

UVA Boeing Training Session #1

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OK everyone, let's make a start, tonight is going to be an introduction to the Flight Director (FD) and Mode Control Panel (MCP). These are pretty standard across the Boeings, this will be ground work only. I will also be glad to answer any of your Boeing questions, please jump in at any time.

Q. What is LVL CHG?

LVL CHG was on the list of things to discuss tonight, and I will go right into it now. It's a very useful tool for climb and descent and is used extensively. On some of the Boeings it is labeled FLCH, on others, LVL CHG -- they are the same thing. As the name suggests this is a mode for changing the altitude level of the aircraft, but it does it in a special way that is much safer than V/S.

First I will talk about climb LVL CHG. If you set an altitude higher than current in the ALT window, then set a desired speed in the SPD window and hit FLCH, then the aircraft will climb to that altitude at that speed, but it does it in a very special way. It sets a fixed climb power, that is a constant, and adjusts speed by raising or lowering the aircraft nose using gravity to control the speed. So if the aircraft wishes to accelerate, the nose will be lowered; if it needs to slow down it will raise the nose to retard speed. If the speed is on target and as desired the aircraft will give you the best rate of climb at that speed by that nose adjustment.

Using V/S to climb can stall the aircraft, if the rate of climb selected is more than the aircraft has the power to handle. FLCH is much safer in that it will always set the appropriate rate of climb.

The nose adjusts for the speed. Think of it this way, if you are going too fast and want to slow down, then raising the nose will slow the aircraft. This is rather like putting a car on a steep hill, gravity slows the aircraft down. Likewise if the nose comes down, gravity causes acceleration. If you redial a new speed during the ascent or descent, the nose will lift or drop until the speed is captured. In a climb, a safety circuit stops the nose dropping to the point where the plane descends.

If you hit FLCH with a new altitude, and don't touch the speed, the aircraft will climb at the speed you currently hold. If you change the speed in the speed window at any time, before or when FLCH is active, the aircraft will adjust to that new speed. This is great if ATC asks you for best rate of climb, at say 300kts. We set FLCH at 300kts and the nose gives us best climb rate holding that speed. But here is the really important take-home point, FLCH always adjusts to a safe nose position. For instance, close to the ground FLCH might give you a climb rate of 4000 fpm. But as we get higher that rate cannot be sustained and FLCH will adjust the rate of climb, to say 700 fpm at above 30,000 ft. It always adjusts through the climb to the best climb rate without running the risk of a stall, purely using gravity at a fixed engine power.

This also is good for the engines, they don't throttle up or down as you climb, they stay at one output level -- better for passenger noise and engine wear.

To quickly cover the descent, which is simpler, an FLCH descent brings power back to close to idle and again uses gravity to maintain a speed. The rate of descent increases if the aircraft needs to accelerate and shallows to slow down. The Boeings with the current FLCH software can stay within 5kts of target speed all the way from cruise alt to ground in FLCH, no overspeed, no need for speedbrakes.

Q. What about the method of descending as quickly as possible to within 1000 ft, at fastest possible descent?

That used to be taught on the older airliners, and is logical to get down when you can. Simply put, a steeper path is more fuel economical, using gravity again rather than engine power, a "big glider mode". But with some of the approaches now in use that is not always possible, VNAV can compute a variable path to match the STAR. So in reality, because of ATC limitations and STAR limitations VNAV gives the best result.

FLCH will always fly to the speed in your speed window so check what is in your speed window when you engage the mode and change it if you need to. When you engage FLCH it will put either the target or actual speed in the window, so if the aircraft was accelerating to a target speed when you engage it, it will still go for the target. If speed was static, then it will use that.

Note, there is no reversion back to VNAV once your target altitude is reached.

Q. What kind of descent rates can you expect with VNAV?

OK, that is dependent on altitude, winds and current speed. Typically at high altitudes, you get around 2500 fpm, whilst holding a speed at low altitudes you only get around 1200 fpm. Using speedbrakes in level change mode can increase the descent rate, as the drag allows the speed to remain constant at far greater rates of descent in FLCH. Always think gravity, letting the aircraft fall to accelerate, or lifting the nose up to climb that hill, gravity is the real key to the mode.

Q. What about runway length requirements?

OK, in the real world we have a performance book for every airport runway we fly into. In the real world what we do is reference the charts in the book giving our weight, winds, weather and the book then tells us how much runway is required. We reference this for takeoff and landing. You can go to the Boeing site, and get a simple performance chart with runway requirements for each aircraft of the fleet. It assumes a sea level runway, but you can interpolate from that, and it is a good guide.

If you think of normal landing weights for a 767 you need about 6000 ft to land, likewise for a 747, and 5000 ft for a 737 and 757 -- that is at landing weight with just the usual landing fuel and reserve. For takeoff, on a 747 at maximum takeoff weight at sea level you need about 13000ft, for a 767 you need 11000 ft.

Sometimes we have to leave cargo behind to get airborne, even at places like LHR, as the more weight we lose the less runway we need obviously.

Q. What is the LNAV intercept logic?

The 747 is slightly cleverer than the 767 so I will cover both, the 737 is the same as the 767.

First off, with the 737/767 LNAV will only engage if the first waypoint of the route is on a runway heading or within 3 nm of the runway. If this isn't part of your route, you need to fly HDG SEL until you are on the magenta line. Once on the line, then engage LNAV. On the 747 you can actually ground engage LNAV, and it will engage anywhere within 10 nm of the airfield. LNAV will not engage after 10 nm from takeoff, then you have to do as above with HDG SEL.

On the 747 there is no requirement for the first waypoint to be on a runway heading, it is purely a matter of distance from the airfield. If you miss your chance to go LNAV, then use HDG SEL to get yourself to the first waypoint, or the magenta line to it, then engage.

On the 747 we have a company SOP that if we are on a fixed SID, we arm LNAV on the ground at the gate.

Q. What is pressure altitude?

Pressure altitude is the indicated altitude when an altimeter is set to 29.92 in Hg (1013 h Pa metric). It is proportional to the density of the air and relates to the ability of the air to generate lift. As such it is used in aircraft performance calculations.

When you are flying above the transition level altitude, you set your altimeter to normal sea level pressure, so then you are actually flying the pressure altitude.

Q. Do you have to arm VNAV?

No, and often I don't use VNAV on departure if I want to fly manually. I often fly manually and use LVL CHG to give me a speed, here is a tip on that. If you fly a departure with a sharp curve, using VNAV can fly the aircraft too fast for the curve and you will go wide of the course. So what we do instead is use LVL CHG at flaps up speed plus 10 kts, until we get around the corners, and then engage VNAV and accelerate. This stops the aircraft oscillating left or right on the path. It is also possible to adjust your target climb speed in the FMC to slow the speed, but it is easier just to use LVL CHG.

Someone mentioned step climbs earlier and I want to point something out. When doing a step climb of 4000 ft or less we tend to use V/S rather than LVL CHG or VNAV. We set a VS of 700 fpm, this gives a much smoother climb and a gentler level off. In climb that's at a constant climb power, in descent that's at idle.

Takeoffs

I would now like to discuss takeoffs.

How many of you know what V2 is?

And here is another question, what do you all put in your speed window on the ground ahead of takeoff?

I have noticed on the forum that many people put 250 kts in the speed window on the ground. For those of you with an FMC payware aircraft., what we actually do in the real world is put V_2 in the speed window.

For those of you who are unsure, V_2 is our safe climb speed. This is defined as the speed at which we can climb if we lose an engine. So we always put V_2 into the speed window, and that we get from the FMC or performance tables. When we take off we climb at V_2+10 to 20 kts until we reach "acceleration height".

At acceleration height, which is company specific (in our case 1500ft above ground for VIR and UAL), we accelerate and retract flaps.

Now here is why we put V_2 in the speed window – it's for the flight director bars on the primary flight display. I am sure you have all seen them, the two red crosshair bars or single chevron. On takeoff, the horizontal pitch bar will show you how to raise the nose to get V_2+10 .

Raise the nose until that bar is central and that will give you the correct rate of climb and speed. Now, this is not fully correct, the FD adds 10kts as a safety margin on takeoff and the bar gives speed window +10. So adjust your pitch to keep that bar central and you're right on the speed without any requirement for autopilot.

Once you get to acceleration height, you can press VNAV and LNAV without switching the autopilot on. Then the FD bar will show you the correct pitch angle for VNAV, and the vertical bar will move left or right to show you whether you need to turn left or right for your track. So if you keep both crosshairs centered, you're climbing at the right speed, and on the route of flight and VNAV, LNAV will automatically move the bars for you to follow. You can fly the whole flight "on the bars" as we call it.

If you want to use autopilot, on a Boeing, what happens is this. You press CMD and the autopilot engages, what the autopilot does is follow the bars! So when you press an autopilot mode, you are adjusting the bars and the autopilot follows the bars.

This is why it's called CMD, you are "commanding" the autopilot to follow the bars. So it's an important thing to remember, the autopilot modes VNAV and LNAV drive the flight director bars and CMD follows the flight director. This means that you can fly partially automated by just following the bars without CMD being on, and we would normally do this until flaps are up.

This is mandatory on the 737 and optional on a 747/767 as the 737 VNAV system will burst the speed for the flaps whereas the 747 and 767 will not accelerate above current safe flap speeds

The last thing on CMD is that you will notice you have 2 or 3 CMD buttons. This is for multiple redundancy. In the normal course of flight there is no right or wrong one to engage. Each airline has its own preference. For autoland, all of them engage simultaneously this is because all three autopilot systems reference each other to double or triple check your position and altitude. If there is disagreement autoland is not allowed.

AutoThrottle

One thing that may surprise you all, on the 747, 767 and 737NG the aircraft are "TBW" - throttle by wire. The throttle levers are connected to the thrust management computer. On the original 737 classics and the older Boeings the thrust levers went straight to the engines. If you were lined up for takeoff on a 737-400 and applied full power, you would blow up the engines!

So the throttle by wire system was introduced -- in effect you always have autothrottle engaged on the newer Boeings. If you apply full power, the computer will disallow any over power. Every movement on the levers is checked by the computer for safety, this is even with the autothrottle switch OFF.

You can override the computers. On the overheads or throttle quadrant you will see switches called EEC. This is Electronic Engine Control, if you switch the EEC switches off, you lose all protection. This is only done in the direst emergency and is a fireable offense if done without reason!

So when we apply power for takeoff, the power you actually get, even if on full throttle forward is the takeoff power in the FMC. You can see the computed power in green digits on the engine display. Throughout all phases of flight, power is limited by the EEC system.

On a 747 this is taken further, if you overspeed, the engines will automatically reduce down, regardless of where you put the levers. If you idle the power and the speed drops close to a stall, it will apply autothrottle to keep a safe speed. This is regardless of whether you have the A/T switched on or not, it is called "alpha floor protection".

So in reality we always have autothrottle, but the switch links the autothrottle to the autopilot modes when engaged and armed, this allows the autopilot to command a speed or power.

As an example, let's go back to FLCH. If we engage FLCH with the A/T switch on, the autothrottle commands climb power which is a fixed power. We can also command fixed power output by pressing a switch called N1, EPR, or THR.

This gives a constant maximum power for the current phase of flight, although these switches are now used quite rarely. On the 767 you can press N1 on the runway and the aircraft will accelerate to takeoff power, this makes it act like a TOGA button.

The SPD button allows you to set a required speed, and the autothrottle system will aim for this speed, there is no guarantee you will get there – if you are climbing too steeply for example. This is again why we use LVL CHG, rather than VS and SPD.

The set speed is a target speed only, and if the aircraft is inappropriately pitched, you might never achieve that speed or you might overshoot. Many airlines make it policy that speed mode will not be used except on final approach.

Policy generally dictates that climbs will be done on VNAV or LVL CHG, and that cruise will be held by VNAV, descent in VNAV or LVL CHG. So speed is only used when going through flap speeds on final approach or following an ILS. It is considered dangerous otherwise because of no guarantee it will be achieved or held.

We also use VNAV in holds to maintain speed, but what we do is use VNAV speed intervention. Pushing the speed intervention button whilst VNAV is active allows us to give VNAV a new speed.

So for safety's sake, when not hand flying, we orbit a hold in VNAV with speed intervention rather than ALT hold and SPD.

My airline allows us to use V/S and SPD in the approach phase, for instance when descending to approach altitudes. But other airlines will not even allow SPD to be used then, and insist on VNAV or LVL CHG all the way to the localiser.

For my airline, we can use it in the last stages of descent, to meet restrictions, but that is it. If I try and climb with VS and SPD then I would be fired.

It is also policy for us to have the autothrottle armed at all times even if not in use.

A nice 747 and 767 feature is this – even if you're hand flying, recycle the A/T off and then back on to arm it, so it is showing as "ARM" on your PFD. Then on final approach, even with your hand on the thrust levers the A/T will provide gust protection and will compensate for gusts and crosswinds working with your hand movements.

This is modeled on the PMDG 747, but not the LDS 767.

This is taken even further if you want to land on ILS tracking in APP mode, on the 767 and 747, always engage all autopilots even if you wish to land manually. Set up for an autoland and the autothrottle system goes into full autoland protection mode offering even finer control and more safety modes.

It is fine to disengage the AP later still and land manually, we use the autoland mode just for the throttle safety modes. If any of you have our 747 DVD from VIR, you will see that all 3 AP's are lit even though Alan is given a visual approach and he later disconnects, this is purely for the A/T modes.

Q. When do you switch the A/T off?

OK, there is no rollout on the 737, so always off at 50 ft AGL, on the 747 and 767 this is airline SOP and varies. Some airlines have you retard in the air on the 74 and 76, others will allow the A/T to flick off on the ground in rollout, its purely an airline thing.

I disconnect at 50 ft AGL, unless in autoland obviously. For CAT3 we do a full rollout. On the 73, 76 and 757 the A/T is not permitted with engine out and will usually disengage. On the 747 and 777 there are compensation tools which still allow the A/T to be used.

On the 777, if it loses an engine on takeoff, it doesn't even lose the centerline. There is a thrust asymmetry computer that kicks in within 0.5 sec to keep the aircraft straight. In fact, 777 pilots only know they lose an engine from EICAS messages!

Q. Things you may not remember to check on pre-flight.

Alternates; cruise altitude against weight? The PMDG and LDS will give you a chart in the docs that gives you a cruise altitude for each weight, which you can crosscheck against the FMC optimum. If you go to the FMC and press VNAV, then page 2 you will get OPT and MAX altitudes. Then once you know your best altitude from the aircraft point of view, check against the winds.

Sometimes the OPT may have adverse winds. Also, don't forget to set up your nav aids even if flying on automatics. I also put FIXES in the fix page, heading on wheels up, and other SID issues.

Q. How can you set an extended runway center line waypoint?

You can enter that as a leg. If you want a waypoint on the centerline from a runway, and the runway is ILS equipped you can do this: IRR275/10 (using the name of the ILS, then heading / distance) and that can be used as a leg. I used to do this when flying the 737 to LNAV from takeoff by creating a fix at the end of the runway.

This can also be used on an ILS approach, so if we want to set up inbound fixes on a centerline for stepdowns we reverse the radial and that puts waypoints inbound to the field. So to set a waypoint on the arrival to 27R at Heathrow IRR095/-10 would set a waypoint 10 miles back from the threshold. Remember to reverse the course as it's course FROM the ILS.

This is great on localiser only approaches, as we can set waypoints down the centerline, and then give altitude restrictions and VNAV it down.

Q. What is the rudder ratio on the upper EICAS?

The rudder ratio is the hydraulic autotrim setting for rudder alignment, the aircraft automatically adjusts rudder during flight, when in autoflight if there is a pressure failure the ratio will change.

Thanks everyone! Hope it was useful.

Next week another GA, then we will talk about overhead systems the week after.

If anyone wants Airbus info, please let me know, I can provide that too.

Jane, you are a treasure trove of information, and you're very kind to spend the time!

I'm always willing to help the VA.

That you are, and it is much appreciated!

Thank you all, I appreciate your all taking the time to turn out, and good night all.