Balancing Your Model Airplane

The relationship of a model's wing center of lift to its centre of gravity (CG) is critical for longitudinal stability. Engines of different makes but of the same displacement vary in weight, as do electric motors and battery packs and onboard receivers and their batteries. On completion, the model may or may not be balanced correctly. Flying the model without checking its CG location invites trouble.

The center of lift (CL) of a wing of a constant width (chord) from tip to tip is easily located. It is on the wing's centreline at a point 25% of the width behind the leading edge (see Fig. 1).

The CG is the focal or balancing point of the weights of all the model's components. It, too, is easily located by suspending the model from its CL. The CG will seek, pendulum-like, to move to the lowest position. If the model hangs "nose down," the CG is in front of the CL. If it hangs level, the CG is vertically in line with the CL. If it hangs "nose up," the CG is aft of the CL.

Longitudinal stability is stability in the pitch axis. A degree of this stability is essential for the model to return to level flight of its own volition after being disturbed by a gust or when the control sticks are cantered, after a manoeuvre.

Position 1: CG ahead of the CL
Position 2: CG vertically in line with the CL
Position 3: CG aft of the CL

Position 1 (see Fig. 2)
Here, the CG is at 20 percent of the wing's width or chord and 5 percent ahead of the CL; on a wing of 10-inch chord, the CL is at 2.5 inches from the leading edge, and the CG is at 2 inches, 1/2 inch ahead of the CL. Lift upward at the CL and weight downward ahead of the CL forms a moment to move the model's nose downward (a moment is force times distance).

If the model weighs 100 ounces, the moment is 1/2 inch x 100 ounces or 50 oz.-in. For level flight, a horizontal tail download is required. If the tail's CL is 25 inches behind the CG, a download of 2 ounces will provide the balancing force, i.e., 2x25 = 50 oz.-in. This download is obtained by a few degrees of up-elevator trim, using the transmitter's elevator-trim lever.

Centrifugal force is familiar to all. In a car, when a driver turns a corner, centrifugal force tries to make the vehicle continue straight on. Only the friction of the tires on the road permits the car to turn.

An airplane resists centrifugal force by tilting or banking the wings towards the center of the turn and by increasing the wing's lift by up-elevator on the control stick. The increased and inward slope of the lift counters both the model's weight and centrifugal force. For example, a model flying at 55mph on a turn radius of 200 feet will encounter centrifugal force of 1 G, or one times the model's weight. This plus the model's weight totals 2 G, or twice the model's weight. Tight turns at high speed can result in loads of 7 or 8 G, and this calls for sturdy structures.

Figure 1
Location of the Center of Lift

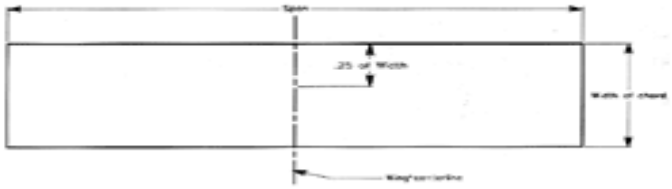


Figure 2
Position 1 - CG at 20% of Chord

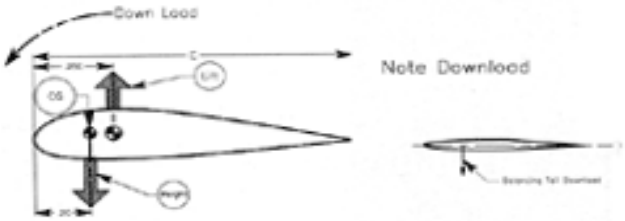


Figure 3
Position 2 - CG in line with Center of Lift

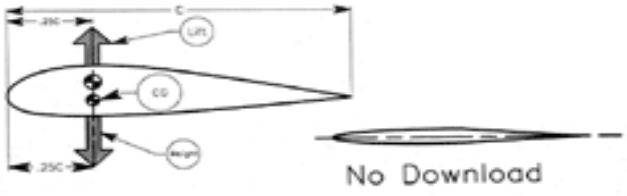
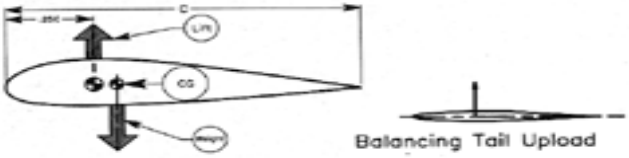


Figure 4
Position 4 - CG at 30% of Chord



Refer to Fig. 2; the increase in weight ahead of the CL and the increase in wing lift double the nose-down moment and require an increase in tail-down force, thus requiring more up-elevator. As elevator travel is limited, the plane may run out of it; it may not have enough to flare for landing and will have limited manoeuvrability. However, the forward CG moderately increases elevator effectiveness in dives. The forward CG does increase the pitch stability. The model is easy to fly.

A forward CG is recommended for novices. Moving the CG further forward, say to 15 percent of the wing's width, will further increase the pitch stability—but at the expense of further reductions in manoeuvrability.

Position 2 (see Fig 3)
Here, the CG is vertically in line with the CL. Weight is directly opposed by lift with little or no load on the elevators, whose potential is undiminished. Pitch stability, while reduced from that of the forward CG, is good and the model is mobile. This is the author's location of choice and one suitable for the experienced flier.

Position 3 (see Fig. 4)
The CG is aft of the CL at 30 percent of the wing's chord and 5 percent behind the CL. Centrifugal force acting behind the CL adds to the elevator's effectiveness. The pitch stability is reduced, but the model is highly mobile. For equilibrium, a small upload at the tail is required. This is the CG location for the expert pilot.

For gas or glow-engine models, the fuel tank is close behind the engine and well ahead of the CL. As fuel

is consumed, the CG will slowly shift aft by up to 2 or 3 percent of the wing's width, dangerously decreasing pitch stability. For this reason, the aft CG location at 30 percent should be established with an empty fuel tank. Electric models do not have this problem.

Note that on our 10-inch-chord wing, the CG range or envelope is only 1 inch from position 1 to position 3, but it has a major impact on flight characteristics.

The vertical location of the CG relative to the CL has a minor bearing on pitch stability. A high wing or cabin model has its CG well below the CL. A degree of pendulum stability exists. A mid-wing model's CG and CL are very close so that there is little or no pendulum stability. A low wing model's CG is above the CL, which does reduce stability, like an upside-down pendulum, but only to a small degree.

Now, the model has been finished, and it is time to locate the CG at any one of the three suggested locations. On gas or glow-engine models, the only components that can be moved to correct the CG location are the receiver and its battery. If this is not effective, the only resort is to use ballast—up front for tail heaviness or behind the CG for nose heaviness. The farther from the CG, the less ballast required. Ballast takes many forms. The best (in this author's opinion) is lead shot coated with glue. The amount of weight to be added is easily obtained, and the pellets are self-adhering in out-of-sight locations. An electric model's battery pack is fairly heavy so that shifting its location should permit the CG to be moved to the desired location without ballast. While the model is suspended at its CL, check that the wings are level. If they are not, the lower side is heavier—an undesirable condition. The correction is to add ballast to the tip of the opposite, higher wing. Happy landings!