Stick and Rudder vs. Digital Dependence

U.S. AIR FORCE

U.S. Air Force Boeing 747 (E-4B) hand-flown during air refueling behind a KC-135 tanker.

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"Can this airplane land itself?" That's a frequent question from the flying public when first viewing a high-tech cockpit. These days the question has morphed into "can this airplane fly without a pilot?" Even in its most recent incarnation, the question boils down to that of autoland.

The only aircraft I've ever flown with autoland capability was a U.S. Air Force E-4B, a Boeing 747-200. The autopilot was a masterpiece for its time and the only thing it wasn't allowed to do that we pilots could do, was fly behind a tanker, hook up, and gulp down 40,000 gal. of jet fuel. Believe it or not, that's easier than it sounds.

The aircraft could also land itself; that's harder than you might imagine. Somedays it would kiss the runway in the touchdown zone, on speed, with nothing for me to do but pull the reverse levers and take a bow on behalf of the electrons while the passengers applauded. The very next autoland could be planted on brick one and make me consider calling my dentist to check the integrity of my fillings. But even that experience was nothing compared to an autoland on a Ceiling and Visibility Unlimited (CAVU) day at a busy airport when the ILS critical area was unprotected.

One day at Will Rogers World Airport, Oklahoma City (KOKC) I was in the flare at 30 ft. when another airplane taxied by the localizer antenna. Just as the throttles came to idle and the nose rotated gently upward, the airplane rolled its 200-ft. wings so quickly all I could do was "pickle" everything off and go around. These thrills happened often enough to encourage a healthy paranoia about anything in an airplane controlled by a computer. Back then, in the 1980s and before, we learned to place a greater trust on our stick and rudder skills than those ones and zeros behind the magical curtain. But these days, most of us have come to accept the autopilot as just another member of the cockpit crew.

The idea that we have become too reliant on automation and have let our basic piloting skills atrophy isn't new. Every few years there is a noteworthy crash, some hand-wringing and a call for pilots to take a little more stick time. This has been around for almost as long as I have been flying. But I don't think more stick time will answer the problem. What we need is better stick time, hand-flying the airplane when it is safe to do so and then do so in a way that helps us improve.

Becoming too reliant on the automation is an easy trap to fall into. I have to admit I am as guilty as the next pilot, even back in the days when the only automation involved was a flight director. My first flight director was in the Northrup T-38 and I remember once watching in fascination as the needles seemed to align themselves, as if there was an autopilot. (There wasn't.) Then I realized my eyes and hands were simply reacting to the crossbars of the flight director and I hadn't looked at the raw data since the course and glideslope were captured. That was in 1979.

Whenever I hear of an airplane that has crashed because its pilots gave up control to the electrons, I think of that day in the T-38. The tendency is natural, your brain seeks the easy way out and would rather be a passenger when the autopilot seems to be doing a flawless job. This, of course, is a recipe for disaster. But you can prevent that disaster by mentally flying the airplane even when the electrons are handling the stick and rudder. That way, when the electrons mess up, you will be fully prepared to take over.

A Misplaced Trust

The first autopilot came soon after the birth of powered flight when Lawrence Sperry mounted a "gyroscopic stabilizer apparatus" in a Curtiss C-2 biplane. He hit upon the idea when studying the gyroscopic effect of spinning wheels that tended to keep motorcycles upright. His design included a wind-driven generator to spin several gyroscopes up to 7,000 revolutions per minute. These gyroscopes were then mechanically linked to a control mechanism. One gyro, for example, would keep the ailerons positioned to keep the wings level. The autopilot, at its inception, was a mechanical device.

By the 1940s, autopilots had evolved into electronic devices capable of much more than keeping the wings and nose approximately level. The Minneapolis-Honeywell C-1, for example, was coupled with the famous Norden bombsight on the Boeing

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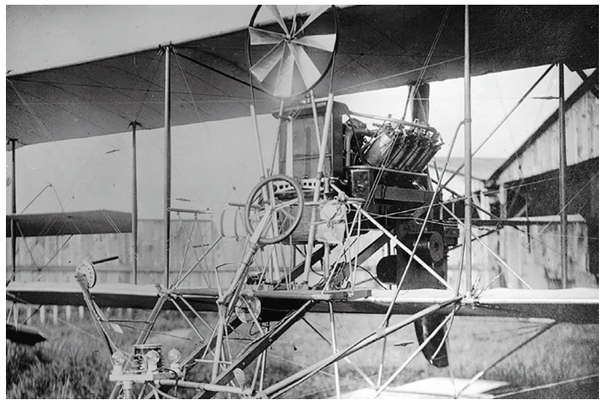
An early autopilot control panel, the Minneapolis-Honeywell C-1.



Sperry autopilot installed on a Curtis biplane. (Glenn H. Curtiss Museum)

B-17 Flying Fortress, the Consolidated B-24 Liberator and the Boeing B-29 Superfortress.

My first autopilot was in the KC-135A tanker, which had hardly progressed from the days of World War II. The device's primary purpose in life was to hold an altitude smoothly to maintain a stable platform for receivers during air refueling. While it could maintain a heading, it did everything else poorly. We never trusted it to maintain a course and the idea of coupling it to an ILS was unthinkable. I flew that airplane down to minimums many times, but each approach was hand-flown. (Because it had to be.)

Fast forward to today: I am now flying a Gulfstream G450 where practically everything is digital, run by computers that think in terms of ones and zeros. The binary wizardry is capable of threading the needle on a Required Navigation Performance (RNP) approach flying a radius around a fix down to a lateral accuracy as tight as RNP 0.1, just over 600 ft. When presented with an approach to minimums in this airplane, the only time I don't couple the autopilot is during simulator recurrent training. I have become so trusting of the ones and zeros that the largest threat during many of my approaches is the tendency of my brain to disengage and become a passenger along for the ride. I am not alone in this.

Case Study: Singapore Airlines Flight 327

On Nov. 3, 2011, the crew of Singapore Airlines Flight 327 had every reason to be confident about their Boeing 777 flying from Manchester International Airport, U.K. (EGCC) to München-Franz Josef Strauss Airport, Germany (EDDM). They were flying a state-of-the-art airplane for a company with an enviable safety record. The weather in Munich was above Category I ILS minimums: 2,000 meters visibility (1.25 mi.) with a cloud base of 300 ft. Their company Standard Operating Procedures (SOPs) recommended that the captain fly the approach with the autopilot coupled. The crew did precisely that. In fact, the only mistake the crew had made up until the landing flare was that they never told the airport tower that the approach was coupled.

Pilots who fly exclusively in the U.S. can be forgiven for thinking there still was no problem. The U.S. Aeronautical Information Manual says when the visibility is less than 2 mi. or the ceiling is less than 800 ft., the ILS critical area will be protected. But that is far more restrictive than the International

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Singapore Airlines Flight 327, aircraft position after stop.

Civil Aviation Organization's criteria of 550 meters (1,805 ft.) visibility and 60 meters (200 ft.)ceiling. The ILS critical area was not protected during Flight 327's approach.

Just prior to the Boeing 777's landing, tower cleared a British Aerospace BAe 146 Avro RJ85 to take off from an intersection. The Avro was still climbing and had not yet passed the runway's departure end when the Boeing neared the runway's touchdown zone. The Avro interrupted the localizer signal, causing the 777 to roll just prior to touchdown. At the moment the Boeing's captain pressed his Takeoff/Go Around (TO/GA) button, the aircraft's left main gear contacted the runway, signaling weight on wheels. This signal disabled the TO/GA function, confusing the pilots as the aircraft continued to track left of centerline. As the aircraft approached the left side of the runway, both pilots pressed right rudder to correct, but it was too late. The aircraft departed the left side, kicking up a cloud of dirt. Their correction finally pushed the airplane back to the right, but too far right and the aircraft departed the right side of the runway, where it came to a rest.

The pilots did a commendable job minimizing the lateral deviations as well as they did. Nobody was injured and the damage to the airplane was minimal. The pilots, the airline and the investigators were left wondering how such a thing could have happened to such a well-run airline flying such a capable airplane. The German investigators placed the blame on the operator, saying they "allowed the decision for an autoland landing without having to consider the required conditions on the ground."

Looking at the Singapore Airlines' SOP the criticism is probably well-founded. But I think we as pilots should learn a lesson here that our automation only behaves well when the conditions on and off the airplane are as the designers predicted. We know that much of aviation is unpredictable and it is up to us, the human pilots, to monitor the automatic pilots and take over before things go beyond design predictions. We have to keep our brains engaged even when the automation is doing the actual flying.

But when it comes time to take over, we have to instinctively know what to do. You can attribute the cause of many recent crashes to pilots suddenly hand-flying their aircraft without a firm grasp about what stick and rudder inputs were needed before things became uncontrollable. In 1988, an Air France crew flew their Airbus A320 on a "low pass" in front of an airshow crowd, not realizing their aircraft committed itself to landing and withheld go-around thrust until it was too late. In 2009, a Turkish Airlines crew was slam-dunked into Amsterdam-Schiphol International Airport, Netherlands (EHAM); they failed to realize a faulty radio altimeter had convinced their autothrottles it was time to retard to idle at almost 2,000 ft. In 2013, an Asiana Airlines crew got their Boeing 777 so far behind the power curve on approach to San Francisco International Airport (KSFO) that getting back to the glidepath became impossible. The list of pilots-turned-passengers goes on and on.

Solution: More Stick Time?

The FAA wants you to hand-fly more often — really. In 2017, the agency issued Safety Alert for Operators (SAFO) 17007, Manual Flight Operations Proficiency. This SAFO says an "air carrier's line operations policy should permit and encourage manual flight operations," as defined by "managing the flight path through manual control of pitch, bank, yaw and/or thrust." But there is a cautionary note: "When deciding to fly manually, crews should apply basic threat and error management principles and take into account the various factors affecting operational workload."

So, it is up to you, the pilot, to apply good judgment. And if you break anything (or anyone), well that's you not applying good judgment. We need to think about this: Good judgment isn't issued with your pilot certificate.

In much of my Air Force upbringing, the automation philosophy was to couple as soon as possible after takeoff and remain coupled until you couldn't. The idea was to free up your brain to think strategically as the electrons waged the tactical war. So, there I was, just a few years after retiring a military uniform for that of a civilian charter pilot when . . .

Our Gulfstream had done a great job intercepting the localizer and once the glideslope had centered, we started down. We were in the clouds and expected to remain so until about 700 ft. above the town of Lalysos, just a few miles west of the Rhodes, Greece, airport. Seven hundred feet is practically Visual Flight Rules (VFR) in our world, so nobody was worried about the approach. I was in the right seat and had only one item left on the checklist, the final notch of flaps. We had intercepted the glideslope at 2,500 ft. on the ILS to Runway 25.

At about 2,000 ft. the captain — who was also the company chief pilot — said, "Do you mind if I increase my proficiency?" Before I could answer he clicked off the autopilot and promptly got us above the glideslope needle that was, moments ago, centered. "A dot high and going higher," I said. We popped out of the weather a dot and a half high and too fast to extend our last notch of flaps. "Well I might be too high," he said, "but at least I'm too fast." The runway was over 10,000 ft. long and he managed to save the landing, if not the approach.

That was one of my first times sitting in the right seat with that captain and I was, to say the least, surprised. I have messed up my share of approaches over the years, but I've never been so cavalier about it. Unfortunately, he repeated this trick often.

The worst incident was when we were flying into a very short runway and the weather was just a hundred feet above minimums. When the weather is that crummy and you have a good autopilot, like we did in this airplane, you let the airplane fly while you watch it like a hawk. That's what I do.

"Do you mind if I increase my proficiency?" he asked once more. The needles were centered, we were at 1,600 ft. MSL and our decision altitude was 400 ft. MSL, just 200 ft. above the runway.

"I would rather you didn't," I said. But it was too late; he clicked off the autopilot.

"Going high," I said. "A dot high," I repeated. "You need to correct," I said. He did not. I repeated myself. He started to increase his vertical descent rate.

At decision altitude I spotted the runway, what was left of it.

He pushed the nose over hard and we found ourselves on the pavement in an instant. He planted the airplane halfway down the runway, but this particular Gulfstream had great brakes and we managed to roll out with less drama.

"Let's never do that again," I said.

The captain simply laughed.

I've replayed that approach in my head many times over the years since, wondering what I could have done differently. The right answer, I realize now, would have been to call for the go around the minute he deviated from our stable approach criteria. But, for the purpose of why we are here now, the takeaway is that all of this captain's stick time was for naught. Over the years I've never seen a pilot take more stick time in an automated airplane than he did. And yet his stick and rudder skills were poor. How can we fix this?

Better Solution: Purposeful Practice

Most proponents of "We need more stick time!" will preach that "practice makes perfect!" But that maxim is demonstrably false. So, then they tell you "perfect practice makes perfect!" But that is unachievable. (How can you practice perfectly to become perfect, if you aren't already perfect?) There are two problems with grabbing some stick time whenever the time permits. First, it can be an unwarranted risk when modern simulators are available. But even without the added risk, practice without outside critique is just about useless. If the other pilot isn't empowered to debrief your performance, you will have practiced without learning.

The 2016 book, Peak: Secrets From the New Science of Expertise, explores the idea of practice that facilitates expertise. Its author, psychologist Anders Ericsson, was also the author of the often-misquoted study that proposes it takes 10,000 hr. of practice to become an expert at anything. (It doesn't.) Dr. Ericsson says what it takes is practice with a purpose.

"We all follow pretty much the same pattern with any skill we learn, from baking a pie to writing a descriptive paragraph. We start off with a general idea of what we want to do, get some instruction from a teacher or a coach or a book or a website, practice until we reach an acceptable level, and then let it become automatic. And there's nothing wrong with that. For much of what we do in life, it's perfectly fine to reach a middling level of performance and just leave it like that."

That pretty much describes how many of us approach flight training. But as professional aviators, a "middling level of performance" should not be good enough. We all know pilots who have 20 or 30 years of experience who are not as sharp as others with just four or five. This is true of just about any profession, such as medical doctors or schoolteachers. Even the act of driving a car as basic transportation can reveal large gaps in skill levels between those who take the skill seriously and those for whom it is just another chore. Ericsson's study shows there is more to practice than repetition.

According to the study, "Research has shown that, generally speaking, once a person reaches that level of 'acceptable' performance and automaticity, the additional years of 'practice' don't lead to improvement. If anything, the doctor or the teacher or the driver who's been at it for 20 years is likely to be a bit worse than the one who's been doing it for only five, and the reason is that these automated abilities gradually deteriorate in the absence of deliberate efforts to improve."

Ericsson calls the efforts many of us employ to get better at something "naive practice." It is doing something repeatedly expecting the repetition alone will improve one's performance. He offers instead what he calls "purposeful practice."

- ▶ Purposeful practice has well-defined, specific goals.
- ▶ Purposeful practice is all about putting a bunch of baby steps together to reach a longer-term goal.
- ▶ Purposeful practice is focused.
- ▶ Purposeful practice involves feedback.
- ▶ Purposeful practice involves getting out of one's comfort zone.

The idea of "purposeful practice" is just what we need to improve our stick and rudder skills in an age of ones and zeros. So, let's do that.

When Is 'Practice' in the Aircraft Appropriate?

This is a decision you have to make based on your operation, your risk tolerance, the capabilities of your aircraft and the experience levels of everyone involved. In my current operation, we do not fly a lot so I would say we are not as proficient as I would like. We will not accept unnecessary risk, but then who really does? Our G450 is highly capable, but the automation does not include autoland or autobrakes. All of our pilots are highly experienced. I am the pilot in charge so here are the decisions I've made.

I think "practice" in the airplane is invaluable but that we should avail ourselves to every possible safety advantage at

our disposal. I think that any instrument approach shot in less than VFR conditions should be coupled when flying an airplane that can do that precisely. So, hand-flying once in Visual Meteorological Conditions (VMC) is OK, but there are ground rules involved. I also believe VFR skills need to be sharpened as well, but there are times when this is not appropriate. For example, if you are flying into a congested airport, or to one with which you are not familiar, perhaps practice isn't such a good idea.

Setting the Ground Rules

Here again, your rules of practice should be tailored to your operation, aircraft and people. Here are the ones we employ.

- When the weather is below basic VFR minimums, instrument approaches are coupled until in VMC. Yes, we can hand-fly our aircraft to minimums and are required to do so in the simulator. But letting the automation do it doubles the number of humans doing the monitoring.
- When the Pilot Flying (PF) is hand-flying the airplane, the Pilot Monitoring (PM) assumes safety/instructor pilot responsibilities.
- No aircraft systems are disabled at any time for the purpose of "training."
- Stable approach criteria are always followed.
- No pilot will exceed any of the aircraft's limitations.

Empowering the 'Safety/Instructor Pilot'

One of the biggest problems with the way most of us exercise our hand-flying skills is that we do so in an incomplete manner. We are exercising our skills while self-critiquing silently. The other pilot is expected to keep quiet before, during and after the practice. We assume this pilot is nothing more than a "safety pilot," as is the normal situation, and will only speak up if something becomes unsafe. This deprives the PF of the most important element of practice: assessment by another pilot.

This problem becomes especially noticeable if the PF has a supervisory role or if the PM is in any way intimidated by the PF. The best way to overcome this situation is with an effective pre-brief that lets the PM know that he or she will be fulfilling two roles in the practice to come. First, they are to speak up if things become unsafe or unstable. Second, they are to observe the PF's performance and are expected to provide a critique in an effort to help the PF improve.

When the weather is good, we often brief, "this will be a visual approach backed up by the ILS" or something to that effect. This might be the perfect time to brief, "This will be an ILS that I will fly 'heads down' on the needles with you as my safety/instructor pilot. Standard callouts apply as if we were IMC. Do not allow me to deviate more than half a dot on the localizer or glidepath at any point. If I do so below 2,000 ft., announce that fact and I will go 'heads up' and take over visually. I might be a bit rusty, so I am counting on you to keep us safe and help me with my proficiency."

A CAVU day might also be the perfect time to practice visual approaches without reference to the electrons. Having a good sight picture of a proper glidepath and lateral alignment is something we can lose after years of flying the needles. Here again, a good pre-brief is important. Let the safety/instructor pilot know that you intend to fly the visual approach without the ILS or other instrument approach guidance in view but that he or she should have them available. For example: "I will be flying this approach visually and will not look at the ILS as a backup but am counting on you to keep an eye on me and the instruments to make sure I don't violate our stable approach criteria. Please speak up if it appears I am getting close to doing so."

The Critique: Maximizing Purposeful Practice

Once the aircraft is on the ground and put away, ask the safety/instructor pilot for a full debrief. Encourage the pilot to be frank and react positively to anything said. For example: "Everything looked great until we got below about 1,500 ft. and the winds shifted. We started to go below glidepath to about a dot when you noticed and pulled it back. But then our speed decreased almost 10 kt. That's when I said something about the approach becoming unstable."

And the response? "That was a good call. I need to do a better job of keeping my eyes moving, even when things are looking good. Thanks!"

As professional aviators we tend to adopt the "professional courtesy" of other professions that basically believe: "Thou shall not criticize another professional." But improvement is impossible without honest critique and you owe it to yourself to ask for just that. You also owe it to your fellow pilot to provide it.

Finally, you also need to keep track of your performances, good and bad. This kind of trend monitoring can help you realize what you need to work on for your next simulator event and can also help you diagnose problems in the future. Here is a personal example.

About 15 years ago, while flying a Challenger 604, I got into a series of poor landings that I was unable to figure out. I tended to flare too early, but now and then I flared too late. (Ouch!) The other pilots kept quiet and if I ever said anything, they would say "We all have good and bad streaks." But I eventually figured out the problem. You see, every airplane I had ever flown before the Challenger had a 4- or 5-deg. nose-up attitude on approach; the nose-low attitude of the Challenger required a larger shift in my eyes from the aim point to the end of the runway during the flare. But I figured it out after a bit of a struggle. Two years later, I needed to relearn my lesson. But my written "grade book" made it easier the second time.

Analog, Digital or Both?

There appear to be two kinds of pilots in accident reports that involve a stick and rudder problem: those who prefer to hand-fly and those who do not. Ignoring the automation during a night flight into a busy airport is a recipe for disaster. Just think of the recent near-calamity of Air Canada Flight 759 at San Francisco International Airport. But not having the skills to fly the same approach without automation can be deadly. Think of Asiana Flight 214 for another KSFO example.

We owe it to ourselves to keep proficient, and practicing in the airplane is invaluable. But there is a right and wrong time to do that. And, more importantly, there is a right and wrong way to practice. **BCA**