Photo courtesy of Garmin

The Need for Speed ...

But Which One? BY JASON BRYS

Most people who become pilots already have experience driving a car; the only thing an automobile driver needs to do to be a "speed reader" is to glance at the speedometer. Since it is a natural tendency to look for the familiar, fledgling pilots generally assume that the airspeed indicator is simply the airplane equivalent of an auto speedometer. Yet, when it comes to airplanes, measuring speed is a deceptively simple concept—but one that is important for a proficient pilot to master. As we will see in this article, it is important for both performance and safety reasons to understand how values, such as groundspeed, true airspeed, indicated airspeed, and calibrated airspeed, are calculated and used.

Groundspeed

Let's start with the obvious one. Since most people perceive flying as a speedy means of moving from point A to point B, one of the first questions a pilot is likely to hear from a non-pilot or passenger is a variation of "how fast does it fly" or "how long does it take" between any two points. Pilots quickly learn that the value needed to answer this question is not necessarily the number shown on the airspeed indicator. Unlike the speed of a ground-bound car, the groundspeed of an airplane is substantially affected by factors such as wind, and it varies accordingly. A pilot cannot answer "how fast" or "how long" questions with any precision without knowing the groundspeed for a particular day, time, and route. Although modern avionics, e.g., in glass cockpits, do provide groundspeed readings, those avionics (like pilots using the more traditional analog gauges) use wind information to calculate groundspeed from a value called "true airspeed."

True Airspeed

True airspeed, or TAS, is a measure of the physical speed of the aircraft in relation to the air around it. Just as differences in wind velocity affect groundspeed, differences in air density affect true airspeed. At the same engine power setting, e.g., 75 percent power, an airplane can move faster through air that is less dense. That's why higher altitudes can translate to higher true airspeeds.

Like aircraft groundspeed, TAS cannot be measured directly. Rather, the pilot uses outside air temperature (OAT), pressure altitude, and calibrated airspeed CAS (see below) to calculate this value.

Indicated Airspeed

The airspeed indicator in the cockpit displays—you guessed it—indicated airspeed (IAS). IAS matters a lot for actually flying the airplane. All the operating speeds for the airplane, such as stall speed, maneuvering speed, performance speeds, and other limiting speeds, are generally provided as indicated airspeeds. It thus indicates to the pilot the bounds of the airspeed limitations to operate the aircraft in.

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To provide this important aerodynamic speed information to the pilot, the airspeed indicator takes information from the pitot-static system. The pitot-static system includes the pitot tube and a static air source. Both are connected to the airspeed indicator. The airspeed indicator measures the pressure difference between the ram, or impact, air from the pitot tube and the still, or static, air from the static

Photo by Tom Hoffmann

source. The airspeed indicator then displays this pressure difference to the pilot as IAS.

Calibrated Airspeed

We have already established that speed in an airplane is substantially more involved than for a car. So you won't be surprised to learn that IAS is not the end of the story. Here's why. As with any mechanism, the pitot-static system on an airplane is not perfect, and it may have errors. As a rule of thumb, the location of the airplane's static source is to blame for most of the system's errors, commonly referred to as position error.

Airplane manufacturers go to great lengths to minimize pitot-static system error. Even in the computer age, where Computational Fluid Dynamics (CFD) programs perform thousands of complex calculations to determine the best location for the pitot tube and static port, chances are good that the airplane manufacturer will still have to make some modifications during aircraft development. For example, the manufacturer might vary the depth of the static port, change the shape or location, or even add an additional static port on the opposite side of the aircraft in order to meet aircraft certification requirements. Still, the system is rarely perfect without the use of software. Because position error has an impact on the accuracy of indicated airspeed, manufacturers therefore define a "calibrated airspeed" (CAS) to correct IAS for position error.

The reason for understanding the difference between IAS and CAS is to avoid inadvertent operations that exceed the airplane's published limitations.

In most airplanes, you can determine the accuracy of the airspeed system and the magnitude of the remaining position error simply from reviewing the airplane flight manual (AFM) or owner's manual (some aircraft were not required to have AFMs). In the AFM or owner's manual, you will find a chart that converts the indicated airspeed to calibrated airspeed.

Why It Matters

It's not hard to understand why it matters to understand the difference among values like groundspeed, TAS, and IAS. However, you may now be wondering why you need to pay attention to the relationship between calibrated and indicated airspeed. The answer may not be that obvious. It can, however, make a difference. You might notice that on many airplanes for speeds below the defined approach speed (which should be close to 1.3 times the stall speed for the approach configuration), the difference between the IAS and CAS may increase. For example, some airplanes will stall at an indicated airspeed of zero—not because the machine is defying the laws of gravity and aerodynamics, but rather because of the difference between IAS and CAS.

Take another example: While the airspeed indicator on a particular airplane might show a stall at an IAS of 50 knots, the airplane is in fact stalling at a CAS of 58 knots. Because of this it might appear to the pilot that the airplane is flying at a speed substantially lower than the published calibrated stall speed, whereas the airplane is really at the same speed.

Be aware, however, of the quirks in your particular airplane. In aircraft certified before December 1978, the airspeed markings on the airspeed indicator were required to be marked in CAS. In these aircraft, the colored arcs and lines on the airspeed indicator may not correspond exactly to the airplane's IAS. On airplanes with indicators marked in CAS, flying just at the edge of these markings may not be the best way to fly the airplane.

For instance, the start of the caution range in one common general aviation aircraft is 210 miles per hour (mph) calibrated airspeed. The caution range is marked by a yellow arc starting at 210 mph. If the pilot is flying 210 mph IAS in this particular airplane, though, the CAS is actually 214 mph, which means the pilot may be unknowingly exceeding the airplane's limitations. The reason for understanding the difference between IAS and CAS is to avoid inadvertent operation at higher or lower speeds than desired, or operations that exceed the airplane's published limitations.

Know Before You Go

As always, the basic message is that being a proficient pilot means knowing the airplane you are flying. Prior to getting into an airplane you should review the published speeds. When you review your AFM or owner's manual look at the speeds given and be sure you understand whether these are indicated or calibrated airspeeds. Don't make any assumptions, because even on older airplanes, takeoff and landing performance data is typically given in terms of IAS rather than CAS. Determine if the markings on the indicator are in CAS or IAS by looking on the type certificate data sheet (found at http://rgl.faa.gov) or in the AFM or owner's manual. If the speeds are listed in CAS, consider making a "cheat sheet" to convert those speeds to IAS for ready reference. By flying the right speed, you can ensure that you are flying within the approved safe envelope of the airplane.

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