

LNAV & VNAV Integration Review Basics

By Lionel Largmann
(Edited and reviewed my anonymous sources)

HDG / LNAV:

1. How can we control the lateral guidance of the B747 in-flight?

Two primary Roll modes are used:

- **HDG SEL** --- Heading Select --- Rolls the aircraft to desired heading
 - This mode is a non-integration mode
 - You manually control your own heading
- **LNAV** ----- FMS controlled ---- Maintains a lateral track (Magenta line)
 - This mode is an integrated mode
 - FMS controls the course guidance as selected in the FMS

V/S / FLCH / VNAV:

1. How can we control the vertical guidance of the B747 in-flight i.e. climb or descent?

There are three primary modes used:

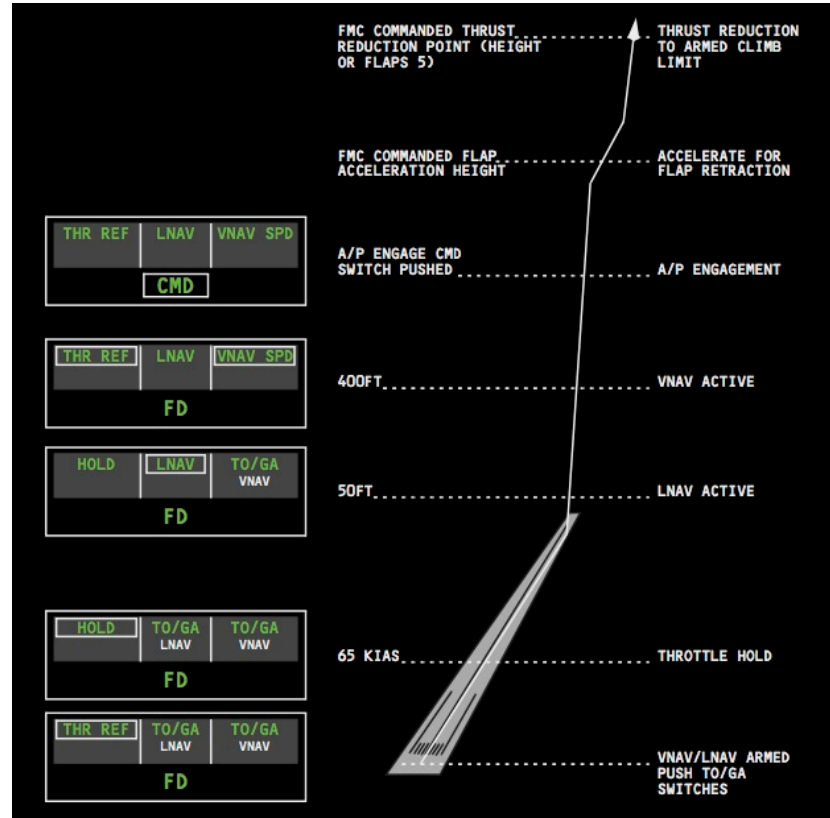
- **V/S** ---- Vertical Speed --- Pitches the aircraft to desired rate of climb
 - This mode is an *non-integrated mode* (No assistance of Auto-throttle needed)
 - Climb or descend via a selected rate in FPM
 - This mode does not respect A/S constraints
 - This mode does not provide speed protections --- (be careful)
- **FLCH** ---- Flight Level change --- Uses thrust to achieve the selected altitude in within 2 minutes. A/T's will use as much as the thrust reference and as little as idle thrust to attempt to reach the desired altitude change in 2 minutes. (Speed window opens to current speed when FLCH selected)
 - This mode is an *integrated mode* (Needs the assistance of the Auto-throttle)
 - This mode *maintains* the A/S as selected in the speed window.
 - This mode does not have anything to do with the FMS.
 - This mode only provides speed protections when both the autopilot and auto-throttles are engaged.

- **VNAV ---- V-NAV ---** Pitches the aircraft to maintain FMS phase / mode. The Aircraft climbs or descends via computed vertical guidance as inputted by the pilot. The FMS then develops a profile to meet that criterion in the most efficient manner possible.
 - This mode is an integrated mode (Auto-throttle is needed)
 - This mode provides the fastest *automated way* to climb using [THR REF].
 - This mode provides the most efficient way to climb or descend to a desired altitude within the VNAV prescribed criterion.
 - This mode will follow all FMS A/S & Altitude constraints.
 - This mode respects the A/S as selected, whether FMC computed /entered or manually selected by opening the airspeed window.
 - This mode does provide speed protections when both the autopilot and the auto-throttles are engaged.

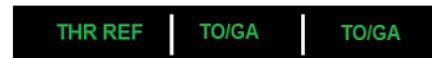
Auto throttle / VNAV Integrations:

1. Explain the vertical guidance of the B747 in all phases of flight?

Takeoff Roll Modes:



- After selecting TOGA switches thrust levers move to *thrust reference*. [THR REF]
- [THR REF] means full FMC selected thrust as seen on the upper EICAS.
- FMA displays:



(See above)

- Next, [THR REF] FMA will revert to HOLD (on T.O roll @65kts)
- [HOLD] means that thrust levers can be manually adjusted.
- **After takeoff:** if LNAV *is armed* at 50' TOGA (roll) is replaced with LNAV
- FMA displays:



(See above)

- At 250' an autopilot can be selected: [FD] is replaced with [CMD].
- If VNAV *is armed*, at 400' TOGA (pitch) is replaced with [VNAV SPD].
- **Note:** A roll mode is normally *verified* or selected at this altitude on a go-around.
- FMA: now Displays:



- **Note:** VNAV uses THR REF for all climbs

Initial Climb phase:

- Aircraft is now maintaining speed V2+10 or the speed reference up to +25kts.
- At acceleration Alt: Initially speed ref graduates with flap limit speed – 5Kts
- At flaps up, speed is now ref. from FMS to VREF + 100. (Climb phase)
- FMC changes reference thrust to CLB determined by NADP 1 or 2 profile selected.
- Climb de-rates are removed at FMC altitudes linearly from 10,000 to 15,000 feet.
- FMA still displays:



- Note: When VNAV is selected the speed window always closes and now looks at the FMC for speed guidance.
- Note: If the speed window is opened during a VNAV climb it will now honor the selected speed rather than the FMS computed speed and remains in [THR REF].

Enroute Climb phase:

Condition: --- During a VNAV climb, the aircraft levels off due to a VNAV climb constraint on the legs page. The MCP altitude is selected above the constraint. What does the FMA display?

- At the VNAV constraint the FMA displays:



- Aircraft levels and maintains FMS Alt. & speed constraint if entered.

Condition: --- What will the FMA display during a MCP level off, that is selected in the MCP altitude window *as directed by ATC* without an altitude constraint set in the VNAV profile?

- During MCP level off the FMA displays:



- When in VNAV the aircraft will always respect the MCP selected altitude.

Condition: --- The aircraft is in level flight (MCP altitude window matches current altitude), then after selecting a new higher MCP Altitude and pushing the MCP Altitude selector (once) a VNAV climb begins. What will the FMA display?

- After the MCP altitude selector is *pushed* the FMA displays:



- Aircraft begins climb to new MCP altitude (*honoring* any further climb const.)
- **Remember**, anytime you use VNAV climb we will always be in [THR REF]

Condition: --- The aircraft is in level flight (MCP altitude window matches current altitude), then after selecting a new higher MCP Altitude and pushing the FLCH button a climb begins. What will the FMA display?

- When FLCH button *pushed* the FMA displays:



- Upon capturing the Altitude in the MCP altitude window the FMA displays:



- Using FLCH will not respect any altitude constraints in the FMS.
- **Remember**, anytime you use FLCH in a climb we will always be in [THR]

Cruise phase:

Condition: --- Aircraft levels off at the VNAV cruise altitude. The MCP altitude window matches the VNAV cruise altitude in the CDU. What will the FMA display?

- At VNAV cruise level off, the FMA displays:



- Aircraft levels and maintains FMS assigned cruise speed and altitude.

Condition: --- During initial climb ATC assigns you a new cruise altitude lower than the programmed VNAV cruise altitude. **Re-cruising** is necessary to get the packs out of high flow and to achieve maximum fuel efficiency. What will the FMA display? And how do we re-cruise the FMC?

- At level off the FMA displays:



Note: We must re-cruise using the Vnav page

- Enter the desired cruise altitude on the Vnav page.
- Push the altitude selector button on the MCP...
- The FMA will now display:

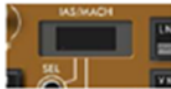


- Re-cruising successful

Descent phase:

Condition: --- Aircraft is in [VNAV PTH] in cruise flight, we now decide to select the MCP Altitude selector to a *lower altitude*. Possibly to follow a “descend via a star clearance” What will the FMA display?

- Currently the MCP / FMA displays:



- Approaching the top of descent (T/D) the VPP now appears and then the aircraft begins the descent profile and thrust levers move to Idle when the path is captured.
- At the T/D the FMA displays:

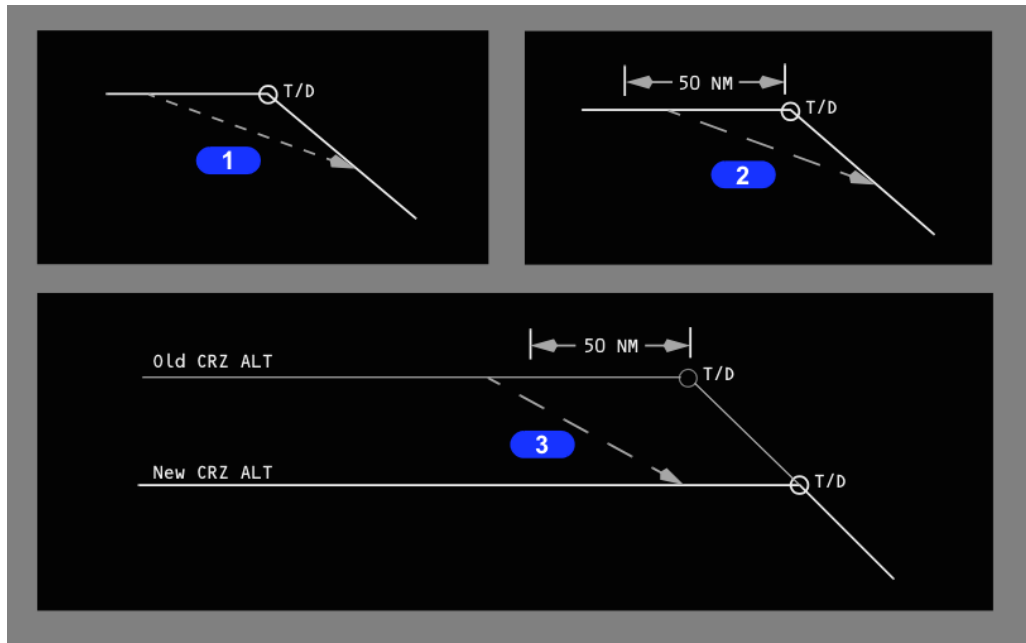


- Next, the FMA displays:



- Aircraft is maintaining FMS descent speed (A/T servos are now disconnected).

Condition: --- In cruise flight [VNAV PTH] *before* the T/D, the MCP Altitude selector is selected to a *lower altitude*, due to ATC. The Altitude selector is then pushed (once). This can be considered an early descent profile. What will the FMA display?



- If descent phase is commenced *early* by selecting a lower altitude in the MCP and pressing the altitude selector button before (T/D) then the FMA will revert to:

[THR] followed by:

HOLD | LNAV | VNAV SPD

(Picture #1)

- Descent now is fixed at 1,250 FPM rate of descent (within 50nm of T/D)
- If **outside** the 50 nm from T/D (*picture #3*) and a decent is required, pushing *descend now* on VNAV descent page, will force the VNAV mode to the descent phase. Or if you decide to push the MCP altitude selector button instead of DES NOW, VNAV will begin a cruise descent path to the new cruise altitude. VNAV may not capture the idle descent path since the target airspeed is economy cruise and the descent path is based on idle thrust and economy descent airspeed.
- Pilot can adjust rate of descent as necessary by adjusting the thrust levers.
- Once capturing the FMS computed path then the FMA will revert to:

[IDLE] followed by:

HOLD | LNAV | VNAV PTH

- Note: If in the “Path” during descent and the speed window (MCP) is closed the pitch will honor the VPP. If speed window is open the pitch will honor speed selected on the (MCP) and disregards the “Path”. This however, is *not true* for the B747-8.

Condition: --- In cruise flight [VNAV PTH] you pass the T/D and the MCP altitude selector is *not selected to a lower altitude*, due to an ATC constraint, what will the FMA display?

- The FMA displays:



- The Aircraft continues to respect the current MCP Altitude and will not descend...
- If descent is initiated after the T/D the FMA displays:



Note: VNAV will not try to regain the path on its own (drag or pilot intervention may be needed).

- Once the aircraft captures the computed FMS (VPP) profile the FMA displays:



- When thrust levers reach idle the A/T FMA will change to [**HOLD**]:



Descent phase interrupted:

Condition: --- While descending on the FMC profile (VPP) in [VNAV PTH] the descent is *interrupted* due to either an ATC clearance or pilot decision. When a MCP altitude is selected in the altitude window that stops the descent what will the FMA display?

- During level off the FMA displays:



- Aircraft again *respects* the MCP altitude and is now out of the FMS prescribed path / profile.

Descent phase Radar Vectoring:

Condition: --- The aircraft is in level flight and now we decide to descend on a radar vector off the VNAV lateral path. The MCP altitude window is selected to a lower

altitude. What is the best method to descend the aircraft off route? And what will the FMA display?

- The best method is to use **FLCH** “rule of thumb off LNAV off VNAV”
- Select: lower altitude in the altitude window on the MCP.
- Select: FLCH
- During descent the FMA displays:

THR | HDG SEL | FLCH SPD

- If idle thrust is required or the thrust levers are manually moved then the FMA displays:

HOLD | HDG SEL | FLCH SPD

- Upon capturing the Altitude in the MCP altitude window the FMA displays:

SPD | HDG SEL | ALT

Approach phase of flight ILS:

Condition: --- The aircraft is level at the MCP assigned Altitude maneuvering in roll modes [LNAV] or in [HDG] if on a radar vector. Now we are going to setup as if we are on the base leg to final and capturing an ILS approach.

- Current FMA Display:

SPD | LNAV | VNAV ALT

OR

SPD | HDG SEL | ALT

- On base: after verifying approach criteria and selecting the APP button. The FMA will arm modes under roll mode and the pitch mode. Roll mode armed is **LOC** and the pitch mode armed is **G/S**.
- Once lateral and vertical *signals* are captured: The FMA displays:

SPD | LOC | G/S

Note: --- This is a *non-integrated approach*

Approach phase of flight Non-ILS:

Condition: --- The aircraft is level at the MCP assigned Altitude maneuvering in roll modes [LNAV] or in [HDG] if on a radar vector. Now we are going to setup as if we are on the base leg to final and capturing an *integrated* non ILS approach such as RNAV-GPS / RNAV / LOC / VOR / NDB.

- Current FMA Display:

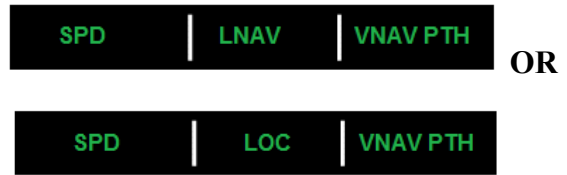


- On base and cleared for the approach: after verifying approach criteria and performing our “LVSA” arm approach acronym. We then **select “L” either LOC or LNAV** buttons. Roll mode is now armed. The FMA will now display roll modes LOC or LNAV, and this will be displayed in white until captured. After capture the Roll mode will display in green.
- Next, we select the “V” which stands for: **VNAV**. This mode becomes immediately active as the new selected pitch mode. The FMA will revert to: [VNAV ALT] in level flight and the pitch mode armed is VNAV path once approach logic is active (this is unseen).
- **Caution:** VNAV Speed window closes when the VNAV button on the MCP is selected. The speed will increase to whatever is selected on the Vnav page for that phase of flight. Re-selecting and matching the current speed with the Vnav page speed avoids such increases (technique only).
- Next, we select “S” for **SPD** by pushing the speed button after the speed window closes. This opens up our speed window. FMA displays:



- The last acronym is “A” for **altitude**; it is now necessary to select the DA(H) / MDA altitude in the MCP window so that the FMS will begin the descent on VPP at the descent point. With the VPP displayed, ensure that the pitch mode reverts to [VNAV PTH].

- Once the Aircraft descends 300' below the missed approach altitude and inside the FAF we can now select the missed approach altitude on the MCP without fear of a premature level off when slewing the altitude selector knob through the aircrafts current altitude.
- Once established on the final approach path the FMA displays:

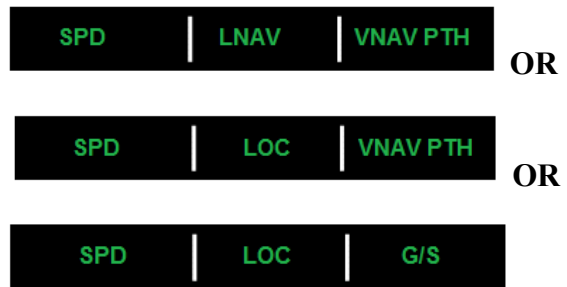


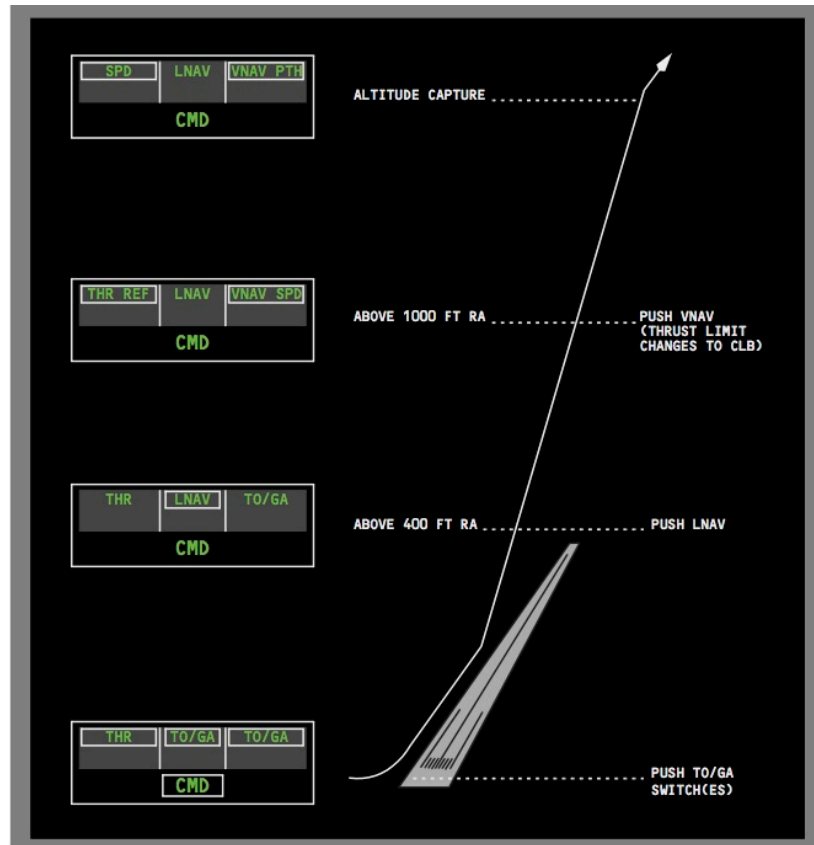
- Note: VPP comes alive at the T/D.
- Note: Once in Approach logic (*see criterion*) Three things happen. If in VNAV ALT the pitch mode can switch automatically to VNAV PTH when the VPP is centered. The speed window is opened and the pitch will remain in VNAV PTH and try to honor the VPP. Next, the altitude can now be changed by spinning the altitude selector switch through your current altitude to MAP altitude, again without reverting to VNAV ALT.

Missed approach phase of flight:

Condition: --- The aircraft is performing a missed approach; the MCP missed approach altitude is in the altitude window. Go-around TOGA switches are selected: Callout: “Go-around flaps 20”.

- Current condition prior to Missed Approach Point, FMA displays:





- **MAP:** After selecting TOGA the FMA displays:



- *Thrust:* Is adjusted to give you 2,000 FPM rate of climb.
- *Track:* A snapshot of track is taken when TOGA selected and is maintained.
- *Pitch:* Maintains present speed or MCP speed (whichever is greater) when TOGA is selected.

- **At 400' roll mode "LNAV" is selected** if following MAP procedure or HDG if on a radar vector the FMA displays:



Or



- **At 1,000' [VNAV] is normally selected** as the pitch mode for cleaning up the aircraft. VNAV speed pointer eventually moves to: $V_{ref} + 100$ after an incremental flap cleanup. If VNAV is selected the FMA will display:



- At altitude capture the FMA displays:

SPD | LNAV | VNAV PTH

(See previous page diagram)

- If on a RV (radar vector) our roll mode would be [**HDG**]. If this is the case, [FLCH] as a pitch mode may be used if desired. But remember, the SPD window will open and maintain the current speed at the time of [FLCH] selection. Slewing the speed switch is *necessary* to get the aircraft accelerating for flaps cleanup. The FMA in this scenario will display:

THR | HDG SEL | FLCH SPD

LNAV & VNAV Integration Review Advanced

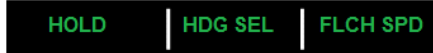
Now that we talked about the basics of LNAV / VNAV and how the auto-throttle functions in various modes of flight now lets look at some advanced integrations in various flight regimes.

1. What happens when we are in a descent with a lower MCP altitude selected in the MCP altitude window and we decide to go against the Flight Director and attempt to level the aircraft off manually (auto-pilot disconnected) before capturing the MCP altitude?

- Current FMA displays:

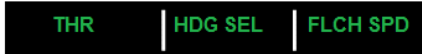
 Or

 Or



- Aircraft is being leveled-off manually (by the pilot / *auto-pilot is off*)
 - Airspeed will *decrease* because the pitch was controlling airspeed and you are pitching away from the flight director. (Flight director will indicate an attitude lower to direct a pitch to maintain commanded airspeed)
 - The auto-throttles are controlling the rate of descent and disregards airspeed.
 - **Warning:** chance of a stall can occur... Even, if the *auto-throttle is still active* (which in this case it is, the aircraft will stall, you are not using the pitch to control the airspeed and it is not the auto-throttles job to do so.)
 - Note: if aircraft captures MCP altitude then the auto-throttle mode will change to [SPD] and will use thrust to protect you from a stall
2. What happens when we are in a climb and decide again to go against the Flight Director and attempt to level the aircraft off manually (auto-pilot disconnected)?

 Or



- Flight director indicates a pitch up attitude is necessary to continue the climb.

- Aircraft is being leveled manually
 - Airspeed will *increase* because aircraft has not arrived at the selected MCP Altitude.
 - An *over-speed* will occur.
3. If we turn off both Flight Directors in level flight and the auto-throttle is turned off how do we re-establish Flight Director functionality?
- Both Flight Director switches are selected on.
 - The FMA mode that immediately activates if in level flight, FMA displays:



- If in a turn, the FMA roll mode will display [ATT].
 - Activating a pitch mode: [VNAV or FLCH] push buttons with Auto-throttle armed will activate the auto throttle immediately and [SPD] mode will display. Again, we are in level flight the MCP altitude matches the aircrafts current altitude.
4. How do we regain the TOGA mode after entering the non-active or dead zone?

Condition: Disengaging an auto-throttle in a critical phase of flight.
 If Auto-throttle is disconnected just prior to landing (2 seconds below RA 5') or after touchdown and subsequent go-around (3 seconds past RA 5') you must remember that this is the dead zone for TOGA activation. Therefore, thrust must be *manually advanced to Go-around thrust* and the TOGA switches will not work. After leaving the dead zone TOGA must be re-selected again to activate the Go-around mode of the FMS and to put it into the Missed approach phase of flight. --- Next, commence with normal MAP procedures.

5. What three purposes does the altitude selector push button have (when pushed)?
1. If in VNAV a climb or descent is initiated
 2. Deletes FMS constraints that are between the aircrafts altitude and the MCP altitude
 3. Resets cruise altitude to the MCP altitude if the MCP altitude is higher

6. When does the Altitude selector need to be pushed and what happens if we push it arbitrarily when not needed?
- If in [VNAV ALT] or PTH in level flight and a climb or descent is desired.
 - VNAV will honor all constraints so if it is pushed more than once subsequent restraints will be deleted in the FMC legs page. (Only constraints between current aircraft altitude and the MCP altitude can be deleted)
 - Aircraft will level off at the FMC cruise altitude entered in the FMS during pre-flight. If a higher altitude is assigned and no constraints exist between the aircrafts current altitude and the higher MCP altitude, then by pushing the button again in this case will reset the cruise altitude to the higher MCP altitude.
 - Caution must be taken in all cases when pushing the altitude select button (don't push it if you don't have a reason to do so).
7. Does the altitude selector switch need to be pushed when using flight level change?
- No in this case after selecting the new altitude in the altitude window, one only needs to select the flight level change "button" on the MCP to begin a climb or descent.
 - Note when in FLCH: pushing the altitude select button will still delete altitudes between current altitude and MCP altitude
8. What happens if I select Climb direct / Descend direct button in the VNAV pg. of the FMC?
- All constraints between the aircrafts present altitude and the altitude selected in the MCP will be deleted in the FMS Legs page. And the aircraft will either climb or descend without regards to any constraints.
 - Note: If vectored off route it is best to use Flight level change and not use VNAV, otherwise if rejoining the arrival constraints can be deleted when using this function.
 - Secondly, if you stay in VNAV on a radar vector the aircraft may level off at a constraint programed in the FMS legs page when not desired, even though a lower altitude is selected in the Altitude window of the MCP.
 - Good rule of thumb: **Off LNAV get OFF of VNAV******* it works!

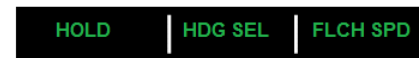
9. What happens if we are in VNAV and ATC gives us an immediate level off during a climb? (Altitude assignment is above current altitude)

- 1st Select ALT Hold switch on the MCP
- 2nd Re-select altitude window to new ATC assigned altitude
- 3rd Select FLCH
- After altitude capture the FMA will display:



10. What happens when you are in a climb (e.g. climbing through FL180) and have not reached your FMS cruise altitude and you want to return back to the airport of departure or some other airport due to some abnormality. How can this be done?

- The FMS is still in the climb phase because the aircraft has not reached its cruise altitude
- Re-select altitude window to new lower ATC assigned altitude
- Select: FLCH
- During descent the FMA will display:



- After reaching assigned altitude the FMA will display:



- **Note:** A VNAV descent in this situation is not possible. FLCH must be used because the FMS is still in the climb phase.

11. What happens when you are in a climb and we need to level the aircraft off within 2,000 feet of the transition altitude with a *low QNH* i.e. 29.70 inches / 1006 mb or less, what is the prescribed method to do this?

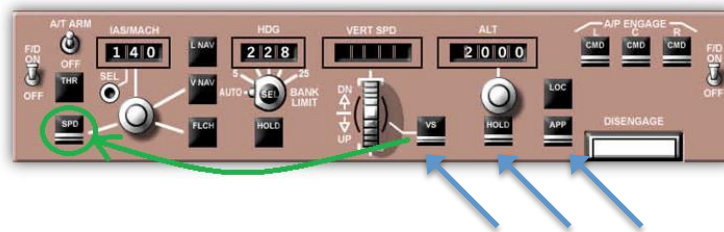
- After selecting the altitude in the altitude window on the MCP caution must be remembered due to *low QNH*.
- Select: FLCH when leveling the aircraft off during this condition.
- Then re-engage VNAV as desired.

12. What can possibly disengage the Auto-throttle in flight?

- Fault
- Any one EEC failure (can be recovered by selecting all EEC's to ALT)
- Failure of the *active* FMC
- 2 Engines out (after the 2nd engine fuel selector is placed to cutoff)

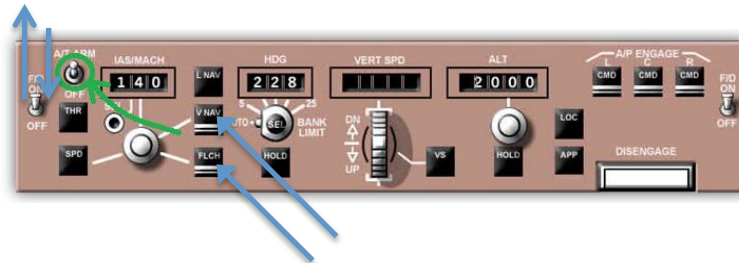
13. How can we re-engage the auto-throttle when in the non-integrated modes of “V/S” “Alt” or “GS”?

- By pushing the speed (SPD) button on the MCP



14. How can we re-engage the auto-throttle when operating in the integrated modes of VNAV or FLCH without changing the pitch mode?

- By turning the Auto-throttle arm switch **off** then **on**



15. What are the ways to regain the auto-throttle after it has been disengaged?

- By selecting a different integrated pitch mode (i.e. VNAV / FLCH). A pitch mode other than you are currently operating in.

16. What can cause us to lose all three modes: Auto Throttle / LNAV / VNAV modes?

- Loss of AC Bus #1 Or #4 will result in loss of: Auto throttle / LNAV / VNAV
- Loss of *active* FMC (but roll and pitch modes can be restored)
- Loss of all FMC's

MAP considerations:

Condition: The Aircraft is performing a missed approach. If given a radar vector or a newly assigned altitude greater than the MAP altitude by ATC ***be very careful if in VNAV*** while on the missed approach segment!

- Remember, what altitude the FMS is looking at... VNAV is looking at the MAP altitude, which is used to set the new cruise altitude, not the newly assigned ATC altitude. Thus, if a higher altitude is required and we are still in VNAV the aircraft will level off at the lower FMS MAP/Cruise altitude--- This of course would be in violation of the new assigned altitude clearance given by ATC. If you want to remain in VNAV press the altitude button again to re-cruise to the higher MCP altitude. Staying in VNAV will allow you to speed up using the FMS flap up speed profile during Flap retraction.
- Other method is to use Flight level change and increase the speed up incrementally to flaps up retraction speed and then adjust the speed selector accordingly.

Approach Logic: How do we get into it? (See CDFA / Non-ILS Approach handout)

- Approach logic is the mode needed on all VNAV / VNAV GPS / LOC / VOR / NDB / & Visual approaches if desired. It provides for us a constant FMS generated path to the E/D at the R/W point. It will allow us to descend to a DA / MDA without a subsequent level off by VNAV ALT when selecting the MAP altitude. It also allows us to open the speed window while staying in VNAV PTH.
- Approach logic is active anytime both an approach is selected and we have sequenced the initial fix of the approach (i.e. course fix). Or
- When the RWY waypoint is the active waypoint (e.g. runway extension is selected) and we are within 25nm.
- The T/D has sequenced in the descent phase 747-8
- Note: The VPP is a function of the descent phase and will always be displayed when the aircraft is in the descent phase. The T/D represents the start of the descent phase and you can expect getting the VPP after passing the T/D. If on a go-around when selecting TOGA the new cruise altitude will be set at the missed approach altitude and / or the MCP selected altitude whichever is higher. In this case when another approach is selected you would expect to see a T/D and consequently, the VPP will display after passing the T/D (i.e. in the simulator environment).

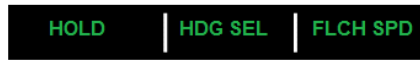
TOGA Logic:

- TOGA mode is active anytime the flaps are out of up. Or
- *Both* the Localizer and Glideslope are captured on an ILS approach.

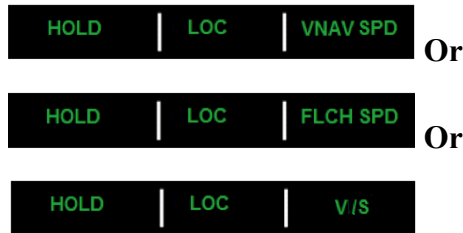
17. What happens if you are on a RV or have captured the localizer and have not yet captured the glideslope (aircraft if above the GS)? The flaps are out of up “ i.e. Flaps 1 etc.” and the TOGA switches are hit accidentally.

- Initially the FMA displays:

Radar Vector:

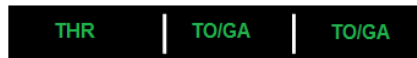


Localizer Capture:



Note: In both cases the aircraft is above the G/S and the APP button has been pushed. In the pitch column the G/S will be armed and displayed in (white)

- The *flaps are out of “up”* TOGA logic is now armed.
- The TOGA switches are hit accidentally or purposefully.
- The FMA displays:



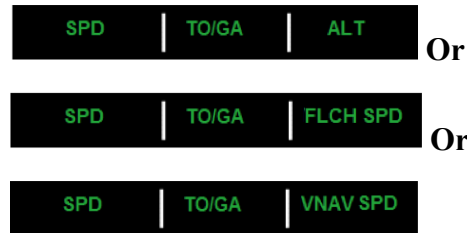
- Aircraft is out of the descent phase and is now in the Go-around mode.
- *Thrust:* Is adjusted to give you 2,000 FPM rate of climb.
- *Track:* A snapshot of track is taken when TOGA selected and is maintained.
- *Pitch:* Maintains present speed or MCP speed (whichever is greater) when TOGA is selected. If the MCP is above the current altitude when TOGA is pushed then the aircraft will climb until reaching the MCP altitude and then the pitch mode will change to ALT but the thrust mode will remain in THR.

- ***If the aircraft captures the MCP altitude in the pitch mode of TOGA then Speed will build rapidly*** and exceed the current flap placard speed unless another pitch mode is selected or SPD is selected as the AT mode.

Recovery: “As always *fly the aircraft* and make it do what you want it to do”

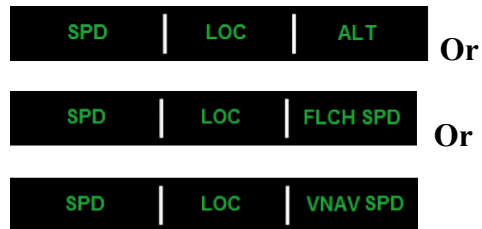
- Select a new *pitch mode*: (Altitude Hold Switch / FLCH or VNAV) if needed disconnect auto throttles.

FMA now displays:



- Re-arm a *roll mode*, approach mode (if desired) “APP” or “LOC”

FMA now displays:

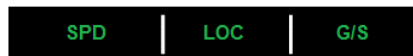


Note: In all cases above the G/S will be armed and displayed in (white) if “APP” button is selected.

- Verify a new *roll mode selected*: (HDG SEL / LOC / LNAV)

18. What happens if we are on both the LOC and GS and the TOGA buttons have been hit accidentally? Of course flaps are out of up, but remember even if they were not, we are still in the TOGA logic.

- Initially the FMA displays:



- We are on path everything is looking good then the TOGA buttons are selected prior to the missed approach point. The FMA now displays:

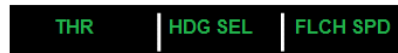


- The way to get the aircraft out of the go-around mode and back on to the ILS is to immediately:
 - Select a new pitch mode: ALT Hold
 - Don't select FLCH or VNAV because the MAP altitude is above the aircraft and will immediately climb.
 - Select a new roll mode: "APP" button push
 - LOC will capture if still within parameters
 - IF GS is now low another pitch mode must be used to regain the glide path i.e. VS.

If you decide to breakout of the ILS / LOC approach: (breakout maneuver)

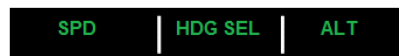
- Autopilot "OFF"
- Turn and climb via ATC instructions (looking through the FD)
- Turn both flight directors off and then back on.
- HDG Select (to desired heading)
- MCP Altitude select (to desired altitude)
- Select FLCH (push the button) --- (if VNAV selected speed window closes 240Kts)

FMA now displays:



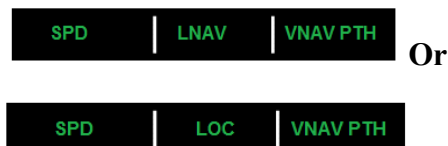
- Reaching MCP selected altitude.

FMA now displays:



19. What happens if the TOGA switches are hit accidentally during a VNAV / VOR / NDB / LOC approaches.

- Initially the FMA displays:



- We are on path everything is looking good then the TOGA buttons are accidentally selected prior to the missed approach point. The FMA now displays:



- A go-around is *recommended* if the approach cannot be continued visually because the approach phase in the FMC cannot be reacquired in a timely manner.
 - **Recognition:** The FMC has entered the CLB phase and loss of approach phase can be identified on the legs page. Whereby, the altitude constraints on the CDU displayed in large font now are displayed in small font. Thereby, invalidating the approach criteria. This means that the constraints are no long honored by the FMC.)
 - The approach must be re-selected in the CDU and the active waypoint must be extended. This may not be completed within a safe time frame to continue the approach. (See Missed Approach Procedures section for details)
20. What happens if we are dispatched with VNAV inoperative? How do we operate the automation within this configuration? Ref. DDG:
- FMC and MCP configuration and programming are normal except do not arm VNAV.
 - Normal T.O / TOGA modes
 - At 400 feet select FLCH.
 - At *flaps retraction altitude* (acceleration HT), select speed switch $V2 + 100$:
 - If acceleration height is 1,000' at flaps five push THR button on the MCP and then select speed.
 - If acceleration height is 3,000' at 1,500' push the THR button on the MCP and then at 3,000 select speed.
 - If E/O, and after flaps retraction, hit a second time the THR button to obtain *max continuous thrust*.
 - Note: If climbing or descending *via* a SID or STAR it is important to remember that you must step up or down each altitude

constraint. Make sure you strictly follow the published profile using FLCH and the MCP altitude selector.

- If VNAV is inop remember no VNAV approaches are allowed.
- Approaches allowed: LOC / VOR / NDB & RNAV / LNAV.
- If a non-precision approach is used, as listed above, VNAV path will still be constructed or built and you may use V/S to follow the path (VPP)
- It is important to select the MCP altitudes to the new step down altitude as the approach commences. If shooting a non-VNAV non-precision approach 50' must be added to the MDA altitude for the approach selected.

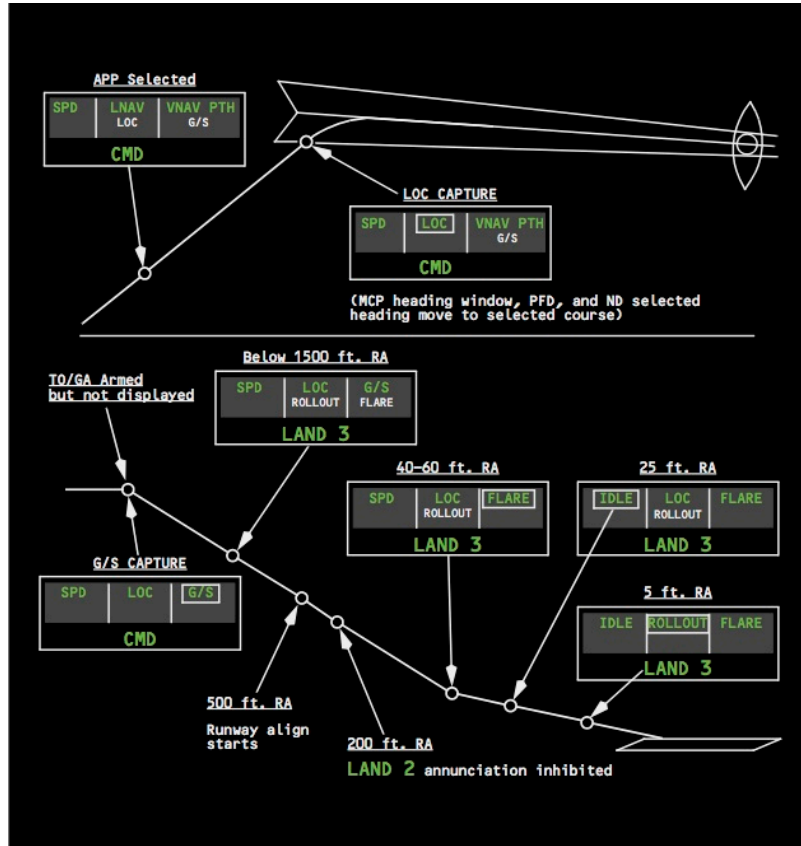
21. How do we operate the aircraft if the auto-throttles are inoperative?

- Basically, the pilot is the auto-throttle. This is commonly practiced during the 2 engine inoperative circuit and landing procedure.
- If the aircraft is on the autopilot the aircraft will neither climb nor descend to the newly selected MCP altitude unless the throttles are adjusted as appropriate.
- This comes natural to pilots when the automation is off. But if the autopilot is on (controlling pitch), then it is necessary for the pilot to add thrust to climb the aircraft in VNAV or FLCH. Conversely, if descent is required thrust must be reduced.

22. What happens if the aircraft speeds up past the TOGA activation speed of 50 knots? What must be done and will the auto-throttles become active again?

- If the auto-throttle is not activated by 50 Kts. airspeed then the TOGA switches will be unavailable
- Thrust levers must be manually adjusted to the takeoff thrust reference limit [THR REF] on the upper EICAS.
- After takeoff (assuming VNAV is armed) the auto-throttles remain inactive *until reaching 400 feet* or above. Then the [THR REF] mode will engage and the auto-throttle will once again become active...

Category III approach Mode and FMA displays:



Reference:

Category III Brief with a Category II Backup:

1. Aircraft qualified:
 - Required equipment
2. Runway qualified:
 - Lighting
3. Approach criteria verify:
 - Minimums (Cat III 100' "AH" radar altimeters is set)
 - Limitations (Max X-wind 15 knots)
4. At 1,500' on Final:
 - Verify: Land 3
 - Verify: "Auto Callouts" **Note:** (*listen* for "1,000" auto-callout req. Cat III)
 - Verify: at 100' AH RA = FMA's do not say: "No Autoland"
 - Monitor: Lateral & vertical guidance: (Within approach criteria)
 - Localizer: 1/3 dot and GS 1/2 dot
 - Note: Needles will turn amber and will blink if out of approach parameters.

- **AH Announce:** “Landing” or “Go-around flaps 20” (as situation dictates)
- Below (AH): “FIR” --- Capt. monitors / FO backup
 - 50’ **F**lare Green
 - 25’ **I**dle
 - 5’ **R**ollout
- Reminder: The FO will monitor: --- (inside)
 - **R**ollout
 - Stopping the A/C --- Braking / Speed-brake / Reverse monitor---

If unable to do a Cat III approach: Revert to a Cat II approach criteria (as long as weather meets Cat II minimums, remember **DH Mins will now apply**)

- Adjust Minimums to CAT DH Mins
- Land 2 --- (DH) Requires visual reference:
 - (REIL)
 - Runway Environment (insight)
 - Position to land

After Landing Intentions:

- Turn off at xxx Taxiway or
- Take it to the end Runway.

Any questions?

Check 1,500’ on Final: (*Thinking* NOT announced)

- Land 3 **OR** Land 2 ----- (as appropriate)
- Landing Criteria:
 - Verify: “Auto Callout” and *listen* for “1,000” callout ---- (req. Cat III not Cat II)
 - Verify: AH 100’ RA and make sure that our FMA’s do not say “No Autoland”
 - Verify: *Lateral & Vertical* criteria is monitored
 - Verify: Rollout and Flare *armed*
 - ***AT AH Announce:*** “Landing: or “Go-around flaps 20” ---- (as situation dictates)
- If unable Cat III then we are going to revert to Cat II:
 - Cat II requires a (DH), Adjust as necessary
 - Visual reference (REIL)
 - Runway Environment insight
 - Position to land

CONTINUOUS DESCENT FINAL APPROACH (CDFA) NON-ILS / NON-PRECISION VNAV APPROACHES

(Excerpted from the ATLAS handout abbreviated format)

When does the FMC transition out of "Approach Logic"?

The FMS transitions under the following conditions:

- Selecting TOGA.
- The airplane lands
- The airplane flies beyond the last waypoint in the approach (missed approach waypoint or runway) and the VNAV page title changes from "ACT xxxxxx DES" to "ACT END OF DES"

What is Approach Logic? The FMC transitions to "on approach Logic" under the following conditions:

- A VFR approach is created and, the airplane has sequenced the FAXXX, or...
- The airplane is enroute to a direct-to or intercept-to the RWYYYY waypoint and the airplane is within 25 nm of the runway threshold.
- A published *instrument approach* has been *selected and incorporated in the active flight plan* and the airplane has sequenced the first waypoint on the published approach

Database Selection: This method is required for RNAV and GPS approaches.

In summary - Database Selection:

- Assures correct waypoint selection for the respective approach.
- "On Approach" logic functions normally.
- Procedure complies with the non-ILS approach obstruction clearance criteria.
- **Note:** HDG SEL should be used to fly the approach ground track.
- **Note:** Automatic procedure tuning and VNAV PTH operation using speed intervention are not available with manually entered waypoints as these are features of "approach Logic"

VNAV should be used only for approaches that have one of the following features:

1. *A published GP angle* on the LEGS page for the final approach segment.
2. An RWxx waypoint coincident with the approach end of the runway.
3. A missed approach waypoint (e.g., MXxx) before the approach end of the runway.

VNAV Temperature Limitation / Correction:

- The temperature limitation will be shown as a note on the published Instrument Approach Procedure (e.g., Jeppesen). Use the MDA(H) + 50 feet “Add on” procedure to preclude descending through the MDA(H) during a missed approach.

When can a published DA(H), or a DA(H) in lieu of an MDA(H) be used: All of the following must be met:

1. *The approach must be in the database* Waypoint and procedure data, including the runway threshold waypoint and VNAV path angle, must be retrievable from the aircraft navigation database. These approaches are fully compatible with VNAV and comply with final approach step down altitudes.
2. *Do not add or delete waypoints on a final segment* of an approach including the FAF. Altitude corrections may be made for cold temperature corrections using a published DA(H) “as is”.
3. VNAV as a pitch mode must be used.
4. For DA(H) in lieu of an MDA(H), in addition to the above, the criteria for Ops Spec C073 must be met.

Note: If VNAV as a pitch mode, is used, “VNAV PTH” should be annunciated by 1000 feet HAA.

When is a published DA(H), or using a DA(H) in lieu of an MDA(H), Not Authorized: An “Add on” of 50 Feet to DA(H) / MDA(H) when:

1. Using Vertical Speed as a pitch mode.
2. No Glide path is published AND no glide path indicated on legs page (both required for DA(H))
3. When Altitude corrections are made to the runway waypoint (RWxx) or a missed approach point (MXxx) fix where no GP angle is published. (Not cold weather corrections)
4. When a waypoint is added/deleted on the LEGS page between the FAF and the runway/missed approach waypoint. In this case vertical speed as a pitch mode must be used due to the potential loss of approach logic. E.g. inability to maintain VNAV PTH as a pitch mode with speed intervention active.

5. Colder than VNAV temperature limitation as listed on the approach chart
6. Criteria of C073 cannot be complied with. Note: see chart below:

	DA(H)	DA(H) in lieu of an MDA(H)	
Approach with a published DA(H)	X		
RNAV/GPS (GNSS) LNAV/VNAV	X*		
ILS GS OTS (US civil airports only)		X	
Approach with ball flag		X	
RNAV/GPS (GNSS) LNAV only			MDA(H) + 50'
All Others			Published minimums + 50'

When must vertical speed as a pitch mode be used? Vertical Speed must be used as a pitch mode and an “Add on” of 50 feet to the minimums are required when:

- a. Approach course waypoints have been manually entered.
- b. Any waypoint is added/deleted from FAF to MAP.
- c. Airport not in database.

When must a Descent to MDA (Dive-and-Drive) be used?

- Equipment failures e.g. Dual FMS failure (no computed path) and no CDFA non-ILS chart is available.

In order to use DA(H) in lieu of MDA(H) the following criteria apply:

1. Approach plate procedure must have a published glide path angle.
2. Procedure must be contained in the FMS database with glide-path angle displayed on the legs page.
3. Final approach segment has not been modified on the LEGS page.
4. VNAV is used as a pitch mode

If any one of these requirements *cannot be met*, **MDA(H) + 50** must be set as minimums. This is referred to as the *Adjusted MDA (AMDA)*.

Approach Chart Requirements Relating to RNP Required Navigation Performance (RNP) is the navigation performance necessary for operation within a defined airspace.

LNAV/VNAV – Approach minima for RNAV approaches and supports both WAAS electronic vertical guidance and Barometric VNAV. The approach minimum altitude will be published as a Decision Altitude DA(H). To use LNAV/VNAV minima, the **aircraft** must have an RNP-0.3 system based on GPS or DME/DME, with an IFR approach approved electronic vertical guidance or Baro-VNAV system.

Note: Company -400 aircraft FMS systems meet the VNAV requirement of RNP- 0.3/GPS or DME/DME-0.3 for LNAV. The Company has approval to use LNAV/VNAV DA(H) minima (see Ops-Specs C073).