THE GOING DOWN BIT

PILOTS new to the 757 will quickly find out how to make the FMC VNAV modes do what they want as far as climb and cruise are concerned. These cases are 'open-ended', meaning that there is no specific final target point specified.

The descent is different. It must end over the runway threshold at 50 feet agl in the landing configuration at Vref + whatever. As soon as an end-of-descent point is specified, the FMC works back to calculate the point at which the descent should be started. Usually, selection by PF of an approach procedure at destination will generate a final fix (with speed and altitude) and a centre fix a little further out (with usually only altitude specified). If no other inputs are made, the FMC will calculate an idle thrust descent path at the *default* (in other words, pre-programmed) descent speed schedule, assuming decelerations at the default schedule, to achieve the final fix speed and altitude. Of course these schedules can be modified by inputs from PF, such as standard Britannia descent speeds and engine anti-ice requirements.

In an ideal world, then, the aircraft could be left in VNAV PATH for the cruise and the entire descent to final fix, with the engines at idle thrust throughout and PF calling for flap selections in accordance with the speed commanded by the orange bug on the ASI. Reality is harsher, of course. It is doubtful that any 757 anywhere in the world has ever followed the descent path described above. To start with, the actual wind encountered is unlikely to match exactly the model assumed by the FMC program, which means that there will be airspeed variations when the pitch attitude changes to hold the path. Secondly, you are likely to be forced to deviate from your ideal path by ATC requirements.

Fuel economy

Up to top-of-descent, your opportunities to save fuel once airborne will have been largely limited by external factors, in that the speed and level you fly at and the route you follow must meet ATC requirements. The same is also true in the descent, but within ATC constraints you will have greater control of how you fly the vertical profile, and therefore greater control over your fuel burn. ***A sloppily flown approach can easily waste the fuel that several other***

more diligent crews have saved between them by taking more care. Unnecessary level flight at low level is particularly wasteful.

Programming the FMC for descent

Fuel-saving in the descent starts during the cruise, when you are programming the FMC. To start with, take the trouble to stick the forecast winds into the descent page. When you have selected a STAR and approach procedure, remove any unnecessary vertical constraints, including the hard heights on the approach (other than the final fix, of course). In this way you will be constructing a minimum thrust vertical path.

The real world

If the actual wind encountered doesn't match exactly the estimates you inputted into the FMC, there will be airspeed variations when the pitch attitude changes to hold the path. Speed loss will be countered by the autothrottle signalling a thrust increase. On the other hand, a build up in speed will make the aircraft jump out of the path if it gets too close to limiting Mach or IAS. You'll then see VNAV SPD annunciated and a path error on the DES page.

Of course, later in the descent the aircraft may sink back onto the path, in which case VNAV PATH will re-engage. Otherwise a higher than programmed speed (VNAV with intervene or FL CH) and or speedbrake will be needed to regain the path. Remember to cancel the intervene if you capture the path from VNAV SPD mode.

If ATC constraints are specified in STARs, and traffic is light, you can contribute to fuel saving by asking ATC if you can be released from these constraints.

Today, amazingly, it's all working out fine, the aircraft trundling down the programmed path at the programmed speed, engines slumbering at idle thrust. What could possibly go wrong . . .

'BRITANNIA 757, CLEARED DESCEND LEVEL TWO THREE ZERO, CROSS EDINA LEVEL TWO NINE ZERO OR ABOVE, EXPECT LEVEL ONE FIVE ZERO TWO ZERO MILES BEFORE PATSY . . .'

No, the air traffic controller is not a sadist. It's just that he has a dozen aircraft apart from you to keep out of each other's way in a small chunk of sky. So much for that perfect descent profile.

What you do, of course, is to type the constraints against the applicable waypoints on the LEGS page. But before you do so, if you have the time, take a look at the difference between the profile demanded by ATC and the original FMC profile. If there's no great difference, no extra modification is required. The FMC will draw straight lines between the vertical constraints and tell you if you are above or below this new path.

But suppose a constraint is well below the ideal path. The new FMC path after the constraint will be shallower than normal, requiring engine thrust to maintain speed and so wasting fuel. Here's a way round this problem:

- as you approach the constraint, hit FL CH
- DELETE the constraint on the LEGS page

Deletion will result in the FMC computing a new idle descent path back from the next constraint or end-of-descent point. Of course, you will now be below this path. By selecting FL CH, you keep the engines at idle thrust and thereby ensure that you will comply with the altitude constraint.

After the constraint, fly (preferably) level or in a gentle VNAV SPD or V/S descent (depending on ATC requirements) and allow the aircraft to pick up the new idle thrust path. If you are in ALT HOLD or V/S you must use your judgement as to when to hit VNAV again as you approach the path. What must be avoided is unnecessary early descent followed by extended level flight at low altitude. Your fuel will disappear at an alarming rate—besides being wasteful, you may also be eroding your diversion capability (diagram A).

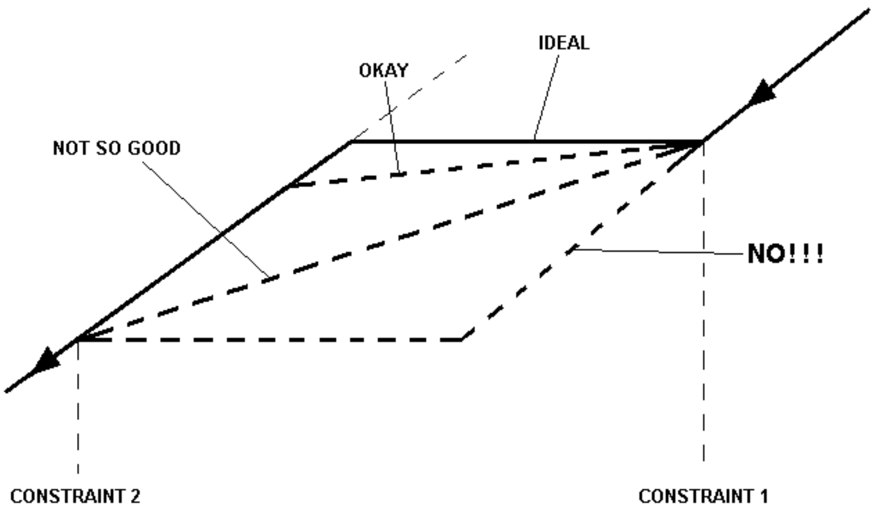

DIAGRAM A

If the constraint is above your ideal profile, consider allowing forward speed to bleed back (subject to ATC requirements). This will keep the engines at low or idle thrust for longer and will also prevent build-up of excess total aircraft energy, so that regaining the ideal path and descent speed after the constraint is passed can be achieved without recourse to pulling the speedbrakes.

'. . . Proceed direct to . . .'

The chances of you following exactly the route you programmed into the FMC are probably less than the chances of winning the National Lottery. If you are in VNAV PATH and then change the route the autopilot will revert to VNAV SPD mode and the autothrottle to THR HOLD while the FMC computes the new path. If you are above this path you will then see IDLE and VNAV SPD or, if below, EPR and VNAV SPD. If by some miracle you are actually on the new vertical path you will see IDLE and VNAV PATH re-annunciate.

As already suggested, if you are below the new path, get yourself back onto it as soon as reasonably practical. If you are above it, you don't have to immediately plummet back onto it—you can tolerate a little excess height. How much excess? As a target, add a zero to your miles to go. If, for example, you are 60 miles from touchdown you can tolerate being 600 feet above the ideal path at this range. Of course, as you get closer you will need to ensure that this path error is gradually reduced, and you must allow for the extra distance required for deceleration if flying at higher speeds than standard.

To summarise: to be a little above the ideal path is much more fuel-efficient than being below it, even if a touch of speedbrake is needed later.

FMC - master or servant?

As you know, FMC stands for Flying Made Convenient. And that is the point—this thing is your servant and not your master. If the effort involved in re-programming it outweighs the benefits then leave it alone. As the descent progresses the workload increases for both pilots and it is not a good idea to be too wrapped up in punching CDU buttons. Both pilots need to be aware what is happening outside the aircraft. Drawing pretty lines on the HSI is no good if meantime the aircraft is about to plough into a CB. And while TCAS is a godsend it will not tell you anything about intruders without transponders. Look out of the window!

Because of the variables described above, most pilots prefer to use FL CH below 10,000 feet, because they then have direct control of IAS. At fixed IAS descent gradient is controlled by engine thrust or speedbrake. As long as you have a reasonable idea of miles to run and you can do your three-times table you can assess your vertical profile keeping yourself:

- if you are geographically close to the purple route line on the HSI, check the path error on DES, and also distance to go on PROG. This number, multiplied by 3, will tell you roughly how high in hundreds of feet you should be (but remember to allow for deceleration and for airport elevation).

- if you are off the purple line and reprogramming the FMC is too distracting, put the airport in the FIX page, assess the miles to run by factoring the direct range (or ask ATC) and then do the three-times calculation above. Localiser DME can be used the same way.

Practising this mental arithmetic will stand you in good stead for both crosschecking FMC data and profile assessment when for any reason the FMC data is not valid. Diagram B shows the ideal descent path and compares it with a nominal 3^{o} (5%) descent path which matches the extended glideslope and equates to the three-times distance path.

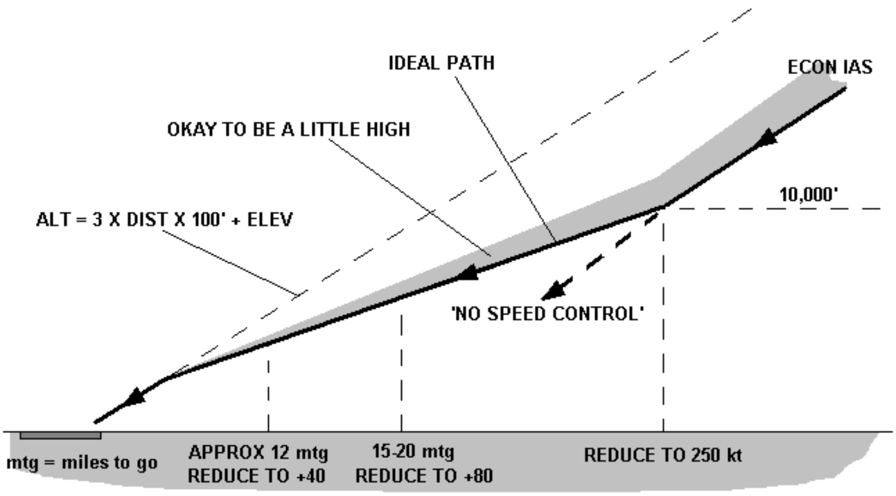

DIAGRAM B

The Boeing Flight Crew Training Manual suggests that the aircraft should be at 250 knots at 10,000 feet above airport elevation with 40 miles to run. The idle thrust path from this point until established on final approach is shallower than 3^{o} because it incorporates deceleration. Diagram B depicts a constant gradient but in reality the gradient will vary during each stage of deceleration. ***This is the area where you can use your professional handling skills to minimise fuel burn***. Diagram B shows suggested ranges for initiating each stage of the deceleration.

Get those mountains out of the way

Many destinations are surrounded by high ground—very picturesque in the holiday brochures but an added complication in descent planning, particularly in IMC. If you are expecting a visual approach, program the FMC accordingly—it is quite acceptable to construct a profile below MSA. If you susequently encounter IMC you will of course have to abandon your FMC profile. If an instrument let down is likely, then incorporate the MSAs into your profile to start with. In other words, ***program the FMC according to what you actually expect to do.***

If circumstances demand an above-ideal profile because of terrain or ATC requirements, give consideration to slowing down earlier to avoid 'over-energising' the aircraft. In other words, try to control the **total** aircraft energy (speed and height in combination). But caution: in busy skies ATC will not thank you for slowing down without approval—they may have to fit you into a stream of arrivals and departures. In case your response is 'so what?' bear in mind that one day it may be you that has to go around because some other twit ignored ATC speed requirements.

'. . . No speed control . . .'

Great! A chance to show off! But don't forget total aircraft energy. You'll have to get rid of all that momentum at some stage. Flashing around at Warp 5 might look impressive but, unless you are very sharp and very careful, there's a good chance you'll end up with a red face. If you capture the LOC at speeds above Vref+80 the autopilot will take its revenge by fishtailing down the approach. Sedate airspeeds give you more thinking time and more flexibility in flight path control. And what about that Cessna 152 drifting past the airport with his transponder switched off? If only you'd seen it earlier . . .

To summarise: the ***closer*** you are to the airport or the ***lower*** you are, the ***slower*** you want to be going.

Oh no . . . we're above the glideslope!

Busy airport—single runway—ATC doing their best to get flights in and out without holding anyone up. The radar controller's vectors might turn you onto the localiser while you're still above the glideslope. No problem: get some more drag out. But suppose you then capture your last cleared altitude before you get onto the glide. An ALT CAP is the last thing you need at that point. Here's a solution:

- once you have captured the LOC and if you are ***absolutely sure*** you're above the ***genuine*** glideslope (by cross-checking range information), arm GS and set the MCP altitude window to final fix altitude. Stay in FL CH (check that speed window!) and use whatever drag is necessary to capture the GS. Remember that the task will be more difficult if you've got the TAI on. If you're not established on the GS by the time you arrive at the final fix, start thinking about a go-around, especially if you are IMC.

There is another way

In fact there are lots of other ways of controlling descent path. One possibility is FL CH, which gives you the advantage of direct control of forward speed but will require closer attention to path error. V/S is another option, but you will lose direct control of forward speed if the engines are at idle thrust. Decelerations can be done in FL CH or V/S or ALT HOLD, depending on individual preference, ATC requirements and descent gradient required. Whichever method you choose, the aim is to stick as closely as possible to the ideal (idle thrust) descent path while meeting all other operational requirements.

Remember: you are trying to avoid level flight, unless you are re-intercepting the ideal path from below after an ATC constraint or decelerating with the engines at idle thrust. After passing the last vertical constraint give yourself bonus points if you can fly a complete descent and approach without getting an ALT CAP (but not if bad weather or a difficult approach displace fuel-saving to a lower priority).

With experiment and practice you will find methods which do the trick. Don't be too proud to ask experienced pilots for their opinions. Watch them at work—you may pick up new ideas.

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