Airships: An Idea whose time has come

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If a transportation technology existed that could 1) lower freight rates, 2) expand international trade, 3) increase employment, 4) solve northern logistical problems, and 5) greatly reduce carbon emissions, who would not want to embrace the idea?
Triple Bottom-line Assessment

Environment: Can transport airships reduce environmental impact and cut carbon emissions?

Economy: Can airships increase trade, competitiveness and industrial growth?

Society: Can an airship industry create employment and investment opportunities, improve living standards and reduce risk?
Distribution of greenhouse gas emissions by economic sector, Canada, 2013

- Oil and gas (179 Mt)
- Transportation (170 Mt)
- Buildings (86 Mt)
- Electricity (85 Mt)
- Emissions-intensive and trade-exposed industries (76 Mt)
- Agriculture (75 Mt)
- Waste and others (54 Mt)
Airships can carry low pressure hydrogen fuel tanks without compromising the space available for cargo

Shipping Emissions Factors:

• Air cargo  - 1.527 kg CO2 per Ton-Mile*
• Sea freight - 0.048 kg CO2 per Ton-Mile*
• H2 Airship  - 0.000 kg CO2 per Ton-Mile

* Source: http://carbonfund.org
Buoyant Aircraft History

1783 Montgolfier brothers

1783 Prof. Charles & Robert

1784 Jean Baptiste Meusnier

1785 Blanchard & Jeffries

1784 English Channel Flight

1785 Henri Giffard

1784 Jean Baptiste Meusnier

1854 Henri Giffard

1901 Santos Dumont

First dirigible airship

1919 R.34 First Atlantic Crossing both ways

1926 Norge First flight across the North Pole

1929 Graf Zeppelin First Circumnavigation of the world

1935 DZR Regular air passenger service across the Atlantic

1919 R.34 First Atlantic Crossing both ways

1930 R100 – Flight to Canada

1935 DZR Regular air passenger service across the Atlantic

1961 US Navy ZPG-3W

1979 SkyShip

2000 Zeppelin NT

2006 LM P-791 flight

1670 Francisco de Lana
• **Strength:**
  – Robust, lightweight materials
  – Carbon fibre composites
  – All aluminum rigid designs

• **Control:**
  – Vectoring motors/engines
  – Modern avionics/hydraulics
  – GPS

• **Safety:**
  – Computer design tools
  – 100 years of aviation research
  – Satellite weather information
  – No human contact during ground handling
  – Gas “sniffers”
  – Static electricity control
Experimental Airships

- **P-791 (Lockheed-Martin)**
- **Atlant-30 (RosAero-Systems)**
- **DynaLifter**
- **Airship do Brasil**
- **Aeroscraft (Worldwide Aeros)**
- **LEMV (Hybrid Air Vehicles)**
Search for the Dominant Airship Design

- **Structure**
  - Rigid
  - Inflated
- **Buoyancy control**
  - Ballast
  - Compression of gas
  - Heating of gas
  - Venting of gas
  - Propulsion
- **Shape**
  - Cigar
  - Catamaran
  - Disk
- **Flight Control**
  - Fins
  - Thrusters
- **Lifting gas**
  - Helium
  - Hydrogen
- **Materials**
  - Metal
  - Composites
  - Nanotubes
- **Propulsion**
  - Turbines
  - Diesel
  - Electric
- **Human Factors**
  - Pilots
  - UAV
- **Manufacturing**
  - Robotics
  - Manual Assembly
- **Maintenance**
  - Inspection
  - Repair
- **Economics**
  - Cost
  - Performance
## Hydrogen for Fuel and Lift

<table>
<thead>
<tr>
<th>Helium</th>
<th>Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inert</td>
<td>• Flammable</td>
</tr>
<tr>
<td>• Rare/finite</td>
<td>• Endless supply</td>
</tr>
<tr>
<td>• Expensive</td>
<td>• 1/100 cost of helium</td>
</tr>
<tr>
<td>• Unreliable supply</td>
<td>• 10% more gross lift</td>
</tr>
<tr>
<td></td>
<td>• Zero GHG emissions</td>
</tr>
</tbody>
</table>

*Hydrogen is not an acceptable lifting gas for use in airships.*

Canadian Air Regulation 541.7
Roma Accident, 1922

Source of the US ban on the use of hydrogen as a lifting gas in airships
# Fuel Safety Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen</th>
<th>Gasoline Vapor</th>
<th>Natural Gas</th>
</tr>
</thead>
</table>
| **Flammability Limits**  
(concentration in air) | 4-74%    | 1.4-7.6%       | 5.3-15%     |
| **Explosion Limits**  
(concentration in air)   | 18.3-59.0% | 1.1-3.3%       | 5.7-14%     |
| **Stoichiometric Mixture**  
(most easily ignited in air) | 29%      | 2%             | 9%          |


Vertical Control

• Changing weight
  – ballast
  – cargo

• Altering displacement of the lifting gas
  – heating
  – compressing
  – venting

• Engine propulsion (fuel consumption)
Gas Venting/Water Ballast

Engine Thrust

Aerodynamic lift

Aerostatic lift

Vectored thrust lift

Weight

Gas Compression
Ground Handling
Landing
Mooring
Cargo Transshipment
Mast-and-Track Zeppelin Ground Handling System
Landing, Mooring and Cargo Exchange at a Turntable Airdock

Mooring the airship MB 310 using winches

Rotating the turntable to point airship's nose in the direction of wind

Unloading the Cargo using a forklift trailer
Cold Weather Considerations

- Snow clearance
- De-icing/icing prevention for essential systems, e.g. valves
- Maintenance with heavy clothing and gloves
- Prevention of ice build-up in flight
- Cockpit windows de-icing/de-misting
- Pre-heat for starting
- Gondola heating
- Heating/anti-freeze for fluid systems and water ballast
Western Arctic

Beaufort Sea

MacKenzie River

Izok Lake

Bathurst Inlet

Bakers Lake

Iqaluit

Approximate northern limit of connecting all-weather roads and rail lines

High Potential Service Area

Eastern Arctic

High Potential Service Area

Northwest Territories

Nunavut

Yukon Territory

British Columbia

Vancouver

Winnipeg

Montreal

Newfoundland & Labrador

Prince Edward Island

Nova Scotia

New Brunswick

Ontario

Quebec

Manitoba

Saskatchewan

Alberta

Hay River

Yellowknife
Limited Transportation Options for Northern Canada
Fort McMurray Airship Gateway to the North

- Located at the edge of a region
- Offers some route advantage
- One-sided, funnel shaped hinterland
- Creates employment in transshipment and distribution services
Current Transoceanic Shipment

- Weight Value
  - >A $/kg
  - >B<A $/kg
  - >C<B $/kg
  - >D<C $/kg

- Cubic Value
  - >W $/cc
  - >X<W $/cc
  - >Y<X $/cc
  - >Z<Y $/cc

- Days in transit
  - Air
    - 5
  - Sea
    - 15
  - ‘Containers’
    - 25
  - ‘Bulk’
    - 25+

- Current Transoceanic Shipment
Transoceanic Freight Market with Transport Airships

- Weight Value
  - $/kg
  - >A
  - >B < A
  - >C < B
  - >D < C
- Value
  - $/cc
  - >W
  - >X < W
  - >Y < X
  - >Z < Y
- Days in transit
  - 5
  - 25
  - 8

- Transport Airships
  - 8
- Air
  - 5
- Sea – containers
  - 25
- Sea-bulk
  - 25+

Transoceanic Freight Market with Transport Airships
Trans-Pacific Airship Routes

Trans-Atlantic Airship Routes

Mid-West Distribution Gateway
Agricultural Trade Opportunity

Transport North tropical fruits fresh vegetables

Transport South beef, pork and dairy products
A VRO C102 (1949)
First Jet Airliner in North America

Hindenburg (1937)
Last Successful Zeppelin

AVRO C102 (1949)
First Jet Airliner in North America

Employment, Investment, Standard of Living and Risk
Advantages of Jet Airliners over Airships, Flying Boats and Piston Airplanes

**Supply**
- Surplus pilots and mechanics
- New concrete landing strips
- Cheap oil

**Demand**
- Desire for speed
- Lower cost fares
- Acceptable safety
- No concerns about air pollution

Air Technology Race: 1936-2016
Reasons for Renewed interest in Airships

• Growth of Air Cargo demand
• Need for access to remote areas
• Concerns about climate change
  – Jet airplane carbon emissions
  – Unreliability of ice roads and melting permafrost
• New materials and airship designs
  – Stronger, lighter structures
  – Autonomous landing (GPS/vectored engines)
Employment/Investment Opportunity

Total Sales 36 airships at $30 million each: $1.08 Billion

Direct Impact
Manufacturing employment @ 400 per 12 airships: 1,200 FTE
Tier 1, 2 and 3 suppliers 600
R&D and Universities 200
Pilots, ground crew and mgt @ 8 per airship 288
Construction Airdocks @ 1 per 24 airships 300
Total 2,588 FTE

Induced Impact
Transport costs (50% fixed and 50% variable) $2 Billion
Transport costs are about 5% of product prices $40 Billion GDP
Induced Employment ~ 40,000 FTE
## Social Impact on Northern Communities

<table>
<thead>
<tr>
<th>Basic Foods</th>
<th>St. Theresa Point</th>
<th>Winnipeg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk 4 Litres</td>
<td>$12.19</td>
<td>$3.48</td>
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<tr>
<td>Tomatoes</td>
<td>$3.80 lb</td>
<td>$1.99 lb</td>
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<tr>
<td>Bananas</td>
<td>$2.31 lb</td>
<td>$0.59 lb</td>
</tr>
<tr>
<td>Apples, Macintosh</td>
<td>$2.94 lb</td>
<td>$1.29 lb</td>
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<tr>
<td>Head Lettuce</td>
<td>$2.69 each</td>
<td>$1.49 each</td>
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<tr>
<td>Bread 60%</td>
<td>$2.49 each</td>
<td>$0.99 each</td>
</tr>
<tr>
<td>Ground Beef</td>
<td>$9.19 Kilo</td>
<td>$4.29 Kilo</td>
</tr>
<tr>
<td>Red Potatoes</td>
<td>$1.60 lb</td>
<td>$0.79 lb</td>
</tr>
<tr>
<td>Cheerios</td>
<td>$8.45 box</td>
<td>$3.50 box</td>
</tr>
<tr>
<td>Coke 2 Litres</td>
<td>$7.99</td>
<td>$2.09</td>
</tr>
<tr>
<td>Coffee</td>
<td>$11.89 Kilo</td>
<td>$6.99 Kilo</td>
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**Total Basket**

<table>
<thead>
<tr>
<th></th>
<th>St. Theresa Point</th>
<th>Winnipeg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$65.54</td>
<td>$27.49</td>
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Food Prices, Health and Housing
# Risks of Climate Change to Ice Roads

<table>
<thead>
<tr>
<th>Year</th>
<th>Days Open</th>
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<tbody>
<tr>
<td>1991/92</td>
<td>59</td>
</tr>
<tr>
<td>1992/93</td>
<td>54</td>
</tr>
<tr>
<td>1993/94</td>
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</tr>
<tr>
<td>1994/95</td>
<td>49</td>
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<td>1995/96</td>
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<td>1996/97</td>
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<td>2001/2002</td>
<td>25</td>
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<tr>
<td>2002/2003</td>
<td>53</td>
</tr>
<tr>
<td>2002/2003 Triangle</td>
<td>35</td>
</tr>
</tbody>
</table>

[Image of a graph showing global temperature anomalies from 1880 to 2000, with a notable upward trend.]
Risks of Climate Change: Sovereignty and Pollution
Risks of Climate Change to Existing Infrastructure

Damage Caused by Permafrost Thaw in NWT

Source: Natural Resources Canada
The Case for H$_2$ Transport Airships

- Zero carbon emissions
- No impact on terrain
- Low infrastructure cost
- Large bulky load capacity
- Reduced freight rates
- Year-round service to the North
- Job creation (manufacturing, operations)
- Responsible resource development
- Increased international trade
- Mitigation of climate change risks
This is not rocket science.

Norge, 1926

It’s just balloon science.
Golden Age of Aviation