Weight & Balance

Section VI

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GENERAL

Proper CG is absolutely critical to safe flight. This is where NO exceptions can be considered - you must verify that the center of weight is in the correct position and if it is not, you MUST correct it before flight.

Warning

Do not use bathroom scales to calculate the center of gravity as they are not sufficiently accurate. Flying outside of the approved center of gravity envelope is dangerous.

You should rent or borrow a good set of accurate beam scales or equivalent. These scales should be able to handle up to 400 pounds each. Often your local EAA chapter will have a set, or know the location of a set available for your use. Many FBOs have them also.

The allowable Center of Gravity range is FS 24.5 to FS 30.3 (15% MAC to 29% MAC)

AIRPLANE WEIGHING PROCEDURE

1. First establish the airframe's empty weight and its empty Center of Gravity (CG). The aircraft and the scales must be level while being weighed on the scales and preferably in a hangar with the doors closed to eliminate any wind effects. (If weighing outdoors, the wind must be virtually calm.) Shims (1 x 4s or similar boards) may be required under the main landing gear to establish this level attitude and these shims become part of the "tare weight". All tare weight is deducted from any scale readings.

NOTE

It is preferable to not have the battery installed at this point. This will allow you to calculate its optimum longitudinal position in the aircraft and thereby locate the final CG location. The battery position can be adjusted during the weighing process and its position established if time "on the scales" permits.

2. Establish a "datum point" from which ALL measurements can be made. For convenience, the back of the spinner is recommended.
3. From this datum point, drop a plumb bob and mark a point on the floor. Also mark an aircraft centerline on the floor. This can be done by also dropping a plum bob point from the tail and "chalking" a line between the two points. (The spinner CL will be slightly to the right of a true centerline, but will be close enough for the purpose of establishing the longitudinal CG.)
4. Drop a plumb bob from the center of each wheel axle. Mark the nose gear axle center onto the ground at the centerline position. Mark the two main gear axle centers on the ground and extend a straight line between the two main gear crossing the fuselage centerline previously "chalked" onto the floor.
5. Read and record the actual weights of the leveled aircraft on the three scales. Log these weights in the appropriate lines on Column A. (See blank Lancair 320 "Weight and Balance Sheets" on pages 10 and 11 of this section, provided for recording these data. Several "Record" sheets are also included as well as an "Equipment List" for your convenience.)
6. Log the weights of any shim stock (the 1 x 4s and any other non-aircraft weight) that is on the scales as tare in Column B
7. Subtract the tare weights from the measured weights and place those figures in Column C.
8. Next measure and record the distance from the datum point to the location of the main gear as marked along the fuselage centerline. Log these distances in the appropriate lines of Column D, these are the "arms" or "moment arms".

You now have all the information required to establish the aircraft's empty Center of Gravity.

MOMENT WEIGHTS

1. Now, to arrive at the "moment weights" of the nose gear and the main gear locations simply multiply the weight of the nose gear and main gear by the distance from the datum point, and record the values in Column E.
2. Total Columns C and E separately.
3. Divide Column E by Column C and the result is the empty weight CG expressed as a distance from the datum point.

This empty weight CG must ultimately be forward of the allowable flight CG range since when the pilot gets into the aircraft, he will be aft of this point and that will move the CG aft into the beginning of the allowable range. The empty CG should be such that the plane is in the most nose heavy condition (full header tank and just the pilot in the plane) i.e., the CG at the front limit.

NOTE:

The allowable Center of Gravity Range is Fuselage Station (FS) 24.5 to FS 30.3

Now locate the above locations so that you can reference your actual CG in meaningful terms.

There are two easy references: 1) the forward face of your firewall is FS = 0 and is easily located thru the nose gear well. Drop a plumb bob line down from that point and mark it onto the centerline of the floor. (This may be on the scales.) Measure from your datum point to this FS = 0 mark and record the dimension. Now calculate your particular moment arm required to align with FS 24.5 and FS 30.3.

Before removing the aircraft from the scales, it is wise to also establish your exact moment arms for various loading items such as header tank fuel and pilot/passengers. While the header tank fuel can be estimated with accuracy since it is a defined shape with known weights, the pilot and passenger moment arms are less defined and should be determined not estimated. They are affected by such as seat back angles, cushions, etc. which can easily change the aircraft's CG.

To determine your pilot/passenger moment arm have someone sit in the plane and log the resultant weight changes on the three scales. (You'll notice the nose gear scale weight is less while the main gear weights increase.) Now recalculate the pilot's moment arm.

EXAMPLE

Let's say you weigh 170 lbs. The net change on the nose gear was (-50#) and the net gain on the main gear was 220# (170 + 50). Multiply the nose gear weight change (a negative number) by its moment arm and the main gear weight change by its moment arm. Combine those two numbers (moment weights) and divide by 170. (Remember that the nose gear number is negative so it will subtract from the other.) The resultant figure is the moment arm for your body. Log that dimension as the pilot & passenger moment arms (assuming both seats are configured the same).

This approach can be used to calculate accurately any loading units like the header tank fuel, wing fuel, and baggage. It is recommended that this be done as this is the most accurate means of attaining a true loading analysis for your particular airplane. If you are measuring for fuel loads, accurately measure the gallons (use 6 lbs/gallon to calculate the weight) and/or accurately weigh the gallons as well as a double check and use the more accurate value. Oil weight is 7 lbs/gallon.

If you have the battery positioned in the aircraft the weights will be final and the aircraft's empty CG should be forward of the allowable forward CG limit. This is because virtually all flight load conditions will move the CG aft. It is ideal is to have the CG located on the forward most point of the envelope when you have a full header tank and only the pilot in the plane. This will be your most forward CG flying condition, all other loads only move the CG aft and as you use the header tank fuel the CG will also move aft. This is mostly effected by the pilot & passenger's moment arm. An empty CG about 2 inches forward (FS 22.5) is about right, but this should be verified for your aircraft.

CAUTION

Do not set the aircraft empty CG at the forward most point of the allowable CG range. This wastes available CG range and thus requires less loading to move the CG range to and beyond the aft limit which is very dangerous and an unacceptable condition.

As noted earlier establishing the battery location is the easiest way to adjust the CG to the desired location. This can be done by weighing the aircraft without the battery and calculating the best position for the battery. Time on the scales permitting, the physical location of the battery (and its box, master relay, installation brackets, hardware, etc.) can be double checked. Some compromise is generally required for the battery's position. Another example for these calculations is shown below.

SAMPLE CALCULATION

Battery Placement

1. Establish the battery weight including the master relay, battery box, etc. For this example 26 lbs is used.
2. The plane weighs 980 lbs (less battery) and its moment arm calculates to be 56, thus providing an FS 20 location (assuming a datum point that was 36 inches forward of FS 0).

We have calculated that an FS 22.5 empty CG position is ideal thus the goal to be attained. That will result in an ideal empty weight moment arm of 58.5 including the battery.

980 x 56 = 54,880	Moment weight (less battery)
980 + 26 = 1,006	Final a/c empty weight.
58.5	Ideal a/c empty wt. moment arm
1006 x 58.5 = 58,851	Ideal a/c final moment weight
58,851 - 54,880 = 3,971	Ideal bat moment weight
3,971 / 26 = 152.7	Ideal bat moment arm (FS 116.7)

3. Thus by the above calculations you would mount the battery at FS 116.7.

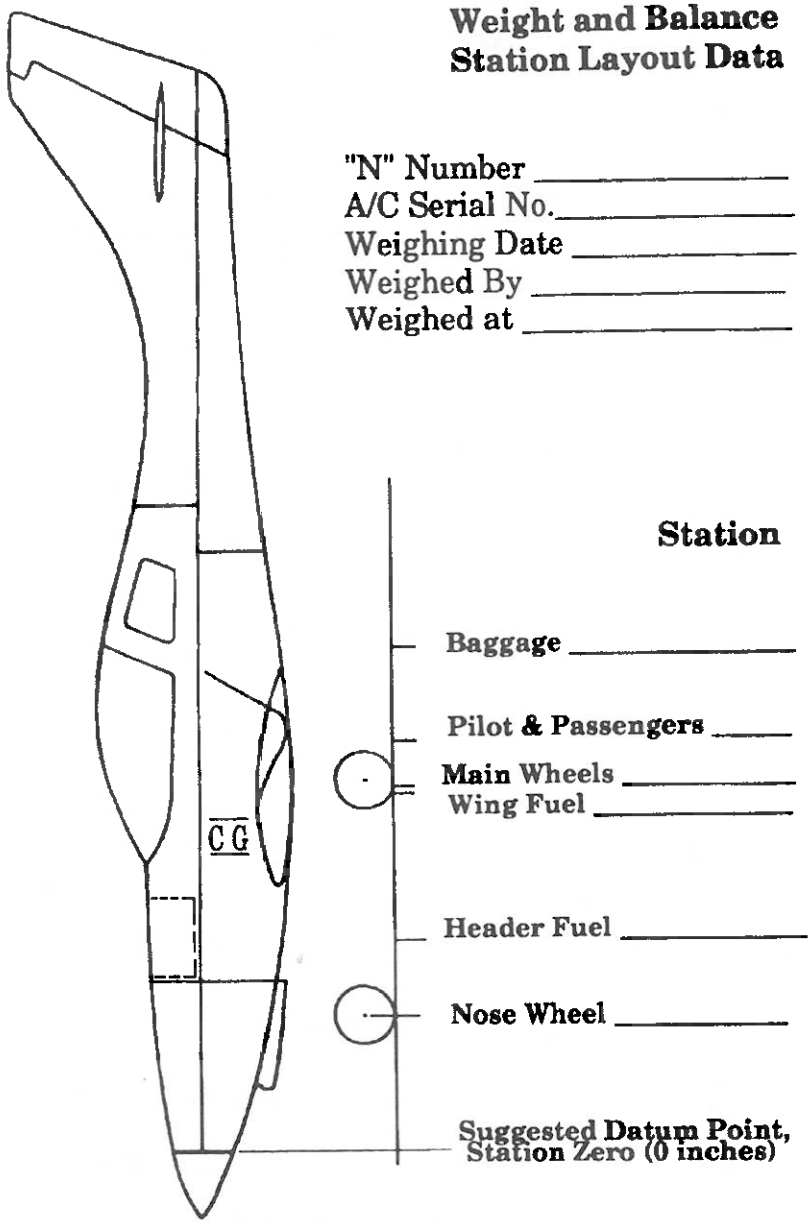
If you need ballast weights in the aircraft to achieve the proper CG try to use such required items as a tool bag. There are also ways within the engine compartment to change the weights by using a lighter or heavier starter or alternator. The last option is lead.

Several sample loading should be calculated to verify that you always remain within the allowable CG range. If there are loadings which result in a CG aft of the allowable location you must placard the plane accordingly. This is usually found as a baggage compartment limit. If a "hat rack" has been built in, it should be placarded for a maximum since it is so far aft. Generally, 3 to 5 lbs is the maximum for this location.

Included are several blank weight and balance sheets for your use. These should be filled in for typical loadings to verify that you will not be inadvertently loading the aircraft improperly.

Weight and Balance Station Layout Data

"N" Number _____
A/C Serial No._____
Weighing Date _____
Weighed By _____
Weighed at _____



Basic Aircraft Station Layout

NOTE

The FAA regulations require that at least one aircraft weight and balance sheet be carried in the aircraft at all times.

Weight & Balance SHEET, 235, 320, 360

(Circle One)

"N" Number_____
Builder_____
_____

CG Range: (Inches) 5.8
FS 24.5 to FS 30.3

	A Wt.(lbs)	B Tare Wt.	C Net Wt.	D Mom. Arm	E Mom. Wt.	Sta.
Nose Gear						
Rt. Main						
Lt. Main						
Empty CG (with oil)						

E/C = A/C Station

	C Net Wt.	D Mom. Arm	E Mom. Wt.	Sta.
Plane				
Pilot only				
Header Tank Full				
Max fwd CG condition				

E/C = A/C Station

Plane				
Pilot & Passenger				
Low Header Tank fuel				
Wing tanks full				
Luggage				
Max aft CG condition				

E/C = A/C Station

Plane				
Pilot				
Fuel (header)				
Fuel (wings)				
Luggage				
Sample Condition				

E/C = A/C Station

Weight & Balance Data Sheet

Weight & Balance RECORD

Lancair model _____	Serial Number _____	Page Number _____										
Date	Item No.		Description of Article or Modification	Weight Change						Running Basic Empty Weight	Running Basic Empty Moment
				Added (+)			Removed (-)				
	In	Out		Wt-#	Arm-in.	Moment	Wt-#	Arm-in.	Moment		

Lancair model ______ | Serial Number ______ | Page Number ______

Date	Item No.		Description of Article or Modification	Weight Change						Running Basic Empty Weight	Running Basic Empty Moment
				Added (+)			Removed (-)				
	In	Out		Wt-#	Arm-in.	Moment	Wt-#	Arm-in.	Moment		

Weight & Balance LOADING FORM

Basic A/C Empty Wt. _____
Empty Moment _____

Occupants		
Weight	Pilots ARM	Moment Arm
120 lbs		
140		
160		
180		
200		
220		

Fuel Gallons*	Header Weight	ARM	Wings ARM Moment
5	30 lbs		
10	60		
15	90		
20	120		
25	150		
30	180		
35	210		
40	240		
45	270		
50	300		
53	318		

* U.S. Measure

Baggage	ARM	Moment
20 lbs		
40		
60		

T.O.Wt. _____, **Moment** _____, **Station** _____
Acceptable Wt/Sta, _____/_____

My Aircraft's Equipment List

Lancair Model 235, 320/360 (Circle)

Serial Number _____ Registration No. _____

Date _____

(Add new date on next line when adding/removing equipment.)

Item No.	Item	Mark √ If Installed	Arm (Inches)	Weight (lbs)

NOTES:

NOTES: