GRENZELOZE LOGISTIEK
Slimme grensregio in actie

met steun van het Agentschap Ondernemen

departement Mobiliteit en Openbare Werken

Feasibility Scan for Airships

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GRENZELOZE LOGISTIEK
Slimme grensregio in actie

- **Grensregio Vlaanderen-Nederland**
- **Topregio voor logistiek**

- **Focus op duurzaamheid, efficiënt ruimtegebruik en technologische innovatie**

Contents

1 Background

- The region of Antwerp (Belgium) is an important, international logistics hub with the Port of Antwerp as one of its key factors. To further develop the logistics sector, promoting logistics innovations is of critical importance.
- A new concept of logistics real estate has already been developed and is now being implemented that will allow for next generation logistics through BPO and gain sharing.
- The region is coping with mobility issues that also require a new and innovative approach. This is the reason why there is a need to consider alternative freight transportation. Hybrid airships may be part of this alternative in the long run although many uncertainties still exist.
- This study is part of the 'Borderless Logistics' programme with the objective to achieve more efficient supply chains with cross border stakeholders in both Flanders and The Netherlands.

Objectives

- **The aim is:**

  To identify the operational, commercial and market feasibility of hybrid airships

  To investigate hybrid airships as a new transportation mode and determine their role in innovative logistics

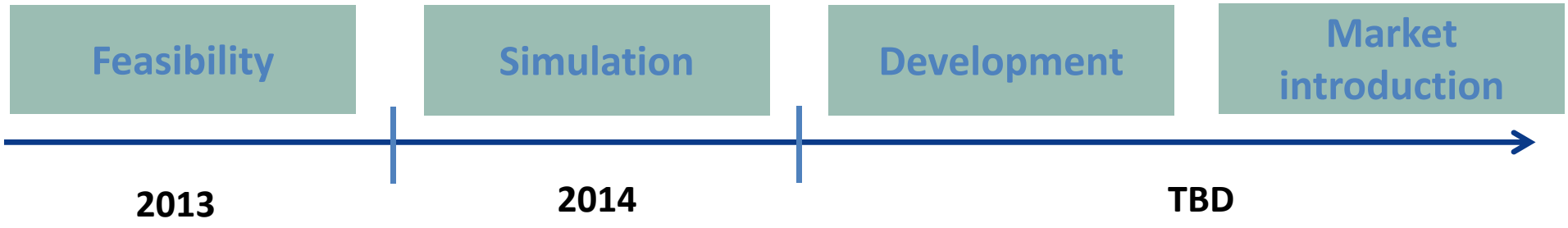
- **The main sources used are:**

  Information from airship manufacturers

  Existing research from universities and research institutes

  Interviews with stakeholders

Project timing



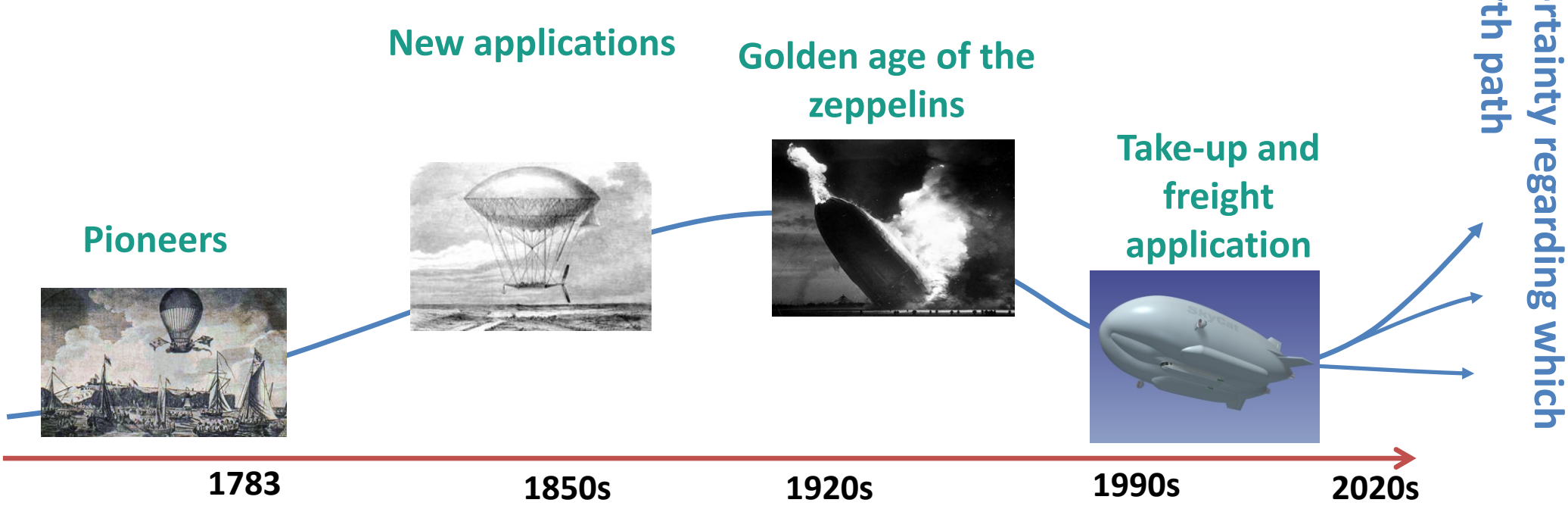
- Identifying feasibility and innovative concepts for cargo airships
- Simulation and business case development

Go / No-go for now

- Product development in order to select the best possible logistics concept
- Developing policy framework in order to make airship movements possible in European skies
- Market the introduction of new logistics concepts with airships

2 Zeppelins and Hybrid Airships

Milestones in airship development



1. Short History

- **First manned balloon flight in 1783**
- **First cross English channel flight in 1785**
- **First steam engine powered flight in 1852**
- **In 1872, an airship powered by an internal combustion engine ran on gas for the first time**
- **First electric-powered flight in 1883**
- **1897 saw the development of the first rigid airship**
- **Golden Age from 1900 onwards with the launch of the Luftschiff Zeppelin LZ1**

  Most successful airships to date were Zeppelins
- **After multiple accidents their popularity diminished significantly**

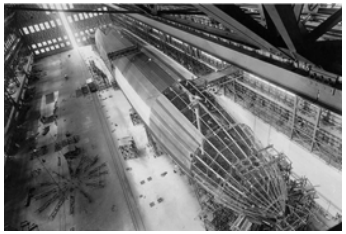
  Most famous accident was the 1937 Hindenburg disaster

2. Types of Airships and Technology Used Today

- Non-rigid airships (blimps) use a pressure level in excess of surrounding air pressure to retain shape during flight.

- Semi-rigid airships maintain the envelope shape through internal pressure, although they have some form of internal support such as a fixed keel to which control and engine gondolas, stabilizers and steering surfaces are mounted.

- Rigid airships have a structural framework that maintains the shape and carries all loads such as gondolas and engines.



- Hybrid airships combine fixed wing technology with lighter-than-air technology.

- **Airships are able to perform a static lift without the use of engine power. It is achieved solely by the lifting power of the gas.**
  - In early developments hydrogen was used as a lighter-than-air substance
  - For safety reasons, the inert helium has been used in recent developments

- **Hybrid airships combine static lift with lift from aerodynamic forces (vertical and horizontal thrusters)**
  - This makes it possible for the airship to be heavier-than-air, similar to a regular aircraft
  - However, there are hybrid airships that are lighter-than-air during flight, making the aerodynamic lift redundant during flight
  - The thrusters are also used for the forward movement and manoeuvring

3. Use of Airships

- **Use includes:**
  - Commercial Tours
  - Advertising (on the hull)
  - Observation platforms for major events
    - Photographers
    - Television reporters
  - Research missions
    - Environmental observations
    - Troposphere research
    - Natural resources prospecting
  - Surveillance purposes (commercial, police and military)

- **The use of airships for cargo transport and heavy lifting remains limited (mainly USA), although several companies are now developing airships for the purpose of freight transport**

4. Airship Companies

- **The Hindenburg accident marked the end of the Golden Age of airships**
- **This resulted in a decline in companies involved in the manufacturing of airships compared to the early 20th century**

  The same can be said regarding the amount of airships that are in operation at the moment
- **However, since the 1990s, several companies from around the globe have once again engaged themselves in the research and the testing of airships**

  With the USA being the leader regarding cargo transport and Europe the leader in terms of the production of non-cargo airships

  This is because technology developments in the USA are related to NASA and US Military developments in logistics concepts

Cargo Developments

Advanced HYBRID Aircraft

VariaLift Airships
tel. 07753 420565

Skylite aeronautics

RosAeroSystems

HYBRID Air Vehicles

MAS skyfreighter corporation

CargoLifter

aeros

World SkyCat

LOCKHEED MARTIN

solarship

Voliris SustainAbility

SKYLIFTER

NORTHROP GRUMMAN

BOEING

Other Developments

A-NSE AERO-NAUTIC SERVICES & ENGINEERING

LUFTSCHIFFBAU ZEPPELIN

Van Wagner AIRSHIP GROUP

SkyYacht

iii solutions

Lindstrand TECHNOLOGIES

Flying-Yachts Inc.

GEFA-FLUG THE AIR COMPANY

Kubíček BALLOONS

CAMERON BALLOONS

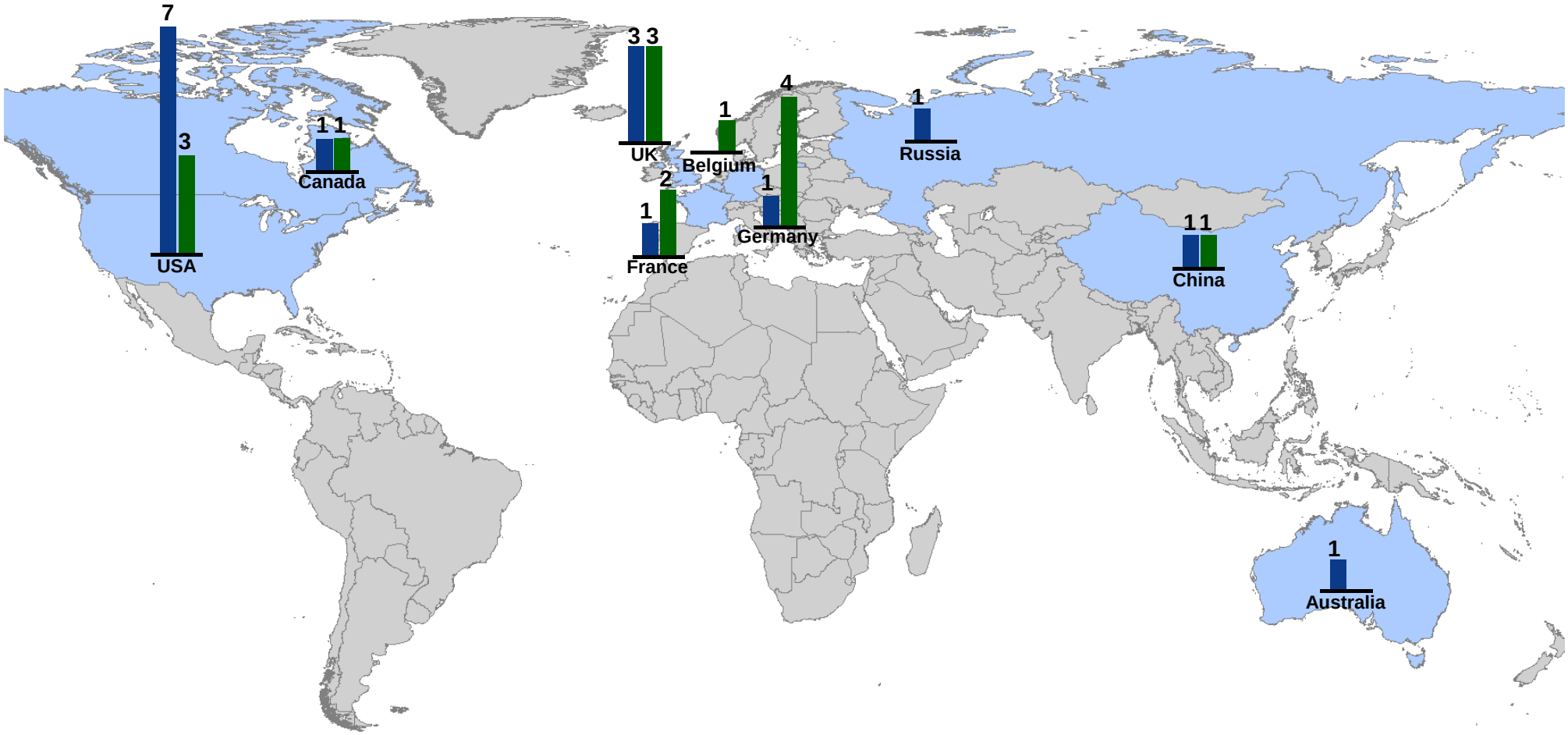
RAVEN AEROSTAR

Huajiao Airship

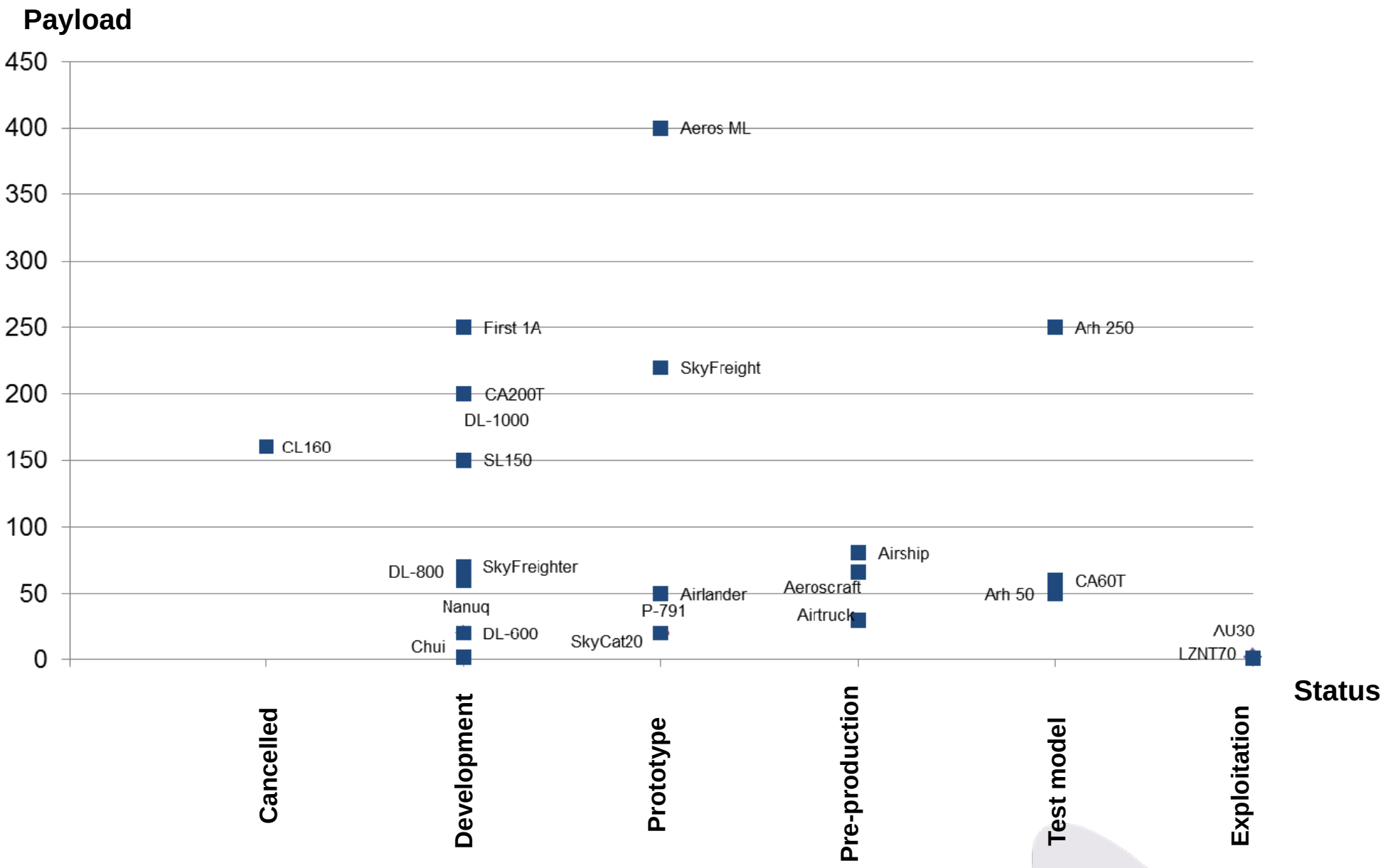
WDL WORLDWIDE

TCOM, L.P.

Development of Airships Worldwide



Cargo Developments
Non-Cargo Developments


Payload
450
400
350
300
250
200
150
100
50
0
Aeros ML
First 1A
Arh 250
SkyFreight
CA200T
DL-1000
CL160
SL150
Airship
DL-800
SkyFreighter
Aeroscraft
CA60T
Arh 50
Airlander
Nanuq
P-791
Airtruck
DL-600
AU30
Chui
SkyCat20
LZNT70
Status
Cancelled
Development
Prototype
Pre-production
Test model
Exploitation

3 Technical and Operational Characteristics of Airships

Speed

- **Depending on the model, cruising speeds range from 75 to 630 km/h**

  However, most airships have a maximum speed of under 200 km/h due to resistance related to the size of the envelope.

Range

- **The maximum range of an airship is from 2,000 up to 11,000 km, depending on the model of the airship and the meteorological conditions.**

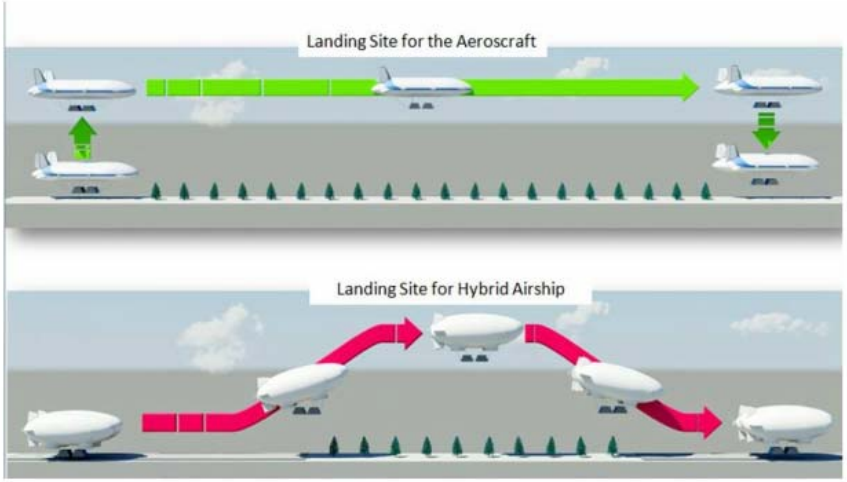
  In cases involving strong winds, the engines of the airship are used. This reduces the range.

Infrastructural needs

- **Airships with VTOL or STOL capacity reduce the need for runway infrastructure**

  VTOL= Vertical Take Off and Landing

  STOL= Short Take Off and Landing



VTOL

STOL

Source: Varialift

- **Hybrid airships require hangars to provide both shelter from poor meteorological conditions and ensure proper maintenance**

  The size of these hangars is substantial and real estate costs are high

  It is estimated that hangars measuring approximately 40,000 – 55,000 m2 are required

  Investment of €12 million and annual maintenance of €400,000 are very rough indications available at the moment *Source: Interview airship provider, 2014*

Energy Use

- **Energy use of airships is limited compared to aircrafts**

  The use of kerosene is estimated to be 2 to 5 times less than for cargo airplanes (given a certain distance and speed)

  Energy use is even lower when accounting for slower speeds
- **For the forward movement and manoeuvring, thrusters are used**
- **Advanced cargo airships are capable of coming close to trucks in terms of freight fuel efficiency**
- **Energy use of airships could further decrease when alternative sources such as solar energy are being integrated**

4 Cost Factors

Operational costs

- At present, cargo airships are either in the design phase or the prototype phase and hard data in relation to exploitation is simply not available. As a consequence, figures are based on estimates and the input of manufacturers.
- Airships are potentially subject to significant economies of scale according to manufacturers.

Airship Cargo Capacity	Freight Rates ($/tkm)
20 MT	$1.50
200 MT	$0.20
1,000 MT	$0.06

- These figures are in line with other estimates but do not include all relevant cost factors (helium, insurance etc.)

Source: Prentice, Beilock and Philips; based on manufacturer information

Maintenance Costs

- **Maintenance costs of airships are low:**

  Scheduled maintenance is limited to two weeks per annum

  Specific need for hangars may be expensive

Manufacturing Costs

- **Manufacturing costs of a hybrid airship vary considerably depending on the model and type:**

  Prices are difficult to find since many models and types are still in the development phase

Manufacturing Costs

- **Airship models with their respective payload and price estimates:**

Airship Model	Payload (t)	Price estimate (million euros)
Rosaeros AU 30	1,5	2 – 6
Zeppelin NT	1,9	2 – 6
Skycat 20t	20	16 – 19
Skycat 200t	200	53 – 62
Aeroscraft	400	40 – 60

Source: Ernst & Young

- **The price per tonne payload is expected to decrease as the total payload increases**
- **The costs of a Boeing 747 Freighter is estimated at €260 million**

  source: Boeing company, 2014
- **Prices may differ as construction and research and development costs vary a lot at this stage of development**

5 Constraints

Impact of meteorological conditions

- **In comparison to traditional airplanes, airships are more vulnerable to lateral winds due to the larger envelope**
  - Smaller airships are less susceptible to wind than larger airships
  - Strong engines are needed to counter strong lateral winds and headwinds
  - Airships need to be equipped with new detection technologies so that they are able to anticipate the impact of weather conditions

Helium

- **Hybrid Airships use helium as a lighter than air substance**

  Helium is expensive and global reserves are limited

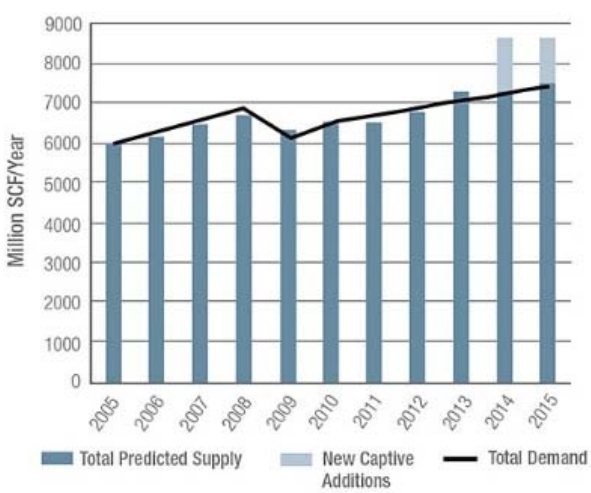
  Hybrid airships are likely to use large amounts of helium

  - Airships with 250 tonnes of payload are likely to use approximately 400,000 m^3 of helium

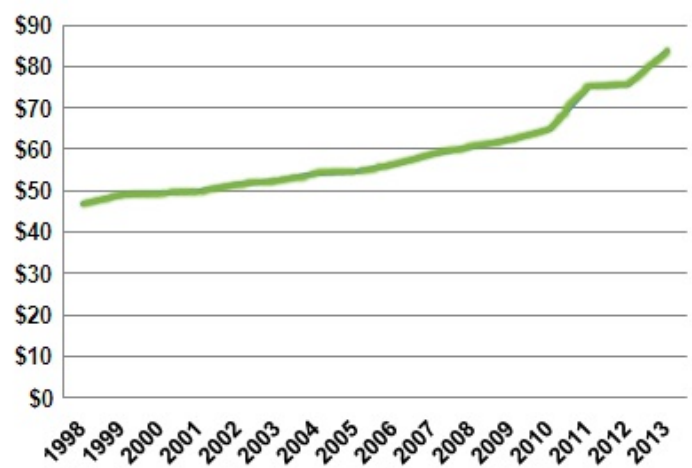
  Current technologies cannot prevent the leakage of helium from a hybrid airship

  - The envelope must become impermeable in order to reduce this leakage (Kevlar and Aramid can be considered as a solution)

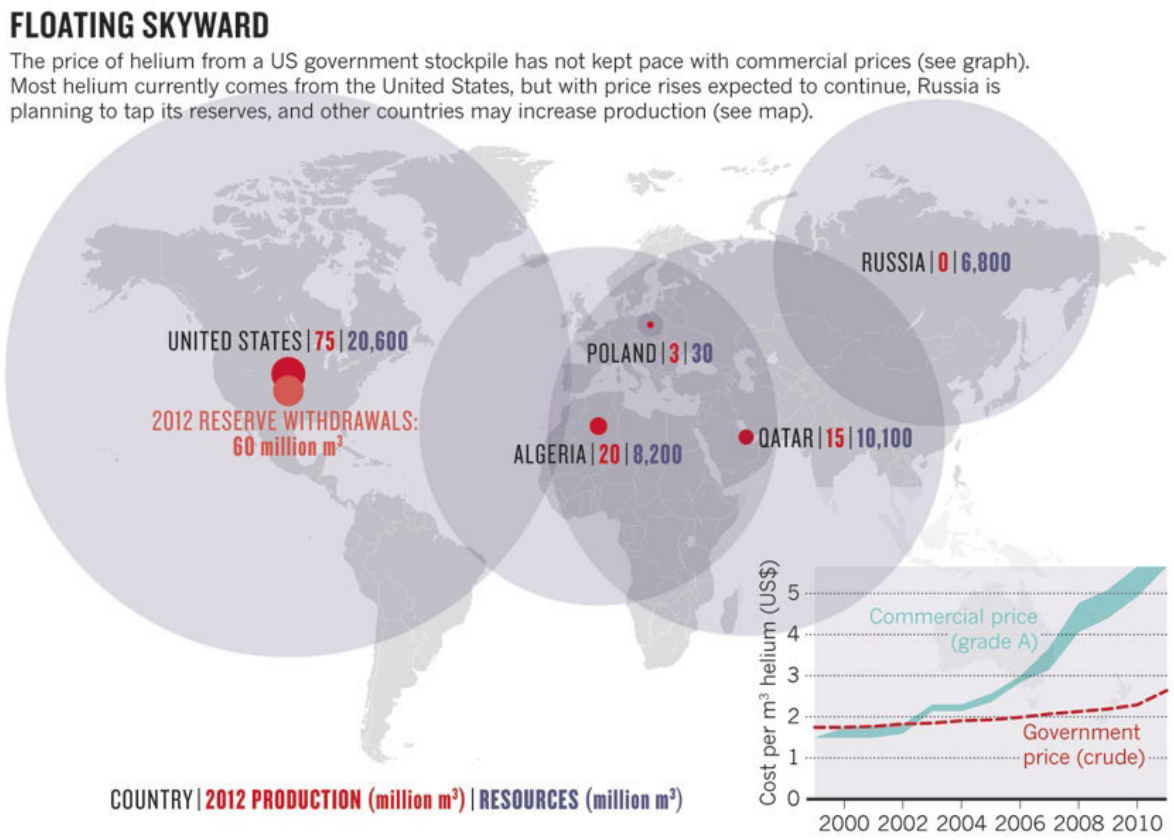
Global helium supply and demand
Source: Spiritus Group, 2011



Open market price development for helium (per McF)
Source: GAWDA and BLM, 2013



- As airships require large volumes of helium it is likely that the price of helium will increase.
- Whilst resources are large, they are also limited and not renewable.
- Availability and the use of helium will not represent a barrier in airship development in the short term, but alternatives (like Hydrogen) need to be considered.



Source: Scientific American

Dense Use of (European) Airspace

- **There is a heavy use of (European) airspace, especially around airport sites in metropolitan regions.**

  It is to be expected that this situation will continue to worsen

  This makes the integration of airships in densely populated metropolitan regions difficult

  - If airships need to land and take off away from metropolitan areas, both pre and post haulage of the goods will become necessary
  - This will have a bearing on the total costs of transport, increase the chances of possible delays and alter the environmental impact of the logistics chain.

- **Once airborne, airships and airplanes operate at different heights**

  Airships fly at approximately 2,000m altitude while airplanes fly at 10,000m altitude

- **Rules and regulations regarding the use of airships in European airspace may pose a barrier in its development. Coordination of this topic is required. In this regard, please see the next chapter.**

6 Rules and Regulations

- **Airfreight is regulated by the Chicago Convention on International Civil Aviation (1944)**
  - No mention of hybrid airships is made in the original convention
  - Since 1944 the convention has been revised on eight occasions (the last time being in 2006) and airships have not been integrated in any of the revisions
  - As of 2013, the Chicago Convention has 191 partner states
- **The use of airspace is also subject to European legislation**
  - Airships are not included in present day legislation
  - The inclusion of airships is not studied in relation to legislation
  - The integration of airships will require a strong political will and take a long time
- **There are currently no specific general licences for airships**
  - The European Aviation Safety Agency (EASA) is working on a licensing system for blimps but is not including the case of airships.

Specific Certification

- **Although no general legislation exists there are developments that are specific for airship certification.**
- **Initially in the US (1990) and later in Germany, minimum requirements for producers were defined.**
- **In 2000, Transport Airship Requirements (TAR) were published by the Civil Aviation Authorities *Luftfahrt-Bundesamt of Germany* and the *Rijksluchtvaartdienst* in The Netherlands.**
- **The TAR is the only reference so far addressing issues regarding safety, construction and airship navigation.**
- **EASA does have certificates issued for individual airships (mainly hot air balloons).**

  Zeppelin LZ N07 is a helium lifted airship that had a certificate issue granted on 17 June 2009

  A-1 Series by American Blimp Corporation is also a helium lifted airship with a certificate issued on 22 December 2011

  Both airships are for passenger transport purposes

Legislative Framework Belgium

- **Things largely depend on European legislation, especially taking into account the Single European Sky initiative**
- **The directorate general for aviation in Belgium is responsible for admitting aircrafts**

  The airworthiness of the aircraft needs to be proven according to standards

  For all commercial aircrafts there must be an ARC (certificate of airworthiness) provided to the directorate, which needs to be drafted by a certified organisation.

  In the end it is required to have type certification for the aircraft, which is most likely to be provided by the EASA (European Aviation Safety Agency)
- **When the airship is admitted it is required to be registered as such at the EASA**
- **For freight transportation purposes, the operator needs to file for a certificate of operation**

  In Belgium this can be done via the Directorate General for Aviation and the certificate applies throughout the EU.
- **In the final stage it is required to have approval for operations**

  In this stage it is necessary to achieve approval of the actual use of the airship in (Belgian) airspace. A number of stakeholders are involved in this stage.

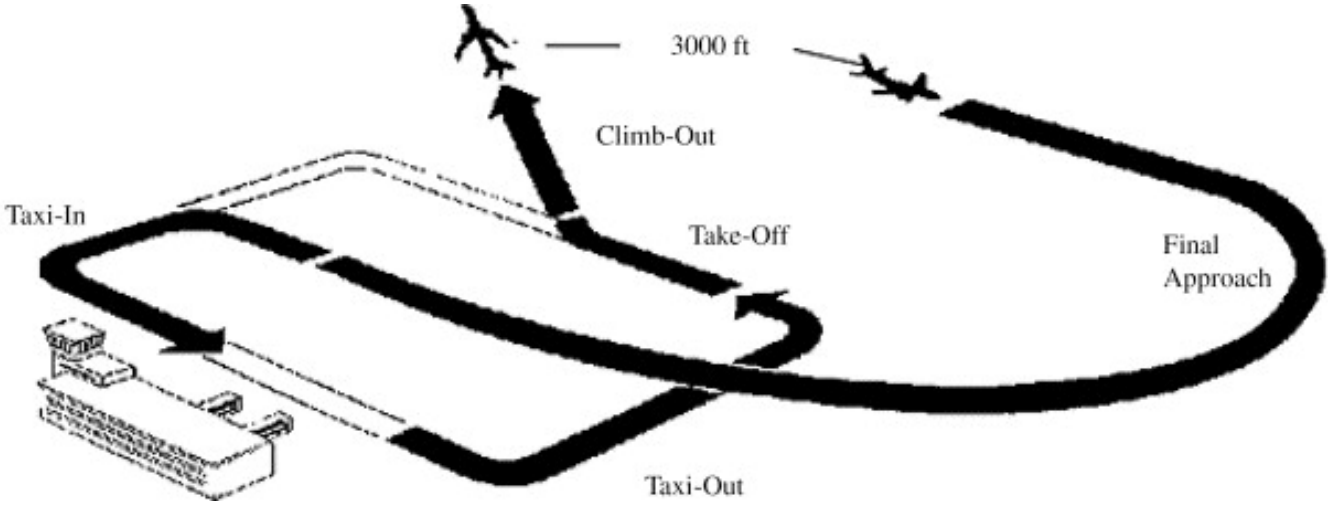
Airport Procedures

- **Airports are not ideally suited for airships due to regulations on LTO-procedures**

  LTO-cycles have been determined for traditional aircrafts

  - Approach with an inclination of 5%
  - Climb-out with an inclination of 10%

  Airships do not have the capacity to obtain the minimum speed required for the LTO-cycle (100 knots or almost 200 km/h)



A summary of uncertainties in legislation

- **A number of aspects need to be addressed in order to make airship movements possible in the future (on EU-level)**

  Rules and regulations regarding the use of airspace and integration in the Single European Sky framework

  General admission framework for hybrid airships as a mode of transport Inspection and certification of hybrid airships according to dedicated guidelines

  Procedures for flight, landing and take-off in coordination with the existing use of airspace (Belgocontrol)

  Requirements and procedures in order to fly with cargo through airspace

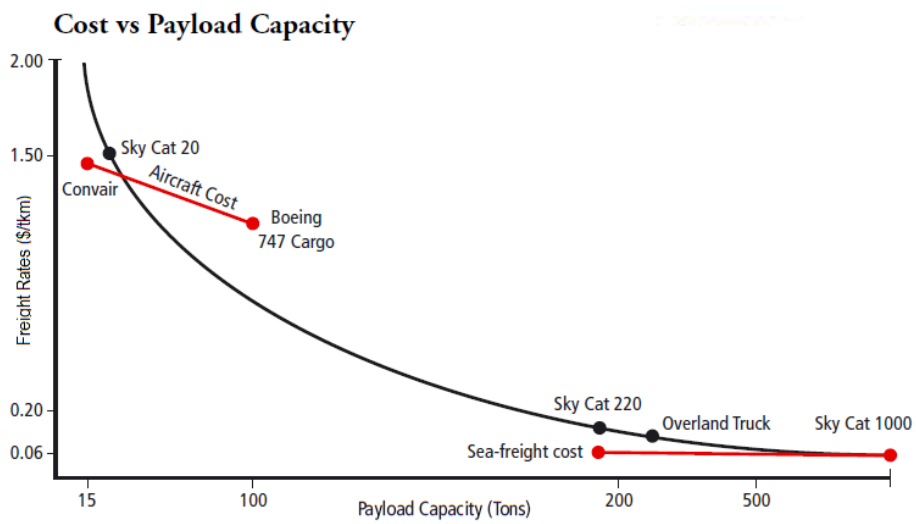
7 Comparison with transport modes

Costs

- **A hybrid airship with a payload of 20 MT would actually be slightly more costly than conventional airfreight**
- **At a payload of 200 MT costs would be comparable with trucking**

  Comparing the total volume in tonnes transported by equivalent number of trucks
- **At 1,000 MT freight rates would be comparable to sea freight**

  There are many uncertainties regarding a payload of 1,000 tonnes; 400 tonnes would seem to be realistic in the medium run



Source: SkyCat

External Costs

- **External costs of airships are comparable to rail and inland navigation but are significantly lower than the external costs of traditional aviation and even road transport**
- **The calculation is based on estimates and need to be internalised in future business case calculations.**

	Road	Rail	IWW	Aviation	Airship
Cost Category	**€/1,000tkm**	**€/1,000tkm**	**€/1,000tkm**	**€/1,000tkm**	**€/1,000tkm**
Accidents	10,2	0,2	0,0	4,0	1,0
Air Pollution	6,7	1,1	5,4	7,2	5,0
Climate Change	9,8	0,9	3,6	375,2	3,0
Noise	1,8	1,0	0,0	8	0,5
Upstream and Downstream processes	3,0	4,2	1,3	56,8	3,0
Nature & Landscape	0,7	0,0	0,4	4,8	0,0
Biodiversity Losses	0,5	0,0	0,5	0,8	0,0
Soil & Water Pollution	0,8	0,4	0,0	0,0	0,0
Urban Effects	0,5	0,1	0,0	0,0	0,0
Total	34,0	7,9	11,2	456,8	12,5

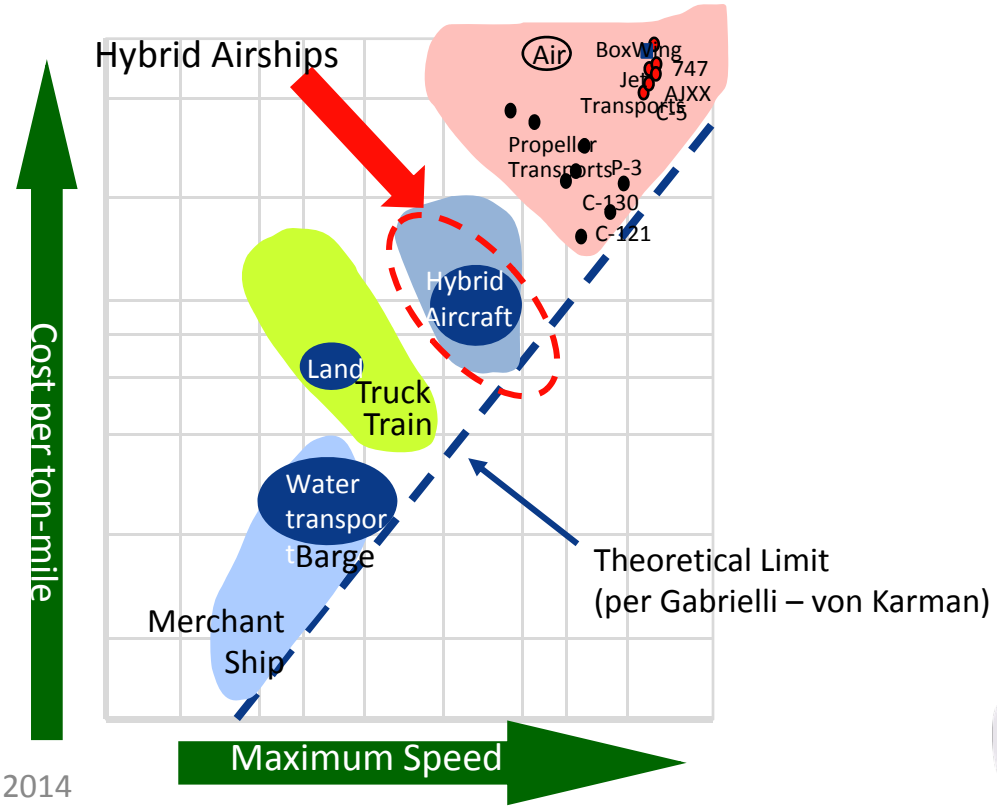
Source: CE Delft, Ernst & Young, BCI

Speed

- **Hybrid airships have an intermediate position between ground and sea transportation on the one hand and aircrafts on the other hand**

  The average speed of an airship is twice the average speed of trucks, three times the average speed of rail transport and four times the average speed of a container ship

  In reality, weather conditions can strongly influence the maximum speed of airships



Source: Tatievsky, Tsach (2011)

Range

- **With a range of 2,000 up to 11,000 km, hybrid airships are comparable to conventional aircrafts that have a similar or smaller range (see table below)**

  However, meteorogical conditions will have an impact on the range

  There is a proportionality between the size of the airship and its maximum range; the bigger the airship, the larger will be the range

Aircraft type	Maximum Payload (t)	Maximum Range (km)
Antonov An-225 Mriya	250	4,000
Boeing 747-8 Cargo	154	8,288
Airbus A380 Cargo	152	10,400
Boeing Dreamlifter	113	7,800
Airbus A330 200F	69	7,400
Airbus Beluga	47	2,779
Antonov An-70	47	6,667
Boeing 767 Freighter	44	6,028
Cessna super Cargomaster	2	1,596

Source: BCI research

Capacity

- **Current blimps and prototypes of hybrid airships have a limited capacity (20 – 60 tonnes).**

  Their current capacity is comparable to the capacity of trucks

  This capacity is too small to be competitive with other modalities

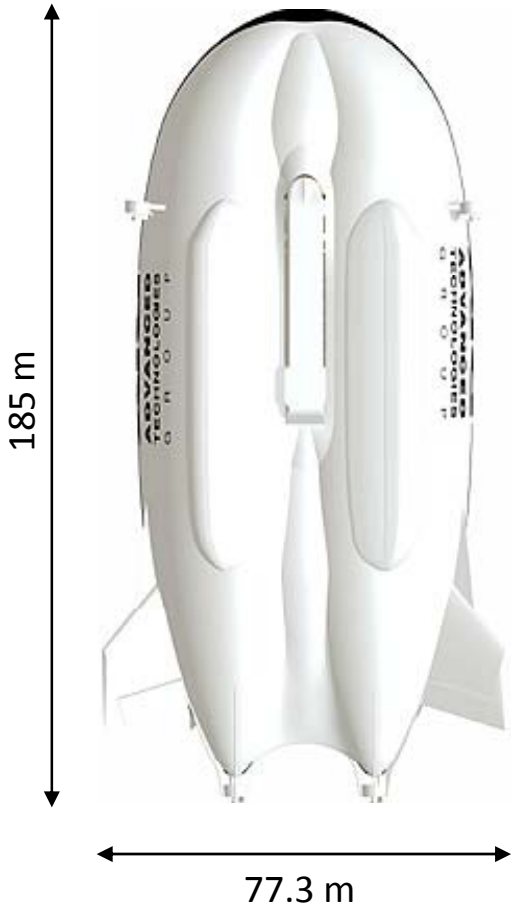
- **However, there are plans to build airships with a capacity ranging from 200 tonnes to as much as 1,000 tonnes.**

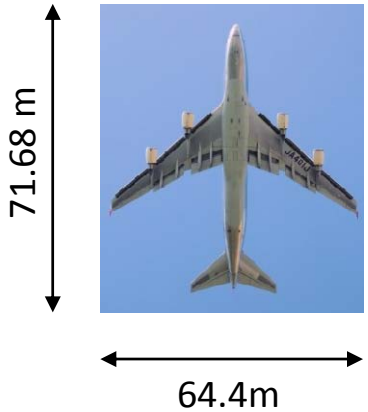
  It is to be expected that the airships with a capacity surpassing 100 tonnes, will have a true competitive advantage compared with other transport modes.

  In the medium term, 200 - 400 tonnes of payload seems to be realistic, for 1,000 tonnes of payload considerable progress in terms of design is required.

Size

- **Airships will be much bigger than freighters and even barges when payload increases.**

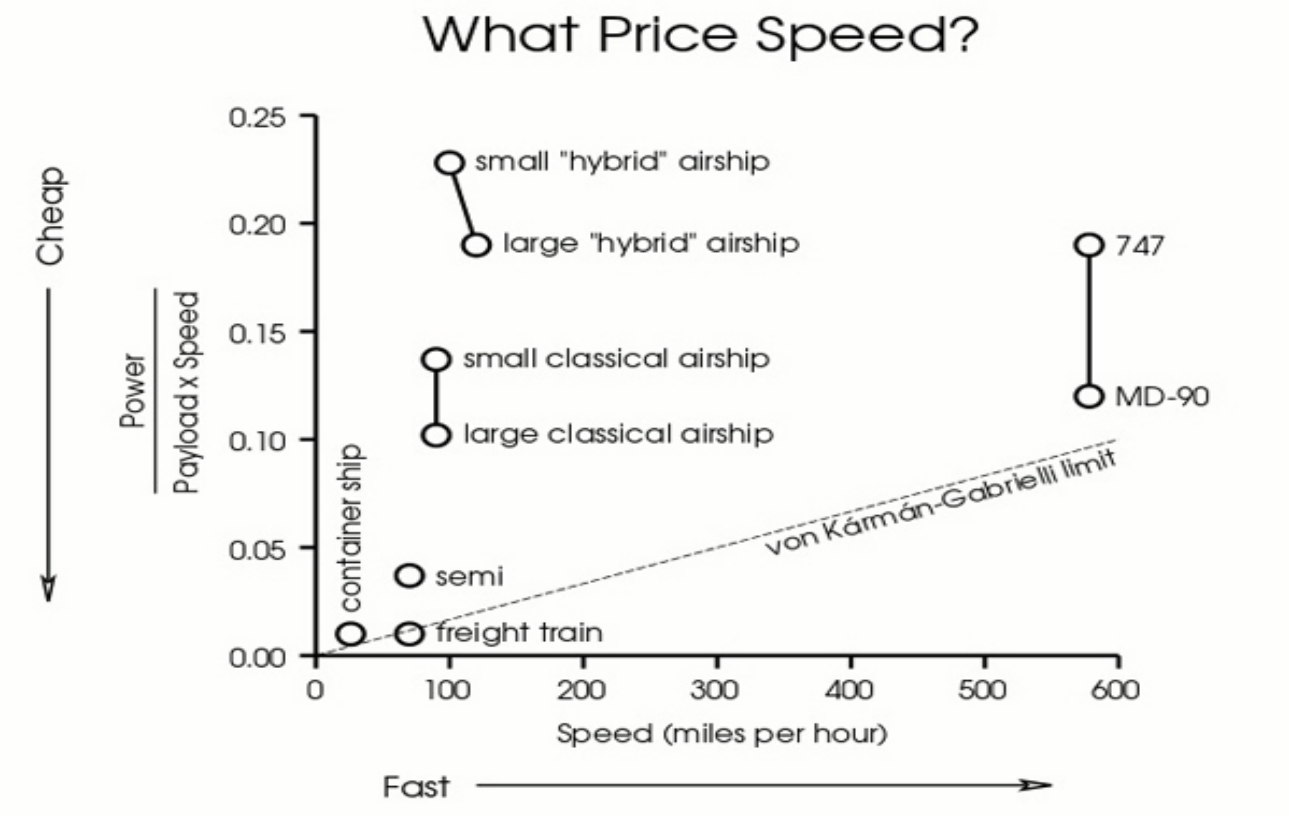




	Length (m)	Width (m)	Payload (Tonnes)
Skycat 200T Airship	185	77,3	200
Boeing 747 Dreamlifter	71,68	64,4	110
CEMT class IV Barge	85	9,50	1.350

8 Critical View on Airships

- **Using the 'von Karman-limit', the score of the hybrid airship is unfavourable compared to other transport modes.**



Critical View

- **Sceptics state that airships got left behind in the transport market due to their inefficiency**

  Any vehicle efficiency is measured by how much it carries (payload) vs. the energy used and the speed of movement.

  In 1950, Theodore von Karman showed that the horsepower of a vehicle divided by its weight and speed will determine how efficient that vehicle is compared to other vehicles.

  Nowadays, we no longer use the weight of the vehicle but instead the weight of the cargo it carries.

  The results of the analysis can be plotted on a log-log scale.

Critical View

- **The figure shows that**

  A train is roughly as efficient as a container ship, but it goes faster.

  Transportation by road (semi-trailer) uses approximately four times as much power as rail transport to achieve roughly the same speed.

  Airplanes use 2.5 to 5 times as much power as a truck but they deliver their goods 10 times faster.

  Classical airships are not much faster than trucks or trains and barely score better than the most efficient airplanes regarding energy use.

  Hybrid airships are slightly faster than trucks and trains but the energy use of even the largest airships isn't higher than the energy use of a 747.

  - Models under development and testing use less energy per tonne moved compared to all other modes of transport.

- **Some sceptics have decided that there is no place for hybrid airships in the current transport market but even in the most pessimistic scenario airships remain attractive from a total logistics costs viewpoint.**

9 Potential Cargo Types and Markets

Strengths

- Substantial payload (larger than truck and most aircrafts)
- (Potential) Large payload volume, 200 MT expected in short/mid term
- Ability to fly point-to-point routes in a straight line
- Ability to land/offload at inaccessible locations or locations with either no or minimal infrastructure (with addition of loading cranes on airship)
- No transfer required to other transport modes in case of direct accessibility to sites
- Faster than train or shipping
- Permits just-in-time delivery of project cargo
- Facilitates the use of simple logistics solutions, and factory assembly instead of on-site assembly

Weaknesses

- Slower than airplanes
- Access to intensively built areas (metropolitan areas) is restricted, which leads to transshipment in the supply chain
- Vulnerable to weather conditions, can lead to increasing costs
- Legislation is currently not up-to-date in order to 'accept' airships
- Airships cannot use airports as a hub given current regulations
- Unclear whether project cargo (high volume and weight) can be admitted
- Currently, market acceptance is low
- Transport cost are difficult to assess

Potential Airship Niches

Type of goods	Description	Markets
• All types of cargo	• Cargo for long distance destinations that are difficult to access with current modes of transport (taking several transhipments) For example: Africa • Cargo for short distances difficult to deliver to congested areas. For example: Main port areas	• Container • Project cargo and construction industry
• Project cargo	• Supply of offshore industry and offshore construction sites with large elements. • Project cargo delivered to deepsea ports (unfit for road transport) can be moved into other port areas and short distance hinterland, without the need for disassembly or vice-versa	• Offshore energy (wind, oil and gas) • Onshore energy sector • Construction industry
• Perishables	• Niche markets for perishables that are of medium value and have a relatively short shelf life	• Food sector

Source: NASA (2011), EY (2013), Khoury and Gillett (2004)

Stakeholders' views

- **BCI has discussed the possibilities and feasibility of airships as a freight transport mode with stakeholders of different supply chains.**
- **Opportunities mentioned/verified in these talks included:**

  Project cargo for offshore energy markets.

  Heavyweight project cargo of between 150 and 400 tonnes.

  Machinery and construction elements that are now being assembled on site at a high cost. With airships this is no longer required.

  Perishables like vegetables and fish that can be kept fresh, but not for very long if lead time decreases.

  Seasonal transportation of goods for which no airline routes are available given a certain (short) time in a year.

  Cargo (general) that needs to be moved into isolated areas, either with or without difficulties, accessible by road or rail. For instance, the African continent, islands, etc.

Potential competitive advantage

- **The table below summarizes the competitive advantage per sector as compared to existing modes, based on literature review and market consultation**
- **Perishables and project cargo provide the most opportunities in which airship transport can have a competitive advantage towards other modes**

	Truck	Rail	Barge	Ship	Air
Bulk (dry and liquid)	-	-	-	-	-
Containerised goods	+	-/+	-/+	-	+
Perishables (agri-food, cut flowers, pharma)	+	+	+	+	+
Project cargo	+	+	+	+	+
Manufactured material	+	-	-	-	+

10 Business Cases

- **In order to assess the feasibility of using hybrid airships in freight transport, business cases are needed.**
- **For this study, two business cases have been developed in order to obtain an initial idea on the viability of the transport solution.**
- **The cases are based on a hybrid airship with a 200 tonne payload.**
- **The cases only focus on operational costs, excluding other costs**
- **The two cases have been chosen based on:**

  the potential niches mentioned most frequently by market stakeholders and

  actual shipments being made by other modes of transport in order to make a comparison possible.

- **Case 1: Fresh fish from Norway to Antwerp**
- **Case 2: Project cargo (wind turbine modules) form Denmark to Antwerp**

Case 1 – Fresh Fish

- **Fresh fish is being transported from Norway to Antwerp**

  The shelf life of fresh fish is three days.

  The transfers/handlings need to be minimised in order to avoid time loss.

  The longer it takes the product to be shipped the lower the remaining value will be.

  The products are increasingly being shipped by reefer containers.

  Cool chain logistics for these products mainly consist of road and rail transport. As a consequence, airship transport is comparable to road and rail transport.

Case 1 - Current Road Transport

- **The fresh fish are being shipped directly by road (cool trucks) from Norway to Antwerp**
- **The transport chain in detail:**

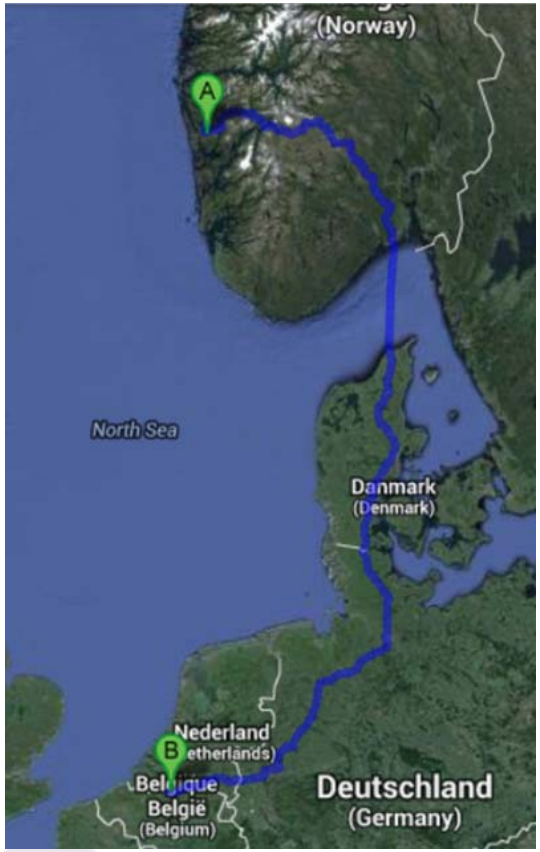
  Road transport Bergen – Oslo (480 km)

  Ferry Oslo – Hirstals (Denmark)

  Road transport Hirstals – Antwerp (1,060 km)

  Handling consists of stuffing in Bergen and stripping of the reefer in Antwerp

  Transit time from Bergen to Antwerp is ~39 hours



Case 1 - Current Rail Transport

- **The fresh fish (40 ft reefer) is being shipped by train from Norway to Antwerp, via Rotterdam**
- **Case of 2,800 tonnes/week**
- **The transport chain in detail:**

  Road transport Bergen – Oslo (480 km)

  Train Oslo – Rotterdam

  Road transport Rotterdam – Antwerp (100 km)

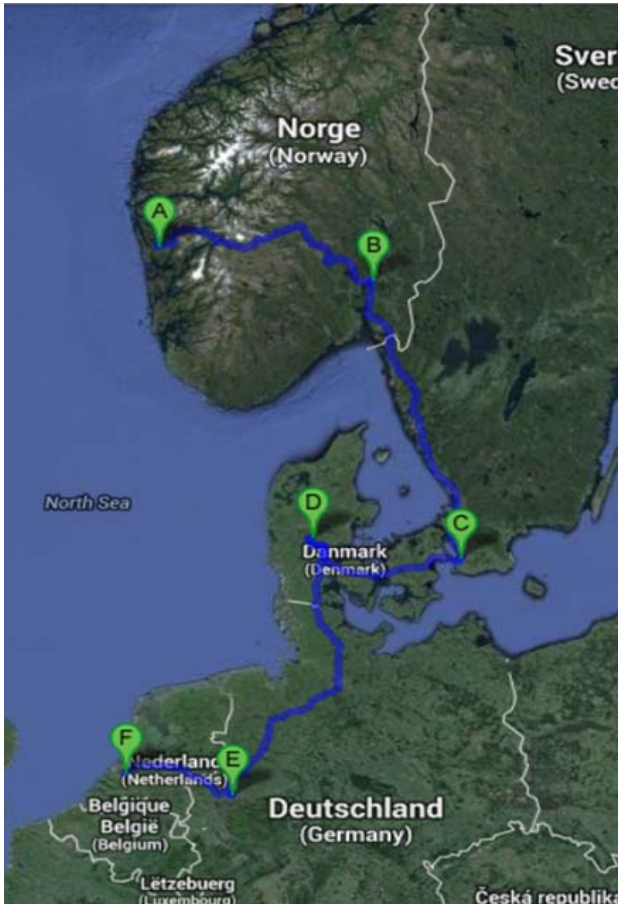
  Handling consists of:

  - Loading/unloading and stuffing/stripping
  - Terminal handling charges at rail terminals

  Service is twice per week

  Total transit time is ~35 hours

  - Transit time is 26 hours by train from Oslo to Rotterdam



Case 1 – Airship Transport

- **The fresh fish (2,800 tonnes/week in 40 ft reefers) are being shipped by airship from Norway to Antwerp,**
- **The transport chain in detail:**

  Road transport from production site to airship (assumed 20 km)

  Airship from Bergen – Antwerp (1,000 km as the crow flies)

  Road transport from airship to Antwerp (assumed 20 km)

  Handling consists of:

  - Loading /unloading and stuffing/stripping of the reefer container

  Total transit time of less than 15 hours is possible, including road transport and handling.

Case 1 – Parameters for Calculations

- **The following parameters were used in the operational business case calculations:**
- **Road transport:**

  18 tonnes per truck

  156 trips per week (2,800 tonnes/18 tonnes per truck)

  €1.08 per tonne/km

  Ferry services are €150 per passage

  Handling in Bergen is calculated at €35 per truck

  Handling and stripping at an Antwerp terminal is calculated at €135 per truck
- **Rail transport**

  Road transport (Bergen – Oslo and Rotterdam – Antwerp) is calculated based on the same conditions as road transport scenario

  65 x 40’ reefer containers per full train

  Train slots (full train) at €1,825 per hour

Case 1 – Parameters for Calculations

- **The following parameters were used in the operational business case calculations**
- **Airship transport:**

  Road transport only for 20 km from production to airstrip and airstrip to Antwerp

  - 18 tonnes per truck
  - 156 trips per week (2,800 tonnes/ 18 tonnes per truck)
  - Based on short distances the hourly rate is €54 per truck
  - Loading in Bergen is calculated at €35 per truck
  - Handling and stripping at an Antwerp terminal is calculated at €135 per truck

  Handling (loading and unloading of airship) at airstrips in Bergen and Antwerp assumed at €65 per handling

  Tonne/km prices of €0.10 and €0.15 assumed to identify price range, both values are assumed for airship with 200 tons payload capacity

Case 1 – Results

- **The airship business case is evidently based on assumptions regarding the tonne/km price. It was set at €0.10 and €0.15 per tonne/km by an airship with 200 tonnes as the payload capacity.**
- **A price range of €0.10 - €0.15 tonne/km is a realistic assumption.**
- **Tonne/km price will decrease with:**

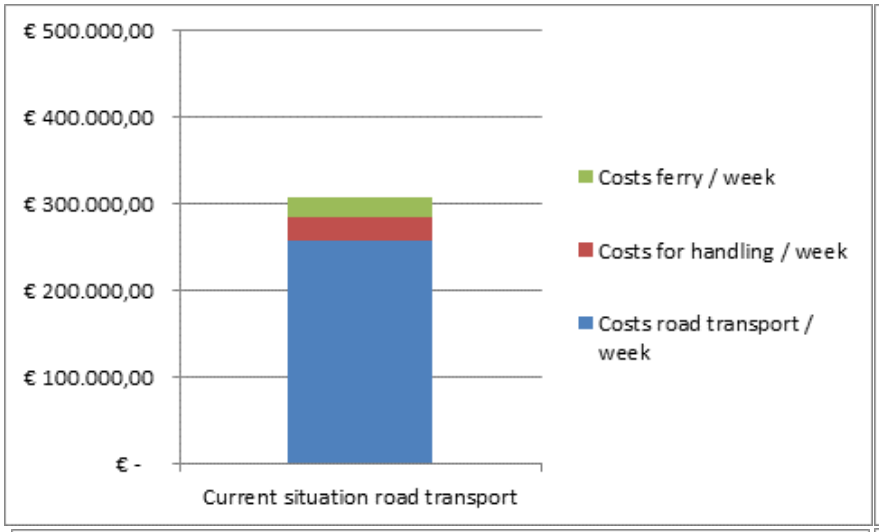
  Increase of payload (to approximately 400 tonnes)

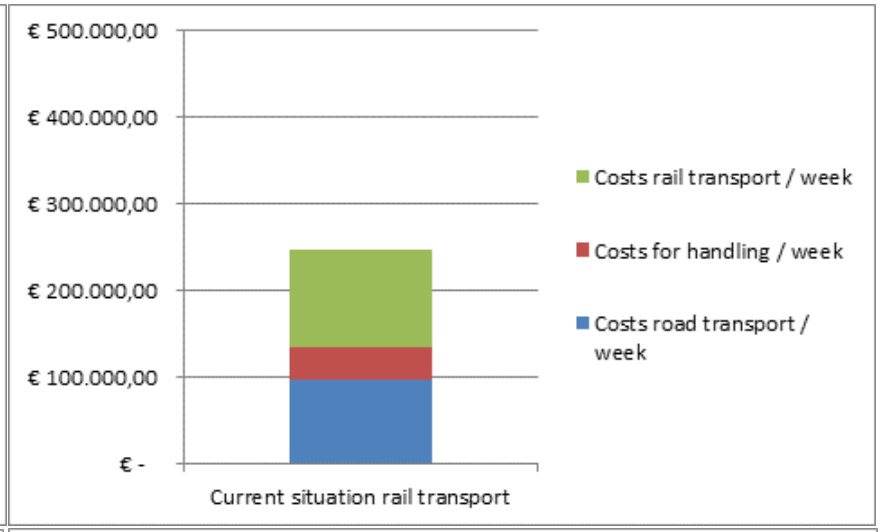
  Operational efficiencies to be achieved
- **As regards transit times, airship transport is on average 20-24 hours faster than road and rail leading to an increase in value for fresh fish as shelf life is conserved, which makes the business case more feasible.**

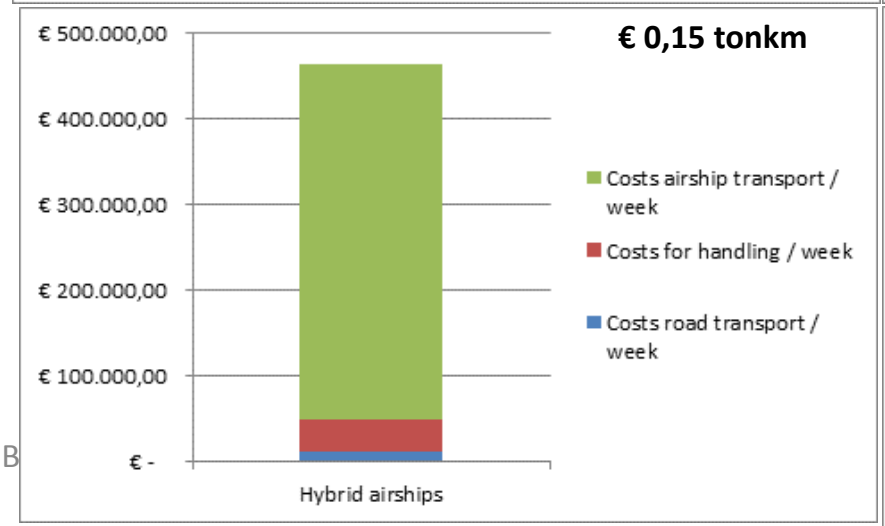
  If the market price of fresh fish is higher due to transit times being shorter it will be possible to support higher transport prices.

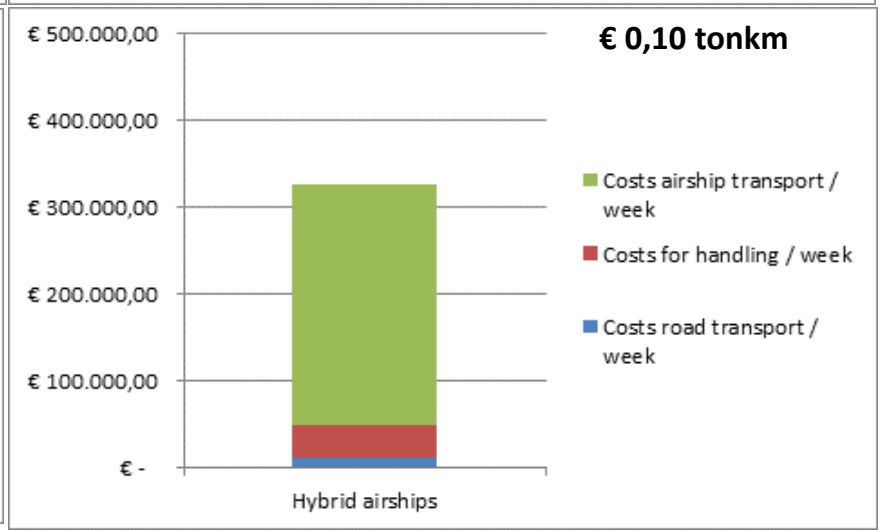
Case 1 – Results

- Business case for road and rail transport modes currently used
- Business case for hybrid airships (both at €0.15 and €0.10 tonne/km)







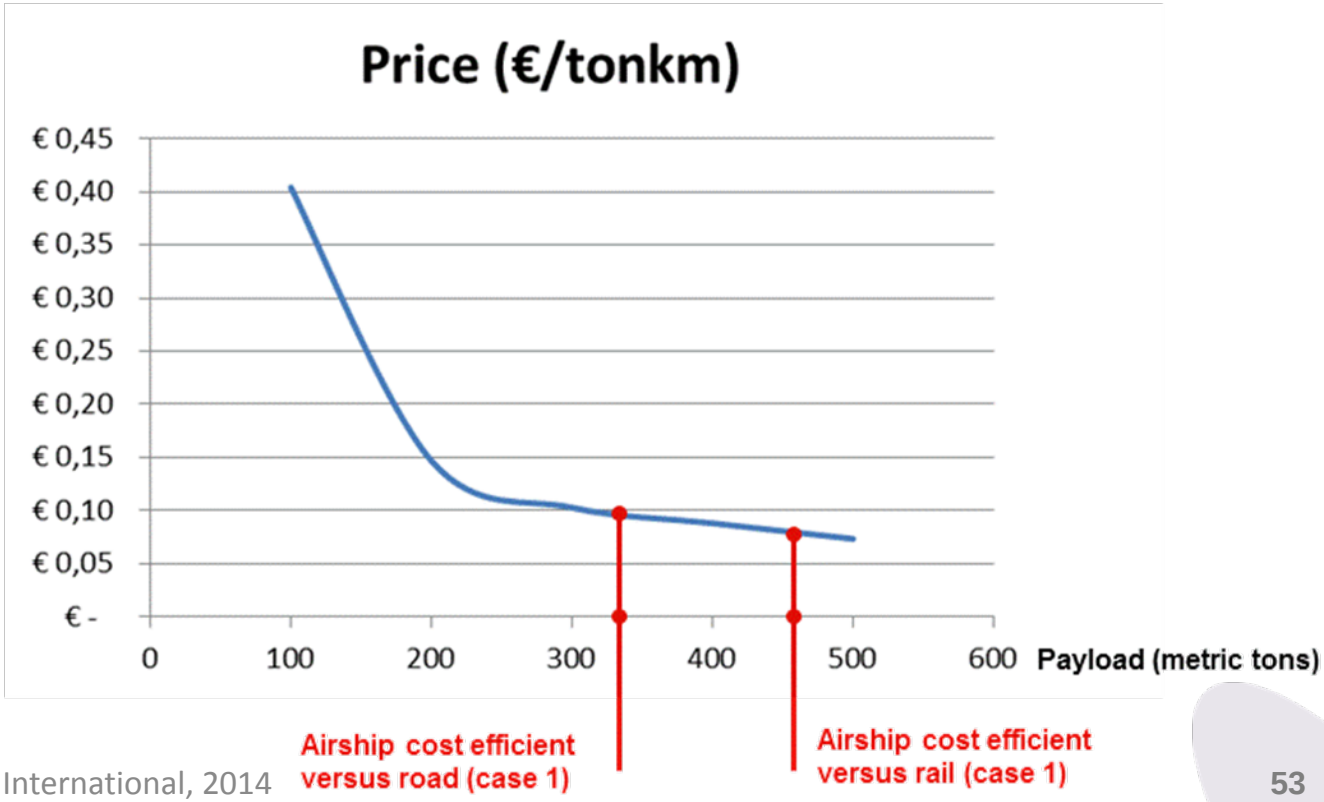


Case 1 – Results

- **Break-even points in the business case can be achieved when the price per tonne/km for hybrid airships drops (and, thus, payload increases)**
- **Break-even points will be reached sooner if:**

  The higher market price of fresh fish is taken into account

  The case for return cargo (fresh fruit, vegetables and flowers) can be made



Case 2 – Project Cargo Wind Turbines

- **This case involves the shipment of wind turbine wings from Denmark to Antwerp.**
- **Wind turbines are shipped in components from production sites to ports where assembly and final offshore shipments take place.**

Transport can be currently achieved by road or short sea shipping.

For the handling of components such as wings, special equipment is required for both modes of transport; this also accounts for airship transport.

In order to arrange transport, special permits need to be requested for road transport. Airship transport must also be authorised with an exception.

Wings measure up to 62 metres and weigh up to18 tonnes, hence airships can carry multiple wings.

In this case airship transport is
transport.

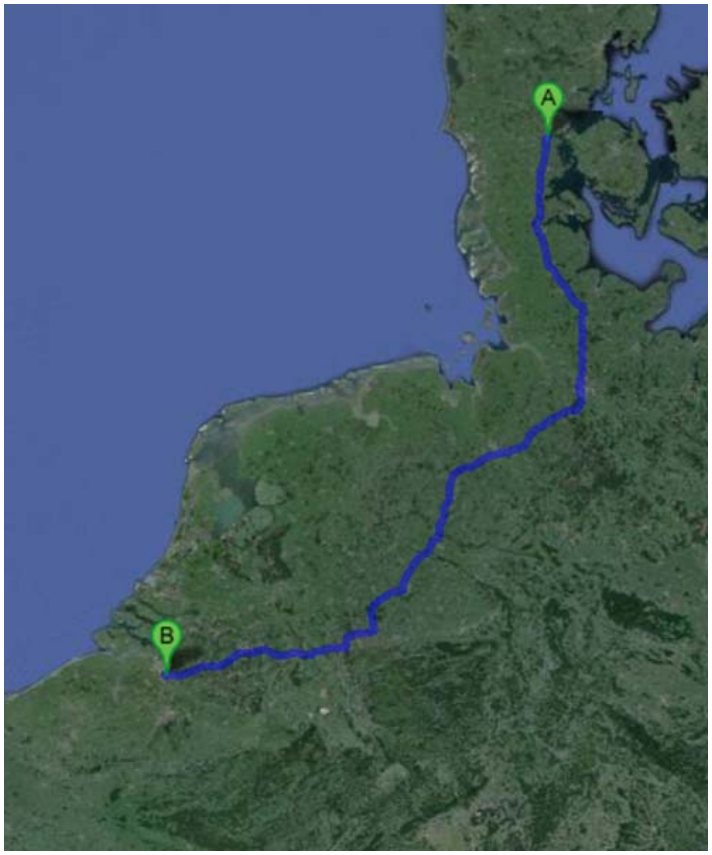
Case 2 - Current Road Transport

- **The wind turbine wings are being shipped directly by road from Denmark to Antwerp**
- **The transport chain in detail:**

  Road transport Kolding to Antwerp

  Fixed price for special transport

  Reception costs and handling of special cargo



Case 2 – Airship Transport

- **The wind turbine wings are being shipped by airship from Denmark to Antwerp.**
- **The transport chain in detail:**

  Loading of wings (90 units) directly at the production site

  Airship from Kolding – Antwerp

  Direct unloading and handling at the Port of Antwerp

  Handling consists of:

  - Loading and handling of the components at both the production site and the port.

Case 2 – Parameters for Calculations

- **The following parameters were used in the operational business case calculations**
- **In both cases 90 wings are being shipped**
- **Road transport:**

  One wing per truck

  Fixed price for exceptional transport at €3,200 per trip

  Handling in Kolding is calculated at €1,230 per wing

  (special loading equipment is required)

  Handling and unloading at an Antwerp terminal is calculated at €450 per wing (existing terminal handling equipment can be used)
- **Airship transport**

  For road transport (Kolding – Airstrip and Airstrip – Antwerp) the calculation is 350 per hour

  1.5 hours of road transport is assumed per wing

  585 kilometres of airship transport is required

  One wing per airship is assumed (which is conservative)

  The same handling and unloading charges are assumed for Kolding and Antwerp

Case 2 – Results

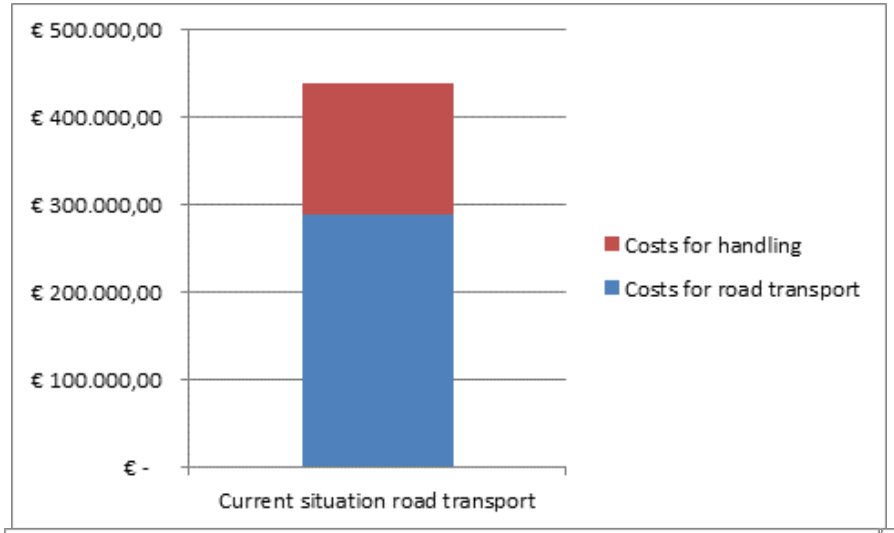
- **Given a €0.10 - €0.15 tonne/km price for airship transport this turns out to be an extremely competitive alternative for road transport.**
- **This is because with exceptional transport solutions the tendency is to work with fixed prices instead of tonne/km rates.**
- **Exceptional transport is more complex and requires road assistance vehicles to accompany the transport.**

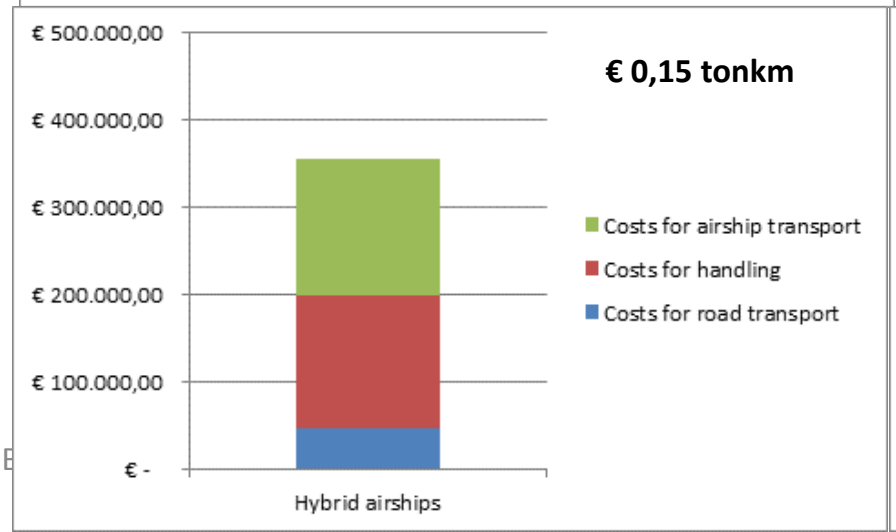
  This leads to high prices per shipment.

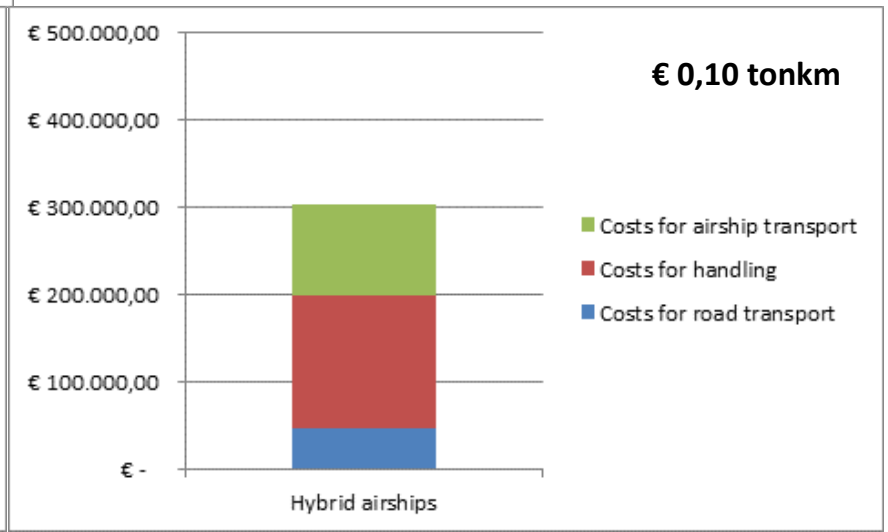
  The lengthy preparation of road transport in this business case is not taken into account. If it were taken into account then the competitiveness of airships would further increase.
- **The transit time for the movement of wings will be reduced by at least 24 hours by using a hybrid airship.**

Case 2 – Results

- **At a price of €0.15 and €.0.10 per tonne/km for hybrid airships a competitive price is established**







11 Conclusions

- **Feasibility is determined by researching technical aspects, legal aspects and business cases**

Feasibility	Current status		Perspectives	
• Technical aspects, product development	●	• Prototype hybrid airships are available and test flights are being made • Some technical challenges need to be resolved • Airships with higher payload are required, approximately 400 tonnes	◐	• Positive signs regarding new types of airships • Higher payloads seem to be realistic on mid-term
• Legal aspects	●	• Procedures for admission of aircrafts seem to be in place, but are not dedicated to airships • Procedures for use of airspace are unclear.	◐	• The certification criteria need to be addressed and coordinated by relevant government institutions. • Airships can be admitted as an exception.
• Business case	◐	• At the operational level, hybrid airships are already competitive for perishables and project cargo cases • Uncertainties regarding investments for large airships exist in the overall business case	○	• It is expected that with the growth of payload capacity in airships the costs per tonne/km will drop, making the business case interesting for more product categories.

Technical aspects, Product development

- **There is currently just a limited use of hybrid airships, mainly involving research missions, advertising and surveillance.**
- **Airships for the transportation of goods are either under development or in the testing phase.**
- **Technical designs are promising:**

  Speeds of 200 km/h or more can be achieved.

  Maximum ranges predicted vary from 2,000 km up to 11,000 km.

  Payloads up to 60 tonnes are being tested and payloads up to 200 - 400 tonnes or more are being designed.
- **Challenges for the industry are also evident:**

  Manufacturing costs are substantial and depend on size and number

  Impact of meteorological conditions is significant, requiring design adjustments and mechanisms for control and stability

  Helium as a lighter-than-air lifting substance is relatively scarce and expensive. Also required is an impermeable hull design.

Legal Aspects

- Certification of airships has been carried out by the FAA (USA) and the EASA (Europe).
- Processes of certification are not dedicated for hybrid airships, but instead follow standard aviation procedures.
- Certification procedure requires a clear view on airworthiness, admittance by the EASA, certificate of operations and approval of operations.
- The use of airspace by hybrid airships needs to be regulated and adapted for heavily used airspace in Europe.
- Take-off, landing and flight procedures are to be coordinated by EUROcontrol (and other air traffic control centres).
- A general admission framework for hybrid airships as a mode of transport is required!

Business Case

- **Using hybrid airships for project cargo shipments appears to be a feasible market opportunity.**
- **To enhance the competitiveness of airships higher payloads are a must.**
- **Payloads of 200 - 400 tonnes are expected to become realistic in the mid term.**
- **Business case calculations require further research and more insights in terms of actual investment costs.**

  Cost factors need to include; investment costs, maintenance costs, operational costs, etc.
- **Speeds of airships may well be very critical for the success of airships**

  Shorter transit times lead to higher value products (perishables) and/or lower costs throughout the supply chain. This implies that the product could sustain higher transportation costs.

12 Recommendations

- **Airships could be an interesting alternative mode of transport contributing to less road congestion.**
- **For Flanders it is relevant to make the necessary progress**

  Hybrid airships add value to the logistics structure in Flanders and the ambitions for a strong, innovative and competitive sector.

  Hybrid airships provide an alternative to different products. Perishables and project cargo are good examples.

- **The following recommendations could be made based on this study:**
  1. **Monitor the technical development of airships as a mode for freight transport, participate in technical development programmes.**
  2. **Prepare a framework approach for resolving legal issues.**
  3. **Raise awareness regarding airship freight transport.**
  4. **Establish a market network for airship development.**

Recommendations

1. **Monitor technical development of airships as a mode of freight transport, participate in technical development programmes**

- **Technical developments are being made by several providers around the world. Monitoring progress is required to establish whether barriers that have been identified could be solved.**
- **Important technical developments are 'weatherproof' designs, payload capacity increase and flight and landing control.**
- **As helium is a limited and non-renewable resource an alternative needs to be found. Hydrogen, natural gas (methane), neon, etc. might be alternatives.**
- **Output from technical research and upgrading of airship designs have a positive effect on the outcome of the business case.**

- ***Government, research institutes and industry (aviation cluster) should jointly set up and participate in research programmes to realise common ambitions.***

Recommendations

2. Prepare a framework approach for resolving legal issues

- **Identify all relevant stakeholders in order to address the legal issues in aviation, type approval and landing and take-off**
- **Ascertain whether current legislation can be adapted (quick wins) in order to meet requirements for the use of airships as a transport mode**
- **Use an industry perspective in legislative designs as they need to be able to work within this framework**
- **Coordinate legal issues at the European level to avoid inefficient approaches.**

- ***Government agencies should take the initiative to organise joint meetings to prepare a framework. The Flemish government needs to address this at a European level.***

Recommendations

3. Raising awareness regarding airship freight transport

- **To become a serious alternative it is required to make the step from 'the drawing board' to the 'real life supply chain' in the form of a small scale pilot project.**
- **Organisation of events aimed at presenting opportunities and developments within the hybrid airship sector.**
- **Events need to have a broad audience, within the supply chain sector as well, to be able to raise support.**
- **The organisation of a demonstration project needs to be examined and - if possible – organised.**

- ***Industry pioneers need to show the potential of hybrid airships as a serious alternative for the transportation of goods. Recent publications in several media suggest the existing interest of industry partners. The Flemish government could support pilot projects and events.***

Recommendations

4. Establishing a market network (supply chain forum) for airship development

- **Sharing experiences in product development and business case development is required at this stage to jointly make progress.**
- **A network of developers and supply chain stakeholders need to be cretaed to share visions.**
- **Site visits to developers should take place in order to raise support for airship development.**

- ***Government could take the lead in establishing a network of supply chain stakeholders.***

Annex 1 Terminology

Technical term	Definition
Envelope	In a non-rigid airship the envelope is the outer surface of the aircraft, containing the ballonets within it. In a rigid airship it is the outer fabric covering, stretched over the structural framework
Gondola	Crew car of an airship, slung beneath the centre of the **envelope**
STOL	Short Take-Off and Landing
VTOL	Vertical Take-Off and Landing

Annex 2 Providers

Different companies are producing non-cargo airships. The most important are:

- **Lindstrand Technologies LTD.**

  Country: UK

  Airship types and uses:

  - Aerostats: surveillance and communications
  - Airships: surveillance, communications and research
  - Gas Balloons: racing, research, weather services
  - SkyFlyer: passenger transport (16 passengers)
  - HiFlyer: recreation, theme parks (30 passengers)

  Cargo capability: no

- **Zeppelin Luftschifftechnik**

  Country: Germany

  Airship types and uses:

  - Zeppelins: passenger flights, scientific research, aerial advertising, airmail

  Cargo capability: no

- **Van Wagner Airship Group**

  Country: USA

  Airship types and uses:

  - A 60+ airship: broadcasting, advertising, surveillance

  Cargo capability: no

- **A-NSE**

  Country: France

  Airship types and uses:

  - T –C350: Surveillance
  - A-N400& A-N800 & A-N1800: manned surveillance

  Cargo capability status: no

Other companies producing airships without cargo capacity are:

- Flying Yachts Inc.
- Cameron Balloons
- GEFA-FLUG
- Kubicek Balloons
- Raven Aerostar
- TCOM L.P.
- WDL Worldwide
- Huajiao Airship
- iii- Solutions
- SkyYacht

Several companies worldwide are in different phases of developing cargo airships:

- **Advanced Hybrid Aircraft**

  Country: Oregon, USA

  Airship types and uses:

  - Hornet RPV: remote controlled, freighter drone

  Cargo capability status: available but minimal (< 1.5 tonnes)

- **Coopership Industries**

  Country: Texas, USA

  Airship types and uses:

  - Coopership: military, telecom, passengers, Commercial cargo

  Cargo capability status: concept phase

- **Skylite Aeronautics**

  Country: Colorado, USA

  Airship types and uses:

  - GeoShip: point-to-point transport, remote location supply

  Cargo capability status: in development

- **Hybrid Air Vehicles**

  Country: UK

  Airship types and uses:

  - Hybrid Air Vehicles : military heavy lift, civil heavy lift, surveillance

  Cargo capability status: in development

- **Shanghai Vantage Airship Manufacturer**

  Country: PR China

  Airship types and uses:

  - Helium manned non-rigid: advertising, surveillance
  - Helium non-rigid tied down/ remote: advertisement, airial photos
  - Combined loading: air transportation, heavy lifting

  Cargo capability status : in development

- **Dynalifter**

  Country: Ohio, USA

  Airship types and uses:

  - DL-100 Patroller: surveillance, reconnaissance
  - DL-600 Light Freighter: aerial transport
  - DL-800 Freighter: aerial transport
  - DL-1000 Super Freighter: aerial transport

  Cargo capability status: in development, prototype DL-100 undergoing testing

- **Worldwide Aeros Corp.**

  Country: USA

  Airship types and uses:

  - Aeroscraft: transport and logistics
  - Airship: advertising, broadcasting, sensor platforms
  - Aerostat: surveillance, telecommunications scientific research

  Cargo capability status : in development, prototype March 2013

- **Millennium Airship**

  Country: Washington, USA

  Airship types and uses:

  - Skyfreighter:

  Cargo capability status: in development

- **Varialift Airships**

  Country: Birmingham, UK

  Airship types and uses:

  - ARH-50: heavy lifting, transport
  - ARH-250: heavy lifting, transport

  Cargo capability status : in development

- **Ros AeroSystems**

  Country: Moscow, Russia

  Airship types and uses:

  - AU -30 multifunctional: patrolling, tourism, advertising
  - ATLANT: hybrid cargo/passenger airship

  Cargo capability status: concept phase

- **World SkyCat**

  Country: Oxford, UK

  Airship types and uses:

  - Multiple types: a.o. surveillance, tourism, telecommunications
  - SkyFreight: heavy transport

  Cargo capability status: in development (?)

- **Solar Ship Inc**

  Country: Toronto, Canada

  Airship types and uses:

  - Chui: small payload cargo transport
  - Nanuq: heavy cargo transport

  Cargo capability status: in development, test version in flying tests

- **Skylifter**

  Country: Osborne Park, Australia

  Airship types and uses:

  - SL 150: heavy lifting, heavy transport

  Cargo capability status : in development

- **Lockheed Martin**

  Country: Maryland, USA

  Airship types and uses:

  - High Altitude Airship: surveillance platform, telecommunications relay, weather observer
  - P-791: surveillance, heavy transport, disaster relief

  Cargo capability status : in development, estimated entry 2014

- **Voliris**

  Country: France

  Airship types and uses:

  - DGV2: transport, containers

  Cargo capability status : concept phase

- **Cargolifter GmbH**

  Country: Berlin, Germany

  Airship types and uses:

  - AirHook & AirCrane: construction, heavy lifting
  - AirBarge: heavy transport (towed, not self-propelled)
  - AirTruck: short-mid distance transport
  - AirShip: long range heavy transport

  Cargo capability: proof-of-concept phase finished. End product within 5 years with sufficient funding

(Temporarily?) Cancelled Projects Include:

- **Boeing**

  Country: Illinois, USA

  Airship types and uses:

  - SkyHook JHL-40: Heavy lifting, transport

  Cargo capability status: project on hold since 2010

- **Northrop Grumman**

  Country: Virginia, USA

  Airship types and uses:

  - Long Endurance Multi-Intelligence Vehicle (LEMV): surveillance,

  Cargo capability status : cancelled in February 2013

Comparison of models

Company	Model	Range (km)	Payload (tonnes)	Cruising Speed (km/h)	VTOL capability	Development phase
HAV	Airlander	4,800	20 - 200	75	VTOL	Prototype
Shanghai Vantage	CA 60T	3,000	60	120	STOL	Test flight?
	CA 200T	3,000	200	120	STOL	Development
Worldwide Aeros	Aeroscraft	7,000	66	185 – 220	VTOL	Production in 2~3 years
	Aeros ML	5,000	400	250	STOL	Prototype
Varialift	ARH-50	6,000	50	630	VTOL	Full scale test model
	ARH-250	8,000	250	630	VTOL	
Lockheed Martin	P-791	11,000	20	?	STOL	Prototype
Skylifter	SL150	2,000	150	83	VTOL	Development
Luftschiftechnik	LZ NT 70	900	1.9	125	VTOL	Exploitation
AAT	First 1A	9,000	250	160	VTOL	Development

Company	Model	Range (km)	Payload (tonnes)	Cruising Speed (km/h)	Landing Capability	Development phase
Cargolifter	AirTruck	500 - 1,000	20 - 40	80 – 120	VTOL	Production ~ 5 years
	AirShip	10,000 (max)	80+	80 – 120	VTOL	Production ~ 5 years
	CL 160	10,000	160	90	VTOL	Cancelled
Millennium	SkyFreighter	3,700	70 (14 TEU)	150	VTOL	Development
Dynalifter	DL-600	1,640	20	185	STOL	Development
	DL-800	2,200-6,000	50-70	185	STOL	Development
	DL-1000	6,000	200	220	STOL	Development
World SkyCat	SkyFreight	6,000	220	155	STOL	Prototype
	SkyCat 20	4,000	20	120	STOL	Prototype
Solarship	Chui	5,000	1 – 2,5	73 - 100	STOL	Development
	Nanuq	6,000	12 – 30	84 - 120	STOL	
RosAeros Systems	AU30	1,600	1,5	90	VTOL	Exploitation

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