Descending in VNAV for Dummies - And I'm a Dummy!

Introduction

The purpose of this short précis is to summarise the operational application of VNAV in the descent, and to suggest situations where VNAV may not be your most suitable mode of automation.

The précis assumes you have a basic understanding of automated LNAV/VNAV flight through the FMC, and associated terminology.

While the software behind VNAV varies between the various generations of Boeing aircraft, this précis is generic to all of the Boeing types I am rated on, i.e. the 747, 757, 767, 777 and 787.

Descent in VNAV

If you have loaded the applicable LNAV track into the FMC and you are tracking in LNAV, or being radar vectored reasonably close to the LNAV track, then descent in VNAV is a reasonable automation selection. If you are not, see below.

Your objective should be to remain in the VNAV path (VNAV PTH) if at all possible. VNAV will try to achieve this for you, but to some extent or other you will have to assist it by managing the thrust or drag. This is because the FMC will use the winds loaded into the flight plan, which are inevitably different to the actual wind you will experience in the descent.

The FMC will maintain descent in VNAV PTH if the resulting airspeed is within the tolerance allowed by the software. This tolerance varies with altitude and between aircraft types (refer to your applicable FCOM). When you are relatively new to VNAV, it is worth varying the thrust or deploying speedbrake, as applicable, to maintain the airspeed within 5 to 10 knots of the programmed descent speed. However as your confidence and understanding of descending in VNAV grows you will find you can allow the aircraft speed to deviate a little more before taking action. Thinking ahead to where you want to be and at what speed, will help you determine if making a thrust or drag adjustment is necessary.

Speed Intervention

Deviation away from VNAV PTH may occur as the result of an ATC instruction to maintain a particular airspeed, and this occurs reasonably often. If you are given an instruction to maintain an airspeed different to the programmed VNAV descent speed, initially select that speed in the airspeed window on the MCP (this is called speed intervention), then apply thrust or drag to achieve the required airspeed as expeditiously as possible.

In Boeing aircraft with earlier generations of system logic (Boeing 757/767/777), when speed intervention is used in VNAV then the VNAV mode will change from VNAV PTH to VNAV SPD, and pitch then controls the airspeed selected on the MCP. Because the selected airspeed is different to the programmed airspeed in the FMC, the aircraft will progressively deviate from its programmed profile (path).

If the speed difference is relatively small and timely application of thrust or drag is applied, the deviation from the programmed profile will be reduced. This is usually optimal.

In Boeing aircraft with the latest generation of system logic (Boeing 787), when speed intervention is used in VNAV then the VNAV mode will remain in VNAV PTH throughout the descent as long as the speed remains within the VNAV speed band on the PFD. Timely application of thrust or drag by the PF will assist this.

In the Boeing 787, when using speed intervention during descent, if that speed is lower than the FMC target speed, closing the airspeed window on the MCP resets the FMC target speed to the MCP IAS/MACH window speed.

If the aircraft's speed deviates beyond the VNAV speed band on the PFD, the pitch mode will change to VNAV SPD, and pitch then controls the airspeed selected on the MCP, as occurs on earlier generation Boeing aircraft (explained above). Because the selected airspeed is different to the programmed airspeed in the FMC, the aircraft will progressively deviate from its programmed profile (path).

The sooner you can regain the programmed optimum descent profile, i.e. the optimal path, the sooner the FMA will change back to VNAV PTH, which is what you generally want.

Rules of thumb that may help optimise your descent management in VNAV. These are tools you can add to your tool box:

- If speed intervention is temporary consider staying in speed intervention on the MCP. Be aware you will deviate from the programmed profile. If you intend on recapturing this profile then thrust or drag will likely be required;
- If you believe the speed change is likely to be retained for an extended period then enter this new speed into the FMC VNAV descent page. This will allow the FMC to recalculate your new descent profile based on the new speed. Don't forget to close the airspeed window on the MCP, otherwise VNAV PTH won't re-engage. It's a three step process; open the MCP airspeed window (speed intervention), reset the FMC VNAV descent speed, close the MCP airspeed window.
- Finally, if a new descent speed has been entered into the FMC VNAV descent page the new FMC calculated descent profile (based on the new speed) will need to be re-captured (VNAV PTH). Large air transport aircraft usually descend significantly faster than their minimum drag speed (the speed for best descent range/minimum descent angle), so a useful saying, to help you quickly figure out if the aircraft is above or below the new VNAV profile is, "If you slow down then you need to go down, if you speed up then you need to go up".

Altitude Intervention

Finally, deviation away from VNAV PTH may also occur as the result of an ATC instruction to level at a particular altitude, but thankfully this does not occur very often. If an unplanned level-off is required, set the MCP altitude window to the required altitude. This will cause the aircraft to level off at the MCP set altitude. The FMA will automatically transition from VNAV PTH (or VNAV SPD) into VNAV ALT (altitude) mode when the aircraft reaches the MCP set altitude. The aircraft will consequently become progressively high on the programmed optimum descent profile.

VNAV will never descend the aircraft below the selected MCP altitude, even if the selected MCP altitude interrupts the programmed VNAV descent profile. Another way to look at VNAV ALT is to think of the ALT portion as ALERT. This should trigger in your mind that you are leveling at an altitude that isn't optimum to your programmed VNAV profile.

In the latest Boeing aircraft the descent can be recommenced by setting the altitude window to a lower (cleared) altitude and pushing the altitude selector, this will get you out of VNAV ALT and descend you in VNAV SPD.

In some earlier generation Boeing aircraft (becoming less common now), the descent can be recommenced by setting the altitude window to a lower (cleared) altitude and either re-activating VNAV through the FMC VNAV page, whereon it will engage in VNAV SPD, or selecting FLCH or V/S. If you are using FLCH or V/S and intend on using VNAV again then you must ensure VNAV is armed.

VNAV SPD will change to VNAV PTH when it is within tolerances to capture the original or re-programmed path. To re-capture VNAV PTH from above you will almost certainly need to increase the rate of descent by increasing airspeed, reducing thrust and/or increasing drag. Often the sooner you recover or reprogramme the descent profile the better.

Descent in other than VNAV

If you have been vectored well away from your LNAV track, the result will be a significant increase or decrease of the lateral track miles, which will lead to the aircraft being low or high on the programmed profile. Consequently it may no longer be reasonable to continue descending in VNAV.

Until you are completely comfortable with what VNAV is trying to achieve it is probably smart to only use VNAV when LNAV is engaged. If, due to vectoring, you are required to fly an MCP selected heading mode then descending in a descent mode other than VNAV, such as V/S or FLCH, should be considered.

When V/S or FLCH are selected the MCP IAS/MACH speed window opens automatically. An appropriate manually selected airspeed, or ATC directed airspeed, should be set in the MCP speed window. This airspeed and an appropriate thrust/drag combination will allow you to control your rate of descent to meet your new target descent profile.

This occurs relatively often, especially at certain airfields which you will become familiar with. When it does occur you should monitor and control the descent of your aircraft by using mental air plot, exactly as you did when you were flying less sophisticated aircraft. The tried and trusted three nautical miles per thousand feet, at a rate of five times the groundspeed, still works well in these larger aircraft. In fact, as you become more confident descending in VNAV you should be cross-monitoring the descent using mental air plot at all times.

Summary

In many situations VNAV is an excellent automation mode and will assist your workload in the descent and arrival phases. However it is your responsibility, both as PF and PM, to recognise situations where VNAV will not assist the descent and a lower level of automation, i.e. flight through the MCP, is required.