



## FMS VNAV

A VNAV path descent can be engaged from VALT at any time, if the altitude selector has been dialed down before the TOD point is reached. The VNAV path descent mode is used to descend to a new flight level at a calculated or prescribed angle (1° to 6°).

- An altitude constraint is entered at a waypoint. The FMS calculates an angle and TOD for the path descent.
- The altitude selector is set to the ATC cleared altitude.

1 minute before reaching the TOD, a VTA is given and the vertical deviation scale is displayed on the EFIS. If the selector is not at a lower altitude, the message *RESET ALT SEL?* is displayed.

At the TOD, the flight guidance computer switches from VALT to VPATH and begins a descent.

The flight guidance computer does a normal level off switching from VPATH to VSEL to VALT.

The VNAV angle is always displayed on the CDU for path descents. The path is always followed except for two cases:

The aircraft approaches VMO/MMO

The aircraft encounters a speed limit altitude constraint (e.g., 250 knots at 10,000 feet).

VNAV tries to satisfy both the altitude selector and the waypoint constraint altitude.

However, VNAV never flies through the altitude selector.

VNAV	Vertical Navigation
TOD	Top of Descent
VTA	Vertical Track Alert
FLC	Flight Level Change
VFLC	Vertical Flight Level Change
VALT	Vertical Altitude Hold
VPATH	Vertical Path
VASEL	Vertical Altitude Select

## General VNAV Rules

- Vertical flight level change is denoted as VFLCH.
- PERF INIT must be completed for VNAV computations.
- VNAV is available for all phases of flight.
- Climbs are flown using VFLCH only.
- Descents are flown using VFLCH or VNAV path (VPATH).
- VNAV never passes through the altitude selector.
- The pilot should set the altitude selector **only** to ATC cleared altitudes.
- VNAV keeps the aircraft as high as possible as long as possible.
- VPATH angles are from 1° to 6°.
- In VPATH, the path guidance is always followed except:  
When the aircraft approaches Vmo/Mmo.  
When the aircraft encounters the speed limit altitude constraint (e.g., 250 knots at 10,000 feet).
- Speed protection and LATCHED SPEED are active in VFLC
- If the altitude selector is set above (climbs) or below (descents) current altitude, the FMS commands the autopilot to begin climb (VFLCH) or descent (VFLCH or VPATH).
- VNAV is engaged by selecting the FMS to EFIS and selecting the VNAV button on the guidance panel. EFIS annunciates the submode of VNAV.
- The FMS must be the selected navigation source and LNAV must be engaged for VPATH to be operational.
- VPATH default descent angle is part of performance initialization. However, after the angle is displayed for each waypoint, the crew can change it.

- When the altimeter is adjusted to display height above the ground (Qfe) rather than sea level, VNAV should not be used.
- VNAV does not function until all PERFORMANCE INIT information has been programmed into the CDU. If any of the PERFORMANCE INIT data are incomplete and VNAV is armed a PERF-VNAV UNAVAILABLE message is displayed in the scratchpad.
- If the altitude selector is properly set, VNAV observes flight plan constraint altitudes.

A vertical track alert (VTA) is issued anytime the FMS commands a vertical track change. It is issued *60 seconds* before a change from level flight to either a climb or descent. If the aircraft is completing a climb or descent, the vertical alert is issued 1000 feet before the level off altitude. A vertical alert is not issued when the level off altitude is set on the altitude selector

### **VNAV Constraints**

- Speed (CAS or Mach)
- Altitude
- Descent angle

VNAV constraints are specified either in the flight plan as a waypoint constraint, in the database with procedures, or on the PERF INIT pages. For the air data modes, the climb and descent speeds from PERF INIT are used as the default limits. For VPATH descents, the DES ANGLE is used from PERF INIT unless a descent angle and an altitude are specified on a flight plan waypoint, and, if the aircraft passes below the PERF INIT SPDLIMIT ALTITUDE, the VNAV limits the IAS to the specified limit.

The constraint is entered on the right line select keys with the speed or descent angle first separated by a "/" and followed by an altitude constraint. For example to enter a speed of 300 knots and an altitude of FL250 at a waypoint, the scratchpad entry 300/FL250. Constraints are displayed in large characters. If there are no constraints, the FMS provides predictions, displayed small characters.

- **VNAV ARM (VNAV)** - When initially selected, VNAV ARM becomes the active mode. While armed, the FMS monitors aircraft position and altitude against the altitude selector and, if any, the next waypoint altitude constraint. From this, the FMS determines when to capture and which submode is appropriate

There are a few conditions where VNAV ARM remains the active mode for some time.

For example, the altitude selector is set above aircraft altitude and the next constraint altitude is below the aircraft altitude. In this example, VNAV cannot determine whether

to climb to the selector altitude or to descend to the constraint. The net result is that VNAV stays in the ARM mode until the conflict is resolved.

While in the armed mode, the FMS does not vertically control the aircraft. Another vertical flight director mode is used to vertically control the aircraft until the FMS transitions out of VNAV ARM.

- **VNAV Flight Level Change (VFLCH)** - This mode is vertical flight level change. It is used during all climbs and, unless a path is defined, during descents. When engaging VNAV, VFLCH is set as the active mode if the altitude selector is above or below the current aircraft altitude and the current flight director mode is not altitude hold. When in other modes of VNAV, a transition VFLCH is made by setting the altitude selector to other the current altitude and pushing the FLCH button. In this mod

VNAV supplies the altitude-leveling target. The speed displayed on the active flight plan is the speed target for this mode.

- **VNAV Altitude Hold (VALT)** - This mode is the same as altitude hold. The flight guidance computer controls altitude by controlling pitch.

If VNAV is disengaged while in VALT, the flight director mode becomes PITCH HOLD, not altitude hold.

- **VNAV Path (VPATH)** - The VNAV path mode is used only during descents when a waypoint altitude constraint has been entered. It is similar to flying on a glide slope. Using targets from the FMS, the flight guidance computer maintains the path by controlling vertical speed. Moving the throttle changes speed.

- **Top-of-Descent** - A TOD waypoint is calculated and can be displayed on the map and on the PROGRESS pages. There can only be one TOD waypoint at a time. If there are no constraints during the descent, the TOD is calculated using the destination elevation (if available) and the speed mode. If there are constraints during the descent, a TOD is calculated using the path mode. For each TOD point, a vertical waypoint alert is given and an automatic descent is initiated if the altitude selector has been selected to a lower altitude.

- **Descent** - Descents are flown as speed descents or path descents. The type of descent is determined by whether or not there is a waypoint altitude constraint in the descent. A speed descent (VFLCH) is flown when no constraints exist in the flight plan during the descent. A VPATH descent is flown when there is an altitude constraint. After passing the last waypoint altitude constraint, VNAV changes from a path descent to a speed descent. All constraints in descent are considered to be AT constraints. AT or ABOVE or AT or BELOW constraints contained in procedures from the data base are considered AT constraints. If the destination waypoint is an airport reference point, or a runway, the elevation from the data base is used to calculate a TOD point. This elevation is not considered a constraint. Constraints are only created by pilot or procedure entry. A pilot entry at the destination is considered a constraint.

- **Speed Descent (VFLCH)** - This mode works like the climb phase. The TOD point is calculated by looking at the destination elevation and present altitude. The TOD is calculated to put the aircraft at 1500 feet above the destination 10 miles before the destination. Also, the TOD is based on any speed constraints in the descent such as slowing to 250 knots below 10,000 feet. The transition to descent is automatic, assuming the altitude selector is set lower than present altitude. One minute before TOD, the vertical track alert is given. The pilot can also initiate a speed descent anytime by setting the selector to a lower altitude and pushing FLCH.