

A CRITICAL REVIEW OF GLOBAL REGULATIONS FOR CERTIFICATION AND OPERATION OF AIRSHIPS

Amol C. Gawale, Project Engineer
Rajkumar S. Pant, Associate Professor

Aerospace Engineering Department, IIT Bombay, Powai, Mumbai 400076.

Abstract:

This paper provides a critical review and comparative analysis of the regulations prescribed by various airworthiness agencies for certification and operation of airships. Commonalities and departures from the regulations applicable for fixed-wing aircraft are brought out. Salient features of regulations that have been prescribed by various airworthiness agencies for certification and operation of airships, pilot and ground-crew certification, maintenance, operation and certification of commercial air carriers, issuance of airship type certificates, and type certificate for external noise emissions are provided. Some peculiarities and differences that exist in regulations related to airship operations are highlighted through examples.

Acronyms¹

AC	Advisory Circular
ADC	Airship Design Criteria
CAP	Civil Aviation Procedure
CAR	Civil Airworthiness Requirements (UK)
CAT III	Category III of Instrument Landing System
CFR	Code of Federal Regulations
CL	Cargo Lifter AG
DGCA	Directorate General of Civil Aviation (India)
FAA	Federal Aviation Authority (USA)
FAR	Federal Aviation Regulation (USA)
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
JAA	Joint Aviation Authorities (Europe)
JAR	Joint Airworthiness Regulation (Europe)
LBA	Luftfahrt Bundesamts (Germany)
LFLS	Lufttüchtigkeitsforderungen für Luftschiffe (Germany)
LuftPersV	Rules for aviation Personnel-Part V (Germany)
RLD	Rijksluchtvaartdienst (The Netherlands)
SAD	Small Aircraft Directorate
TAR	Transport Airship Requirements (The Netherlands & Germany)
WDL	West Deutsche L'werbung
ZLT	Zeppelin Luftschifftechnik GmbH

Introduction:

Design, manufacture, safety, airworthiness and certification criteria are stringently applied on all forms of aircraft by aviation regulatory authorities all over the world. Aircraft certified by these standards are deemed airworthy. Conformation to accepted standards ensures a minimum level of safety during operations, and helps obtaining a type approval in countries other than the country of manufacture and/or certification.

Detailed regulations for fixed wing planes, helicopters and other aircraft are available with most

¹ The country of issue and applicability of the regulations is mentioned in the brackets.

regulatory agencies, and are very well known. However, except in the very early days, airships had not played any significant role in global aviation, hence few rules and regulations were established for certification for safe construction of small airship which have been used in the past. Owing to modern developments in materials and manufacturing technology and control system design, airships have emerged from the hibernation that they were forced to enter in late thirties, due to the much publicized *Hindenburg* disaster. In their new avatar, non-rigid airships are now being considered as the aerial vehicle of choice for several scientific applications such as HALE (High Altitude Long Endurance) platform for communications, stabilized platform for aerial photography and photogrammetry, and military applications such as anti-submarine warfare, airborne mine detection, airborne early warning, psuedolite based platform for precision navigation system, and integrated battle management, to name a few. In recent times, airships have also started revisiting their historic role as a vehicle for aerial sightseeing, and transportation of goods and passengers over mountainous terrains.

Nayler has been reviewing the airship developments programs worldwide. As per his latest report [1], 20 countries worldwide had some airship related activities (research, development, manufacturing, or operation) in progress in 2003. At present, there are 23 active manufacturers who have built manned airships, and another nine who have built unmanned, remotely-piloted airships (including stratospheric airships). Manned airships are being operated today in seven countries viz., Brazil, Canada, Japan, France, Germany, Switzerland, and USA. Thus, it can be said that airships are now returning in a big way as niche vehicles for applications where they score over their Heavier-Than-Air counterparts.

Owing to the obvious need to establish safety, operational and airworthiness standards related to airships, many regulatory agencies have started developing regulations for airships. Many components, equipment, processes and operating and testing procedures in airships can be considered to have a large degree of commonality with their fixed-wing counterparts. Regulations for these are either the same or largely derived from those applicable to fixed- or rotary-wing aircraft. Also, since the extent of airships operation are on the increase worldwide, the need for an internationally agreed set of operating rules is being felt.

Regulations for the airworthiness of airships in the United Kingdom have existed since the late 1970s due to the requirements of various companies headed by Roger Munk who has created many of the successful modern non-rigid airship designs. The current airworthiness requirement is British Civil Airworthiness Requirements, CAP 471, Section Q, Non-Rigid Airships. This document is known universally as BCAR Section Q. The document was originally published on 17th December 1979 with further reprints in April 1984 and May 1986, and was again republished in its entirety in February 2001, as Issue 2.

This paper is largely derived from the information provided by Gritzbach [2], Pavel Novak [3], Donaldson & Rentell [4] and the deliberations during a workshop on airship regulations [11]. The paper also reviews the current situation with regard to airworthiness regulatory developments, and outlines the progress that has been made in the development of operational regulations of airships.

Advisory Material, Policies & Guidance issued by FAA:

The impetus for creation of airship design criteria in the US arose from an application for a type certificate of a non-rigid airship in 1979, and then another such application in 1983. Prior to this, airships in US were built to the US Navy detail design specifications, and civil approval for the type certificates was based on the Navy's approval of the airship design. This procedure was unique at that time, and was predicated on the extensive experience of the U. S. Navy with airship design, construction and operation, since the early forties. The U.S. Navy, however, decommissioned the last airship in the early 60s, and to the best of the knowledge of the authors, does not presently operate any airships.

The FAA launched a program to arrive at the airworthiness criteria through the revision of § 21.17(b) of FAR-21 vide amendment 21-60 based on a critical review of the experience of US Navy personnel,

BCAR Section-Q, and portions of FAR-23. As a result, the FAA developed airship design criteria that are suitable for the U.S. type certification of non rigid airships. The criteria are based primarily on the FAR-23, U.S. Navy detail design specifications of airships, and additional criteria developed by FAA/NASA that were determined to be appropriate for current airship designs.

In 1987, the FAA issued an Advisory Circular AC 21.17-1A [6], which was later revised on July 24 1992 [7]. These documents provide advisory material and guidelines pertaining to type certification, and list the requirements for type certification of airships. Further, these circulars (with minor modifications as applicable) have been adopted by the civil aviation regulatory authorities in several other European countries like UK, Germany and Russia, which operate manned airships commercially.

Regulations for the issuance of airship type certificates:

The following regulations are currently in force for issuance of type certification for airships:

BCAR, Section Q:

These regulations apply to the type certification of the multi piston-engined non-rigid airships and manually operated control systems with maximum inflated envelope volume not greater than 42450 m³ (1.5 million ft³). These requirements are not applicable for other types of airship i.e., rigid airships, or for single engined airships, or for the transport category. Subsequent amendments may be incorporated to extend the applicability of BCAR Q to cover rigid or semi-rigid structures, installation of gas turbine power plants, powered control systems and other features as necessary to cater to an application for certification of a specific airship project.

FAA: P-8110-2 Change-1 Airship Design Criteria:

Based on the revised AC [7], a change in the original FAA document P-8110-2 titled, "*Airship Design Criteria*" (ADC) was incorporated to suit the requirements mentioned therein, while applying this new version of the ADC to actual type certification projects. Later, a modification of this ADC as Change-1 [8] came into circulation in 1992. Modern Non-rigid Airships in America are built to adapt to these criteria, which defines an airship as an engine driven, steerable lighter-than-air aircraft that is capable of achieving zero static heaviness in normal flight operations and whose structural integrity and shape is maintained by the pressure of the gas contained within the envelope. It provides acceptable airworthiness requirements for the type certification of conventional, near-equilibrium, non-rigid airships with passenger accommodation not exceeding nine seats. FAA also offers a category of *Experimental* aircraft for people who wish to experiment in single seater aircraft. However, the carriage of passengers requires the full majesty of the law [4].

Further regulations for type certification are detailed in Part 21 of the 14th Amendment of the CFR (14 CFR Part 21) titled "*Certification Procedures for Products and Parts*". Additional information on type certification is available in the several parts of the CFR, such as Part 21.17 for designation of applicable regulations, Part 21.183 for issue of type certificate, and Part 21.183 for issue of standard airworthiness certificates as reported in [2].

FAA has also stretched BCAR Q to cover larger Airship with up to 12 occupants (passengers and crew), but stated that an airship with greater capacity will need to be certified under Transport Category under FAR-21 paragraph 17b and registered as a special class. Therefore, FAA identifies Normal and Transport categories for airships, with the cut off at 12 occupants to harmonize the development of regulations for Transport Category Airships.

LFLS:

To develop formal airworthiness regulations to suit the large semi-rigid design of the Zeppelin NT N-07 class of airships, measures were put in hand by LBA. As an outcome of this activity a document titled "*Lufttüchtigkeitsforderungen für Luftschiffe der Kategorien Normal und Zubringer*" which

translates into English as “Airship airworthiness requirements for Normal and Commuter categories” (Generally referred as LFLS) was published on 3rd August 1999. They are valid in Germany for following two categories of airships.

- (a) The Normal category airship is a non rigid airship consisting of an envelope filled with the lifting gas and pressurized slightly above ambient, whose shape is maintained by the pressure of the lifting gas and that uses nose to tail structure for distributing the car weight into the envelope using catenaries. It is limited to airships that have a seating configuration, excluding pilot seats, of nine or less.
- (b) The Commuter category is limited to propeller-driven, multi-engine airships that have a seating configuration, excluding pilot seats, of 19 or less.

However, LFLS has some provision to certify the airships in more than two categories, if the requirements of each requested category are met by these airships.

Earlier, LBA has also been in the forefront of developing airworthiness regulations for both non-rigid and semi-rigid airships. There have been a number of German non-rigid airships, mostly constructed by the WDL Company in Mülheim. The WDL-1B airship received its certification in 1988 and its certification was based on an ad-hoc mixture that can be comparable with the BCAR Section-Q for the appropriate requirements. These requirements incorporated elements from airworthiness criteria for blimps by the Goodyear Aircraft Corporation, FAR-23 (12th Amendment) for engines and electrical systems, FAA-P-8110-2 Change-1, and additional LBA requirements for commercial passenger transport. Beside these requirements, the FAA criteria have been amended to provide airworthiness requirements for the type certification of airships in Normal and Commuter categories in LFLS.

TAR (March 2000 Issue):

LBA and RLD have developed common comprehensive airworthiness requirements for large airships to accommodate Type Certification applications for such aircraft in their countries [4]. Existing airworthiness codes such as FAR P8110-2 and JAR-25 have been selected to form the basis of these Transport Airship Requirements (TAR). Terms used in this TAR are as contained in JAR-1, “*Definitions and Abbreviations*”. The new category Transport Airships Regulations are applicable for the Conventional (Rigid and Semi rigid) and Non rigid airships in near static equilibrium². It defines airship as an engine-driven, lighter-than-air aircraft that can be steered. For the transport category airship, TAR defines airship as multi-engine propeller-driven airships that have a seating configuration excluding crew seats of 20 or more, or a maximum weight of 15000 kg or more, or a volume of 20000 m³ or more, whichever is greater.

JAR:

JAR is directly not available for normal, utility, and large airships. For that FAR or TAR may be adopted. However, the JAR regulations for various aircraft parts such as engines (JAR E), propellers (JAR P), APUs (JAR APU) and the Technical standard orders (JAR TSO) which are primarily for air planes can also be applicable for airships [2].

SA-CATS-AR

These regulations have been issued by the South African Civil Aviation Authority in 1992, and they are applicable for rigid and non-rigid airships. The motivation for issuing these regulations came from the ambition program of Hamilton Airship Company of South Africa, which aimed to develop a 65 passenger rigid airships capable of flying non-stop from Johannesburg to London. These regulations are mainly derived from BCAR-Section-Q and FAR-21 Design Handbook.

² Near static equilibrium is the capability of achieving zero static heaviness resulting in zero vertical air speed during normal flight operations.

Regulations on certification procedures for aircraft, products and parts by JAR:

In Europe, the regulations suggested in sections of JAR-21 can be applicable for aircraft and airships. According to this regulation each applicant for type certification of an airship must be certified as a development organisation. Since no JAR is available for issuance of a JAA airship type certificate, the approval of design organisations for airships according to JAR-21 section JAA can only be granted on national basis, i.e. not to be certificated on behalf of all JAA members. Each manufacturer of an airship must be certified as a production organisation according to JAR-21 section G. The approved production organisation is allowed to perform maintenance of non-commercial operated airships. Also, according to JAR-21 Section 145 for type certification, every production organisation should have the licensed staff due to training plans approved by the authority. However, no approved airship qualification and training material is available.

Regulations for Pilot Certification:

Civil aviation authorities specify special training requirements to fly different types of aircraft. Similarly, airship pilots are required to be qualified and should have the minimum requisite flying experience as stipulated in the corresponding regulations in order to be licensed to fly an airship. FAR-61 stipulates rules for certification of pilots and instructors. The applicant has to complete flight instruction in the areas of operation listed in Part 61.127 of the 14th Amendment of the CFR (14 CFR Part 61.127), section 61.127. Practical Test Standards for Airships are given in FAA-S-8081-18 [5].

The regulation for the training of the pilots in the Federal Republic of Germany can be found in the LuftPersV under the aviation act LuftVG, according to which if an applicant wants to become an airship pilot within the purview of the LuftPersV, s/he has first of all to prove sufficient knowledge of the English language, Mathematics, Physics and Chemistry by passing a written and oral test with an expert approved by the aviation authority (LBA). Furthermore, s/he has to prove physical fitness and reliability. Then s/he has to go through a ground school of at least 300 lessons, followed by flight training of at least 50 flight hours under different weather conditions within 24 months before undergoing a test with an LBA approved examiner. The entire training must be completed within 2 years. The flight test may not be taken later than 12 months after the written test. After having passed both knowledge test and flight test and after having received the license, the applicant is entitled to fly the airship type s/he has been trained on as a Pilot-In-Command.

At present the training of airship pilots is not a major problem, although it differs from the way of airline pilots education. The reason for this is that there does not exist any flight school for airship pilots, so that the training is carried out by the airship operators [3].

Regulations for issuance of a type certificate for External Noise Emission:

In many countries environmental noise pollution has assumed great importance. Some countries in Europe, such as Switzerland, do have very stringent noise restrictions. Some countries issue a certificate called "*environmental angel*", if the noise limit level is shown to be lower than 4 or 5 dB(A) compared with the required noise level. Many local airports and areas have also restrictions on noise emission. This may limit the daily operating hours of an airship, or limit the total amount of traffic on an airport. Further, the air carrier has to establish noise reduction procedures for instrument flights (JAR-OPS 1.235/ ICAO).

Hence it is important that issues related to external noise certification should be considered right from the scratch in a new airship type design. But no authority has a proper regulation available for noise certification of airships. Most of the regulations existing for fixed wing planes were based on the maximum take off weight, which is not of comparable magnitude to airships. Airships behave quite differently from aircraft; they fly at much lower speeds and have a lower maximum operating altitude. They have different modes of operation and also be capable of hovering and performing running take offs and landings.

In LuftVg §2 of the LBA, Germany defines the noise level requirements which are applicable for all aircrafts. But it does not specify the limitations or the tests requirements in details. However, a proposal is under discussion for the noise emission by propeller aircraft under take off and cruise mode (mentioned in Chapter 6 of LuftVg §2) and by Helicopter under take off and hover mode (mentioned in Chapter 10 LuftVg §2). These regulations recommend six valid flights over a microphone installed 1.2m above ground to check the noise levels.

JAR-36, which is a regulation for aircraft noise certification, is not valid for airships. It is obvious that the equipment and test facility to perform measurements according to the regulations above must be certified before issuance of a type certificate for external noise emission.

Regulations for Airship Maintenance:

As specified by the FAA, operating and flight rules for airships can be located in Part 91 of the 14th Amendment of the CFR (14 CFR Part 91). FAR concerning maintenance (including preventive maintenance), rebuilding and alteration of airships can be found in Part 43 of the 14th Amendment of the CFR (14 CFR Part 43). The FAA Advisory Circular AC 43.13-1B [9] lays the framework for inspection and methods.

Section-1 of JAR-145 [10] prescribes the requirements for issuing approvals to organizations for the maintenance of aircraft and aircraft components and prescribes the general operating rules for approved maintenance organizations. The approval, when granted, will apply to the whole organization headed by the accountable manager. According to this regulation, an organization which is located, in whole or in part, within the territories of the JAA full member States will be granted approval in respect of any such location within those territories when in compliance with this JAR-145. Other organizations will only be granted approval in respect of any such location outside those territories if the JAA full member Authority is satisfied that there is a need for such approval to maintain aircraft/aircraft components at that location and when in compliance with this JAR-145. Alternatively, the JAA full member Authority may accept such an organization on the basis of an approval granted by an Authority that is not a member or full member of the JAA subject to the organization being in compliance with published JAA maintenance special conditions to ensure equivalence to JAR-145. The alternative accepted organization may be required to show a need before being accepted.

JAR-OPS 1.875 Section M – Maintenance are applicable during the pre flight checks and mentions that these checks need not to be performed by the approved maintenance organisation according to JAR-145.

JAR-66 certifying Staff Maintenance is limited to aircraft and helicopter with a maximum take off mass of 5700 kg, and does not cover airships. JAR-145 requires appropriately authorised certifying staff to issue a certificate of release to service.

There are some categories provided in JAR which are applicable for Line maintenance and simple defects type rating (Category A), Components mechanical and electrical systems and simple tests type rating (Category B1 &2), Aircraft in its entirety, including all systems type rating (Category C). For airships, new categories are under discussion by JAR-66 Study Group, such as the proposed new category D1 and D2 for airship Components, and Category E1 and B2 for airships in their entirety.

JAR-147 Approved Maintenance Training Organisation are applicable for conducting the approved training courses and examinations by JAR-66. These regulations previously were not applicable for airships, and there is no training organisation for airships other than the existing airship operators.

Regulations for Operation and Commercial Air Carriers:

JAR-OPS 1&3 for Commercial Air Transportation Section A, though applicable for airplanes and helicopters, doesn't include airships so far. However, the further section in this regulations are usable

for airships such as Air carrier organisation certification, Organisation operation procedures, All weather operation (included in Section B to E, respectively). Also sections K-L to P and Sections Q-S are applicable for airships for Instruments & Equipment, Maintenance, Flight Crew, Cabin Crew, Technical and operational logs, Dangerous goods and security respectively [2].

JAR-FCL 1&3 for Flight Crew Licensing and JAR-OPS 1.235/ ICAO for noise reduction procedures for instrument flight doesn't include airship so far.

Safety and Operational Issues:

The most important safety criterion to be strictly adhered to is for the type of lifting medium. A passenger carrying airship should not, by statute, use Hydrogen as the lifting gas. In the type certification of the airships, it is clearly mentioned that Helium only is to be used as the lifting gas. In addition, airships must comply with other safety regulations involving behavior and controllability in severe weather (gusts, storms, etc.).

After investigating the 1993 crash of a US-LTA airship which was the result of Helium loss due to a tear in the envelope, the National Transportation Safety Board (NTSB) of the US Department of Transportation made several recommendations to the FAA to implement an interim policy which required an Envelope Monitoring System following which, the SAD enforced a clause in [8] to require an envelope rip warning system on all airships.

In Germany, LBA has announced its intention to amend the German operational regulation LUFT-BO by the 7.DVO, to adopt airships, due to the lack of JAR regulations.

All weather operations are different for airships. Ground handling, ice and snow handling and ground wind handling need to be considered. IFR operations might be different for airships, and very time consuming, hence special procedures will have to be adopted. It will definitely be possible to track an airship down an ILS glide slope. However, due to the slow airspeed, the airship may block the airport slots. But an airship would be able to follow a much steeper glide slope than fixed wing planes, and even be able to hover. This enables an airship to perform CAT III approaches without any precise glide-slope information. It may be noted that in 1940-50, US Navy pilots had developed special procedures/rules for airship approach procedures.

Additional instruments and equipment is required for various operational scenarios, sometimes contradictory to the regulations available. Such instruments and equipment again must be additionally type certificated and installed by the manufacturer and the operator would not be allowed to install it.

Recommendations of the Workshop on LTA Regulatory Issues:

This workshop was held as part of the 14th AIAA LTA Technical Convention and Exhibition held at Akron in July 2001 [11] in which issues related to Airworthiness, Certification and Operational Regulations of airships were discussed at length. One of the main recommendations made during this workshop was that a working group should be set up to look at the harmonization of regulations related to airships. It was suggested that ICAO should be contacted to take a lead in this matter, though they are known to be very slow to adopt any issues on a global case. Harmonization is desirable, and there seems to be no resistance from regulatory bodies. It was strongly recommended that not just TAR – the entire spectrum of LTA activity should be taken up for harmonization. Further, it was generally agreed that most of the expertise and knowledge related to airships rests mainly in the operators and users, and many of the regulatory bodies do not have much experience in regulating/certifying airships, hence their inputs should be sought before any regulations are implemented.

Peculiarities and differences in regulations related to airship operations:

During the deliberations in the workshop on Airship regulations, several peculiarities and differences that exist in regulations related to airship operations were brought out, for instance:

1. In UK only an authorized radio license holder can remove & replace any radio equipment, but in USA this is not essential. Thus, airships operated under UK regulations suffer from an operational advantage, since a certified radio engineer is always required for any radio change.
2. Operation of airships in UK is permitted only from a licensed airport to another licensed airport. But a hot-air balloon can operate from anywhere, and land at any farmer's field!
3. In USA, the Operations Manual is signed by the user and the regulatory body takes care of all specific features.
4. In UK, any civil operation requires an approved Operations Manual, however, in USA an approved Operations Manual is not essential for all commercial operations, since most operators work under FAR-91.

Conclusions:

At present, there are no regulations for airship design, manufacture and operations in India. This review indicates that regulations for airships developed for military and commercial applications may be derived from BCAR-Section-Q and FAA-8110-P-Change-1. However, TAR regulations are more suitable for airships for applications related to civilian transport.

As far as the regulations for certification of operation of airships, pilot and ground-crew certification, maintenance, operation and certification of commercial air carriers, and type certificate for external noise emissions is concerned, there seems to be no uniformity in the regulations, and hence the regulations in force for fixed wing and rotary wing aircraft may be suitably adopted for airship use, as is generally the case worldwide.

Acknowledgements:

The work reported in this paper was carried out by the authors as part of the tasks carried out in a study project on Design and development of airships for transportation of goods and passengers over mountainous terrains in Uttaranchal. The first phase of this project, which has recently been completed, was sponsored by TIFAC (Technology Information Forecasting and Assessment Council), Department of Science and Technology, Government of India under the Technology Vision 2020 Mission Program. The authors would like to express their thanks to TIFAC for providing sponsorship for this study project.

:References:

1. Arnold Naylor; “*Airship Activity and Development World Wide-2003*”, AIAA’s 3rd Annual Aviation Technology, Integration, and Operations (ATIO) Technical Forum, Denver, Colorado, USA, 2003.
2. Robert Gritzbach; “*Application of Regulations for Certification and Operation*”, 3rd International Airship Convention and Exhibition, Friedrichschafen, Germany, 2000.
3. Pavel Novak; “*Regulations for the Training of Airship Pilots in Germany*”, 3rd International Airship Convention and Exhibition, Friedrichschafen, Germany, 2000.
4. Ian Donaldson, Michael Rentell; “*The State of Airship International Regulatory Developments Today*”, 4th International Airship Convention and Exhibition, Cambridge, UK, 2002.
5. FAA-S-8081-17; “*Private Pilot Practical Test Standards for LTA Balloons, and Airships*”, U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Service, Washington, DC 20591, 1996.
6. FAA Advisory Circular, No. 21.17-1A, “*Type Certification-Airships*”, U. S. Department of Transportation, General Services Section, M-443.2, Washington, DC 20590, USA, 1987.
7. FAA Advisory Circular, No. 21.17-1A Change-1, “*Type Certification-Airships*”, Small Airplane Directorate (ACE-100), Aircraft Certification Service, Federal Aviation Administration, 601 East 12th Street, Kansas City, MO 64106, USA, 1992.
8. FAA-P-8110-2, Change 1, “*Airship Design Criteria*”, Small Airplane Directorate (ACE-110), Aircraft Certification Service, Federal Aviation Administration, 601 East 12th Street, Kansas City, MO 64106, USA, 1992.
9. FAA Advisory Circular, No. 43.13-1B Change 1, “*Acceptable Methods, Techniques, and Practices-Aircraft Inspection and Repair*”, Airworthiness Programs Branch, AFS-610, PO Box 25082, Oklahoma City, OK 73125, USA, 1998
10. JAR-145, Section-1, “*Requirements for The Granting of A Maintenance Organization Approval*”, Joint Airworthiness Agency of Europe, Hoofddorf, The Netherlands, 2001.
11. Proceedings of 14th AIAA LTA Technical Convention and Exhibition held at Akron, Ohio, 2001.