Speeds

Used sensibly, speed control is a very helpful tool for separating aircraft and maintaining sequences.

Types of speeds

A distinction is made in aviation between different speeds:

- **IAS (indicated airspeed):**
  The speed displayed to the pilot on the airspeed indicator. It is decisive for the aerodynamic behavior of the aircraft, i.e. how many air molecules actually flow around the wing and generate lift. In powered flight, it is generally indicated in KIAS (knots indicated airspeed) (kts=NM/h)
- **TAS (true airspeed):**
  The speed actually flown, i.e. the relative speed of the aircraft in relation to the surrounding (still) air. The discrepancy between IAS and TAS therefore increases as an aircraft flies higher, as the air becomes thinner and thinner and the aircraft must fly faster and faster in relation to the TAS so that the IAS remains constant, i.e. the same amount of air molecules flow around the wing per unit of time. It is specified in KTAS (knots true airspeed).
- **GS (Ground Speed):**
  The speed of the vertical projection of the aircraft onto the earth's surface. This is therefore the TAS with the wind influences factored in, which cause the aircraft to fly slower over ground than the TAS if there is a headwind and faster if there is a tailwind. This is the speed displayed to the controller on the radar.

- **Mach Number:**
  Percentage of the speed of sound. Indicated with a dot and the percentage, e.g. "Mach .80" = 80% of the speed of sound. The Mach Number depends on many values, such as air density and temperature.

> Similar to the rule of thumb for descents (1000 ft in 3 NM), speed reduction is approximately 10 kts in 1 NM.

Using the different speeds

Below FL280, the **Indicated Airspeed (IAS)** is used, as it is responsible for the aircraft’s aerodynamic behavior.

Above FL280, the **Mach number** is generally used, as the aircraft then become so fast that the upper limit of the possible speed is no longer determined solely by aerodynamic aspects, but also by the so-called "critical Mach number". This is the Mach number at which the first effects of supersonic air flow occur on the aircraft, causing not only turbulence but also decreasing controllability of the control surfaces. The higher the aircraft climbs, the lower its maximum IAS becomes, while the Mach number remains the same.

If speed control is used for descending aircraft, IAS can and must be used above FL280, which might easily happen at e.g. FL340.

Depending on the aircraft type, the "switching altitude" between IAS/mach/IAS can also be above or below FL280.

> A change of **Mach 0.01** causes a change in **TAS** of about **6 kts**.

If necessary, the following phraseology can also be used. However, you must be aware that not every pilot will understand this instruction!

> “ DLH123 maintain Mach decimal 80, on conversion 320 knots

Some example values at which FL is switched from IAS to Mach:

Mach	IAS	Conversion FL
.82	**310**	FL303
.82	**280**	FL350
.82	**250**	FL399
.78	**310**	FL278
.78	**280**	FL324
.78	**250**	FL374
.74	**310**	FL250
.74	**280**	FL299
.74	**250**	FL350

Calculations

Rules of Thumb

0.01M difference~ 6 KT GS
1000ft altitude difference ~ 6 KT GS (The higher the faster)

1 KT GS = 1 NM per hour
60 KT GS = 1 NM per minute

Distance at a certain point

Additional distance = Additional distance between 2 aircraft in NM
m = 60 minutes / flight time to the point at which the distance should exist
Additional distance * m = Speed Delta in KT
Speed Delta in Mach = Speed Delta in KT / 6

> A detailed explanation of the rules of thumb is available as a video here.

Example

We have aircraft A and aircraft B at the same altitude, both leaving the sector at point P.

Aircraft A still has 150 NM (20 minutes) to point P.
Aircraft B still has 146 NM (19 minutes) to point P.

We want a separation of at least 7nm at point P. We already have a separation of 4nm, so we need to achieve a separation of an additional 3 NM (7 NM we want minus 4 NM we already have) in 20 minutes.
Now we calculate how many kts GS difference we need between the planes to reach this distance. Since the speeds are per hour, we now extrapolate this to 60 minutes.

60 minutes / 20 minutes = 3
*3 NM spacing * 3 = 9 NM spacing*
Since we know that 1 KT GS = 1 NM per hour, we now know that we need a speed difference of 9 KT GS to achieve a distance of 3 NM in 20 minutes

We know 0.01M ~ 6 KT GS, so in this case we need a Mach difference of 0.02M, which will be a difference of 12 KT GS, this will lead to 4nm more difference in 20 minutes, therefore leading to a total of 8 NM (4 NM current distance + 4 NM new distance due to speed difference) distance at point P. If the aircraft are not at the same altitude, we must subtract 6 KT per 1000ft from the speed delta if the higher aircraft is the leading one. If the higher plane is following, we have to add 6 KT per 1000ft to the speed delta.

Distance after a certain time

If speed control is used, the distance after a certain time can easily be calculated:

> Spacing = Speed difference / 60 per minute

As a rule of thumb, a speed difference of 30 KT (e.g. 250 KT and 280 KT) over a distance of 30 NM gives a spacing of about 3 - 3.5 NM.

Example

If the preceeding aircraft flies 30 KIAS more than the suceeding, this results in a spacing increase of half a NM per minute! Be careful if the preceedingaircraft is significantly higher than the suceeding! Remember that the TAS decreases the lower the aircraft flies. It is therefore possible that the suceeding aircraft is already flying 30 KIAS slower than the preceeding aircraft, but is still faster in relation to the GS, precisely because it is higher. It is therefore a good tactic to bring the aircraft that you want to fly slowly to the desired altitude first and then reduce the speed. If you want to maintain a high rate of descent, it is of course difficult to radically reduce speed. This should be taken into account!

When approaching an airport and holding is expected, the phrase "Reduce Minimum Clean Speed" is often used, i.e. the request to reduce to the lowest possible speed without setting the flaps. It should be noted that such a speed can always vary depending on the aircraft type and load. It can therefore not be used as a basis for relaying. The phrase "Reduce Minimum Approach Speed" should not be used!

The following rule applies on the final: On the way to the 10 NM final point, approx. 1 NM spacing is lost because the front aircraft reduces earlier. The same applies at the outer marker. You should therefore aim for minimum separation + 2 NM when vectoring so that the separation remains sufficient until touchdown!

Advanced: Ground speed effect

First of all, we need to take a look at the different speeds. The pilot has his indicated airspeed (IAS). The controller has the groundspeed (GS). The connecting element is the true airspeed (TAS). The IAS is only an indicator of how fast the aircraft is currently moving through the air. The GS is an indicator of how fast the aircraft is moving relative to the ground, corrected for influences like air density, wind, etc. This speed corresponds exactly to the speed a car would have on the ground. The TAS is a bit tricky. It expresses the speed that a solid body has in a certain medium. If we ignore the wind , we only have to deal with the solid body (our aircraft) and the medium (air) in which it is moving. At high altitudes, the air becomes thinner. This means less resistance from the medium, which leads to a higher speed of the solid body. The conclusion: the higher the aircraft, the greater the speed. These speeds are all interrelated. The TAS can be determined using a simple formula. The groundspeed is known to the controller, the indicated airspeed must be requested from the pilot.

> TAS = IAS + FL / 2

Example

Let's assume that approach has received two aircraft as a package from center. Both are on the same STAR at different altitudes and there is not enough space to separate the aircraft laterally.

Our scenario is as follows: **DLH123 at FL150 / 300 KIAS - CFG999 at FL160 / 300 KIAS**, same lateral position, same flight direction. We now need them both at 5000ft and 3NM separation within 40NM using vertical techniques only. We assume that there is no wind, so GS = TAS

> TAS DLH123 = 300 KT + 150 / 2 = 375 KT TAS
> CFG999 = 300 KT + 160 / 2 = 380 KT

We need both aircraft at 5000 ft, so for DLH123:

> TAS DLH123 = 300 KT + 50 / 2 = 325 KT

This leads to a speed difference between the aircraft of 55 KT (380 KT - 325 KT), so that the lateral separation increases by about 1 NM per minute (55 KT / 60 minutes).

We therefore need three minutes to separate the aircraft at the speed difference of 3 NM. We must let both aircraft descend simultaneously and one must reach our target fix three minutes before the other. What must the descent rates be in order to achieve this?

First, we calculate the descend rate of the higher aircraft. This moves at 380 KTS GS. It needs approx. 6 minutes for the 40 NM (40 NM / (380 KT / 60 minutes)) and must lose 10,000ft. This leads to a sink rate of 1700 ft/m.

DLH123 also needs 6 minutes at its current altitude and speed, but has to be there 3 minutes later than the higher CFG999. So it has to lose the 11,000ft in 3 minutes (6 minutes total flight time and the 3 minutes needed to increase separation leaves 3 minutes for the descent). This means a descent rate of about 3600 ft/m

Further links

- **Skybrary**: Basic Controller Techniques - Speed Control
- **Youtube**: Enroute Speed Control (LOVV FIR)
- **Youtube**: Speed Control - Rules of Thumb

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