GUIDANCE ON WEIGHT AND BALANCE

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For use with Form LAA/WB and LAA/WB/MICROLIGHT

These notes are for use with forms LAA/WB and LAA/WB/MICROLIGHT which may be downloaded from the LAA website in a choice of imperial or metric format. You should choose the format based on the units as stated on the aircraft's Permit to Fly Operating Limitations document or, for aircraft not yet issued a Permit to Fly, in accordance with the TADS (Type Acceptance Data Sheet) or TCDS (Type Certificate Data Sheet). Please do not mix metric and imperial measure. I.e. use inches and pounds, or kg and mm but not hybrids such like lbs.mm or kg.inches!

WEIGHING AND MEASURING

- The aircraft may either be weighed professionally by a specialist weighing company or it can be weighed under the supervision of your LAA inspector.

- In either case, it is important that the scales have been suitably calibrated - use the **correction column** to correct for any known deviations of the scales determined by the calibration. For 'do it yourself' weighing, the calibration of the scales need not be to certified standards but must be carried out using test weights in a manner accepted as adequate by your inspector.

- The aircraft must be weighed in the attitude called for by the designer – normally the flying attitude, verified by a specified level datum. For tailwheel types you will need to raise the tailwheel to this attitude, whereas nosewheel aircraft will require little adjustment to be levelled. Remember to note the positions of where the weights were measured, usually the wheel axle centres, whilst in the attitude that the aircraft was weighed. This is most easily done by dropping a plumb line from the axle centre to the floor and making a mark on it so that measurements can be made after the aircraft has been moved out of the way.

CALCULATING EMPTY WEIGHT AND CG

- Usually you can calculate the aircraft empty CG from the weights and wheel positions (**arms**) recorded, however you may have to compensate for any usable fuel left in the tanks to arrive at the empty weight. Note that empty weight should *include* unusable fuel and that more accurate results are usually obtained when the aircraft is weighed with only unusable fuel in the tanks.

- **Optional equipment** left in the aircraft during weighing should be recorded in the appropriate section of the weight document as it may be taken out at a later date, in which case the Weight & Balance Report would need to be amended. There is also a section to record **changes in service**, but as all the figures would change slightly, it is generally preferable to complete a new form. (Available from the LAA website www.laa.uk.com)

- The aircraft's **Operating Limitations** document states the *datum* for all distances for fixed and variable loads to be measured from. If the datum is forward of any part of the structure, then all the arm figures will be positive. If, as is common, the datum is the wing leading edge then arms forward of this will have a negative value. For instance, weight on the nosewheel would have a negative arm value and therefore a negative moment if the datum was the wing leading edge.

- **Moment** is calculated by multiplying the **weight** of each item by its **arm**. All the moments are added giving the **total moment**, which is divided by the total weight to give the **empty CG position,** relative to the *datum*. I.e. Forward or Aft of it. It is not appropriate to quote %MAC (Mean Aerodynamic Chord) if the CG range on the **Operating Limitations** document is not quoted using this method**.**

CALCULATING WORST FORWARD AND AFT CG CASES

- Weighing the aircraft and calculating its empty centre of gravity does not provide sufficient information to establish whether the aircraft can be easily operated within safe limits for flight. To do this you must carry out some loading calculations. On the reverse side of the report sheet is a table to record the maximum weight, arm and moment for **Variable Load Items**; items such as occupants, fuel and baggage. These figures are usually obtained from the Pilot's Operating Handbook, or by measurement as a last resort. If determination of variable load arm positions by measurement is necessary, note that the pilot CG position is usually assumed to be the position of his navel, rather than the seat back as is sometimes mistakenly used.

- Using the data from the Variable Load Items table we can calculate 'worst' forward and aft CG cases for the aircraft. It is necessary to carry out several loading examples to check that the aircraft will stay within weight and CG limits.

- For checking that the aircraft is reasonably tolerant of variations in pilot and passenger weights, the range of standard occupant weights used in the design codes CS-VLA and BCAR Section S should be used. These standard occupant weights are used for the example loading calculations, but of course, for weight and CG calculations before a flight, you must use actual occupant weights.

- Load cases should be checked using a pilot weight of both 55 kg (121 lbs) and 86 kg (189 lbs) and with either no passengers or those that weigh 86 kg (189 lbs) each. For vintage aircraft it is permissible to use a maximum occupant weight of 77 kg (170 lbs) instead of 86 kg (189lbs). For aerobatic aircraft, add 9 kg (20 lbs) to the standard occupant weight to represent the weight of each parachute.

- Add the occupant's weight plus the other weights of the other payload items to the aircraft empty weight as appropriate and add all the moments together. Divide the total moments by the total weight to give the **loaded CG position**.

- To check the worst forward CG case, enter the maximum weight of all variable load items that are forward of the aircraft's empty CG (not datum) and leave out all items that fall behind it. If the pilot sits aft of the empty CG, use the 55 kg pilot weight; if he sits forward of it you should use the 86 kg pilot weight. Likewise, with passengers, either leave them out or use 86 kg (189 lbs) each depending on where they sit relative to the aircraft's empty CG.

- To check the worst aft CG case, enter the maximum weight of all variable load items that are aft of the aircraft's empty CG (not datum) and leave out all items that fall ahead of it. If the pilot sits forward of the empty CG, use the 55 kg pilot weight; if he sits aft of it you should use the 86 kg pilot weight. Likewise, with passengers, either leave them out or use 86 kg (189 lbs) each depending on where they sit relative to the aircraft's empty CG.

- Check both CG cases each with both zero fuel and full fuel to check whether the weight and CG remain within the limits irrespective of fuel uplift. Depending on the fuel tank position in the aircraft, the most critical effect on the loaded cg may occur with either empty or full tank(s).

- Should the results of be shown that the aeroplane has an undue tendency to exceed one or other CG limit, restricting the loading opportunities to an impractical level, it may be possible to correct this by moving a heavy item (e.g. battery) forward or aft, or as a last resort by adding fixed ballast to the aircraft. Consult with LAA Engineering for advice.

RE-WEIGHING

- Aircraft must be re-weighed and a new weight and balance report created after significant modification or after re-covering or painting and at intervals to monitor weight growth.
- It is recommended that all aircraft are re-weighed at intervals not exceeding 10 years, to keep track of unplanned weight changes.

COPIES FOR LAA RECORDS

All new and revised aircraft weight schedules should be copied to LAA, either at the time of weighing, or as part of the subsequent Permit to Fly renewal application package. The original should be kept with your aircraft's other essential airworthiness records, and we suggest owners make a working copy for the use of pilots in making their weight and balance calculations before flight. The LAA will file the information securely and can provide further copies to interested parties on request, should the original go missing.

SPECIAL REQUIREMENTS FOR MICROLIGHTS

When microlights were first introduced, they were generally pretty simple types of flying machine and the microlight pilot training syllabus was kept as basic as possible to try to encourage more people to sign up to this delightful new form of flight. One of the results of this was that the coverage of weight and balance matters was very 'thin' – the syllabus didn't cover how to carry out a weight and balance calculation to check the loaded cg. Recognising this, and to keep the operation of these machines as simple as possible, when BCAR Section S, the design code for microlights, was introduced back in the early eighties each microlight was required to be able to carry up to full fuel and (depending on the number of seats) one or two people of anything from lightweight (55 kg) to fairly heavy (90 kg) in any combination without exceeding either the max weight limit or the cg limits. This meant that most microlight pilots could fly any Section S approved microlight without having to think about weight and cg – unless, of course, he chose to carry baggage – but then the early 'tube and rag 'machines weren't exactly in the baggage-carrying class.

As microlights have got more sophisticated over the years, responding to pressure from industry these requirements have been changed to allow more reliable four stroke engines and more equipment to be carried. In doing so the previously generous margins on payloads were sacrificed, meaning that pilots even of average weight now had to make loaded weight calculations to ensure the aircraft was not going to be overloaded. In the late 1990s, the requirements for payload were adjusted to align with those in JAR-VLA which has allowed a solo pilot on a two seater machine to benefit from increased fuel capacity and reduced the specified upper bound of pilot weight from 90 kg to 86 kg. The fuel load that the 86 kg folk have to be able to be carried has been reduced to enough for one hour's flight rather than 'full tanks', while staying within the max total weight authorised (MTWA) specified on the Permit to Fly.

Until 2017 it was normal practise to weigh microlights stripped of optional equipment in order to demonstrate that the as-weighed basic empty weight condition met the Section S requirements. From February 2017 the procedures have been changed to specify that the aircraft should be weighed in its fully-equipped form as typically flown, and to show by calculation that the aircraft would meet the Section S empty weight requirements in its basic form.

Calculation of Maximum Permitted Basic Empty Weight for Microlights

For a two seat microlight, this can be calculated by subtracting the weight of two 86 kg crew (i.e. 172 kg) from the maximum total weight authorised and then subtracting the weight of fuel consumed by the engine during an hour of flight at maximum cruise power. For the common types of engines in use, the weight of fuel for an hour's flight at max cruise can be taken to be as follows:

Jabiru 2200	10 kg	Rotax 582	18 kg
Rotax 912	10 kg	Rotax 618	23 kg
Rotax 912S	13 kg	Rotax 532	15 kg
D-Motor	10 kg	Rotax 503	15 kg

For other types of engine, consult the LAA or engine manufacturer's specifications

Example:

Jabiru UL-450 (which has a 450 kg MTWA) with Jabiru 2200A engine:

Max Permitted Basic Empty Wt = Max total weight authorised - 172 kg - wt of fuel for 1 hr

= 450 - 172 - 10 = 268 kg

a. While it is an LAA requirement that the basic empty weight of an LAA microlight does not exceed the maximum permitted basic empty weight when the microlight is first built, it is accepted that unforeseen weight gains can occur in service and this may erode or even nullify the original basic empty weight margin on the aircraft. However it is not acceptable to use this flexibility as a means of allowing extra equipment or modifications to be knowingly built in which make the aircraft have an excessive basic empty weight, except when the modification is one that has been imposed to deal with a continued airworthiness or other safety issue.

b. In the case of certain individual older aircraft, which first operated as 'Group A' machines prior to transferring to the microlight category, a greater maximum permitted basic empty weight is allowed on a 'grandfather rights' basis.

For two seat microlight aircraft falling into the category of either a. or b. above, the FULLY EQUIPPED empty weight must nevertheless not exceed that calculated in accordance with FAR 23.25 and 23.29, i.e. the addition of the fully equipped empty weight with two 77 kg crew and the weight of fuel required for half an hour's flight at a maximum continuous power must not result in the aircraft exceeding max permitted total weight authorised.

Microlight re-weighing

Until 2016, CAA required that microlights be re-weighed at intervals of not more than 5 years in order to keep track of weight changes and make sure that the payload on each microlight still met the Section S requirements. In 2016 the CAA withdrew this rule and the LAA therefore now recommend re-weighing at not more than ten year intervals, as for other classes of aircraft on the LAA fleet. As for LAA's other classes of aircraft, microlight aircraft must in any case be re-weighed after any significant changes are made, and any significant repairs or major refurbishment, re-covering or re-painting which are likely to affect the empty weight.

Microlight Weight Placard

In order to help pilots operate microlights within the permitted MTWA, all LAA microlights should be fitted with a microlight weight placard, clearly visible in the cockpit, listing the following data. The data should be updated following any re-weighing and/or changes to the aircraft's empty weight or other listed parameters.

1. Fully equipped empty weight
2. Date of weighing
3. Maximum permitted basic empty weight
4. Maximum permitted total weight authorised
5. Maximum fuel load with two crew of 86 Kg each (zero baggage)
6. Maximum combined crew weight with full fuel tanks (zero baggage)

Guidance on compiling the data for the microlight weight placard is provided on the microlight weight and balance form.