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We're halfway through the list of maneuvers required for the Primary Smooth Achievement Award. We'll continue to work on precision and discipline here, as well as the concept of not automatically correcting errors made during the various maneuvers. With aerobatic turns and one-turn spins comfortably under our belt ("Primary Smooth Award: Turn & Spin," in the April issue), let's now add in the full loop and the slow roll.

THE FULL LOOP

Although the overall size of the loop is immaterial, the rules require not only a round shape, but also a smooth and continuous arc. We need to compensate for the effects of head wind and tail wind components to accomplish this. Furthermore, the loop must begin and end in level flight and at the same altitude, and the wings must remain level throughout. The loop cannot have any visible crab angle, either.

We detailed the elements of the loop in the August 2007 issue ("Flying the Classic Loop"). If you've been practicing loops accordingly, you're already well on your way to earning a qualifying score. Even so, let's review the key points.

Power Management

This is easy for those who fly airplanes with constant-speed propellers: set the rpm and manifold pressure, and then leave the power controls alone! In most cases, something like 24- or 25-squared should do.

Those of you flying airplanes with fixed-pitch propellers, on the other hand, will have to coordinate throttle changes with your loop inputs. In essence, your throttle hand becomes the constant-speed prop controller. With the airplane stabilized in level flight at 2500 rpm, it should be apparent that when the nose of the airplane points skyward upon entering the loop, it's appropriate to increase power. When the nose points earthward later in the loop, it's necessary to reduce power.

Entry

Trim the airplane for level flight. Clear the area and choose prominent ground references that will define your heading. Dive for the recommended loop entry speed if necessary (maintain 2500 rpm if you have a fixed-pitch prop!), return to level flight, and pause for a beat.

Now pull straight back on the elevator control. Some airplanes may require a dash of rudder to counteract gyroscopic precession during the pull-up (e.g., a touch of left rudder in a Pitts); others won't need any rudder whatsoever (e.g., an Aerobat). The pull should be smooth but firm, without being abrupt. We need to generate +3.5*g* at the start of the maneuver. Upon hitting the target *g*-load, freeze the stick/yoke where it is. Allow the airplane to carve out the remainder of the front side of the loop on its own. Remember, however, that as speed changes, you will have to vary the force being applied to the stick/yoke to keep it locked in place. If the stick/yoke position drifts from this spot, the shape of the maneuver will visibly change. Remember to sight down the left wing as you pull into the loop as well, and watch the wing pivot continuously around a point on the horizon.

Apex

A loop that feels round actually looks pinched to someone observing from the ground. Consequently, we must stretch out the top portion of the loop to achieve the required roundness. When the chord line of the left wing appears to be 20 degrees or so from level inverted flight, it's time to push across the top of the maneuver. Look back over the nose and steadily slide the stick/yoke forward far enough to feel light in your seat. The objective is to retard the pitch rate without causing it to stop altogether. You'll need to stretch out this part of the maneuver a bit more when encountering a head wind across the top, less so with a tail wind. Continue feeding in forward elevator until you reach the high point of the maneuver, then slowly back away from the push. You may sometimes need a small amount of rudder to cancel slow-flight engine effects as you traverse the apex, thus preserving your heading (e.g., perhaps a pinch of right rudder in a Decathlon).

Exit

We're backing away from the forward elevator, allowing gravity to pitch the nose earthward. As soon as the nose touches the horizon, however, it's time to bend the flight path back around to level flight. Don't pull too tightly too suddenly here. Slide the stick/yoke aft until you reach the same spot held during the front side of the loop. Apply whatever force is necessary now to hold the stick/yoke stationary until the nose swings up to the level flight attitude. The very last part of the loop typically requires some rudder to stay on heading (e.g., a smidge of left rudder in a Zlin 242L). Instantly unload the aft elevator and fly away in level flight.

Common problems to be aware of: crooked pulls and pushes on the stick/yoke; insufficient *g* at the outset; transitioning to forward elevator too soon across the apex; fiddling with ailerons; pulling too tightly during the exit (judge's parlance: "out high, e-shaped"); and insufficient rudder to maintain heading during the exit.

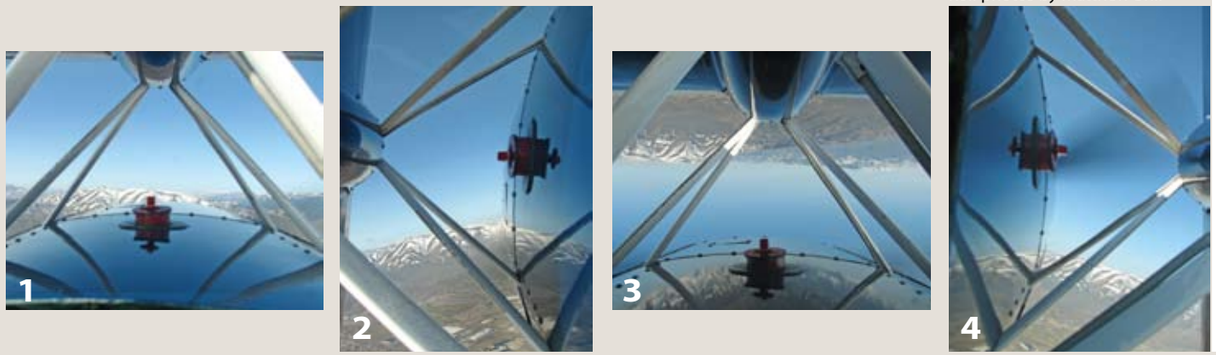
THE SLOW ROLL

Our slow roll must begin and end in level flight, and pitching the nose up first is not permitted. The rules also require a constant heading and constant altitude. And the bank must change exactly 360 degrees without any hesitations or variations in roll rate. The maneuver should end by crisply stopping the roll rate.

Many of the elements described in "Mastering the Aileron Roll" (June 2007) apply to the slow roll. What really distinguishes the two maneuvers from each other, though, are the initial inputs: For an aileron roll, we start by pitching the nose well above the horizon with the elevator; for a slow roll, we yaw the nose upward with the rudder as we roll. Ultimately, the nose traces the letter "D" around our reference point during an aileron roll, whereas it should trace a perfect circle during a slow roll.

The classic description of a slow roll advocates applying aileron and same-side rudder before quickly transitioning to opposite rudder (e.g., simultaneous left aileron and left rudder, then right rudder). This sequencing of rudder is necessary in airplanes that have not only sluggish roll rates, but also significant adverse yaw (e.g., Citabria 7ECA or stock J-3 Cub). Without same-side rudder at the outset, the adverse yaw in such airplanes could be sufficient to spoil the roll altogether. It may also be beneficial in such airplanes to sneak in a small amount of aft elevator to help raise the nose as the ailerons are applied. But if you do this, it's important to mask the elevator input by subtly blending it in with the aileron input. Otherwise, a judge might see the nose pitching up and downgrade your score.

Roll photos by Matthew Brill



By contrast, same-side rudder isn't really necessary in airplanes that roll faster with less adverse yaw (e.g., Decathlon, RV-7, or Pitts). We can actually take advantage of adverse yaw in these airplanes to get the nose moving upward right away. To see this, establish level flight and put your feet flat on the floor. Smoothly drive in left aileron, rolling to about 60 degrees of bank. Watch how the nose instantly carves out a counterclockwise arc toward the sky. The faster and fuller you make the aileron input, the more distinct the arc. You're witnessing the beginnings of Eric Müller's sacred circle! This certainly simplifies the start of a slow roll in these particular airplanes. The discussion that follows assumes that we won't need same-side rudder when initiating the maneuver.

Stabilize the airplane in level cruise flight. Clear the area. Select a reference point on the horizon over the nose—this is the center of the sacred circle. We're now going to cause the nose of the airplane to circumnavigate this point during a slow roll to the left (for a slow roll to the right, reverse the aileron and rudder actions described below).

Entry (First Quarter)

Start with a positive and full left aileron input. Give that yoke a healthy twist or drive that stick straight to the side. Don't let anything prevent you from pressing the control against its stop. Adverse yaw instantly sweeps the nose upward and to the right of your reference point.

We must smoothly press in right rudder next (slow roll parlance: "top rudder," meaning *rudder to the sky*). Full deflection of the left aileron occurs rather rapidly; even so, the top rudder input should lag slightly behind the aileron action. And don't overdo the rudder, either. We only want to augment the adverse yaw to keep the nose rising above the horizon.

To Inverted (Second Quarter)

Pushing the elevator control forward once the wings roll past 90 degrees of bank will push the nose up to the top of the sacred circle. Practically speaking, the airplane is usually well on its way to inverted by the time the ailerons reach full deflection. It helps, therefore, to visualize the control movements as though you are shifting a manual transmission into gear: move the shift lever over, then forward. In the airplane, separate the aileron and elevator actions by applying the aileron fully before commencing the push. Be sure to push the stick/yoke forward and toward your left knee, not toward the center of the cockpit (the mechanics of rolling with a yoke are somewhat easier in this regard).

It's also not uncommon for pilots to jab the elevator control forward all at once. The push should be a smooth input. Time this movement to be completed as the wings hit the level inverted attitude. Similar to the aileron roll, start pushing sooner than you think during the slow roll. The difference here, however, is that the stick/yoke must be displaced farther forward. We must transition from +1.0*g* at the start of the slow roll to -1.0*g* by 180 degrees of bank; the airplane will descend otherwise.

From Inverted (Third Quarter)

Once the airplane passes through inverted, it's time to release both the forward elevator and whatever right rudder is still being held from the entry. "Release" is the operative word, especially regarding the forward elevator; physically pulling back will cause the nose to drop rapidly and the heading to change. Just release the push and ease off the right rudder. But keep those ailerons deflected!

Exit (Fourth Quarter)

The last quarter of a slow roll is similar to the entry in that top rudder is required—left rudder now. Smoothly, but continuously, depress the left rudder pedal until either you run out of rudder or you reach wings-level flight. Avoid the temptation to pull the stick/yoke aft when adding the rudder. If the roll rate suddenly dwindles, you're inadvertently releasing the aileron input as you step on the top rudder. On the other hand, if you consistently sense an increase in roll rate when adding the rudder, reduce the amount of aileron a little to keep the roll rate constant.

Dragging the elevator aft during the last half of a slow roll is the dominant error. We must work hard to avoid this tendency. That said, a certain amount of pull *is* required to exit the slow roll in a level flight attitude. The aft elevator, however, should be a relatively minor pitch adjustment; moreover, it should be applied late in the roll, perhaps only in the last 20 to 30 degrees of bank. Pulling any sooner than this will pull the nose off heading (judge's parlance: "dished out"). The instant the wings reach level flight, briskly neutralize the controls.

During the maneuver, you're continuously switching between rudder and elevator inputs to draw the sacred circle, which in turn preserves altitude. Be sure to practice slow rolls in both directions, too. If you encounter any persistent problems, try slowing the roll down a few times. This will require you to exaggerate rudder and elevator actions and will pinpoint where faults are occurring. Breaking the maneuver down into half slow rolls can also help with troubleshooting.

Common problems with the slow roll include a timid aileron input and too much top rudder too soon at the start; pushing the stick/yoke forward too hard and too late; not pushing the elevator control far enough forward; releasing the aileron input when pushing to inverted; pulling the elevator control aft as the airplane rolls past inverted; insufficient top rudder; and pulling the nose off heading near the end of the roll.

As usual, take some dual and always give yourself plenty of altitude. Visualize the steps in each maneuver beforehand. Make notes on a sequence card if necessary. Clear the area and choose your reference points. And concentrate your efforts on the primary control movement needed at each stage of each maneuver: elevator when turning/looping, rudder when spinning, and aileron when banking/rolling.

Practice up—judgment day is next!

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PRIMARY SMOOTH LOOP & SLOW ROLL

PRIMARY SMOOTH LOOP With area clear, reference line chosen, rudder inputs as required for heading, and throttle changes as required:

Entry Elevator—Firmly pull to 3.5g and hold that spot • Look—Sight down the left wing; watch it pivot on the horizon

Apex Look—When 20 degrees from level inverted, sight back over the nose • Elevator—Smoothly push the stick/yoke forward to float across the top, then back away and allow the nose to fall

Exit Elevator—As the nose touches the horizon, smoothly pull the stick/yoke aft to the same spot held during the entry
Stop—Neutralize the elevator in level flight

PRIMARY SMOOTH SLOW ROLL With the area clear and reference point chosen:

Entry Aileron—Positive and full deflection • Rudder—Feed in top rudder

To Inverted Aileron—Maintain deflection • Elevator—Smoothly push forward and feel -1.0g by the top of the sacred circle

From Inverted Aileron—Maintain deflection • Rudder & Elevator—Release these inputs

Exit Rudder—Feed in top rudder • Aileron—Adjust as needed for constant roll rate • Elevator—When practically wings level, subtle pull to the level pitch attitude • Stop—Briskly neutralize the controls