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Advanced Airship Technology and Design Approaches

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Perspicuous Technologies Inc.
November 2016

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Airship Engineering – Design Science or Luck?

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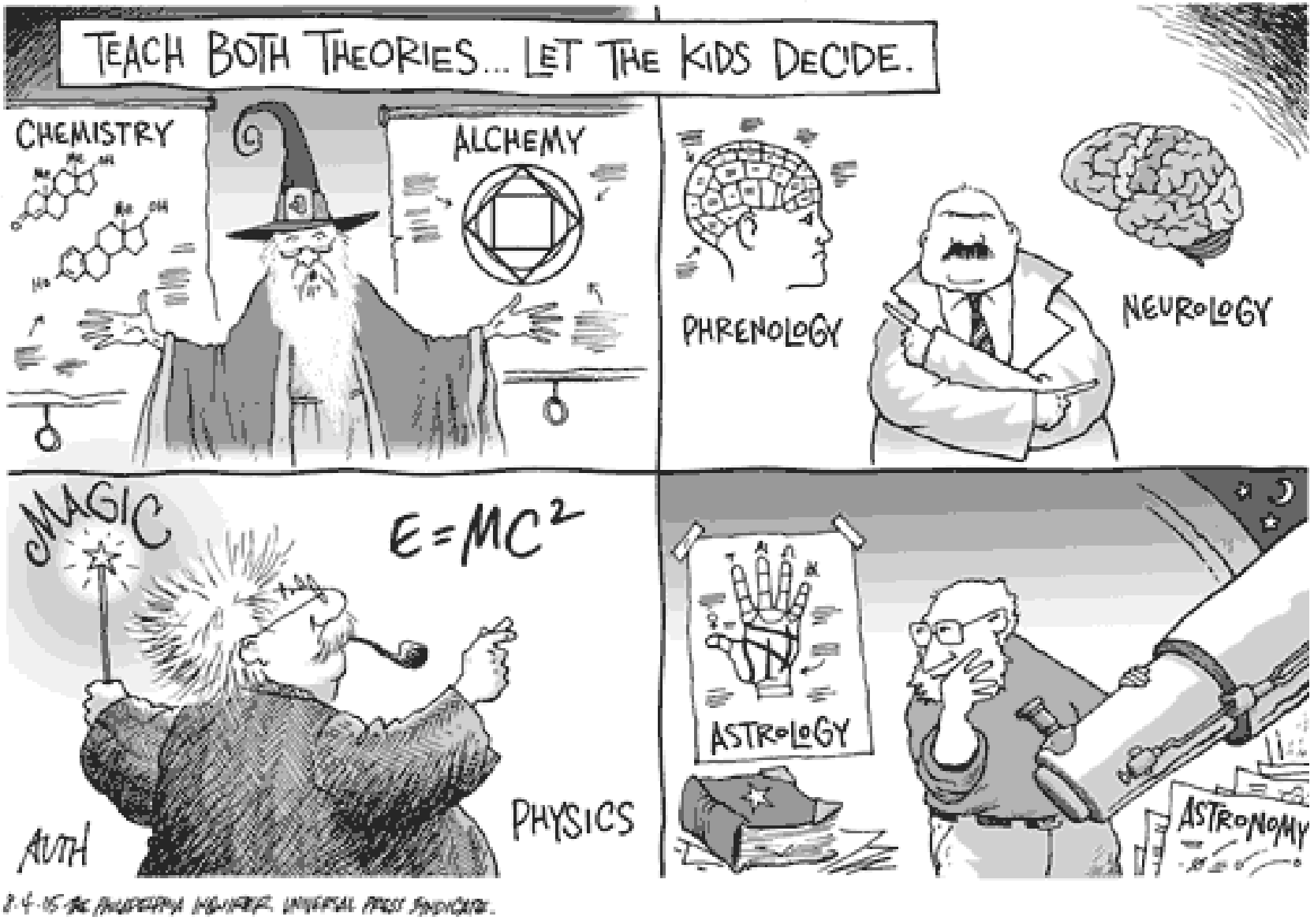

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Abracadabra
AL-ooza-mahkeys
ABrexifah-now

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What Nevil Shute Said

"It has been said an engineer is a man who can do for five shillings (30¢) what any fool can do for a pound ($1.22)."

- Deputy Chief Engineer of the R100 project under Barnes Wallis in 1929 and later, himself, Chief Engineer
- Author of *'No Highway'* – all about anticipating a metal fatigue - later formed the basis of the 1951 film '*No Highway in the Sky*' - Jimmy Stewart and Marlene Dietrich

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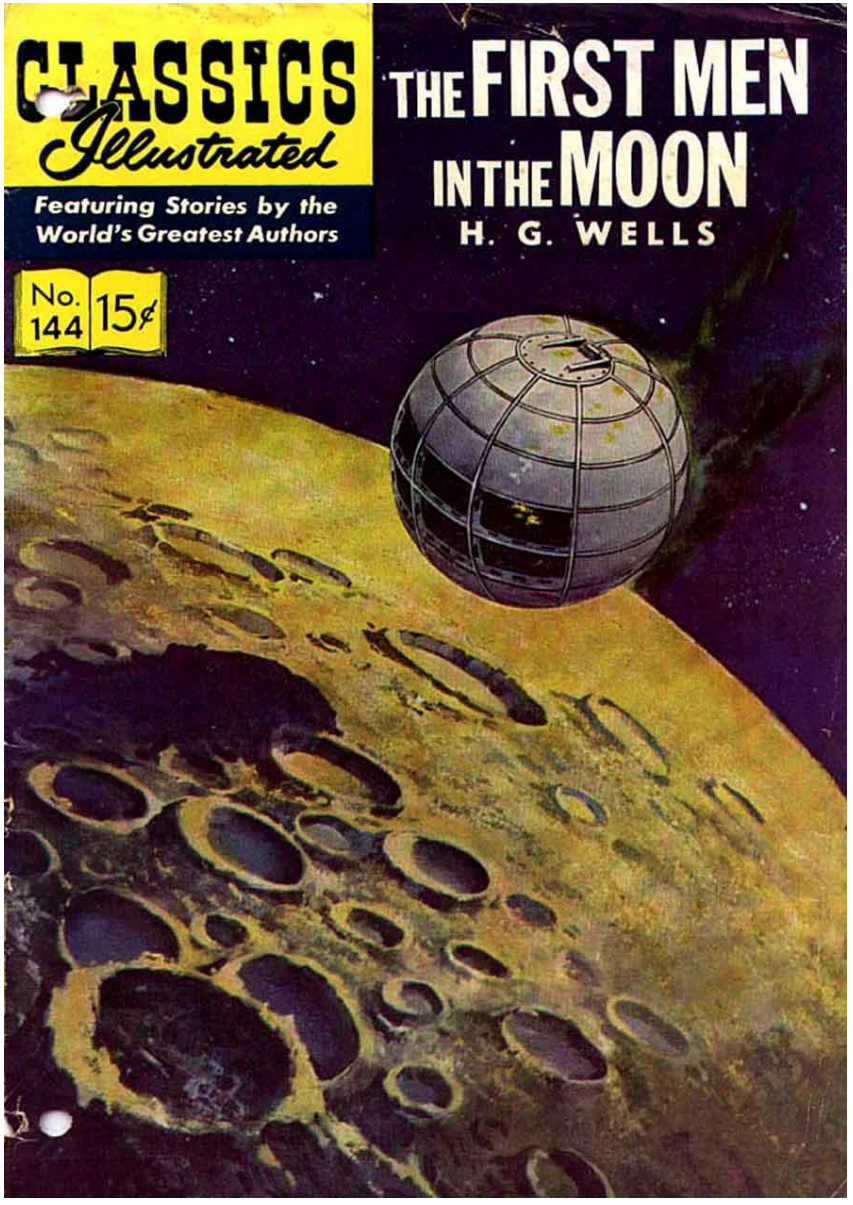
Cavorite

- According to the author H.G. Wells in his novel “First Men in the Moon”- is an artificial metallic substance that has “gravity-blocking properties and enabled Dr Cavor to travel to the Moon
- When a sheet of *Cavorite* is exposed, “it makes the air above it weightless”
- Helium gas, at lower earth atmospheric altitudes, is a sort of anti-gravity material – Think about this…



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‘Free Lift’ – What Design Engineers Can Exploit

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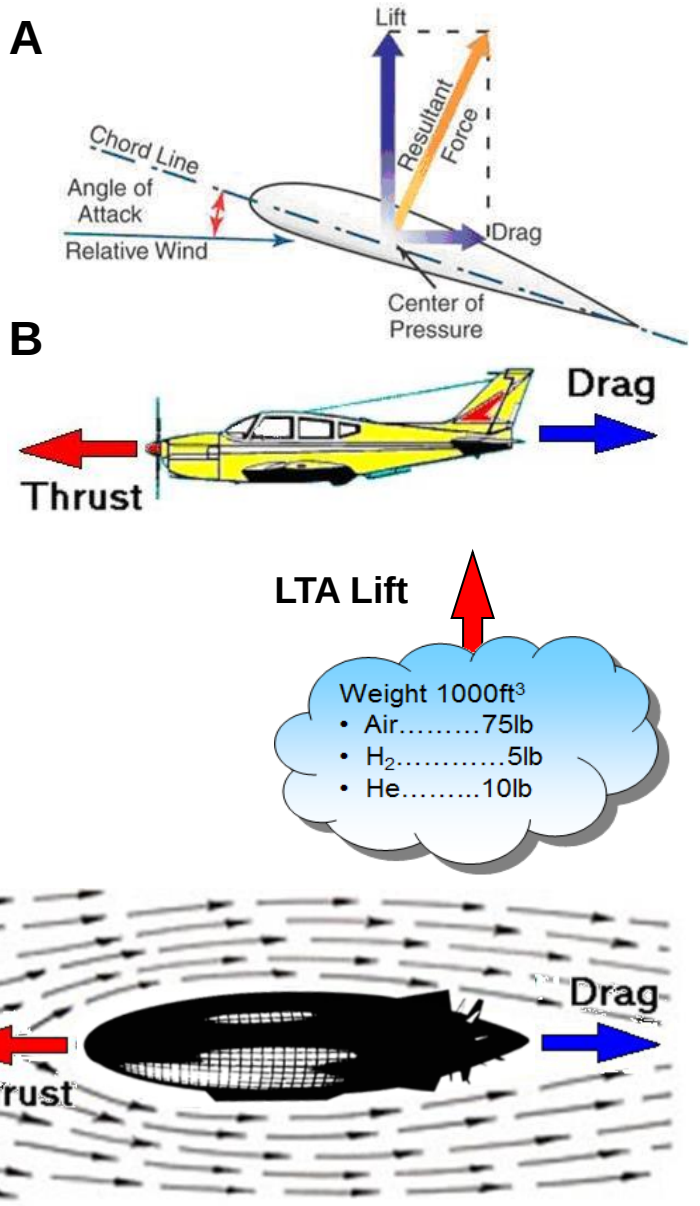
Winged aircraft

- Simplify for moving in two planes:
  - Vertical to climb and maintain altitude
  - Forward to achieve useful transit speed
- Separate the two:
  A. Imagine aircraft is stopped (say, a wind tunnel) - use fuel to overcome induced drag resulting from generating vertical lift component
  B. To then move forward (like a car and air resistance), additional resistance drag must be overcome – requires more fuel

Airship

- Lighter-Than-Air gas provides free vertical lift without the need to generate aerodynamic lift – saves this fuel
- Only fuel to overcome forward drag - like a road vehicle, moving at speed etc



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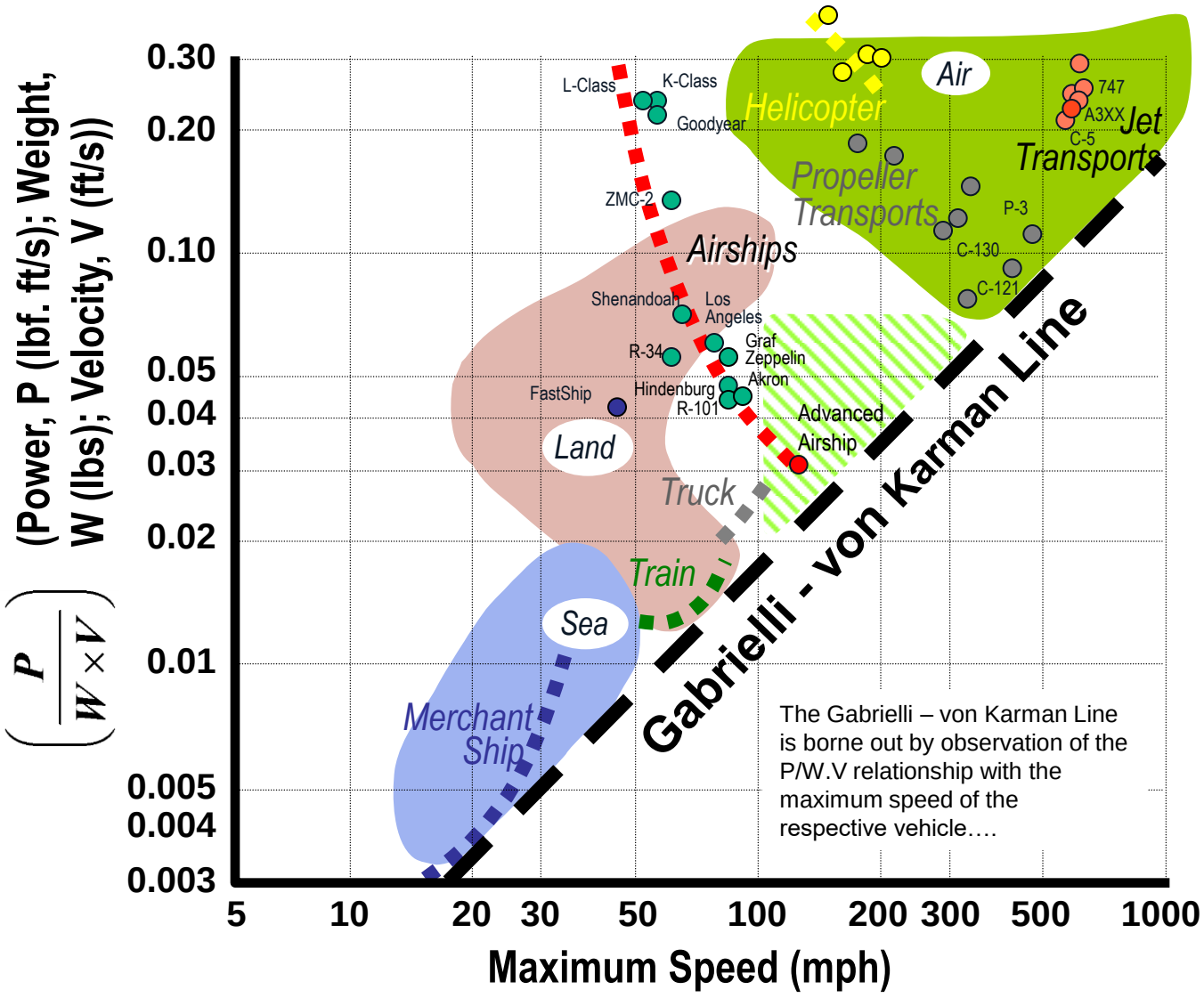
Comparative Transport



Courtesy: ASME, Journal of Mechanical Engineering, Volume 72, 1950, Pages 775-781, "What Price Speed"– Specific Power Required for Propulsion of Vehicles" by Gabrielli and von Karman

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So, Why Aren't There So Many Airships in the Sky Today, That We Live in their Shade*

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- The aspirational goal for airship technology is, perhaps, its successful utilization for heavy/outsize-airlift platforms – but has remained elusive primarily because of four issues:
  - Record of development failure – undermined credibility
  - Critical technologies – not well identified or addressed
  - Executive leadership and execution – incomplete due diligence, disregarding risk, not learning or ignoring lessons learned, flawed vision – 'Wilkins Micawber-like'
  - …and what Sidney Camm said:

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* Dienekes was thinking about arrows

Record - Crashes, Cancellation and Credibility

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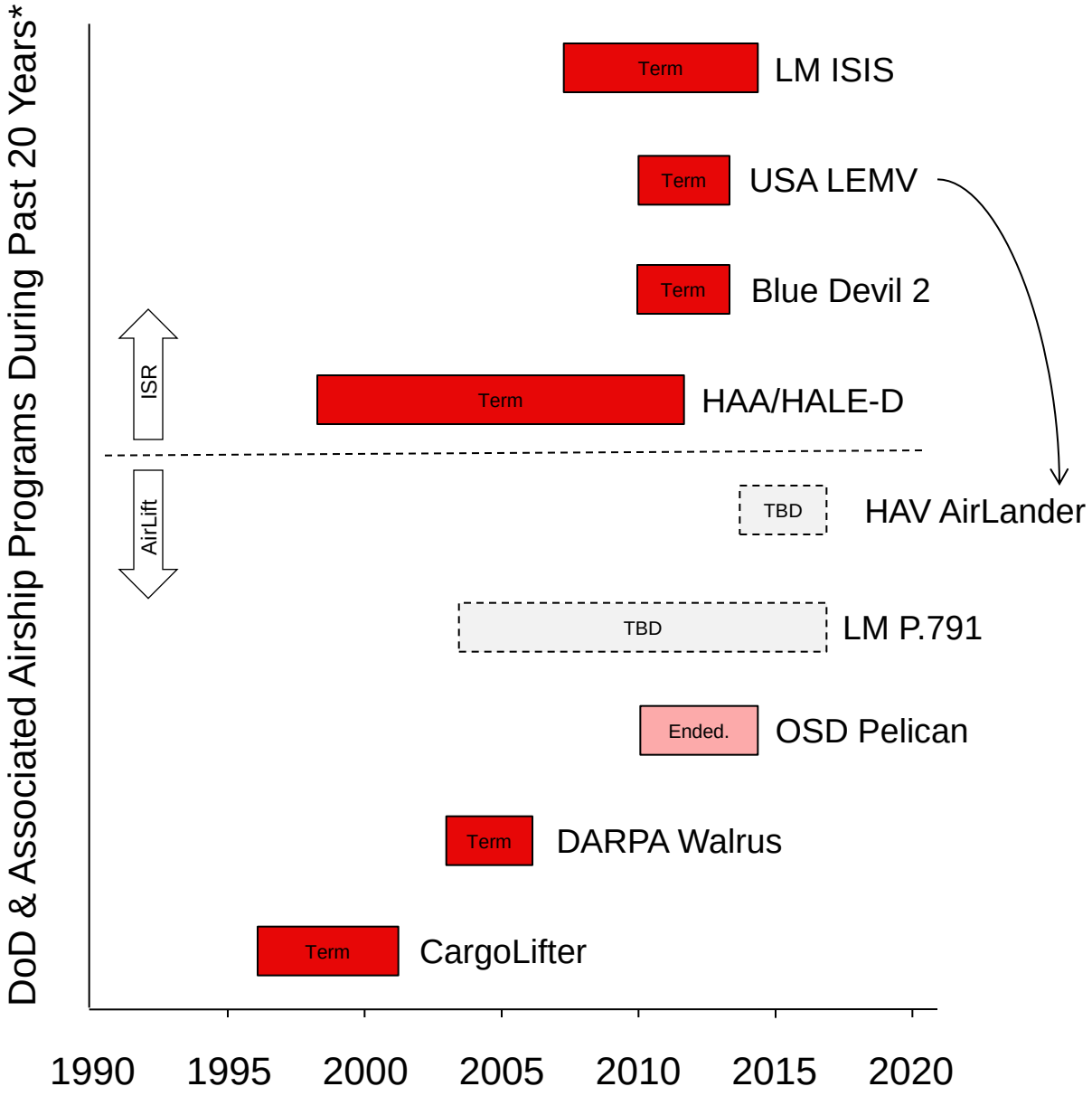

* GAO-13-81 Defense Acquisitions

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Critical Technologies

AIR TRANSPORT

Revival In The Air?

Manufacturer believes Goodyear's interest will help renew pursuit of zeppelin technology

JENS FLOTTAU/FRIEDRICHSHAFEN, GERMANY

German airship manufacturer Zeppelin Luftschiffteschnik says it has made a breakthrough as the leading company in its field, following a major order by the Goodyear Tire & Rubber Co. However, it concedes that, overall, zeppelin use remains flat.

Goodyear recently decided to replace its three U.S.-based aging blimps with three zeppelins. The airships, to be stationed in Akron, Ohio; Miami and Los Angeles, will take on the advertising roles performed by their predecessors.

Zeppelin Luftschiffteschnik first presented the Zeppelin NT (New Technology) in 1997 based on market studies that indicated hundreds would be ordered worldwide. But the company, funded by a foundation and supported by shareholders with deep pockets, has built only four so far. The original prototype was destroyed in 2006 after a two-year assignment in Botswana. One airship is based in Los Angeles. A third zeppelin was bought back by the manufacturer from Japan last year and is being refurbished at its headquarters here. The fourth zeppelin is based here and is primarily used for sightseeing flights.

Managing Director Thomas Brandt has led the company since 2006. He was previously a member of the executive board of Fairchild Dornier, the U.S.-German regional jet manufacturer that filed for bankruptcy in 2002 and was unsuccessful in its re-launch attempts. Brandt took the helm at Zeppelin during a phase of great uncertainty. The airship had been developed and introduced into service, but its prospects were unclear. Earlier predictions about market size had proven to be overly optimistic, so the company abandoned its proposal for a 19-seat version of the NT in favor of the current version, which seats 12.

Canceling the larger version and developing a longer-term strategy topped Brandt's to-do list. This involved sorting out the teething problems and searching for a partner that would not only operate several airships, but also help in receiving FAA approval—deemed key for access to important potential markets such as the U.S.

After several years of talks, Zeppelin has now found that partner in Goodyear. The tire manufacturer has decades of experience in building and operating its own airships. But with its current fleet up for replacement in the coming years, Goodyear decided to go with zeppelin. Unlike blimps, they have a semi-fixed internal carbon-fiber structure that allows engines and control surfaces to be moved away from the gondola and placed farther outboard, making the zeppelin more maneuverable and less noisy.

Goodyear will not only fly the zeppelins, but also take over final assembly. Parts production still takes place in Friedrichshafen, but the finished items are then shipped to the U.S.

There was fatal crash of a Goodyear-hired Lightship A-60 blimp near Oberursel, Germany, on June 18. The pilot was killed in the accident after the engine and subsequently the cabin caught fire following a first unsuccessful landing attempt, though the pilot managed to get his three passengers to a height where they could safely jump out.

Some were concerned that this could affect the business strategy. However, Brandt says he has not received any signals that Goodyear might change its plans.

Zeppelin says it has experienced some "serious interest" from other potential operators. To make ongoing operations profitable, the company needs to sell 10 zeppelins initially, not counting non-recurring development costs.

But the question is whether zeppelins could be used in other roles beyond the advertising platform. Brandt does not believe that scheduled passenger transport is an option because the service is [illegible] airships are slow and dependent on the weather. He is also skeptical about using them for outsize cargo transport. While the concept is appealing in theory and several attempts have been launched in recent years, Brandt points out that "major technical issues are not yet resolved." Most pressing is the problem of off-loading cargo without the zeppelin instantly becoming too light.

Environmental surveillance could be a viable application. Zeppelin is rebuilding one of its airships to the new production standard (including [illegible] and payload). The zeppelin will be ready for re-entry into service early next year and already has been booked for three months by a German research institute to take air quality measurements across Europe. It will also be used as a back-up for the Friedrichshafen-based sightseeing operation.

The company is pondering unmanned zeppelins for military and civil surveillance roles, but has no concrete plans. A larger 50-seat variant is being considered for the tourism market. But this would require €300 million (€435 million) and cannot be financed without a strategic investor.

Aviation Week & Space Technology, p. 31, 2011

- Zeppelin NT is perhaps the most practicable airship presently flying
- Zeppelin Managing Director Thomas Brandt: *"…is skeptical about using them for outsize cargo transport…[he] points out that 'major technical issues are not yet resolved.' Most pressing is the problem of off-loading cargo without the Zeppelin instantly becoming too light."*

Aviation Week & Space Technology/July 11, 2011

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Calculate Risk, Insert Experience and Apply Sound Judgment

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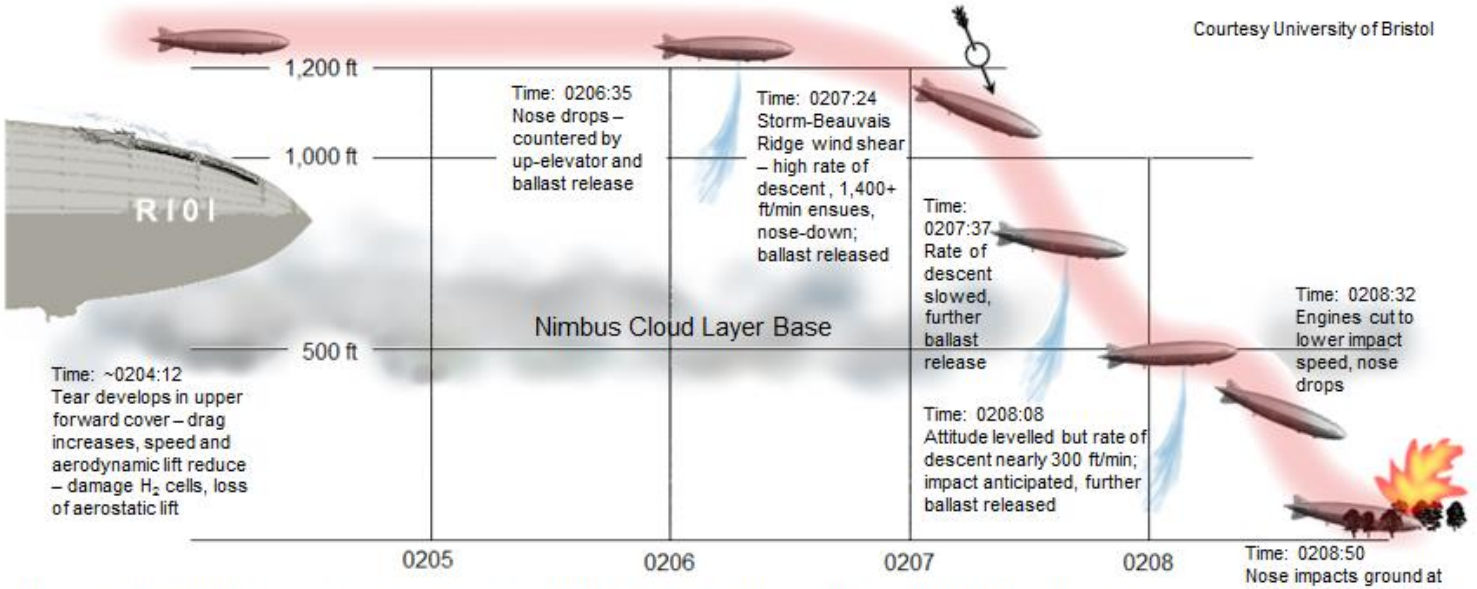
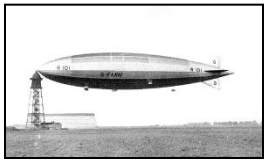
Program Leadership?

"Everyone is rather keyed up now, as we all feel that the future of airships very largely depends on what sort of show we put up. There are very many unknown factors, and I feel that that thing called "Luck" will figure rather conspicuously in our flight."*



Loss of the R.101 – Occurred over a period of 4 minutes 38 seconds; control effectors were insufficiently responsive/effective to reverse a high rate of descent and recover to safe flight following envelope damage and probable wind shear

* Lieutenant Commander Atherstone*, First Officer R.101, personal diary entry on the eve of the R.101 departure for India, Friday, 3 October 1930; died in the R.101 loss outside Allonne, France, October 5, 1930



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Sidney Camm

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"All modern aircraft have four dimensions: span, length, height and politics…"

Sidney Camm*






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* Chief designer at Hawker Aircraft Company until 1965 – responsible for aircraft including Hawker Hurricane, Typhoon, Fury, Hunter and Harrier - Statement made on the cancellation in 1965 of the BAC TSR-2

Summarize and Identify a Way Forward

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- Airships were very successful until the later 1930s after which time the burgeoning operating utility and practicability of winged aircraft gradually led to their demise (1960s)
- However, airships retain the advantage that their ton.mile energy requirement can be dramatically less than for a conventional aircraft (heavy lift/ISR)
- Nevertheless, recognize that an airship redux will not prove to be easy - witness a number of failed or cancelled airship programs and consequent struggle to be taken seriously - a history of expectation being revved to run ahead of reality in the effort to keep programs 'sold'
- Problem traceable to poorly conceived and executed programs in which the conceptual designs have been found technically short, management poor and a palimpsestic attitude to important early 20th Century airship experience
- Essential to introduce an era of more prudent airship design, clear vision and more critical management…and establishment support
- Airships that are more truly in synch with the 21st century aviation practices and advanced military-commercial operating utility needs – need a truly advanced airship technology approach

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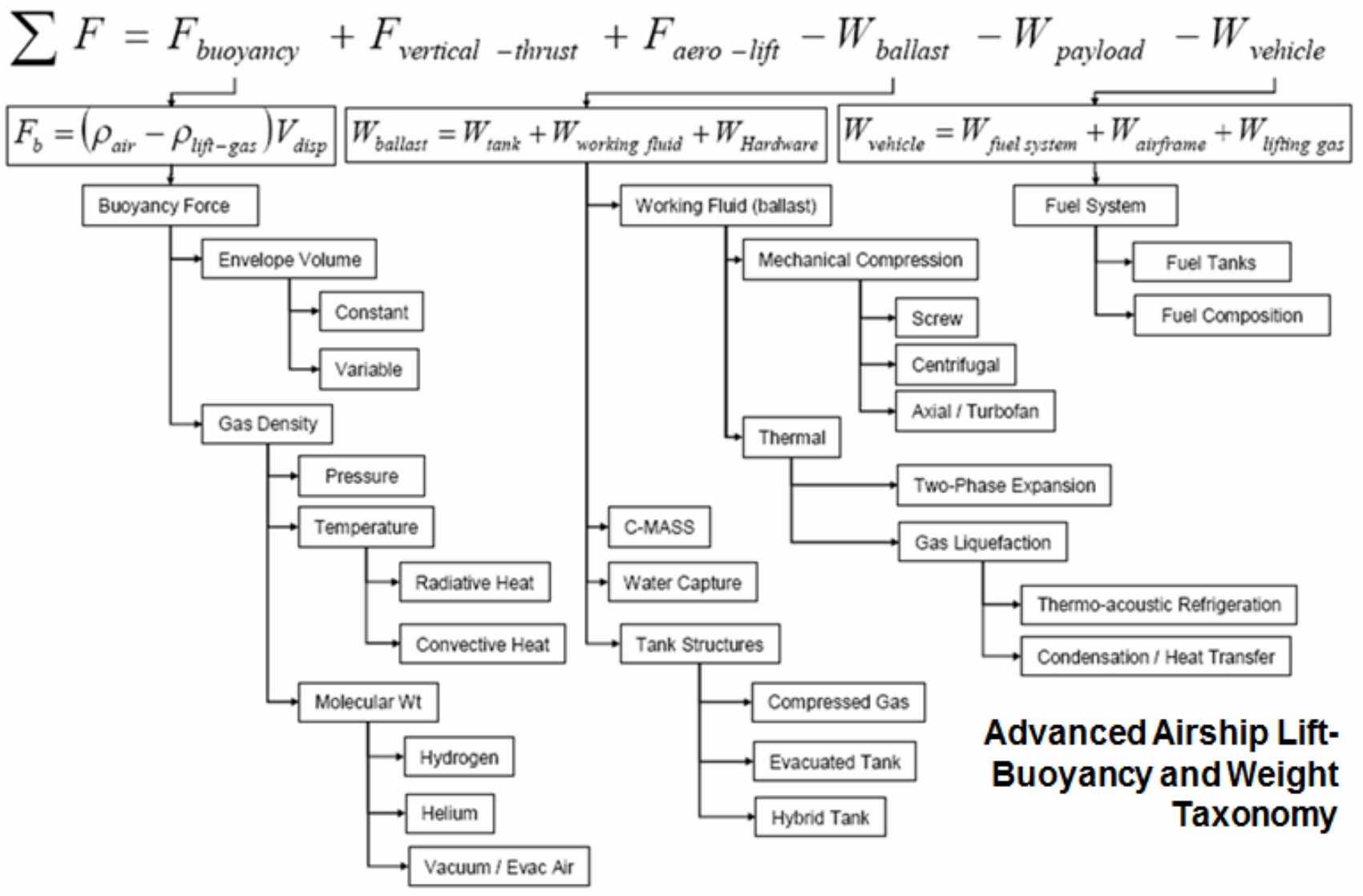
Establishing Point of Design Departure



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Key Configuration Approaches

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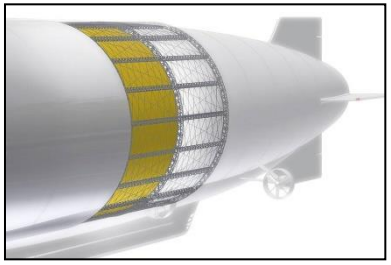
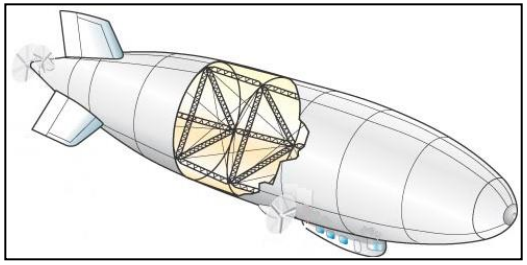
Three structural approaches:

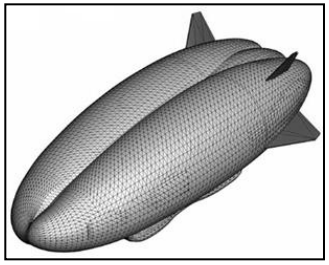
- Rigid
- Non-rigid
- Semi-Rigid



Mold-line Internal Frame



Internal Keel-Frame



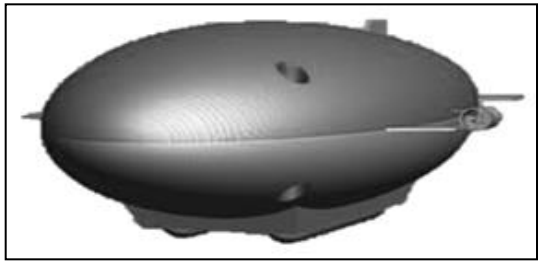
Inflated Envelope(s)

Three primary lift-technology airship approaches:

- Simple buoyancy (Lighter-than-Air (LTA) Flight)
- Hybrid (Heavier-than-Air (HTA) Flight)
- Advanced Technology Airship (Lighter/Heavier-than-Air Flight)

Buoyancy
Thrust Vectoring

Buoyancy
Thrust Vectoring
Aerodynamic Lift (>40% AUW)



Buoyancy
Thrust Vectoring
Aerodynamic Lift
Integrated Lift-Ballast System

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Advanced Modal Flight

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Airship Type	Ground Operation	Take-Off & Ascent	Cruise	Descent & Landing	Payload off -load
Simple Buoyancy 	**LTA** Requires ground crew support	**LTA** Requires ground crew support	**LTA**	**LTA** Requires ground crew support	**LTA** Requires ballast exchange
Hybrid 	**HTA**	**HTA** Requires runway	**HTA**	**HTA** Requires runway	**HTA** Requires ballast exchange
Advanced Technology 	**HTA**	**LTA**	**LTA/HTA** Established by mission needs	**LTA** Hover	**HTA**

Operating Modes:
LTA - Lighter Than Air operation
HTA – Heavier Than Air operation

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Transformational Technology Approach

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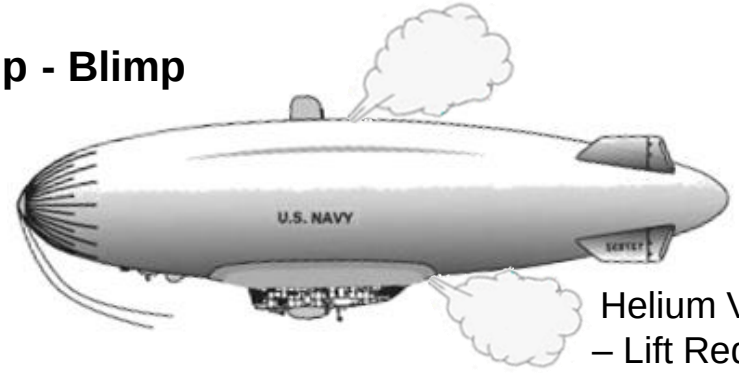
Airship - Blimp

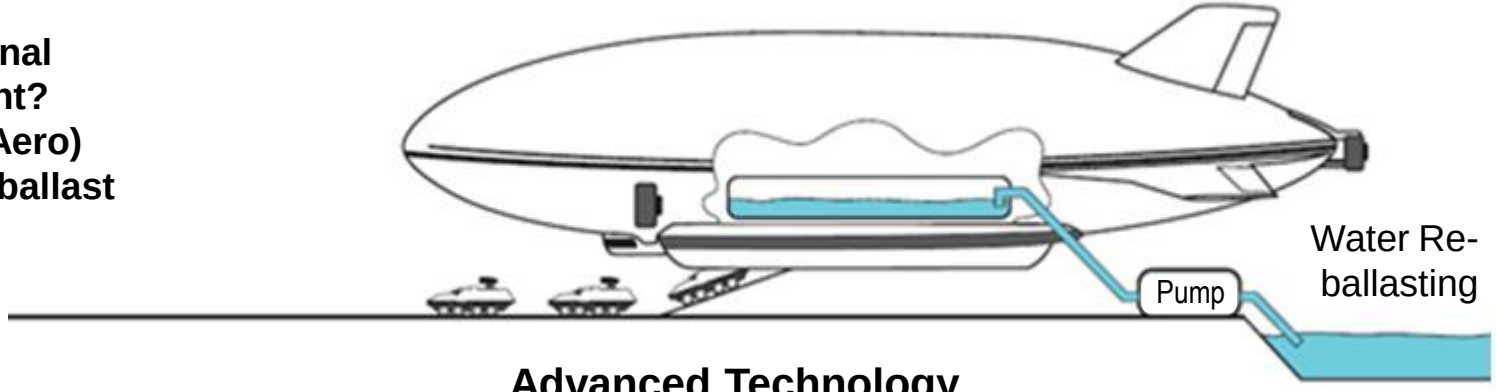
Unloading - additional support requirement?
- **VTOL**
- **Infrastructure required - ballast**
- **Replacement Helium**



Helium Venting – Lift Reduction

Conventional Hybrid

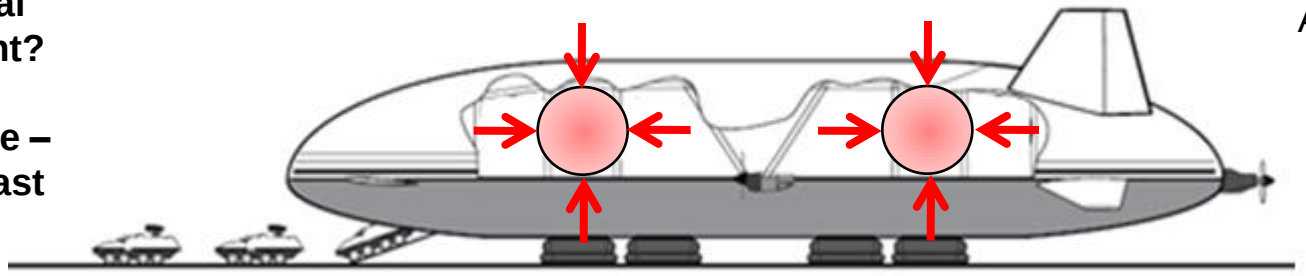
Unloading - additional support requirement?
- **No VTOL (40% Aero)**
- **Infrastructure - ballast**



Water Re-ballasting

Advanced Technology

Unloading additional support requirement?
- **VTOL**
- **No infrastructure – no external ballast source**



Air Vehicle Organic Ballast/ Buoyancy Control System

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Advanced Airship – An Integrated System of Lift-Ballast Systems

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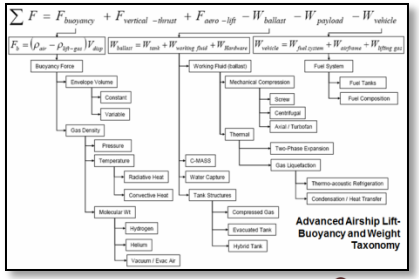

Air Vehicle Structure Trades – Rigid, Semi-rigid or Non-Rigid

Pressurization/ Depressurization Concepts

Modular Cargo Bay Concept

Tank Structure Trades

New Skin Materials

Vectoring Propulsion Technologies

Maintenance Systems (Self Healing Skins)

Gas Buoyancy – Light Gas, Heating and Cooling

New U/C Concepts

Vacuum Ballast Tanks

Diagnostics (Envelope Health)

Adv. Propulsion Technologies – Vapor Recovery

Aerodynamic body/wing/canard lift or tail

Lowered Drag (Reduced Skin Friction)

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Advanced Integrated Lift-Ballast System

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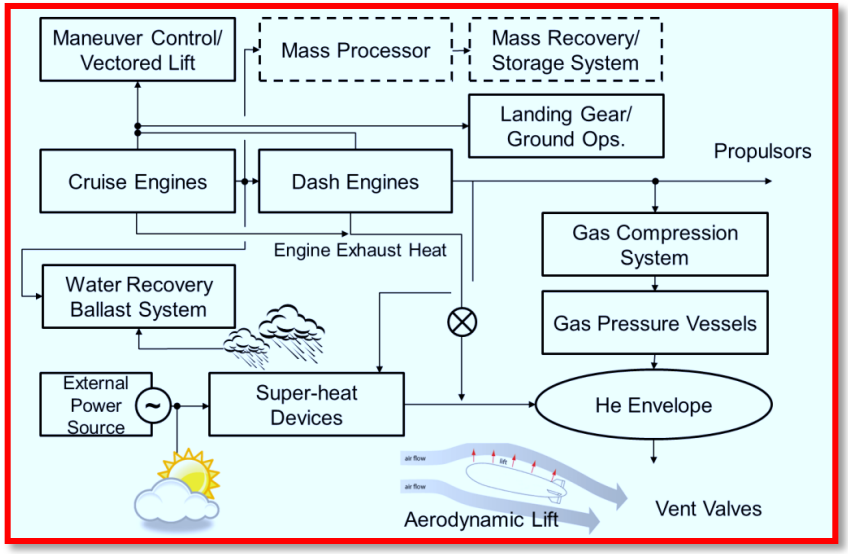
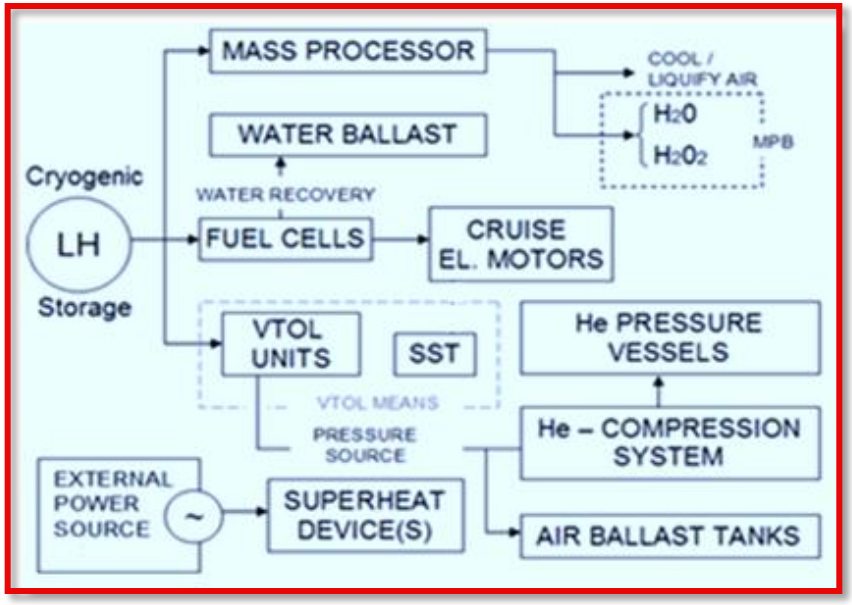
- Two principal aspects:
  - Enabling lift technologies:
    - Aerodynamic Lift
    - Direct Lift
    - Gas buoyancy (static heaviness) manipulation and management systems:
      - Compression
      - Superheat
    - Ballast generation:
      - Condensate
      - Other
    - Fuel choice
  - Integrated operation - working as a fly-and-forget lift control system:
    - Vehicle organic, Full Authority Airship Lift Control system (FAALCS)





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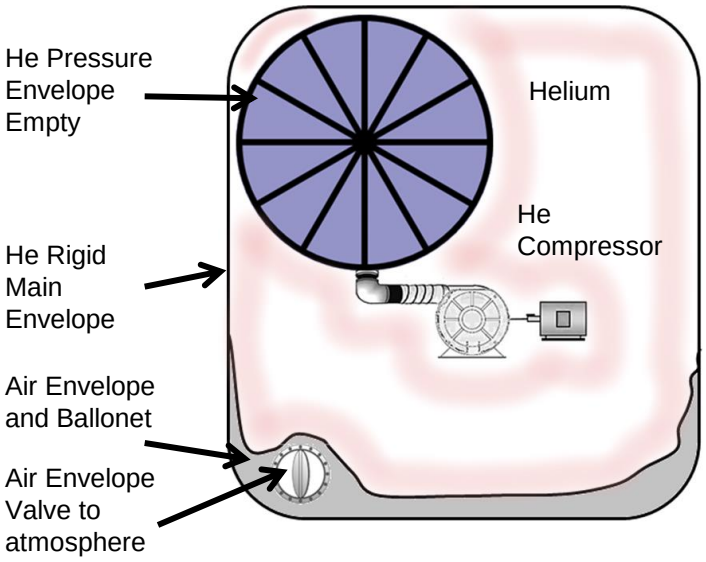
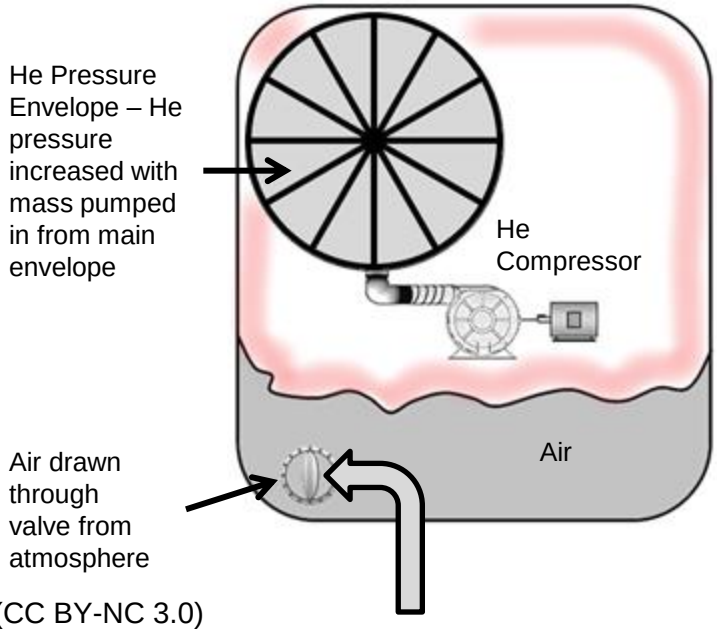
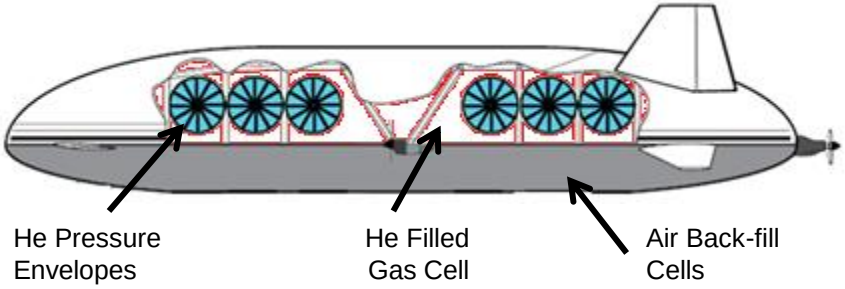
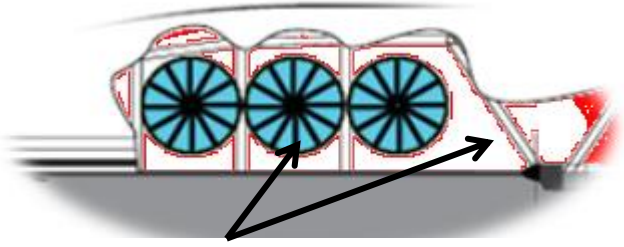
Critical Technology – Static Heaviness Control



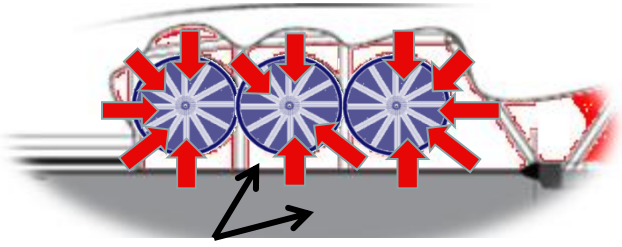
Static Heaviness Increases by the weight of the mass of Air filling the volume void resulting from He being compressed into pressure vessels







- In neutrally buoyant flight
- He in gas cell and pressure envelopes nominally equal
- Air back-fill cells notionally empty



- He volume in the Gas cell is reduced
- Back-filled by off-board air into air containment cells
- Results in overall air vehicle mass ↑
- Air vehicle descends

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Airship Technology ‘Iron Bird’

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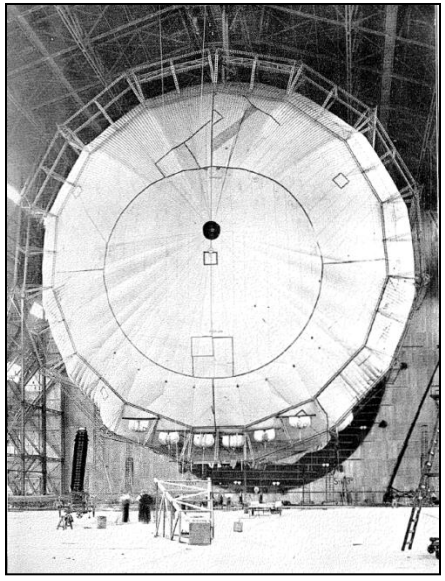
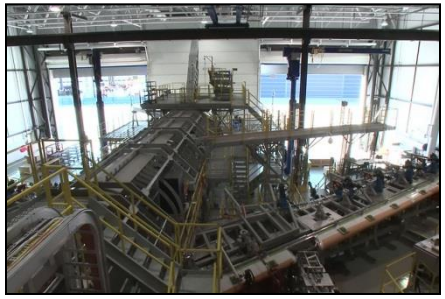
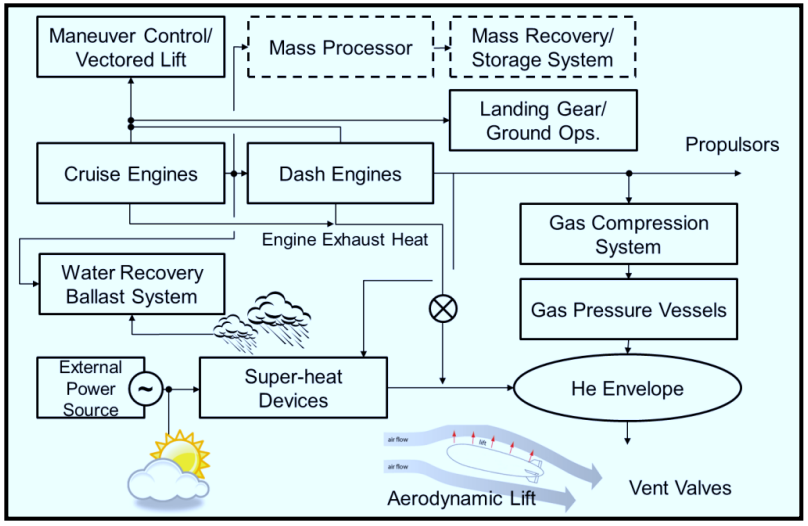
R.101 Lift Bag-Frame ‘Iron Bird’



Bombardier ‘Iron Bird’

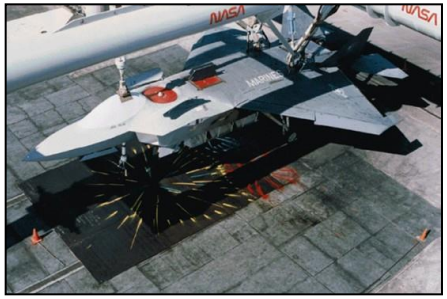


VC 10 ‘Iron Bird’



- Prove feasibility of an advanced airship propulsion-lift/ballast generation system
  - Integration
  - Performance
  - Weight
  - Scalability
  - Discrete technologies – system choice
  - Volume
  - Ballast/lift generation
  - Lift Control response and bandwidth
- Leads to airship concept selection
- On/Off ramp decision point - whether to proceed to flight demonstration or stop
- Affordable – sensibly incremental

DARPA Common Affordable Lightweight Fighter (CALF) ‘Iron Bird’



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Airship Technology 'Iron Bird' – What it will Involve?

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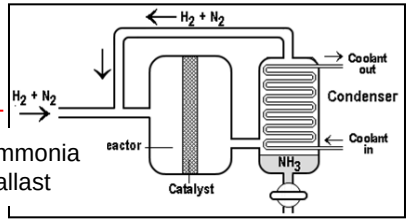
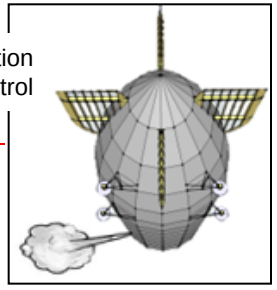


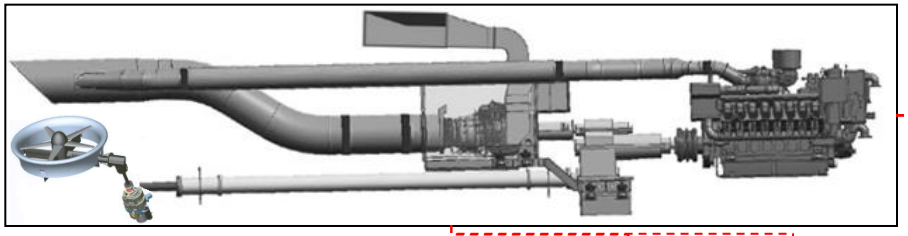
Ammonia Ballast

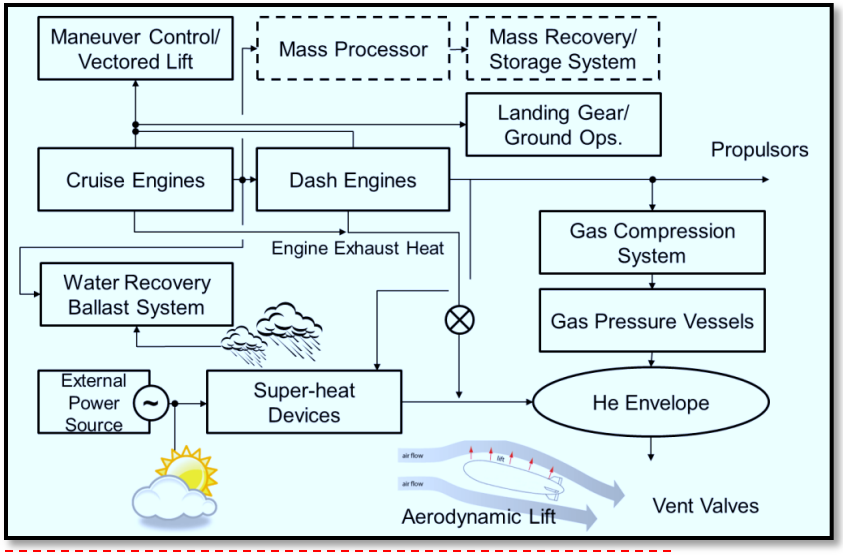
Reaction Control



Landing System

CODOG Power System

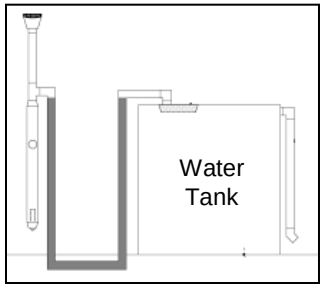




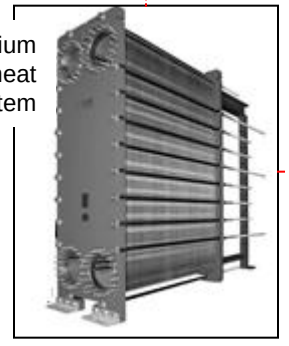
Exhaust Condensate Recovery System

Solar Heat

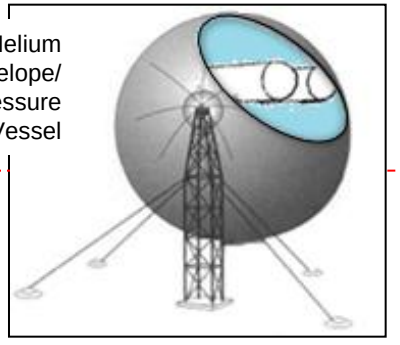
Hull Water Collection Gutter



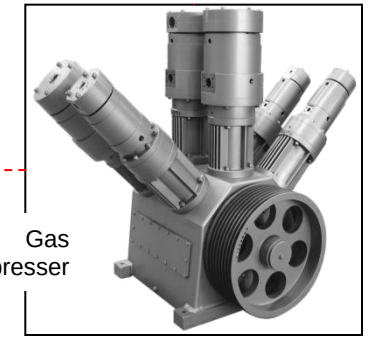
Helium Super-heat System



Helium Envelope/ Pressure Vessel



Gas Compresser



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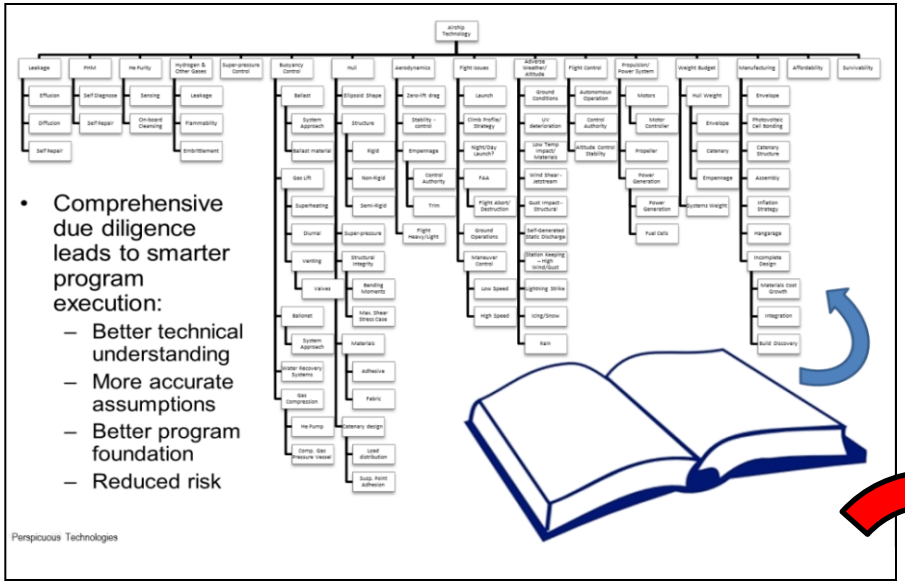
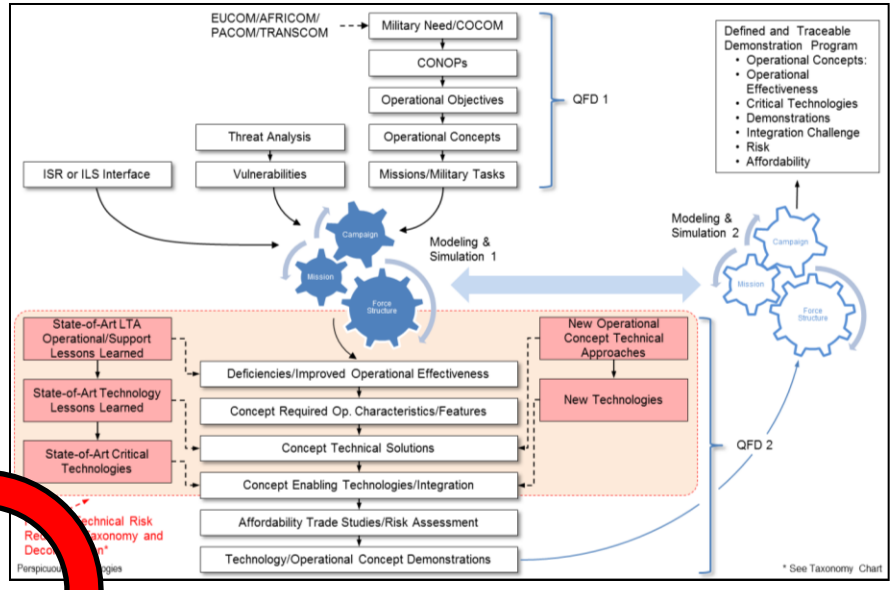
An Airship Development Program To Succeed Where Earlier Efforts Have Failed

Perspicuous Technologies

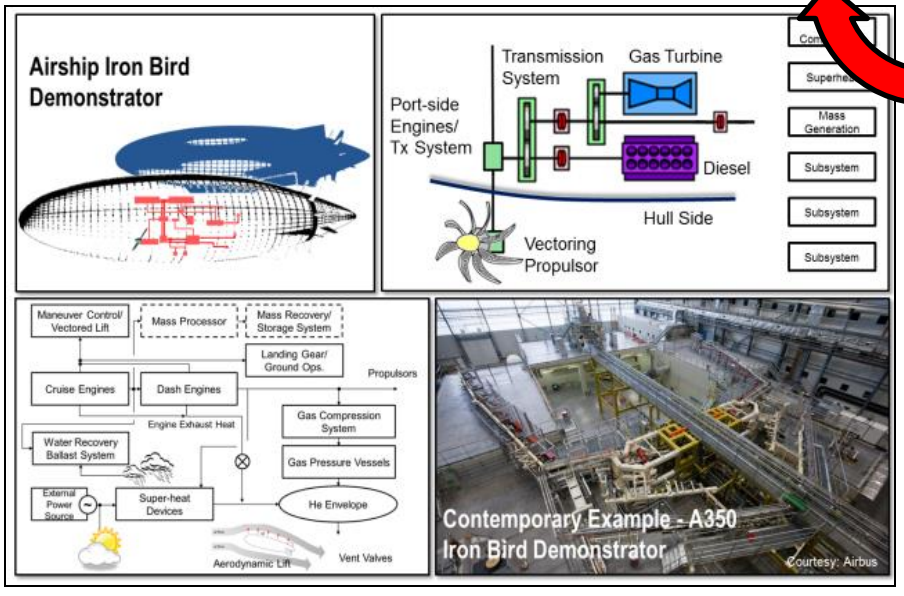
Due Diligence



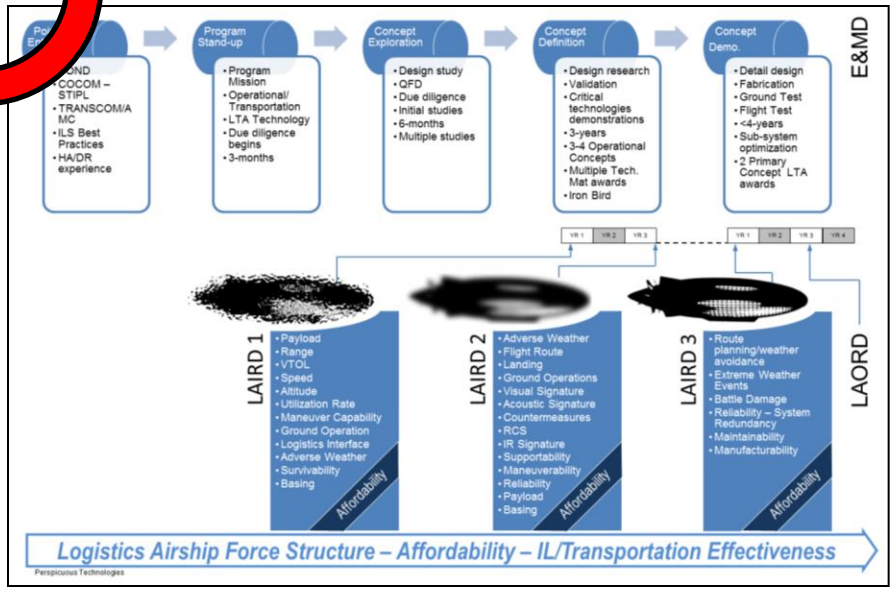
Structured Analysis



Experimentation leads Demo.



Capability Growth



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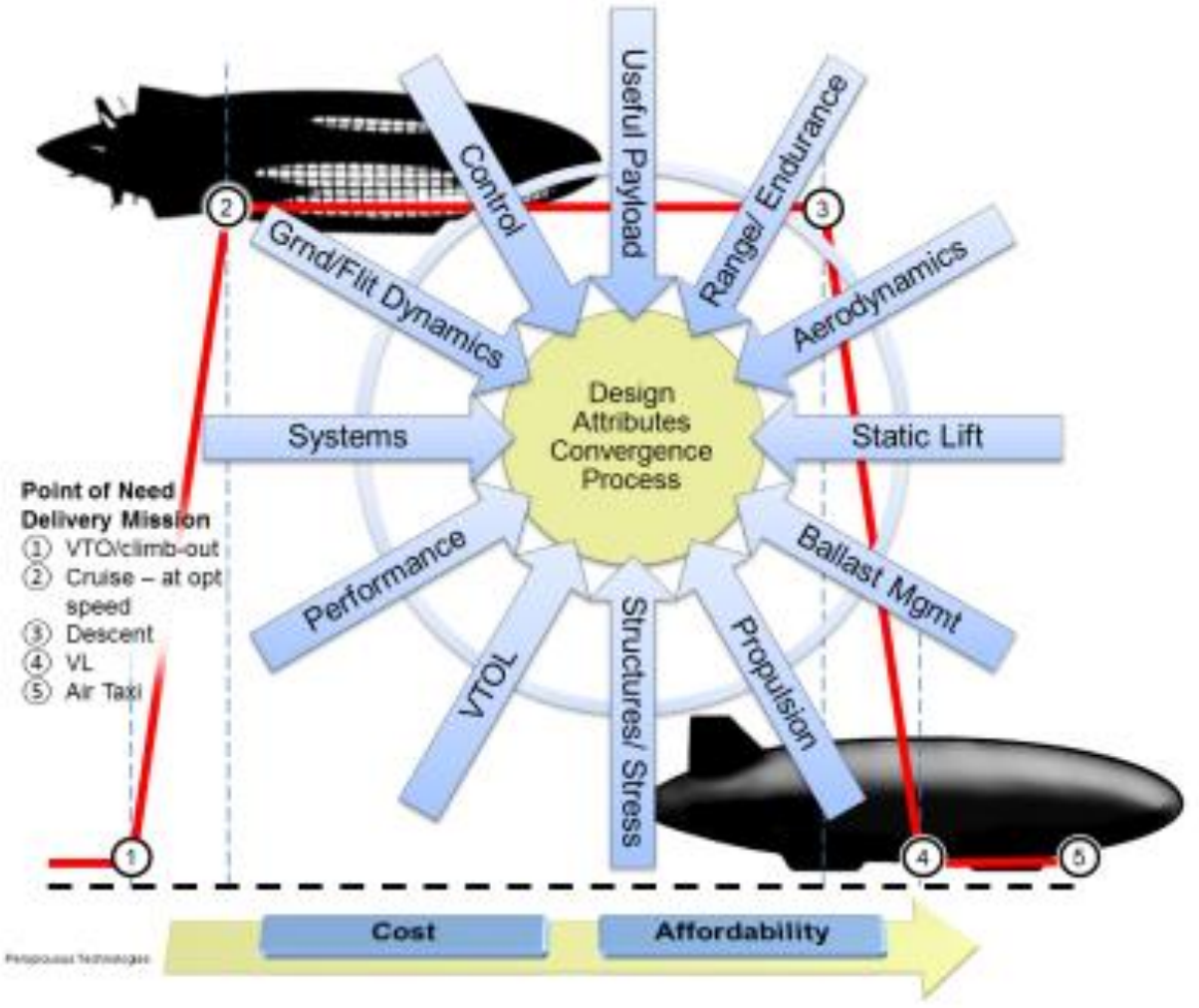
Advanced Air Airship Tradespace

Perspicuous Technologies



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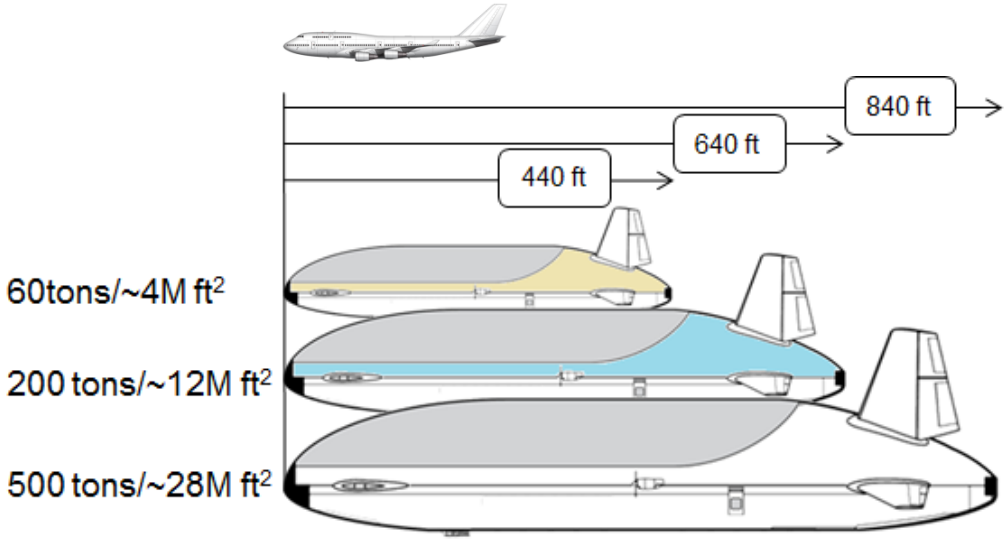
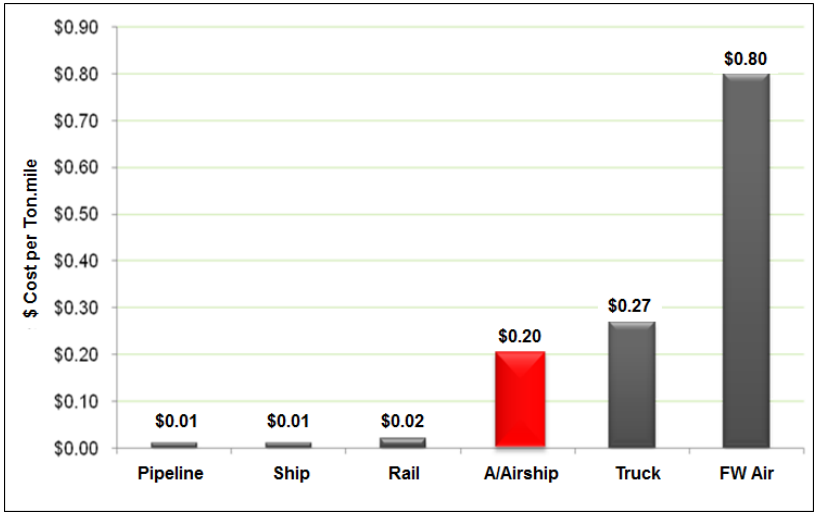
Advanced Air Airship Scaling

Perspicuous Technologies





	C-17	C-130J	C-5	A-400	IL-76 MD	Advanced Airship 60T	Advanced Airship 500T
Length (ft)	174	95.4	247	144.3	150.08	440	840
Span (ft)	165.6	129.3	223	135.68	161.6	160	300
Max Take-off Weight (lb)	583,660	153,450	840,000	310,200	374,000	296,853	2,240,000
Max P/L (lb)	170,500	41,998	263,200	81,400	94,600	134,400	1,120,000
Range @ Max P/L (nm)	2,420	1,800	2,400	2,450	2,200	3,100	5,300
Max Speed (kts)	450	320	500	420	490	110	110

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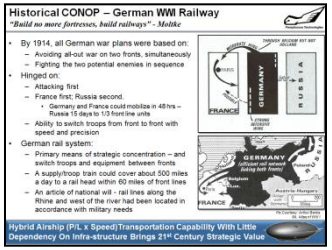
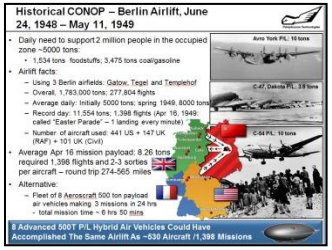
Advanced Air Airship Missions

Perspicuous Technologies

- Inter/Intra-theater - little supporting infrastructure
- Sustainment, logistics re-supply; ship-like or train-like payloads
- VTOL operation - airfield independence – unimproved landing sites
- Helicopter-like hover airlift operations - independence from off-board ballast – operating to a sea base
- Operations above denied access maritime or land and in restricted airspace* – munitions/ personnel

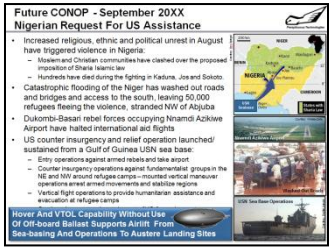


Maneuver



Sustainment

Disaster Relief



Counter Insurgency/ Rescue/Relief

Geo-political Confrontation – Options Other Than "Hot War"

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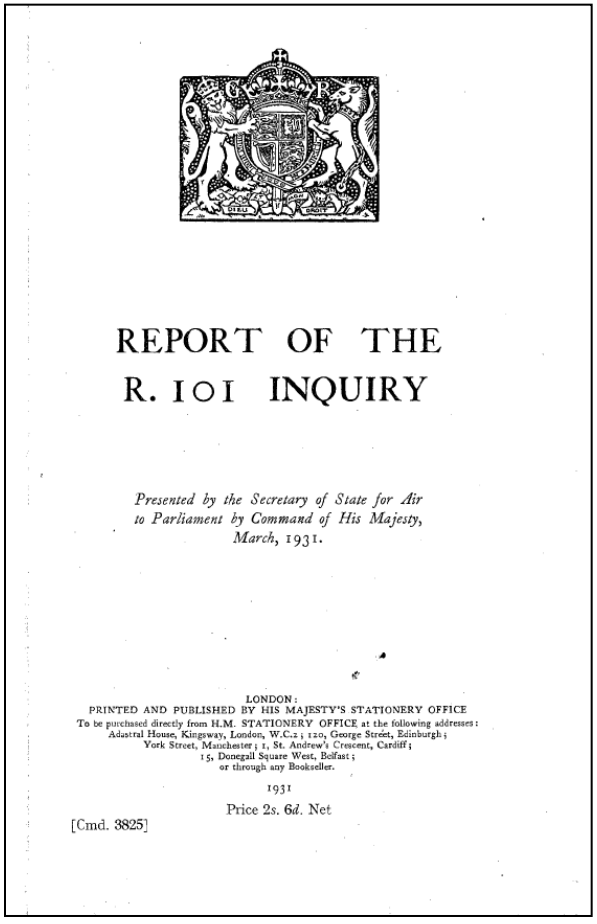
Don’t Read My Book – Read the Simon Report

Perspicuous Technologies



REPORT OF THE
R. 101 INQUIRY

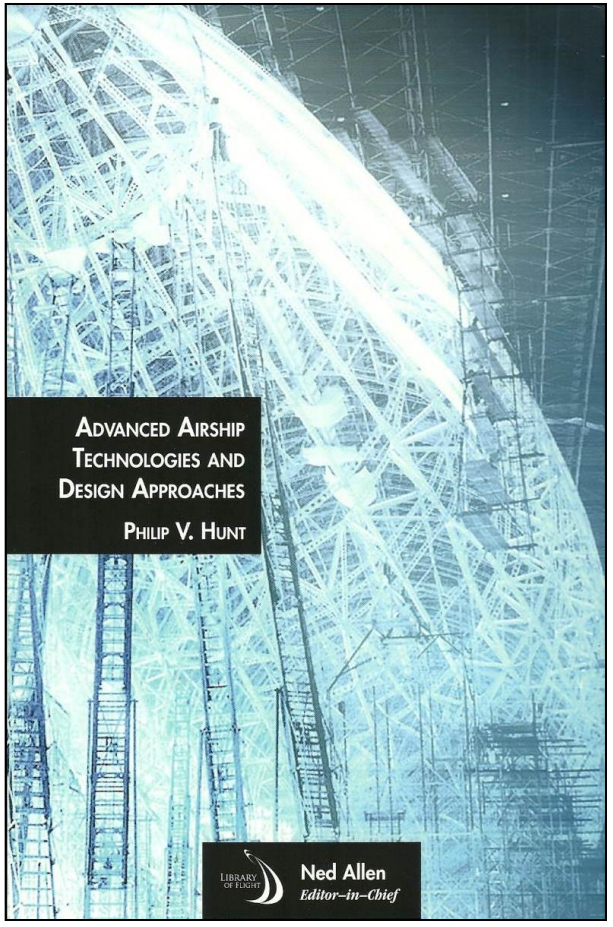
Presented by the Secretary of State for Air to Parliament by Command of His Majesty, March, 1931.

LONDON:
PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C.2; 120, George Street, Edinburgh;
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff;
15, Donegall Square West, Belfast;
or through any Bookseller.

1931

Price 2*s.* 6*d.* Net

[Cmd. 3825]



John Simon Report, March 27, 1931

www.perspictech.com/

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Fueling Advanced Airship Innovation?

Perspicuous Technologies

"Ideas are more powerful than guns. We would not let our enemies have guns, why should we let them have ideas?"

Joseph Stalin

Questions?

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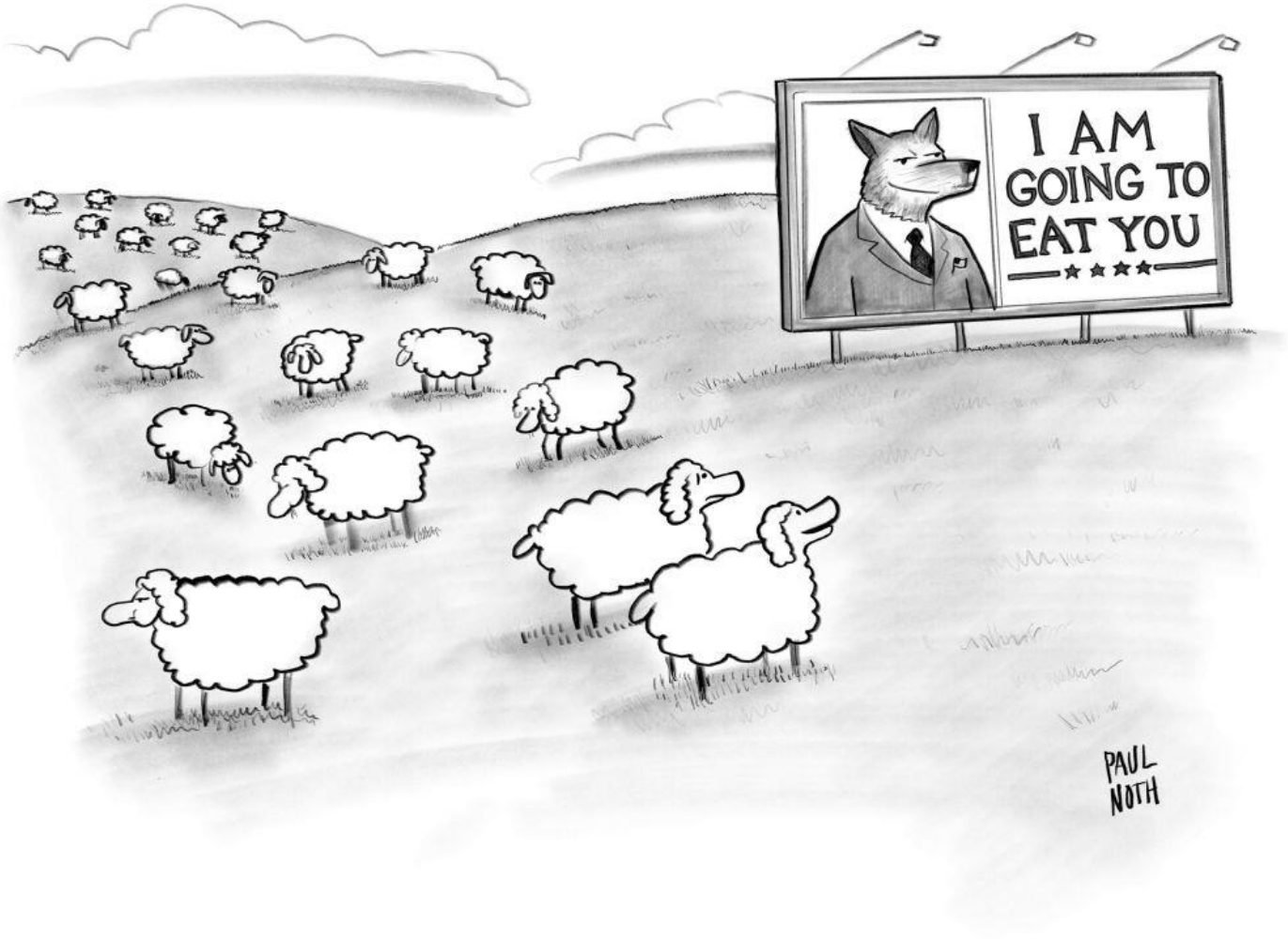
Courtesy: Pictures Wikipedia

“He tells it like it is”

Perspicuous Technologies



BACKUP

New Yorker Cartoon, Published August 29, 2016

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Conflicting Views On Hydrogen Safety

Perspicuous Technologies

"Burns cool and quickly" – This is not a Hydrogen gas burn victim from R101 crash (post October 5, 1930); it is an actor about to audition for the part of the "Invisible Man" in the movie

"Unlikely to explode" – This is not a Hydrogen explosion in the earthquake hit Fukushima Nuclear Power plant's No 3 reactor, and it did not wound 11 people (March 14, 2011) or ex-radiate the area with nuke contamination

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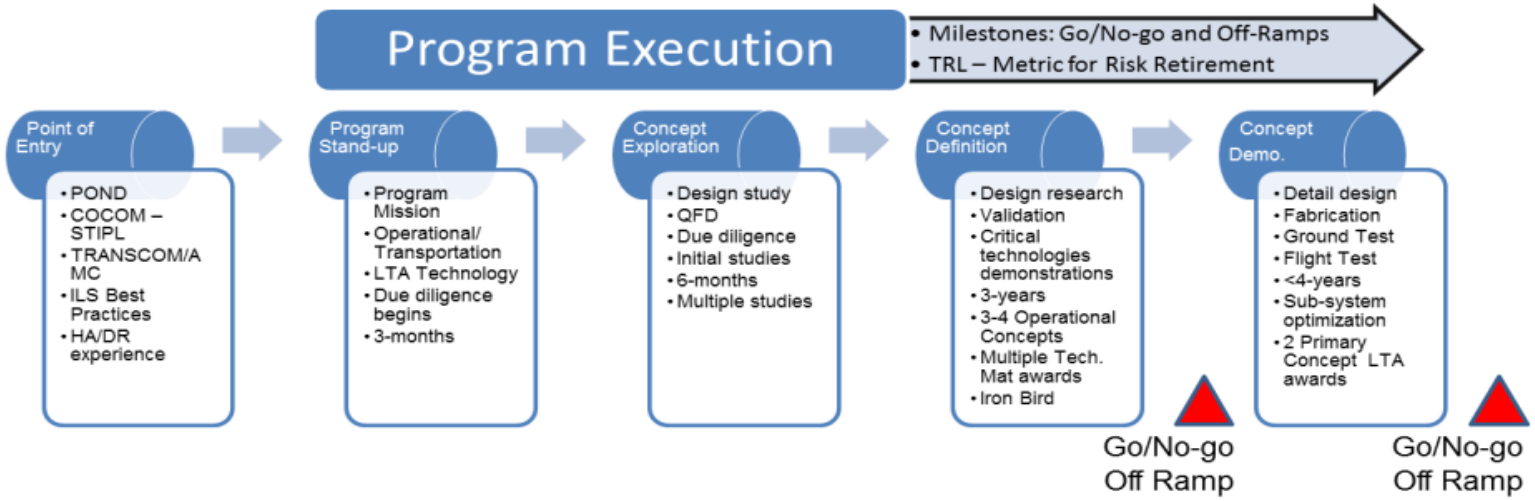
Built-In Airship Program Transparency – Mandate (Off-Ramp)To Stop If Failing Or No Productivity



Stage	Understanding	Feasibility	Exp./Demo./ Maturation	Mature Design/ To Flt Demo
TRL	1	2-3	4-5	6-7

Perspicuous Technologies

Proving Airship Technology Is Within Reach – It Offers Revolutionary Benefits for Transportation and ISR – My Book Offers A Path To Be Successful This Time

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Hydrogen

Perspicuous Technologies

Weight 1000ft^3
- Air 75lb
- H_2 5lb
- He 10lb

Helium Cost

1915	$2500/ ft^3
1940	1.5 Cents/ ft^3
Today	$37.50/ 1000ft^3

Explosion potential
- Liquid H_2 has 2.8 times the energy as gasoline
- Explosive in wider range of concentrations in air (13- to 79-percent) - requires sparkless environment

Hydrogen
- H_2 2.8 x energy density JP-8
- 4 x volume JP-8

Weight Budget

2H2 + O2 -> 2H2O

2kg + 16kg -> 18kg

Fuel Carried X 9 = Water Ballast Weight

- **Helium**
  - Lifting capacity 1000ft^3 around 64lbs
  - Non Flammable
- **Hydrogen**
  - Lifting capacity 1000ft^3 around 70lbs
  - Extremely Flammable
- **Hull delta pressure –** Typical envelope super-pressure (non-rigid) is ~ O.07 – 0.18 psi
- **Air**
  - Weight 1000ft^3 around 75lbs

sfc

Jet A (Turbo Shaft)	0.53 lbs/hp. hr
H_2 (Turbine)	0.18 lb/hp.hr
H_2 (Fuel Cell)	0.11 lb/hp.hr

Storage

STP H_2	0.00561 lb/ft^3
2000 psi H_2	0.723 lb/ft^3
Cryogenic H_2	4.43 lb/ft^3

(C