AIRSHIPS TO THE ARCTIC
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Calgary - 2009

Developing an Airship Industry in Canada.

"Airship Transportation System – Helium Handling and Storage

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Why has it not yet happened?

- Commercial risk
- Maneuverability concerns
- Weather vulnerability
- Competition from alternatives
- Available lift gas
- Infrastructure cost
- Ignorance

Commercial risk ?

- The solution is a partnership between interested industries – Northern First Nations and Provincial and / or Federal support.

- Need to hammer away
  - until the penny drops !

Manouverability and bad weather

- Modern design tools (e.g. CFD) can develop airship optimal shape, engines location and controls on the drawing board. Ground crew is minimized.
- Hybrid craft (HTA) may have more flexibility in control of buoyancy, altitude and attitude
- Accurate weather forecasting allows route optimization (A2A4 presentation)
- A Hangar is still needed to protect from high winds or snow load. (or Barry Prentice idea).

Competition with alternative transport solutions

Mode of transport	positives	negatives
Boat	Almost unlimited load.	Year round access is limited to ice-free ports. Relatively slow – 20 kts
Sea-Plane -	Fast - 200 kts.	Limited load, expensive to run (fuel), requires ice-free water to land
Helicopter -	Fairly fast up to 200 kts.	Limited load, expensive to run (fuel), Vulnerable to bad weather
Ice Roads -	Less expensive than air transport Moderately heavy loads.	Limited to 3 months in winter. Very expensive to build. Quite slow 30-40 km/h
Airships -	Moderate speed 70-90 kts cruising Environmentally friendly – quiet Economical. Potentially large loads	Vulnerable to bad weather. Needs infrastructure at main hub Lift gas required.

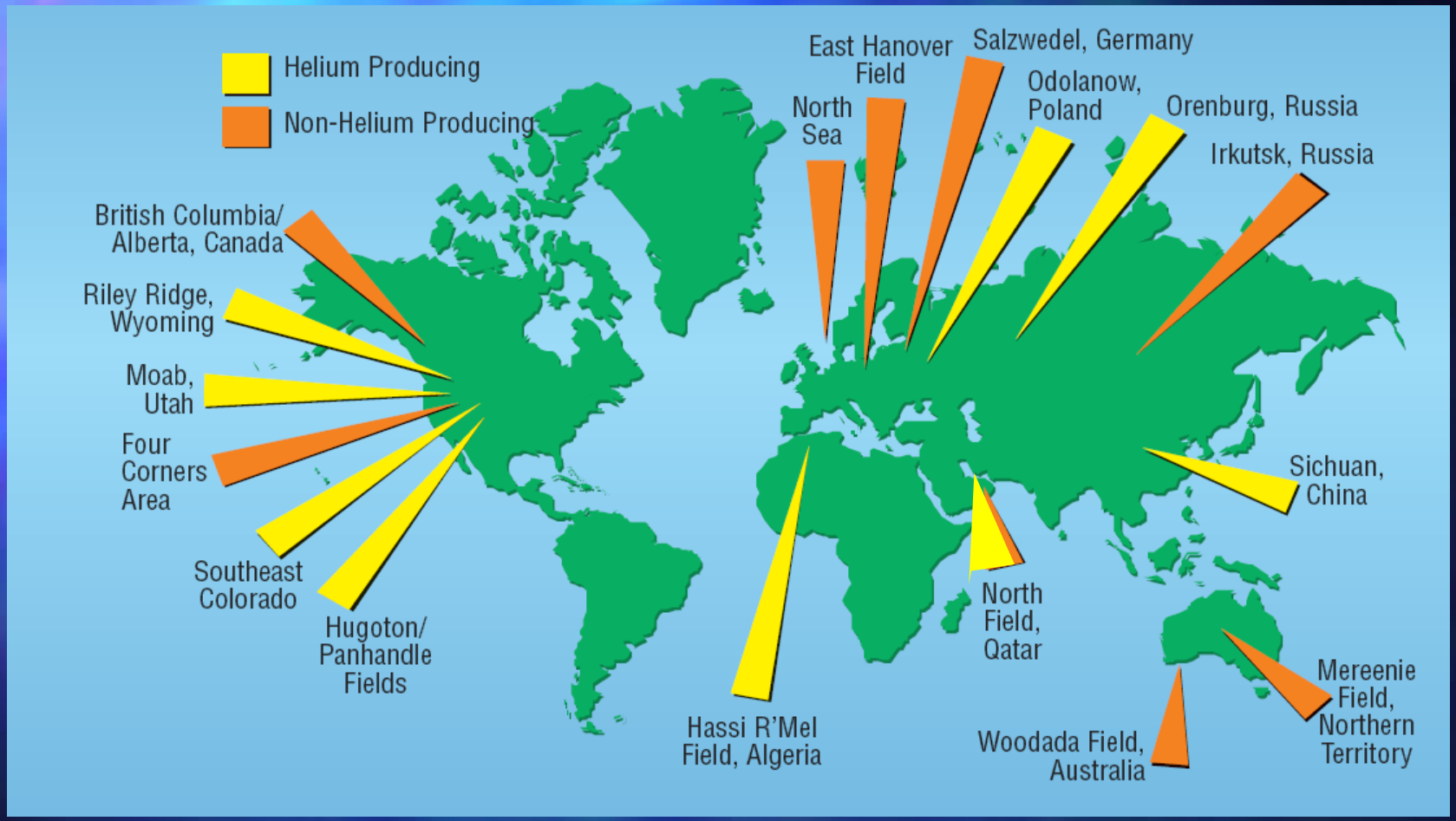
Airship – perceived negatives

- **Vulnerability to weather**
  - Need good forecasting and route planning
  - Round trips where possible
  - Hangar for weather protection at main port
- **Lift Gas availability**
  - Helium from USA and (potentially) Canada
- **Infrastructure needs**
  - Not trivial – but alternatives need too !

Sources of Lift Gas

- USA - current
  - Kansas, Oklahoma, Texas Panhandle
  - Wyoming – Riley Ridge - start 2009 (AP-Matheson Trigas)
- Canada - potential
  - NWT
  - Saskatchewan
- Everywhere
  - Air Separation Units - modest amounts
    - need to separate Neon

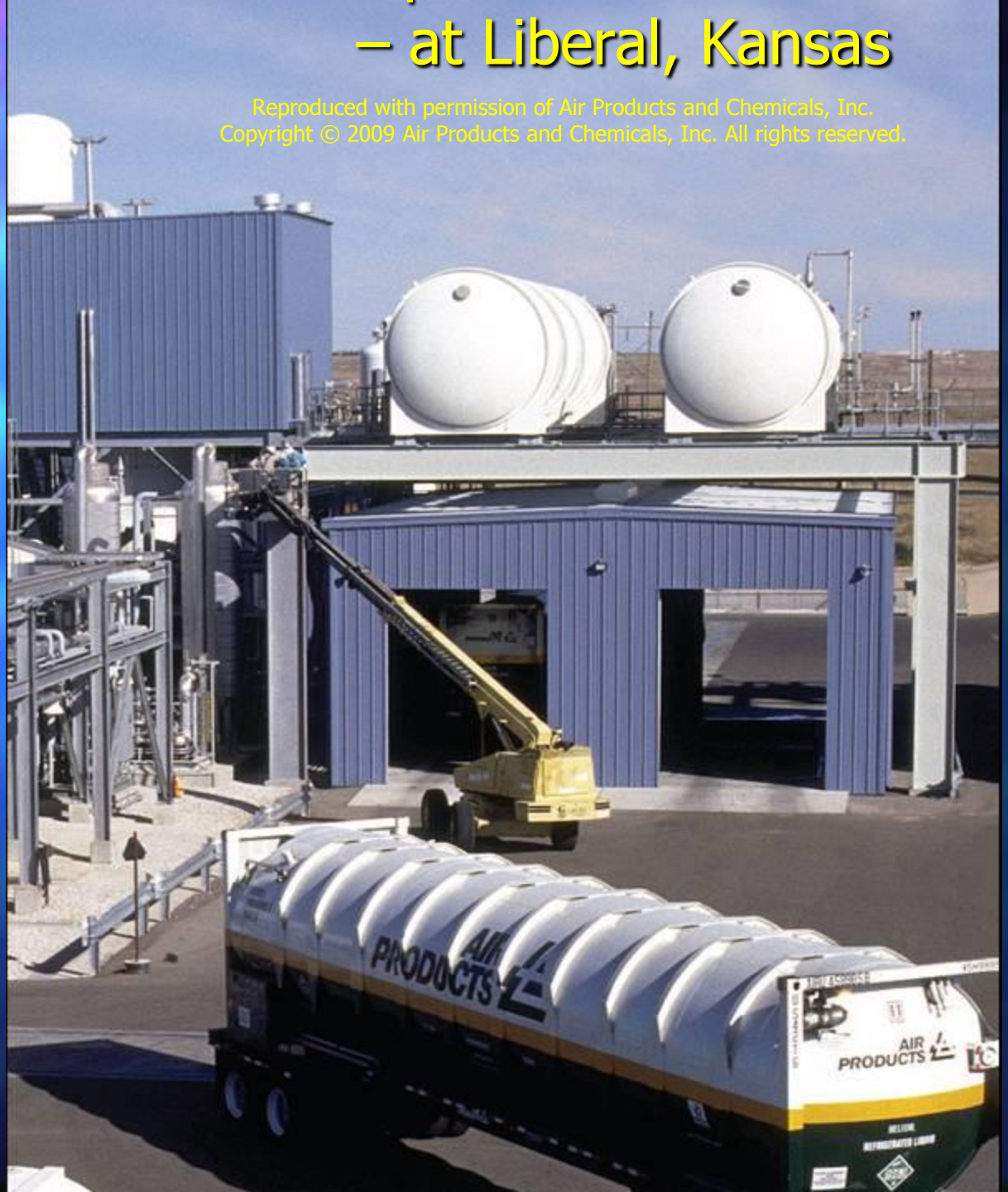
Worldwide Helium Sources



Helium Transport from source to main Airship port (hub)

- Road tanker – liquid 8500-13500 gallons (4-6 tonne).
  - probably method used for initial airship charge
    - Liquid Helium density 125 kg/m3 (1/8 water)
- Tanker load can deliver ~30,000 sm3 gas (m3 at STP)
    - STP = standard temperature (15C) & pressure (1.013 bar)
- Modest amounts (makeup gas) in HP gas in tube trailer with 8-12 tubes 20’ or 40’ long.
    - Gas stored at 200 bar gives ~4 - 5000 sm3
- Small amounts as liquid in Dewars. (Vacuum containers)
- Or - transport in Airship itself…

– at Liberal, Kansas



Liquid helium tanker – inerting space shuttle

Nominal Liquid Helium Dewar Weights

(Based on Air Products data)

Size (liters)	Empty Weight		Full Weight	
	lbs	(kg)	lbs	(kg)
30	180	(82)	190	(86)
60	190	(86)	209	(95)
100	210	(95)	237	(108)
250	375/440	(170 / 200)	445/510	(202/231)
500	500/645	(227 / 293)	640/785	(290/356)

Weight of container is 78% to 95% of total full weight

Helium Dewar

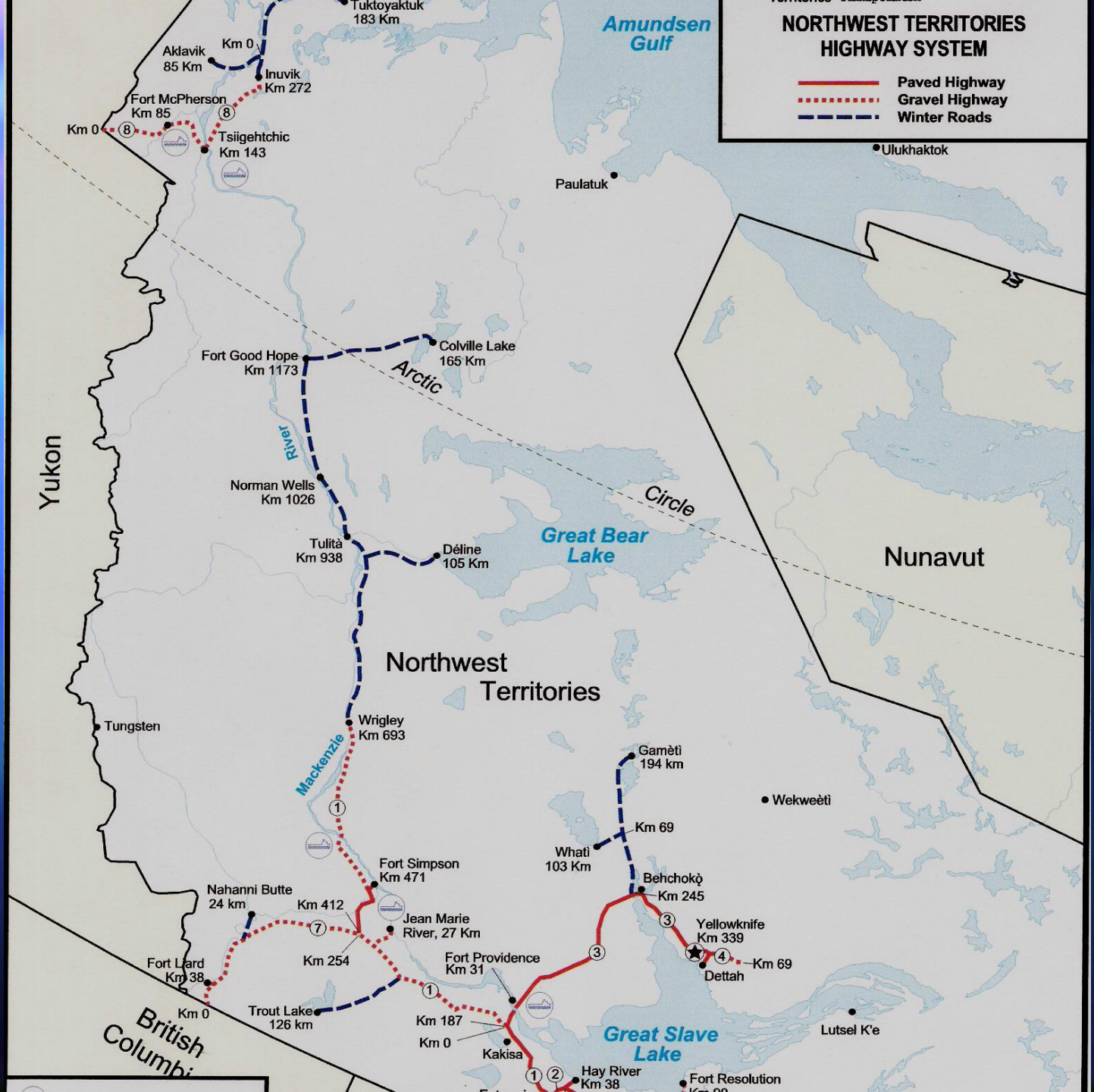
Airborne Dewar concept

- Could an airship carry a Liquid helium Dewar to replenish losses in flight?
- Yes – in principle
- A 100 litre Dewar contains 12.5 kg of Liquid => 74 cubic metres of gas (STP) when vapourised.
- Enough to keep a 10 tonne payload airship replenished for 2 months.
- The Dewar itself weighs about 95 kg (empty)

(Assumed diffusion/leak rate 0.3 litre/m2-day)

Airship Port Overview

- Factors affecting location of major hub
  - Access for personnel suggests as far North as possible for conventional surface transport
  - For heavy goods – large reactors etc may be constrained by road bridges or transport frames
- Some candidates:
  - Hay River or Yellowknife (ferries)
  - Off Extended McKenzie highway in NWT
  - Fort McMurray or High Level in Alberta.
  - Need to look at future infrastructure projects.
- Synergy opportunities
  - Research park
  - Medical centre - scanners


NORTHWEST TERRITORIES
HIGHWAY SYSTEM
Paved Highway
Gravel Highway
Winter Roads
Amundsen Gulf
Tuktoyaktuk
183 Km
Aklavik
85 Km
Km 0
Inuvik
Km 272
Fort McPherson
Km 85
Km 0
8
Tsiigehtchic
Km 143
Ulukhaktok
Paulatuk
Fort Good Hope
Km 1173
Colville Lake
165 Km
Arctic
Circle
Mackenzie River
Yukon
Norman Wells
Km 1026
Tulità
Km 938
Déline
105 Km
Great Bear Lake
Nunavut
Northwest Territories
Tungsten
Wrigley
Km 693
Gamètì
194 km
Wekweètì
Km 69
Whatì
103 Km
Behchokǫ̀
Km 245
Fort Simpson
Km 471
Nahanni Butte
24 km
Km 412
Jean Marie River, 27 Km
Km 254
Yellowknife
Km 339
Km 69
Dettah
Fort Providence
Km 31
Fort Liard
Km 38
Km 0
Trout Lake
126 km
Km 187
Km 0
Kakisa
Great Slave Lake
Lutsel K'e
Hay River
Km 38
Fort Resolution
British Columbi

Northwest Territories

Ferry and Ice Crossings

Highway Numbers

1. Mackenzie Highway
2. Hay River Highway
3. Yellowknife Highway
5. Fort Smith Highway
6. Fort Resolution Highway
7. Liard Highway
8. Dempster Highway

Don't Miss The Boat!

MV "Louis Cardinal"

CF "Abraham Francis"

MV "Johnny Berens"

MV "Lafferty"

MV "Merv Hardie"

Legend

- Paved Surface
- Gravel Surface
- Winter Access Only

Yukon

MACKENZIE MOUNTAINS

NUNAVUT

British Columbia

Alberta

Saskatchewan

Great Bear Lake

Great Slave Lake

YELLOWKNIFE

Northwest Territories Transportation

June 2006

Main Airport 'Hub' basic facilities

- Secured perimeter
- Hangar(s)
- Workshop for repairs / servicing
- Communications centre (control tower)
- Weather centre
- Possible rail spur with unloading facilities for freight / liquid helium
- Road access and freight handling.
- Administration block and passenger area – check-in food hall etc.

Gas Processing facilities at Main 'Hub'

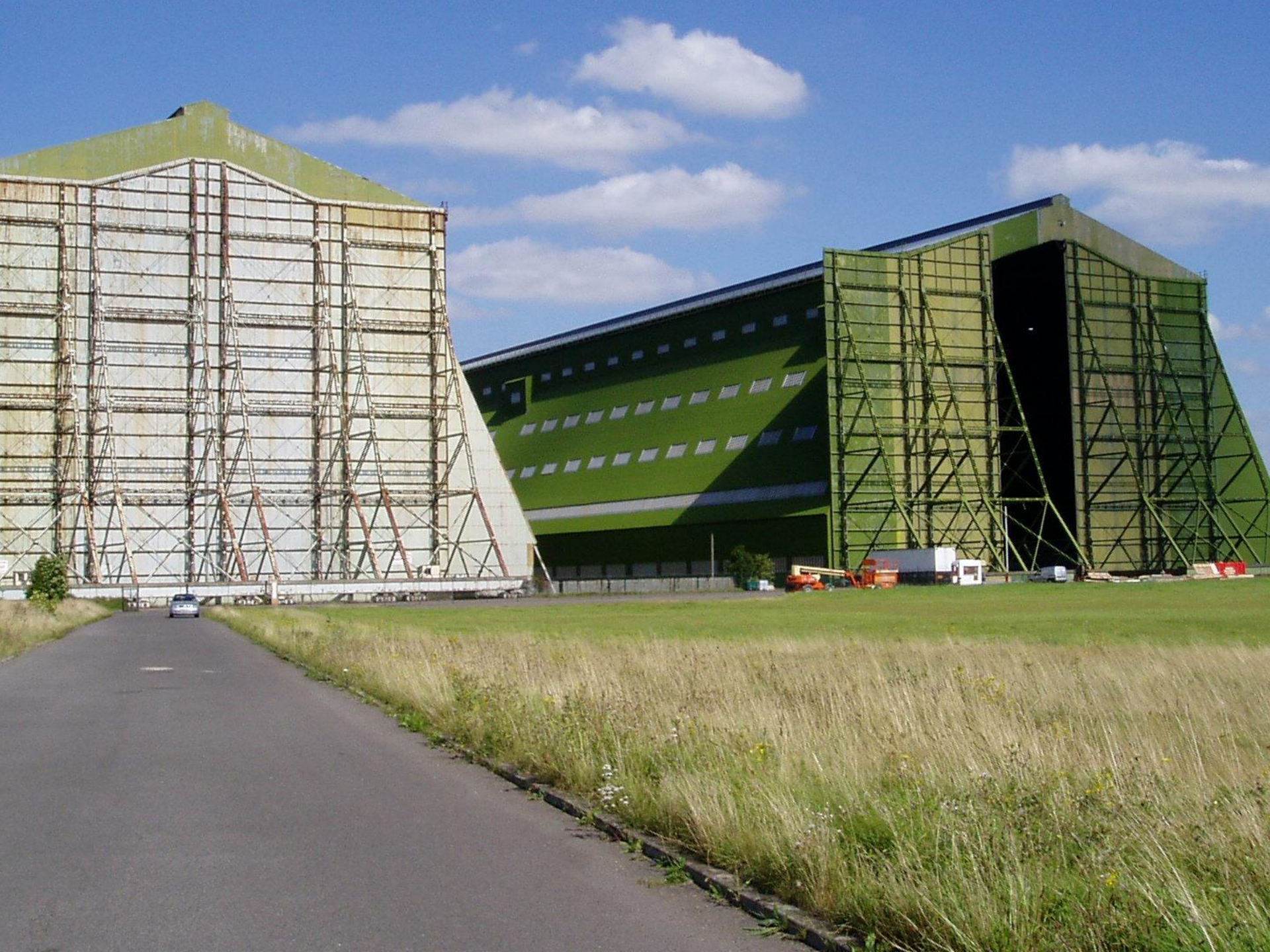
- Liquid helium tank and trans-fill station
- Weighbridge for tankers
- Boil-off gas compression
- Liquid helium vaporizer (bath)
- Tube trailers for HP gas storage
- Interconnecting piping to airship servicing area
- Air separation plant (ASU)
  - producing Liquid N2 with fill stations
  - optional oxygen production
  - perhaps a small amount of gaseous Helium.
- Helium purification unit for contaminated airship envelopes.

Conversion of liquid Helium to gas

- We need helium as a gas at ambient temperature for use in an airship
  - so we need to convert from liquid at 4°K above absolute zero to ambient gas - in a controlled manner
- Latent heat of vaporization = 20.7 kJ/kg (< 1% of water's LH)
- 1 Tonne vaporized and heated to ambient produces abut 6000 sm3 gas – a 750-fold increase in volume.
- Handling liquid can be a challenge!

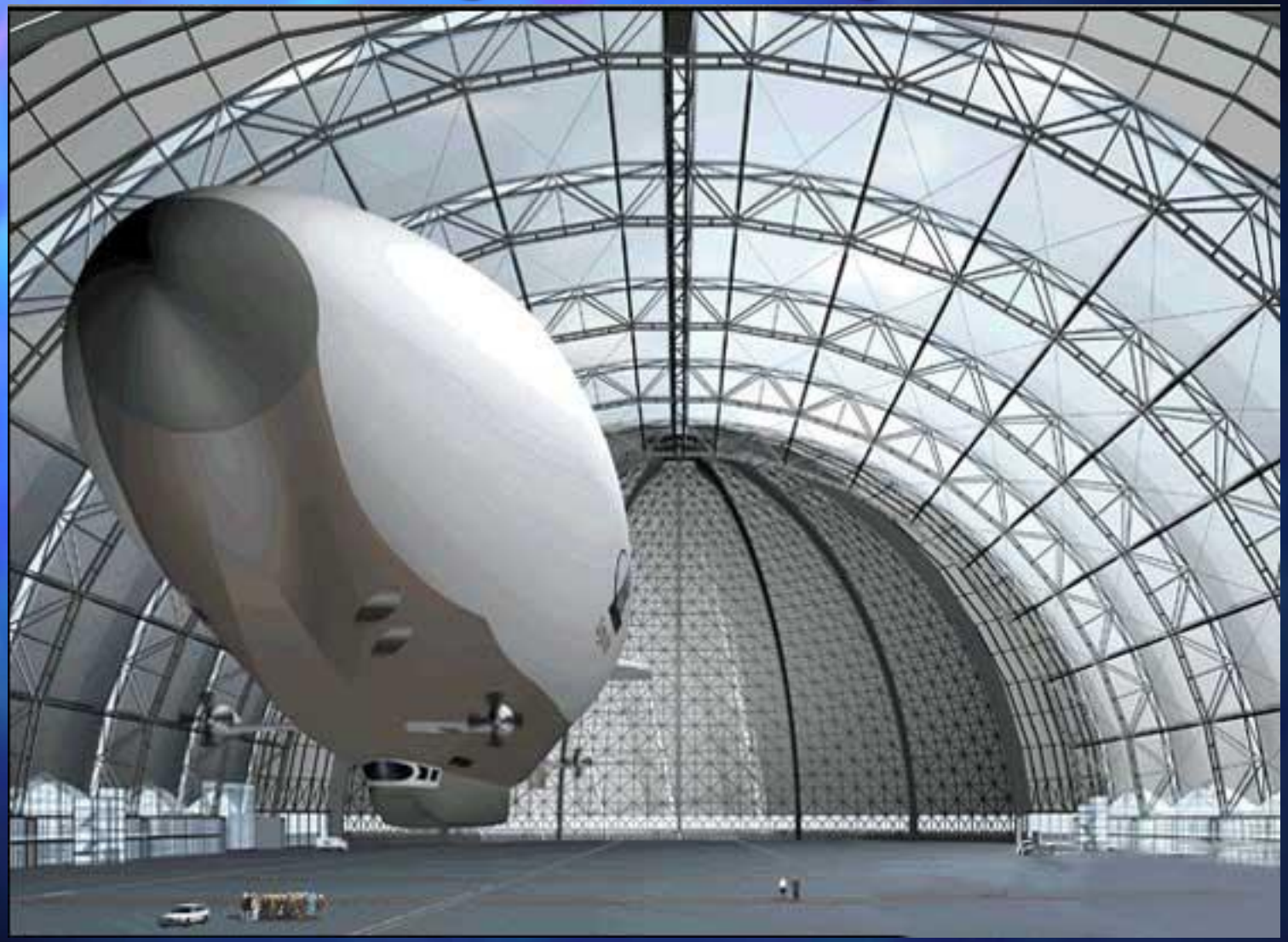
Remote airship port facilities

- Customised to suit function and scale of operation
- May be temporary or permanent
- Initial requirements minimized
- No Hangar – Airships make round trip.
- Optional Helium storage in tube-trailer for emergency makeup
- Optional gas purification skid
- Fuel depot
- Basic Passenger amenities



CargoLifter Hangar

CargoLifter Hangar



Tustin CA – Blimp Hangar nr 2

Tustin CA – inside hangar

Tustin CA – Hangars and Airship mooring area

Tustin CA – aerial view of Hangars etc

Transfer of liquid helium to HP Bullet (tube trailer) storage

- Ideally pump the liquid to storage pressure and then heat to ambient.
- This saves the capital cost and power consumption for a large compressor
- Requires careful operation and proper overpressure relief protection.
- Liquid He pump is a very special item. Vacuum super-insulated on suction side.

High Pressure Liquid helium pump

6000 PSIG LHe Pump

Features:

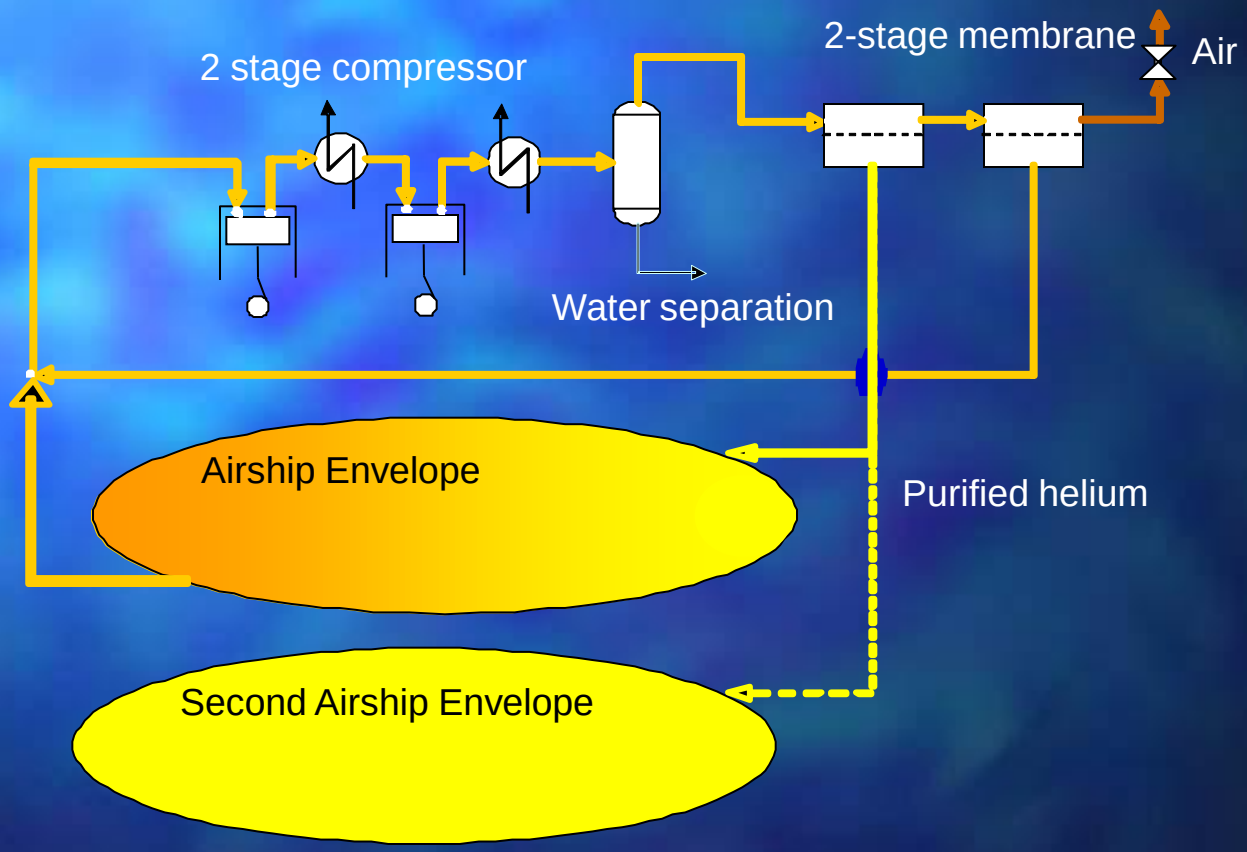
- A pump for compressing low temperature liquid gas e.g. liquid Helium
- Unique to Air Products - protected by US Patents 4,447,195 and 4,559,786
- Liquid Tank as inlet (eg 5,000 or 11,000 Gallon liquid helium containers)
- High flow capacity up to 100,000 SCFH (Nominal capacity is 75,000 SCFH)
- Discharge pressure as high as 6000 psig (400 bar g)
- 20 times more power efficient than current gas compression alternatives (Pump uses 60 HP motor versus a 1200 HP gas compression system)
- Meets product purity requirements of Space industry
- Successfully in use at the Aerospace Industry customers site
- Currently pumps available for leasing.

Other Processing facilities

- Cleanup of contaminated envelope gas
  - It is crazy to throw it away if still contains 80-90% helium
- All methods probably pre-compress the gas:
  - Molecular sieve adsorption of impurities – air and water vapour,
  - Can be ambient PSA (adsorption) or
  - Cryogenic adsorption after drying the gas
    - Both deliver the purified helium at high pressure – useful for putting into storage.
  - Membrane separation
    - Delivers purified gas at low pressure - useful if to be fed immediately into an airship envelope

PSA = Pressure Swing Adsorption

Helium Envelope purification Process using Membranes



United States Patent [19]

Czarnecki et al.

[11] **Patent Number: 4,675,030**

[45] **Date of Patent: Jun. 23, 1987**

[54] **PURIFICATION OF HELIUM**

[75] Inventors: **Bogdan A. Czarnecki,** Westhoughton; **David I. Limb,** Stockport, both of United Kingdom

[73] Assignee: **Costain Petrocarbon Limited,** Manchester, England

[21] Appl. No.: **713,572**

[22] Filed: **Mar. 18, 1985**

[30] **Foreign Application Priority Data**

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Jul. 29, 1984 [GB] United Kingdom 8419090

[51] **Int. Cl.**[4] **B01D 53/22**

[52] **U.S. Cl.** **55/16;** 55/23; 55/68; 55/158

[58] **Field of Search** 55/16, 23, 68, 158

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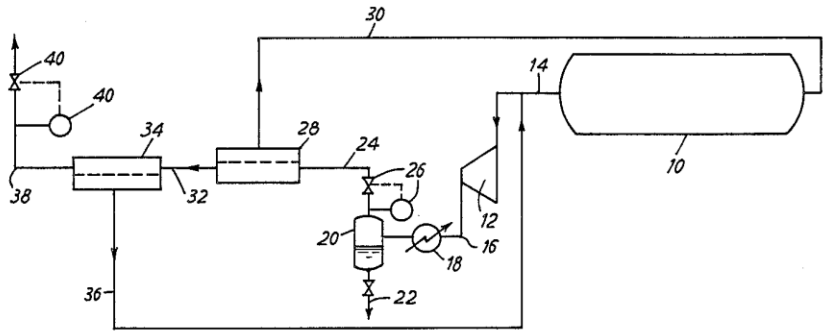
Primary Examiner—Robert Spitzer
Attorney, Agent, or Firm—Browdy and Neimark

[57] **ABSTRACT**

Helium contaminated with minor amounts of air, water vapor and carbon dioxide and from an envelope (**10**) is compressed in a compressor (**12**) and thereafter cooled in cooler (**18**) and fed via water separator (**20**) to a first of two substantially helium-permeable, oxygen/nitrogen-impermeable membranes (**28,34**), the permeate from which is substantially pure helium. The impermeate still containing helium is fed to the second membrane (**34**), the permeate from which is recycled to the first membrane while the impermeate is rejected with little loss of helium. The method is useful in purifying helium in an airship or balloon.

12 Claims, 2 Drawing Figures



Summary

- Of the various hurdles en route to an established airship transport system for Northern Canada, the required infrastructure can be reasonably well defined.
- Whilst there are some challenges and different technologies peculiar to handling helium and its unique nature, the solutions to these issues are known and proven.

- So what are we waiting for?

Thanks for your attention!

- Any questions?

Airship Fleet helium demand estimate

Net payload	tonne	10	20	50	100	200	500
efficiency - estd.	%	70%	70%	70%	70%	70%	70%
Total weight	tonne	14.3	28.6	71.4	142.9	285.7	714.3
Lifting capacity	kg/m3	1.056	1.056	1.056	1.056	1.056	1.056
Envelope volume	m3	13528	27056	67641	135281	270563	676407
r = L/D of envelope	-	4	4	4	4	4	4
ellipticity e	-	0.9682	0.9682	0.9682	0.9682	0.9682	0.9682
length, L	m	74.5	93.9	127.4	160.5	202.2	274.4
diameter, D	m	18.6	23.5	31.8	40.1	50.6	68.6
surface area, A	m2	3511	5574	10268	16299	25873	47658
specific leak rate, q	litre/m2-d	0.3	0.3	0.3	0.3	0.3	0.3
leakage rate, Q	sm3/day	1.05	1.67	3.08	4.89	7.76	14.30
Loss per year	sm3 / yr	385	610	1124	1785	2833	5219
Percent of charge	% per year	2.8%	2.3%	1.7%	1.3%	1.0%	0.8%
Loss per tonne PL-yr	sm3/tonne-yr	38.5	30.5	22.5	17.8	14.2	10.4

Notes

1 A fleet of 4 x 50 tonne airships and 2x 10 tonne airships would require 5266 sm3/year
2 One 1000 tonne/day oxygen plant recovering 80% of the helium in the feed air would recover this same amount.
3 Envelope shape assumed to approximate prolate spheroid