Sustainable Air Transport by Airship?

Potentials of Lighter-Than-Air

10 December 2020
Hamburg Aerospace Lecture Series

altran

Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V. Bezirksgruppe Hamburg | ROYAL AERONAUTICAL SOCIETY HAMBURG BRANCH e.V. | ZAL | VDI Verein Deutscher Ingenieure Hamburger Bezirksverein e.V. Arbeitskreis Luft- und Raumfahrt

HAW HAMBURG

Hamburg Aerospace Lecture Series

Hamburger Luft- und Raumfahrtvorträge

DGLR in cooperation with the RAeS, HAW Hamburg, ZAL and VDI invites to a lecture

Sustainable Air Transport by Airship?

Dipl.-Ing. **Johannes Eißing**, ALTRAN Deutschland

Date: **Thursday, 10 December 2020, 18:00**

Online: http://purl.org/ProfScholz/zoom/2020-12-10

For a group of missions, airships can provide an answer to the goals set by Flightpath 2050 such as drastic emission reductions, safety, and cost reduction. Where slow and low flying as well as vertical take-off and landing are prerequisites, airships offer a tried and tested alternative with considerable fuel savings. The lecture is dedicated to the topic of eco-efficiency in aircraft design. Advantages of airships versus obstacles and boundary conditions in airship development are discussed.

The dawn of the airship

John Murphy, CC BY-SA, https://bit.ly/37zPxUT

HAW/DGLR Prof. Dr.-Ing. Dieter Scholz Tel.: (040) 42875-8825 info@ProfScholz.de

RAeS Richard Sanderson Tel.: (04167) 92012 events@raes-hamburg.de

Hamburg Aerospace Lecture Series DGLR HAW Hamburg RAeS VDI ZAL

DGLR Bezirksgruppe Hamburg https://hamburg.dglr.de

RAeS Hamburg Branch https://www.raes-hamburg.de

ZAL TechCenter https://www.zal.aero

VDI Hamburg, Arbeitskreis L&R https://www.vdi.de

Die ***Hamburg Aerospace Lecture Series*** (http://www.AeroLectures.de) wird gemeinsam veranstaltet von DGLR, RAeS, ZAL, VDI und HAW Hamburg (Praxis-Seminar Luftfahrt, PSL). Der Besuch der **Veranstaltung ist steuerlich absetzbar**. Bringen Sie dazu bitte eine ausgefüllte Teilnahmebestätigung zur Unterschrift zum Vortrag mit. Mittels **E-Mail-Verteilerliste** wird über aktuelle Veranstaltungen informiert. **Vortragsunterlagen** vergangener Veranstaltungen, aktuelles **Vortragsprogramm**, Eintrag in E-Mail-Verteilerliste, Vordrucke der Teilnahmebestätigung: Alle Services über das Internet: http://www.AeroLectures.de .

About The Author

Johannes Eissing
Expert
Dipl.-Ing. Aircraft Design
HAW Hamburg

CargoLifter Development
Brandenburg
Aerodynamics

Boeing
High Altitude Airship
Sizing-Lofting-Performance

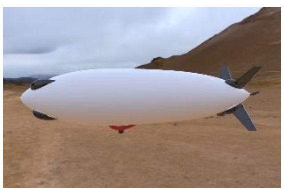
IBK
Airbus Hamburg
Component Loads

Zeppelin Luftschifftechnik
Friedrichshafen
Flight Physics

HEAD Engineering
Airbus Hamburg
In-Flight Loads Simulations

Airship Ventures
Moffett Field
California

P3 Voith
Airbus Hamburg
In-Flight
Incident Investigations



Altran Germany
LTA Aerostructures
Cargo Airships for Canada

Altran Germany
AerobotX
ObliX LTA UAV

Altran Germany
Airbus DS
ALtAIR LTA UAV
CONOPS/Flight Simulation

Altran Germany
Altran Spain
ECOSAT HAPS

Altran Germany
Innovation
Printed Electrics

Leadership across 3 domains and 11 industries

Product Design & Engineering

Accelerate the design and development of tomorrow's products & services

Digital & Software

Foster digital transformation at scale throughout value chains and ecosystems

Manufacturing & Operations

Increase industrial performance and manage transition to Industry 4.0

Automotive

Aeronautics

Space, Defense & Naval

Rail, Infra & Transportation

Energy

Industries

Life Sciences

Communi-cations

Semiconductor & Electronics

Software & Internet

Finance & Public Sector

Who is altran ?

altran

Agenda

1 Eco-Efficiency in Aircraft Design

2 Flightpath 2050

3 Where and why can Airships be superior?

4 Obstacles for Airship Development

5 Essential Boundary Conditions

6 Way Forward

Agenda

1 Eco-Efficiency in Aircraft Design

2 Flightpath 2050

3 Where and why can Airships be superior?

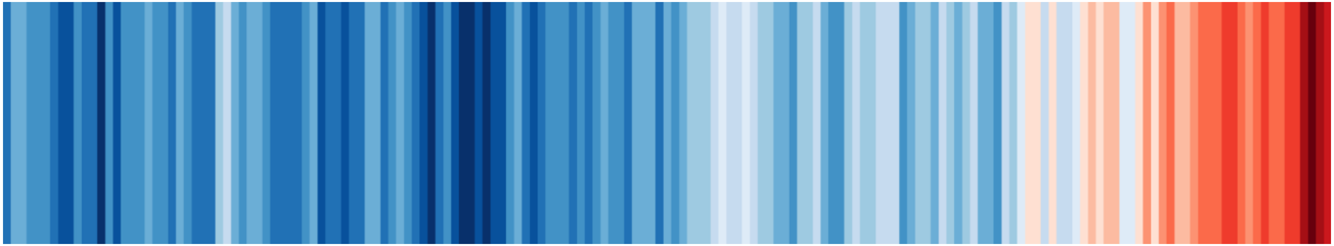
4 Obstacles for Airship Development

5 Essential Boundary Conditions

6 Way Forward

altran

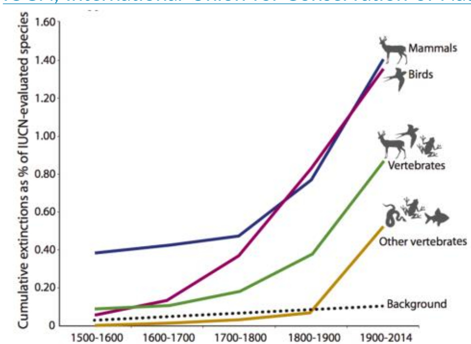
1 Eco-Efficiency in Aircraft Design



Ed Hawkins, representation of temperature from 1850-2017

- Climate change
- Species extinction
- UN Sustainability Goals

IUCN, International Union for Conservation of Nature



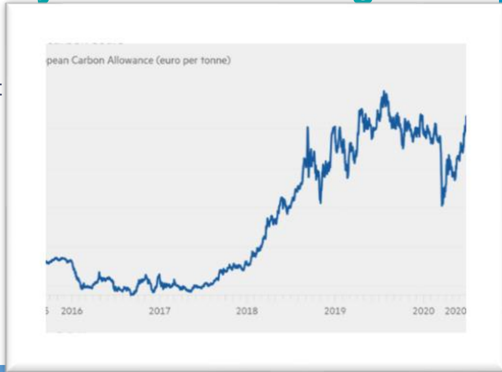
https://advances.sciencemag.org/content/1/5/e1400253

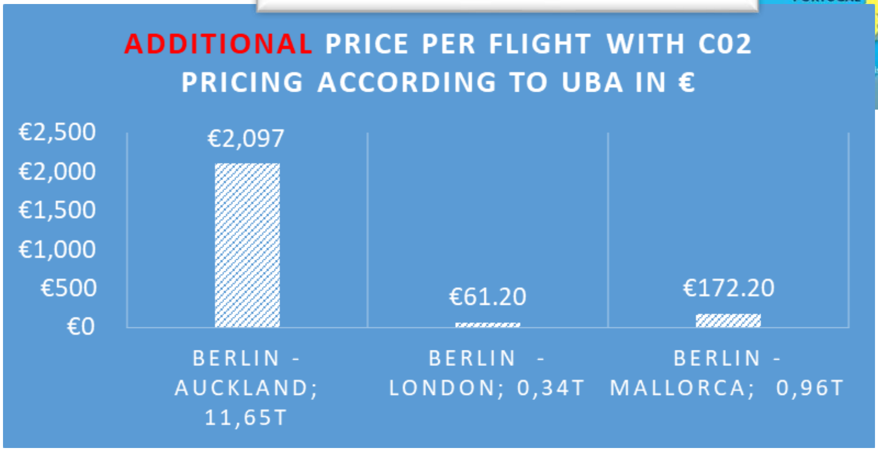
altran

1 Eco-Efficiency in Aircraft Design

CO2 Tax

Carbon Allowance market





Source: https://www.welt.de/wirtschaft/article191661247/

CO_2 Emission Allowance July 2020: €27/tonne

altran

Agenda

1 Eco-Efficiency in Aircraft Design

2 **Flightpath 2050**

3 Where and why can Airships be superior?

4 Obstacles for Airship Development

5 Essential Boundary Conditions

6 Way Forward

2 Flightpath 2050

Flightpath 2050 - Europe's Vision for Aviation
Report of the EU High Level Group on Aviation Research
https://ec.europa.eu/transport/sites/transport/files/modes/air/doc/flightpath2050.pdf

Goals for 2050 (as compared to 2000):

Safety
- 80% reduction of the number of accidents for SAR Missions

- Manned and unmanned air vehicles to safely operate in the same airspace.

Emmissions
- 65% reduction of noise emmissions
- 75% reduction in CO_2 emissions
- 90% reduction in NO_x emissions

Costs
- 50% reduction in cost of certification

Agenda

altran

3 Where and why can airships be superior?

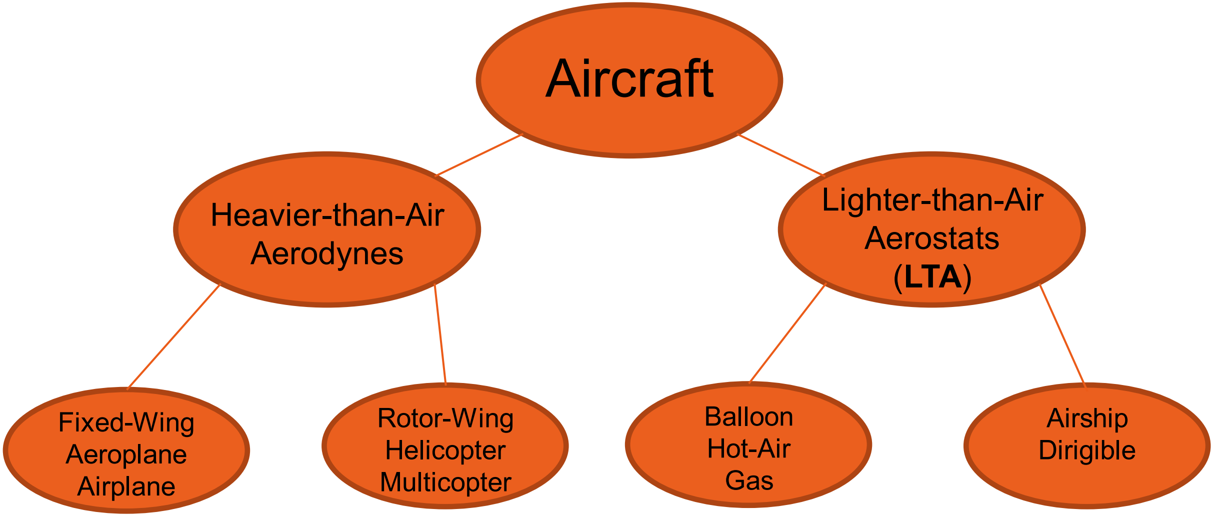
LTA – What is This?

Efficiency

Safety

Costs

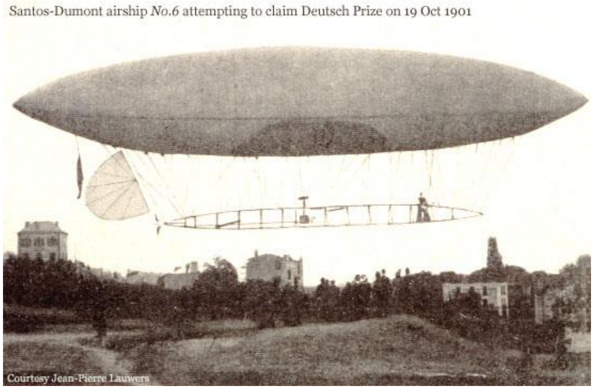
3 Where and why can airships be superior?
→ LTA – What is This?



3 Where and why can airships be superior?
→ LTA – What is This?

Wright Brothers
December 1903
59 sec
260 m

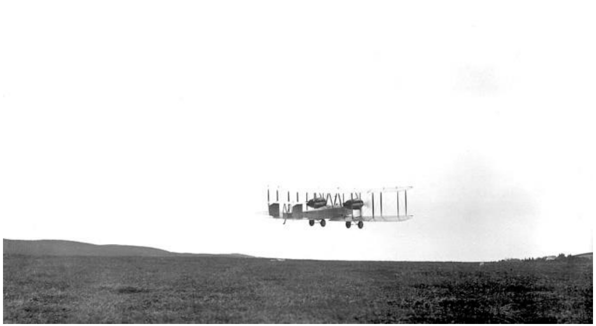
Alberto Santos Dumont
October 1901
30 min
15 km

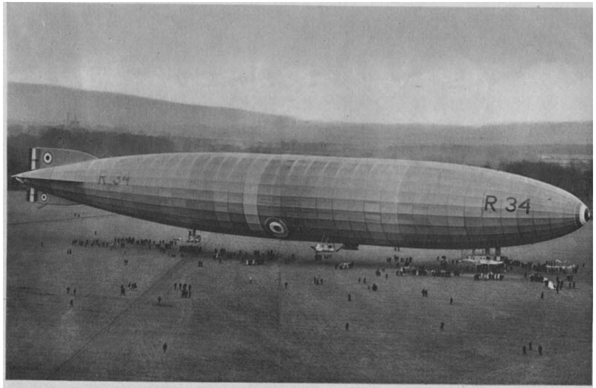


3 Where and why can airships be superior?
→ LTA – What is This?

June 1919
John Alcock
Arthur Whitten Brown
Atlantic West – East

July 1919
Major George Herbert Scott
31 Crew
Atlantic East – West – East
+ 1 Blind Passenger
+ 1 Cat („Whoopsie“)





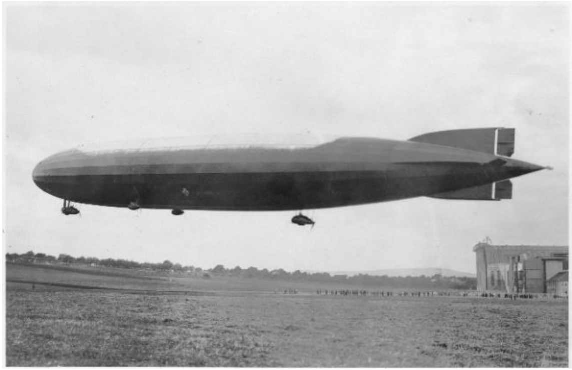
R34, Britain's titanic airship, 670 feet long and 1,250 h.p., launched at Inchinnan, near Glasgow, March 14th, 1919.

3 Where and why can airships be superior?
→ LTA – What is This?

LZ 101/„L 55“
October 1917
Altitude 7600 m

LZ 104/„L 59“ “Africa Ship”
November 1917
95 Hours
6757 km
50 tonnes Useful Load

(Compare 1956
Douglas C-133 Cargomaster)



altran

3 Where and why can airships be superior?
→ Efficiency

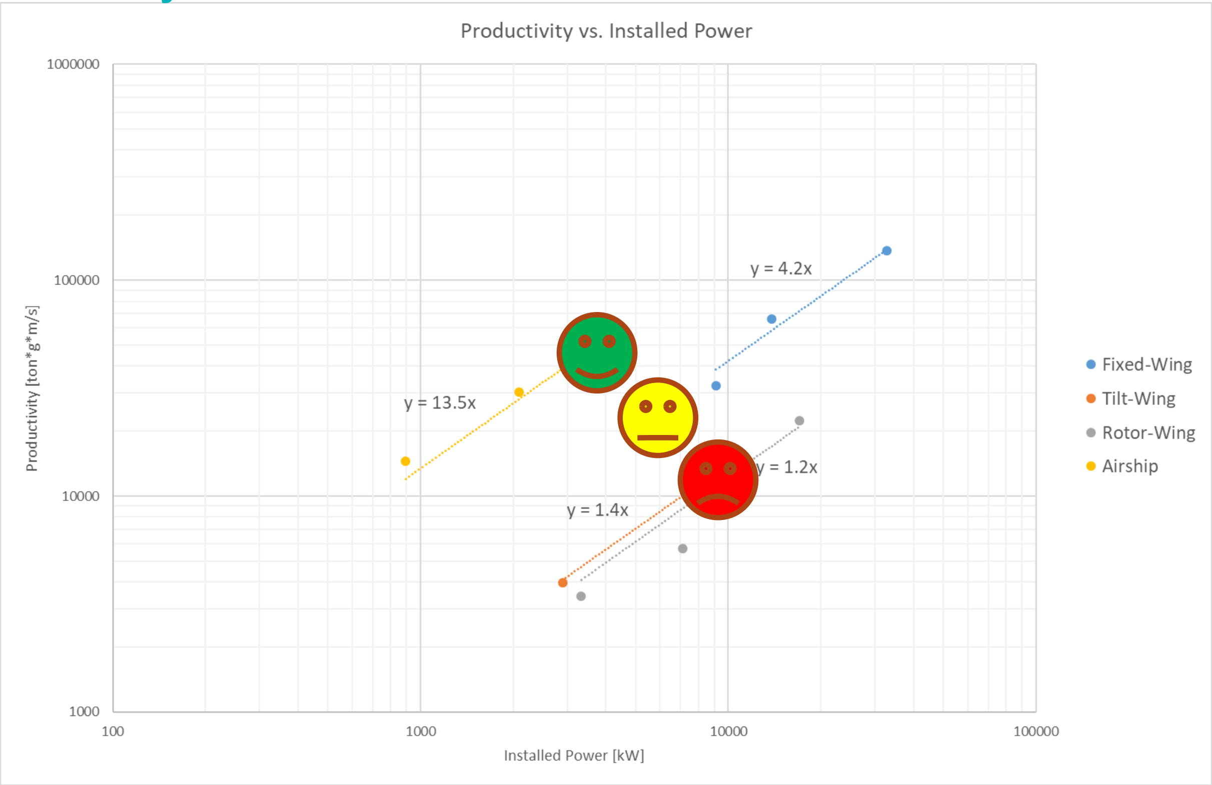
A/C	Name	MTOW	OWE	OWE/ MTOW	MTOW -OWE	Max Speed	Max Speed	Productivity	Installed Power	ε*	η**
		[ton]	[ton]	[%]	[ton]	[m/s]	[kmh]	[ton*g*m/s]	[kW]	[-]	[-]
Fixed-Wing	**Average**			**52%**			**655**			**0.11**	**4.2**
A400M	A400M	141.0	76.5	54%	64.5	217	781	137229	32800	0.11	4.2
C-160 NG	Transall	51.0	27.8	54%	23.2	143	513	32447	9098	0.13	3.6
C-130J	Hercules	70.3	34.3	49%	36.0	186	671	65862	13832	0.11	4.8
Tilt-Wing	**Average**			**64%**			**547**			**0.26**	**1.4**
V-22 STO	Osprey	24.9	14.8	59%	10.2	157	565	15622	9180	0.24	1.7
V-22 VTO	Osprey	21.5	14.8	69%	6.7	157	566	10405	9180	0.28	1.1
AW609	AgustaWestland	7.6	4.8	63%	2.9	141	509	3959	2894	0.27	1.4
Rotor-Wing	**Average**			**52%**			**266**			**0.48**	**1.0**
S-64	Skycrane	19.1	8.7	46%	10.3	56	203	5710	7110	0.67	0.8
Mi-26	Halo	56.0	28.2	50%	27.8	82	295	22341	17000	0.38	1.3
NH90	NH90	10.6	6.4	60%	4.2	83	300	3432	3324	0.38	1.0
Airship	**Average**			**44%**			**122**			**0.04**	**14.6**
LZ-129	Hindenburg	242.0	118.0	49%	124.0	38	135	45603	3532	0.04	12.9
LZ-127	Graf Zeppelin	126.6	62.1	49%	87.0	35	128	30286	2088	0.05	14.5
L-59	"Afrika Schiff"	79.5	27.6	35%	51.9	29	103	14563	895	0.04	16.3

*ε = Specific Resistance = P/(MTOW x V) [kW/(tonne x g x m/s)]

**η = Transport Coefficient = ((MTOW-OWE)*g*V)/P [(tonne*g*m/s)/kW]

altran

3 Where and why can airships be superior?
→ Efficiency



3 Where and why can airships be superior?
→ Safety

Balloon mode: "Don't use the **E**-Word!"

→ An "All Engines Out" is not an **E**mergency

Impact Energy

→ If they come down, they come down slowly

Visibility, LoS, Distance

→ Size Does Matter

No Downwash

→ Safer for Pax and Groundcrew

altran

3 Where and why can airships be superior?
→ Costs

- **Certification Specifications**

• Commuter Airplane:	CS-23:	429 pages
• Commuter Airship:	CS-30C:	76 pages
• Transport Airplane:	CS-25:	473 pages
• Transport Airship:	CS-30T:	125 pages

- **Engine and DOC**
  - Acquisition
  - Depreciation
  - Maintenance
  - Fuel burn

altran

3 Where and why can airships be superior?
→ Costs

- **Low Altitude**
  - No Oxygen Systems
  - No Cabin Pressurization

- **Low Speed**
  - Dynamic Pressure
  - Inertia Loads
  - ~~Mach Effects~~

altran

Agenda

1 Eco-Efficiency in Aircraft Design

2 Flightpath 2050

3 Where and why can Airships be superior?

4 **Obstacles for Airship Development**

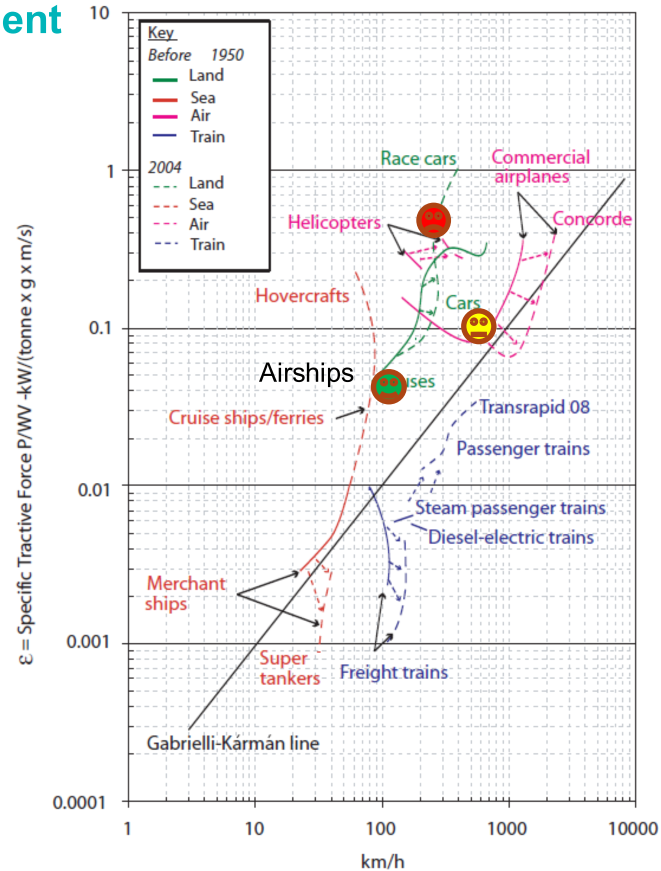
5 Essential Boundary Conditions

6 Way Forward

4 Obstacles for Airship Development

Speed
- Airplanes and Helicopters are faster
- PAX = Time-critical Cargo

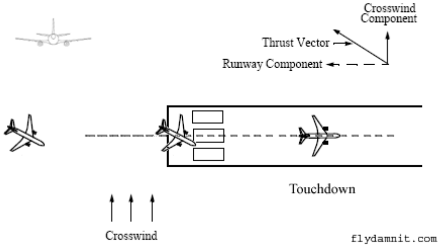
Infrastructure
- Hangar
- Mast
- Helium Supply
- Ground Crew



Source: "WHAT PRICE SPEED – REVISITED"

altran

4 Obstacles for Airship Development



Prejudice

- **But the Side-Wind!**
  → Airships usually dont fly sidewards
  → As VTOL aircraft, airships dont do crosswind starts and landings

- **But they are soo slow!**
  → Airships withstand wind of **70kts** on the mast (Beaufort 12)
  → **70kts** is a common top speed for airships

- **But the Hindenburg exploded!**
  → „The Lifting gas must be non-flammable!“
  → 62 out of 97 persons on bord survived

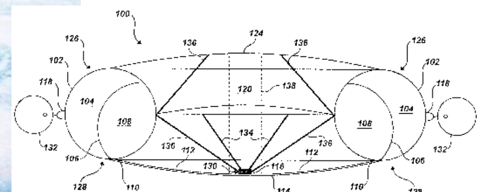
altran

4 Obstacles for Airship Development

Reinventing the Wheel:

Off-Eqilibrium Airships („Air Vehicles“) →
- About 50% heavier than air
- No Balloon mode
- Snow loads
- Landing loads
- Larger Fins needed (Weight and Drag)
- Need run-way, but can‘t handle side-wind

← Lenticular Airships →
- See above
- Unstable in pitch and yaw



← Variable Buoyancy Airships
- Burgess‘ Book „Airship Design“:
- Chapter „Known Airship Fallacies“:
- → Heavy, complex, Fuel-hungry

Agenda

5 Essential Boundary Conditions

Economical
CO2 tax
(Compare Oil Crises)

Ecological
Emission Reduction
CO2 Footprint

Political
LTA as Clean Sky Topic

→ Clean Sky 3 Time is now!

Agenda

1 Eco-Efficiency in Aircraft Design

2 Flightpath 2050

3 Where and why can Airships be superior?

4 Obstacles for Airship Development

5 Essential Boundary Conditions

6 Way Forward

6 Way Forward

LTA UAVs

Fuel Gas

Fuel-Cell

Photovoltaics

HAPS

Utility Airship

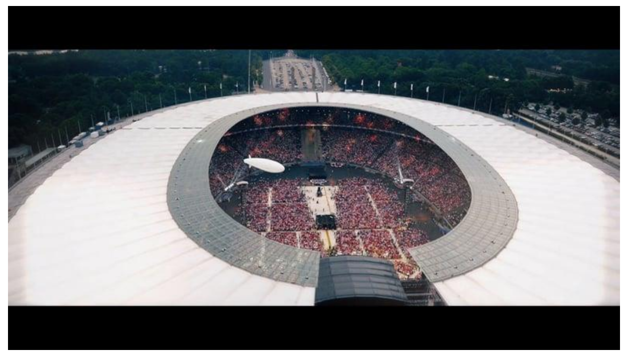
6 Way Forward, LTA UAVs

LTA UAVs

- SORA Risk Assessment
- Permit to Fly
- Endurance

Jülich Institute „FieldShip“

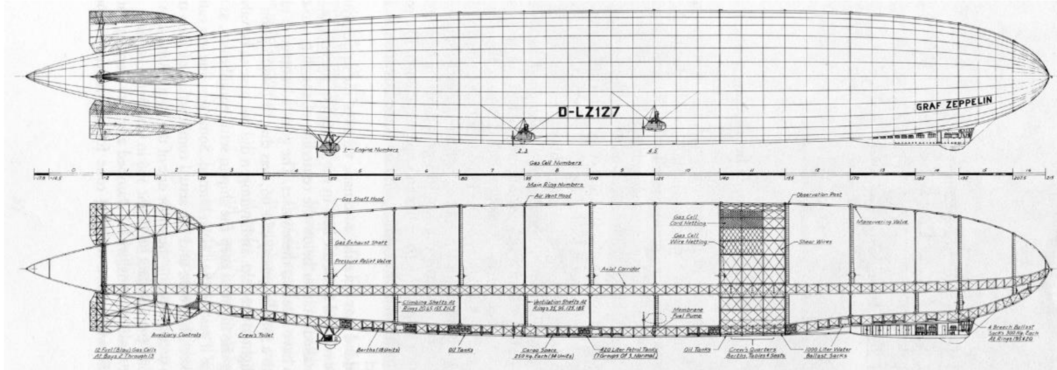
Airbus DS „ALtAIR“



TVN‘s „TVN-Z1“
Berlin Olympiastadion

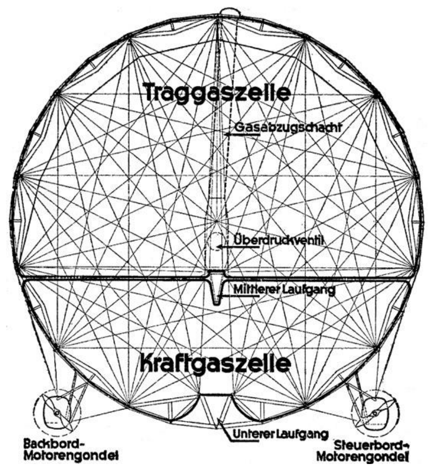
altran

6 Way Forward, Fuel Gas



Fuel Gas

- 90 Years ago: Around the World on „Fuel Gas“
- Fuel with „No Weight“
- Redefinition of Energy Density
- Bio Gas?



altran

6 Way Forward, Fuel Cells

Fuel-Cell

- Better Energy Density Than Batteries
- What if …

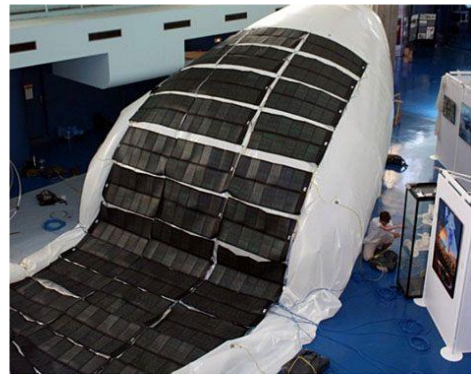
  H2 was carried as a Gas?
  (No Weight!)

Disrupt That!

Kelluu, Finland

altran

6 Way Forward, Photovoltaics



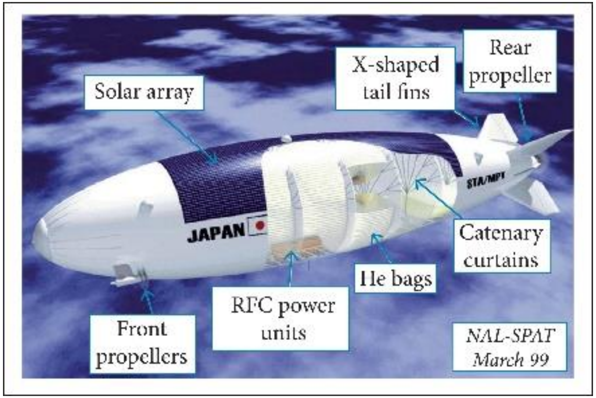
Photovoltaics

- Large Surface Area
- Photovoltaics on Rigid Airships:
- Outer cover is secondary structure

(Imagine Solar Impulse, around the world in one go,
But with proper bunks and – toilets!)

6 Way Forward, HAPS

HiSentinel80 Airship, SwRI, Aerostar



High Platform II Airship, 1970, Raven

HAPS: High Altitude Pseudo Satelites

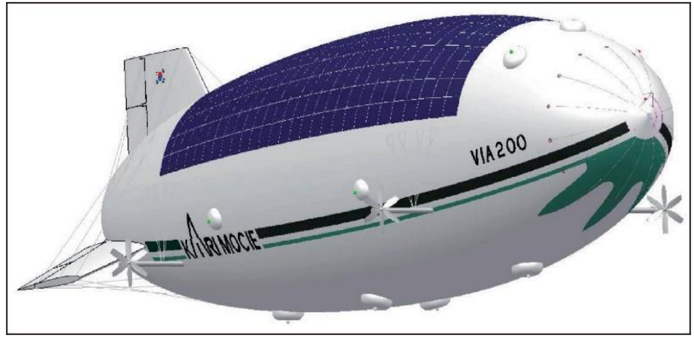
Ecosat, Altran Spain

altran

6 Way Forward, HAPS

Thales Alenia Space' Stratobus

Lockheed Martin HALE-D



VIA 200 Airship, KARI (Bang et al. 2008)

HAPS: High Altitude Pseudo Satelites

6 Way Forward, Utility Airship

easn European Aeronautics Science Network

https://easn.net/research-technology-areas/10/#128

AERONAUTICAL RESEARCH & TECHNOLOGY AREAS:

Innovative Concepts and Scenarios:

Unconventional configurations and new aircraft concepts:

Lighter-than-air (LTA) vehicles/airships - cargo transport, surveillance, communications, remote imaging.

altran

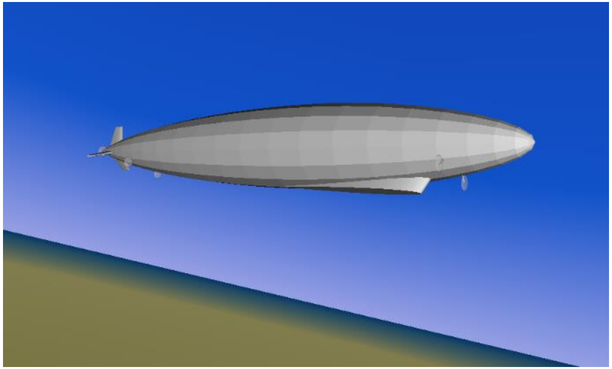
6 Way Forward

easn European Aeronautics Science Network

Lighter-than-air (LTA) vehicles/airships – cargo transport, surveillance, communications, remote imaging:

Proposed Technology Demonstrator:

Rigid Airship
Commuter Category
MTOW 14.7 tonnes
Length 110m



altran

Summary

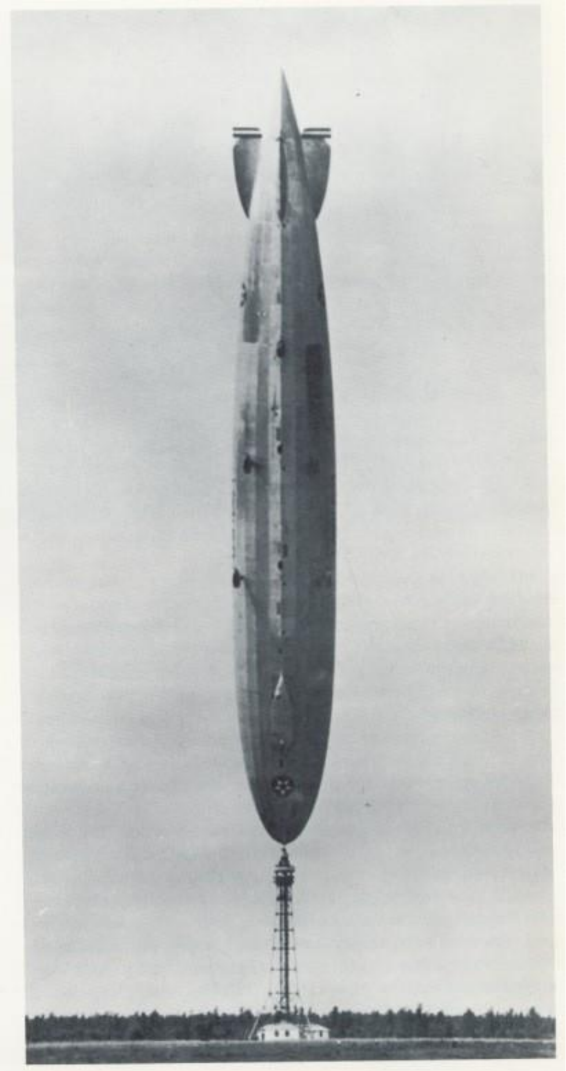
→ For Missions requiring

- Low-and-Slow
- VTOL
- Zero Downwash
- Low Noise

→ Airships can answer Flight Path 2050 Goals for

- Reducing Emmissions drastically
- Increase Safety
- Save Costs

Questions?

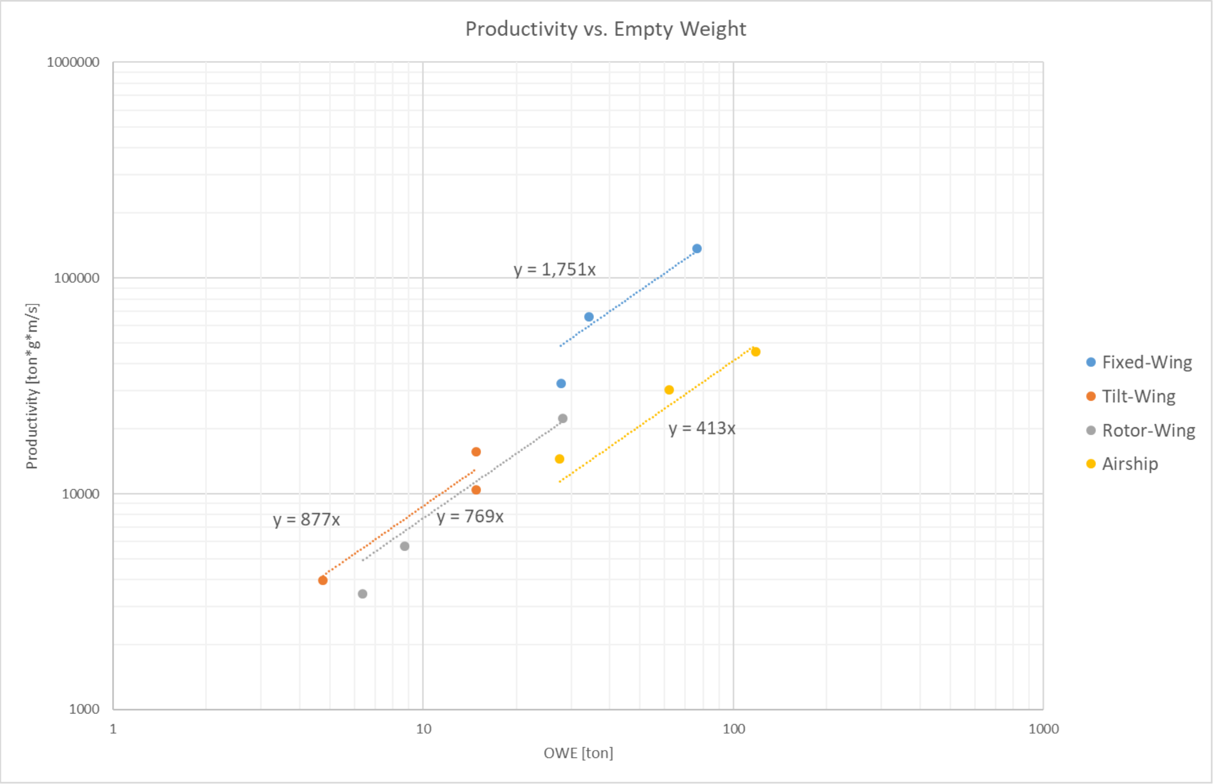


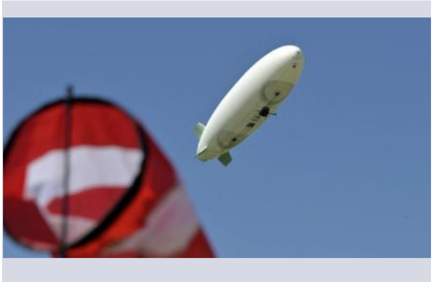
altran

3 Where and why can airships be superior?
→ Efficiency, Sources

A/C	Name	
Fixed-Wing	**Average**	
A400M	A400M	https://en.wikipedia.org/wiki/Airbus_A400M_Atlas
C-160 NG	Transall	https://en.wikipedia.org/wiki/Transall_C-160
C-130J	Hercules	https://en.wikipedia.org/wiki/Lockheed_Martin_C-130J_Super_Hercules
Tilt-Wing	**Average**	
V-22 STO	Osprey	https://en.wikipedia.org/wiki/Bell_Boeing_V-22_Osprey
V-22 VTO	Osprey	https://en.wikipedia.org/wiki/Bell_Boeing_V-22_Osprey
AW609	AgustaWestland	https://en.wikipedia.org/wiki/AgustaWestland_AW609
Rotor-Wing	**Average**	
S-64	Skycrane	https://en.wikipedia.org/wiki/Sikorsky_S-64_Skycrane
Mi-26	Halo	https://en.wikipedia.org/wiki/Mil_Mi-26
NH90	NH90	https://en.wikipedia.org/wiki/NHIndustries_NH90
Airship	**Average**	
LZ-129	Hindenburg	<https://de.wikipedia.org/wiki/LZ_129>, <https://en.wikipedia.org/wiki/LZ_129_Hindenburg>
LZ-127	Graf Zeppelin	"FEASIBILITY STUDY OF MODERN AIRSHIPS PHASE II, VOL. III"
L-59	"Afrika Schiff"	"AIRSHIPS - DESIGNED FOR GREATNESS", Max Pinucc1, <https://de.wikipedia.org/wiki/LZ_104>
*ε = Specific Resistance = P/(MTOW x V) [kW/(tonne x g x m/s)]		"WHAT PRICE SPEED – REVISITED"

3 Where and why can airships be superior?
→ Efficiency, Weight





ALtAIR Flight Test

DesX-Tail

Cruciform Tail

TEAM SIZE: 1.5
START: 2016 - 2018

ALtAIR

CUSTOMER
Airbus DS

CONTEXT & OBJECTIVES

ALtAIR is a Lighter-Than-Air UAS by Airbus DS.
To provide a low-and-slow flying platform with enhanced endurance, range, safety and acceptance compared to conventional VTOL UASs.
Challenges being special flight characteristics.

CHALLENGES

- No flight Simulator available off the shelf
- Equations of Motions are more complex that for aircraft heavier-than-air
- Very few experts available

BENEFITS / RESULTS

- Delivered Physics engine for flight Simulator in Matlab/Simulink
- Proposed Flight Test Maneuvers for Parameter Identification

ALTRAN's ROLE

- Provided expertise in aircraft architecture and flight physics
- Worked from Altran offices, regular meetings