Sustainable Air Transport by Airship

Potentials of Lighter-Than-Air for Flightpath 2050

03.09.2020
DLRK 2020

ALTRAN

V 01 2017-06

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

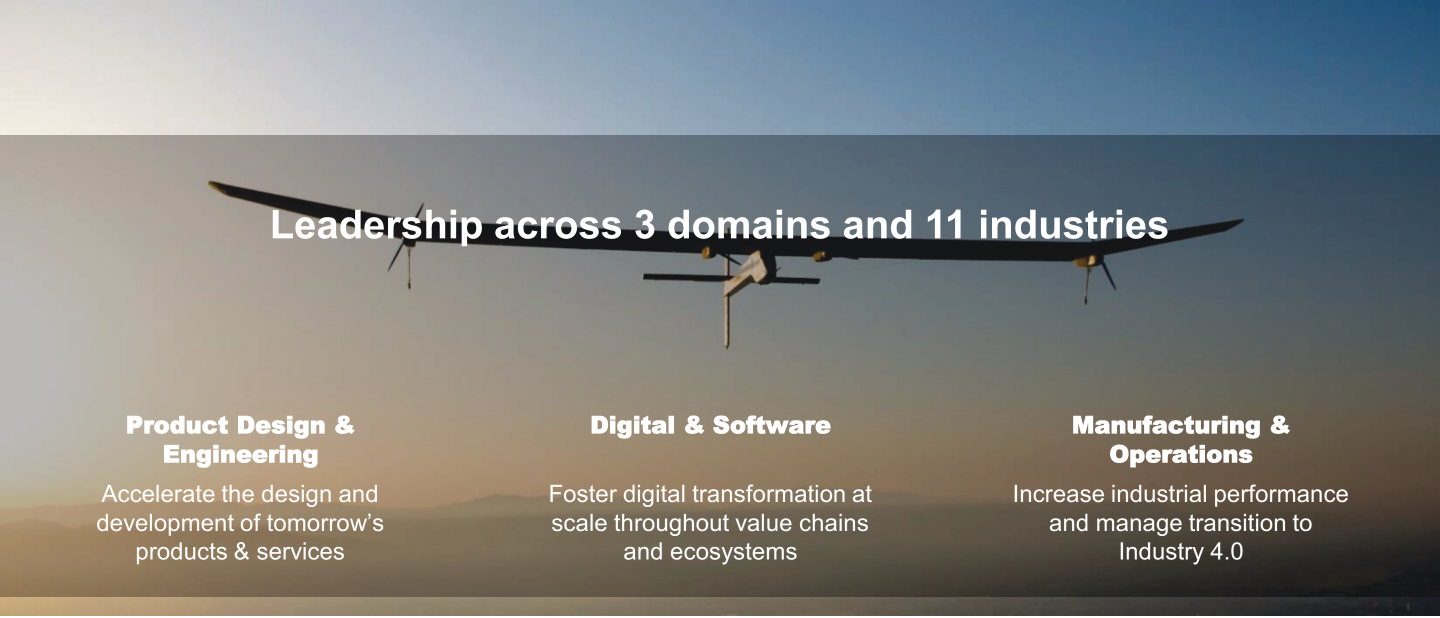
Altran Germany
LTA Aerostructures
Cargo Airships for Canada

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 ?

Agenda

altran

Agenda

1 Eco-Efficiency in Aircraft Design

2 Flightpath 2050

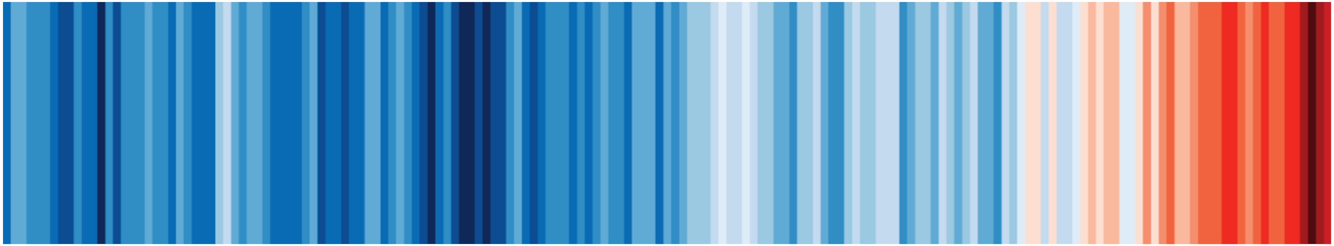
3 Where and why can Airships be superior?

4 Obstacles for Airship Development

5 Essential Boundary Conditions

6 Way Forward

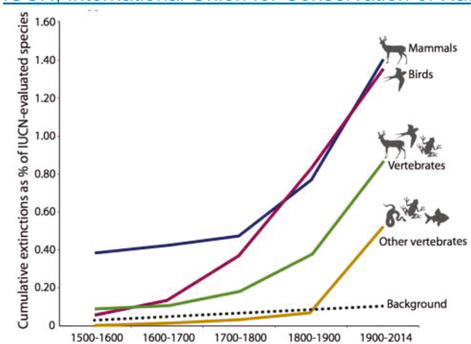
1 Eco-Efficiency in Aircraft Design



Ed Hawkins, representation of temperature from 1850-2017

- Climate change
- Species extinction
- UN Sustainability Goals

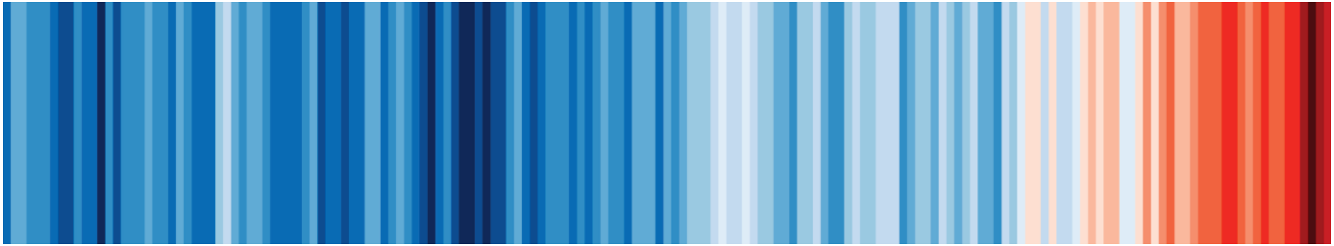
[IUCN, International Union for Conservation of Nature]



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

altran

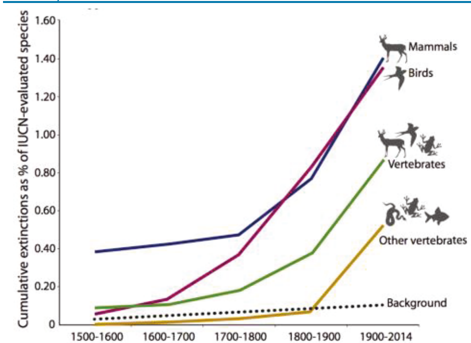
1 Eco-Efficiency in Aircraft Design



Ed Hawkins, representation of temperature from 1850-2017

- Climate change
- Species extinction
- UN Sustainability Goals

[IUCN, International Union for Conservation of Nature](#)

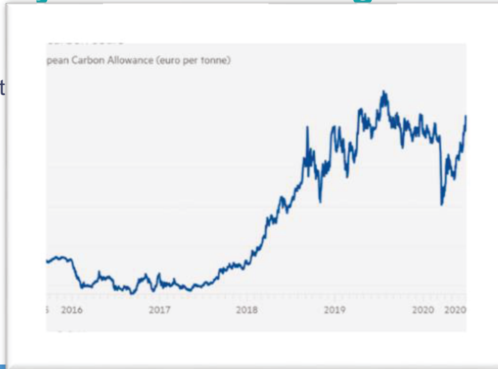


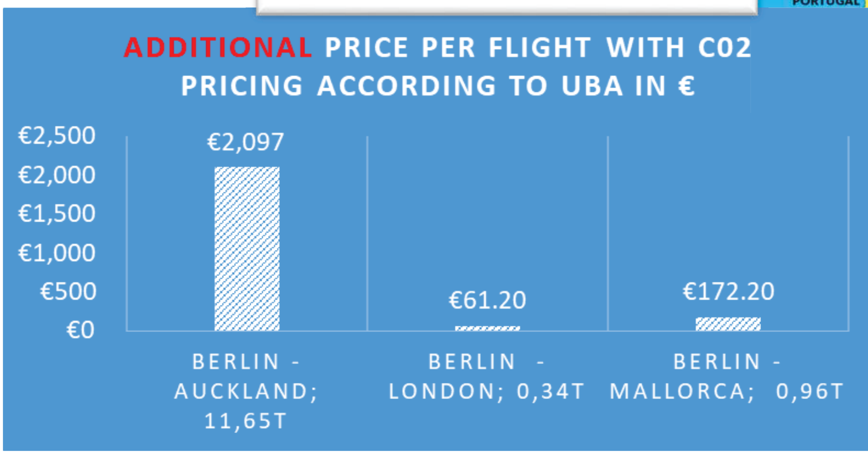
https://advances.sciencemag.org/content/1/5/e1400253

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

V 01 2017-06

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

V 01 2017-06

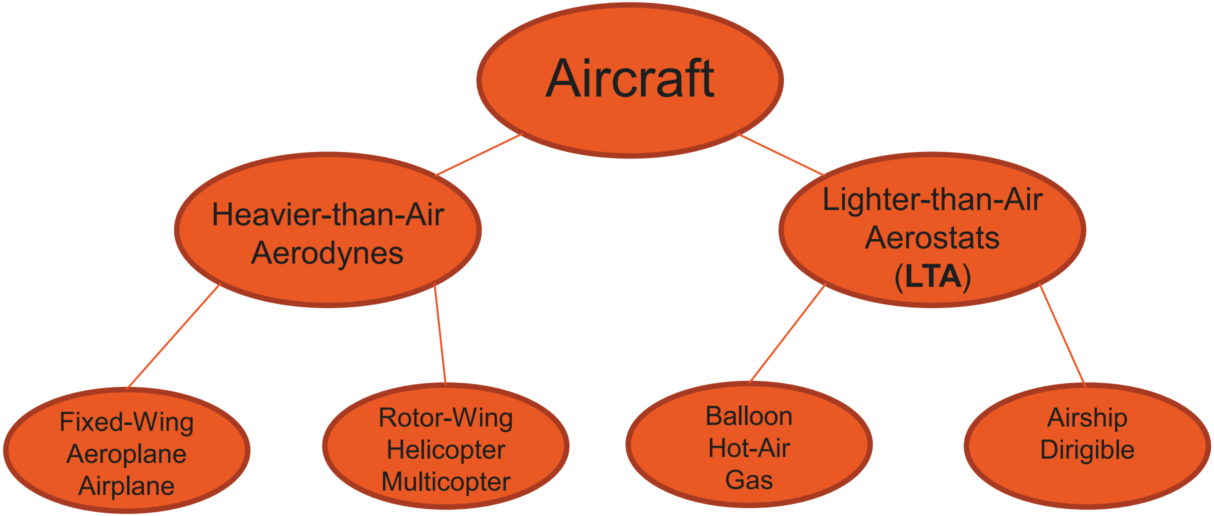
LTA – What is This?

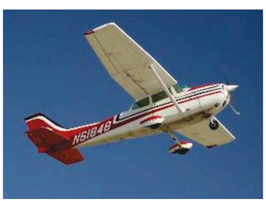
Efficiency

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?

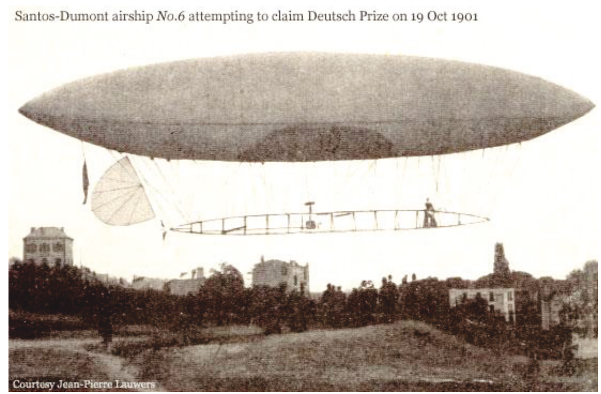
Wright Brothers
December 1903
59 sec
260 m

altran

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

Wright Brothers
December 1903
59 sec
260 m

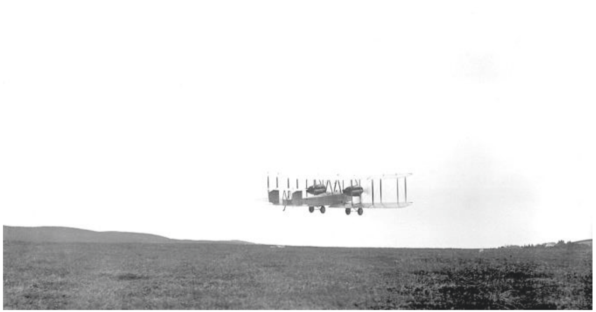
Alberto Santos Dumont
October 1901
30 min
15 km



altran

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

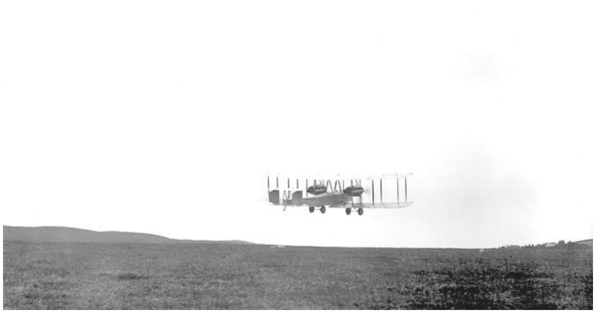
June 1919
John Alcock
Arthur Whitten Brown
Atlantic West – East

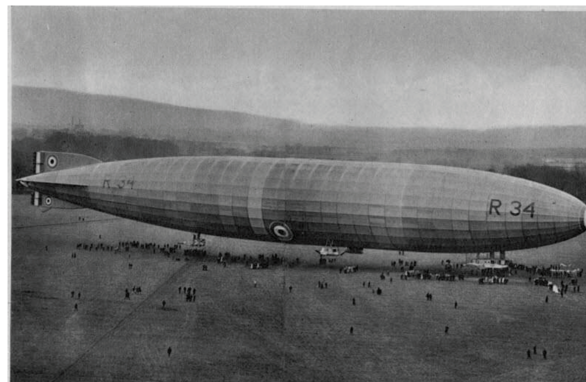


3 Where and why can airships be superior?
→ LTA – What is This?

June 1919
John Alcock
Arthur Whitten Brown
Atlantic West – East

July 1919
Major George Herbert Scott
31 Crew
Atlantic East – West



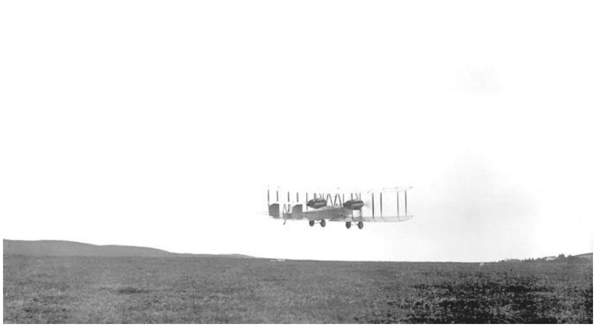


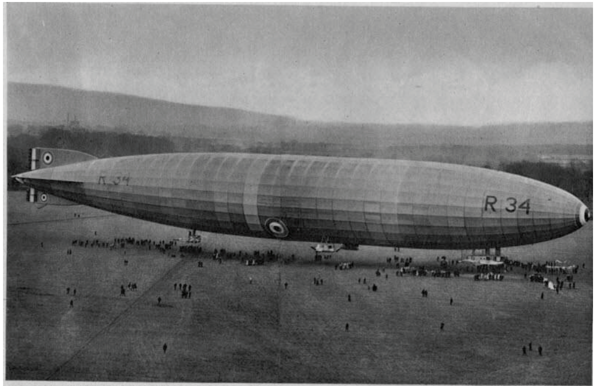
R34, Britain's titanic airship, 670 feet long and 1,250 h.p., launched at Inchinnan, near Glasgow, March 14th, 1919.

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

June 1919
John Alcock
Arthur Whitten Brown
Atlantic West – East

July 1919
Major George Herbert Scott
31 Crew
Atlantic East – West – East



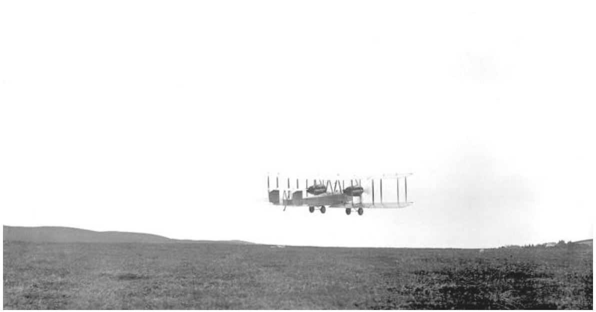


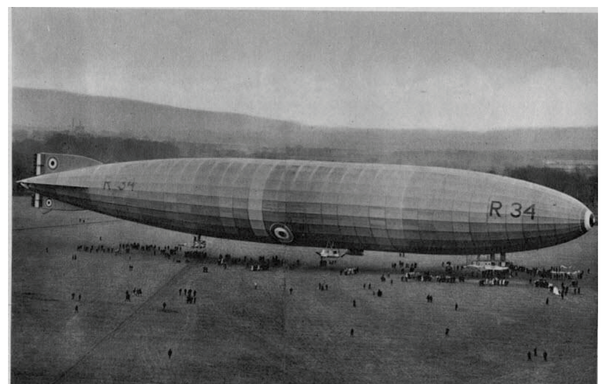
R34, Britain's titanic airship, 670 feet long and 1,250 h.p., launched at Inchinnan, near Glasgow, March 14th, 1919.

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

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

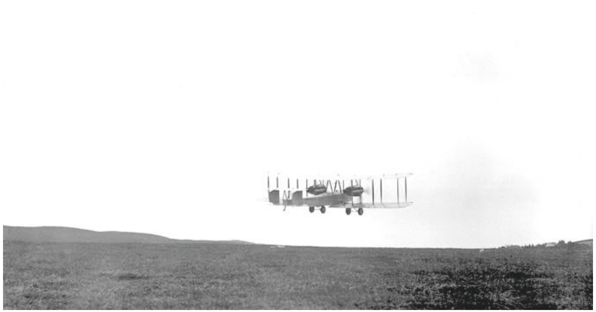




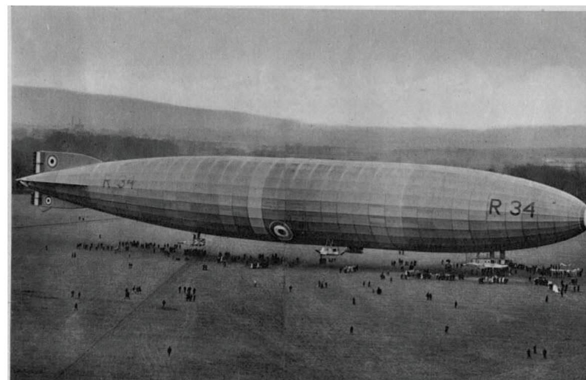
R34, Britain's titanic airship, 670 feet long and 1,250 h.p., launched at Inchinnan, near Glasgow, March 14th, 1919.

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

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.

V 01 2017-06

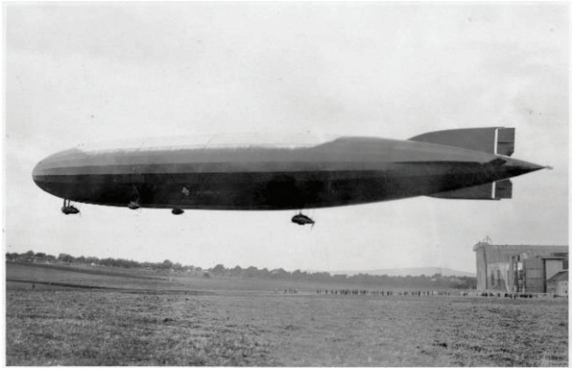
altran

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

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

(Compare 1956
Douglas C-133 Cargomaster)

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



3 Where and why can airships be superior?
→ Efficiency

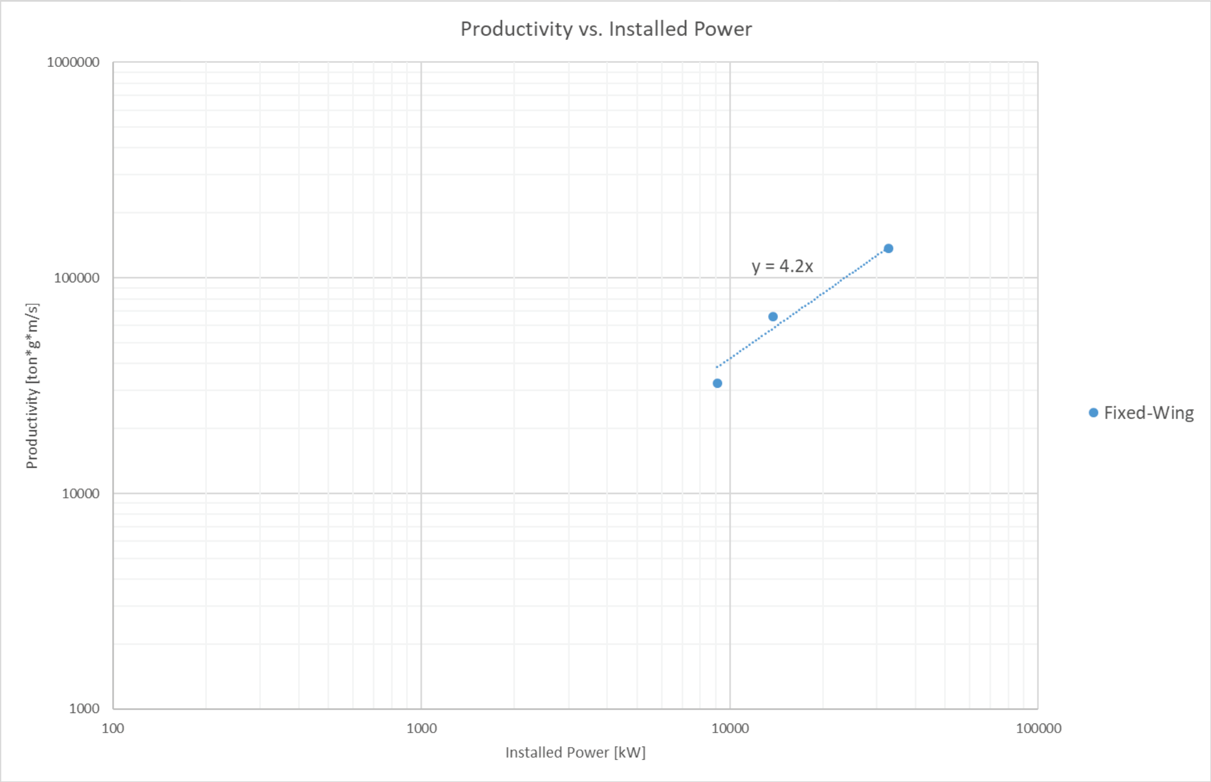
A/C	Name	MTOW	OWE	OWE/ MTOW	MTOW -OWE	Max Speed	Max Speed	Productivity	Installed Power	ε*	η**
		[ton]	[ton]	[%]	[ton]	[m/s]	[kmh]	[ton*g*m/s]	[kW]	[-]	[-]
Fixed-Wing	**Average**			**52%**			**655**			**0.11**	**4.2**
A400M	A400M	141.0	76.5	54%	64.5	217	781	137229	32800	0.11	4.2
C-160 NG	Transall	51.0	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]

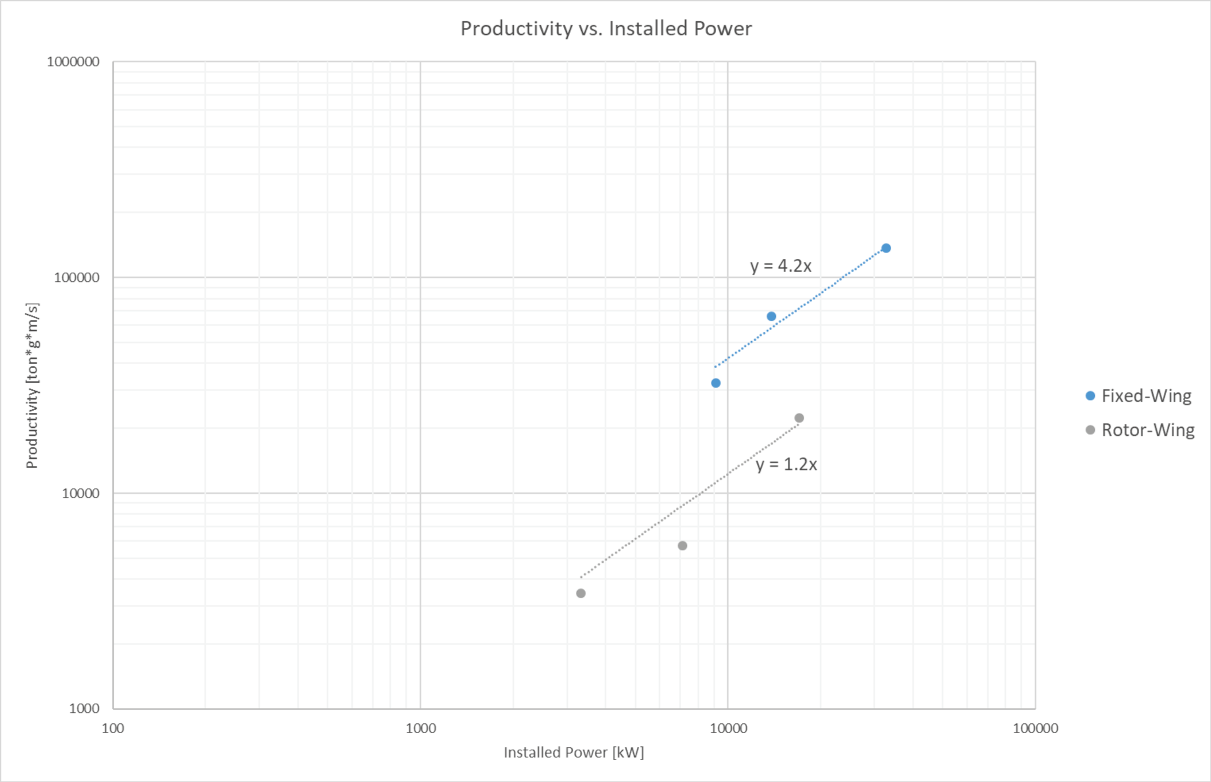
altran

3 Where and why can airships be superior?
→ Efficiency

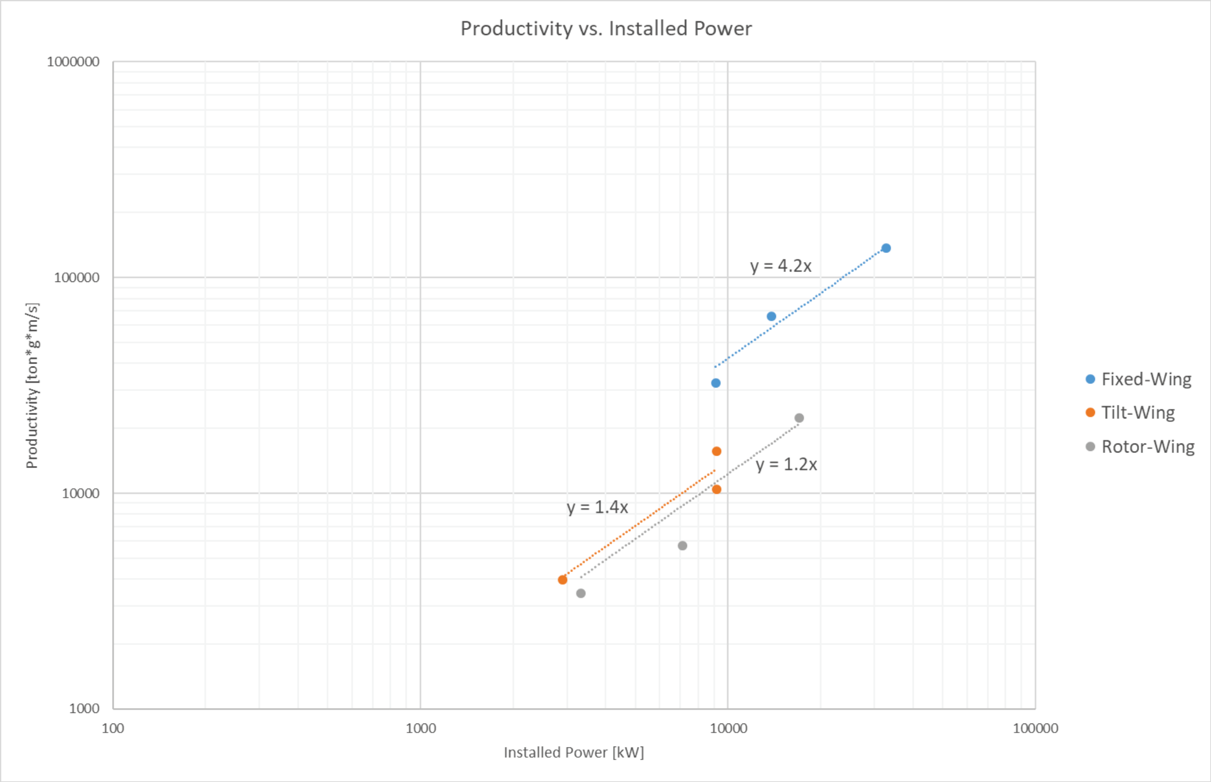


altran

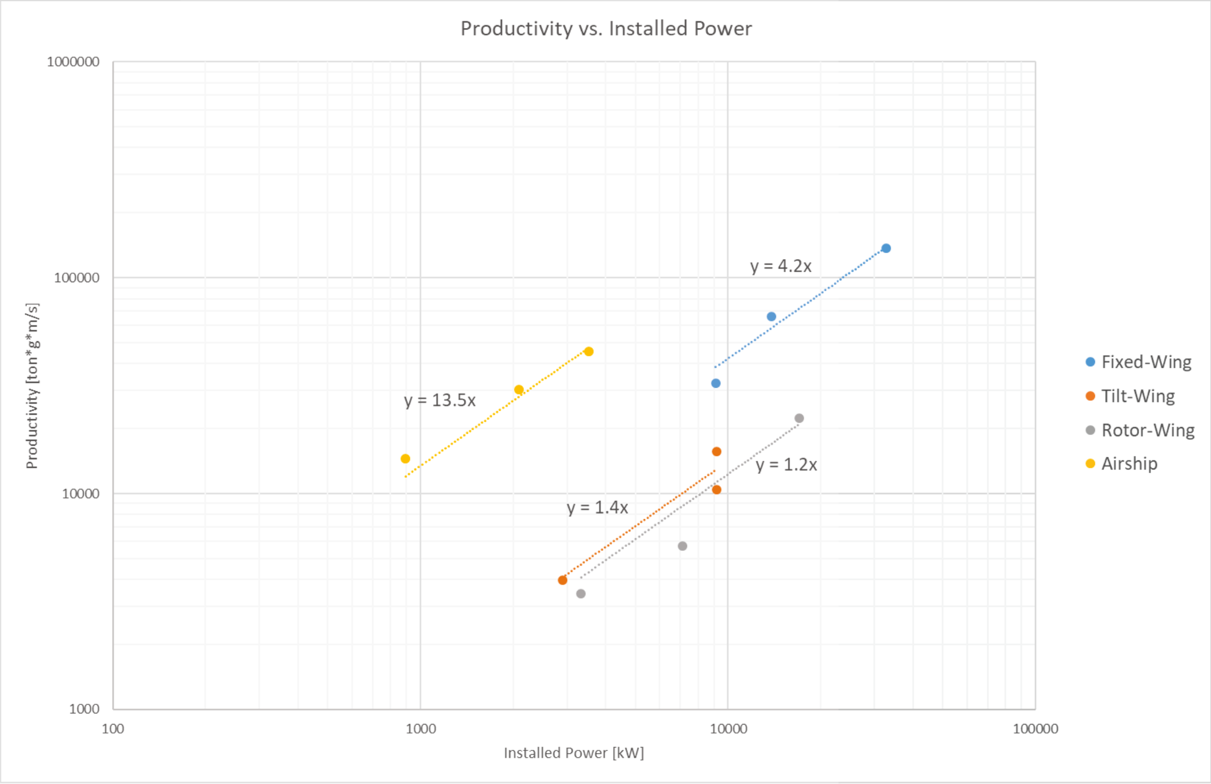
3 Where and why can airships be superior?
→ Efficiency



3 Where and why can airships be superior?
→ Efficiency

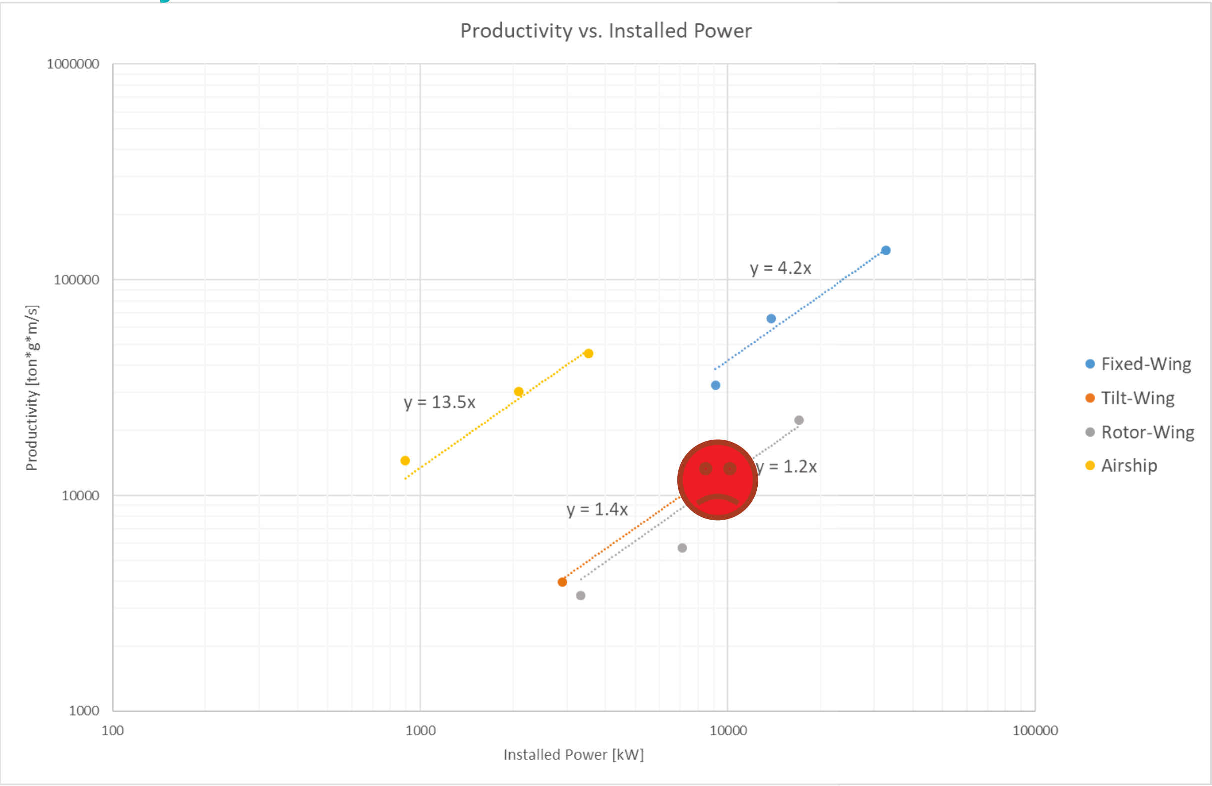


3 Where and why can airships be superior?
→ Efficiency



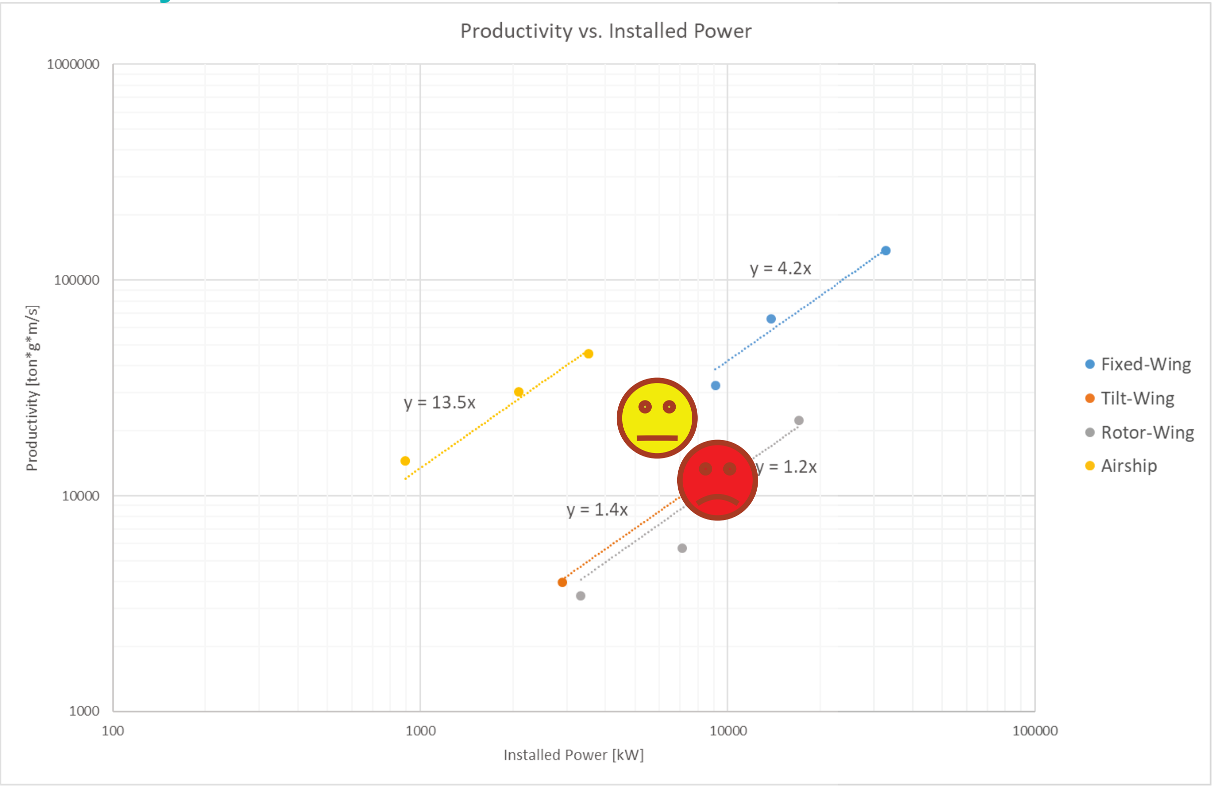
V 01 2017-06

3 Where and why can airships be superior?
→ Efficiency



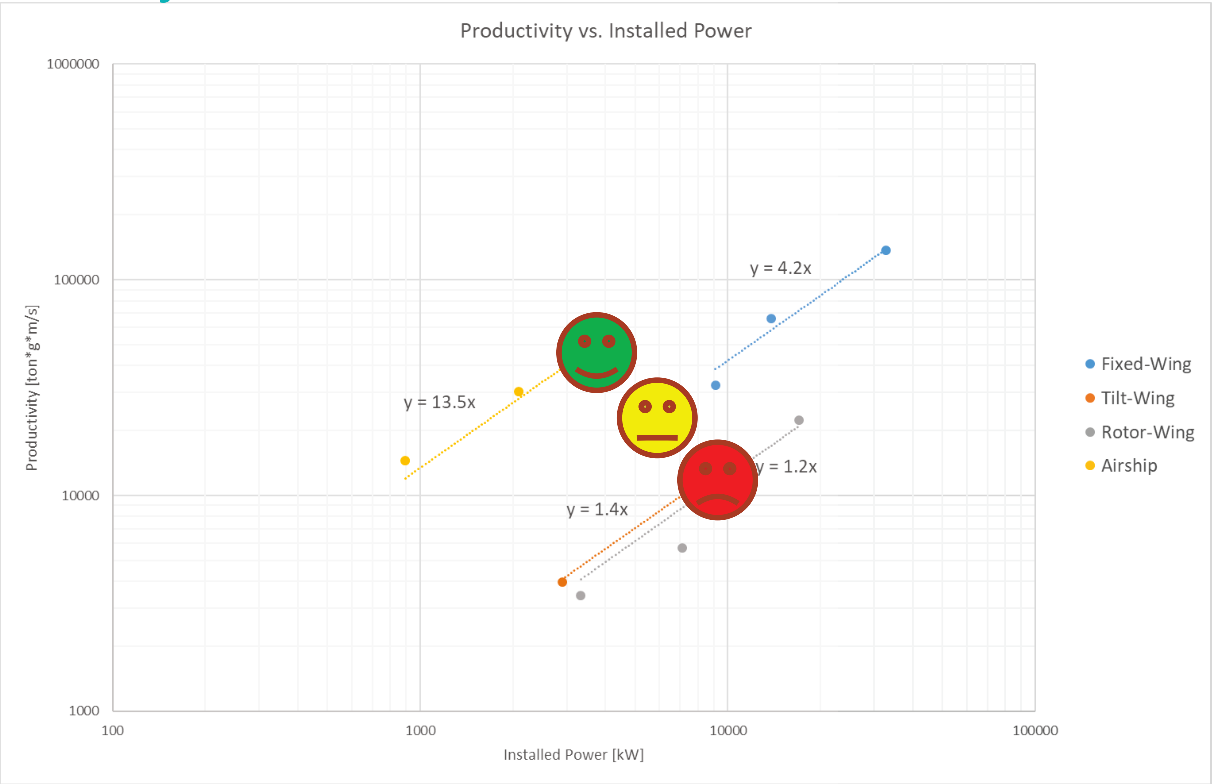
altran

3 Where and why can airships be superior?
→ Efficiency



V 01 2017-06

3 Where and why can airships be superior?
→ Efficiency



V 01 2017-06

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

3 Where and why can airships be superior?
→ Costs

- **Certification:**
  - CS-30C vs. CS-23
  - CS-30T vs. CS-25

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

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

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~~

Agenda

altran

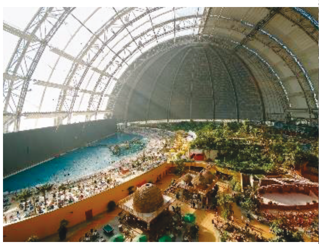
4 Obstacles for Airship Development

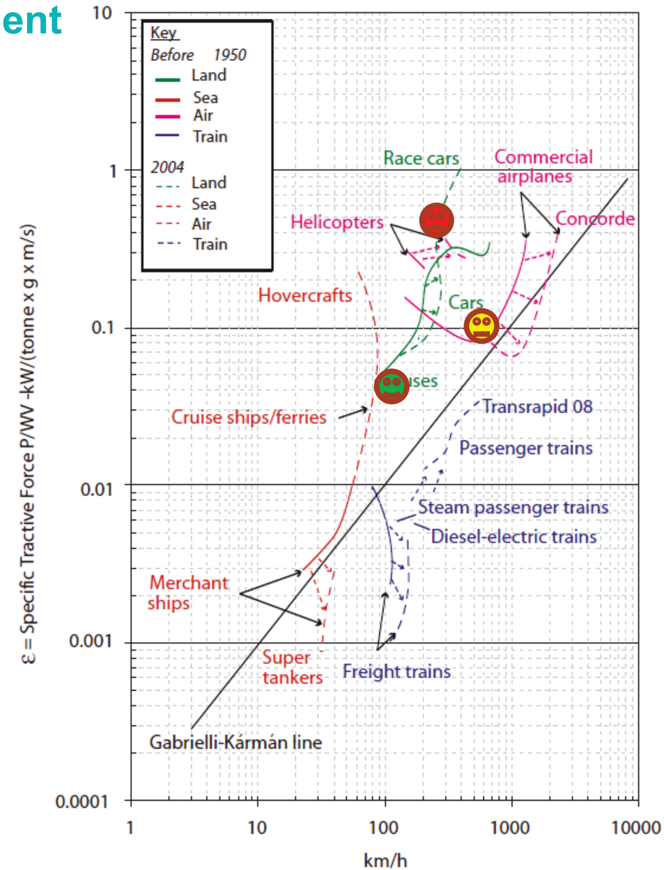
Speed

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

Infrastructure

- Hangar
- Mast
- Helium Supply
- Ground Crew

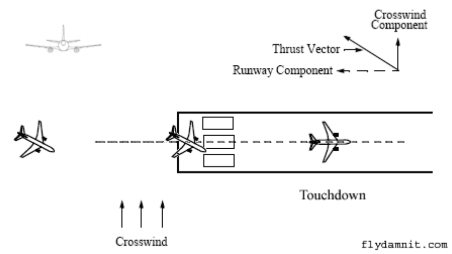




Source: "WHAT PRICE SPEED – REVISITED"

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

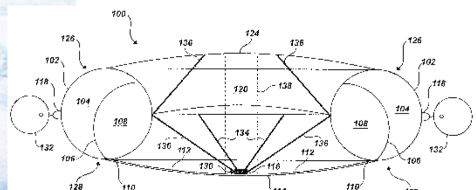
altran

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)
- No side wind landing

← Lenticular Airships →
- See hybrid airships
- 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

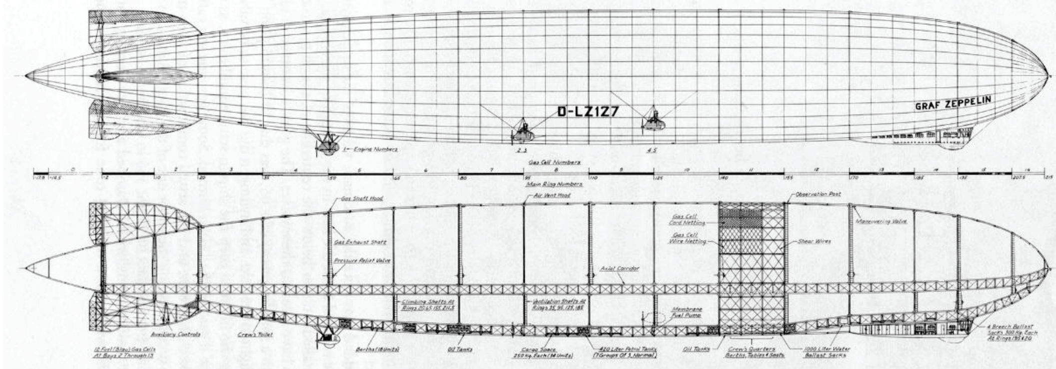
- SORA Risk Assessment
- Permit to Fly
- Endurance

Jülich Institute „FieldShip“

Airbus DS „ALtAIR“

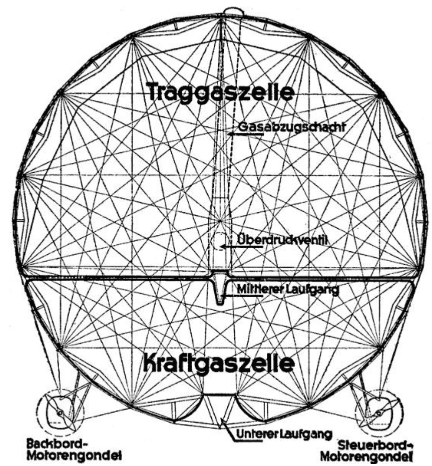
TVN‘s „TVN-Z1“
Berlin Olympiastadion

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?



6 Way Forward, Fuel Cells

Fuel-Cell

- Better Energy Density Than Batteries

6 Way Forward, Fuel Cells

Fuel-Cell

- Better Energy Density Than Batteries
- What if…

6 Way Forward, Fuel Cells

Fuel-Cell

- Better Energy Density Than Batteries
- What if …
  H2 was carried as a Gas? (No Weight!)

Kelluu, Finland

6 Way Forward, Fuel Cells

Fuel-Cell

- Better Energy Density Than Batteries
- What if …
  H2 was carried as a Gas? (No Weight!)

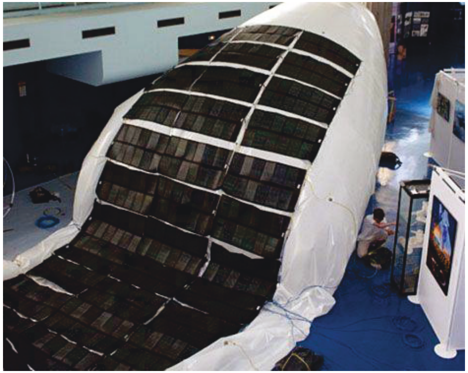
Disrupt That!

Kelluu, Finland

altran

V 01 2017-06

6 Way Forward, Photovoltaics



Photovoltaics

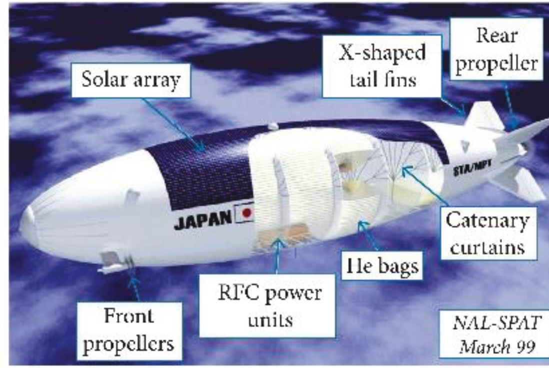
- Large Surface Area
- Photovoltaics on Rigid Airships:
- Outer cover is secondary structure

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

aLTRan

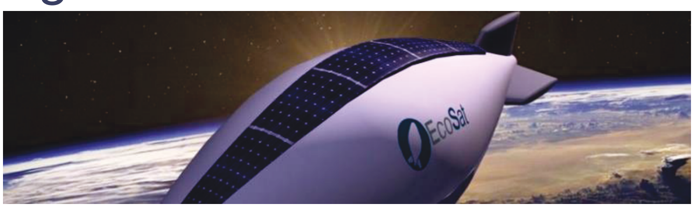
6 Way Forward, HAPS

HiSentinel80 Airship, SwRI, Aerostar



High Platform II Airship, 1970, Raven

HAPS: High Altitude Pseudo Satelites

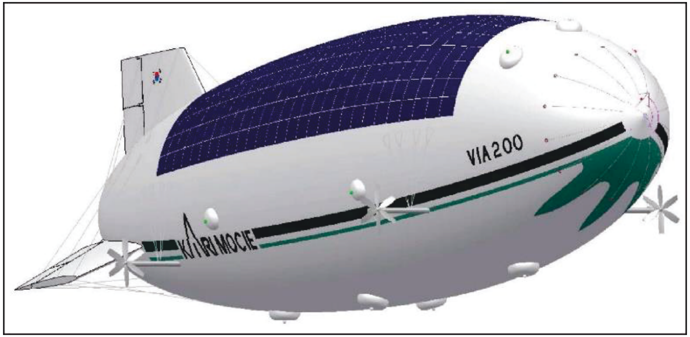


Ecosat, Altran Spain

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

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

AERONAUTICAL RESEARCH & TECHNOLOGY AREAS:

6 Way Forward, Utility Airship

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

AERONAUTICAL RESEARCH & TECHNOLOGY AREAS:

Innovative Concepts and Scenarios:

6 Way Forward, Utility Airship

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

AERONAUTICAL RESEARCH & TECHNOLOGY AREAS:

Innovative Concepts and Scenarios:

Unconventional configurations and new aircraft concepts:

6 Way Forward, Utility Airship

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.

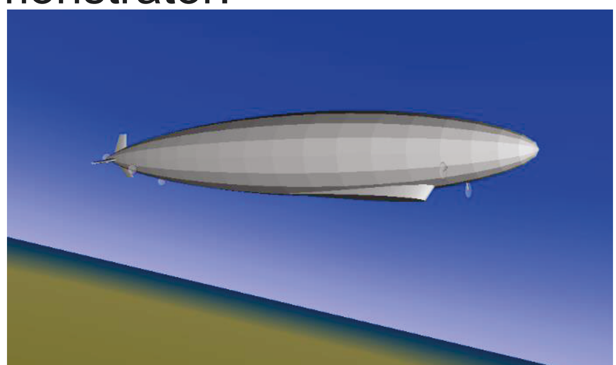
6 Way Forward

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

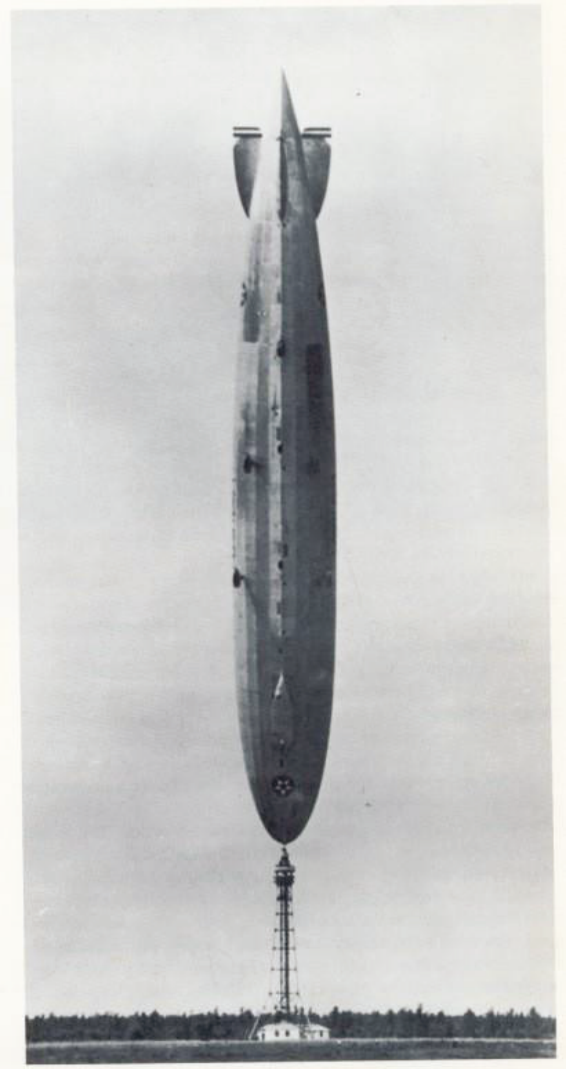
→ For Missions requiring

- 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

V 01 2017-06

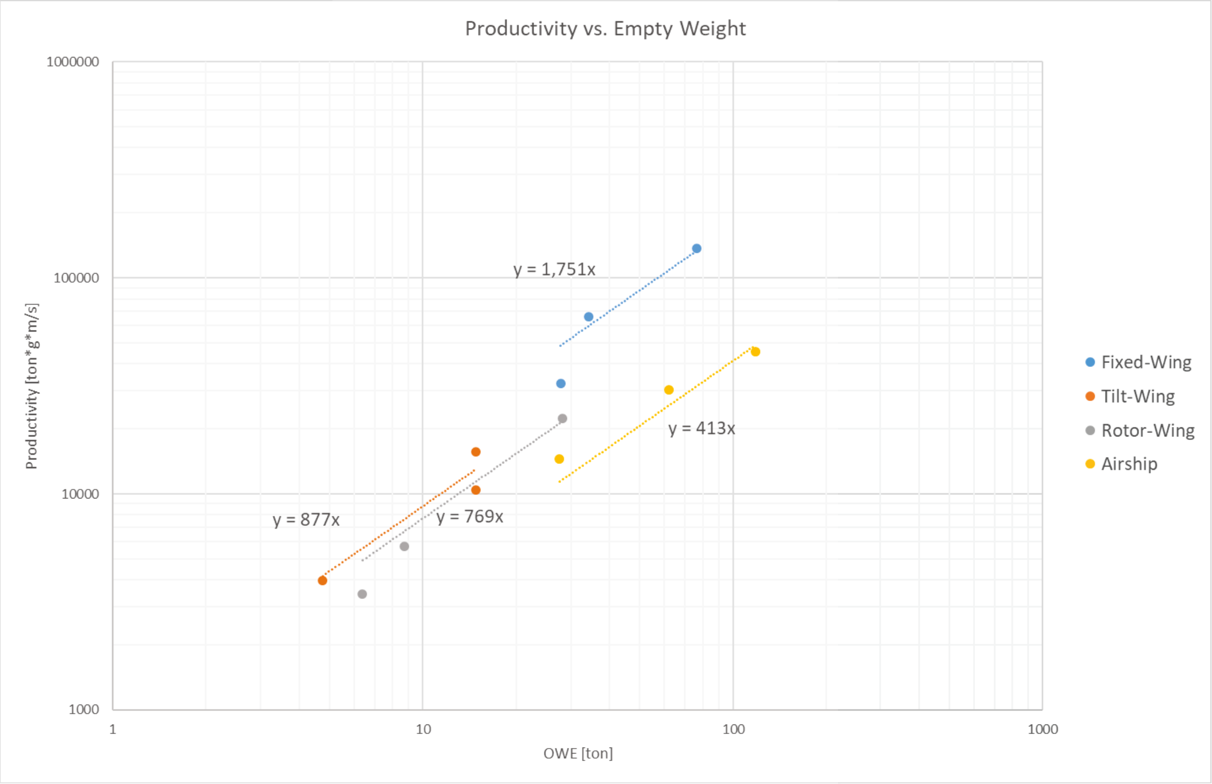
3 Where and why can airships be superior?
→ Efficiency, Sources

A/C	Name	Source
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"

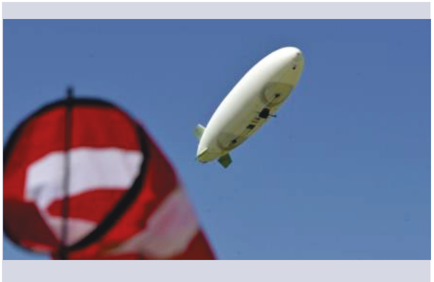
altran

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



altran

V 01 2017-06



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