Expanded Envelope Exercises, Almost Aerobatics for Normal Category Aircraft

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INTRODUCTION BY MICHAEL LENTS, *Assistant Professor – Aviation, University of North Dakota, Master CFI – Aerobatic*

Among the pages of Sport Aerobatics *have been tales, teachings, lessons learned, technical reviews, and more for pilots just starting out in the sport to seasoned professionals. There is always something to learn. Maybe for some of us, a single-seat, high-powered monster just doesn't fit the bill when the family wants to fly, too. While brilliant, a Pitts S-1 isn't the machine to take a friend, relative, son, or niece along for the lessons we learn from flying aerobatics. What if there's a targeted way to bridge the gap between aerobatics and more conventional training? What if these maneuvers expand an aerobat's own experiences in ways that rolling for "style points" does not?*

After years of aerobatics and flight instruction (and a few spinal surgeries putting a stop to aerobatics), Dr. Ed Wischmeyer developed E3 as a way to continue teaching the benefits of exploring the flight envelope without the need for more than 2g and parachutes. This approach makes normal category aircraft capable of these maneuvers designed to instill lessons of airmanship. E3 helps a pilot quickly develop a sense for an airplane's control harmony. Dr. Ed Wischmeyer explains more:

FULL AILERON DEFLECTION in the nonaerobatic RV-9A gives a nice roll rate, even at 80 knots. Under guidance, the nonaerobatic pilot stops at a 60-degree bank and turns 90 degrees, the turn rate impressive at that low speed. We're deliberately not concerned with holding altitude, so the turn is less than 2*g*. After 90 degrees of turn, it's full aileron the other way for another 90-degree turn, then again and again. The pilot does a sloppy job and knows it, but with great excitement asks, "Can we do that again?"

Welcome to the Expanded Envelope Exercises, also known as E3, designed to expand a pilot's personal flight envelope with nontraditional exercises that can be done in most normal category airplanes with less than 60 degrees bank, 30 degrees pitch, 2*g*, and no spins. Originally developed to reduce Loss of Control (LOC) accidents, E3 has an unexpected benefit in that it helps a pilot quickly get a feel for the airplane. And E3 is lots of fun and rewarding.

The new idea in E3 for reducing LOC is to increase the pilot's awareness of what the airplane is doing at all times, rather than training specific VFR LOC accident scenarios. This goal is accomplished by exposing the pilot to an expanded envelope, defined beyond the traditional envelope of *g* and airspeed. The expanded envelope includes full aileron deflections at low airspeeds, roll rates both fast and glacial, stall recoveries beyond the Airman Certification Standards (ACS), landings and taxiing with deliberate offsets from the painted centerline, and so much more. None of it is all that hard, just different.

Ed's RV-9A will happily buffet its way through the E3 exercises.

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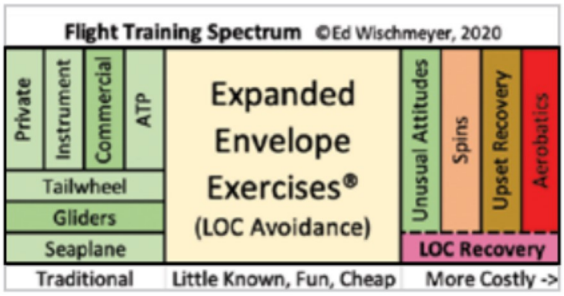

The phrase coined for E3 is to increase a pilot's "cognitive availability," the ability to process all of the information already available. External factors aside, pilots don't lose control within their comfort zone because they are cognitively available to process all of the cues. By expanding a pilot's comfort zone, E3 increases cognitive availability. Thus, E3 helps keep LOC precursors from developing into LOC accidents.

But what about the fun, rewarding parts of E3? It's the new sensations, the mastery of the airplane, the learning. A 550-hour commercial/instrument pilot wrote, "In our short E3 flight, I learned things I had never encountered in 25 years of general aviation involvement. The exercises you showed me helped me push the boundaries of my situational awareness ...." A Cirrus standardized instructor pilot put it this way: "The picture out of the windshield, the control feels, the sound, inputs from the vestibular system are all foreign. ... This is an experience that all pilots should have."

Because E3 is so different and some exercises are contrary to the ACS, E3 is not recommended for very low-time pilots.

Safety is most appropriate for E3, which, after all, started out as a safety enhancer. As all pilots know, FAR 91.3(a) states, "The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft." Just because somebody else did something similar in another airplane doesn't necessarily mean that E3 is appropriate and safe for you (or your students) in your airplane.

Safety elements include:

- Many airplanes have a 2*g* limit with flaps extended. Because some E3 exercises can, if botched, inspire a too-vigorous pullout, most all of E3 is flown flaps up.

- Some E3 exercises can quickly lead to spectacular unusual attitudes if the instructor is not on top of the situation. Both for this reason and for the learning experiences, most of E3 is low speed, often well below V_A.

- Because so much of E3 is low speed, clumsy or abrupt control inputs can lead to spins. We flew E3 in a Beech Baron with an extraordinarily well-qualified pilot, but even so, omitted the stall portions of E3 and made sure we had plenty of altitude.

- There are too many safety considerations to be included in this article, and those include airplane selection, exercise selection, instructor pilot qualification, and altitude. Do not assume that aerobatic experience will replace adequate preparation for attempting or instructing all of E3.

- No funny tricks are played in flight. Every exercise is discussed in flight immediately before the exercise.

- Remember FAR 91.3(a). The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft.

Here's what a typical E3 flight might look like. The preflight briefing includes discussion of who is pilot in command, pilot skills and recent experience, airspace, and positive transfer of controls — all of the normal considerations. But considering that E3 will be largely outside the student's comfort zone, the briefing is especially important. For want of a better word, "student" is used to describe the pilot seeing E3 for the first time, whether that person is an airline transport pilot, designated pilot examiner, fighter jet test pilot, or mere mortal.

E3 starts on the taxi out. Instead of sticking to painted centerlines, the instructor will ask the student to track pavement joints to the left and right of centerline. This step sets a tone of the pilot being in command of the airplane.

Takeoff and climb to altitude is briefed that the student will fly the airplane normally to clear airspace and a sufficient altitude, just in case. For airplanes unlikely to spin, altitudes similar to those used for teaching commercial maneuvers may suffice. Remember FAR 91.3(a).

The first exercise is usually the glacial Dutch roll. At an airspeed comparable to a fast traffic pattern speed with flaps up — and this will vary from airplane to airplane — the airplane is rolled at 1 degree per second while keeping the nose pointed at a point on the horizon. One degree per second is extraordinarily slow, and even the experienced former military jet test pilots have not done it correctly on the first try. Once the airplane runs out of rudder, the pilot recovers to straight and level at 1 degree per second again, but it is even harder to recover at this glacial roll rate than to enter. Without stopping, a glacial Dutch roll is performed in the other direction with the same glacial recovery.

The glacial Dutch roll is extremely challenging the first time, believe it or not, and has an extremely high workload. It teaches full rudder deflection, of course, but it also teaches that the pilot is in command of the airplane — just like the taxi exercise did. It's worth pointing out to the student that here's something not all that far out of the ordinary, but that is indeed challenging.

Next come the fast Dutch rolls: full aileron deflection to 60 degrees of bank, left, right, left, right, with the nose at a fixed point on the horizon. The airplane is not paused at 60 degrees but immediately rolled the other direction. Entry speed is maybe a little faster than the glacial Dutch roll. In many airplanes, it is best done with rudder to help start the bank. The envelope expansion here is that not many normal category pilots use full aileron deflection, and not many have used rudder with full aileron deflection. A clumsy-footed pilot can quickly get the instructor queasy.

After that part, it is time for some stalls if the airplane is suitable for this exercise and for a variation. Starting at cruise speed or low cruise speed, the airplane is put into a 30-degree bank. Power is reduced to idle; altitude is held with increasing back-pressure, bank is held constant, full flaps are lowered at flap speed, and the airplane is stalled. Bank angle is held constant during the stall and recovery, and power is added gradually. But the nose is not dumped over for airspeed. Rather, the airplane is allowed to accelerate out of the stall, still in the turn. Flaps are retracted when appropriate. After doing this exercise, the variation is to recover in a 30-degree bank in the other direction — if the airplane stall/spin characteristics allow it to be done with manageable risk. A clumsy-footed student could put the airplane in danger of a spin.

Student reaction to this variety of turning stall, especially with the opposite recovery, is usually amazement at what the airplane can do. Of course, this technique is contrary to what is normally taught, but if the student ever has to maneuver at low speed, say, after an engine-out and to avoid an obstacle not seen till the last moment, it is a good experience for the student to have.

Ed getting ready to teach pilots to expand their comfort zones and increase their cognitive availability in stressful situations.

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Somewhere at this point in the E3 flight, both pilots might be ready for a break with straight and level flight. If the student doesn't bring up the topic, the instructor can point out that the student is getting a feel for the airplane, for what it can do. In contrast, during an airplane checkout, the student is taught to master a bunch of maneuvers with completion standards. Once those are mastered, the student is good to go and will, hopefully, get a feel for the airplane over time. An unexpected benefit of E3 is that by focusing on the sensations of the exercises without the distraction of maneuver completion standards, the student will more quickly get a feel for the airplane. And it's lots more fun.

After the break come the 60/90s, mentioned in the opening paragraph. The 60/90s are the poster child exercise of E3, with high sensory input, full control deflection, high roll rates (at least by normal category airplane standards), and turns to a point on the horizon. Holding altitude is not, repeat not, a consideration. It is an exercise, not a maneuver. Entry speed may be a fast traffic pattern speed. I use 80 knots in the RV-9A, but when I enter at 70 knots, the RV-9A will be in the stall buffet most of the time with occasional stall breaks. For my RV-9A airplane with me as safety pilot, it can be a cool learning experience, as the RV-9A will happily buffet its way through the exercise. For other airplanes, maybe not. When we did 60/90s in the Cirrus, the best entry speed was 105 knots. One hundred knots had the nose too high, and to get the highest turn rate, we wanted the speed as low as possible. When we did it in the Baron with the former test pilot flying, he was surprised to get an occasional stall warning. Remember FAR 91.3(a).

The 60/90s are not all sweetness and light, however. One of the early students to attempt it did not apply adequate back-pressure, and the RV-9A was quickly in a low-speed spiral. We hit 80 degrees of bank and 30 degrees nose down — pretty spectacular, but at least I recovered below V_A. Since that episode, I've researched low-speed spirals extensively, and I demonstrate them on E3 flights. I do not ask the student to do them. See chart above right.

Close examination of NTSB accident report narratives and dockets, digital flight data from some accident airplanes, and my own research flights suggest that there are two variants of low-speed spirals that can masquerade as incipient spins:

- A first-accident scenario is that a distracted pilot is late turning base to final, banks steeply, thinks he's high, and pushes the nose over. This situation is a low-speed, low-AOA scenario but can resemble the incipient phase of a spin. In a 30-degree, nose-low situation with the horizon not readily visible to the startled pilot, further nose-down inputs to recover from a perceived spin can be inappropriate. When I've demonstrated low-speed spirals with a relatively prompt recovery, altitude loss is typically 500 feet, with the range being 400-800 feet.

Botched Low Speed Steep Turn: Spiral, not Spin (1 row/sec)

Safety pilot started recovery at green line

AOA	KIAS	Bank°	Pitch°	G	Alt	V/S	Hdg°
0.32	66	15	-3	1.1	-0	- 650	0
0.40	67	43	-5	0.8	-10	- 550	5
0.32	68	68	-10	1.1	-18	- 640	21
0.31	71	78	-20	1.2	-32	- 950	37
0.36	78	80	-30	1.7	-58	- 1720	62
0.28	87	60	-36	1.8	-100	- 2750	86
0.43	94	34	-26	2.4	-160	- 3660	109
0.56	99	26	-9	2.7	-230	- 4050	123
Level flight 7 seconds later…					-390		133

One of E3 exercises is for the nonaerobatic pilot to bank at 60 degrees and turn 90 degrees. Early students to attempt it did not apply adequate back-pressure, resulting in a low-speed spiral.

- A second scenario is a steep turn base to final with inadequate back-pressure. This one feels even more like an incipient spin entry, and the same kinds of unusual attitudes can be encountered. Altitude loss in this scenario is somewhat less than in the first scenario.

The industry has much to learn about low-speed spirals, and much of conventional spiral wisdom is suspect. Putting it into perspective, the Cirrus SR20 and SR22 pilot's operating handbooks state, "If, at the stall, the controls are misapplied and abused accelerated inputs are made to the elevator, rudder and/or ailerons, an abrupt wing drop may be felt and a spiral or spin may be entered. In some cases, *it may be difficult to determine if the aircraft has entered a spiral or the beginning of a spin.*"

Accident data research shows that a major next step in reducing loss-of-control accidents will be a thorough re-examination of low-speed spirals.

There is more to E3, but there's no more room in this article. There are about 100 E3 exercises tabulated so far, and there's room for others to contribute. E3 has been flown in a dozen nonaerobatic airplanes so far, from Cessna 150 to RV-9A to Mooney 205 to Cirrus SR22 to Beech Baron B55. Approving pilots have included three senior former military test pilots. One of those, an intermediate/advanced competition pilot, agrees that E3 teaches things that aerobatics does not.

But for those who are looking to do something different in a normal category airplane, E3 may be just the ticket. The invitation is open to come fly E3 with me in Savannah, Georgia, no charge.

The next steps in E3 development are to get the word out, to get more people to try E3, and to establish an E3 consortium to provide wisdom and guidance beyond my experience. Like aerobatics, E3 must be tailored to each airplane type, including entry speeds, techniques, caveats, and appropriateness for students at various levels. But remember FAR 91.3(a). ***IAC+***

ED WISCHMEYER, ATP/CFII, has flown roughly 200 makes and models of aircraft and has been published extensively in general aviation publications. Three spinal surgeries ended his aerobatic flying, but the resulting 2*g* spinal limit serendipitously helped lead to E3. His Ph.D. is from Massachusetts Institute of Technology.

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