10

Advanced spins

We addressed basic upright spins in detail in our first aerobatic book, *Basic Aerobatics*. We dealt with flying spins for spin training, performing upright spins in competition, and handling inadvertent spins that might surprise you during the course of maneuvering. We devoted a lot of space to emergency spin-recovery techniques, chief among them the Beggs/Müller emergency spin recovery. While we present a brief summary of the basic upright spin here, it would be most useful if you also took a moment to review the spin chapter in *Basic Aerobatics* before tackling advanced spins.

Also bear in mind that different aircraft might recover differently from various spins. Always follow and become highly proficient in the manufacturer's spin recovery procedures presented in the aircraft operating manual before trying other techniques, such as the Beggs/Müller emergency recovery technique. If your aircraft operating manual leaves you in any doubt about recovery from any form of spin, consult the manufacturer.

Spins are as an important part of advanced aerobatics as they are of basic aerobatics, often seen in competition flying. The aspiring advanced aerobatic pilot must become proficient in several advanced forms of spinning. The most common advanced spin is the inverted spin. Inverted spins are a staple of all advanced aerobatic competition events. There are also the accelerated spin and the flat spin, in both upright and inverted modes. These spins are seen only in the four-minute freestyle, because they are impossible to precisely stop on heading consistently, which makes them unsuitable for conventional competition. In addition to intentionally flying all these spins with confidence, the novice must also learn to recognize them and recover from them if they are entered inadvertently.

Before we proceed to advanced spins, let's briefly review the basic upright spin. The spin is an autorotational maneuver. To induce the spin, you must first slow down the aircraft by bringing the throttle to idle. Then you pitch up the aircraft to exceed the critical angle of attack. As the stick approaches full aft, you simultaneously yaw with rudder in the desired direction of rotation.

The yaw causes the inner wing to slow down even more and the outer wing to accelerate. The lift generated by the slowing inner wing diminishes in relation to

AOA; nevertheless, they continue to generate some lift, but not enough to co
tinue "flying.") The inside wing drops as the aircraft rolls along the longitudi
axis (Fig. 10-1). The inside wing's AOA increases further while the outside win
AOA decreases because of the shift in relative wind induced by the roll. The insi
wing generates more drag, which is added to the drag caused by the rudder-
duced yaw. The asymmetric drag causes the aircraft to rotate around its verti
axis. The autorotation along the two axes continues as long as the control inp
are maintained. At this point the controls are full aft stick, full rudder in the dir
tion of yaw. The throttle is at idle. The aircraft is in a spin. The aircraft's simul
neous movement around the longitudinal and vertical axis yields a resultant a
that is known as the spin axis (Fig. 10-2).

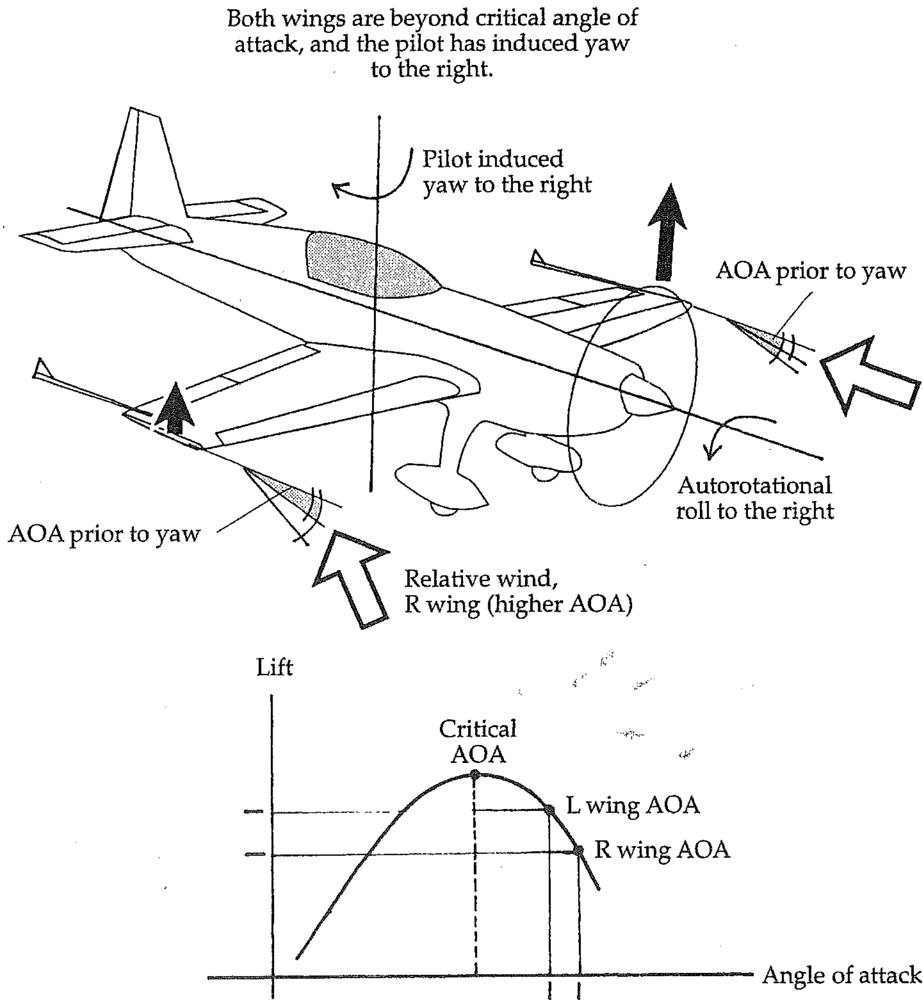


Fig. 10-1. Wing drop and the commencement of autorotational roll.

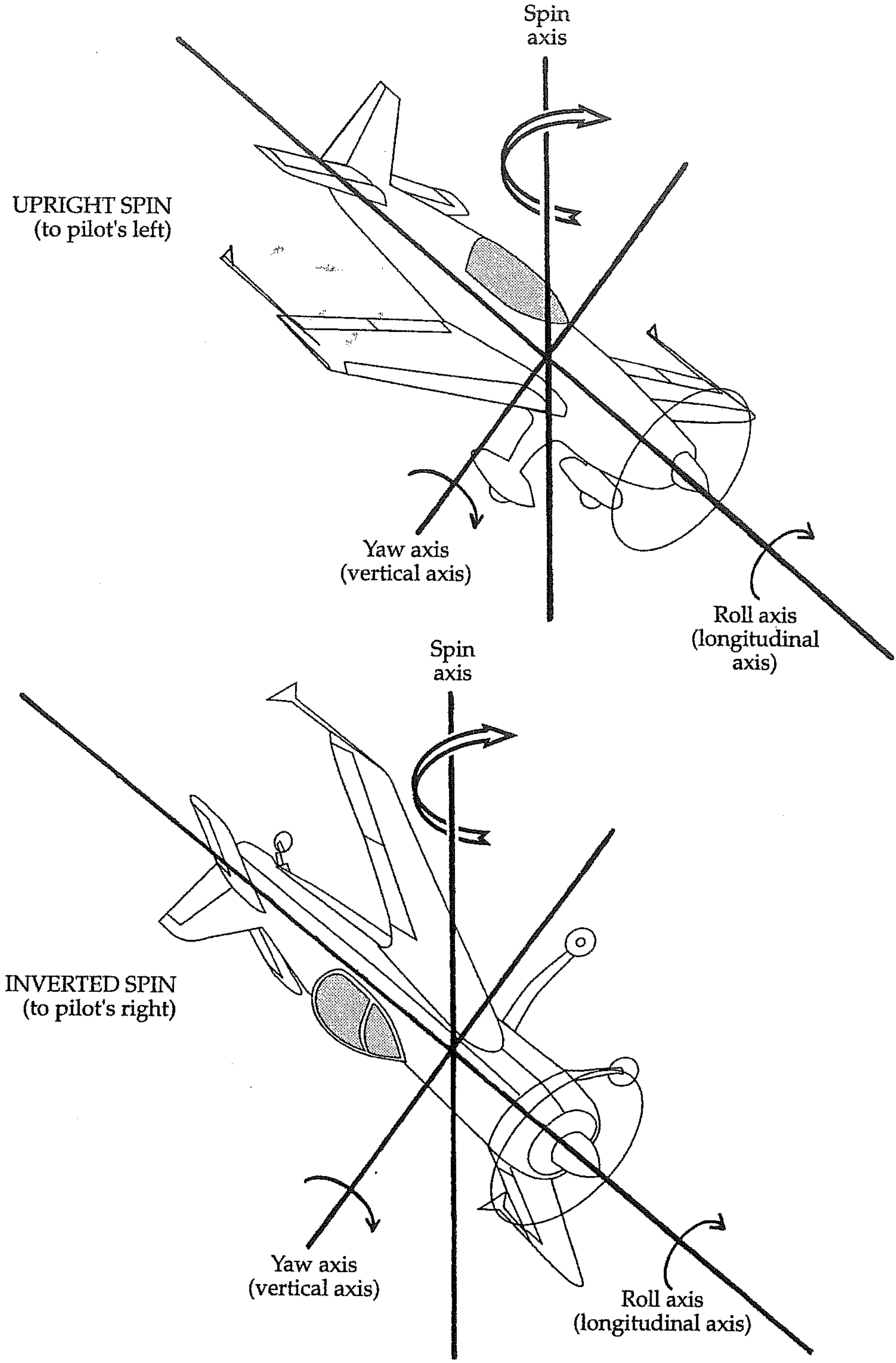

Spin
axis
UPRIGHT SPIN
(to pilot's left)
Yaw axis
(vertical axis)
Roll axis
(longitudinal
axis)
Spin
axis
INVERTED SPIN
(to pilot's right)
Yaw axis
(vertical axis)
Roll axis
(longitudinal axis)

Fig. 18.2 The

To recover from the spin, you must stop the yaw (to equalize drag on the wings and stop rotation), and you must break critical AOA. Here is the reco sequence (confirm that the power is at idle):

1. Apply full rudder opposite the yaw and wait for the rotation to stop.
2. When the rotation stops (and only then), apply forward stick (down elevator, forward of neutral) to break critical AOA.
3. At this point, the aircraft will be flying again in a dive, accelerating rap Pull out of the dive, but be careful not to pull so hard as to induce an accelerated stall and possibly an inadvertent secondary spin.

Before we move on to advanced spins, let's discuss two important poi more detail than we did in *Basic Aerobatics.*

Why is it important to keep aft stick (up elevator) in the spin until the rotation s

It is most important in aircraft with the conventional horizontal/vertica bilizer layout that is found on most aerobatic aircraft (as opposed to T-tail lay for one simple reason (Figs. 10-3 and 10-4). To stop the yaw most effectively need maximum available rudder. If the stick is pushed forward, applying dov evator, the effective rudder surface exposed to the relative wind in the spin duced. Therefore, if down elevator is applied before the yaw stops, less eff rudder surface is available to stop the yaw. It will at best delay stopping the and at worst make it impossible.

Note that aircraft with low-mounted stabilators can be notoriously diffic recover from a spin because aft stabilator almost completely blankets the part of the rudder.

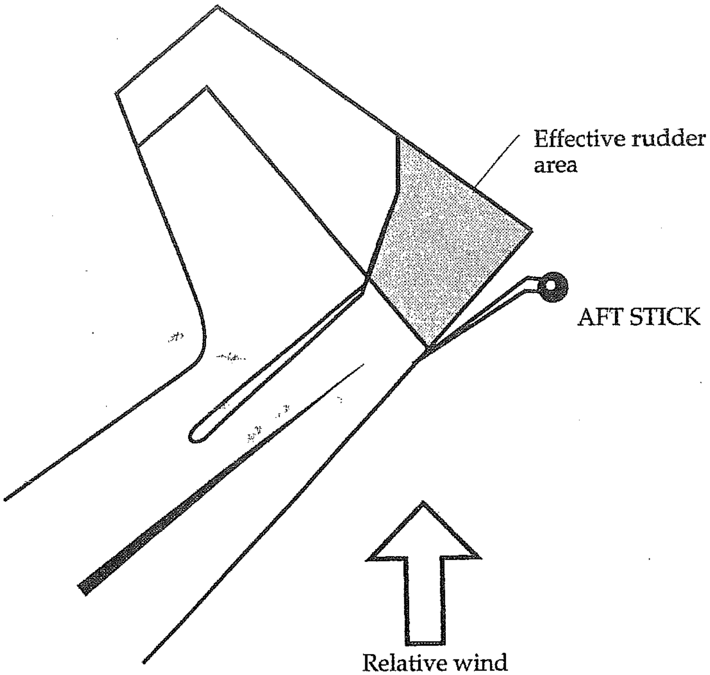
What really happens aerodynamically when forward stick (down elevator) is app break critical AOA in a developed spin?

When down elevator is applied, it is pushed down against the re wind. The relative wind pushes back up against it, reestablishing a new librium. In the process the nose is swung downward, and critical AOA is ken (Fig. 10-5).

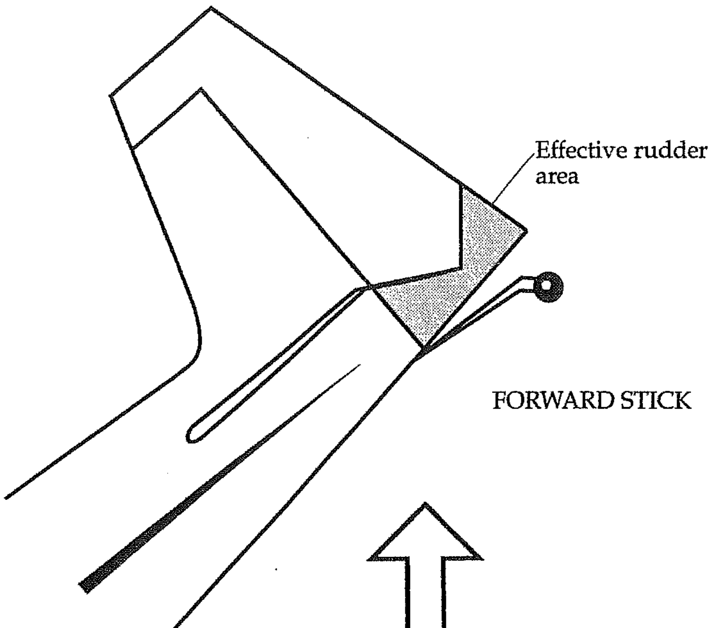
INVERTED SPINS

The aerodynamic forces acting on an aircraft in an inverted spin are exact same as they are in an upright spin. The only difference is that the aircraft verted, requiring different control inputs to induce the spin. A simpler exam the same principle is inverted straight-and-level flight. Thrust and drag, lif gravity are exactly the same as in upright flight, except they now act on t verted airframe.

The inverted spin is not more difficult to fly than the upright spin, but th ferent perspective requires some getting used to by the aspiring advanced batic pilot. Let's see how it is flown.



Effective rudder area
AFT STICK
Relative wind



Effective rudder area
FORWARD STICK

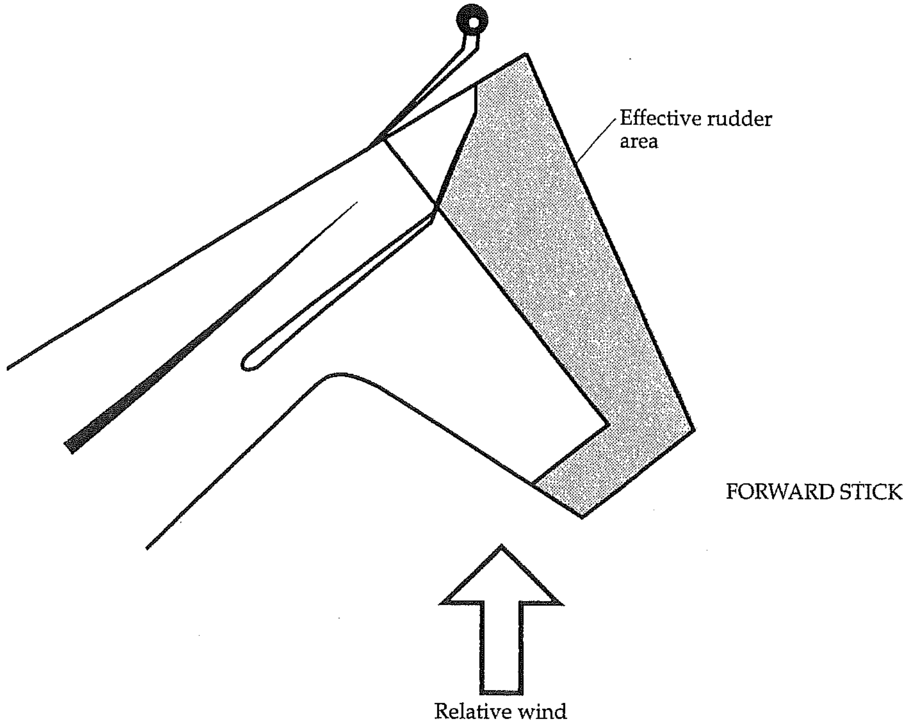
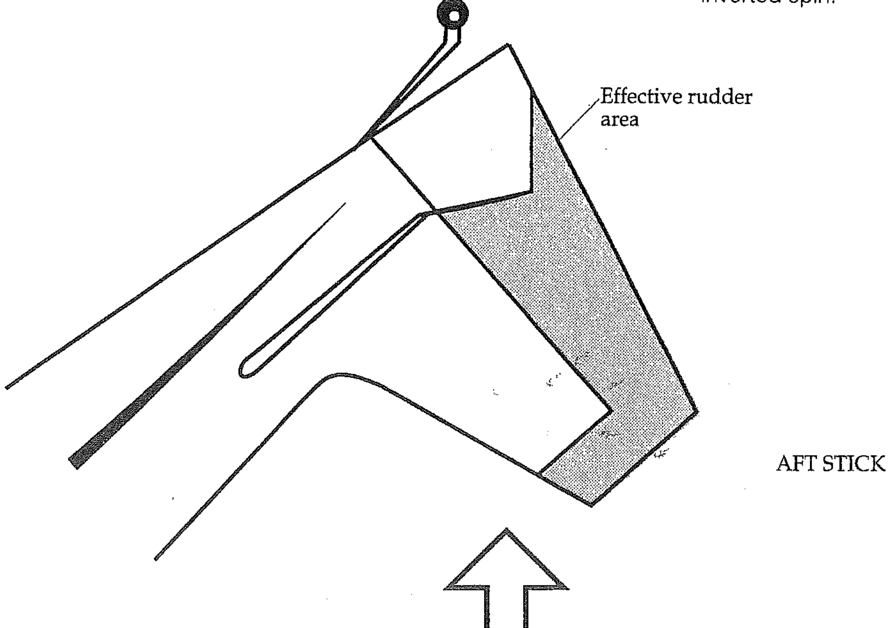
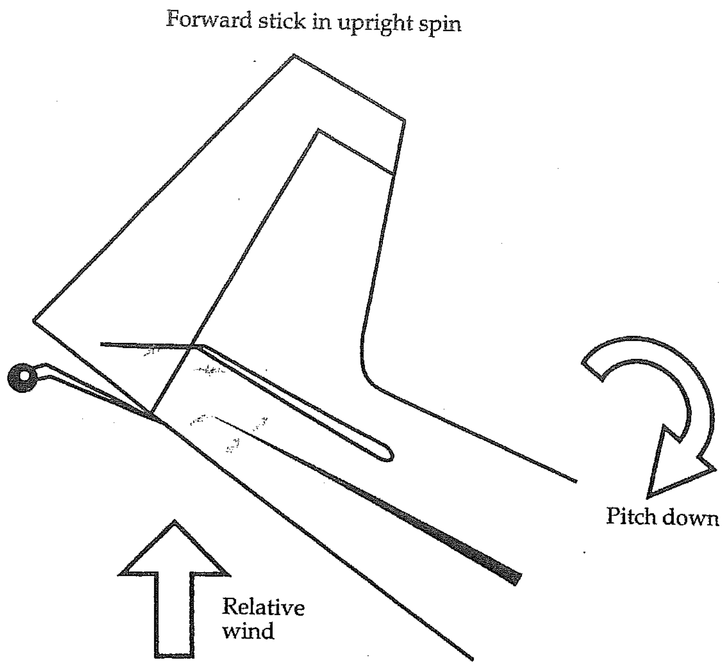


Fig. 10-4. Why the r
effective with forwa
inverted spin.





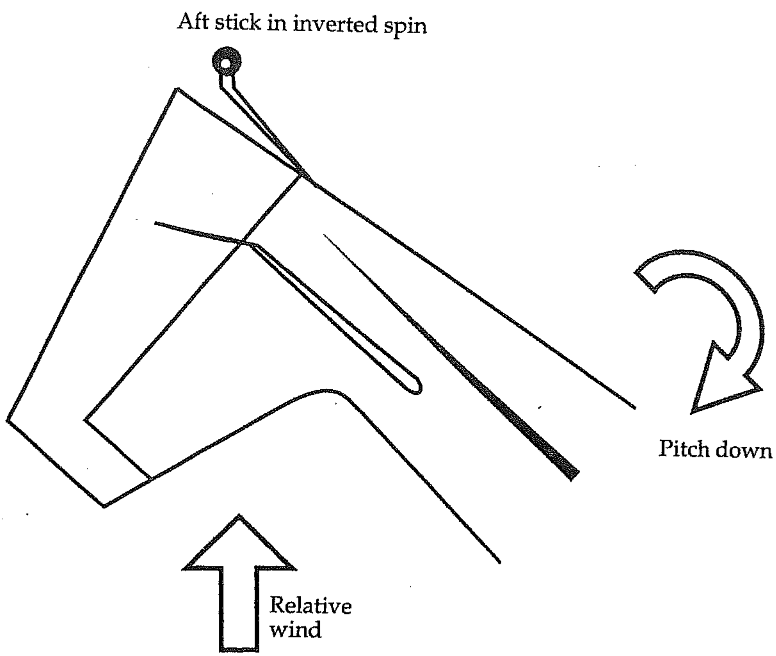


Fig. 10-5. The relative wind striking the changed elevator causes the nose to

Flying it

The inverted spin is best set up from a preceding maneuver that leaves the air at a slow airspeed, such as a layout off of a vertical line or from a half loop t verted. The 1½-turn inverted spin is also the most common inverted spin flow competition.

1. Establish straight-and-level inverted flight at the top of a vertical maneuver, after a half loop, directly over a good reference line such as straight highway. While not difficult to fly, the inverted spin can be qui disorienting to the novice, so a solid, clearly identifiable reference line i very important to aid recovery. Retard the throttle to idle. Look over th nose (continue looking over the nose throughout the maneuver).
2. Ease the nose up with down elevator (forward stick). Continue to add forward stick until you feel a buffet as the aircraft approaches the critic angle of attack. Maintain altitude by reference to the altimeter. It is easi than trying to do it by reference to the horizon as the nose pitches up. is a rare occasion in aerobatics when you fly by reference to the altimet instead of just casting an occasional glance at it. Now the aircraft is rea to spin. Note that the stick is not yet fully forward.
3. As the aircraft begins to buffet just prior to the stall, add full rudder in desired direction of rotation. As the inside wing drops, apply full forw stick (down elevator) to keep the aircraft stalled and have maximum rudder authority.
   As autorotation sets in, the aircraft will stabilize in a fully developed inverted spin.

To recover, you have to accomplish exactly the same things as you do i upright spin:

- You must stop the yaw to equalize drag on both wings.
- You must break critical AOA.

These tasks are accomplished as follows:

1. Apply full opposite rudder to stop the yaw.
2. As the rotation slows significantly, smoothly apply aft stick (up elevat break the critical AOA.
3. As the rotation stops, neutralize all controls. The aircraft will now be f again and will be more or less vertical.
4. Establish a precise vertical down line and pull or push out of the maneuver.

In most advanced aerobatic aircraft, it will take anywhere from ¼ to ½ tu recover from the inverted spin.

The finer points

One of the first things you'll notice about inverted spins is that the rotation is more rapid than in upright spins. This is because there is more effective rudder surface available to maintain autorotation (see Fig. 10-4). For the same reason, recovery from an inverted spin is also more rapid than from an upright spin.

As you discuss inverted spins with your peers, you might get into heated discussions about whether or not yaw and rotation are opposite each other in an inverted spin. The reason for contrary opinions is one of perspective. A critiquer who is rightside up on the ground observing the aircraft in an inverted spin will say the aircraft is spinning to the left (the critiquer's left). Yet this so-called spin to the "left" was induced by the pilot (who, along with the aircraft, is inverted) with right rudder. So was the aircraft yawed to its "right" to rotate to the critiquer's "left"? The critiquer might see it that way, but as the pilot, you must look at the world from the pilot's perspective. So just remember this:

- If you apply left rudder, the aircraft will always rotate to your left. From your perspective, you are in a left spin, although the critiquer, from his or her perspective on the ground, might call it a spin to the right.
- If you apply right rudder, the aircraft will always rotate to your right. From your perspective, you are in a right spin, although the critiquer on the ground might call it a spin to the left.

Note that this interpretation differs from what we said in *Basic Aerobatics*, where we defined left and right from the critiquer's perspective. We have since come to believe that the best way to clear up this confusing matter is to always talk from the pilot's perspective. If you get into a heated discussion about this topic, the first question to ask to sort it out quickly is "whose perspective?"

ACCELERATED AND FLAT SPINS

You can perform accelerated spins as well as flat spins independently of each other, but as you will see, there is a natural progression from the plain spin to the accelerated spin to the flat spin. We therefore believe that in learning to perform accelerated and flat spins it is most effective to first learn how to accelerate a spin and then learn how to make that accelerated spin go flat.

Due to gyroscopic precession caused by the propeller's rotation, spins can be made to go flat only opposite the direction of the propeller's rotation, and they will also accelerate more effectively in that direction (they can, however, be accelerated in either direction). Therefore, we'll assume that you are flying an aircraft with a right-turning propeller (the majority of modern aerobatic aircraft) and will discuss accelerated and flat spins accordingly:

- Upright accelerated and flat spins to the pilot's left
- Inverted accelerated and flat spins to the pilot's right

If you fly a Sukhoi, Yak, or any other aircraft with a left-turning propeller, need to substitute left for right and vice versa for control inputs throughout discussion.

Upright accelerated and flat spins

In an accelerated spin, the aircraft usually has its wings almost level, its rate o tation is much higher than in a normal spin, and its nose is slightly further up ward the horizon than in a normal spin. In a flat spin, the nose is pitched up e further, to an attitude practically level with the horizon.

As we discussed earlier, pilot-induced pitch, roll, and yaw are all essen tools for making an aircraft spin. We use the controls and power (which inclu gyroscopic effect) to change the magnitude of pitch, roll, and yaw developed in basic spin to turn it into accelerated and flat spins.

In a developed spin, the rate of autorotation is stabilized. The "spin" and ' tispin" forces are in equilibrium. Increasing the "spin" forces in a basic spin to celerate autorotation is the objective of the accelerated spin. Rotation stabilize a higher rate when the "spin" force and the "antispin" force reach a new stat equilibrium.

The unequal lift components of the inside and outside wings in the basic s add the roll component to the spin, which is stabilized at a certain roll rate. We induce a change in this state of equilibrium by applying out-spin (right) aile Out-spin aileron reduces the difference between the lift component on the wings by reducing the difference in AOA (which remains above critical for b wings; consider the relative wind), and reduces the roll component. However, down left aileron causes greater drag than the up right aileron. This imbalance celerates autorotation.

Autorotation is now hindered by the drag caused by the lower surface of rudder (the section below the elevator) exposed to the relative wind, which is r from below as the spin has become stable. Down elevator (forward stick) gre reduces the rudder surface below the elevator, significantly reducing the rudd drag. Exposed to greatly diminished "anti-spin" forces, the autorotation acce ates further. The aircraft is in an accelerated spin.

As the autorotation accelerates, the nose pitches up slightly, due to the creased centrifugal force. Advanced aerobatic instructor Randy Gagne has a g method of demonstrating this effect. Tie a tennis ball to a long string at the en a stick. Hold the stick vertical and slowly rotate the tennis ball. It will find a l of equilibrium as it rotates at a low constant speed. Now increase the speed o tation. What happens to the tennis ball? It rises. This is exactly what happens to aircraft's pitch attitude as the spin accelerates.

To turn the accelerated spin into a flat spin, the objective is to raise the r even further. To do so, simply apply full power. The propeller's gyroscopic cession brings the nose further up.

The nose of a short-coupled airplane, such as the Pitts, will not pitch up as high as the nose of a long-coupled airplane, such as the Extra 300S, as should be obvious to anyone who understands weight-and-balance calculations. But enough of all this discourse. Let's go flying!

Flying them

1. To fly an upright accelerated spin, first put the aircraft into a fully developed basic upright spin to the left. Look over the nose and continue doing so during the entire maneuver. If you try to look at the blur of the horizon for a landmark, you'll just feel ill. When the spin is fully developed, you are ready to accelerate it.
   Apply full out-spin (right) aileron. Doing so has two important consequences:
   - Roll is significantly reduced because the lift component on the two wings is almost equalized.
   - As roll is reduced, yaw is simultaneously increased due to the greater drag of the left (down) aileron. The spin begins to accelerate as the autorotation forces become stronger, and the wings will become almost level.

2. Smoothly apply forward stick (down elevator). The reduction in the rudder surface below the elevator exposed to the relative wind diminishes rudder drag, further accelerating the spin.
   The nose also comes up due to the increased centrifugal force (the "tennis ball on a stick" effect). Applying forward stick and seeing the nose come up might feel disconcerting at first, but that's the fun of advanced aerobatics. Straight-and-level "rules" don't always apply.
   When the rotation stabilizes at a higher rate, you are in a fully developed accelerated spin.

If you are flying a Pitts, you should try something that might surprise you. (Don't you love surprises in the middle of an accelerated spin?) Apply full right rudder. NOTHING HAPPENS! There is so much rudder area in the dead air above the elevator that the rudder is now completely ineffective. (If you try it in a monoplane, the rudder retains some effect.)

Now let's turn the accelerated spin into a flat spin. It's easy.

3. Simply apply full power and watch the nose come up almost level with the horizon (more in a long-coupled aircraft than in one that is short-coupled). Note that the rotation rate is not affected because the propeller's gyroscopic precession acts parallel to the vertical axis.

You can also do a flat spin without first doing an accelerated spin by not applying forward stick. Let the basic spin develop, and apply out-spin (right) aileron and full power. The spin goes smartly flat, but the rotation rate is slower th the accelerated flat spin, and the nose does not come up as high.

Let's return to the accelerated flat spin and see how to recover from it. you are used to the very high rates of rotation, it is rather easy. The techniq based on the Beggs/Müller emergency recovery technique:

1. Reduce power to idle. If you didn't add power to the accelerated spin make it go flat, the power should already be at idle.
2. Let go of the stick. COMPLETELY! This is extremely important! The st will come aft and centered as the relative wind pushes the elevator up the differential drag caused by aileron input is equalized. The rudder resume its role as the primary source of yaw and the aircraft will retur into a conventional basic spin.
3. Apply opposite rudder, and when the rotation stops, apply forward st to break the critical AOA and pull out of the dive.

Inverted accelerated and flat spins

What happens to the aircraft in inverted accelerated and flat spins is no diff from what happens to it in the upright version of these maneuvers. Howeve cause the aircraft is inverted, different control inputs are required to achieve the effect. Keeping in mind the differences in control inputs between convention verted and upright spins, read the section below. You should find it quite easy t low. We first accelerate the conventional inverted spin, and then we make it go

Flying them

1. Start by placing the aircraft into a conventional inverted spin to your r (right rudder).
2. As the inverted spin is developing, you are ready to accelerate it. Appl spin (right) aileron to reduce the difference in the lift component betw the wings and greatly reduce the roll. Asymmetric drag caused by the aileron deflection (right aileron down, left aileron up) causes the autorotation to continue. The rotation will begin to accelerate.
3. Now, to minimize the drag caused by the rudder, you need to reduce t rudder area under the top surface of the elevator (remember, you are inverted) exposed to the relative wind. Accomplish this by smoothly moving the stick aft (up elevator). The spin accelerates further. The nos pitches up slightly because of increased centrifugal force (the "tennis b effect" again). When the rotation stabilizes at a faster rate, you are in a fully developed accelerated spin.
4. To make the accelerated spin go flat, add full power. The nose rises approximately to the horizon, depending on type of aircraft.

If you want to go into an unaccelerated inverted flat spin, skip the aft stick input. From a conventional inverted flat spin, apply in-spin (right) aileron and full power. The nose won't pitch up as much, and the rotation will be slightly slower.

Recovery is similar to the upright inverted flat spin, accomplished by the Beggs/Müller emergency recovery technique:

1. Reduce power to idle. If you are only in an accelerated but not a flat spin, the power should already be at idle.
2. Let go of the stick COMPLETELY. As in the upright version of the maneuver, this is very important. The stick will center itself and move forward, the nose will drop, and the aircraft will reestablish itself in a conventional inverted spin. Rudder will again be the primary source of yaw.
3. When the nose has dropped, apply full opposite (left) rudder. When the rotation stops, apply aft elevator to break the critical AOA and pull out of the dive.

Advanced spinning is very challenging, but if you plan to do advanced aerobatics, particularly advanced outside maneuvers and gyroscopic maneuvers, it is mandatory from a safety standpoint that you become fully proficient in all kinds of advanced spins, inadvertent or intentional. It is guaranteed that as you learn and practice advanced maneuvers, you'll repeatedly find yourself in inadvertent advanced spins of all sorts, and when that happens you had better know exactly what to do. Every time.

COMMON ERRORS

The inverted spin is attempted before the pilot is ready

If you fly the inverted spin before you are totally comfortable flying inverted, you'll scare yourself, you'll find it difficult to learn the maneuver, and you'll get depressed by the lack of your progress. As is the case with outside snaps, be as at home inverted as you are upright before tackling inverted spins.

Failure to develop internal timing for performing inverted spins

The inverted spin is more disorienting than the upright spin. You can't see the horizon well and have few if any good reference points. To perform inverted spins to competition standards accurately, you therefore have to develop a good sense of internal timing for when to stop the maneuver.

The accelerated spin is accelerated before it is fully developed

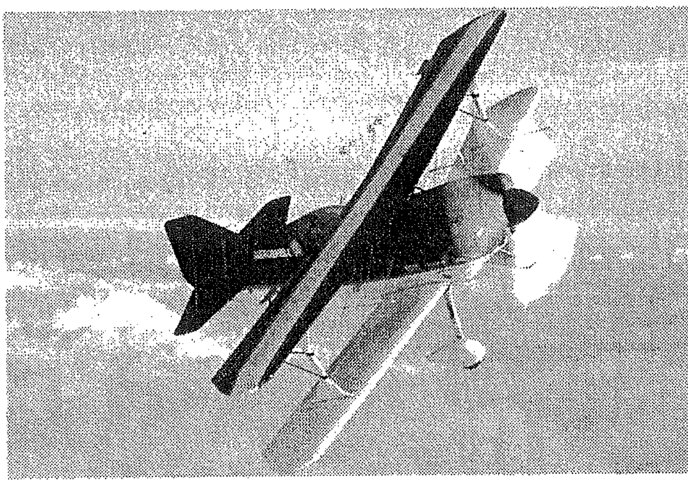
This problem occurs when you try to rush the accelerated spin an ate the spin before it is fully developed. The result of this error is aircraft will recover from the spin instead of transitioning into phase of the spin.

Failure to apply the required amount of control inputs in a flat spin

Failing to apply the required amount of control inputs in a flat spin ous. It is caused by the excessive centrifugal force that presses you You have a tendency to subconsciously apply the controls with the force that you are accustomed to when not subjected to strong centri result is that you might think that you are applying sufficient force control, when in fact you are not, and the control is only partially a

As a result of this phenomenon, you might fail to retard the po and might not apply full opposite rudder on recovery, even thou vinced that you are doing everything right. You need to consciousl throttle is full aft and the rudder is applied to the stop. If you do might not recover, and you might end up jumping out of a perfectl which is embarrassing, to say the least.

In some aircraft, depending on cockpit layout and the length might end up not having enough leverage to apply full rudder trifugal force. To prevent this situation from occurring, always ma takeoff, when you are strapped in, that your leg presses down on t neutral position at a 30° angle relative to the airplane's longitudin gle ensures that you have enough leverage.



Bob Meyer in the family Phoenix biplane.