

## Airworthiness Approval of Design Firms

Kanchan Biswas

*Centre for Military Airworthiness & Certification, Bangalore-560 037*

### ABSTRACT

Aviation as a mode of transportation requires that the aircraft designed, developed, and operated must be maintained under airworthy condition. The basic tenet of airworthiness is that the aircraft designed and developed are certified by the independent airworthiness regulatory organisations. This requires strict vigil during the development stages. With quantum jump in the design and development activities, it has been extremely difficult for the regulatory bodies to cope up with the demand of certification. Delegating this responsibility to a few approved firms prove very effective in maintaining the design control through approved agencies and personnel. Airworthiness approval of design firms taken up by the Centre for Military Airworthiness & Certification, Bangalore, which is the airworthiness approval authority for military aircraft in India, is one such step. This paper discusses the scope and extent of such approvals.

**Keywords:** Airworthiness, design approval, design approved firms, Design Approval Authority, certification, regulatory bodies, airworthiness certification

### NOMENCLATURE

AAA	Airworthiness Approval Authority	DDA	Design/Development Authority
DA	Design approval	VTO	Visiting technical officer
DAF	Design approved firm	CRE	Chief resident engineer
COD	Certificate of design		
CDA	Coordination Design Authority		
DAA	Design Approval Authority		
AAQA	Approval Authority for Quality Assurance		
DGAQA	Director General Aircraft Quality Assurance		
DGCA	Director General Civil Aviation		
MDI	Master drawing index		

### 1. INTRODUCTION

All aircraft designs, military or civil, are required to be certified for meeting the airworthiness requirements. The certification is carried out by the regulatory bodies or the Airworthiness Approval Authority (AAA). In India, Centre for Military Airworthiness & Certification (CEMILAC), Bangalore, is the AAA for military aircraft. With significant increase in the quantum of design and development activities, there is substantial increase in the attention required from the CEMILAC. With an intention to proliferate design and development activities, design approval

of firms has been initiated. The firm so approved is a design approved firm (DAF). Airworthiness approval of design firm is an indirect but very effective way of exercising control over the design by the AAA. In this, besides approving the firm, certain key designers are also approved and made authorised signatories on whom the design authority is delegated. This is a five-stage approval process, the culmination of which certifies that the firm so approved has the capabilities to carry out design and development activities in the military aviation field.

The firms which are designing and/or manufacturing/repairing/refurbishing military aircraft or airborne stores can seek design approval of their firms from the airworthiness approval authority to supply/repair airborne equipment to be used by the Air Force, Army and Naval aviation. The tasks undertaken by these firms will follow the general requirements stipulated in military specifications, defence standards, and DDPMAS:2002 documents.

## 2. AIRWORTHINESS

Airworthiness can be defined as fitness to fly. This implies the demonstrated capability of the aircraft/equipment to perform satisfactorily and fulfil the mission requirements, throughout the specified life in the prevailing environment, with acceptable level of safety and reliability. Airworthiness requirements are to ensure safety and reliability during design, manufacture, and maintenance. These requirements are specified as design requirements and various other requirements. As no machine can be built which would never fail and human error is inescapable, a certain amount of risk is to be tolerated in any mode of transportation. Airworthiness evaluation *inter alia* becomes a question of assessing the level of risk, which is considered acceptable.

All airworthiness standards, military or civil, whether those of USA, Europe, or Russia, have a common point of reference, which is that an inverse relation should exist between probability of occurrence and degree of hazard inherent in its effect.

A fundamental difference between civil and military airworthiness lies in the fact that military

aircraft design quite often precedes the development of well-matured technology. To get slight edge over the contemporaries, military aircraft development uses technologies, which are yet to be proven to the maturity level to be acceptable for civil application. Thus, the civil aircraft design aims at passenger comfort and safety.

For military aircraft design, on the other hand, maximum priority is given to completion of mission/task, while safety levels are set as agreed between the manufacturer and the user. For comparison, safety levels are defined as fatalities per ton kilometer of transportation for civil aircraft while for military fighter aircraft, it is the number of accidents per 10,000 h of flight.

### 2.1 Airworthiness Philosophy

Major considerations for the airworthiness are:

- *Flight safety*: Assessment of risk associated with flight
- *Assured life*: Both theoretical and experimental determination of life through fatigue and endurance testing
- *Improved reliability*: Estimation of critical failure mode and redundancy management to improve reliability
- *Deterioration*: Protection against deterioration due to life cycle environment.

It must be made clear at this stage that flight safety and airworthiness are not synonymous. The level of flight safety available at any stage depends on the knowledge-base of the airworthiness evaluation. If the airworthiness standards available at any stage are inadequate due to improper knowledge of the subject, the certified aircraft may be unsafe. Airworthiness standards for evaluation are to be constantly upgraded to keep pace with the technological innovations. Following are some of the examples which may be cited to support it:

- Fatigue as design criterion was considered only after the catastrophic failure of the Comet aircraft in 1950.

- Combined effect of environment with load on the composite material fatigue/damage tolerance is yet unknown.
- Arc tracking of polyamide cables (electrical wires) has been considered as a technical requirement only after Aloha accident of the Boeing aircraft.
- Independent verification (do things right) and validation (do right things) have been introduced for large-scale software and embedded software to protect against malfunctioning.

## 2.2 Airworthiness Certification

Certification is a process of evaluation and documentation of compliance of a product that it meets the stipulated requirements of the specifications and is declared safe to fly by the competent authority. It is an assurance to the user that the product has been designed, developed, evaluated, and produced in such a manner that its quality, reliability, and integrity is as per the standards that meet the requirements.

The basic concept of airworthiness certification is that an independent body, not under the command and control of the contracting firm, examines the design for safety and performance. It can be seen that while certification is a declaration that a product conforms to the stipulations as defined in specifications, airworthiness is an explicit declaration that the product is certified to be airworthy, with

limitations as applicable. A product that is certified need not to be airworthy, unless certified as also airworthy.

## 3. CONCURRENT DEVELOPMENT PROCESS

It is also necessary to differentiate between the terminologies of clearance and certification. In a system of concurrence certification, viz., the action to eventually certify the aircraft along with progress of the design/development activity, an element of work/stage is accepted by the certification authority and the work then progresses to the next element. Such a procedure is necessary if the programme is a major one, like an aircraft development. This permission to go to the next stage is given through clearance issued by the airworthiness authorities.

### 3.1 Airworthiness Certification Tools

The various tools used for ensuring airworthiness requirements along with the objectives are listed in Table 1.

## 4. FUNCTIONAL AUTHORITY

- (a) *Design/Development Authority*: Design/Development Authority is the firm responsible for the detailed design / modification / indigenous substitution, etc of a system, to approved standards and authorised to sign certificates of design (CODs) in accordance with the procedures laid down in DDPMAS-75.

**Table 1. Tools needed for ensuring airworthiness requirements and objectives**

Objectives	Airworthiness tools
Acceptable levels of performance and handling qualities	Analysis of aerodynamic configuration, handling and flying qualities
Safe operation throughout the life	Design and analysis of Airframe structure and construction
Acceptable levels of reliability of aircraft and systems	Reliability analysis, (FMECA, FTA)
Establish durability levels of airframe and systems	Fatigue, endurance, ageing, and life tests
Ensure electrical power availability	Electrical load analysis
LRU certification	Qualification test of LRU
System integration	Rig integration tests
Establish interchangeability and maintainability	Design for maintenance programmes and schedules
Ground evaluation	Interface ground test on aircraft
EMI/EMC	Qualitative/quantitative EMI/EMC tests on complete aircraft
Reduce pilot workload, increase safety and comfort	Human engineering and ergonomics
Aircraft certification	Flight test and evaluation

- (b) *Coordinating Design Authority*: Coordinating Design Authority is responsible for the overall design of the system, including integration of sub-systems/airborne stores designed by the other design approvals into the main system. The CDA may also be a design approval for some of such subsystems/airborne stores.
- (c) *Airworthiness Approval Authority*: Airworthiness Approval Authority is the Government authorised regulatory body responsible for accepting the design. While Director General Civil Aviation (DGCA) is the AAA for the civil aircraft, Chief Executive, CEMILAC is the AAA for the military aircraft in India.
- (d) *Approval Authority for Quality Assurance*: Director General Aeronautical Quality Assurance (DGAQA) is the authority for quality assurance for the military aircraft in India.

## 5. DESIGN APPROVAL SCHEME

The scheme of design approval of firms is designed to assist the procurement of airborne stores to the laid down standards. The award of the design approval signifies recognition that, "because of its ability and experience in the design and development of products within a specified range, AAA accepts the COD issued by the firm, which would indicate that, a particular performance or objective has been achieved for a product or service compared with what is required by the specifications. For such range of products and/or services, the firm can be approved as the design authority or coordinating design authority as appropriate". The design approval can be issued for the following products/systems:

- Total integrated aircraft and rotorcraft system
- Guided weapon systems
- Aircraft, rotorcraft, and associated equipment
- Aircraft and rotorcraft engines, accessories and materials
- Modifications to the existing/bought aircraft, rotorcraft, engines, systems, and accessories

- Lifing evaluations and indigenisations of aircraft, systems and equipment of license built and bought aircraft.

Though it is not mandatory, but Ministry of Defence normally places the defence development contracts on the design approved firm (DAF). Airworthiness Approval Authority (AAA) accepts the COD issued by the Design/Development Authority (DDA). The design approval is like a contract agreement, a set of promises, the breach of which can be considered as an offence while the performance, as per the contract, should be recognised as a duty. In the case of design approval, the DAF while applying for the design approval, undertakes an agreement to carry out design and analysis as per the design requirement specified by the AAA.

The design approval is, however, limited to the extent that the prerogative for final acceptance of the product and/or services will still be with the AAA, who would verify conformance to the specification and the requisite test requirements.

### 5.1 Basis of Design Approval

Following are the broad guidelines on which the design approval is to be processed:

- The firm has the capabilities to carry out design and development of aircraft/airborne stores.
- The firm has adequate number of qualified design team members in the areas of specialisations required with well-defined responsibilities.
- The biodata of each member of design team along with his or her signature is available and produced.
- The firm has properly defined list of authorised signatories for signing the reports and design calculations in specific areas of specialisation.
- The firm has well-defined organisational chart, including manufacture and quality assurance teams.
- The design practice/standard followed by the firm along with the drawing office practice is clearly indicated.

## 5.2 Scope of Design Approval

There are, in general, the following three types of approvals within this scheme:

- (a) *General Approval*: This type of approval would be applicable for all types of design and development work in a specified category of work defined in the scope of the approval. This approval will be valid till it is revoked by the CEMILAC.
- (b) *Particular Approval*: This would be applicable for a specified equipment and/or project with a specified validity.
- (c) *Design Authority for Product Manufactured under Licence*: Design organisations of firms engaged in the manufacture of aircraft / rotorcraft/ airborne equipment under licence could also seek approval on design matters for specified stores. The design organisation of such firms, in cases like these, should possess the requisite design data, either by transfer of technology from the licensor or developed within the organisation, to the satisfaction of the AAA.

## 5.3 Requirements for Design Approval

The design organisation of the firm seeking approval is expected to satisfy all the requirements stipulated for such approval. The essential requirements are given below:

### 5.3.1 Infrastructure/Facilities

- *Organisation Structure*: The organisation structure of the firm shall be such as to ensure that in all matters that affect airworthiness, full and efficient coordination exists within the design office and related technical departments, and between the design office and other production departments of the firm.
- *Office Accommodation & Equipment*: The design department shall have adequate and furnished office accommodation for the design staff. It should also have requisite facility for printing as well as storage for all drawings and design documents.

- *Test Facilities*: The firm shall have facilities or access to suitable approved houses for making the tests as are necessary to establish compliance with airworthiness requirements. The tests may include facilities for structural and metallurgical testing, ground rig integration and flight testing. Test results are to be properly recorded.

### 5.3.2 Design Control

- *Design Office Staff*: The design office should have adequate number of qualified designers with appropriate specialisations. There should be adequate number of key designers to lead the team.
- *Specialist Staff for Design Organisation*: The chief designer or head of design organisation, qualified in design specialisation, will be the one approved by name. He will be responsible for the competency of his staff and the efficiency of his design organisation to the satisfaction of AAA.
- *Specialist Staff for Design House*: In addition, the design house shall include specialists in aeronautics, metallurgy, systems, engines, and related fields, as necessary, for progressing the design activity.
- *Design Input & Output*: While design specifications and goals are design input, the design output are the drawings, simulation results, flow charts, manufacturing procedures, etc.
- *Design Reviews*: Records of reviews for each planned design review with agenda/attendance should be preserved.
- *Design Verification & Validation*: Prototype acceptance, performance, and reliability test results should be recorded.
- *Design Changes*: Records of customer approval and waivers should be available.

### 5.3.3 Document & Data Control

- Procedure for the control of all the document and data, including storage and retrieval systems, should be defined.

- Change control through engineering change order or document change order should be recorded.
- Process for approval and issue of all documents to both internal and external agencies should be defined.
- Identification of all control documents and establishment of master drawing index (MDI) should be ensured.
- Records of reviews with date of implementation of the customer document/specification should be kept and maintained

#### 5.3.4 *Acceptance of Design*

Design approved firm shall submit type records comprising drawings, component test results, flight test results, production specifications, etc at the conclusion of development for type certification. All the relevant drawings, specifications, test sheets, process records, etc should be sealed by the chief engineer and the resident engineers or the visiting technical officers, as the case may be.

### 6. PROCESS FOR DESIGN APPROVAL

As indicated earlier, the approval is a five-stage process. This includes the following:

- Application by the firm
- Scrutiny of the application
- Independent assessment by a joint team
- Issue of design approval
- Monitoring the performance related to design activity and renewal.

#### 6.1 Application for Design Approval

The application form has the following parts:

- Part I has to be completed by the organisation seeking the design approval. This part seeks general information about the firm with details of the project/design carried out by the firm; the organisation structure and list of design

team members along with their biodata; a mention about the test and other facilities.

- Part II is applicable to the management of organisation who contractually undertakes the work from a design approved firm/government. The firm applying for design approval is required to get the application countersigned by the main firm.
- Part III is applicable if the application is being submitted by a firm, which is a subcontractor to a design approved firm.
- Part IV is applicable where a design approved firm may not directly subcontract, but Airworthiness Approval Authority may require assistance of already design approved firm to sponsor the firm seeking design approval and also for undertaking periodic assessment.

#### 6.2 Assessment of the Firm for Accreditation

On receipt of the application for design approval from a firm, if it is considered that the firm merits an assessment for according design approval, an expert committee of evaluators is constituted. The expert committee is constituted keeping in view the field of activity of the firm seeking design approval. The assessment is on the lines of system audit to evaluate the firm's capability to undertake the design work. The benchmark for selecting the evaluators and the code of ethics for them have been established to maintain impartiality and confidentiality. The code of ethics to be followed by the evaluators is:

- To act strictly in trustworthy and unbiased manner
- Not to take any commission, discount, gift or any other profit from the firm
- Not to disclose their findings to the firm or any third party
- Not to act in any way prejudicial to the reputation or interest of the firm
- Not to act in any way prejudicial to the credibility of the AAA.

The assessment aims at establishing long-term confidence in the firm's design, development, and test personnel, organisation and facilities relevant to the class of product/services/technologies concerned. The assessment report should be based in terms of:

- Current and projected technical activities
- Design and related supporting organisation and facilities
- Qualification and experience of the relevant personnel.

### **6.3 Accreditation of Design Approval Status**

Based on the evidence presented by the firm, if the appraisal by the expert committee shows that the firm meets the requirements of AAA, a certificate of approval will be issued listing:

- The scope of approval (generalised or list of classes of product)
- The names of the approved signatories for the certificate of design
- The board members or their authorised equivalents, who have the overall responsibility for the availability of resources and the security/scrutiny of the design
- The authorised signatories along with alternate signatories for each field of specialisation
- The names of the other senior key design personnel and their specified responsibilities
- Chief executive or visiting technical officer, CEMILAC, responsible for the supervision.

### **6.4 Designs Completed by Non-approved Design Firms**

If some design activities are subcontracted by a design approved firm to a non-approved design firm, the veracity and integrity of the design will have to be verified by the DAF before its acceptance by the AAA from the airworthiness point of view. In case the design contract with a non-approved

design firm is placed directly by the Ministry of Defence, the procedure for check points would be laid down by the AAA, in each individual case, defining the extent and scope of control to be maintained, either by a design approved firm designated for this purpose or by one of the chief resident engineers.

Airworthiness Approval Authority shall include, from time to time, firms with defined scope of activity in their list of approved firms. Supervision will be exercised by the AAA through the resident engineers/or periodical visits by the visiting technical officers (VTOs).

### **6.5 Maintenance/Renewal of Design Approval**

The design approval granted to a firm initially is for three years. During this period, the firm shall send annual report of the design and development activities carried out by the firm and the acceptance of such activities to AAA. The design organisation shall be maintained at the standard originally approved. The CRE or the VTO shall, at all reasonable times, be given access necessary to establish this fact. If any significant change is contemplated in the constitution of the design staff, the same shall be notified to AAA in writing prior to implementation.

The firm shall consult the AAA if there is any difficulty in the interpretation of the requirements or on any airworthiness matter, which, in its experience, requires clarifications. If, subsequent to the approval of an aircraft or aero-engine or any airborne store, indigenous or produced under licence, as and when the firm becomes aware of the defects, the firm shall appraise the AAA, in order that an appropriate joint action is taken.

Based on the performance during the initially approval period of three years, further extension of approval period may be considered.

### **6.6 Withdrawal, Suspension or Modification of Approval**

The design approval granted may be withdrawn, suspended, or modified, if the conditions under

which it was granted are not met. The terms of approval may also be changed as a result of changes in the firm's undertaking. Subcontractor firms are also governed by the above requirements.

## 7. CONCLUSION

Centre for Military Airworthiness & Certification, Bangalore, is the Airworthiness Approval Authority in India for the military aircraft. Based on the assessment made by the expert committee setup for design approval of firms, more than 50 firms have already been approved. They cover wide range of areas like aerodynamics and computational fluid dynamics analysis, structural design and analysis, avionics, electrical and instrument, software verification and validations, development of hardware with embedded software, etc. These approvals have made it possible to subcontract part of the project work, while the main contractor can concentrate on taking up turnkey project.

## ACKNOWLEDGEMENTS

The author wishes to express his sincere thanks to all his colleagues in the Associate Director (Aircraft)

office for their help in preparation of this paper. The author also wishes to express his gratitude to the CE, CEMILAC for his encouragement and permission to publish this paper.

## REFERENCES

1. Design, development, production of military airborne stores-2002 (DDPMAS-2002), Ministry of Defence, India.
2. Sohrab. Quality audit. Allied Publishers Pvt Ltd, New Delhi, 1996.
3. Bennett, F. & Lawrence P.E. The management of engineering. John Wiley & Sons Inc, 1996.
4. Juran, J.M. & Gryna, Frank M. (Jr). Quality planning and analysis, Ed. 2. Tata McGraw-Hill Publishing Co Ltd, New Delhi, 1992.
5. Feigenbaum, A.V. Total quality control, Ed. 3 McGraw-Hill Inc, Singapore, 1991.
6. Naroola, Gurmeet P.E. QS-9000: Implementation and registration. Marcell Dekker Inc, USA, 1997.

## Contributor

**Mr Kanchan Biswas** is BTech (Aero Engg) from the Indian Institute of Technology, Kharagpur and MTech (Aircraft Design) from the Indian Institute of Technology Bombay, Mumbai. He joined DRDO at the Centre for Military Airworthiness & Certification (CEMILAC), Bangalore, in 1975. Subsequently, he served at the DTD&P(Air) and Institute of Armament Technology, Pune, as Professor in Guided Missile Faculty. In 1993, he moved as Regional Director, Regional Centre for Military Airworthiness, at the Hindustan Aeronautics Limited (HAL), Nasik, where he continued till 2003. Since March 2003, he has been the Associate Director (Aircraft), CEMILAC, Bangalore, where he is responsible for the certification and approval of all design and development activities in respect of military aircraft and helicopters. He is a life fellow of both the Institution of Engineers (India) and Aeronautical Society of India (ASI) and a life member of the Society of Aeronautical Quality and Reliability (SAQR). He has received commendation from the Scientific Advisor to *Raksha Mantri* in 1991. He is also a recipient of *Outstanding Engineers Award* (1999) by the Institution of Engineers (India).