Guidelines to Wiser Airplane Choices

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Illustrations by Dave Scott

NOTICE: The following information is intended to provide practical guidelines that recreational pilots can use to better predict the flying qualities of different types of airplanes and thus the skill levels required to fly them. Some readers will no doubt feel that certain nuances been have been left out, and some may be upset because the advanced principles and formulas (e.g., moments, aspect ratios, etc.) that are the stock and trade of professional aerodynamicists are not also included. However, the aim here is not to try to cover every obscure exception or teach aerodynamics, but to condense flight dynamics into simple rules-of-thumb that the average pilot can wrap his head around and therefore make better airplane choices that improve his or her opportunities for success.

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Introduction

By far, the most frequent request that 1st U.S. R/C Flight School receives is for airplane recommendations. In many cases, people are often confused and frustrated by trying to make smart buying decisions amidst all the "best" claims and widespread promises that they will soon fly like a pro if they purchase "X" airplane.

Of course, how well an airplane flies is subjective depending on the skill level of the pilot and other factors. I.e., What a pro pilot feels is easy to fly, easy to land, and compliments his flying style may not be nearly as easy for others and could even end up getting them into trouble. Indeed, flying/landing troubles and flying that falls short of expectations is quite often due to pilots flying airplanes that aren't suited or set up for their skill level (e.g., a sport pilot looking to fly with greater precision is not going to be happy with the results achieved flying an airplane designed and setup for extreme 3D).

However, since all that most people have to go on are the recommendations of individuals often with different skill levels, and text that claims the airplane does every trick in the book and also supposedly lands like a trainer, pilots often chalk up their troubles to just needing more practice rather than questioning whether their issues are inherent to the airplane or the way it's setup. Thus, by default, many pilots continue to fly with mixed results until finally another airplane that promises to make them fly much better grabs their attention.

The tricky part of choosing the "best" airplane has therefore always been matching the plane to the pilot's immediate skill level. Keep in mind that a pilot who buys and sets up an airplane outside of his comfort zone actually delays his future aspirations if he ends up wrecking it or becomes apprehensive about flying because it's no fun to fly (and especially no fun to land). Thus, logic dictates that the "best" airplane and setup is the one that best compliment the type of flying a person does most often.

While many factors contribute to an airplane's characteristic performance, the single most influential design factor determining how an airplane flies is the wing. Since just a handful of wing configurations are found on nearly all model airplanes, the general performance, handling qualities, and skill level required to fly them can be anticipated with a general understanding of how different wing types affect performance. Therefore, in addition to some practical considerations and fundamental setup tips, the aim of this article is to teach you to look past the hype to the wing configuration to determine what kind of performance each airplane will offer, and thus which are suitable for you.

General Principles

Even though airplane design decisions are targeted at achieving specific performance regardless of size, larger aircraft generally fly better. For example, larger models appear to fly slower and are obviously easier to see at greater distances and thus give the pilot more time to think. But the biggest practical advantage of flying larger models is that they tend to be more stable in turbulent windy conditions, and therefore open up more flying opportunities with better results.

As a rule, how quickly an airplane responds to control inputs is a function of how fast and how far the control surfaces deflect, regardless of whether the plane is small, large, high or low performance. Seldom can you go wrong by initially setting up the control surface deflections/travels to the manufacturers' recommendations. However, to fly your best, you must then adjust the control surface travels to suit your immediate skill level. All too often, perfectly good airplanes are faulted or retired because the pilot did not like how the airplane handled, but for one reason or another put it upon himself to get used to it, and then went looking for another airplane when the one he was flying proved not much fun to fly. So, understand that YOU primarily determine the control response, and by changing the travels to suit your comfort level you can immediately start flying with more confidence and subsequently building on that success, rather than continuing to fight an airplane that may only be an elevator adjustment away from becoming a real joy to fly.

A note about *exponential (expo)*: After adjusting the travels/dual-rates to suit your immediate skill level, only add more expo if you feel that the airplane response is too sensitive or "touchy" around neutral. On the other hand, if your aim is to fly with maximum precision and predictability, don't hesitate to take some expo out if any of the controls feel sluggish or you sense a lack of correlation between your control inputs/intentions and the response of the plane (a.k.a., a "wet noodle" response). Ultimately, you should strive to use the least amount of expo possible and still feel comfortable so that you don't lose the direct correlation between your control inputs and the response of the plane that is so vital to precision flying.

Where you chose to balance your model will also have a huge impact on how it handles and thus how well you fly it. Choosing to fly with an aft C.G. (tail-heavy) will cause the plane to be unstable and harder to fly. While it's true that a tail-heavy condition does tend to increase maneuverability, as a consequence, the airplane will be less forgiving and require more effort to fly, thus retarding overall success. I.e., It won't matter how well a tail-heavy model flat spins if you end up tearing the gear off because it's so hard to land. Conversely, a nose heavy airplane tends to be more stable, but also loses some maneuverability along with behaving a lot differently during speed changes. Thus, all things considered, the best overall performance is achieved when the airplane is set up neither tail-heavy nor nose-heavy.

Basic Trainer Aircraft Features

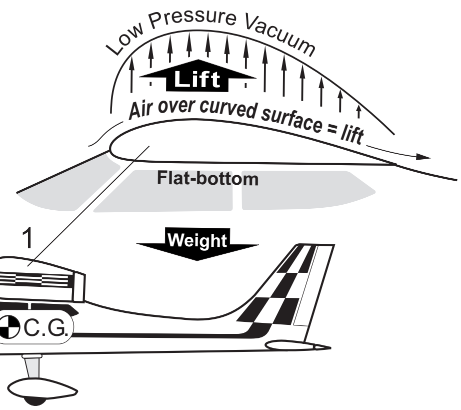
A well trimmed and balanced basic trainer is designed to fly slower and feature "positive" stability. Meaning, when it is disturbed it will tend to return to upright level flight. This type is therefore more forgiving in the event of pilot error and allows a pilot reasonable periods of hands-off stability when it is upright. The design features that produce these qualities center around the wing airfoil and thickness, wing area and length, the wing's location on the fuselage, dihedral, and the wing shape or planform (figure 1):

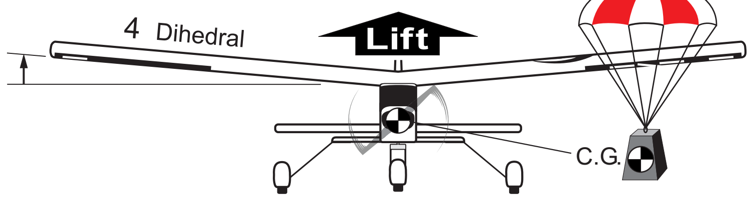
1. A flat-bottom wing with a curved top surface produces significant "lift" (a low pressure vacuum/"suck" supporting the plane's weight) as air flows over it and thus enables a basic trainer to fly at slower airspeeds.

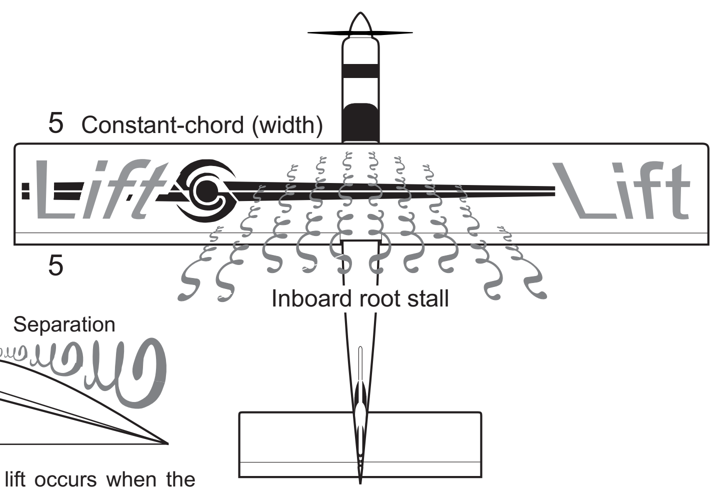
Basic Trainer

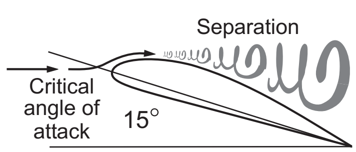
The primary features that make a good basic trainer are a thick flat-bottom airfoil, high wing placement and constant-chord.

The thick flat-bottom wing positioned high on the fuselage with dihedral enables slower landings and nearly hands-off upright stability.









A stall or loss of lift occurs when the wing exceeds its critical angle of attack and the airflow becomes turbulent and separates from the wing.

A constant chord wing inherently stalls at the root while the airflow continues to flow smoothly over the outboard portions of the wing. The resulting loss of lift at the root results in a controllable mush or sink while the tips continue to provide lift and aileron control during a stall.

2. A thicker airfoil with therefore greater curvature generates more lift to allow flying (and landing) at especially slow speeds.

3. A high wing location on top of the fuselage places the lift support well above the plane's center of gravity (C.G.). Thus, like a parachute supporting the man below, a high wing airplane inherently wants to stay upright, and if inverted, this type will eventually right itself given enough time and altitude.

4. Wing dihedral primarily improves upright stability by further angling the wing above the C.G. for an even greater parachute effect, a.k.a. "plumb bob" effect.

5. When stalled, a constant-chord wing inherently loses lift first at the center "root", while the airflow remains smooth and thus continues to provide lift and aileron effectiveness out toward the wing tips. A "root stall" consequently results in the airplane remaining controllable and a milder sink or mush when flown too slow (figure 2).

Summary: The primary features of a good primary trainer are its flat-bottom airfoil to enable slow flight and slower landings, a high wing placement to enhance upright stability, and a constant-chord wing to ensure milder controllable stall characteristics.

Note: Even though a primary trainer with ailerons is capable of aerobatics, because it is positively stable, the pilot has to work especially hard to maneuver it through unusual attitudes. It is ultimately a lot easier to perform and learn aerobatics utilizing an airplane designed for aerobatics, i.e., one featuring a symmetrical airfoil wing.

Sport / Basic Aerobatic Aircraft Flight Characteristics

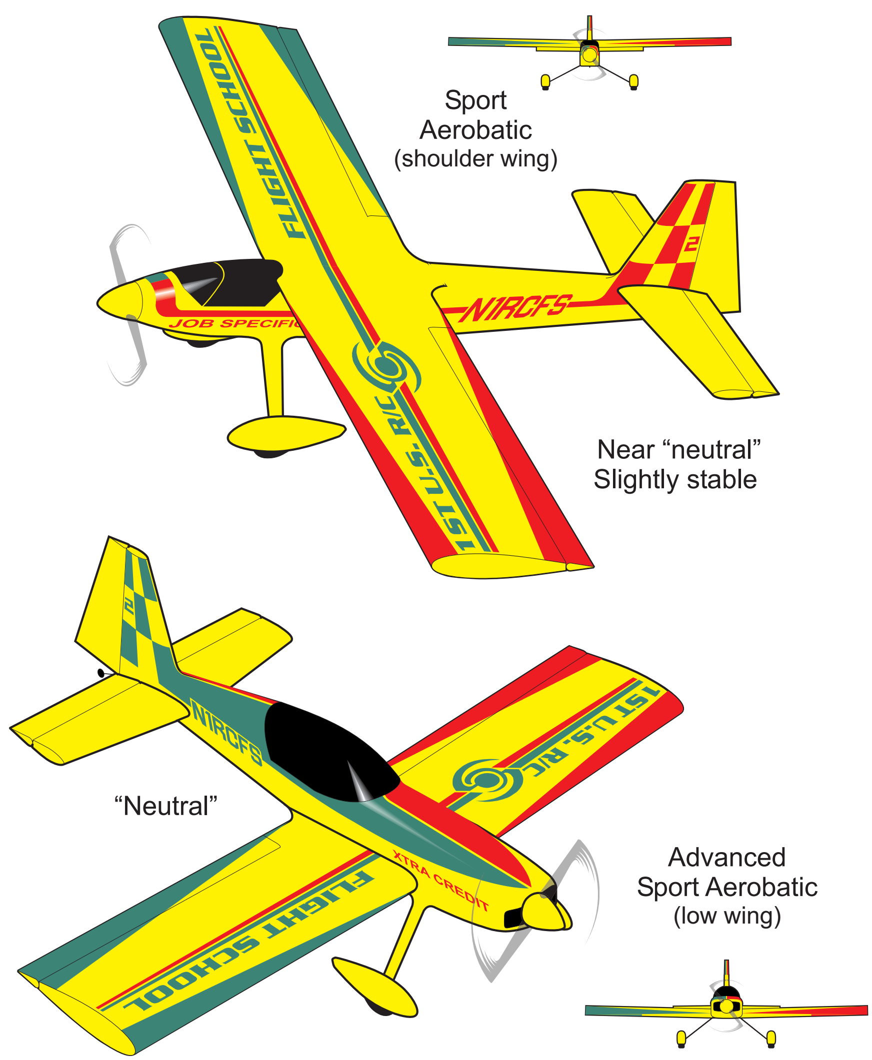
Nearly all airplanes with symmetrical wings, minimal dihedral, and ample power are well suited to flying aerobatics. Assuming that they are trimmed and balanced properly, symmetrical wing airplanes are mostly "neutral", meaning, they maneuver nearly as well upside-down as they do upright and are inclined to stay in whatever attitude the pilot puts them in "like they're on rails!" A symmetrical wing typically necessitates higher speeds to maintain level flight, so when this type is slowed down to set up a landing, the sink rate tends to be steeper than that of a primary trainer. Most importantly, a good "sport" or basic aerobatic airplane features the constant-chord wing that enables it to be slowed down or stalled without spinning out of control (figure 3).

A. The shoulder-wing variant will still exhibit a slight amount of positive (upright) stability due to the wing positioned slightly above the C.G., and thus is a little easier to fly normally. However, the very existence of positive stability requires a slightly more vigorous technique to maneuver it aerobatically, but consequently it won't exaggerate over-controlling either. As such, a shoulder-wing sport airplane is ideal for pilots ready to move beyond a basic trainer and learn basic looping and rolling maneuvers without the airplane causing any nasty surprises.

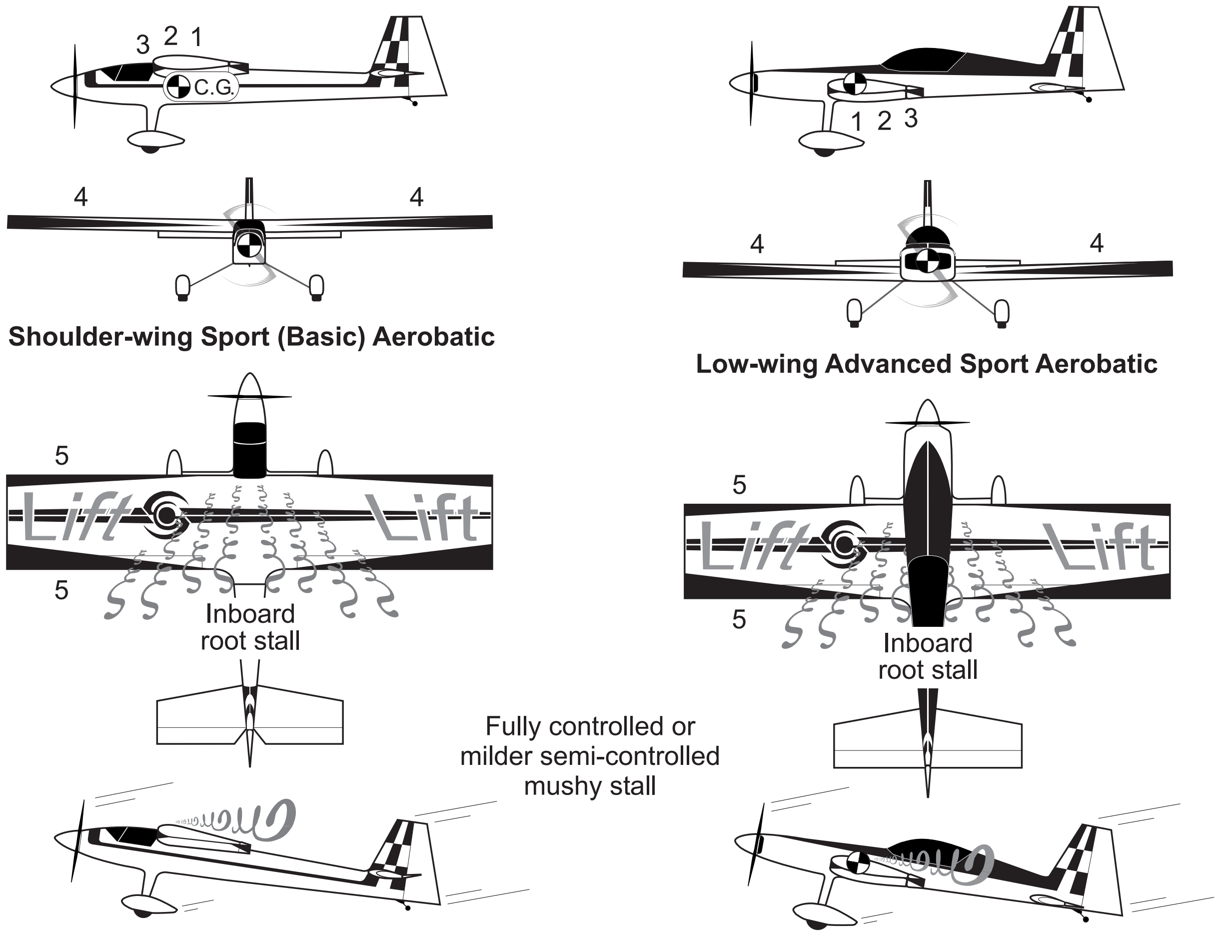
B. The slightly more advanced mid or low wing variant is more neutral due to the wing position closer to the C.G.. Consequently, this type is more maneuverable and inclined to do precisely what the pilot tells it to do. Pilots must therefore control all aspects of flight with greater finesse since it will obey improper commands just as easily as correct inputs. In other words, it's not harder to fly, but there's less margin for error compared to a high wing airplane. Hence, a mid or low wing sport (constant-chord) aerobatic airplane is ideal for pilots who are becoming proficient at basic aerobatics and are looking to fly with greater precision, but still want to keep the milder stall characteristic during landings.

Sport Aerobatic Aircraft Design Features

Once again, the primary design features that determine this airplane's performance are the shape of the wing and its location on the fuselage (figure 4):



A good sport airplane will feature a thick constant-chord symmetrical wing to make it well suited for looping and rolling maneuvers and prone to staying in whatever attitude you place it, yet also capable of flying/landing slower without exhibiting nasty tendencies (assuming it's not tail heavy).



A shoulder wing sport plane is easier to fly, but harder to fly precisely. The slightly more advanced mid or low wing sport plane is a bit more precise, yet requires more attention.

1. A semi or fully-symmetrical wing enhances penetration, furnishes the "neutral" characteristics that cause the airplane to "fly like it's on rails", and enables it to maneuver well in all attitudes.

2. A thicker symmetrical airfoil expands the flight envelope by providing lots of lift at slower speeds (high angles of attack), yet when the power and speed are increased the capabilities of a plane sporting a thicker symmetrical airfoil increase considerably.

3.A. A shoulder wing position slightly above an airplane's C.G. causes the plane to remain slightly stable and thus more forgiving when flown upright, at slow speeds, and during inside (pulling) maneuvers. 3.B. A mid or low wing position closer to the plane's C.G. causes the plane to be more neutral and thus more inclined to doing precisely what the pilot tells it to do and perform a wider variety of more precise maneuvers in capable hands.

4. Little or no dihedral also contributes to neutral stability by keeping the overall wing closer to the C.G..

5. A constant-chord wing is the critical feature that enables these airplanes, while highly aerobatic, to still exhibit forgiving stall characteristics when over-controlled or flown too slowly.

Summary: Thanks to the wide flight envelope permitted by the thick constant-chord symmetrical wing and lower overall wing placement, a good sport airplane is effectively several planes in one -- offering several levels of crawl-walk-run performance depending on the speed their flown and the amount of control surface travel one chooses to set them up with.

Note: A constant chord wing's aversion to tip stalling tends to produce less than dramatic snap roll performance. Thus, when a pilot is ready to start performing snap rolls and spins, a tapered wing airplane with its inherent tip-stall characteristic is more suitable (figure 5).

Advanced Aerobatic Aircraft Considerations

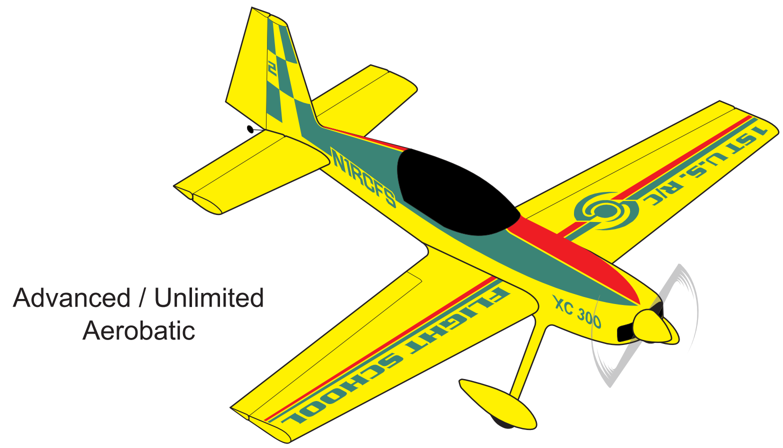
Once a person graduates to a fully-symmetrical tapered wing model like an Extra, Edge, MX, Sukhoi, Yak, etc., there are virtually no limits to what you can do. They are all equally capable and any differences that are not setup related are usually so small that they are undetectable to all but the most expert flyers. All that remains is how far do you want to take it and will yours be set up to promote rapid advancement.

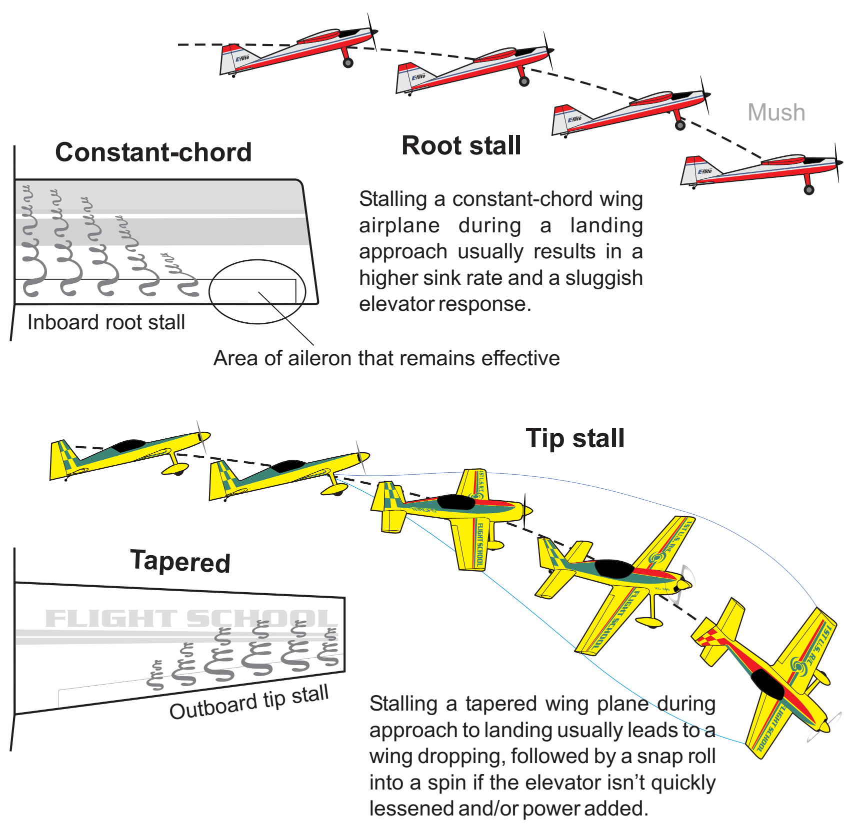
When stalled, a tapered wing loses lift more out toward the tips (figure 6). When a large amount of elevator is intentionally applied and a yaw force is also introduced, the “tip stall” can be exploited to produce excellent snap roll and spin performance. Of course, this also makes the plane less forgiving if accidently over-controlled or flown too slow on approach to landing. Thus, as the more forgiving qualities of constant-chord airplanes are forfeited for the higher performance of a tapered-wing plane, the pilot’s ability to land this type must also be considered.

Note that when a tapered wing stalls, both wings seldom stall exactly the same and thus one wing will typically drop ahead of the other -- followed by a snap roll or spin if the elevator isn’t quickly reduced and/or power added to increase airspeed. So, while this type doesn’t require any special skills to fly, continued success often comes down to the pilot’s ability to quickly recognize the signs of an impending stall so that corrective action can be taken before control is lost.

Pilots transitioning into tapered wing planes therefore need to recognize that inadvertent tip stalls are often preceded by pulling increasing amounts of elevator in an attempt to keep a steep or slow turn level, or stretch an approach to landing. So, if you ever find yourself steadily increasing the elevator on final approach, or in a turn, with little apparent effect, and are urged to pull more, don’t! You are on the verge of stalling and need to reduce elevator and/or add power to keep from losing control and spinning into the ground.

The exception to the tip stall behavior described here is when a tapered wing airplane is extremely light. As a rule, the heavier a plane is in proportion to its size, the more important its aerodynamics are. And the lighter a plane is, the less critical its aerodynamics are. Thus, some exceptionally light tapered wing airplanes have such mild stall characteristics that they exhibit almost no tendency to tip stall. Experience will tell.





A *constant-chord* wing inherently stalls at the wing root first, while the tips continue to provide lift. While more forgiving, this wing’s aversion to tip stalling tends to produce less than dramatic snap roll results.

The primary feature of an advanced aerobatic airplane is the fully-symmetrical tapered wing for its inherent “tip stall” characteristic that can be exploited to produce excellent snap roll performance.

Note: Space does not permit addressing the variations of 3D airplanes, biplanes, and swept wing airplanes. Let it just be said that most symmetrical wing aerobatic biplanes effectively offer “neutral” mid-wing type handling and most swept wings behave like a tapered wing when stalled. Also note that “flat-plate” airfoil foamy’s tend to be highly unstable and difficult to trim, and therefore would not be a good choice for a low-time pilot. However, their instability often makes them excellent 3D (stunt) performers in the hands of skilled pilots.

Final summary: A flat-bottom wing airplane allows a pilot more time to think, but has limited capabilities. Symmetrical wing airplanes offer greater speed, performance, and are less affected by wind, but usually require higher landing speeds. Symmetrical wing planes do whatever they are told, so they need to be controlled correctly or they will expose any poor fundamentals that a flyer could otherwise get away with flying a basic trainer. Thus, those who cannot yet comfortably land a basic trainer would find the transition to a faster symmetrical wing plane very difficult and mixed with surprises (usually blamed on radio problems and wind). On the other hand, if a pilot can comfortably landing a trainer, thus proving good fundamentals, he'll enjoy stepping up to the "flying on rails" feel and increased capabilities of a symmetrical wing sport airplane. Then when he is able to comfortably grease every landing with that airplane, once again proving good technique, transitioning to a tapered wing airplane will be a successful and enjoyable experience! Good luck.

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