ACCEPTANCE PROCESS FOR NEW AIRCRAFT DESIGNS

1. BACKGROUND

The LAA was formed in 1948 by a collection of enthusiasts in the UK who wished to be allowed to operate homebuilt and vintage ultra-light aircraft on an amateur basis. At the time, post-war restructuring of the civil aviation regulations had resulted in the authorities not allowing such aircraft to be flown.

By recruiting the support of technically qualified people on a voluntary basis, the association won the confidence of the Ministry of Civil Aviation (fore-runner of the CAA) and negotiated for the issue of Permits to Fly to various aircraft which were not eligible for the issue of a Certificate of Airworthiness.

The LAA has grown rapidly over the years and now has around 8,000 members, operating over 2700 homebuilt aircraft and restored vintage machines. Around 100 new aircraft are completed each year. Twelve full time members of staff are responsible for engineering matters and for carrying out the day to day running of the Association. A Board of volunteers elected by the membership decide on matters of policy. In addition, around four hundred selected LAA inspectors distributed around the country carry out inspections of LAA aircraft in their areas, many of them on a voluntary basis, and are available to advise members on technical matters. Local branches of the LAA organise regular meetings, fly-ins, social evenings, etc, all over the country and provide encouragement and support for new members.

A monthly magazine, *Light Aviation*, is supplied free to all members.

1.1 What is an LAA aircraft?

The LAA is authorised by the CAA to make recommendations for the issue and renewal of Permits to Fly to aeroplanes which are:

Minimum speed power off in the landing configuration not to exceed:	70 mph
Design dive speed not to exceed:	299 mph
Maximum number of seats:	4
Maximum take-off weight not to exceed:	2000 kg
Maximum individual engine installed power	400 hp
Maximum total engine installed power	600 hp

Amateur-built aircraft (including from kits) must comply with the '51% rule' (the majority of the work to be done by the amateur builder).

1.2 How can LAA help me get a new design aircraft flying?

For a new design of light aircraft to be cleared for flight in the UK, there are three options:

a. A CAA Approved aircraft design and manufacturing company can test fly an aircraft under 'B' conditions. In order to get CAA approval it is necessary to demonstrate that the company has adequate technical staff, facilities, and properly documented procedures, and pay annual charges to the CAA.

b. An individual can apply direct to the CAA and negotiate for the issue of a Permit to Fly. The CAA charge around £130 per hour for their time checking reports, making visits, etc, so this route will cost many thousands of pounds in CAA charges alone.

c. An individual member of the LAA can submit his reports to the LAA Engineering Department and LAA will give advice, assess the design and make a recommendation to the CAA for the issue of a Permit to Fly. In addition, the member can call upon his local LAA inspector for carrying out inspections or to draw upon his experience, usually at minimal cost. LAA can also put members in touch with other technically qualified engineers who can help create the submissions, carry out stress analysis, etc, on a consultancy basis.

1.3 How is the design acceptance process funded? (2 seaters)

Permit Renewal fees, together with the other similar charges made for initial issue of a Permit to Fly, provide sufficient income to allow the engineering staff to invest some time reviewing new designs. This is done to ensure that the best of the new aircraft designs are made available to LAA aircraft builders. As a consequence, LAA Engineering reserves the right not to proceed with a proposed new design where the benefit to other LAA members is not commensurate with the predicted LAA resource commitment.

1.3.1 Recovery of external engineering costs

In some cases where the applicant for approval of a new design is required to invest in the engineering services of a consultant to prepare the necessary detailed reports for LAA Engineering approval, they may be faced with considerable costs. In order to allow the first applicant to recover these costs, the applicant may expect to recover a royalty of up to 10% of the costs from each subsequent builder who benefits from the approval of the design.

- If this facility is to be used then the first applicant will need to inform LAA of his/her intention to recover costs. LAA will then let the applicant know of each subsequent project registered to build the approved design.
- The responsibility for collection of the said royalty lies at all times with the first applicant.
- The responsibility for release of the original design submission documents (if they are required to complete the design to the approved standard) also rests with the first applicant.
- This is completely separate from the ownership of the design rights to the aircraft, although in some cases the same person may own both.

1.4 How is the design acceptance process funded? (4 seaters)

The evolution of 4-seat aircraft and the corresponding higher standards of demonstrated airworthiness demanded by the CAA has led to an acceptance charging structure being developed specifically for these larger aircraft.

- Firstly they will have to show compliance with a higher level design code – CS-23. This is essentially the same code as is applied to the Cessna 172 and Piper Warrior.
- The second significant difference is that full compliance has to be shown with the all the main applicable parts of the design code. Minor non-compliances will be subject to individual negotiation. There is no facility to use service experience and judgement alone as a basis for the structural clearance.

The burden of approving a 4-seater will therefore be much higher than that for a 2-seater. In recognition of the greater demand this will place on LAA Engineering resources, the following charges have been introduced effective from 1st April 2004.

1.4.1 Type acceptance fee of £2000

This is charged to the manufacturer or UK agent who imports the example presented for LAA acceptance. The charge is triggered after the "Initial Aircraft Type Evaluation". If the conclusion of this evaluation is that LAA Engineering is to proceed with the type acceptance process, this advised together with an invitation to provide this payment in order to proceed. In cases where the manufacturer or agent declares an unwillingness to provide this payment, it falls to the first UK builder of the type to meet this shortfall.

2. WHAT INFORMATION WILL I NEED TO PROVIDE TO THE LAA?

The LAA will require a data package consisting of a descriptive data, definition of the design code and compliance data showing how the aircraft complies with the stated code.

2.1 Design code (Certification Basis)

In order to qualify for a Permit to Fly, the design must generally be in accordance with the set of requirements (design code) which would be applicable if it were a fully certified aircraft. Some areas of non-compliance may be accepted if it can be shown that the feature either demonstrates equivalent safety to the requirement, or that there is a long history of the feature being used on similar types of aircraft in the past without causing airworthiness problems.

The first step is to select which design code is to be used for your design. The choices are as shown below:

Design Code	Max gross weight	Stall speed, power off	Max number of seats
BCAR Section S (microlight aircraft)	450 kg	35 knots	2
CS-VLA (very light aircraft)	750 kg	45 knots	2
CS-23** (small aeroplanes)	5700 kg*	61 knots*	9*
CS-22 (motorgliders)	750 kg	43 knots	2
CS-LSA (light sport aeroplanes)	600 kg	45 knots	2
BCAR Section T	600 kg	n/a	2

* Note that LAA limited to 2000 kg, 70 mph (61 kts) and 4 seats except with specific permission from the Civil Aviation Authority (CAA)
** For Aircraft of US origin, FAR-23 may be used rather than CS-23

The design requirements are generally more stringent the heavier the aircraft, so you should choose the lightest category which your proposed design will comfortably fit into. Copies of the design codes are obtainable from the EASA web-site (CS specs) www.easa.eu.int or the CAA website (BCARs) www.caa.co.uk.

Each of these design codes utilise the same basic format and share a common system of paragraph numbering so that comparisons can easily be made between the various codes. Each code is broken down into Subparts as follows:

SUBPART A	General	This short subpart simply defines the applicability of the design code.
SUBPART B	Flight	Defines all the requirements relating to aircraft performance, stability, control, stalling and spinning, ease of take-off and landing.
SUBPART C	Structure	Provides all the strength requirements including the main structure, engine mounting, tail surfaces, control systems, undercarriage, crash loads, and fatigue criteria.
SUBPART D	Design	Defines particular required items of design practice including material strength properties, special stressing factors, control system details, undercarriage details, cockpit details such as seatbelt requirements, cockpit controls, door latches, etc.

SUBPART E	Powerplant	Requirements relating to the engine itself and to itsinstallation, including propeller, fuel tanks, fuel valves, vents, engine cooling, exhaust, firewalls, cowlings, etc.
SUBPART F	Equipment	Requirements relating to instruments, electrical systems, etc.
SUBPART G	Information	Requirements relating to operating limitations (speeds, cg limits, weights, temperatures, etc) which must be defined, cockpit placards which must be installed and the information which must be available in the operators manual for the aircraft. (With a prototype aircraft the operators manual is usually condensed to a very basic form or neglected altogether.)
APPENDICES		The appendices provide helpful advice about how to show compliance with various requirements, including (in some cases) a simplified method for estimating gust loads, tailplane and control surface loads.

2.2 Descriptive Data

Having selected the design code, the next requirement will be to provide LAA engineering with sufficient descriptive data to allow us to examine the design and to provide a record of the type. The format of the data will depend to some extent on the type of construction of the aeroplane and the facilities available to the designer, but will generally consist of engineering drawings, photographs and a written description.

a. Engineering Drawings

A 3-view and GA drawings will be required, along with drawings of the structure, undercarriage, control system, engine installation fuel system, etc. It will not be necessary to provide detailed drawings of every single component, bracket, cleat, etc, but only to provide enough information to understand the construction and function of the part or assembly and to be able to verify that the analysis submitted is appropriate.

b. Photographs

A collection of photographs can be used to substitute for certain drawings – for example in demonstrating the arrangement of the pipework and controls in an engine installation, an instrument layout or a fairing of complicated shape.

c. Written description

A written description should be provided of the structure and systems of the aircraft. The extent of the description required will vary depending on the number of unusual features incorporated and the degree of detail of the drawings submitted.

2.3 Compliance Data

Compliance data consists of information supplied to demonstrate how the design complies with the design code requirements, and usually takes the form of an aerodynamics summary, a loads report, stress report, strength test reports, materials specifications and a compliance checklist.

a. Aerodynamics Summary

Until the prototype has been flown it obviously cannot be proved that the aircraft meets the flight handling requirements of Subpart B of the design code in terms of stability, rate of climb, stall speed, etc. For an aeroplane of conventional layout it will be sufficient to provide a brief summary of wing areas, tail areas, moment arms, surface setting angles, tail volume coefficients, estimations for lift coefficients, weights, stall speeds, aerodynamic centre position and static margin, and an assessment of the likely spin recovery characteristics using simple criteria relating to the degree of effective fin, rudder and keel area. A simple performance estimate should also be provided (power curves, level speeds and rates of climb). For an unconventional layout it will be necessary to present estimated stability and control characteristics in greater detail.

b. Loads Report

In order to check the strength of the aeroplane is adequate, it is first necessary to determine the various loads acting on its parts under the required conditions specified in Subpart C of the design code. The report generally commences by deriving a flight envelope, then estimates wing pressure loads and pressure distribution along the span, wing bracing and attachment loads, derive spar shear and bending moment diagrams, wing torsion, drag and anti-drag loads acting on the wing, spar end loads, etc. Likewise the report will go on to analyse tail surface loads, fuselage loads, engine mount and undercarriage loads, control system component loads, etc.

Useful sources of information in carrying out the analysis include the ESDU data sheets (copies held in RAeS library).

c. Stress Report

Having derived the loads in the various components the next step is to examine the strength of each critical part of the aeroplane (either by analysis or by carrying out a physical test). In each case, the predicted maximum allowable stress (or load) for the part is divided by the factored predicted maximum occurring stress (or load) for the part to provide the reserve factor. If, for example, the calculated reserve factor is 2.0, then, in theory at least, the part is twice as strong as it strictly needs to be.

Reserve factors should be placed in the right hand margin of the report at the base of the calculations concerned.

d. Test Reports

In some cases it is difficult to predict the strength of parts conclusively by calculation, and it may be easier to proof load either a sample part or the structure of the prototype aeroplane itself. In the latter case it is particularly important to check that damage has not been done to the structure during the proof test which has weakened it for future use.

In any case, tests must be carried out in a properly disciplined fashion, reporting accurately on all items which may be significant to the test (such as the temperature and humidity if testing a composite structure), the means of loading the structure, method of restraining it, orientation of load, etc. As well as checking for signs of failure, cracking, buckling, etc, deflections should be measured and plotted against load during the loading and the unloading process in order to identify any non-linearity which may show up the onset of buckling or some internal invisible failure.

e. Material Specifications

MIL-HDBK-5 and ANC-18 provide detailed information relating to metals and woods commonly used. If materials are used in the construction of the aeroplane which are non-standard then it will be necessary to provide substantiating evidence of the properties of the materials.

f. Compliance Checklist

The compliance checklist is the document which shows clearly how the requirements of the design code have been met and which areas may be outstanding or deficient.

The compliance checklist document runs through each requirement (i.e. each paragraph) of the design code in order and in each case states:

I. Whether the requirement is complied with or not, or whether still to be proven, or whether not applicable.
II. Where the reference in the other documents is that proves compliance has been achieved (e.g. the page number in the stress report, test report or the written description).
III. States how the requirement has been met (e.g. 'shown by proof test' or 'a fuel filter is fitted in the manner required' or 'proven by stress analysis').

3. AT WHAT STAGE CAN I START BUILDING THE PROTOTYPE?

It is normal for the detailed design of a new aeroplane to evolve during the actual construction of the prototype. We therefore will issue the project with a prototype LAA serial number and issue the builder with a build record, and put him/her in touch with a suitable local LAA inspector as soon as we are satisfied that the builder has a promising design concept and is aware of the requirements which are going to have to be met. The LAA inspector will come to examine the aircraft a dozen or so times during its construction, to provide helpful guidance and to check on the quality of the build. He may want to supervise directly during critical phases of the build, such as the gluing of a mainspar or the drilling of wing attachment lugs. He may also be asked to witness proof load testing and engine ground runs.

Once the aircraft is basically complete we will require all the descriptive information and compliance reports to be supplied to the LAA for examination. An LAA Design Engineer will come to examine the aeroplane. At this point all the information will be reviewed by the LAA, there will be a flurry of form-filling, the payment of the applicable fees, discussions over who will be permitted to fly the aircraft and where it is to be based during testing. If all is well we will then issue a flight test authorisation and guidance material about carrying out the initial and subsequent flights.

4. IS EXTENSIVE FLIGHT TESTING NEEDED?

The LAA supplies a simple pro-forma describing all the tests that need to be made, and prototype aircraft often need changes made to optimise the flight handling, stall characteristics, engine cooling, etc. Do not expect your aircraft to fly perfectly 'straight off the board'. Lack of attention to detail at this stage will spoil the aircraft. We will not recommend that the unrestricted Permit to Fly is issued until the flight handling has reached an adequate standard. Typical changes we have had to deal with over the last few years include:

- Increase in the area of tail surfaces, or addition of elevator 'down spring' to increase static stability.
- Change in tailplane setting angle to optimise trim range.
- Change in chordwise position of hinge axis on all-flying tailplanes to increase stick forces and cure pitch oscillations.
- Addition of wing leading edge cuffs and strakes to improve stall characteristics.
- Addition of stall wedges to increase stall warning buffet.
- Fitting of alternative engines to give satisfactory climb performance.
- Complete re-design of pitot-static systems to give acceptably low pressure errors.

Each of the changes made will need to be discussed and agreed with LAA Engineering before further flight.

4.1 Independent flight test evaluation

Once the aircraft has reached a suitable stage of development, it will need to be evaluated against the flight requirements of Subpart B of the design code by one of the LAA's independent evaluation pilots. The LAA will supply a detailed form showing what tests are to be carried out. In addition, the pilot will be asked to comment on any other areas he feels are unsatisfactory.

5. WHAT HAPPENS NEXT?

On completion of the flight tests, the flight test report is added to the compliance data package and the compliance checklist is filled in to include the details relating to Subpart B (Flight). LAA will then carry out a final review of the information and, if all is in order, recommend that the CAA issue a Permit to Fly, valid for one year, and renewable annually.