



J. MAC MCCLELLAN

COMMENTARY / LEFT SEAT

Avionics Can Give a Helping Hand

New systems from Garmin and Avidyne help pilots avoid the really big mistake

AN AIRPLANE THAT CAN safely fly itself—at least when the pilot’s attention is diverted—has been a dream for many and certainly would improve the safety record. But to be acceptable to us pilots, a system that adds stability and helps us avoid disastrous mistakes can’t be intrusive or we won’t put up with it.

For a number of years starting in the late 1960s, Mooneys had an artificial stability system the company called Positive Control (PC). As the name implies, PC provided positive control in the form of continuous wing leveling. PC was a basic pneumatic autopilot that always leveled the wings unless the pilot pushed a large button on the control wheel to temporarily disengage the system.

PC made perfect sense because when the wings are level the natural speed stability of a well-designed airplane keeps the airplane flying very close to its trimmed airspeed. When the wings are level it’s almost impossible to lose control of an airplane.

Most pilots hated PC. There appears to be an improvement in the accident record of PC-equipped Mooneys compared to others, but every pilot I know devised some way to disable PC. Some wound tape around the



Garmin’s ESP is applying at least 10 pounds of left aileron stick force building to 20 pounds of force in this situation to help the Cirrus pilot recover from the steep bank and nose-low attitude. The double slash marks at the 30-degree bank angle mark shows ESP is active and that 30 degrees is the bank angle recovery target.

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button to hold it down. Back when 35 mm camera film came in metal cans, other pilots discovered that the can fit neatly over the control wheel horn and then you could crush the can to hold the button down, disengaging PC. The best PC disabler I saw was the rubber cup off the tip of a crutch that you would use when you sprained your

When I rolled the Cirrus into a steep bank ESP kicked in so smoothly that I couldn't feel it engaging, but could certainly feel the extra stick force resisting my roll control input.

ankle. That rubber cup fit just right and held the PC button down indefinitely so you could fly without PC constantly fighting you to level the wings.

Mooney's PC proved that artificial stability works and can be a big help to a pilot who may have lots to do in the cockpit. But PC also proved that we want help only at the edges of the normal flying envelope, not for every second of a flight.

The pilots and engineers at Garmin know all about the Mooney PC system and were determined to deliver most of the benefits of PC without continuous pilot interference when they developed

Garmin's Electronic Stability and Protection (ESP) system.

Avidyne also has developed an electronic system that will prevent a pilot from making a dangerous mistake while using its new DFC90 autopilot for the Cirrus. When the autopilot is engaged, the DFC90 will not stall the airplane even though the pilot has selected a vertical or airspeed mode without adding enough power to maintain the commanded altitude or speed. If you do that with the earlier autopilots in the Cirrus, the autopilot will fly the airplane into a stall, and recovered flight data from the Entegra avionics system shows that has happened several times with fatal results.

GARMIN ESP HAS NASA ROOTS

Garmin's ESP development traces its roots back to NASA's Advanced General Aviation Transport Experiments (AGATE) of the 1990s. The goal of AGATE and the wider NASA Small Aircraft Transportation System (SATS) program was to develop technology that could make small airplanes safer and easier to fly, particularly under IFR and on longer trips. Loss of control is the largest single cause of general aviation accidents when pilots are flying IFR in the clouds, and that situation must be improved if light airplanes are going to provide reliable transportation.

Using an autopilot is an obvious way to relieve pilot workload under IFR, and AGATE devoted a lot of attention to improving autopilot performance and the way human pilots use the autopilot. But autopilots can't be used for the entire flight, so AGATE looked for ways to make it easier to safely hand fly the airplane, particularly in poor weather or during high workload



Avidyne's DFC90 autopilot with its envelope protection logic fits in the same panel space as the original unit.

periods. And that's where Garmin's ESP development began.

The key word in ESP is really "stability," not "protection." A properly designed airplane is stable, meaning it tries to fly straight and level and maintain its trimmed airspeed until the pilot makes control inputs or the flight path is disturbed by turbulence. What Garmin's ESP does is use electronics to add to that natural stability without altering the way we normally fly.

ESP uses the servos that are the core part of Garmin's autopilot system to add stability—stick force, really—when the human pilot deviates too far from a normal attitude. Just as natural aerodynamic forces demand more stick force to pull the nose further and further up from the trimmed condition, or to roll into a steeper bank, ESP adds stick force to let a pilot know his attitude is moving far from straight and level.

ESP can start to add stick force at any attitude, but in the Cirrus and Beech King Air 200, the first two airplanes certified with ESP, the system comes on at 45 degrees of bank. In the world of transport flying the maximum normal bank angle is 30 degrees, but Garmin's testing with a variety of pilots found that in GA airplanes pilots will sometimes fly steeper banks briefly, particularly in the VFR traffic pattern. But in any phase of flight 45 degrees is a lot of bank and is never really flown unintentionally.

So, at a 45-degree bank angle ESP comes on very smoothly and adds 10 pounds of force to the stick. In other words, the servo is exerting 10 pounds of effort to move the controls to level the wings. If the pilot persists in holding the steep bank, the ESP added stick force builds smoothly to 20 pounds. The added stability force of ESP remains on until the bank angle returns to 30 degrees or less.

Actual stick forces may be higher or lower in other airplanes as ESP is certified in them, but the concept of half the available added stability coming on initially and then gradually building to all available stick force will be the same. ESP does the same thing in pitch, coming on at 17.5 degrees nose-up and building to max force at 20 degrees.

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It is accurate to think of ESP as an “electronic spring” in the control system. Many—actually most—airplanes have springs or weights in the control system to add stick force beyond what is available from air loads. ESP is a “smart” spring that adds stick force to alert the pilot to an unusual attitude, and to guide him back toward a normal attitude.

To see ESP in action, Garmin’s top test pilot, Tom Carr, and I flew the Cirrus SR22 that Garmin used to develop the system. When I rolled the Cirrus into a steep bank ESP kicked in so smoothly that I couldn’t feel it engaging, but could certainly feel the extra stick force resisting my roll control input. ESP felt totally natural, just as though the Cirrus had grown new stability that wanted it to bank less than 45 degrees. The 10 pounds of force was noticeable, but the full 20 pounds was really impressive, particularly when rolling left and trying to twist the side stick away from my body.

I had to zoom the Cirrus to get to the ESP pitch-attitude onset because a smooth pull-up would usually get to the low-speed ESP activation first. Obviously, ESP needs to do its best to help the pilot avoid a stall no matter what the attitude, and it does. At stall-warning onset ESP engages, adding nose-down stick force to turn the stall warning off. If you are near redline airspeed in a dive, ESP pulls back on the stick to help you slow the airplane.

Because ESP is part of the complete Garmin system it’s possible for the autopilot to jump in automatically if the human pilot fails to recover to a more normal attitude. If ESP is engaged for 50 percent of the previous 20 seconds—meaning the airplane is in a very steep bank, very nose high or low attitude—the autopilot will engage automatically and maintain a level attitude and maintain altitude if there is enough available engine power. This automatic autopilot

engagement is an option the airplane maker can select, and Cirrus has.

If ESP or the autopilot engages at a non-critical altitude, the system will attempt to hold 80 knots with wings level. If altitude is critical because the airplane is on approach or otherwise close to the ground, the system will pull up to stall warning and then maintain an airspeed 2 knots faster than stall warning. It is really eye-opening to see an SR22 clawing along nose way up just 2 knots above stall warning, but that is the best angle of climb to get back to a safe altitude. I don’t think I could force myself to maintain that high of a deck angle at that low airspeed, particularly in the clouds, if I hadn’t tried it several times and gained such confidence in ESP. The system also can fly an autopilot coupled go-around, because even if the human pilot is slow to add power and raise the flaps, the autopilot will not stall the airplane but will fly it to the maximum climb angle attitude.



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AVIDYNE DFC90

Avidyne's DFC90 that replaces the S-TEC autopilots in Cirrus SR22s uses slightly different logic to prevent the autopilot from flying the airplane into a stall.

A big change for the DFC90 autopilot is that it uses attitude information from the electronic gyros in the flat glass Avidyne Entegra system installed in many Cirrus airplanes. The DFC90 autopilot computer and control head fits into the same mounting tray as the S-TEC autopilot it replaces, but a couple of new wires from the Entegra system import the attitude info. Flying based on attitude is optimum, and the DFC90 does a superb job of controlling the Cirrus using the S-TEC servos that are already installed to move the flight controls.

The DFC90 knows the indicated airspeed and also the g-loading based on sensors that are part of the Entegra system. With this information the DFC90 knows when the Cirrus is approaching a stall and

will automatically lower the nose very gradually to keep the airplane flying above stalling speed. At the same time the DFC90 is issuing aural and visual alerts to the pilot that the airplane is flying too slowly.

Autopilot-induced stalls happen when the pilot selects an autopilot mode but there is not enough available energy to actually fly the selected flight path. For example, if the human pilot doesn't add power after the autopilot levels the airplane from a descent, conventional autopilots will simply keep raising the nose in an effort to maintain the commanded altitude. Or if the human pilot selects a vertical climb speed and there isn't enough engine thrust to maintain that rate, the conventional autopilot will keep raising the nose following its one and only command to maintain a selected rate of climb.

The DFC90 also will try to fly the flight path selected by the pilot, but what it won't do is stall the airplane, or fly it faster than redline on a descent. If the human pilot fails

to notice the airspeed situation, the DFC90 trades the minimum amount of altitude for airspeed by gradually lowering the nose to keep the airplane flying, all the while yelling at the pilot to do something.

I know many of you are thinking that you would never let an autopilot fly your airplane into a stall, or that you would never allow a steep bank to develop while you were distracted or flying in the clouds, but it happens to somebody else with alarming frequency. And maybe you and I will be good enough, and fortunate enough, to never need some electronic help. But what we all want is an airplane that gets us home safely on our worst day, not our best day, or even an average day. The Garmin and Avidyne systems can give us the second chance we may need someday. *EAA*

J. Mac McClellan, EAA 747337, has been a pilot for more than 40 years, holds an ATP certificate, and owns a Beechcraft Baron.

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