Stability

Mumbo Jumbo #118 from the Glue Guru

Shamelessly reproduced here from the Jan-Feb 2005 issue of the Flying Aces Club News, "Colonel" Lin Reichel, CinC

Adequate longitudinal, or fore and aft stability, has been achieved by most of us. Those annoying nose up and down (phugoid) oscillations have been licked with a combination of a forward C.G. and a larger horizontal tail. The usual formula of a tail area equal to at least 25% of the wing area meets the test of reality, though 30-33 % is even better. True scale tails, at about 15 % just won't do.

Why aren't full scale tails made larger? Surely pilots would appreciate the greater inherent stability — approaching that of an auto-pilot — or would they?

There is a catch. Greater inherent stability implies reduced maneuverability. At about the 25% point the aircraft becomes reluctant to dive steeply, no matter how much force the pilot applies to his controls. When employed by the BE2c, a WWI Royal Aircraft Factory design, complaints were fierce. Men died because they were unable to dive away from attacking German aircraft. Upon investigation, the BE2 was officially declared a "non-diver". The commotion strongly influenced full scale design thereafter. Result: tails are small.

Model designers know this. Making the tail bigger is an obvious and necessary step. The problem is a tendency to make the vertical tail larger as well. Doing so maintains a sense of scale — if only the horizontal tail is enlarged, the vertical tail seems too small. The catch is that making the vertical tail larger will probably lead to spiral instability.

We struggle with two basic forms of lateral instability: that sensed under power and that developed in glide. These differ because the prop blast itself is a powerful factor in lateral stability; prop blast presence or absence has much to do with the result.

The blast doesn't go straight back; it spirals, reflecting the motion of the prop. The usual affect of a too large vertical tail, taken together with the motor torque, is to force the model into a left bank. Unless corrective action is taken, the final result may well be a spiral dive into the ground. Fortunately, for most models the cure is simple: offsetting the prop a few degrees to the right, or adding right thrust.

When in glide, with torque and prop blast no longer significant, oversized vertical tails can produce a delayed spiral dive either to the left or right. Because the disturbing force is small, it sometimes takes many seconds for the instability to become clear. In some models, only a lengthy thermal flight will force the slight "divergence" to reveal itself.

We tend to write off such late flight oddities as flukes, owing to some peculiar gust. Sometimes this is the case, but sometimes not. If you see it on two separate flights, the chances are that the instability is real.

As to the cure, some believe in potent combinations of washin and washout. I don't. There will always be some gust/breeze/thermal combination that will unravel those washin/washout settings to freshly recreate exactly that unwanted spiral dive.

Instead, I think the only genuine solution is to chop the vertical tail down in size to something acceptable. It should be less than scale in size — certainly never more. Unfortunately, the process is no fun. Removing the vertical tail is not easy and reworking it is a nuisance. When all is said and done, it will seem too small.

Can this resizing be overdone? What happens if the vertical tail is made too small? A new form of instability then arises, called Dutch Roll, in which the model rolls slightly clockwise, then counterclockwise, etc. This happening is rare; I've seen it exactly once, and then only by flying a model after having removed its entire vertical tail. As a practical concern, we needn't worry about this one.

With full scale vertical tails so large, most real aircraft are spirally unstable. Oddly enough, pilots don't complain. They like that feeling of being in control, granted by a large vertical tail.

Editor's Note: The above ideas help explain various behaviors of all model aircraft, however, if you are building a proven endurance design, be cautious about screwing around with fin and stab sizes until you are sure that is the problem. A scale model which has a true scale fin and stab isn't likely to fly without the above adjustments — hence the failure rate of most Guillows models.