Transport Airships: Not Just Another Aircraft

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Introduction

Three new airships are being delivered to the US military that are the largest dirigibles to be built since the giant Zeppelins of the 1930s. Other countries that have airships flying are Germany, Russia, Thailand and China. Design teams are working on new airships in the UK, Brazil, Portugal, France and Canada. Despite all this activity, less than two dozen airships are flying anywhere in the world at this time. Moreover, airships rarely operate in the northern latitudes during the winter season.

So few airships exist worldwide, that the civil aviation regulations for building and operating airships remain either non-prescribed, or are improvised as an extension of regulations designed for airplanes, helicopters and hot air balloons. The regulatory environment for large freight airships has seldom been considered because only one, the ill-fated CargoLifter airship (1995-2002), ever came close to being produced. As airship technology evolves from novelty to mainstream transport, regulations and policy appropriate to the characteristics of this mode become more important.

Some aspects of airships are similar to other aircraft. They have flight controls, navigation systems, weather monitoring, communications systems and pilot duty responsibilities. They also have unique capabilities. Airships operate more like fast boats than slow airplanes.

Flight duration can be measured in days and they are able to hover (float) without consuming fuel. Airships can safely fly low and slow, and as demonstrated by the Navy blimp program, they can operate in weather conditions that ground all other aircraft.

The application of fixed-wing and rotary wing aircraft rules to airships does not recognize these vehicles as a dissimilar mode of transport. Buoyancy, or aerostatic lift, makes airships and balloons different than airplanes and helicopters because these heavier-than-air vehicles depend on aerodynamic lift provided by the wings or rotors to stay aloft. "Dirigibility" makes airships different than free balloons. The engines of an airship provide lateral thrust that makes them steerable. Airplanes and helicopters also rely on engine thrust for forward motion and control, but consume about half their fuel just to remain airborne.

The use of regulations devised for airplanes, helicopters and balloons create barriers to the emergence of airship as a competitive and useful addition to the economy. The next section examines the regulations for airworthiness certification of large airships and pilot licencing in the United States and Canada. This is followed by some proposals for change that have been set forward for consideration. The paper concludes with a discussion of airship policy development.

Status of Aviation Regulations Governing Manned Airships

Due to the almost complete absence of airship activity in Canada, the regulations within Transport Canada that even acknowledge the existence of airships or provide guidance on their operation are based on the U.S. approach to airships. The U.S. Federal Aviation Administration (FAA) sets the *de facto* world standards for aircraft certification and general aviation operations.

<u>FAA Air worthiness certification: airships</u>
Prior to April 13, 1987, the United States had no Federal airworthiness criteria for type certification of airships. Until that time American commercial airships were built to thirty year old U.S. Navy detail design specifications. Approval of these civilian airships for

FAA type certificates was based on approval of the airship design by the US Navy. Approvals were predicated on the extensive experience of the U.S. Navy with airship design, construction, and operation. However, the U.S. Navy decommissioned its last airship in the early 1960‘s, and did not resume operation of airships until 2009.

The FAA still does not have airship certification regulations, but it does have an office, the Small Aircraft Directorate in Kansas City, MO, that has overall responsibility for FAA certification of civilian airships. The Kansas City FAA office provides oversight of the local FAA certification authorities. The FAA office nearest to the airship manufacturer’s location has responsibility for day-to-day interaction. The FAA’s certification activities are carried out at sites identified by the airship manufacturer.

With respect to guidance on airship design, the FAA has the “Airship Design Criteria” (ADC) that was developed in January 1983 with NASA assistance. The FAA established the Airship Design Criteria (ADC) based on FAR Part 23, the U.S. Navy detail design specifications for airships, the British Civil Air Requirements (BCAR) section Q, and additional FAA/NASA criteria appropriate for conventional non-rigid airships. The FAA has made just one revision to the ADC since its issue and these changes were incorporated in change 1 to FAA P-8110-2 dated July 24, 1992.

The fixed wing and rotary wing design communities have mature, well defined FAA regulations to guide new aircraft development. The ADC provides “guidance” but not “requirements” for airship designers. In addition, the ADC is neither mandatory, nor regulatory. The ADC merely contains a list of design criteria found acceptable to the FAA Administrator for the type certification of airships. Added to the confusion, these criteria are not the only criteria that may be considered acceptable by the FAA.

Transport Canada Air worthiness certification: airships

In Canada, airworthiness standards for the issuance and changes of type certificates for non-rigid, near-equilibrium airships of conventional design and construction are set out in Section 541 of

Canadian Aviation Regulations (CARs).[i] These regulations are based on seating capacity. For up to 9 seats excluding the pilot, airships must meet the standards set out in the U.S. Federal Aviation Administration document FAA-P-8110-2 that is the "Airship Design Criteria" described above.

Airships with 4 or less seats including pilots, and a maximum displacement of 4,250 m3 (150,087 cu. ft.) for hot-air airships, or 1,840 m3 (64,979 cu. ft.) for captive-gas airships, may be designed to meet the applicable airworthiness standards in CARs Chapter 531, "Manned Free Balloons" provided it can be demonstrated that with the engines shut-off the aircraft may be operated as a free balloon. For the powerplant, CARs Chapter 522, "Gliders and Powered Gliders", Subchapter E applies, unless approved as an integral part of the airship.

No airworthiness regulations are listed in the CARs for airships that have seating configurations greater than 9 seats, excluding pilots. No reference is made for rigid airships, or transport airships.

European Air worthiness certification: airships

A more ambitious and thorough effort to develop design regulations for large cargo carrying airships was initiated in Europe during the late 1990's. The impetus for this initiative was the anticipated development and deployment of the 160 metric ton payload commercial airships then being developed by CargoLifter in Germany. The Transport Airship Requirements (TAR) was issued in March 2000 by the Civil Aviation Authorities Luftfahrt-Bundesamt of Germany and Rijksluchtvaartdienst of The Netherlands. The TAR is currently administered by the European Aviation Safety Agency (EASA). It provides the most comprehensive set of airworthiness requirements in existence for large airships to accommodate the Type Certification of airships in Europe.

The TAR drew its basis from the FAA ADC and European aircraft certification standards and encompasses all types of airship designs and flight modes. It provides particular language governing design and manufacture of non- or semi-rigid, conventional rigid, metal rigid

or metal pressure airships. It also speaks to airships capable of horizontal or vertical take-offs and landings. The TAR defines a transport category airship as one that is characterized as multi-engine propeller-driven, with a passenger seating capacity of 20 or more, or has a maximum weight of 15,000 kg or more, or a volume of 20,000 m^3 or more, whichever is greater.

Due to the financial collapse of the CargoLifter program in 2002, the regulatory authorities were unable to complete the development of the TAR into a comprehensive regulatory document. Also, since the time of its initiation, new airship concepts such as the "hybrid airship vehicles" have been developed that the TAR was never designed to address. However, despite its limitations the TAR remains the principal reference document for both the FAA and EASA for certification of large airships.

Regulatory development

The FAA became aware that substantial updates to FAR Part 135 and Part 125 that were overdue. The current FAA regulations did not adequately address new industry issues, new technologies, or new air taxi operational options. In 2003, the FAA established the Aviation Rulemaking Committee (ARC) for Part 135/125 to allow the FAA and aviation industry to collaborate on the evaluation of regulatory issues and development of recommendations for rule changes.

The FAA established multiple work groups to interact with a steering committee that would have a membership representing a cross section of the General Aviation industry. Ten work groups were created that had the authority to review other working group papers, consolidate new regulation recommendations, and forward the recommendations to the FAA for their consideration. The Airship Work Group (AWG) was specifically tasked to develop definitions, applicability, safety and maintenance standards for airship operations. Regulations were reviewed for their relevance to the most commonly conceived airship operations. In addition to reviewing and generating updates for Part 135 and Part 125, the AWG was directed to evaluate all FAA regulations, (except Part 121 that governs scheduled civil airlines) and

recommend changes that would provide much needed regulatory guidance for current and future airship operations.

Some of the 104 recommendations were submitted to the FAA by the Airship Work Group. Space allows for only a couple of examples. The first example deals with airship cargo, crew and ballast exchange.

RECOMMENDATION DOCUMENT
Number: Airships 65
Issue: Adding paragraph §91.615 *Airship cargo, crew and ballast exchange operations,* to be applicable to airships only.
Discussion: It is proposed to add a paragraph that allows airship cargo exchange operations when such operations are defined and approved by the FAA. Large airships are considered to be capable of performing certain types of operations that other aircraft cannot perform, so enabling and specifying statements need to be included in the operational rules. Large airships are considered to have a potential, especially as in house cargo-carrying aircraft, of being used under Part 91. Enabling language introduced at this time will eliminate having to expend resources in the future considering such large airship operations on a case-by-case basis. The current cost impact is considered to be nil.
Recommendation: **Create new Part 91.615: "Airship cargo, fuel, provisions, crew, and or ballast exchange operations."** **"Airships as defined in 91.501 may conduct tethered, moored, or position-holding cargo, ballast, fuel, provisions, personnel exchange, or observation operations when such operations and required equipment are defined in FAA approved Airship Flight Manuals, Airship Ground Handling Manuals, or other FAA approved document."**

This recommendation illustrates the need for regulatory language that conforms to the unique operational capabilities of modern airships. It also highlights how in many cases airship technologies are so different than other aircraft systems that the airship capability cannot be adequately characterized or comfortably incorporated into traditional aircraft regulatory conventions or terminology.

The second example deals with cold weather operations, and specifically icing. Unlike an airplane that loses aerodynamic lift

when ice forms on its wings, an airship relies on aerostatic lift that is not affected by icing. Of course, the presence of ice or snow does add weight to the airship such that it makes it less buoyant. However, the risk posed to airships by ice is no means comparable to that of fixed-wing aircraft.

RECOMMENDATION DOCUMENT

Number: § 135.227 Icing conditions: Operating limitations.

Issue:

As the airship is an aircraft that can achieve flight without complete dependence upon aerodynamic lift, provided the flight control system is not frozen and accumulation of ice/frost exceeds available buoyancy or accumulation of ice/frost is such that the airship trim is affected, there is not real threat to safety in flight. All of these parameters can be checked prior to flight.

Historically, Navy tests of airships in flight in icing conditions proved the airships were safer than those moored on the ground in the same weather.

Developing procedures to ensure the airship is in safe condition for flight is a relatively easy task.

Recommendation:

Add the following paragraphs to Rule 135.227:

(a), (3) Takeoffs may be made in an airship provided the flight control surfaces are checked and remain moveable, a static weigh-off confirms airship static trim is within approved limits and control of buoyancy is possible within the approved takeoff static weight range.

(g) No certificate holder may authorize an airship to take off and no pilot may take off an airship any time conditions are such that frost, ice, or snow may reasonably be expected to adhere to the airship unless the pilot has completed all applicable training as required by §135.341 and unless one of the following requirements is met:

(1) A pretakeoff contamination check, that has been established by the certificate holder and approved by the Administrator for the specific airship type, has been completed within 5 minutes prior to beginning takeoff. A pretakeoff contamination check is a check to make sure the flight control surfaces remain maneuverable.

(2) The certificate holder has an approved alternative procedure and under that procedure the airship is determined to be free of frost, ice, or snow.

(3) The certificate holder has an approved deicing/anti-icing program that complies with §121.629(c) of this chapter and the takeoff complies with that program.

This recommendation was developed to provide certification of airships to conduct operations in the presence of snow and ice conditions. This kind of specificity is essential for airship operators providing service in northern areas who wish to obtain hull insurance for their operation. Note that this regulation does not specify the technology necessary to provide the airship with a deicing/anti-icing

capability, but rather puts the responsibility on the airship designer to prove this feature by whatever means they devise.

This regulation also is an example of the type that is much needed for the establishment of acceptable airship operating standards against which other non-technical or operational ancillary provisions (such as affordable hull insurance) can be accommodated.

The greatest challenge the AWG wrestled with during its deliberations was whether the language of the rules should be specific, or performance based. When changes to the current regulatory language were necessary, the group attempted to make only the most minimal changes possible. They drafted wording that made rules as broad as possible but required a particular capability without specifying the means to achieve it. Finally, all the recommended regulatory changes had to conform to the standards expressed in current FAA rules and conform to the EASA TAR.

FAA Operating requirements: airships

The Federal Aviation Administration (FAA) language that deals with the operation of airships can be found in FAR Part 61 - Section 61.129 titled; "Aeronautical experience". The minimum requirements for obtaining a private pilot lighter-than-air license are (1) a written exam and (2) 25 hours of airship instruction. For an FAA commercial pilot lighter-than-air license, the minimum requirements are that the individual must already possess a Commercial Pilot's License, take a written exam and undergo a total of 50 hours airship instruction.

Minimum flight hours for a Commercial Airship Pilot's License:

Heavier-than-air flight hours	200	
Required airship flight hours:		
Airship Pilot-in-Command	30	
Cross Country	10	
Night	10	
Instrument	10	(Minimum in airship)
Total airship hours	50	

As a practical matter, airship operating companies know that a substantial additional experience base is necessary for commercial airship pilots to be safe. Beyond the minimum airship flight hours required by FAA regulations, all airship operators require their trainee airship pilots to hold an Instrument Rating. They also require airship pilot candidates to have at least 700 hours of Pilot in Command (PIC) experience with a multi-engine aircraft. An additional 150 hours plus of airship PIC flight experience is also a typical requirement for employment as a commercial airship pilot.

Transport Canada Operating requirements: airships

Under the CARs, "balloon" includes any lighter-than-air aircraft, such that anyone wishing to pilot an airship must obtain a balloon pilot's licence. The balloon pilot requirements are set out in CARs 421.25. Pilots must be over 17 years old and have a valid Category 1 or 3 Medical Certificate.

The knowledge, experiences and skill requirements specified in CARs 421.25 for applicants are:

Knowledge –

(a) completed a minimum of 10 hours of balloon pilot ground school instruction on the following subjects:
- (i) *Canadian Aviation Regulations*, NOTAM and Air Traffic Rules and Procedures,
- (ii) Aerostatics and Meteorology,
- (iii) a balloon and its accessories, inflation, rigging and patching in conformance with manufacturer's recommendations,
- (iv) management of takeoffs and landings in free and tethered flight regimes,
- (v) precautions against cold and high altitude,
- (vi) instruments,
- (vii) navigation and aeronautical charts, and
- (viii) human factors including pilot decision-making; and

(b) obtained a minimum of 60% in a written examination, Pilot Licence - Balloon (PIBAL).

Experience –

(a) Within the 24 months preceding the date of application for the licence, an applicant shall have completed a minimum of 16 hours balloon pilot flight time, of which a minimum of 11 hours shall be untethered flight time under the direction and supervision of the holder of a Flight Instructor Rating - balloon.

(b) Untethered flight time shall include a minimum of:

(i) 6 dual instruction flights of a minimum of 30 minutes each including 1 ascent to an altitude of a minimum of 5,000 feet above ground level; and

(ii) 2 flights as sole occupant of a minimum of 30 minutes each between takeoff and landing.

Skill –

(a) Within the 12 months preceding the date of application for the licence an applicant shall demonstrate, in flight and on the ground, familiarity with and the ability to perform both normal and emergency manoeuvres and procedures appropriate to the balloon used in the test and with a degree of competency appropriate to the holder of a Pilot Licence - Balloon.

(b) An applicant shall submit a letter from the holder of a Flight Instructor Rating - Balloons, qualified on the method of inflation for the balloon used in the test, attesting to the applicant's satisfactory completion of the skill requirement.

Once an applicant has received a balloon pilot's licence in Canada, they can jump into any lighter-than-air vehicle (according to the definition), and fly away.

The discrepancy between the U.S. and Canadian airship pilot regulations is wide. However, the differences between the pilot requirements of commercial airship operators and the minimum stated in the regulations illustrates how outdated and dangerous the existing airship pilot regulations are.

Current regulatory developments

Among the recommendations for new crew certifications submitted by the AWG to the FAA were:

Airship pilot type ratings for large or complex airships (ATP)
Airship Flight Instructor
Airship Flight Engineer
Airship Navigator
Airship Dispatcher

New airship training and educational requirements were drawn up that would allow airships to operate at current helicopter minimum altitudes. Airships would also be exempted from IFR "minimum en route altitudes" because there were many operational scenarios where a large airship would be physically incapable of flying high enough to follow the existing minimum en route altitudes. Due to the slow speed and inherent stability of airships it was felt that they would be able to navigate via GPS through low lying areas around high terrain and still provide the airship with an equivalent level of flight safety.

A particularly difficult area of deliberations dealt with airship flight crew duty and rest rules. The issue was prompted by the question of what constitutes adequate crew rest on an airship. What onboard facilities should be required and how do you configure the airship to minimize the number of flight crew while not overworking them? How do you draft duty rest rules that can accommodate for short, medium, and long duration flights? Some airship flight operations could run 24 hours or more. In the end the AWG recommended that the existing duty rest rules governing flights up to 16 hours (the current maximum) be applied to airship operations, and that regulations for any flights with durations between 16 hours and 24 hours would require some determination from the FAA. For airship operations beyond 24 hours it was suggested that the duty rest regulations be patterned after a three shift crew schedule as is used on seagoing vessels.

One area where the AWG was not able to provide the FAA with any recommendations was in regard to how airships and hybrid-airships could be accommodated within a common set of regulations. Neither the AWG, nor the FAA, was able to decide what constitutes the definition of a "hybrid" airship. The matter was shelved because the FAA determined that the first goal of the AWG was to define new

rules for airships then at some time in the future the FAA rules could be adjusted to include hybrids. Clearly, the development of adequate definitions is needed for both “airships and “hybrid-airships”. Another approach could be to develop an entirely new Part 135 sub-section that specifically addressed hybrid-airships.

The AWG devoted a great deal of their personal time between 2003 and 2005 working on their recommendations. The FAA was supposed to have issued new airship rule changes in a “Notice of Proposed Rulemaking” (NPRM) in late 2005. To date, the FAA has not followed through with any actions on this topic.

Towards a new airship policy

In addition to safety and operating regulations, transportation policy involves a long list of economic considerations. Effective transportation policy creates an environment that encourages innovation, promotes efficiency, supports economic growth, provides safe operations and brings mobility all regions of the country. The existing modes of transport are mature in the sense that they are established and self-sustaining. Transport airships are non-existent, but crucially needed in the North where climate change is advancing most rapidly. Melting permafrost and failing ice roads are disrupting surface transport and even some airstrips.

From an economic development perspective, Canada resembles two economically separated countries. Where the railways and all-weather roads connect communities, Canadian industry is directly plugged into the world economy. In the other 70 percent of the land mass, the country is cut off from the world economy by transportation services that are either expensive, seasonal or cargo-constrained (choose two).

The regulatory framework for the manufacture and operations of airships has been reviewed. This section compares the economic characteristics of the various modes: the ratio of fixed to variable costs, infrastructure requirements, scale economies and competition. In Table 1, these characteristics are compared for truckload trucking, freight railways, airplanes, bulk ships and transport airships. As a unit

of measure, airships are assumed to carry between 50 tonnes and 250 tonnes of cargo.

Table 1 Economic Characteristics of Trucking, Rail, Airplanes and Airships

	TL Truck	Freight Railway	Airplane	Bulk Ship	Transport Airship
Ratio fixed: variable cost[ii]	low	high	medium	low	low
Infrastructure costs	high[iii]	high	medium	medium	low
Scale economies	constant	increasing	increasing	constant	constant
Number of competitors	many	two	two	many	?

Truckload trucking has the lowest ratio of fixed to variable costs, while the railways are the highest. This can largely be explained by the ownership of infrastructure. The railways own and maintain their infrastructure; the trucks use publicly provided roads. Bulk ships and airships have a low fixed to variable cost ratio because they have the least infrastructure needs. Airplane cost ratios are in-between the other modes because these aircraft are expensive to purchase and maintain and airport infrastructure is costly.

Another significant difference between these modes is scale economies. Railways and airlines enjoy increasing economies because they are network industries. They become more efficient the larger they become. Truckload trucking, ships and airships have constant economies. As truck, ship and airship fleets expand operators may enjoy improved purchasing power on inputs, but the addition of another vehicle does not improve the efficiency of others in the fleet.

As a result of these economic differences, the trucking industry has hundreds of large and small competing truckload carriers and many bulk ships compete on the ocean shipping lanes, but only two Class 1 railways and two large airlines serve the national market.

The operating characteristics of trucks, railways, airplanes, bulk ships and airships are compared in Table 2. Each mode is given a cardinal ranking where one is best and 5 is worst. Cost and speed are often inversely related because the physics of transport require more expenditure of energy and capital to go faster. Airplanes are the fastest and most expensive transport; ships are the slowest and least expensive.

Table 2 Operating Characteristics of Alternative Transport Modes

	TL Truck	Freight Railway	Airplane	Bulk Ship	Transport Airship
Cost	2	1	4	5	3
Speed	3	4	1	5	2
Capacity	4	2	5	1	3
Flexibility	1	4	3	5	2
Reliability	1	2	5	3	4
GHGs	4	2	5	1	3

Ships and railways can carry freight that is heavy and indivisible. A ship can carry 30,000 to 100,000 tonnes, while a single train can easily transport 10,000 tonnes of cargo. Airships can accommodate more awkward shapes and larger loads than trucks which are constrained to bridge and road limits. Airplanes are limited to the size and shape of freight that will fit through their cargo doors.

Trucks are the most flexible mode of transport because they can offer door-to-door service. In theory, airships can pick up and drop with no prepared infrastructure. Airplanes, trains and ships are all constrained to the limits of their infrastructure. Of course, intermodal options are possible to shift freight in ISO containers between ships, trains and trucks to achieve a door-to-door service.

In terms of reliability, trucks and railways are the best because they can transit almost any weather conditions. Of course, trucks are more reliable than rail in terms of hitting narrow delivery windows. Ships airplanes and airships are more susceptible to inclement weather conditions. Airplanes have some advantages in terms of headwinds,

but airships are able to fly in conditions of icing and fog that would ground airplanes.

The last category is greenhouse gas emissions (GHGs). Ships and railways are the best in terms of GHGs per tonne-kilometre, but airships would be close. Given the size of airships and their low energy requirements it is conceivable that airships could use hydrogen as a fuel that has zero carbon emissions and use their large surface areas to collect solar energy. Trucks and airplanes are the most polluting forms of transport. The GHG emission of airplanes at high altitudes may be more damaging than truck emissions are the surface.

Discussion

The need for new airship regulations that can govern and facilitate the initiation and growth of commercial airship operations is desperately needed. The profound potential of the commercial airship for economic development and expanded employment calls out for a new approach to the promulgation of efficient and effective regulations to govern this emergent industry.

Airships are not just another aircraft. Their economic characteristics suggest that airships would be more complementary than competitive to other modes of transport. Adapting this distinctive and sophisticated technology to Canadian conditions requires investment in innovation and testing. Investment requires business confidence and transportation policy has a role in creating the right conditions. The Government of Canada cannot take a laissez-faire stance given the challenge of climate change. It is time to establish a policy environment that encourages private sector competitors to emerge that will accelerate the development of transport airships for operations in the northern latitudes.

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[i] http://www.tc.gc.ca/eng/civilaviation/regserv/cars/part4-standards-421-1086.htm

[ii] The approximate ratios are trucks 20:80, railways 75:25, airplanes 50:50, ships 30:70 and airships 30:70.

[iii] The trucking industry has very high infrastructure costs in the form of all-weather road, but these costs are borne by the public so that the fixed costs of the trucking firms is very low.