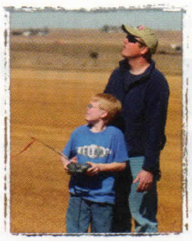

PRIMARY TRAINING

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Understanding CG

All model airplanes have both fixed and variable design and performance criteria. Wingspan, length and control surface size are some of the fixed design items. Those cannot be easily changed, and so we simply accept them and worked within their constraints. The variable design aspects include weight, control surface throw, radio settings such as exponential mixing, and probably the most important – center of gravity. As a new modeler, the idea of center of gravity (CG) may seem a little foreign. In reality, the best way to mentally approach CG is to consider it a balance point. There are several different balance points or CG's based on which axis of the airplane we're considering. Lateral relates to rolling, vertical relates to yaw, and longitudinal relates to pitch. The longitudinal CG is the one we're going to focus on in this article as it is arguably the most important setting on your model to assure airworthiness as it carries the most aerodynamic influence.

CG THEORY

Most traditional model aircraft have their CG located between 25 and 35 percent of the wing chord. The chord is the distance from the leading edge of the wing to the trailing edge, parallel to the fuselage centerline. In all cases, it is important for the builder to reference the CG position recommended by the manufacturer or designer. It will be clearly marked and referenced in the builder's manual or on the model's plan sheet.

In models with the traditional wing and tail configurations, the CG is located in front of the wing's Center of Lift (CoL). The CoL is the aerodynamic center, for lifting purposes, of the wing. When the wing creates lift, a nose-down pitching moment is created. The tail plane counteracts this nose down pitching moment by creating a down force and thus preventing the nose from pitching down. The interaction between the wing and tailplane creates that state of balance while flying, with the wing lifting and the tail pushing down. In the case of a stall, where the airflow over the wing is disrupted due to the high angle of attack (AoA), the wing loses lift and because the CG is ahead of the CoL, the nose drops, AoA is reduced and the airplane accelerates and recovers virtually unassisted.

The actual CG of any aircraft is adjustable. In full-scale aircraft, we move the passengers, cargo, and fuel load to achieve an acceptable CG. In models we can move components like the fuel, receiver, servos, and batteries. We can also add ballast, and stick-on weights are readily available at your local hobby shop. While adding stick-on weights is easier than reconfiguring your models components, I much prefer to exhaust the latter option first to avoid adding unnecessary weight. Always remember though, that it is much preferable to make your first flight with a few extra ounces in the nose than with even a slightly aft CG.

While the CG must be in a specific range to achieve successful flight, varying the CG location within that range will have a large effect on the flight characteristics and performance of the model. An aircraft trimmed for a forward CG will have very stable pitch characteristics. A consequence of increasing longitudinal stability through the increased nose-down pitching moment of a forward CG position is that the tail has to push down harder, thereby creating more aerodynamic drag. This increase in drag will cause a slight increase in the thrust required to maintain flight. A reasonably forward CG is also desirable as it helps ensure stall recovery with little pilot input other than reducing the elevator deflection. This is extremely desirable in trainer aircraft.

Establishing the proper CG is critical for success regardless of the size of the airplane. A balancing stand such as this EZ Balancer from Southwest Systems removes the guesswork and helps ensure a successful first flight.

Conversely, as the CG is moved aft, the down force required by the tail is reduced, as is the pitch stability of the model. There is a smaller tendency of the model to pitch down both in normal flight and during stalled/spinning flight. Aircraft with a significant aft CG will be less stable in forward flight and will require a more aggressive recovery technique during a stall/spin recovery. An aircraft with a severely aft CG may be virtually uncontrollable in normal flight and recovery from a stall/spin may not be possible.

Initial measurement and verification of actual CG is done by balancing the model at the manufacturer's intended location, adjusting internal equipment to achieve the target CG. It is easiest to balance high-wing and shoulder-wing models with the model upright and supported from underneath the wing. With low wing models, it works better to balance the model upside down. There are many methods for determining the actual balance including commercially available balancing stands or even just using your finger tips.

ADJUSTING YOUR CG

Keep in mind that the recommended CG in the manual is just

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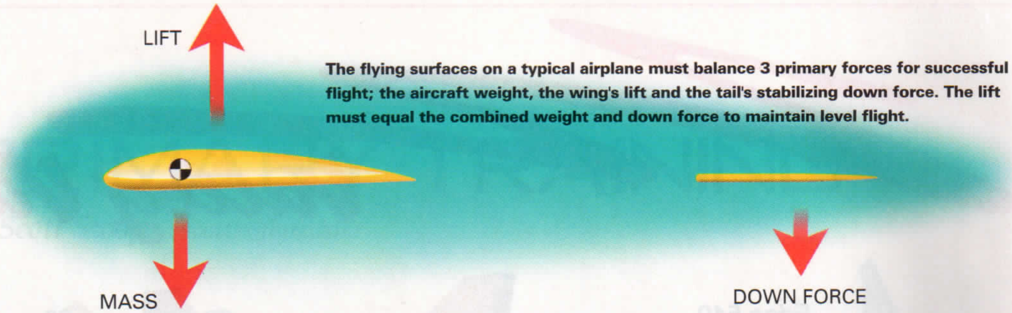

The flying surfaces on a typical airplane must balance 3 primary forces for successful flight; the aircraft weight, the wing's lift and the tail's stabilizing down force. The lift must equal the combined weight and down force to maintain level flight.

a starting point. Many manufacturers recommend a very conservative initial CG position for the first couple of flights to ensure the model is flyable, but that doesn't mean that it can't or shouldn't be adjusted to better fit your preferences later on. In a very general sense, I prefer the CG of all of my models to be slightly ahead of neutral, i.e. slightly nose heavy. For trainer type aircraft that aren't flown inverted, the easiest way to check for CG in a well designed model is to check the elevator setting after your initial trim flights. If the elevator is deflected significantly up while in trim during level flight, the model is likely very nose heavy. In a perfect world, the elevator should be roughly neutral to very slightly up when trimmed for level flight. It should almost never be deflected down in stable level flight as this would indicate it is compensating for a tail heavy condition, which is undesirable in trainer aircraft.

As your experience grows and you transition to more aerobatic aircraft, you can use both inverted flight and vertical downline tests to verify a good CG. When flying inverted while trimmed for level upright flight, your model should descend ever so slightly, requiring only a very slight down elevator input to maintain level flight. If the model descends abruptly, adjust the CG aft and repeat the test. If the model holds a perfectly level inverted flight, or climbs inverted with neutral elevator, adjust the CG slightly forward. For most aerobatics, I recommend a slightly forward CG, allowing the instantaneous snap and spin recovery required for precision aerobatics. A good secondary CG test is found flying vertical downlines with the throttle closed. If the model maintains the vertical downline with a neutral elevator input, both the incidence and CG are very close to perfect. If the model pitches to the landing gear, adjust the CG forward. If the model pitches towards the canopy, adjust the CG aft.

CONCLUSION

Although many new RTF models don't allow much in the way of CG adjustment beyond adding ballast, you'll definitely want to add this tuning skill to your toolbox as your fleet and experience level grow. Adjusting CG can literally be the difference between having a lousy flying airplane or the queen of your fleet that always makes the trip to the field. Until next time, remember that learning is fun and fun is what this great hobby is all about. ⚙

Links
EZ Balancer, www.ezbalancer.com, (805) 527-6337

For more information, please see our source guide on page 113