Flight Instruments:

They Deserve More Attention Than We Give Them

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No matter how old or new your aircraft is, you're probably staring at a few examples of something called a "flight instrument" when you fly. Even if you're lucky enough to be in a certified aircraft with a glass panel displaying computer-generated versions of conventional gauges, you still have a set of backup instruments to help get you home if all the "magic" fails.

We're talking, of course, about aircraft nominally equipped to operate in instrument meteorological conditions; aircraft not intended for such use might have only instruments as basic as a magnetic compass and some means to determine airspeed.

A night view of Jeb Burnside's instrument panel.

Whether you refer to them as round dials, steam gauges or use some other description, flight instruments are a fact of life for most aircraft owners. And most owners pay them little real attention. Sure, we monitor them when flying, paying very close attention to them when flying in a cloud, close to the ground or in restricted visibility, and always urge the airspeed indicator up to new records. But, for the most part, we don't think about them much.

That's a shame, because the flight instruments mounted in your panel are really little marvels of simplicity, accuracy and dedication to a specific task. They are extremely sensitive, robust enough to operate reliably under a wide range of conditions — including constant vibration and extremes of heat and cold — and can have internal mechanisms revolving at speeds much higher than, say, your propeller. They can be powered by an air or vacuum pump mounted to the engine, by the electrical system, by a venturi hanging in the breeze or not at all.

And they can and do fail. Failure of some flight instruments can be a bona fide emergency depending on the pilot's skills and experience, as well as the weather. When others fail, it's more of an inconvenience and a hit to the wallet than a potential catastrophe. In some cases, failure of one instrument — the airspeed indicator or ASI — is grounds for deliberately breaking another one — the vertical speed indicator or VSI — allowing the ASI some return to normalcy.

And, to complicate things further, some instruments can fail slowly, providing erroneous indications or sluggish performance, either of which is a warning sign a shop visit should be planned for repair or replacement.

Splitting Up the Six Pack

Flight instruments can be divided into two basic categories based on how they work: pitot/static instruments and gyro instruments.

Pitot/Static Instruments

This group of instruments comprises the ASI, the altimeter and the VSI. All three are based on sensing ambient air pressure outside the aircraft, but that's where their similarity ends.

The ASI's presentation is based on measuring the difference between the pressure of static, ambient air and that exerted on the pitot tube as the aircraft flies through the air. The altimeter displays the difference between a "known" pressure exerted at sea level versus the instrument's altitude. Meanwhile, the VSI measures the rate at which that pressure changes.

Gyro Instruments

As their name implies, gyro instruments rely on a gyroscope spinning in at least one plane to measure the angle and rate of any displacement from that plane. The artificial horizon, or attitude indicator (AI), for instance, measures displacement in the longitudinal (pitch) and lateral (bank) axes. The directional gyro (DG), or heading indicator, presents the angle of change, if any, in the vertical (yaw) axis.

Both of these instruments are usually — there are exceptions — powered by an engine-driven vacuum or pressure pump; they also can be electrically driven. The turn coordinator, or turn-and-bank indicator, also presents displacement in the lateral axis but, because of differences in design versus the AI and built-in inclinometer, is optimized to display the quality of a bank or turn as it relates to the aircraft's speed, rather than its quantity.

The importance of these six instruments — often dubbed the "six pack" — cannot be overemphasized. Not only are they the pilot's principal references for determining and verifying aircraft performance, they also reflect how well the pilot is controlling the aircraft. At night over remote areas or when flight visibility is restricted, they provide the pilot's only references to help ensure the "dirty side is down." That's one of the reasons the FAA is relatively concerned about their condition, their maintenance and their quality.

Maintenance, Management...

Unlike so many other components installed in the average certified aircraft, the FAA doesn't allow just anybody to work on the flight instruments. In addition to the required 24-month pitot and static system checks, anytime these three instruments are replaced or reinstalled, a qualified technician must again certify the system as airworthy.

Usually, this means going to a repair station or avionics shop using the right equipment; your friendly neighborhood A&P likely won't cut it.

When you need one of these instruments repaired or overhauled — including the "lowliest" of instruments, the magnetic compass — only certain shops legally can do the work. Granted, these are delicate devices, and working on or replacing the very small components in gyro-driven instruments can require special tools and conditions approaching a NASA "clean room."

The FAA recognizes the safety-critical nature of your flight instruments and has in place maintenance requirements differing substantially from those applicable to, say, overhauling a magneto or replacing a damaged wing panel.

For example, let's say your altimeter is sluggish and won't remain past the 24-month static-system check. This kind of problem is fairly common, especially with older instruments, and its causes can include a pinhole leak in its bellows, or aneroids, and inadequate lubrication of the indicator mechanism. After a qualified instrument shop repairs the instrument — either as part of a complete overhaul or the less-expensive "inspect and repair as necessary" instruction — the instrument must be tested and certified before it is returned to service. Once it's installed, the static system again must be checked to ensure it is within specs.

Keeping the gyros turning can be as simple as ensuring the system's internals remain as clean as possible, since even minute dust particles can interfere with the close-tolerance mechanisms in modern instruments. One way to help prolong your system's health is to replace its filters at each annual inspection. New filters are relatively inexpensive and, depending on your aircraft and access behind its panel, can be replaced easily. While you or your mechanic are doing an inspection — annual or otherwise — take an extra moment to ensure the tubing and hoses comprising connections between your vacuum/pressure pump

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and the instruments are in good condition.

Many pilots think very little about their flight instruments beyond, perhaps, noticing when the DG begins to precess abnormally, when the AI won't erect quickly after engine start or when the ASI doesn't react as power settings and the aircraft's attitude say it should. Just like any other component you carry aloft, the flight instruments' moving parts can wear out, requiring replacement and recalibration. If your aircraft's AI and/or DG are powered by vacuum or air pressure, other components — including the engine-driven pump, the system regulator and associated plumbing — may need attention or replacement.

...and Achilles

This is especially true if your gyros are driven by a "carbon-vane" or "dry" vacuum pump. Originally designed and offered as more modern replacements for the heavy, messy and more-complicated "wet" or oil-lubricated pumps, the dry pump's reputation is for a relatively short life span and failure without warning.

Photo by Jeb Burnside.

As this pairing of older and newer portable GPS navigators from Garmin shows, cockpit portables have come a long way in only a few short years. If you're considering a new cockpit portable, think about how you will use it, how you will mount it and how it might interfere with your No. 1 job: flying the airplane.

Photo courtesy of Mid-Continent Instruments

Over the years, far too many aircraft have been lost after a dry pump failed, leaving the pilot without the two gyros needed most in instrument conditions: the AI and DG.

One way to spot a dry pump's impending failure is the presence of fine, black dust on its exhaust port's interior. This could mean its internal vanes are wearing faster than normal. Since most dry pumps are not repairable, replacing it is the only long-term solution. Many operators, especially those who fly a lot of IFR, opt to replace a dry pump proactively after it's reached a certain number of hours in operation.

Recently, many operators have begun installing electric-powered gyros — either as their primary references or as backups to the vacuum/pressure-driven instruments. The FAA, acknowledging the dry pump's poor reliability record, adopted a policy easing installation and approval of electric instruments.

Other operators have snapped up the new-technology dry pumps appearing on the market because their design eliminates the Achilles' heel of carbon-vane pumps: vanes fracturing and failing the pump without warning.

Instrument manufacturers have responded with new, electric-powered versions of both the AI and the DG. Newer models even have an inclinometer built into their face, allowing them to replace a turn coordinator or turn-and-bank indicator, with the FAA's blessing. Installation usually is a snap: Bolt the electric instrument into a vacant position in the panel (preferably among or adjacent to the "six pack"), install a new, dedicated circuit breaker, run the wiring and do the paperwork. Usually, even the technician signing off on your annual inspection can do this installation.

Frustrated with depending on an air or vacuum pump — and its 1930s-era farm-tractor technology — some operators of certified aircraft are taking a page out of the homebuilder's book of tricks by removing them entirely, opting to go all-electric instead. Following this path means ensuring a back-up power source because an electrical failure at the wrong time, while rare, could leave one in a position much worse than when an air/vacuum pump fails.

A small-capacity sealed battery powering an essential avionics bus usually meets this need nicely, along with FAA requirements.

Not Created Equal

Before you decide to yank out any instruments for repair or replacement — regardless of how they are powered and what will be installed in their place — consider the certification basis and reliability of what you'll put back in your panel.

A few years ago, when installing an electric AI as a backup was all the rage, many operators tried to save a buck or two by obtaining inexpensive instruments. They worked, for a while, but obtaining parts and service proved troublesome. The choice often came down to buying another instrument of identical reliability or springing for a more expensive replacement with factory support and repairability (which probably should have been done the first time).

Which highlights a regulatory area of which many pilots and aircraft owners just aren't aware: instrument certification standards. Basically, the FAA doesn't want operators installing just any primary instrument in their certified aircraft. Those lucky enough to be flying an experimental category aircraft capable of hard IFR can pretty much do as they please from a regulatory standpoint, but even they should pay attention here.

One result is, the typical imported airspeed indicator — even if your avionics/instrument shop agrees to mark it accordingly — probably doesn't meet the FAA's minimum standards. This is true even if the failed instrument you yanked from behind your panel doesn't meet the agency's applicable technical standard order (TSO), a document describing the minimum qualities a device or component must meet before installation in a certified aircraft.

But how did a non-TSO'd instrument get into your aircraft in the first place? That's fairly easy to understand. Essentially, when your aircraft manufacturer certified its type design with the FAA, it chose to equip the panel with certain instruments. During the certification process, your aircraft's manufacturer proved to the FAA the instruments met industry-recognized minimum standards, even if they didn't meet an applicable TSO, probably because an appropriate TSO didn't exist at the time.

Just what industry-recognized standards are there besides the TSO? Interestingly, one must look to the automotive sector for those standards. Yes, the Society of Automotive Engineers (SAE) has developed a long list of standards for a wide variety of appliances,

Photo courtesy of Mid-Continent Instruments

products and components, including aircraft instruments.

In fact, SAE aircraft instrument standards often are used as the basis for a new FAA TSO. So, when you need to replace an instrument in your panel and a TSO'd version isn't available, ask the manufacturer which industry standard the device meets. If it meets the applicable SAE standard, there's a good chance you can still use the device.

Flight instruments aren't rocket science, but they do require a bit of knowledge to maintain correctly. Doing your homework, and performing regular inspections and maintenance, can help reduce your overall cost of aircraft ownership while enhancing safety and your panel's reliability. It's hard to find a better deal anywhere. ■