AIRSPEED DEFINITION

1. Introduction

Airspeed is the speed of an aircraft relative to the air.

We present the common conventions for qualifying airspeed:
- indicated airspeed = IAS
- calibrated airspeed = CAS
- equivalent airspeed EAS
- true airspeed = TAS
- ground speed = GS

2. Indicated airspeed – IAS

Indicated airspeed (IAS or KIAS) means the speed of an aircraft as shown on its pitot static airspeed indicator, calibrated to reflect standard atmosphere adiabatic compressible flow at sea level, uncorrected for airspeed system errors.

The pitot-static system comprises one or more pitot probes facing the in-coming air flow to **measure pitot pressure** (also called stagnation, total or ram pressure) and one or more static ports to measure the static pressure in the air flow.
The airspeed is derived from the difference between the ram air pressure from the pitot tube, or stagnation pressure, and the static pressure.
An airspeed indicator is a differential pressure gauge with the pressure reading expressed in units of speed, rather than pressure.

Indicated airspeed is simply what the airspeed indicator shows.

Most airspeed indicators show the speed in knots (KT) i.e. nautical miles per hour.
Other airspeed indicators may display miles per hour or kilometres per hour.

The static pressure measurement is subject to error due to the inability to place the static ports at positions where the pressure is true static pressure at all airspeeds and attitudes. The correction for this error is the position error correction (PEC) and varies for different aircraft and airspeeds.

Further errors of 10% or more are common if the airplane is flown in "uncoordinated" flight.

Indicated airspeed is the starting point for all other calculations.

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3. Calibrated airspeed - CAS

Calibrated airspeed (CAS) is indicated airspeed corrected for instrument errors, position errors (due to incorrect pressure at the static port) and installation errors.

During clean flight, position and instrument errors are usually small. That means that the CAS value is nearly equal to the IAS.

This really only comes into play when the flaps are down.
What happens when the flaps are down? The angle of incidence of the pitot tube changes.
Rather than having the pitot tube aligned perfectly with the airflow, the center of lift is moved aft (how much depends on the type of flaps) and the pitot tube pitches slightly down.

Indicated airspeed will be a few knots lower. This is because the pitot tube is not picking up as many air molecules as it should, because of its angle of attack. Your real speed did not change, but the airspeed indicator thinks it did.

4. Equivalent airspeed - EAS

Equivalent airspeed (EAS) is the airspeed at sea level in the International Standard Atmosphere at which the dynamic pressure is the same as the dynamic pressure at the true airspeed (TAS) and altitude at which the aircraft is flying.

At standard sea level pressure, calibrated airspeed and equivalent airspeed are equal. Up to about 200 knots CAS and 10,000 feet the difference is negligible, but at higher speeds and altitudes CAS must be corrected for compressibility error to determine the EAS.

It really only comes into play with very high performance airplanes.

But for your own information, a pitot tube has a limit to how much air it can take in. If you fly faster than it can accept the air, then it will show an IAS that is less than what you would expect.

The basic definition for EAS is CAS corrected for compression air in the pitot tube.

5. True airspeed – TAS

True airspeed (TAS or KTAS) is the speed of the aircraft relative to the atmosphere. The true airspeed and heading of an aircraft constitute its velocity relative to the atmosphere

TAS is the true measure of aircraft performance in cruise, thus listed in aircraft specs, manuals, performance comparisons, pilot reports, and every situation when actual performance needs to be measured.
It is the speed listed on the flight plan, also used in flight planning, before considering the effects of wind.

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5.1.   Explanations

At sea level in the International Standard Atmosphere (ISA) and at low speeds where air compressibility is negligible, IAS corresponds to TAS.
When the air density or temperature around the aircraft differs from standard sea level conditions, the IAS will no longer correspond to TAS, thus it will no longer reflect aircraft performance. The airspeed indicator will indicate less than TAS when the air density decreases due to a change in altitude or air temperature.

For this reason, TAS cannot be measured directly. In flight, it can be calculated either by using an E6B flight calculator or its equivalent.

- For low speeds, the data required are static air temperature, pressure altitude and IAS
- Above approximately 100 knots, the compressibility error rises significantly and TAS must be calculated by the Mach speed.

If two airplanes (not linked together) had an indicated airspeed of 180kt, **the higher one would be going much faster**.
While there are only enough air molecules to give an indicated airspeed of 180kts, the true airspeed could be around 220kts (depending of the atmosphere condition: altitude and temperature).

Modern aircraft instruments use an Air Data Computer to perform this calculation in real time and display the TAS reading directly on the EFIS.

5.2.   Calculation

The simplest way to compute true airspeed is using a function of Mach number:

$$TAS = a_0 \, . \, M \, \sqrt{\frac{T}{T_0}}$$

TAS = True airspeed
a_0 = Speed of sound at standard sea level = 661.478 KT
M = Mach number
T = Temperature in Kelvin
T_0 = Standard sea level temperature (288.15 Kelvins)

One approximation is when temperature is at standard value (*T=T₀*):

$$TAS = a_0 \, . \, M \ \approx 600 \times Mach \ number$$

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Since temperature variations are of a smaller influence, the airspeed indicator error can be roughly estimated as indicating about 2% less than TAS per 1,000ft of altitude above sea level (approximation for altitudes below 12000ft):

$$TAS = IAS + IAS \times \left(\frac{2}{100} \times \frac{Altitude}{1000} \right)$$

Be aware that calculation is one of the possible approximations.

Example, an aircraft flying at 15,000ft with an IAS of 100kt:

$$TAS = 100 + \left(100 \times 0.02 \times \frac{15000}{1000} \right) = 100 + (100 \times 0.02 \times 15) = 130 \, KT$$

At high speed (240KT<IAS<400KT), another approximation can be:

$$TAS = IAS + \frac{FL}{2} = IAS + \frac{Altitude}{200}$$

6. Ground speed – GS

Ground speed (GS) is the speed of the aircraft relative to the ground. This speed is the combination of the true airspeed vector of the aircraft and the speed vector of wind at aircraft altitude.

GS = TAS + V$_w$

GS = Ground speed
V$_w$ = Wind speed vector
TAS = True airspeed

This speed is measured by air traffic controller radar. This is the speed which is displayed on our IVAO radar software IvAc.

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