What's It Doing Now?

Autopilots are often the least well-understood pieces of equipment in the panel. But knowing your flight director/autopilot can make your flying safer.

BY PAUL K. SANCHEZ

It's unfortunate, and happens way too often, that the equipment/software in the aircraft that can do the greatest harm to the pilot, is probably understood the least. The very piece of equipment that can wrest the yoke away from you, initiate a radical roll and descent, is woefully ignored in the training environment.

Of course, the autopilot/flight director can also serve as a useful tool—enhancing safety and relieving a single pilot from mundane chores to focus on planning, emergencies or just enjoying the ride. Understanding the autopilot in the airplane you fly is critical to enhancing the safety of your operations.

Too often, though, flight instructors dictate that their students may not use/learn/observe the aircraft's flight director/autopilot because it "interferes with the basic learning."

Obsessive/Compulsive

Interfering with the basic controls of the aircraft is what exactly happened to one hapless pilot in Cooper Landing, Alaska, on August 6, 2001.

The Private pilot was renting a very well-equipped, nearly brand-new Cessna 172S with a KAP140 autopilot featuring altitude and vertical speed select, two moving maps, a KLN94 GPS, etc. The pilot had done some instrument training in the aircraft but had never been taught about the KAP140, electric trim, or any other functions that can control the aircraft.

"The only thing worse than a pilot not understanding what a flight director is suggesting is a pilot not knowing what the autopilot is doing."

During the sightseeing flight the autopilot was unintentionally engaged with a preselected altitude of 7000 feet msl. The pilot was in an arm-wrestling match with the electric trim all the way down to the ground. She eventually fought the airplane to something approaching a draw with the electric trim but the aircraft hit hard on a gravel strip.

An insurance underwriter had to total the aircraft, basically due to the lack of training by the instructor. In its finding of a probable cause, the National Transportation Safety Board referred to the "pilot's inadequate remedial action to disconnect the autopilot during an uncommanded altitude deviation while in cruise flight," "the pilot's lack of familiarity with the airplane's autopilot system" as well as "the operator's insufficient training standards for the airplane, and the pilot's flight instructor's failure to provide adequate upgrade/transition training in the airplane."

Who's In Charge Here?

It stands to reason that the less a pilot knows about an aircraft system, the less he/she will use it. Unfortunately with flight directors/autopilots, the opposite is usually true. Many times pilots abdicate their command responsibilities of the flight to the autopilot, with a mentality that since the autopilot can fly better than they can, it can make better decisions.

With that in mind, this is a good time to emphasize something: Never stop providing mental inputs to the command of the flight just because some piece of equipment is providing mechanical inputs for the control of the flight.

Unfortunately, the situation of who or what is in control of the aircraft

The Bendix/King KFC225 autopilot/flight director pictured above might be found in a high-performance single or piston twin.

can be much worse. This would happen if, for instance, the aircraft is equipped with a flight director the pilot has not yet programmed for the task at hand. The result would be a flight director using its cue bars to make suggestions for pitching and rolling the aircraft that the pilot does not understand.

The only thing worse than a pilot not understanding what a flight director is suggesting is a pilot not knowing what the autopilot is doing.

Sum Of All Parts

The autopilot computer has selector switches for heading bug input (HDG), navigation mode (Nav from the CDI or, if roll-steering is available, directly from a GPS navigator), altitude hold (ALT) either by pre-selecting an altitude or staying at the current altitude. Vertical speed may also be specified with a capture function, if the system is properly equipped.

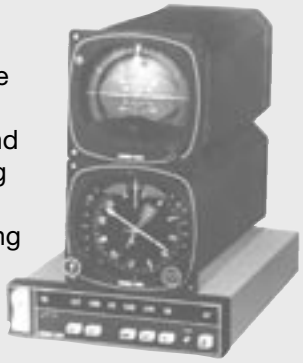
Aircraft roll is controlled by a second servo attached to the aileron system. When this set-up (roll control) alone is installed, it's known as a "single-axis" autopilot. If a similar servo is added to control the aircraft's pitch—either by directly manipulating the elevator/stabilator or simply the trim tab—the system is a "two-axis autopilot," since two axes are being controlled. Some autopilots installed in personal airplanes—the Bendix-King KFC225 and KFC325, the S-Tec 55x and the Chelton AP3—can also add a third axis by installing a yaw dampener, allowing the system to control aircraft yaw through the rudder.

Other modes on most autopilots include approach (APR), glideslope (GS) and reverse course (REV). Approach mode is more sensitive and the autopilot will be quicker to respond to the left/right CDI errors and get the airplane on to the course centerline. To use the glideslope mode, you must be in approach mode and receiving a usable ILS (localizer and glideslope)

Typical Autopilots

One of the first steps necessary to understand the autopilot in the airplane you fly is to identify it. Older airplanes may be equipped with an out-of-production Century (née Mitchell) II or III unit in a Piper, a Cessna/ARC box in, well, a Cessna, a Tactair or Brittain installed in an older Bonanza or something else entirely. Here are some of the major players in the current autopilot market:

Honeywell/Bendix-King



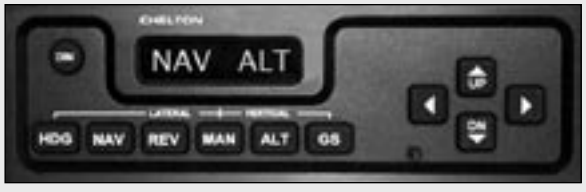
The Honeywell KFC150 (pictured at right), KFC225 and KFC325 are attitude-based autopilots. This means they exclusively use the attitude indicator to obtain information on the aircraft's pitch and roll and then send the appropriate inputs to servos controlling the ailerons and elevators. The very common KAP140 is a rate-based autopilot using the turn coordinator. Pilot's guides for these autopilot systems are available at <https://www3.bendixking.com>.

Meggitt/S-Tec

Similar in operation to Honeywell's KAP140, all S-Tec autopilots are rate-based. Instead of using the attitude indicator, they use the aircraft's turn coordinator for roll information and a sensitive pressure transducer to detect changes in altitude (pitch). Rate-based autopilots have the added benefit of continuing to work when vacuum-driven instruments like an attitude indicator or directional gyro/HSI fail.

Pilot's guides for S-Tec autopilots are available online at <http://www.s-tec.com/publications.html>.

Coming Attractions



One of the new kids on the block is Chelton Aviation's AP-3C, the basic design of which dates to 1973. Chelton acquired the product and redesigned it to take advantage of the latest technologies without changing the basic design's stabilization algorithms.

Additionally, Garmin has been working on a new autopilot to complement its all-glass G1000 integrated flat-panel navigation system.

Getting To Know Your Autopilot

Each airplane and each autopilot installation is different. Use this checklist to determine how yours is configured and can be used best.

Paperwork

❒ Start with your airplane's AFM/POH and the section on supplements. This is where you'll find the FAA-approved manual on operating and configuring your autopilot.

❒ Pay particular attention to any limitations in the AFM/POH supplement on autopilot use. For example, using the autopilot may be prohibited above a certain airspeed or below a certain altitude.

❒ Review the supplement's recommended procedures for engaging and disengaging the autopilot. For example, engaging NAV mode when the radios are not set up correctly can make for a wild ride.

Installation and Controls

❒ Locate all of the autopilot's controls and switches. Find the system's circuit breakers.

❒ Identify the autopilot disconnect button. It's usually on the left yoke.

❒ Before flight, perform the autopilot checklist found in the AFM/POH supplement.

❒ On a good-weather day, perhaps with a safety pilot, run through all the autopilot modes and emergency procedures. — J.B.

signal. Some autpilots require a period of straight-and-level flight in APR mode before "capturing" the ILS. Using this mode, one can fly "coupled" approaches is the airplane is properly equipped, often allowing a much smoother and more accurate ILS than when hand-flying. Reverse course is not something we do very often anymore but is an annunciation that the autopilot will fly opposite the CDI needle. It's used for back-course approaches and may also be used when flying a missed approach and passing the localizer antenna. Reverse sensing is not applicable to aircraft with horizontal situation indicators (HSIs), which provide heading/course information at the same time.

Don't Get A Bum Steer

GPS steering (GPSS), or roll-steering, is the newest alternative method of getting your GPS's course guidance information directly to your autopilot, bypassing the CDI or HSI. Honeywell KAP140, KFC225 and KFC325 can accept roll-steering information. KFC200 and KFC150 cannot. All S-Tec autopilots can accept roll-steering. However, the GPS navigator must be able to output the correct signal—usually in ARINC 429 format— and may require a separate interface box. When using GPSS, the autopilot and/or interface box computes the very minute roll commands necessary to follow every twist and turn in an active flight plan. When there is a turn in your flight plan (such as a 90-degree turn on a GPS approach), GPSS will compute when to start the turn, the bank angle to use during the turn, and help keep the airplane symbol on the magenta line. Pretty fancy stuff.

The Flight Directors Guild

Any time you have a flight director built into an autopilot, you have a wonderful tool available for hand-flying the airplane. The flight director is an instrument instructor (darn good one at that) who can't talk, but makes suggestions to you or the autopilot by moving his hands (cue bars). If you have told the flight director the task (hold heading, climb at 500 fpm to 9000 feet, for example), it will position cue bars on the attitude indicator to suggest what you should do for pitch and roll to achieve the performance and accuracy desired. When you are getting close to the target altitude the flight director will suggest decreasing pitch for a smoother capture of the altitude. When in a turn to the heading bug it will suggest rolling out when you are close to the target heading.

This flight director/instrument instructor will never talk too much on the intercom, never ask you to buy lunch, never be late and never have his hand out at the end of the flight. The only thing the flight director asks is that you tell it what task you had in mind (HDG or NAV or both, ALT hold or vertical speed to ALT) so that it can make the best suggestions for you to get there.

A Failure To Communicate

Okay, all this sounds great so far. Excellent flight director/autopilot, altitude selector, color moving maps, GPS that outputs roll-steering director to the autopilot. All is well in our big happy avionics fam-

ily. What could go wrong?

Of course, the answer is plenty. We spend a great deal of budget on the avionics but all attitude-based autopilots use the attitude indicator for reference and, unfortunately, a failure-prone vacuum or pressure pump usually powers that instrument. If you have a vacuum-driven attitude gyro and an attitude-based autopilot, your autopilot will become inoperative if/when that vacuum pump fails and takes with it the attitude indicator (AI) and, probably, the directional gyro (DG). If you're in IMC and are the type who depends on the autopilot, you will need some recent partial-panel experience. This is when a backup vacuum or pressure system driving both instruments will be handy.

Rate-based autopilots such as the S-Tec series or the KAP140 do not depend on the AI or DG but use the (usually) electric-powered turn coordinator for bank information. Of course, turn coordinators can and do fail, though their failure rate is much better. And, other system failures can affect the autopilot. See the sidebar for more.

Trust, But Verify

Modern autopilots are wonderful devices, but it's still the pilot's responsibility to command the flight rather than be an uninvolved, unaware passenger sitting in the left seat. Before engaging your autopilot, verify that your navigation sources are correctly programmed to go where you want and any altitude settings are correct. Are you at a safe altitude to engage the autopilot? Have you verified the autopilot's configuration? Flying with an autopilot may not be a hands-on affair, but it does require knowledge and understanding of the airplane and its various systems.

Paul Sanchez <sanchezpaulk@aol.com> is a CFII-MEI who does insurance qualification courses and avionics training nationwide at his clients' locations.

Autopilot Failure Modes

The electronics in modern autopilots are pretty bulletproof and rarely fail. In fact, many autopilot anomalies can be traced to wiring issues—either between various autopilot components or the interfaces between the autopilot and navigation equipment. But because many autopilots must work and play well with other systems in the airplane, an instrument, power or electrical problem can render the autopilot inoperative, usually when you need it most. Do you know which system failures will affect the autopilot?

Instrument Failures

With most attitude-based systems, you will lose the autopilot—in addition to the attitude indicator and directional gyro—after a vacuum-system failure. The same thing is true for an individual failure of either instrument. Often, the first indication may be a lazy roll or wandering heading. With rate-based autopilots using the turn coordinator for roll control, the same thing can happen when that instrument fails. Look for the failure flags, if any. Disengage the autopilot and don't use it until the failure is resolved. This kind of problem is another good argument in favor of a backup vacuum system.

Electrical System Failures

Although a handful of older autopilots are pneumatic, modern ones are powered by the ship's electrical system. With a total electrical system failure, you'll lose your autopilot, as well as a bunch of other stuff. With a partial failure, and especially if running on battery alone, this would be a good time to know how much of a drain the autopilot imposes. Use the system's circuit breaker to completely eliminate any current draw.

Runaway Trim

Autopilot servos are the mechanical connection between the autopilot and the airplane's control surfaces. Just like any other mechanical devices, they can fail. Perhaps the most dangerous failure mode is an uncommanded pitch excursion, or runaway trim. You may need to overpower the system to maintain level flight before hitting the autopilot disconnect. This is when knowledge of which switches do what comes in handy—you can usually continue to use the system for roll control (HDG and NAV modes, for example)—but may need to disable the electric trim system. —J.B.