned about the consequences of climate change that might raise the level of the oceans. As the Europeans take a harder look at the environment and the carbon emissions of fixed-wing aircraft, airships are going to attract more attention.

Also in 2002 the UK Engineering and Physical Science Research Council (EPSRC) published a study titled, "Airships and Sustainable Freight Conveyance"[6]

> "This research investigated the strategic integration of advanced airship technology into the existing freight transport system and the potential contribution such a technology would make to the development of a sustainable aviation industry, with particular focus on the UK."

In Germany, the CargoLifter Company conducted research that indicated a substantial market for movement of "project freight". Out sized and heavy items are not easily moved by conventional means. Subsequent market assessments identified an annual market segment of at least $3 billion that could be served by airships with the capacity to transport 160 metric tons of freight. The market data and expressions of customer interest collected by CargoLifter were sufficient for the company to raise over 325 million Euros for airship development.

Market Definition and Considerations

The demand for transport airships comprises four general market needs:

- Provision of short haul service where transportation infrastructure is congested or has reached maximum capacity;

- Movement of "project freight" as indivisible units (not requiring disassembly and reassembly on site);
- Deliveries where cost favors airship speed, endurance and volumetric capacity; and,
- Transport into and out of remote areas that have poor or non-existent conventional transport infrastructures.

Commercial applications for transport airships are diverse and sufficient to spur further development once the basic technology is proven. Examples are:

- Support to gas & oil exploration, pipeline construction projects and the shipment of natural gas;
- Loading and loading shipping containers at congested ports;
- Transport of large outsized industrial equipment (chillers, power generators, aircraft sections, etc.);
- Forestry operations and log transport;
- Transport of fuel and mining concentrates;
- Short distance movement of equipment and crane operations at construction sites;
- Transport of fresh fruits and vegetables;
- Roadway and bridge construction, building relocation;
- Disaster and famine relief; and,
- Military logistics

Climate Change and Environmental Concerns

The impact of rising ocean levels due to climate change is a grave concern to coastal population centers. The disruption of the world's most important cities and port facilities would cripple the global economy. Climate change could be especially damaging for tropical countries that lack the resources to build replacement transportation infrastructures on higher ground. Transport Airships could provide a critical transportation option for movement of essential goods around coastal regions inundated by rising sea water.

Adaptation to climactic changes will be slow and expensive. The construction of new transportation infrastructures to compensate for the loss of existing facilities may not keep pace with continued demands for freight transport. Northern countries are already experiencing the negative effects of climate change. Ice roads that provide a key means for re-supplying northern settlements are recording shorter operating seasons. Ice roads are later getting started and are finishing earlier each year. Remote communities are being imperiled by the lack of supplies.

Airship technology is one of the rare cases in which both the transportation industry and the environmentalists can agree on the benefits of growth. Airships require less energy and can burn alternative low carbon fuels more easily than fixed-wing aircraft. If Transport Airships replaced cargo airplanes, they would average down the aviation GHG contribution to a more sustainable level.

An optimum transport solution for northern regions is a vehicle that could carry loads greater than a truck, accommodate outsized equipment as easily as bulk commodities and be operated throughout the year at affordable costs. Transport Airships are the only vehicles that have the potential to provide all these capabilities. By building on current engineering experience and applying selected new technologies, modern Transport Airships can be designed to offer the enhanced transport performance and affordability necessary to continue and even expand economic and societal activities in underdeveloped or remote regions.

Transport Airship Capabilities

For the airship, the vehicle is the infrastructure. They are not dependant on vulnerable and expensive road, rail, port or landing infrastructure. They are more fuel efficient than comparable airplanes or helicopters for the same payload weights[7]. The airship easily accommodates the use of alternative fuels such as ethanol, diesel, and hydrogen. More advanced airship designs can also be powered to an extent by solar cells, which airplanes and helicopters cannot.

Transport Airships can operate by picking up freight and materials from distant locations such as railroad sidings, surface roads, open fields, or ship ports, and carrying it directly to another site. Airships do not need an airport in the traditional sense. A Transport Airship can fly at an average speed greater than present ground based transports and be able to do so year round. The Transport Airship has a very small "footprint" on the ground, so damage to terrain or wildlife is virtually eliminated outside the immediate area of the "Load Exchange Zones" (LEZ's), and extremely limited within them.

A Transport Airship can provide cargo service to almost any location less than ~2,000 meters above sea level. Operations at slightly higher altitudes are possible if the airship is specially adapted for those elevations, however most populated areas are located below 2,000 meters.

The ability to conduct a load exchange almost anywhere allows LEZs to be set up on a temporary or seasonal basis, for shipment of local crops, or for other items that need transportation on a less than regular basis. This also provides additional security to the LEZ operation because it can be located and timed to avoid disruption by groups that may wish to oppose or exploit the load exchange operations. This is not something that can be done with conventional, permanent ground transportation infrastructures. The impact of poor weather (or climatic) conditions can also be minimized by timing the load exchange in locations and during times that have more favorable weather.

Applications for Remote Areas

Transport Airships offer a sustainable method of exploitation of mineral and energy resources without the need for initial investments in expensive and vulnerable ground transport systems (roads or rails) to haul in the necessary extraction equipment and support materials. Natural resources that may otherwise be uneconomic to extract due to high transport logistics costs or unacceptable environmental impacts

can be responsibly exploited. Airships also avoid the collateral problem of other parties using roads and rails as conduits to enter the region for nefarious purposes.

For infrastructure poor and remote communities the airship can be utilized in a freight-passenger combination format. An airship could move tourists, resource workers, educators, and medical staff between locations just as a surface ship moves between islands in an archipelago. The Transport Airship can also bring in modular medical clinics, educational facilities, water purification systems, and the fuel necessary to power these facilities.

The transport of pre-fabricated or modular building sections into poor or remote communities is another unique capability of the Transport Airship. The modules or building components can be relocated or replaced by upgraded versions as needed. Commercial buildings would then be thought of as assets that can be permanently invested in but which do not have to be permanently fixed in a specific location because they could be airlifted to a new location if needed.

The airship transportation system is not a permanent installation, but can be retrieved from any particular operation when needed. This is not an option for roads, rail systems, landing strips, or port facilities. This unique ability to move and relocate industrial resources provides a strong incentive to disperse commercial development rather than concentrating operations in overcrowded industrial urban complexes. Higher paid, year round jobs could be brought to people in the remote regions. The quality of life benefits are obvious; and the economic independence is significant.

A Transport Airship offers the promise of bringing developed world resources and employment into remote communities. An airship could bring in the raw materials to a remote factory, and transport back the finished goods produced in the factory. The wages earned in the remote community could be spent on goods and products also brought in by the airship for local sale.

Development Teams

Several large Transport Airships have been built. The Hindenburg is the largest example, but as recently as the late 1990's the CargoLifter Company was formed in Germany to develop a 160 metric ton lift airship for cargo transport. This start-up company employed 400 engineers and consultants at the height of its development. While their principal focus was a Transport Airship, in 2000 they built a 60 meter heavy lift towed cargo balloon (the CL-75) that was designed to lift up to 75 metric tons. They also developed a load exchange system and were able to demonstrate this in field conditions.

The CargoLifter program tapped into the world demand for Transport Airships but was not able to bring a prototype design to the point of construction. The failure of the company was not due to inherent technical limitations but to a cash-flow crisis that forced the company into receivership. The team of experts brought together by CargoLifter has been scattered, but forms a sufficient knowledge base from which more than one new airship development team can be reconstituted.

Airship industrial expertise is spread among a dozen companies located in ten different countries and some independent LTA engineers. One or more airship development teams are needed to bring together the prerequisite LTA and aerospace expertise required for the development of a Transport Airship, and support the ideas described above. Existing aerospace defense firms are not well suited to developing low cost, moderate technology airships of the sort embodied in a Transport Airship concept. In addition to the available LTA skill base there is supportive engineering capacity available in the General Aviation industry. These domestic and international firms are familiar with computer based design techniques and modern composite material construction; many have excess engineering and manufacturing capacity, and extensive experience with certification of commercial aircraft.

Airship Technology

There are three types of airships (non-rigid, semi-rigid, and rigid) and two types of airship classes, (fully buoyant and semi-buoyant also referred to as a "hybrid"). A fully buoyant airship obtains almost all of its lift from the static lift of the LTA gas (usually helium), while the hybrid concept obtains approximately 20 percent to 40 percent of its lift from dynamic means just as airplanes and helicopters do. Lockheed Martin Skunkworks recently built and flew a proof of concept hybrid airship and is investigating the possibility of developing a much larger cargo carrying version (Dornheim, 2006).

One cubic meter of helium lifts approximately one kilogram at sea level. Consequently, an airship needs to be large if it is to have an appreciable payload lift. The great size also produces enormous aerodynamic drag as speed increases. The economic cruising speed of an airship is generally less than 85 mph. At higher speeds, fuel consumption increases exponentially. Airships need only modest propulsion power to lift substantial payloads, because all or most of the lift comes from the LTA gas.

Minimal environmental impact is one of the strongest arguments in favour of airship technology. No independent calculations exist on the GHG emissions of airships on a tonne-mile cargo basis, but they would be closer to rail or marine transport than to trucks or airplanes if powered by conventional fuels. The Hindenburg (LZ129) carried 80 tons and could across the Atlantic Ocean in about two days. The LZ129 used less horsepower than is required by one engine on a four engine C-130 transport plane that carries a 20 ton payload.

Depending on the particular design, both fully-buoyant and semi-buoyant airships can make vertical take offs and landings, in addition to conventional rolling landings. Some Transport Airship concepts incorporate a hovering, precision load exchange capability by employing an aerial crane installed at the bottom of the airship. Less ground handling is necessary if the airship can hover above the LEZ during the payload exchange. The vertical crane type airship could move goods and services within a remote region, and interface with

other (conventional) transportation systems. Freight could also be exchanged with long distance airships, or other transportation systems for further transport of goods to urban areas or international markets. In this way goods and products from a remote region could be moved to major markets where they command higher prices.

An airship of simplified design is favored to minimize development risks and maximize the utility of the first transport airship to be developed. A simple design would offer the greatest lift for the least empty weight and require the shortest development time. However, no one knows which of several airship concepts is the most likely to succeed commercially. The airship industry sits at a technological crossroads similar to that of fixed-wing aircraft before the DC-2 popularized the semimonocoque aluminum fuselage. All airplanes have followed the monocot structure, but no dominant airship structure exists today.

The initial development cost of a Transport Airship would be in the area of $100 to $200 million. Assuming a production run of approximately 20 plus cargo airships the procurement cost per airship would be in the range of $50 to $75 million. This is far less than an airplane of comparable lift and reflects the lower costs. The cabin is not pressurized, most of the mass is fabric and gas, less power is required and no expensive landing gear is required.

Funding

The funding for the development of an X-Prize airship could come from the organizations that will eventually become the lead users. These include the oil and gas companies, mining operations and the military. Other organizations that may join this pool of potential users include NGO food agencies, governments and aerospace companies.

The payoff for these organizations is relatively near-term and the technical hurdles are not as steep as with other novel transport concepts under consideration. In addition to awarding an initial prize to the first team that builds and operates a successful Transport

Airship there should be follow on contracts for subsequent use of the winning airship in test evaluations by the major corporate and governmental patrons. Those follow on contracts of 6 months to a year of field tests would provide a substantial revenue stream and an immediate ROI to the sponsors of the winning airship.

Winning Criteria

The criteria for winning this prize should be significant enough to produce an airship that has an economically viable performance, cost effectiveness and environmental superiority. It should also have performance qualities that would enable it to be FAA certified and placed into series production. A candidate specification for the winning airship might include the following parameters:

Minimum payload	50 tonnes
Time to load and unload payload	1 hour or less
Round trip range	1,000 kilometers
Weather conditions	-40C operations
Greenhouse gas emissions	zero emissions
Average speed	100 kilometers per hour

At a 50 tonne payload airships would be competitive with a transport truck over an ice road. The load and unload time needs to be quick for efficient freight movement. The distance (500 kilometers one way) covers most of the market demand that has been identified. The trip flight time is important because the vehicles must obtain high utilization to offset its capital costs.

Commercial airships need to operate year round in general weather conditions in order to minimize their costs and provide a reliable service. Systems must be designed to deal with snow and ice accumulation and cold temperatures. The criteria for winning the prize could be two round trips to a remote northern community that meet or exceed the parameters. One trip would be taken in the summer and the second trip would be taken during winter conditions.

Conclusion

The modern world is served by centuries of investment in the current air, land and sea modes of transport infrastructure. As the 21st Century begins three economic problems are apparent. First, the transportation system is becoming more congested as ever increasing volumes of trade and travel encroach on existing capacity that is difficult to expand. Second, the GHG emissions from transportation are being recognized as one of the most difficult environmental problems. The inherent energy and mobility requirements of transport vehicles make them dependent on carbon-rich liquid fuels that are difficult, if possible to replace. Third, the gaps in the global transportation system are becoming more obvious as resource demands push exploration and development into more marginal and remote corners of the earth.

Infrastructure investments can help alleviate the first problem, but the others need a new approach to transportation. The Transport Airship is unencumbered by the limitations of infrastructure and has the potential to be a zero emission vehicle. The technology exists to design and develop airships that could transport goods between peoples in almost any location on earth. Heavy lift airships that offer novel transport capabilities could shatter economic paradigms and come closest to fulfilling the original dreams of the earliest pioneers of aviation; that of bridging the gaps that separate people in all nations.

Airship developers cannot capture all of the positive externalities of a new transportation mode. The full social benefits of Transport Airships will be shared with secondary users who represent the majority of the earth's populations that live and work in remote or undeveloped areas of the world. Transport Airships hold the promise of freeing the poorest of the world's citizens from economic deprivation caused by geographic isolation. Remote and economically undeveloped regions may also be the most affected by the detrimental environmental impacts of climate change. Not only do Transport Airships offer a more benign system of transport that

reduces the source of climate change, they provide a means of mitigating the damage done by existing transport services.

The concept of a great competition offers the motivating incentive for cautious investors to bring forward the development of a Transport Airship. Though it may be the commercial and military lead users who provide the financial backing to build these leviathans, the ultimate beneficiaries are the weakest and poorest peoples of the world. These ships must be built, and an X-Prize for the first Transport Airship can be the catalyst to do it now!

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[2] It currently takes longer to approve and construct one new runway at a major US airport than was required to construct the Great Pyramid of Egypt!

[3] CO2 emissions at 35,000 feet can take 100 years to "wash" out of the atmosphere.

[4] A fourth *Airships to the Arctic* is planned for the fall of 2007. Information can be obtained at www.isopolar.ca

[5] www.onderzoekinformatie.nl/en/oi/nod/onderzoek/OND1296716/

[6] The EPSRC Link grant (reference GR/R324499/01) funded a feasibility study of the potential environmental and operational benefits of airships for freight conveyance. www.cate.mmu.ac.uk/project_view.asp?chg=projects&chg2=7&id=38

[7] This especially applies to airships with payload capacities of 20 tons or greater.