OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

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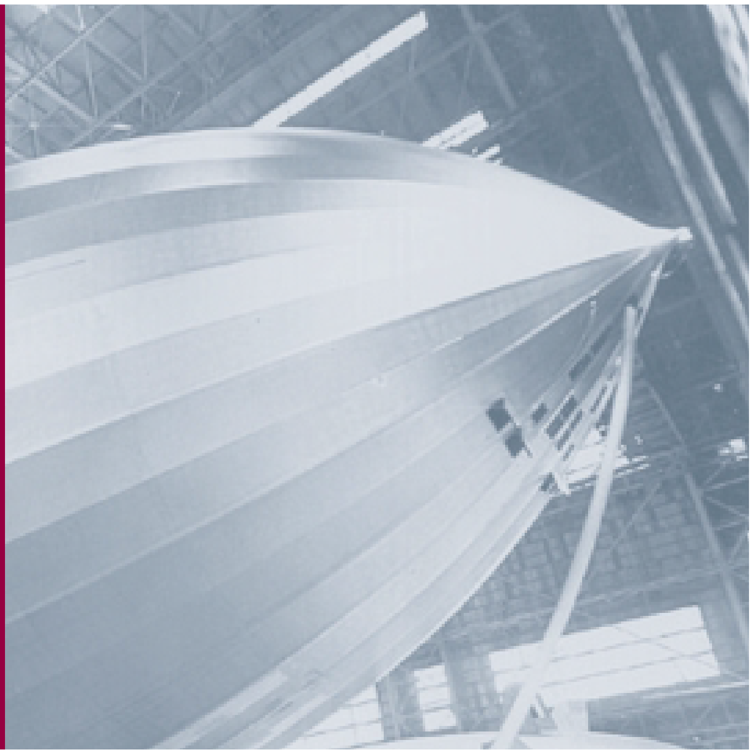
Lighter-than-air technology

Summary



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SUMMARY

The old human dream of floating weightlessly in the skies seemed to be coming true with Graf Zeppelin's giant cigars at the start of the last century. This dream was rudely shattered by the spectacular fire which destroyed the »Hindenburg« in 1937. Nevertheless, airships have remained a fascinating idea for many, and even today there are optimistic expectations about future uses of »lighter-than-air« (LTA) technology in numerous markets and for a wide range of civilian and military applications.

NEED FOR R&D

If we consider that the available LTA knowledge is based to a considerable extent on archives which are 40–60 years old (Zeppelin archives, NASA reports), we can see that current airship projects are based on a comparatively meagre stock of data and knowledge. This is why LTA technology is still relatively far away from a status which allows for design optimizations, which is generally the case in conventional aviation. There is need for R&D in many fields.

Hull materials

One optimization problem is that high mechanical strength and low gas permeability have to be achieved with the lowest possible weight. There is, accordingly, need for R&D in the design of individual material layers in terms of the desired combinations of properties (e.g. high tensile strength and tear resistance, high gas impermeability, good processing characteristics, kink resistance).

Structure and design

The interaction between structure and hull or ballonets respectively creates complex structural problems whose solution requires intensive R&D, particularly for very large airships.

Propulsion and steering technologies

With respect to conventional propulsion technologies there is need for research mainly into drives and drive shafts and drive control (e.g. for manoeuvring drives). Electrical drives need further development of concepts for batteries as

energy storage devices or fuel cell systems. There is also need for research into high-efficiency flexible solar cells for application e.g. on stratospheric platforms.

To improve the aerodynamic stability and control of airships, further development of fly-by-wire control is needed.

Lifting gas management

Development of effective and low-cost hull inspection procedures is required, particularly for larger airships. On-board systems in the airship and/or external measuring systems are needed to monitor helium purity. Such systems must accordingly be conceived and optimised in R&D projects. If hydrogen is used as the lifting gas, potential hazards must be considered in addition to technical suitability.

USES, MARKET POTENTIAL

Advertising and tourism (sightseeing flights) are the established commercial uses of current small and medium-sized (Zeppelin NT) airships. These uses could be more intensively exploited in stages, based on tried and tested technologies. No major advances in technology are required here. These airships could also be used for mission platforms (e.g. for TV transmissions, environmental monitoring or mine detection), when the opportunity arises.

There could be future potentials for LTA technology in particular in stratospheric platforms for telecommunications and monitoring applications and in the cargo market. However, these markets could only be served by large airships 250 m or more in length. However, the technologies needed for these airships are still in some cases in the stage of fundamental research. Given the long development times and high costs, it is doubtful whether potential investors will take on this high potential risk in the foreseeable future.

Advertising

The advertising market generally is highly competitive, and airship advertising, which is not directed at specific target groups, is competing e.g. with banner and billboard advertising. The relatively high rental price limits the market to major companies with a large marketing budget. Possibilities for developing this market segment are present specifically in incremental improvements to existing concepts, e.g. airships with special lighting equipment or specific designs (e.g. a »flying beer bottle«).

Tourism

The most important segments of the airship tourism market are sightseeing flights and multiday cruises. However, the market for such circuits and sightseeing is a highly competitive tourist niche market. Airships are competing with established systems – aircraft, helicopters and balloons. The advantages of airships (e.g. good view, comfort) are partly offset by cost disadvantages compared to competing systems. The possibilities of expanding this market segment lie particularly in developing airships with greater capacity than the 13 passengers carried by existing ships. This would reduce operating costs per passenger and improve profitability.

In the cruise market, airships would be competing primarily with established cruise ship lines. It is difficult for airships to match the luxury these offer. It is also doubtful whether prices could be charged which cover costs, even in the luxury travel segment.

Mission platforms

Airships can be equipped with a variety of sensors and analytical systems as well as transmitters and receivers for a range of uses - civilian (e.g. TV broadcasts), government (e.g. traffic monitoring) and military (e.g. mine detection). These involve smaller airships which operate at low altitudes, unlike the stratospheric platforms (see below).

Depending on the requirements, airships are competing with helicopters, aircraft and satellites. Compared to helicopters and aircraft, airships have advantages where a high level of intensity in monitoring is required, and compared with satellites airships offer more precise monitoring of smaller structures. Airships also have advantages for several applications because of their low noise and vibration levels.

A common feature of most of these applications (particularly in the nonmilitary area) is that they involve brief or local use. As a result, airship operators could serve this segment as a secondary market, provided that the required equipment is proven and available.

Passenger transport

The passenger transport sector poses high demands in terms of reliability and punctuality which conventional airships have difficulty meeting.

There are two main concepts for consideration in scheduled passenger transport. First, airships could be equipped with very powerful engines, so that they can reach the planned speed even with strong headwinds. This could, however, destroy the environmental advantages (lower fuel consumption, lower noise emission) which airships generally have over other means of transport. The second strategy would be to develop hybrid airships which generate part of their lift aerodynamically (like an aircraft). This would require new technological developments. There are already concept studies for this.

Cargo transport, heavy loads

The cargo market is largely covered by conventional means of transport (trucks, ships and aircraft, including helicopters). The main potential niches for airships are in heavy loads and special loads. A decisive advantage of airships would be point-to-point transport. This could reduce or even eliminate the disadvantage airships have compared with aircraft in terms of speed.

Although the cargo market seems to be an interesting area with future potential, it is doubtful at the moment whether the civil market is big enough to motivate potential investors to accept the heavy financial demands and high degree of risk in developing airships for transporting heavy loads. Accordingly military funding of basic technology development is widely seen as a chance for future market progression.

Stratospheric platforms

Stratospheric platforms operate at high altitudes (c. 20 km). They are primarily suitable for two uses – as relay stations for telecommunications, and as platforms for monitoring purposes. The first field is primarily civil, the second predominantly military.

An airship in the stratosphere acting as a relay station would technically be able to provide broadband services in an area of up to 400 km diameter. In contrast to communications satellites, stratospheric platforms could be recovered for maintenance, repair or retrofitting with new hardware and software, and would probably be significantly cheaper.

The second possible use is for surveillance and monitoring missions. Here, stratospheric platforms compete primarily with satellites and manned and unmanned (drone) surveillance aircraft. Compared with satellites, they have the technological advantage of higher resolution and sensitivity (by a factor of c. 50). In contrast to surveillance aircraft, there is the possibility of long and continuous monitoring of larger areas.

The primary market barriers cited are the high development costs and high risk potential. Important technologies required are still relatively far from maturity. The fact that the USA is pursuing a series of apparently coordinated military programmes in this field suggests that this issue has been given high priority. Many experts expect that basic development driven by the military could generate a technological advance which opens up new prospects for civil application of LTA technology.

LTA in developing countries

Airships are often regarded broadly as having particular appeal for use in developing countries. The reason given is the deficiency or absence of the infrastructure for passenger and cargo transport. However, more distinction needs to be made, depending on the specific use.

One field with future potential could be special missions in the government and civil area, such as securing national borders, monitoring gold mines, oil fields, pipelines, forests and agricultural areas, transporting patients and detecting landmines.

In terms of using appropriate technology, hot-air ships are particularly suitable for consideration in this area. A competitive advantage over established competitors – particularly helicopters – is that they are relatively easy to construct and the technical knowhow required to operate them is modest.

ENVIRONMENT AND SAFETY

Current airships are comparatively low in emissions, making them an environmentally friendly means of transport. In contrast to other aircraft, they can hover without using energy and move at a relatively low speed (mostly below 80–100 km/h). Specific uses have to undergo a detailed analysis to establish if this still applies to large airships to be developed. One point to consider, for example, is that an increase in cross section area means greater air resistance, with a resulting increase in the energy required. The energy required also rises if a higher airspeed is desired, particularly if this is to be attained in difficult weather conditions (e.g. strong headwind). The energy consumption of an airship in practice also depends on the operating scenarios, e.g. if flight often involves operating the motors or turbines under partial load conditions which are relatively inefficient in terms of energy consumption and emissions.

Airship operation could be virtually free of emissions if renewable energy (solar cells, hydrogen produced with renewable energy, fuel cells) could be integrated into the drive. A permanent deployment of airships in the stratosphere would be hardly conceivable without technologies using renewable energy.

As virtually all nonmilitary uses for airships are niche markets, there is no reason at present to see them as a significant substitute for conventional means of transport, with a detectable reduction in transport-related total emissions.

Airships are not intrinsically safer than aircraft. Damage to the hull means a loss of gas, and hence of lift. This loss would be relatively slow, even with extensive damage, so that there is little danger of a sudden fall. The force of a crash would accordingly generally be less than in the case of an aircraft crash. On the other hand this is already taken into account when designing the cabin and other safety equipment, so overall the safety level generally can be regarded as roughly equivalent to that in aircraft.

Airships can in principle be equipped to operate in all weathers. Nevertheless, airship operation is still dependent on the weather. Meteorological mission planning, involving calculating the potential lift at takeoff and landing and making the necessary preparations, is accordingly necessary.

OPTIONS FOR ACTION

A range of options for action are outlined below for state support in fully exploiting the potential of LTA technology as described. These could be selected in isolation or in combination, allowing development and implementation of a coordinated, stepwise strategy for promoting LTA technology.

Promoting synergies

LTA technology is characterised less by fundamental new developments than by adaptation and integration of technological advances in other areas. Promoting synergies with these areas is accordingly indicated.

Establishing an LTA research and development agency

LTA technology involves high development risks over a broad technological front. To enable actors pursuing LTA research and development to master these challenges, consideration should be given to logistical and coordination assistance in the form of an LTA research and development agency. The central functions of this agency would be to promote cooperation between actors in LTA research, to assemble existing knowhow and prepare it for marketing, and to classify product development for future LTA projects. In this way, an LTA research and development agency could act as a multiplier to secure German leadership in the technology.

Broaden the knowledge base and encourage pooling of experience

Another possible way to consolidate the relatively scattered knowledge would be to promote scientific exchanges in Germany and worldwide. The LTA expert group of the German aerospace organisation Deutsche Gesellschaft für Luft- und Raumfahrttechnik (DGLR) holds regular conferences on LTA and related topics. Reinforcing activities such as these – including in a European framework – is something for consideration.

The CargoLifter project was engaged intensively in research and development, and has made decisive progress in many aspects of LTA knowhow. This knowledge should – as far as possible – be secured and organised, and the results should be accessible to the public.

Create reliable rules and standards

Generally valid and internationally harmonised rules and standards are required for developing, constructing and operating aircraft. In the case of airships, such regulations are in a rudimentary state, and there is no international harmonisation at all.

A proactive role by the Luftfahrt-Bundesamt (German Civil Aviation Authority) and EASA (European Aviation Safety Agency) in formulation and international harmonisation of these regulations would be desirable. Intensive cooperation is recommended with manufacturers and operators during development. It could be a major competitive advantage for future LTA projects in Germany if a decisive contribution to the basis for international regulations was made in Germany.

Create a flexible promotional programme

If exploitation of the described potentials of LTA technology is regarded as economically and socially important, and the aim is to maintain Germany's technological leadership in this field, consideration should be given to creating a public promotional programme to demonstrate the technological feasibility (particularly of stratospheric platforms and airships for moving heavy loads) and to push ahead with construction of prototypes. Orientation for this could be provided by the current stratospheric platform programmes in Japan and the USA.

For realistic prospects of success, such a promotional strategy must be conceived as a long term programme, with a time horizon of 10–15 years. The total value of such a programme would probably be of the order of EUR 300–400 million over the entire period. However, this could only be supported if substantial funding from industry could be mobilised at the same time.

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