

ROCKWELL COLLINS FLIGHT MANAGEMENT SYSTEMS



Rockwell
Collins

FMS OPERATIONS

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This training manual is intended to be a generic manual for all FMS applications. Thus, your aircraft system may not have all the features described herein.

Chapter 1: What is FMS

The New Generation Collins Flight Management Systems (FMS) function primarily as a navigation computer. They closely follow ARINC characteristics for Navigation Database (ARINC 424), Flight Management Computers (ARINC 702), and Multi-Purpose Control and Display Units. They have other abilities such as radio tuning, making performance calculations, and data communication on an ACARS, AFIS or SATCOM link.



Navigation, however, is the principal job. In order to provide successful navigation, the FMS must accomplish two distinct processes. It must determine its position and then must provide steering. Once it knows where it is and the pilot has told it where it needs to go, it will provide steering guidance to complete the mission.

The FMS receives heading data from an Attitude Heading Reference System (AHRS) or an Inertial Reference System (IRS) and true airspeed inputs from an air data source. The FMS receives data from multiple Long-Range Navigation (LRN) sensors - and using a Kalman filter, computes a position estimate.

Normally, the FMS uses all installed and available navigation sensors (GPS, DME/DME, VOR/DME and IRS) to determine position. Each sensor's position is independently calculated, then the individual positions are blended to create the FMS position. The FMS POSITION SUMMARY page on the MFD provides a bearing/distance difference between the blended (FMS) position and each sensor capable of calculating a position.



FMS POSITION SUMMARY - Figure 1

Using true airspeed and heading information – Dead Reckoning (DR) – it is able to very rapidly perform position estimates. It then, at a much slower rate still many times a second, compares those estimates with a blended position obtained from the LRN's. Using that information it makes any necessary position corrections.

Now that it has established a very accurate position and the pilot has defined a course, the FMS can get to the task of providing guidance. Using great circle navigation logic, it computes a solution and sends steering commands to the flight director / autopilot. Because of the very rapid position updating, the course guidance is extremely accurate.

Steering commands are sent directly to the autopilot. Using crosswind components, speed, cross track distance and other data it computes and sends commands to the autopilot to provide a constant bank maneuver for course capture. Overshooting as well as excessive roll maneuvers are minimized.

Pitch commands are also sent to the autopilot for vertical descent captures. Again, it takes into account any tailwind or headwind component and is able to anticipate where the pitch command should be given to make a smooth capture of the vertical path.

An FMS is basically a "TO" navigator. It knows where it is and, from pilot input, it knows where it must go "TO." The pilot assembles a flight plan by organizing the desired waypoints into a logical order. If AUTO Sequencing is enabled, when the FMS determines it has reached a waypoint it automatically sequences "TO" the next one on the list.



Sequencing is accomplished in one of two ways – with or without turn anticipation and is directed by the database software. If the waypoint is coded as “*fly-over*” then there is no turn anticipation. If the waypoint is coded as “*flyby*” then the FMS will use turn anticipation – unless it is the final waypoint in the flight plan or the waypoint prior to a discontinuity.

Turn anticipation is provided at all fly-by waypoints when AUTO leg sequencing is selected.

Turn anticipation accounts for the course change, the current winds, the speed of the aircraft and corner cut limitations. The corner cut limitation is the distance from the waypoint that the turn may be initiated. This limitation ensures the aircraft remains inside the protected region associated with the route. For enroute flight, this limitation is 7 nm for true airspeeds less than 350 knots and 12 nm for true airspeeds greater than 350 knots.

Note:

The FMS treats all pilot-defined waypoints as flyby.

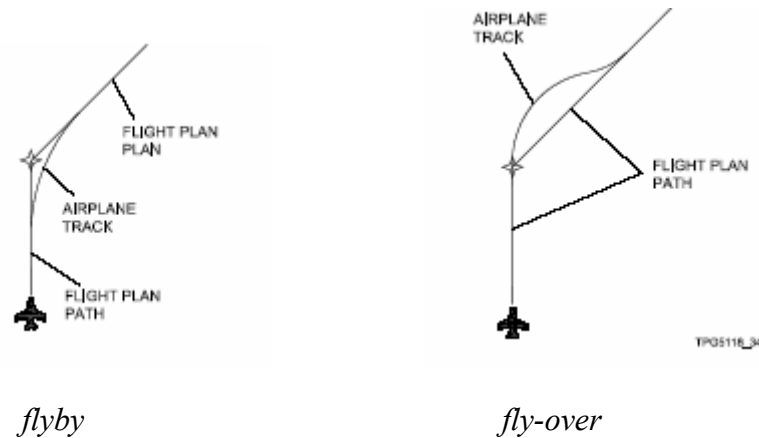
For the purposes of this publication:

Fix = A point determined by bearings from two or more known points, or bearing and distance from radio signals, or the actual radio location

Waypoint = A point on a defined route

Note:

A fix becomes a waypoint when it is made part of a flight plan.



TURN SEQUENCING - Figure 1.2

The FMS identifies all waypoints using latitude/longitude. If an altitude constraint is added to the definition, it actually becomes a waypoint in space.

For ease of operation, published waypoints are stored in a database within the FMS and are normally called up by name rather than entering the tedious lat/long identification.

Pilot-defined waypoints may also be created and stored in the FMS.

The FMS manages the database by organizing waypoints into flight plans or routes. It is also able to assemble waypoints into published procedures. The pilot identifies the procedure and the FMS selects the waypoints and builds it. The FMS is able to fly Standard Instrument Departures (SIDS) and Standard Terminal Arrival Routes (STARs), approaches (and their associated transitions), missed approaches, jet and victor airways, and Q Routes.

The communication link between the pilot and the flight management computer is the Multi-Function Control Display Unit (MCDU) or just CDU. From this combination display and keyboard unit the pilot enters the specifications of a flight plan. Desired waypoints or procedures are entered and then modified to fit the desired routing. Intersecting courses, courses between waypoints, vertical paths, speed restrictions, and performance predictions may become part of the flight plan.

The FMS communicates back to the crew by presenting maps on the MFD, guidance and data on the PFD when the FMS is selected as the Nav Source. Also, data is presented on the CDU, warnings and messages on the PFD, MFD and CDU.

Chapter 2: FMS Operating Basics

Control Display Unit

Function of the Collins FMS is controlled by the keys located immediately below the display.

The alphanumeric keys are used to enter information directly into the scratchpad.

Line select keys are located next to each data line on the display.

Pressing a key transfers information to or from the scratchpad.

Data computed by the FMS is displayed in small font.

If data is loaded from the database or changed by the pilot, the data is presented in large font.

On other occasions the line keys are able to select and control FMS functions. If a mode is pilot selectable, the inactive mode is in small letters and the active is in large letters, sometimes there is also a color change with the selection.

The appearance of a caret, < or >, indicates a function instead of data entry.

Many of the functions have more than one page of information or options associated with the operation.

Additional pages are indicated in the upper right hand corner of the display (i.e., 2/4). Pressing the NEXT PAGE or PREV PAGE keys will move through those pages.



FMS CDU - Figure 2.1

The bottom line on the display is reserved as a message line to alert and inform the pilot.

Color definition for the displays:

Amber:	Cautions
White:	Primary information, flight plan, down track data
Cyan:	“From” waypoint and Second flight plan
Magenta:	Active leg (“To” waypoint) – (VNAV on Falcon models)
Green:	Active selections – VNAV data – Availability status

Entering Information

All data is first entered into the scratchpad located between the cyan brackets near the bottom of the display. It is then moved from there, using the *line select keys*, into the proper place on the display.

Information entered by the data entry keys goes directly into the scratchpad. If a data field on the display contains a slash (/), data may be entered either before or after the mark without filling the other side. It is generally wise to enter the slash.

If the scratchpad is clear, pressing a *line key* copies line information into the scratchpad. This method simply copies and does not erase the line information.

Data in the scratchpad may now be edited and verified by the crew. Information transfer to the desired line on the CDU is completed by pressing the appropriate *line select key* on the same page or carried to another page.

If data is inappropriate or improperly configured, the FMS will not accept it. The data will be replaced with an annunciation stating the reason why it was not accepted. The annunciation



lasts for approximately one and one-half (1.5) seconds; then the previous scratchpad information will be displayed.

Note:

A complete list of MESSAGES AND ANNUNCIATIONS can be found in the Pilot's Guide for your FMS version.

The **CLEAR** key is the preferred way to remove information from the scratchpad. A momentary press removes one character at a time, starting from the right. Pressing and holding the key clears the entire scratchpad.

A good operating technique is to often check for and clear erroneous information in the scratchpad. It should always be checked and cleared prior to entering data. Newly entered data added to existing data would not be recognized by the FMS.

EXECUTE Function

Pressing the EXECUTE button makes a modified flight plan active. Any time an active flight plan is changed, a MODIFIED flight plan is created. As a side benefit, it also functions as a “save” feature. As a flight plan is being “built” or changes are being made and verified, **EXECUTE** should occasionally be pressed to “save” the entries.

The FMS will not fly the changes until they are “executed.” If a flight plan modification has not been executed, the pilot will be alerted with an amber EXEC FPLN MOD annunciation on the CDU and an amber MSG on the PFD. The pilot also has the option to cancel a modification. Pressing the **CANCEL MOD line key** will discard any changes to the flight plan made since the last EXECUTE.

Power Cycle Response

The FMS will treat a power interruption one of two ways depending upon how long the power is off.

If the power is off for less than two minutes (a “warm start”) the system will continue as it was prior to power interruption.

With power removed for more than two minutes (a “cold start”) there are several things that change. A list of those changes follows:

- * The scratchpad is cleared.
- * Any modified flight plan is cleared.
- * Pilot-defined routes and waypoints are not affected.
- * The prior destination airport is copied into the AIRPORT field on the POS INIT page.
- * If on-ground, sensor usage selections are reset to default settings.
- * If on-ground, NAV radio tune mode (AUTO/MAN) is set to MAN.
- * If on-ground, any REF waypoint specified on the FIX page is cleared.
- * History points used for MFD FPLN HISTORY screen are cleared.
- * MFD FPLN PROGRESS and HISTORY screens are cleared.
- * Pending AFIS flight plan request is cleared.
- * Entered value for TOGA is cleared and TOGA is selected as active N1 source on the THRUST page.
- * WING A/I and COWL A/I are set to OFF on the THRUST page.
- * The flight number is cleared.
- * (4200 only) The active flight plan is cleared.
- * (4200 only) The prior destination airport is copied over to the origin airport on the FPLN page.
- * (4200 only) All MFD background data selections are cleared.

Chapter 3: Status Page

After power up, the first screen shown is the **CDU STATUS** page.

Note:

Because some newer FMC's take too long to boot, the CDU will default to the MCDU menu if another client is installed (such as AFIS).

This page displays the navigation database coverage, the effective dates of the two navigation database cycles, the universal time and date and the FMS software version.



STATUS PAGE - Figure 3.1

If the selected navigation database cycle is out of date it will be displayed in amber. Pressing the *line select key* next to the second database cycle will copy it to the scratchpad. It then may be entered as the active by pressing the ACTIVE DATABASE *line select key*. The active will then move to the SEC DATA BASE location.

Note:

Changing database cycles is enabled only on the ground and will erase the active flight plan.

Time and date are set to Universal Time Coordinated (UTC) or Zulu time. These are automatically set by the GPS if installed and cannot be modified using the time/date set function in the FMS or the MDC.

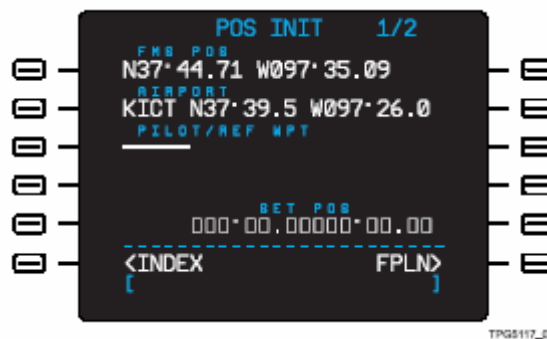
The program identification code is the installed FMS software version.

The second CDU STATUS page identifies the software version of the installed performance and/or VSpeeds database (if applicable).

Chapter 4: Initialization

The FMS and LRN's must be initialized before each flight.

When the FMS is shut down following a flight it remembers that position and assumes that is the correct location when power is reapplied. Initialization of the FMS either simply confirms the position as "OK" or actually moves the FMS position to a different location.



POSITION INITIALIZATION PAGE 1/2 - Figure 4.1

This is normally the first time the crew is presented with **Character Prompts** ([]), think of these as **Must Enter Boxes**. Not entering data at the character prompt will result in the loss of some function or computation.

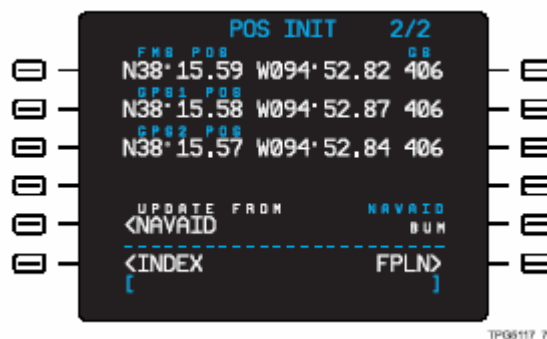
If there is an Inertial Reference System (IRS) installed in the aircraft it also will be initialized with the FMS. The IRS mode selector switches should be in NAV mode for initialization. If initialization is to somewhere other than where the IRS expects or the FMS position is moved more than 40 miles, the system will ask for the initialization to be redone with an amber message on the CDU. Once the correct position is entered in the SET POS location, two presses of the SET POS line key will complete the process.

Note:

It is recommended that the exact ramp or gate location be used when initializing the FMS.

The FMS position may also be updated to the departing runway by completing the runway update as the aircraft is taxied into position at the runway threshold.

On all initialization pages, the top line is the FMS-computed position. It can easily be compared with the position data of the airport and/or a pilot reference waypoint located immediately below. The FMS fills the airport location by using the destination of the last flight plan as the reference airport.



POSITION INITIALIZATION PAGE 2/2 - Figure 4.2

A pilot-reference waypoint will automatically appear if there is one located within 3 miles of the FMS position. These could be FBO or operations ramps. Pilot-reference waypoints are built from the database page accessed from the index.

Note:

*If more than one LRN type is installed in the aircraft, additional POS INIT pages will be provided. The pages will present the positions of the LRN types in the following order:
Global Positioning System (GPS), then Inertial Reference Systems (IRS).*

For installations with GPS and IRS, page two displays the FMS-computed position and the position of the GPS sensor; page three displays FMS-computed position and IRS position.

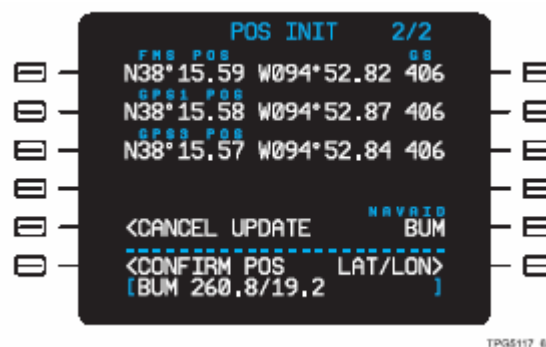
The update from NAVAID feature moves the position of the FMS to the radial/bearing from a VOR/DME and is inhibited while on the ground. Prior to initiating an UPDATE FROM NAVAID, the following conditions must first be met:

- * The crew has not deselected the navaid.
- * Navaid has collocated VOR and DME components. (VOR/DME or VORTAC).
- * Both on-side VOR and DME radio frequencies are the same as the navaid.
- * Both on-side VOR and DME data are valid.
- * The position based on VOR/DME signals is within 30 nm of FMS position.
- * DME distance measures less than 100 nm.
- * If a DME identifier is received, it is the same as the published navaid identifier.

If the on-side NAV radio is in auto-tune, the FMS will automatically fill the navaid identifier of the tuned VOR/DME. The crew may also manually enter the identifier for a VOR into the space rather than directly tuning the radio from the CDU or RTU.

Pressing UPDATE FROM NAVAID will show the bearing and distance from the VOR/DME in the scratchpad. Repeated presses of the *line select key* will toggle the position display between RAD/DIS and LAT/LON.

Pressing CONFIRM POSITION initializes the FMS as well as any other LRNs capable of being updated.



POSITION INTIALIZATION PAGE 2/2 - Figure 4.3

For systems that allow initialization from a GATE, the airport four letter ICAO identifier must first be placed in the airport line for this feature to be enabled.

Runway Update

Using this procedure will update the FMS position, and any other LRN sensor capable of being updated, to the runway threshold.

A departing runway must be entered in the flight plan. The option will appear at the bottom left side of the active LEGS page while the airplane is still on the ground. The update occurs when either the *line select key* or, if supported by aircraft installation, the takeoff go-around “TOGA” button is pressed.

When the update has occurred, **COMPLETED** will appear only on the on-side CDU.

Note:

A runway update moves the FMS position to the ORIGIN airport's departure runway threshold, as entered on the flight plan page, regardless where on the ground the aircraft is located. Care must be taken to confirm that the update runway does not have a displaced threshold. Intersections are not provided so performing an update at an intersection can not be accomplished.

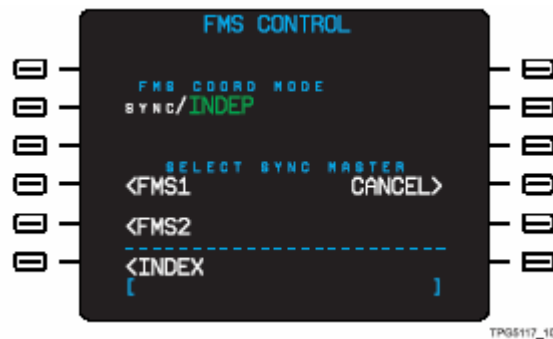


LEGS PAGE - Figure 4.4

This option remains operational, however, for situations where a second RWY UPDATE is desired after the first has completed.

Chapter 5: FMS and Sensor Control

The FMS CONTROL page is accessed from the CDU INDEX page. Multiple FMS installations may be operated in synchronized, independent or split modes. The power on default (Independent or Synchronized) and whether the FMS CONTROL page offers the pilot the option of selecting SYNC or INDEP is controlled by CSU strapping. Selecting SYNC will require the pilot to select the master FMS. The flight plan from the master FMS will be cross-talked to the other FMS. After initial selection of the master, the two FMS's are equal. Selecting INDEP will require the pilot to confirm the selection. It is possible to have no entries on the CDU FMS CONTROL page. The selections within the CSU are part of the certification of the aircraft and should not be changed unless the Type Certification (TC) holder or Supplemental Type Certification holder approves the change.



FMS CONTROL PAGE - Figure 5.1

Independent Mode

Independent mode allows each FMS to operate independently of the other. However, data may still be manually cross-filled to the other FMS. For instance, a flight plan built on one side and executed will have no effect on the cross side. But, if desired, the flight plan can be transferred to the other FMS. MAG/TRUE selections, initialization procedures and performance inputs remain independent to each FMS.

Synchronized Mode

Synchronized operation ties the FMS's together. This permits all data entries to be done, for instance, on the right FMS then automatically transferred to the left side. In this example, as soon as the flight plan is executed, it will automatically be loaded in the cross side FMS. MAG/TRUE selections, certain initialization procedures and performance inputs are automatically transferred. Crew coordination and communication are a must.

Split Mode

Split mode is an automatic mode should a failure be detected in the cross side FMS. This, in effect, severs the tie between the two FMS's and does not allow any exchange of information. Split mode may not be selected by the crew.

Mag/True Navigation

Courses and bearings are normally flown using magnetic north as the reference. When navigation requiring a true north reference is needed the FMS can be set to operate in that mode from the INDEX page using the FMS CONTROL *line select key*.

Note:

This feature is only available with IRS equipped aircraft.

Sensor Control

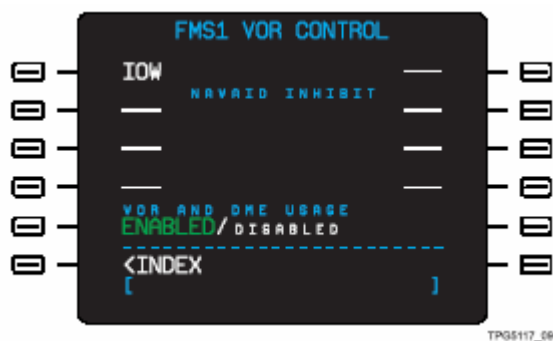
Typical installations will include combinations of sensors for VOR/DME, DME/DME, GPS, and IRS.

If the sensor is installed on the airplane, control for it is found on the INDEX page.

VOR/DME Control

The CDU VOR CONTROL page is used to either selectively ignore a particular VOR station or to control the use of the VOR/DME data for position solution.

If a station has a NOTAM entry for not using, the station identifier is simply entered.



FMS VOR CONTROL PAGE - Figure 5.2

If, for any reason, the pilots want all VOR and DME data to be used by the FMS, pressing the *line select key* beside ENABLED/DISABLED will toggle its use on and off.

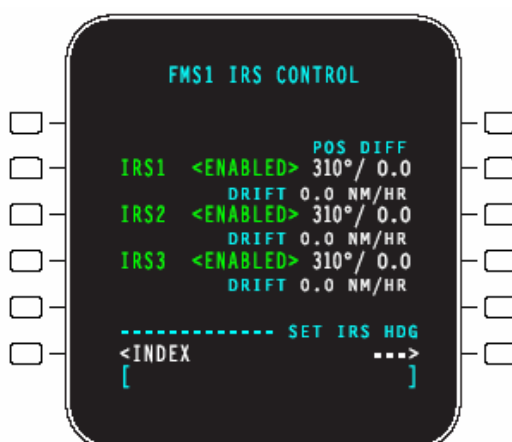
IRS Control

The CDU IRS CONTROL page shows whether each individual unit is enable/disable, the drift rate and the position difference of each unit compared to the FMS position.

An individual IRS sensor may be removed from the system by simply pressing the *line select key* beside the desired unit. Normal acceptable drift rate is less than 2.5 nm per hour.

Note:

In FMS Versions 2.2 and beyond the drift limit is a flat 5.0 nm for the first hour, then 2.5 nm hour until a max of 25 nm is reached.



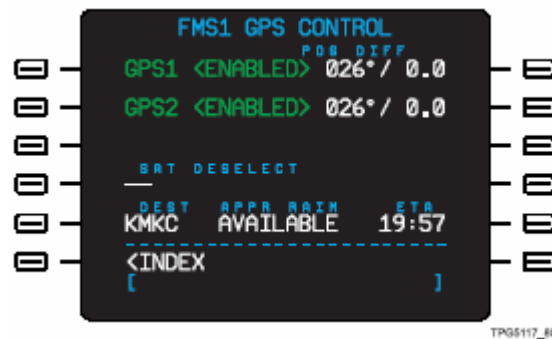
IRS CONTROL PAGE - Figure 5.3

For installations with two IRS's – position information is on-side only in normal operations.

If an IRS is switched over to attitude mode, a line will appear on the bottom right of the display in which the IRS heading may be set. Data from the IRS is not used for position estimation if it is in ATTITUDE mode.

GPS Control

The CDU GPS CONTROL page allows the pilot to remove a GPS sensor from the position solution. Simply pressing the *line select key* beside the sensor will toggle the mode to either ENABLED or DISABLED.



FMS GPS CONTROL PAGE - Figure 5.4

- The position of each GPS sensor is also compared to the FMS position.
- This page also allows for up to 8 satellites to be deselected from use.

Note:

There are two names for the GPS satellites PRN and SVID. Use the GPS Control page to deselect a satellite.

Approach RAIM availability is displayed provided predicted performance mode is selected or an ETA is manually entered.

Note:

The crew is always able to determine nav sensors being used for the FMS position estimation on the CDU Progress page. Sensors in use appear on the line above the scratchpad.

Chapter 6: MFD Control

MFD DATA Button

Pressing the MFD DATA function button will toggle the Multifunction Display (MFD) between the map mode and the data mode. Once in the data mode, the type of data presented may be selected from a menu accessed by pressing the MFD MENU button.



MFD MENU PAGE - Figure 6.1

MFD MENU Button

This provides a menu of information features that can be displayed on the MFD. Pressing the *line key* beside the desired feature will present that information on the display. Care must be taken to not over clutter the display.

Choices for both the left and right displays (for aircraft with two MFDs) are shown on each CDU. When the MFD is toggled between the map and data modes, the on-side menu selection will also change. The menu for the map presents the options for on-map data or off flight plan nav aids.

MFD ADV Button

If the MFD is in DATA mode, pressing MFD ADV will present a method for selecting additional pages that may be available. For example, on a flight plan with several waypoints, there may be more than one page of information when the PROGRESS page is selected.

Pressing the PREV PAGE or NEXT PAGE *line keys* will “turn” the page on the display. The number of text pages available is shown in the upper right-hand corner of the display.

If the MFD is in the north up or planning mode, the pilot has the option of stepping through the flight plan by using the **PREV WPT** or **NEXT WPT** keys. Pressing these keys will place the selected waypoint at the center of the map. Pressing **TO WPT** makes the center the TO waypoint. The pilot also has the option of naming a waypoint either on or off the flight plan as the center of the map. The identifier is entered on the CTR WPT line.

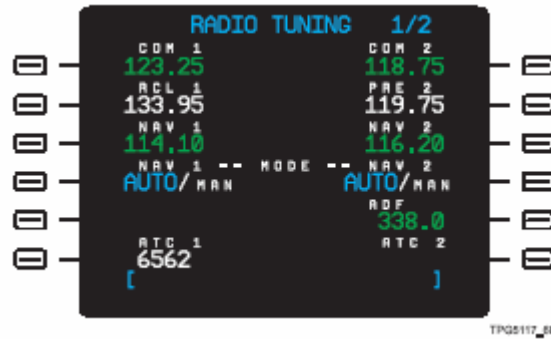


PLAN MAP CENTER PAGE - Figure 6.2

Chapter 7: Radio Tuning

The radio tuning method is a crew preference. Either the FMS CDU or the radio tuning units (RTUs) may be used for radio control.

Pressing the **TUNE** function key shall cause the top level RADIO TUNING page to be displayed. A frequency is entered into the scratchpad by either the data keys or by copying from the CDU. Moving a frequency from the scratchpad to the active line will tune the selected radio and move the previously active frequency to the recall line. Entering a frequency in the recall line will change the annunciation from recall (RCL) to preset (PRE).



RADIO TUNING PAGE 1/2 - Figure 7.1

The nav radios may be tuned by either the radio frequency or by the identifier. Rather than looking up the frequency, for example, for Cedar Rapids (CID), simply enter CID and the FMS will tune the proper frequency. The system will also tune localizers by their ident for the origin, destination and alternate airports in the flight plan.

AUTO Tuning

The FMS is capable of automatic tuning of the nav radios for position estimation. Because it knows its position, the FMS uses the internal database to select VOR/DME stations to tune. Tuning a nav radio manually from either the FMS or the radio-tuning unit will disable AUTO tuning.

Chapter 8: GPS Navigation

GPS may be used for primary means of navigation in oceanic and remote areas provided a qualified GPS sensor is installed on the airplane. Pre-departure verification of GPS availability is required for GPS primary means of navigation before each flight.

RAIM

Receiver Autonomous Integrity Monitoring (RAIM) is required during all GPS navigation operations to monitor the validity and integrity of the signals and the satellite geometry.

The status and integrity of the GPS solution is displayed on the **MFD LRN STATUS** page. Different levels of accuracy are required for en route and terminal operations:

Oceanic/remote	4 nm
En route	2 nm
Terminal	1 nm
Approach	0.3 nm

RAIM automatically flags the signal when accuracy falls below acceptable limits for the current phase of flight.

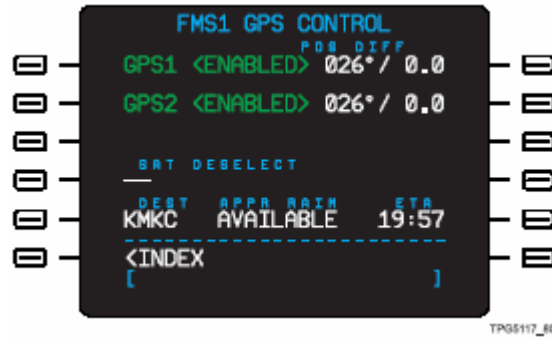


MFD LRN STATUS PAGE - Figure 8.1

If there are insufficient satellites available or the satellite geometry cannot support en route, terminal or approach RAIM, the message ***NO GPS RAIM*** is displayed on the CDU message line. Annunciations on the GPS CONTROL page are:

AVAILABLE:	GPS approach RAIM is available
UNAVAILABLE:	GPS approach RAIM is not available
REQ PENDING:	RAIM status being evaluated
INIT GPS:	RAIM cannot be evaluated, GPS not initialized

If RAIM is not available, then GPS Figure of Merit (FOM) is used to verify navigation accuracy. If FOM does not meet the specified accuracy for the enroute or terminal phase of flight, the measurements will not be used to update the FMS position and GPS NOT AVAILABLE is displayed on the CDU message line. If no other navigation sensors are available, the FMS will navigate by dead reckoning.



GPS CONTROL PAGE - Figure 8.2

Predictive RAIM

The GPS equipment is capable of predicting the future positions of satellites to estimate the availability of approach accuracy for some future time. Predictive RAIM is normally used by the FMS to let the crew know if approach GPS RAIM will be available when they reach the destination.

The availability of predictive RAIM can be viewed on the GPS CONTROL page in the index. The destination and arrival times for the current flight plan are entered automatically by the FMS (predicted performance mode only); however, the crew may insert other destinations and times to ascertain approach RAIM availability.

Chapter 9: Vertical Navigation - VNAV

The FMS will provide vertical guidance for nearly all segments of flight including FMS approaches. Climb profiles are airspeed based and descents are based on a Vertical Path Angle (VPA).

The departure and destination airports must be entered on the flight plan page in order to take full advantage of the VNAV features. Very simply, it is able to determine the halfway point of the flight and to appropriately apply climb or descent logic. It also uses the airport elevation to determine the top of climb and top of descent points for the flight plan.

Crew or database entered altitude constraints are displayed and edited on the LEGS pages. These constraints may be placed along the lateral course before, at, or after a waypoint. An altitude constraint followed with a letter **A** means “at or above,” letter **B** means “at or below” and a constraint without the letter A or B means “at.”



LEGS PAGE - Figure 9.1

Speed constraints may also be entered at a waypoint. These are currently only advisory in nature. Speed and altitude constraints may also be displayed on the MFD map.

Altitude constraints are identified with an arrow on the LEGS pages as climb or descent constraints. The FMS makes the initial climb or descent assignment; however, it may be changed by the pilot.

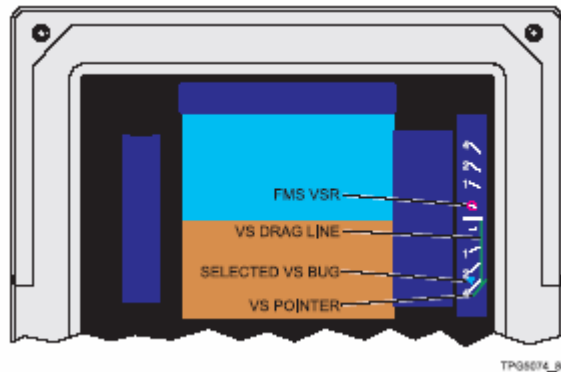
The Vertical Path Angle (VPA) and vertical speeds (feet per minute) for each segment are displayed immediately above the altitude constraint on the LEGS pages. The values will default (which may be edited) to the conditions set on the VNAV SETUP page. The pilot can alter a specific VPA leg by entering an angle from 1° to 6° on the LEGS page.

Note:

Altitude constraints associated with departures, arrivals and approaches are automatically entered from the database when the procedure is selected.

The next altitude constraint is displayed on the PFD. The vertical speed required to reach the next constraint from present position is displayed as a circle on the vertical speed scale. For climbs, the circle will appear when the climb from present position to the constraint is at least

100 fpm. The climb constraint must be an “at” or “at or above.” For descents the circle will not appear until the required vertical rate is at least 500 fpm and the TOD is less than 50 miles from the present position. In this case the constraint must be an “at” or “at or below” value. The current required vertical speed is also displayed on the MFD VNAV text window.



VERTICAL SPEED DISPLAYS - Figure 9.2

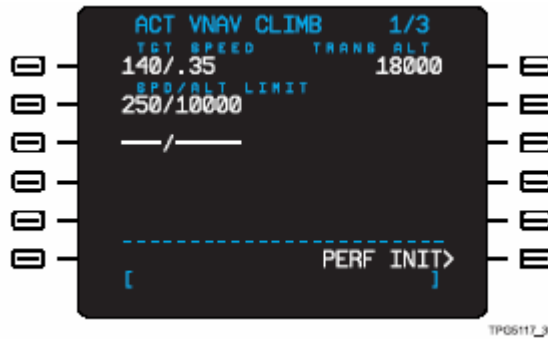
It is important to note the pre-selected altitude always takes precedence over altitude constraints in the flight plan. The only exception occurs while the aircraft is flying a properly configured non-precision approach as discussed in the approach section of this manual. In this instance the VNAV ignores the preselector and continues following the glide path to the missed approach point.

VNAV will not allow the aircraft to depart an altitude until the pre-selected altitude has been reset. In order for VNAV to navigate a vertical flight path, the altitude preselector must first be set either at the altitude restriction or ATC clearance altitude.

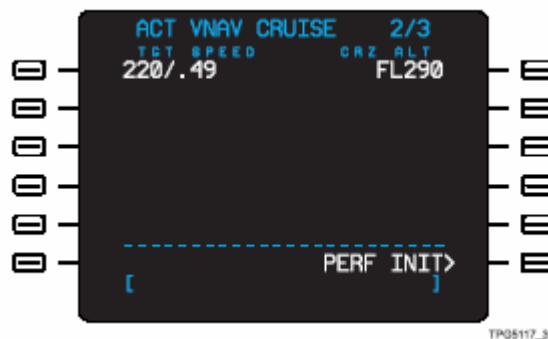
A cruise altitude should be entered on the PERF initialization page. If the aircraft climbs higher than the entered altitude VNAV will change the cruise setting to match the preselector. If an altitude is not entered on the performance page, all VNAV features are still available. However an altitude constraint must be entered at some waypoint in order to create a VNAV problem. That may be as simple as selecting an arrival runway.

The VNAV SETUP, found under the PERF menu, is divided into separate pages for climb, cruise and descent default speeds. The VNAV logic uses these climb, cruise and descent speeds,

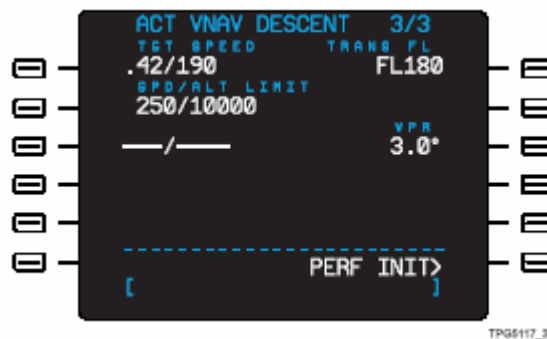
along with the VPA (Vertical Path Angle) found on the descent page, to determine the TOC (Top of Climb) and TOD (Top of Descent) points. Individual values may be changed by the crew for a given flight or the defaults may be changed under the INDEX page. The FMS also uses these values to make fuel and time calculations if the aircraft has a performance database.



VNAV CLIMB - Figure 9.3



VNAV CRUISE - Figure 9.4



VNAV DESCENT - Figure 9.5

The vertical navigation logic in the FMS is tied to the flight director by pressing the VNAV button on the FCP or MSP. The preceding “V” indicates VNAV is active.

The flight director altitude hold modes displayed on the PFD are:

VALTS Preselector Altitude or Path Smoothing

VALTV VNAV Reference Altitude

VALT Pressure Altitude

Armed and not in altitude hold:

ALTS Preselector Altitude

ALTV VNAV Reference Altitude

Additionally, there are other armed sub-modes displayed along with ALTV and ALTS:

FLC Flight Level Change (speed and climb only)

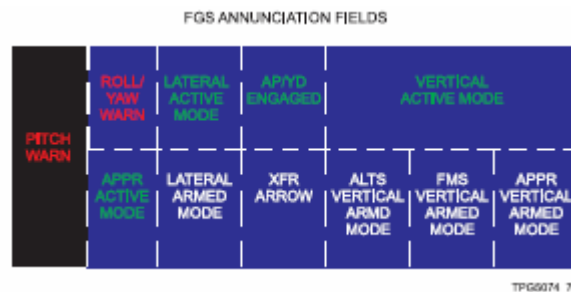
PTCH Pitch (descent only)

PATH Vertical Path Armed (descent only)

There is a third mode that will be displayed for an approach:

GS Glide slope

GP Glide path



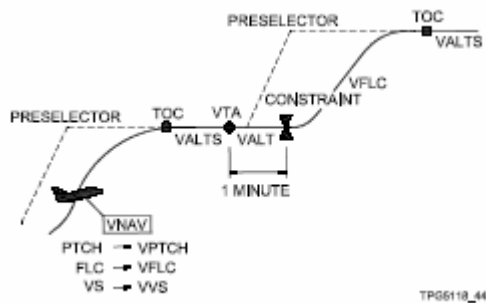
MODE ANNUNCIATION	ALTITUDE TRACKED
VALTS	Preselector
VALTV	VNAV Target
VALT	Pressure

MODE ANNUNCIATION	ALTITUDE ARMED
ALTS	Preselector
ALTV	VNAV Target

FGS ANNUNCIATION - Figure 9.6

VNAV Climbs

When an altitude constraint or preselector altitude is encountered during a climb, the altitude is captured and held. VNAV climbs are airspeed based. This default reference speed is displayed at the top of the airspeed tape. The pilot using the speed knob may change it, selecting IAS/Mach mode, or pressing the flight director sync button on the yoke.



VNAV CLIMB - Figure 9.7

Typically there are few occasions when climb constraints are used in today's ATC environment. There are, however, departure procedures that contain *at or above* constraints. These will automatically load when the procedure is selected. Other procedures or ATC instructions may require an *at or below* constraint for traffic avoidance. No matter how the crew elects to climb the aircraft, the circle on the vertical speed scale will indicate the rate needed to meet the constraint.

Note:

The vertical speed advisory pointer position on the VSI scale is a reflection of the FMS calculation of the required climb/descent rates associated with the flight plan, and does not imply that the aircraft is capable of meeting the required rate of climb/descent.

If the system is in altitude hold the FMS will alert the pilot by displaying a BOC (Bottom of



Climb) one minute before reaching an altitude constraint. If the preselector is not changed at 45 seconds before the constraint, the pilot will be reminded to make the change with a CHECK PRESELECTOR message on the CDU.

The pilot must set sufficient engine thrust to achieve the climb speed. Once climbing, the rate is controlled by thrust. VNAV will continue to climb the aircraft until reaching an altitude constraint or the pre-selected altitude, whichever occurs first.

VNAV Descents

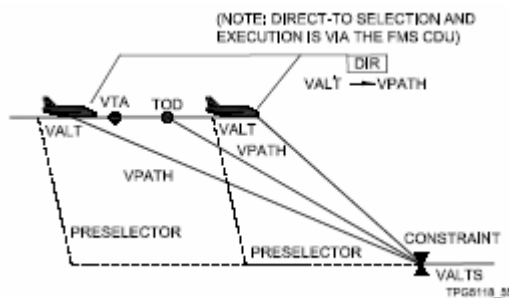
The FMS is able to provide guidance for descents, based on predetermined paths, or “direct-to” descents to an altitude constraint. The FMS continually computes a vertical path, typically a 3° geographical line, from a waypoint constraint. In essence, the path is computed backwards from the waypoint and exists out in front of the aircraft, much like a glide slope, regardless of the altitude. All vertical path angles are restricted to a minimum of 1° and a maximum of 6°. The FMS will alter the default angle within those limits to meet a constraint.

If a constraint has not been entered in the flight plan, the VNAV will place a DES point into the flight plan indicating a reasonable point to begin a descent to the destination airport so as to arrive 10 nautical miles from the airport at 1,500 feet above destination airport field elevation. This will appear on the MFD map and FPLN PROGRESS pages and will include distance, time

and fuel to the point. However, it is advisory only. An altitude constraint must be placed at a flight plan waypoint in order to create a VNAV solution.

Vertical Direct-To

The *vertical direct-to* feature allows the pilot to make a direct descent from the aircraft's present position to an altitude constraint at a waypoint. This may be direct at the next waypoint or another waypoint downtrack. If a downtrack waypoint is used, all altitude constraints between the aircraft and the selected waypoint are cleared and the VNAV computes a vertical path to the new constraint.



VERTICAL DIRECT-TO - Figure 9.8

The **DIR** button is pressed and the desired altitude constraint is entered on the line adjacent to the appropriate lateral waypoint. The FMS will calculate and display the required vertical speed and path angle to reach the constraint.

The pilot may enter a current constraint, a new constraint, or use the preselector altitude as the target. Normally, when ATC issues instructions for a descent, the preselector is changed, the altitude is copied up to the *vertical direct-to* line, and when the descent is to begin, EXECUTE is pressed. The FMS does the rest.

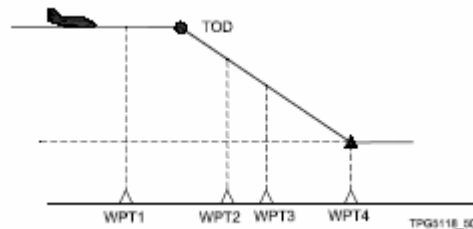
A *vertical direct-to* may not be done across a DISCONTINUITY, a heading leg or an altitude terminated leg, within a procedure turn or a holding pattern, or with crosstrack deviation greater than 10 nm. It also cannot be planned to an altitude above the airplane or an altitude that requires more than a 6° vertical descent path.

When multiple altitude constraints are placed in the flight plan, the FMS attempts to smooth the vertical path. This provides a continuous descent and eliminates leveling on the steps between waypoints.

A **DES** annunciation displayed on the map is an indication the aircraft will not automatically descend. The pilot must make sure the FMS and FD are configured for a VNAV descent.

Normal VNAV Descent

To intercept a vertical path, VNAV is selected on the Flight Control Panel (FCP) or Mode Select Panel (MSP) and the preselector is lowered prior to the aircraft reaching the TOD. The system will issue a TOP OF DESCENT visual alert in the lower left-hand corner of the PFD one minute before reaching the TOD. VPATH, in white, will also be the armed mode for the flight director. At 45 seconds prior to TOD, a CHECK PRESELECTOR message will be displayed if the preselector has not been lowered. At 5 seconds prior to the top of descent the TOD on the PFD begins flashing and the system issues as aural alert.



NORMAL VNAV DESCENT - Figure 9.9

When the aircraft reaches the **TOD**, the flight director will push the airplane over to follow the programmed vertical path. The pilot retains speed control with the throttles. A 3° path usually provides a comfortable descent requiring reduced thrust settings.

When armed, the FMS will capture and track a vertical path. Much like lateral navigation, the aircraft must be put on a course that will allow it to intercept the path. If the path is beneath the airplane, a rate of descent must be set up that will, in effect, dive the airplane into the path. If the path is above the aircraft, simply holding altitude or using a vertical rate less than the *vertical direct-to* rate will drive the aircraft into an intercept.

Vertical direct rate is displayed by the circle on the vertical speed scale and at the top of the MFD when VNAV is selected for display in the text window.

If the aircraft is flown past the TOD before the preselector is lowered, the flight director will simply hold at the last altitude. At this point the FMS is looking for direction from the crew on how to get to the next altitude constraint. The crew must select a vertical mode, start the aircraft down, and make sure VNAV is active. If and when the aircraft comes across the vertical flight path, the VNAV will capture the flight path and track it to the altitude constraint. Using the *direct-to* circle as a guide, a vertical rate can be established for a path intercept.

A descent may begin before the TOD on other occasions. Again, the crew selects a specific vertical mode and rate and may arm VNAV on the FCP to intercept a vertical path. If the aircraft does not cross a vertical flight path, it will continue at the crew-selected vertical rate until reaching either an altitude constraint or the pre-selected altitude and track that altitude.

There are times when the VNAV system is not able to compute an intercept with a vertical path. Basic VNAV operation assumes the flight plan will be followed. However the airplane may fly through a discontinuity, fly ATC vectors or capture a localizer in which cases the flight plan will not be followed.

In these instances the armed mode “PATH” will display in yellow. It is basically alerting the pilot that if the present course is continued the vertical path will probably not be intercepted. This most often will be seen on vectored approaches where the aircraft heading is taking it away from the altitude constraint.

The reason for the condition will be annunciated on the CDU:

NO VPATH – XTD	Cross Track Deviation exceeds limits
NO VPATH – TAE	Track Angle Error exceeds limits
NO VPATH – DISCON	Discontinuity downtrack interrupting vertical path
NO VPATH – PILOT CMD	Pilot selected another autopilot mode
NO VPATH – VECTORS	Heading leg downtrack interrupting vertical path
NO VPATH – THIS LEG	A heading or holding leg is active
NO VPATH CONDITION	Pilot must create a condition for VPATH intercept

Chapter 10: Database

Today, pilots flying with Rockwell Collins FMS's receive both a printed copy and an



electronic navigation copy of the same procedure. The pilot carries the printed copy onto the aircraft; the electronic copy is loaded into the Flight Management System. Often the same data supplier directly or indirectly supplies both types of data. For Rockwell Collins FMS systems, Jeppesen supplies the electronic copy.

The database in the FMS contains all the published waypoints and procedures in the world that a pilot could use to build a flight plan. These include nav aids, airways, enroute waypoints, airports, terminal waypoints, SIDs, STARs, approaches, etc.

The database is updated every 28 days. This navigation data includes all of the information for two sequential data cycles, the current cycle and the next (new) cycle. This allows a user to upload the navigation database prior to the effective date, then use the current cycle until the effective date.

The FMS Status Page displays the effective dates of the two navigation database cycles. It also allows the user to switch the active and the inactive navigation databases (weight on wheels only). Press the left *line select key* adjacent to the date range of the inactive data. This action will copy the date range to the scratchpad. Then press the *line select key* adjacent to the active database. This action will copy the contents of the scratchpad to the active database. The dates associated with the former active date range are automatically copied to the inactive date range.



STATUS PAGE - Figure 10.1

It must be understood that the FMS navigation database does not always match data contained on printed charts, approach plates, SIDs, and STARs. For approaches, new waypoints, contained only in the FMS database, must be inserted to aid FMS navigation (ARINC 424). FMS-defined waypoints provide logic for lateral and vertical steering commands. For example, many approaches have an extra waypoint called a final approach Course Fix or **CF**. This simply enables the FMS to navigate to a point prior to the final approach fix. As another example, a SID may have an altitude contained in parentheses, indicating that a turn will occur when the aircraft reaches that altitude – conditional waypoint. These differences are intentional. The process of converting from a paper chart or approach plate to an electronic database often requires changing the database to enable the machine to fly a procedure that a human pilot accomplishes with little effort.

Approach step down altitudes after the Final Approach Fix is not in the database. Instead, a path starting at the missed approach point and extending back to the FAF is created that clears all altitude restrictions.

SIDs and STARs with an “or” condition are often coded as an “and” in the database. For example: “Climb straight ahead and turn upon reaching 500 feet, or 4 DME, whichever occurs first.” It may be coded as a waypoint at 4 DME with an altitude constraint of 500 feet (or 500 feet and above).

If the computer finds duplicate database entries for a given identifier, it displays the SELECT WPT page with all of the duplicate identifiers listed in ascending distance order from the

preceding waypoint. To select a waypoint from the list, press the *line select key* adjacent to the desired waypoint.

Additional Information

Pilot-Defined Waypoints

Pilot-defined waypoints are typically established for initialization needs or as RNAV waypoints. They are set up by referencing them on a distance bearing from an existing waypoint or by identifying them with latitude/longitude information. The system can store up to 100 pilot-defined waypoints.

To locate an aircraft at a specific spot on the airfield, a pilot-defined waypoint could be constructed. For example, this could be a flight operations ramp or gate.

RNAV points can be made up along a direct route if transition points are needed or if the pilots merely want to use them for reference.

Valid database waypoints are nav aids, enroute intersections, and non-directional beacons, airport reference points and pilot-defined waypoints. Also usable are terminal waypoints and runway thresholds related to the origin and destination airports. Pilot-defined waypoints using the shorthand LAT/LON entry method are not usable.

If the pilot simply is adding the waypoint to the flight plan and there is no need to store the information. The FMS will automatically name the new waypoint using the reference waypoint identification and a number. The complete description of the point can be viewed by copying it back into the scratchpad. If the point is to be stored, a slash and five-digit name is added. The FMS automatically stores the route as a pilot-defined waypoint. The waypoint is not stored if the FMS applies its own identification.



Pilot-defined waypoints may also be “built” by defining them under the database *line select* key in the index. In this situation, the pilot simply fills in the appropriate lines, names the point and stores it into the memory.

Bearing and Distance Waypoints

A bearing/distance waypoint can be established by either copying an existing waypoint from the flight plan or entering a new waypoint into the scratchpad. A bearing and distance are entered following the waypoint’s name.

The bearing must be at least three whole numbers and any distance up to 199.9 can be entered.

The new waypoint is transferred into the flight plan by pressing the appropriate *line select* key.

Place Bearing/Place Bearing Waypoints

Using the bearings from two waypoints may create a waypoint. The intersecting point will be the new waypoint. This new location must be within 400 nm of both “place” locations.

The reference waypoints and the appropriate bearings from each are entered into the flight plan from the scratchpad.

Latitude/Longitude Waypoints

A waypoint based on latitude and longitude may be created.

The LAT/LON is entered in the scratchpad then copied into the desired position in the flight plan.

Pilot Routes

Pilot routes are custom routes built using the FMS database and stored as a recallable route. Up to 100 pilot routes may be defined.

Gate Locations

Gate locations for selected airports may be included, for a monthly fee, in the navigation database. Inclusion of gates must be specifically requested. This feature may not be available on all FMS's.

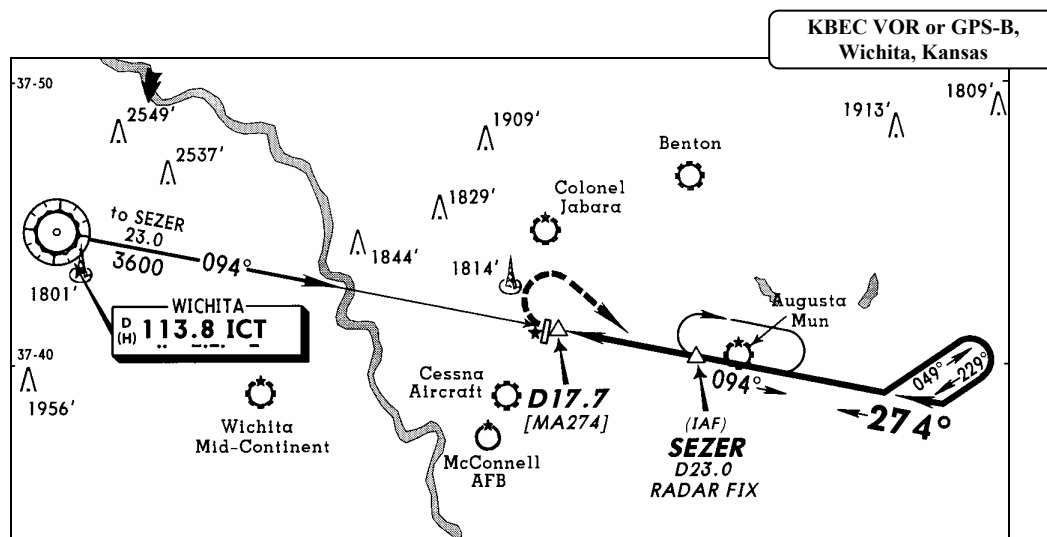
Company Routes

Company routes are defined by the user's flight department and sent to Collins for inclusion in the navigation database. Up to 1000 company routes may be defined; each route may contain up to 100 waypoints.

Differences between Pilot-Entered and Displayed Course Values

Subject: **When 274° Does Not Equal 274°**

"85 Charlie Romeo, fly heading 255 to intercept final approach course, cleared for the GPS B to Beech field." The approach is already selected and displayed on the map. All that is left to do is press the **DIR**ect key, select **SEZER**, key in an intercept course of 274° and hit the **EXEC**ute key – right? *But why do the PFD and the CDU LEGS page show a course of 277°? Shouldn't it show 274°?*



Approach plate courtesy of Jeppesen Sanderson, cycle 9802

The conversion process causes this difference in course displays from one course reference system to another.

When a course is entered via the CDU, this course is converted to a true north reference, since all FMS internal calculations are done referenced to true north. Course displays in the cockpit, however, are generally based on the magnetic heading reference frame. Differences between entered and displayed courses occur when the conversion from magnetic to true course uses a different value than is used in the conversion from true back to magnetic course.

Magnetic Variation (either computed or published) and Published VOR Station Declination are used by the FMS to convert between true and magnetic reference frames. Before proceeding, some definitions are in order.

Magnetic Variation (Mag Var):

Mag Var is the angular difference between true north and magnetic north at a given location. It varies over time and is also a function of position on the earth.

Computed Mag Var: The value of Mag Var for a geographic location, as calculated by the FMS using an internal mathematical model.

Published Mag Var: The value of Mag Var for a geographic location, as published by a government agency and provided to a database supplier (such as Jeppesen).

Published VOR Station Declination: The angular difference between true north and the zero degree radial of a VOR station, as published by a government agency and provided to a database supplier (such as Jeppesen).

The FMS Converts from Pilot-Entered (mag) Course Values to True Course Values Using the Rules Listed Below.

For Approaches, the Following Logic Applies:

The Published Mag Var for the airport reference point is used to adjust the entered course value to a true course value for the FMC to use internally.

For Procedures (SIDs and STARs):

If the leg begins or ends at a VOR, then the published VOR Station Declination is used to adjust the entered course value to a true course value for the FMC to use internally.

If the leg does not begin or end at a VOR, then the Published Mag Var for the airport reference point is used to adjust the entered course value to a true course value for the FMC to use internally.

For all Other Course Entries:

If the leg terminates at a VOR, then the Published VOR Station Declination is used to adjust the entered course value to a true course value for the FMC to use internally.

If the leg does not end at a VOR, then the Computed Mag Var for the leg termination waypoint is used to adjust the entered course value to a true course value for the FMC to use internally.

The FMS Converts From Internal (True) Course Values Back to Magnetic Course Values Using the Rules Listed Below. The Resulting Course Value is Displayed on the CDU and PFD.

If the leg ends at a VOR, the FMS-computed magnetic variation at present position plus a "correction factor" is used to adjust the true course value to magnetic course. The correction factor is the difference between the computed mag var at the VOR and the published VOR station declination (the purpose behind the correction factor is to have the displayed course become "more correct" as the distance to the VOR decreases).

If the leg ends with a waypoint other than a VOR, the FMS-computed present position magnetic variation is used to adjust the true course value to magnetic course.

Due to the variety of conversion rules, it is possible to use one rule to convert a pilot-entered magnetic course entry to true course (for internal FMS use) and then use a different rule to convert the true course back into a magnetic course for display in the cockpit.

In the example at KBEC, the values of interest are shown in the table below.

ICT Published Station Declination:	7° E
KBEC FMS Computed Mag Var:	6° E
KBEC Published Mag Var:	9° E

Because SEZER is associated with an approach, the entered course of 274° is corrected to true course by adding the airport's Published Mag Var, giving a true course of $(274 + 9)^\circ$ or 283°. When the value is converted back to be displayed in the cockpit, the FMS-computed Mag Var is subtracted from the true course; $(283^\circ - 6)^\circ$ or 277°, which is displayed on the PFD and CDU.

These differences will occur most often on a SID, STAR, or an approach where the published Mag Var for the airport is noticeably different than the FMS computed Mag Var at the airport, as in the example above. A difference between course values may also manifest itself when a procedure is defined in terms of VOR radials, but the procedure uses intersections or other waypoints (that is, not the VOR) and the VOR's published station declination is noticeably different from the FMS-computed Mag Var at the VOR station.

Chapter 11: Flight Plans

Overview

All flight plans may contain up to 100 legs. Entry methods apply to both active and second plans.

All flight plans may include:

Origin Airport	Departure Runway
Standard Instrument Departure (SID)	Published Waypoints
Pilot-defined Waypoints	En route Airways and DIRECT Legs
Parallel Offsets (Active only)	Holding Patterns
Standard Terminal Arrival (STAR)	Approaches
Destination Runway	Destination Airport

Alternate Airport

Additionally, a flight plan may include vertical navigation profiles and waypoints as well as performance and fuel calculations. The performance and vertical navigation features are discussed later in this manual.

A flight plan may also contain conditional waypoints that are not located at a geographical fix. Conditional waypoints are entered from the database as part of a departure or arrival procedure and can not be manually entered. These points are required in order for the FMS to be able to fly various procedures. Examples are turn points located at specified altitudes or located at the intersection of a heading leg and a VOR radial. These FMS-generated waypoints are enclosed with parentheses on the CDU and MFD.

Flight Plan Page

The Flight Plan (FPLN) page displays a flight's routing that generally corresponds to ATC filing language. The plan is laid out by the pilot using direct routes or specific airways and departure, arrival and approach procedures. Selection of runways, departure and arrival procedures and approaches are selected from the menus under **DEP/APP** button. The selected procedures are automatically loaded into the flight plan page.



FLIGHT PLAN PAGE - Figure 11.1

There are several ways to load a flight plan. It may be loaded manually, entered from a data disc or retrieved from a stored pilot or company route list. Airborne Flight Information System (AFIS) flight plans can be automatically data linked into the system. No matter the source, once loaded the crew is able to edit any flight plan.

LEGS Page

The LEGS page breaks down a flight plan into individual waypoints to provide the details of each leg. The LEGS page is typically where individual edits of waypoints are completed. *Direct-to*, individual waypoint deletion, vertical nav constraints, “From” waypoints and selected courses are some of the more common edits done on the LEGS pages.



LEGS PAGE - Figure 11.2

Types of Flight Plans

There are two flight plans available for viewing and editing, the Active Flight Plan (ACT FPLN) and the Second Flight Plan (SEC FPLN).

ACTIVE Flight Plan

The active flight plan is just what it implies. It is the flight plan that is currently providing steering information to the flight director. An additional flight plan, a modified flight plan, is created when changes are made to an active flight plan. The active flight plan can be modified at any time from either the ACT FPLN or ACT LEGS pages. When information is changed, MOD FPLN or MOD LEGS will display in the upper left corner of the CDU. The active flight plan remains in the background as the master plan and is not changed until EXECUTE is pressed. At that time all modifications are incorporated into the flight plan. Prior to executing, a CANCEL MOD option is also available. This simply removes any changes since the last EXECUTE and brings the active plan back to the display.

Remember, pressing the **EXECUTE** button “saves” a flight plan when working with the active flight plan.

Note:

*There is **not** an UNDO for CANCEL MOD or EXECUTE.*

In synchronized mode the offside active flight plan will not change until the on-side flight plan is EXECUTED.

The FMS will continue to fly the “old” flight plan until the execute button is pressed. If the crew does not execute the flight plan within a short period of time the FMS will prompt them on the CDU and PFD to complete the procedure.

SECOND Flight Plan

Additionally, a second flight plan may be created. It provides a place for the crew to build up a second flight plan for the return trip, tomorrow’s trip, an expected optional arrival procedure or approach, etc. It may include all the elements of an active flight plan including lateral and vertical navigation as well as performance and fuel calculations. It can not be coupled to the flight director. It then may be stored as a route plan, moved over as the active flight plan, or simply be used to make “what if” calculations for time and fuel management. AFIS flight plans are loaded as a second flight plan.

A second flight plan is retained when the avionics power is shut down. When the avionics are restarted the SECOND flight plan is made operational simply by pressing ACTIVATE and then EXECUTE.

Any edits to a second or route plan are incorporated immediately and EXECUTE is not available or required. Also in sync operating mode, any changes made to the second plan are immediately transferred to the offside second plan. EXECUTE and CANCEL MOD are not available when working in the SECOND flight plan.

After a route has been entered as a second flight plan and the ACTIVATE *line select* key is pressed, the MOD FPLN page will be displayed. However, if a modified flight plan already exists it must first be canceled before the second flight plan can be moved. Once made active,

the flight plan may still be modified at any time. All performance data except initial fuel weight is automatically initialized on the PERF INIT pages. If the flight plan was originally a stored route plan, modification at this point does not change the original route.

When the second flight plan is activated while airborne the MOD LEGS page rather than the MOD FPLN page will be displayed after activation. This gives the pilot an immediate access to any waypoint contained in the route plan to make it the “TO” waypoint.

Pressing EXECUTE makes the modified plan active and moves the previous active flight plan to the second flight plan.

FPLN		
<u>Displayed</u>	<u>ACTION</u>	<u>CREATES</u>
ACT FPLN	Edit	MOD FPLN
MOD FPLN	Execute	ACT FPLN
ACT FPLN	Copy Active	SEC FPLN

If a Modified flight plan does not exist, then:

SEC FPLN	Activate	MOD FPLN
MOD FPLN	Execute	ACT FPLN

(The Active and Second change places)

Both the Active and Second flight plans may be stored as a route in the route list. The procedure is performed from the Pilot Route List on the Route Menu page.

Company or Pilot Route

The identifier for a pilot-defined or a company route may be entered in lieu of the origin and destination airports. The FMS will automatically fill in the flight plan information from the stored route database.

Airport Entry

It is vital for the pilot to understand that the origination and destination airports should always be entered into a flight plan. Pertinent runway, departure, approach and arrival information is not made available until the appropriate airports are entered. Even if the procedures are never used for a flight, entering the airports ensures their immediate availability. The vertical navigation logic needs both the origin and destination airports entered into the flight plan in order to determine the midpoint of the flight. The performance sections need the airports to calculate fuel and time. Remember, no terminal deviation scaling is available without origin and destination airports.

A flight plan may be created without entering an originating or destination airport. Waypoints may be entered and the FMS will navigate to them. There are times, for instance, when it might be appropriate to not enter an originating airport. When a destination is changed mid-flight there is no real need to put in an originating airport. Normally, however, it is wise to always enter the originating and destination airports.

Entering only the airports does not make a flight plan. A “NO FLIGHT PLAN” message will continue to be displayed across the HSI until a TO waypoint is entered either on the flight plan or legs page.

Origin Airport

When the originating airport is entered on the flight plan page, any previous active flight plan will automatically be cleared. It also makes runway, Standard Instrument Departure (SID) procedures and terminal waypoints specific to that airport available. Arrivals and approaches to the airport are also available should there be an immediate need for the aircraft to return to the airport. Deviation scaling is enabled for the named airport within the terminal area (30 nm).

Destination Airport

When the destination airport is entered, Standard Terminal Arrival (STAR) procedures, Instrument and Visual approaches and runway information are made available for that airport. This also permits the terminal waypoints for the destination to be displayed on the MFD. The great circle distance between the two airports is also displayed.

Again, deviation scaling is enabled for the named airport within the terminal area.

Alternate Airport

When an alternate airport is entered on the ALTN line, an additional page is appended to the end of the flight plan and the legs pages and labeled with an ALTN prefix. This provides an area to build the route to the alternate airport. A space will be left between the final leg of the missed approach from the destination airport and the first leg of the alternate routing. When needed the first leg is simply made the TO waypoint and executed.

There will not be any access to arrivals or approaches for the alternate destination until the airport identifier is moved from the ALTN to DESTINATION positions on the first flight plan page. If an alternate airport is filed, it should be entered. It greatly simplifies the workload for the crew when and if it becomes necessary to proceed to the alternate.

Discontinuity

A DISCONTINUITY annunciation in the flight plan or on the LEGS page alerts the pilot the FMS needs further instructions on how to navigate between two waypoints.

If a DISCONTINUITY is left in the flight plan, the FMS will inhibit automatic sequencing on to further waypoints and simply hold the wings level after passing the waypoint before the discontinuity. A yellow FPLN DISCONTINUITY warning will be displayed on the CDU when on the leg to the final waypoint.

Selecting a “vectored” or visual approach automatically enters a DISCONTINUITY. This provides an area in the flight plan for accepting ATC vectors before sequencing on to the initial approach fixes.



LEGS PAGE - Figure 11.3

When an aircraft is operating within a flight plan DISCONTINUITY, vertical navigation will be computed based on great circle distance navigation.

Deleting the DISCONTINUITY will cause the FMS to enter a DIRECT route linking the adjoining waypoints.

Note:

A DISCONTINUITY associated with a “vectored” approach can not be deleted.

A waypoint may be used to close the gap.

Rather than deleting, a waypoint may need to be added in place of the DISCONTINUITY. (Examples might be a course reversal, too tight a turn, incorrect order of waypoints, etc.)

A DISCONTINUITY may be removed on the LEGS page by entering a waypoint in its place. It is often simplest to just move the next waypoint up into the DISCONTINUITY. However, an entirely new waypoint may also be entered to resolve any course reversal or other conflict that would make flying the route impractical or impossible.

Selecting AUTO Sequencing on the LEGS page will make the waypoint following the discontinuity the TO waypoint.

Departure/Arrival Procedures – Runways – Approaches

All runway, departure, arrival and approach information is found by pressing the DEP/ARR function key.

When a departing runway is selected, the threshold becomes the FROM waypoint in the flight plan. If a departure runway is not selected the airport reference point is used as the FROM waypoint. After selecting a runway, departures that apply to that runway will be presented for selection.

Note:

The FMS, navigation receivers and the IRS systems can not be updated to the runway threshold if the runway selection is left blank.

If a SID or STAR is to be included in the flight plan, the appropriate procedure and transition are selected. On the flight plan page, the FMS will enter a SID or STAR by name under VIA and the transition waypoint in the TO position.

For approaches, the pilot will be offered a menu of available instrument and visual approaches. Selecting the approach will enter it on the flight plan page.

Departure, arrival and approach data for airports not included in the airport may be accessed by entering the airport identifier into the “OTHER” lines on the DEP/APP page. However, they are not selectable for use in the flight plan and are for reference only.

Enroute

Routing using airways or DIRECT is entered on the flight plan page. FMS logic assumes the pilot wants a DIRECT routing between two waypoints unless told differently. If DIRECT is the desired routing, only the waypoint needs to be entered under TO and the FMS will fill in DIRECT under VIA.



If an airway is the desired routing, the airway identifier is entered, i.e. V67, J81, BR7L, AR3 under the VIA legend. Entry and exit points must be at a waypoint on the airway. The FMS will fill in all the individual legs making up the

desired route, which can be viewed, on the LEGS page.

To add an airway to a flight plan, the pilot may either enter the airway identifier or the exit point first.

The individual waypoints and legs may also be viewed on the MFD North-Up Planning Map. Using the MFD ADV function allows the crew to step through a flight plan to verify the routing.

Waypoints and any altitude constraints may be edited, added or deleted on the LEGS page.

The crew also has the option on the active flight plan page to set up right or left offset courses. This feature is only accessed with weight-off-wheels.

Holding procedures may be entered anytime and are very quickly set up using the HOLDS option via *line select* or function key.

The FMS will also provide the crew FIX information from any waypoint. The FIX page is accessed via *line select* or function key. FIX information is displayed graphically on the MFD.

Chapter 12: Performance

Performance

Airplane performance predictions are available for all flight plans. Aircraft performance data is stored in the memory of the FMS. Time and fuel predictions may be made for the active flight plan. Predictions will be made for a modified flight plan in order to provide predictions for “what-if” situations. Future trips built up in the second flight plan may also have performance included as part of the plan.

Notes:

Both the originating and destination airports must be entered on the flight plan page in order to generate performance calculations.

Pressing the PERF button will give access to the PERF INIT page where the performance variables for a flight may be entered. The available predictions are landing weight, fuel remaining and time to waypoints/destination.

On the first Performance Initialization page, passenger, cargo and fuel weights are entered, along with cruise altitude. All other performance data have default values. The gross weight is automatically computed using the default basic operating weight (BOW). The crew enters the beginning fuel weight and the FMS uses either a predicted, measured, or manually input fuel flow to compute remaining fuel. The fuel weight may be re-initialized at any time on the ground. When fueling is completed, total fuel on-board should be entered.

Typically, Performance Data should be entered after the major portions of the flight plan have been entered. Selecting the FPLN PROGRESS page on the MFD will display fuel remaining and time at each waypoint, destination and alternate airport, if entered.

The pilot may specify default settings for many of the performance and vertical navigation functions of the FMS. These can be set from the index page as a standing default, or may be changed on the performance and VNAV initialization pages for an individual flight. These values are automatically loaded into a new flight plan.

A cruise altitude entered on the PERF INIT page will be automatically entered on the VNAV setup cruise page.

Average forecast block winds may be entered on page 2 of the PERF INIT along with any forecast ISA deviation. Entered wind values are used to make final computations for fuel remaining and ETAs. Wind values may be entered by direction and speed, headwind or tailwind component, or plus or minus.

Fuel allocations for the default taxi and reserve quantities may be edited on the third page of the PERF INIT. Also, entering an Estimated Time of Departure (ETD) here will yield a performance computation for ETA, as well as predicted RAIM on the GPS control page. An ETA is also computed at takeoff.

VNAV set up is also done under the PERF pages. Default speeds may be changed for the cruise, climb and descent phases of flight. Also altitude speed limit restrictions as well as the Vertical Path Angle (VPA) for the entire flight plan may be changed here.

Chapter 13: Flying the FMS

Flight Plan Changes

Once the initial flight plan has been built, individual waypoints are easily deleted, moved or added on the LEGS pages.

The flight plan page displays the routing in the same basic form, as it would be filed with a Flight Service Station. The LEGS pages break the flight plan down into individual legs between waypoints of an airway or route.

LEGS pages display the waypoints in sequence. Distances between waypoints, the course to the active waypoint, the outbound course from a waypoint to the next waypoint, airspeed and altitude constraints are also displayed.

FMS-generated waypoints are also displayed on the LEGS pages. For instance, the FMS may place a Course Fix (CF) outside the Final Approach Fix to use as an alignment waypoint for an approach. Crews will also see turn points based on either distance or altitude. These simply give the FMS heading change points in order to comply with departure and arrival procedures. A line on the LEGS page will also indicate DME arc arrival and departure procedures.

Waypoint SEQUENCING options are also controlled on the LEGS page. AUTO allows the FMS to sequence on to the next waypoint in the flight plan automatically. The legs will not automatically sequence unless the aircraft's path in relation to the inbound course is less than 110° and there is less than 2500 feet between the aircraft and the waypoint. Selecting INHIBIT disables sequencing, allowing the crew to pick the time for the sequencing to occur. Sequencing is inhibited when passing the Final Approach Fix on an approach.



Remember that any change made to the active flight plan on either the FPLN or LEGS pages will create a modified flight plan, and it must be **EXECUTED** for it to be active.

Flight plan waypoints are saved as history data as they are passed. Selecting DIR then PREV accesses the previous fifteen waypoints.

Offsets

An offset track may be set up by entering an L or R along with a number of miles (up to 99 miles) required for the offset. The FMS will draw a parallel course along the original track.

Direct-To command or setting the offset back to 0 miles will cancel the offset.

Speeds and Altitudes

If there are speed and altitude constraints associated with a selected arrival or approach procedure, they will be displayed to the right of a waypoint on the LEGS page. The crew may also place constraints at any lateral waypoint in order to create a vertical waypoint or note a speed restriction. The FMS displays advisory altitudes in a small font and constraints are shown in large font.

The entered speeds are advisory only and may also be displayed on the MFD using the SPEED selection in the menu.

DELETE

Pressing the **DELETE** key loads it into the scratchpad. It can then be moved up into the LEGS page to delete a leg or discontinuity simply by pressing the appropriate *line select key*.

A DISCONTINUITY before a VECTORED approach can not be deleted. However, a waypoint may be inserted into that point.

As always, the changes do not become active until EXECUTE is pressed.

Adding a Waypoint

A waypoint may be entered into any point of a flight plan on the LEGS page at any time. The identifier is entered from the scratchpad into the desired waypoint sequence by pressing the

appropriate *line select key*. The waypoint it replaces will move down and follow the newly installed waypoint.

Confirm the change is correct, clear any DISCONTINUITY and EXECUTE.

FROM Waypoints

FROM waypoints may be created on the LEGS page. A waypoint entered in the top left position, in cyan, becomes the FROM waypoint. To make and fly a course between two waypoints, the FROM identification is put in the top position and the TO point is placed immediately below it.

For example, if an aircraft has been vectored off course and is then directed to resume the flight plan route, all the crew needs to do is enter the waypoints before and after their current position. An appropriate heading is then selected by the crew or assigned by ATC to get back on course, and NAV is armed on the flight control panel. When nearing the course the aircraft will capture and proceed to the TO waypoint. This is also the method used to intercept an arc between the end points.

Direct-To

Creating a course DIRECT TO a waypoint is accomplished on the LEGS page. The waypoint identifier is entered from the scratchpad into the second position down on the left side of the CDU. It can be the current TO waypoint, another waypoint in the flight plan or a new waypoint not in the flight plan.

For instance, after flying ATC vectors following departure, an aircraft is cleared “Direct” to the first waypoint. The pilot simply presses the key beside the TO waypoint two times and then EXECUTES to complete the process. The first press loads it into the scratchpad and the second press places it back into the TO position. The FMS will now create a course from the present position *direct-to* the TO waypoint. It’s very quick and simple.

When the new waypoint is entered, a MODIFIED flight plan will be created and before EXECUTE is pressed the crew has the option of setting up an intercepting course to the waypoint. The intended inbound course is entered via the lower right *line select key* at the INTC

CRS caret. The aircraft is flown on a heading that will intercept the inbound course. NAV is armed on the flight control panel to capture the course.

If the new TO waypoint was a part of the flight plan, all waypoints between the current TO and new TO waypoint will be removed. If this is not the desired result, CANCEL MOD will cancel the change.

If the new TO waypoint was not a part of the original flight plan, it is simply entered in place of the current TO waypoint.

Confirm the change is correct, clear any DISCONTINUITY and EXECUTE.

Direct-To Using DIR Button

An alternate method of going DIRECT is to first press the DIR button.

Again, a waypoint may be selected from the list, or a new waypoint may be entered from the scratchpad into the boxes below the DIR TO legend on the CDU. If an intercepting course is not desired, pressing EXECUTE will complete the process.

If the crew wishes to return to a previous waypoint, pressing the PREV function button will bring up a list of the last 15 waypoints that have either been sequenced through or by-passed because of previous DIRECT-TO operations. The desired waypoint is simply selected and it becomes the “TO” waypoint.

There are times when the actual desired intersecting course is automatically entered. For instance, when making the initial fix of an approach the TO waypoint, because of the DISCONTINUITY immediately before it, the inbound course for the approach is shown as the INTC CRS. The temptation is to assume the correct course is entered and not press the key beside it. The *line select key* must be pressed to tell the system the intent is to establish an inbound course to the waypoint. Not pressing the INTC CRS key will simply create a course from present position to the new waypoint.

Note:

Arrival and runway data will not be available unless the destination airport has been entered in the flight plan.

Arrivals

It is sometimes not practical to select a specific arrival or destination when initially loading a flight plan. There also may be instances when ATC clearances will require changes in existing arrival and approach procedures. On the Collins FMS all changes are accomplished very quickly and efficiently with a minimum of “keystrokes.” A flight plan may be EXECUTED without arrival and runway information.

Pressing the **DEP/ARR** button will bring up arrival information for the originating airport if the aircraft is less than 50 miles away or less than half way to the destination airport. A second press of the **DEP/ARR** button will bring up the departure/arrival index. If the aircraft is beyond those limitations, the information for the destination airport will immediately be displayed. If there are no arrival procedures for an airport, only the available runways and associated approaches will be displayed.



After a procedure is selected, transition waypoint options, if any will be displayed and are simply selected by pressing the adjacent *line select key*. The FMS places the completed arrival procedure at the end of the flight plan. The individual legs may be viewed on the LEGS page.

If the last waypoint in the flight plan is not the STAR entry point, the FMS will place a DISCONTINUITY in the sequence. The crew will then need to edit out the gap between the waypoints.

Changing the selection of a STAR will cause the new selection to replace the old STAR unless one of its legs is active. In that case the new STAR is inserted following the active

waypoint. Additionally, if a runway has previously been selected that is not associated with the new star the runway designation will be removed.

Chapter 14: Approaches

Overview

Note:

Approach data will not be available unless the destination airport has been entered on the flight plan page.

The FMS will provide lateral and vertical guidance to fly nonprecision GPS, GPS overlay, VOR, NDB, and RNAV approaches. Lateral and vertical guidance is also provided for visual approaches. Localizer based approaches are setup using the FMS.

Approach selection is done on the arrival page. Pressing the DEP/ARR button will present the approaches available for the airport. After selecting the desired STAR, all approaches and runways served by that arrival procedure would be listed. There may be several pages of runway information for a large airport. Pressing PREV and NEXT will *turn* the pages.

The logic of the FMS accommodates transitions to an approach either with ATC vectors or by using published procedures for the crew to shoot the approach “on their own.”

An instrument or visual approach is selected by pressing the adjacent *line select key*. A transition into the approach or VECTORS is then selected to complete the procedure. The runway threshold and centerline extensions are displayed on the MFD when a runway is selected. Instrument Guidance System (IGS), TACAN, standalone NDB and LORAN approaches also may be included in the database.

Missed approach procedures are automatically loaded into the flight plan when an approach is selected. They are entered following the missed approach waypoint. The waypoints and procedures are always visible on the LEGS page and are presented to the crew on the MFD map as part of a “Go Around” maneuver.

Transitions to an Approach

Vectors

The most common transition to an approach in today's environment is by radar vectors. The default transition is *vectors*.. In other words if a transition is not specified, *vectors* will be automatically selected.

Selecting a VECTORS approach transition creates a DISCONTINUITY in the flight plan between the last waypoint of the arrival and the first waypoint of the approach. This provides a gap for the aircraft to be vectored into position for the approach. It can not be deleted; however, a waypoint may be entered to fill the gap.

Normally, once flight control is switched over to flying ATC headings, the crew simply sets up an intercept course to the first appropriate waypoint on the approach. Remember, the INTC CRS key must be pressed to load the course into the TO waypoint.

When armed, the flight director will intercept the course and continue the approach.

Procedure Hold Transition

A special note about a hold as part of an approach. If a hold is used as the procedure transition for an approach, exit is automatically armed. For a teardrop or direct entry, the hold will become active when the aircraft first crosses the fix. A parallel entry may require the aircraft to cross the fix, fly the entry procedure and the hold becomes active when the fix is crossed the second time. Under normal conditions, the next time the aircraft crosses the fix, the hold will be exited and the FMS will go on to the next waypoint in the approach.

If a procedure hold is to be used as an impromptu ATC hold, the approach and transition hold should be entered in the normal manner. The ATC clearance should be followed and the hold may be altered on the HOLD page to meet the clearance requirements. Altitude is controlled by the preselector as specified by ATC. Since this is a procedure hold, EXIT ARMED will automatically appear on the LEGS page once the aircraft has entered the hold. Another menu item offered would be CANCEL EXIT, which should be selected. This will cancel the exit from the hold into the approach and the aircraft will continue to fly the hold.

After ATC has cleared the aircraft for the approach, assuming the altitude is correct, EXIT HOLD is selected on the legs page, and executed. The preselector may be lowered to the fix altitude restriction. The FMS will complete the hold by tracking to the (INTC) point located on the inbound leg to the fix. It will also begin a VNAV descent at the appropriate time.

DME Arc Transition

The FMS will navigate a DME arc if it is loaded from the database. Arcs are commonly seen as an approach transition, however, they may also appear on a STAR or SID.

Under normal circumstances an arc is entered at the entry waypoint. In these cases, the FMS will capture the arc, put a slight roll into the aircraft, usually less than 4-5°, and follow the arc around to the exit waypoint. It will fly a perfect circle. VNAV is available in the arc and on many approaches the aircraft will actually start to descend before the exit waypoint.

Note:

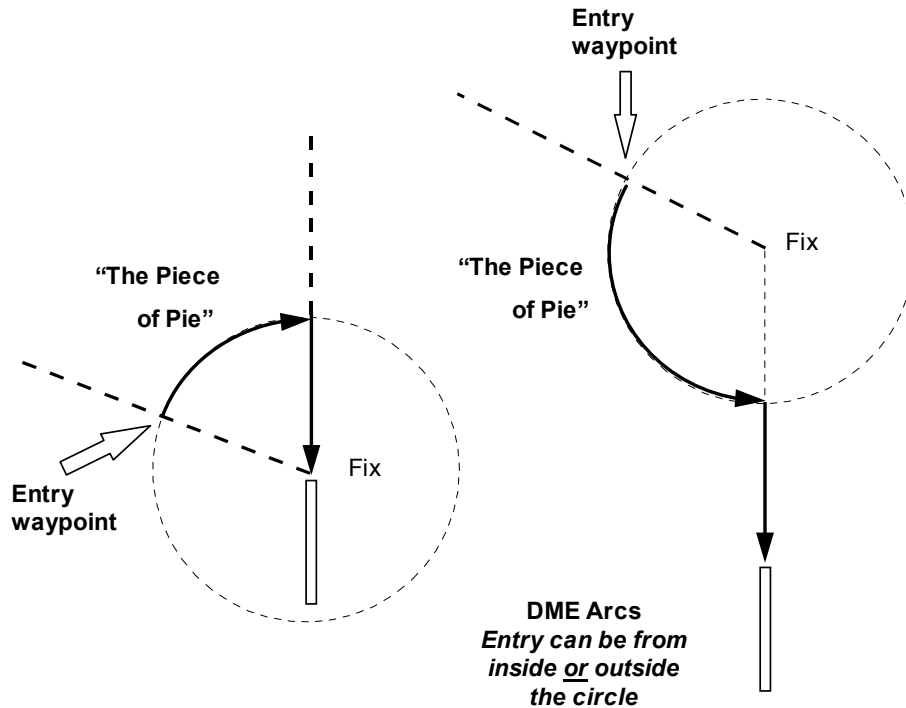
If waypoint sequencing is inhibited, when the aircraft crosses the final waypoint of the arc, it will remain in the slight roll until either a new mode is selected or a new “TO” waypoint is identified.

A DME arc may also be intercepted between the entry and exit waypoints. Heading vectors are flown and when the aircraft is within the “piece of pie,” APPR is selected on the FCP. The aircraft will capture the course and follow it to the exit point.

“Piece of pie” is defined as being bounded by the radial to the entry waypoint and the inbound course (extended).

To set up an intercept, the entry waypoint is moved to the FROM position on the legs page. The inbound arc will remain and the exit waypoint will become the TO waypoint.

The “normal procedure” would be to not arm NAV until in a position to capture in the “piece of pie.”



DME ARC TRANSITION - Figure 14.1

The reason for waiting is to avoid capturing and tracking outside the published end points of the procedure. When the waypoint is moved to FROM, the FMS draws an invisible circle clear around the fix. If the aircraft is on the opposite side of the fix from the actual arc, the deviation scale and course could be exactly opposite of what is expected. In fact, if NAV or APPR is selected, the aircraft will capture the circle and fly it on around.

Procedure Turn Transition

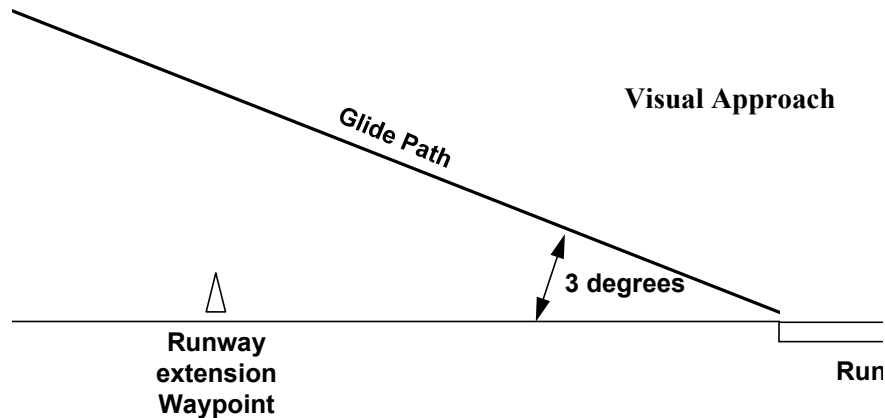
Visual Approach

Visual runway options are found under the VISUAL reference on the ARRIVAL page following non-precision approaches.

Selecting a visual approach installs the runway threshold as a waypoint and creates a runway extension waypoint 5 nm from the threshold. The crew may edit the runway extension. However, care must be taken to not interfere with other waypoints in the flight plan. The runway and centerline extensions are also presented on the MFD to provide situational awareness for the crew.

The FMS provides straight in lateral and vertical guidance to the runway. The vertical glide path is 3° and ends 50 feet above the surface of the runway.

The 3° glide path value may be changed, again between 1° and 6°.



VISUAL APPROACH GUIDANCE - Figure 14.2

An altitude constraint may not be entered in place of the RWY annunciation at the runway waypoint vertical reference.

A DISCONTINUITY is created between the last leg of an enroute or STAR segment and the visual approach. As with vectored transitions to an approach, this provides space for ATC vectors to the final approach course. When appropriate, the runway extension waypoint is selected as the TO waypoint.

Selecting APPR on the Flight Control Panel (FCP) sets the flight director on a glide path (VGP) rather than a vertical path (VPATH). Deviation scaling for a visual approach is one mile with GPS.

Note:

The altitude pre-selector must be set to field elevation for vertical guidance to the runway threshold.

WARNING:

A visual approach must *not* be used in IMC as a substitute for an Instrument Flight Rules (IFR) approach.

ILS / LOC Based Approach

A localizer-based approach and transition are setup from the arrival pages. Once a localizer-based approach has been selected, the displays, autopilot, and localizer receiver are all automatically preset and tuned by the FMS. At the appropriate time, the navigation source *may* automatically switch from FMS to localizer depending on the installation.

At 30 miles from the airport the FMS automatically tunes the onside localizer. A preset second course is displayed in cyan on the HSI. LOC is automatically selected as the preset NAV source and presented, also in cyan, to the right of the active nav source.

If the onside nav radio is in manual tune mode, the system will alert the pilot with a message “LOC WILL BE TUNED” and delay tuning for thirty seconds. If the FMS first tunes the localizer and then the pilot changes the frequency, to set up a DME hold for instance, the FMS will not retune the proper localizer frequency. The pilot must then manually retune to the proper frequency.

If the approach is changed after the aircraft is within 30 miles of the airport, the FMS will still automatically tune to the new LOC frequency and set the inbound course.

All ILS approaches include a database waypoint called the Final Approach Course Fix (FACF). It will not be found on published charts and exists solely as an FMS waypoint. It is typically located 3-6 miles outside the final fix. This provides an intermediate leg before the final fix to get the aircraft set up for the final leg of the approach. The label on the MFD map and the CDU will be CF followed by the runway number, e.g., CF14L or CF14R. Using the above runway example, the Final Approach Fix is identified as FF14L, and the runway threshold is identified as RW14L on the MFD map.

The crew must be aware of their position in relation to these two points. ATC vectoring will often turn the aircraft onto final somewhere between the CF and FF waypoints. In this situation,

it is best to simply move the CF point into the FROM position and EXECUTE. This will set up the correct inbound course without having to enter any other information.

As the aircraft is maneuvered into a position to capture the localizer, the pilot presses APPR on the FCP to arm the flight director to capture and follow the LOC/GS to the runway. The FMS automatically changes the nav source from FMS to the localizer when the aircraft is in a position to receive and capture the localizer signal. VNAV guidance is provided up to the point of glide slope capture or in the case of a LOC-only approach, the final approach fix.

Once the nav source has been switched, the FMS continues to follow along through the waypoints. When crossing the final approach fix, automatic waypoint sequencing is inhibited as shown on the top right corner of LEGS page. There will also be a reminder, SEQ INHB, on the PFD below the NAV source to remind the pilot the waypoint will not advance past the missed approach point.

WARNING:

For all types of localizer-based approaches manually set the DH or MDA alerters. It is the pilot's responsibility to recognize when the airplane reaches the DH or MDA, and to make a decision on whether or not to continue the approach.

Upon declaring a missed approach, Go Around (GA) is pressed on the throttle lever and the NAV source must be manually switched to FMS. Along with providing vertical and lateral guidance this also sequences the FMS to the missed approach procedure and displays the legs on the MFD. The sequencing may also be switched to automatic earlier by pressing the *line select* key adjacent to the annunciation on the LEGS page. The pilot can confirm the switchover by keeping the LEGS page displayed on the approach. This should be included as part of the approach checklist.

Note:

If a missed approach is declared, the nav source must be manually switched back to the FMS in order to provide missed approach procedure guidance.

FMS Non-Precision Approach

The Collins FMS is certified to do both stand-alone GPS and multi-sensor non-precision approaches. All FMS approaches are GPS based. The GPS is the dominant navigation source; however, blending of other navigation sources continues.

Lateral and vertical guidance is available throughout all, including visual approaches. The intent is for the approach to look and be flown much like an ILS. Lateral deviation is presented on the HSI and vertical deviation is presented by a “snowflake” glideslope look-alike. Required RAIM accuracy for a selected approach is also computed. The crew is responsible for proper monitoring of any required backup navigational aids such as an NDB or VOR.

WARNING:

For all types of FMS-based and/or non-precision approaches, the pilot must manually set the MDA alerters.

The VNAV system uses the aircraft’s altimeter as the reference for computing the vertical profile for the approach. GPS altitude, without a differential signal, is not good enough for the VNAV solution. Therefore, there is not an outside source of information, like a ground-based glideslope, to confirm the vertical position of the aircraft.

The aircraft must be flown into a position to capture the glide path. If below the path, level flight will cause an intercept. However, if the airplane is above the glide path, a descent rate must be selected manually that will cause it to fly down into the glide path. At that point it will capture and track the path. Of course, VNAV must be selected on the FCP to enable vertical guidance.

As with all approaches, the crew must maintain vigilance and verify the aircraft is tracking the correct lateral course and vertical profile. Decision Height (DH) or Minimum Descent Altitude (MDA) alerters should always be set to the correct altitudes.

Internal approach logic is automatically enabled at 30 nm from the Airport Reference Point (ARP) and remains active until after the MAP. The pilot may disable approach reasoning at any time. The approach must be disabled in order to transition into a missed approach procedure.

An approach is disabled by:

Selecting **NO** under the APPR ENABLED label on the ARRIVAL page

Selecting **GO AROUND** on the throttle lever

Making any lateral changes to the flight plan between the FAF and MAP

Manually sequencing through the flight plan past the MAP waypoint

Deleting the **FAF** or **MAP**

In other words, when the crew has decided to abandon an approach and selects **GO-AROUND**, does a **DIRECT-TO** edit, or simply advances the flight plan past the MAP, the approach is disabled.

Disabling an approach by deselecting APPR on the FCP will change the vertical mode to pitch hold. Selecting HDG or NAV also disables the approach but the vertical mode will go to VPATH. It is always the pilot's responsibility to provide terrain avoidance.

Note:

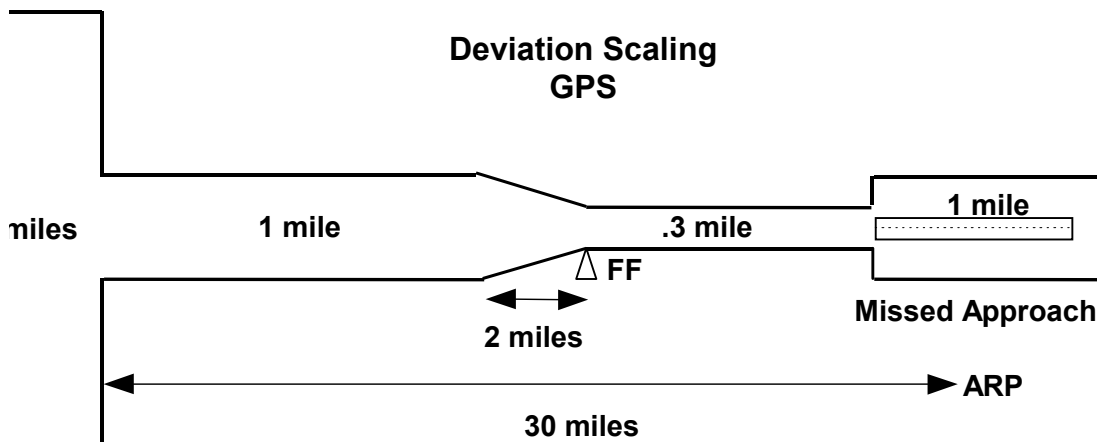
The system will not attempt to stop a descent or level the aircraft, unless it comes across a preselected altitude.

Display Deviation Scaling

Vertical and lateral display deviation scaling is changed as the aircraft nears the airport. Ideally, the final approach course intercept should be at least two miles prior to the Final Approach Fix (FAF). This will assure the scaling change is completed upon arrival at the FAF. Deviation scaling should always be checked when passing the FAF.

Full Needle Deflection – Laterally and Vertically

<u>Location</u>	<u>Lateral Dev (nm)</u>	<u>Vertical Dev(ft)</u>	<u>PFD Message</u>	<u>RAIM integrity</u>
>30 from ARP	5 miles	1,000	No message	Enroute
@ 30 miles	1 mile	1,000	GPS TERM	Terminal
2 nm from FAF	0.3 mile	500	DEV CHG	Approach
FAF to MAP	0.3 mile	500	GPS APPR	Approach
MAP	1.0	1,000	GPS TERM	Terminal



DEVIATION SCALING - Figure 14.3

VNAV Path / Glide Path

The VNAV descent profile is determined by whether the Missed Approach Point (MAP) is at the runway threshold waypoint or somewhere else. There are two basic descent profiles.

The pilot must understand which type of approach the aircraft is on. The response to the MDA by the FMS is different and the pilot must know what to expect.

It is important to note that current VNAV solutions are based on the barometric altimeter in the aircraft. The approach will only be as accurate as the altimeter. Extreme cold weather operation will require temperature conversions to be made to the baro setting.

Runway Approach (RWY)

This type of approach usually terminates at the runway threshold and always at the missed approach point. The Vertical Path Angle (VPA) to the runway is specific for a given approach and provides obstacle clearance to the runway.

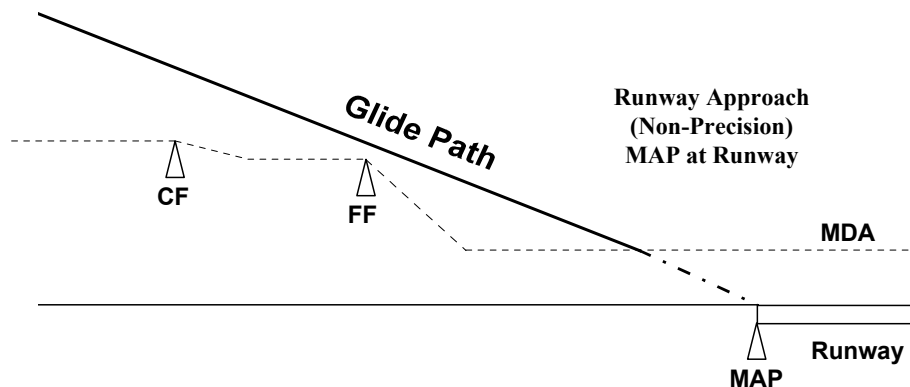


RWY APPROACH LEGS PAGE 1/2 - Figure 14.4

This type of approach is identified on the LEGS page by the RWY annunciation in the altitude constraint line at the runway waypoint. The altitude constraints at the runway MAP and the vertical path angle may not be changed.

The runway altitude value is typically 50 feet or more above the runway surface and is not displayed since it does not correspond with any published charts.

This approach looks much like an ILS in that it provides both vertical and lateral guidance to the runway threshold.



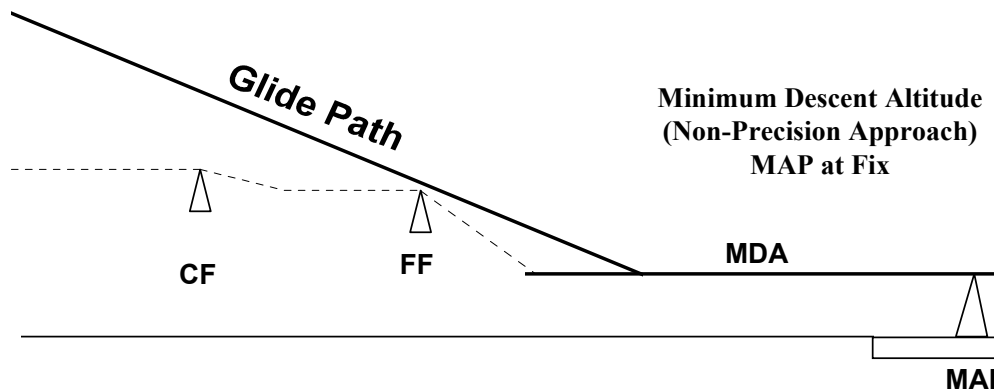
RUNWAY APPROACH - Figure 14.5

WARNING:

It is the pilot's responsibility to recognize when the airplane reaches the MDA and to make a decision on how to continue the approach. In airplanes with coupled VNAV capability, the FMS will not level the airplane at the MDA for RWY type approaches.

WARNING:

With coupled VNAV capability, even though the VPA for a RWY type approach provides compliance with step-down fix altitude restrictions down to the MDA, it is the pilot's responsibility to monitor for that compliance, and intervene if necessary to prevent a descent through a step-down fix.



NON-PRECISION GLIDE PATH - Figure 14.6

Minimum Descent Altitude Approach (V-MDA)

Minimum Descent Altitude (MDA) approaches terminate at a Missed Approach Point (MAP) that is somewhere other than the runway threshold. An example of this is a circling approach or where the MAP is the VOR station located on the field.



V-MDA LEGS PAGE - Figure 14.7

The vertical path for the approach is structured differently from that of a RWY approach. The vertical path (typically 3°) is defined from the top of the path, at the FAF, rather than from the lower point, the MDA. So instead of taking the aircraft to the runway, it simply starts a 3° glide path at the FAF and stops the descent when it reaches the MDA constraint. VNAV then vertically tracks the MDA altitude along the inbound course to the MAP.

WARNING:

Refer to the AFM for the limitation for V-MDA approaches. The use of VNAV vertical guidance for a V-MDA type approach between the final approach fix and the missed approach fix is prohibited.

V-MDA located above the altitude constraint for the MAP on the LEGS page, identifies this type of approach.

It is imperative the MDA value is verified as correct for the approach and equipment. The MDA altitude should be validated and changed, if necessary, to accommodate differences in weather reporting, equipment, designated runway, etc. Arctic operations require the pilot to calculate the proper density altitude difference and again verify the MDA reflects the correct altitude. In any case, the MDA constraint must not be set lower than the applicable published altitude.

The angle of the descent path may also be changed for an MDA approach. However, it may only be changed when the path does not cross a step-down fix.

WARNING:

Pilots must review the appropriate terminal procedures for an approach and adjust the MDA when appropriate in accordance with the airplane's approach category requirements. It is the pilot's responsibility to recognize when the airplane reaches the MDA and to make a decision on how to continue the approach. In installations with coupled VNAV capability, the FMS will capture and track the MDA for V-MDA type approaches.

Changing the angle may create a path that would conflict with the terrain. The pilot may change the altitude constraint at the FAF.

WARNING:

A descent path angle must never be changed when it crosses a step-down fix.

WARNING:

The FMS does not recognize step-down fixes between the FAF and the MAP and will not try to comply with them. It is possible on some V-MDA approaches, for a selected VPA to result in a vertical flight path that would go below a step-down fix altitude restriction. If a given approach has any step-down fixes between the FAF and arrival at MDA, VNAV should not be used for this portion of the approach.

Flight Director Modes

For either type of non-precision FMS approach, selecting APPR on the Flight Control Panel (FCP) will cause the flight director to disregard the altitude preselector and to follow the vertical guidance provided by VNAV to the MAP. Of course, the preselector must be set at or below the FAF constraint in order to get the aircraft down to the appropriate altitude. It is important to note the preselector will be ignored only on the legs into and out of the FAF. This allows the crew to reset the preselector to the missed approach altitude early in the approach.

An approach may be flown using either NAV or APPR mode. All of the deviation scaling changes will occur, the FMS will know it is on an approach, and the aircraft will behave exactly the same. Again, the only difference will be how the preselected altitude is treated and the vertical profile will be VPATH rather than VGP. There will not be any PFD indication that the system is being flown in APPR mode. The controlling lateral NAV mode will simply continue to show LNAV. Confirmation of the APPR selection is made by observing illumination of the green indicator lights on each side of the FCP APPR button.

The flight director will annunciate a VNAV armed mode of GP in white on the PFD. When captured, the active vertical mode will annunciate VGP in green and the altitude preselector may be reset.

Conditions required to **ARM** VGP are:

- FCP APPR mode must be selected
- VNAV mode must be selected
- FMS must be the navigation source
- Localizer can not be the preselected navigation source

Conditions required to **CAPTURE** GP are:

- VGP must be armed
- The nonprecision approach must be enabled
- The current active waypoint must be either the FAF or the MAP
- The VNAV descent path is within capture range

RNAV Approach

The FMS will provide lateral and vertical guidance for RNAV approaches. Missed approach procedures are loaded with the approach.

The FMS will autotune the appropriate navaid for an RNAV approach when the aircraft is 30 nm from the airport. (Autotune must be selected.) The system does not set up a preselected nav source or course.

Deviation scaling is also changed as the aircraft approaches the airport. At 30 miles the full needle deflection goes from 5 nm to 1.25 nm and TERM is annunciated to indicate the change. At 2 nm from the Final Approach Fix (FAF), APPR is annunciated; however, deviation remains at 1.25 nm for the remainder of the approach. If vertical guidance is desired, the altitude preselector must be set equal to at least the lowest approach altitude constraint. For a pilot-defined RNAV approach, the FMS will not provide deviation scaling, vertical guidance or accuracy checking. It doesn't recognize it as an approach.

Missed Approach Procedure

NOTE:

If the original approach is to be flown again, it should be set up from the arrival page in the same manner it was originally loaded.

All approaches (except visual) stored in the FMS database include missed approach procedures. The missed approach procedure is automatically placed at the end of a flight plan immediately following the MAP of the approach. The annunciation, MISSED APPR, is placed at the beginning of the missed approach procedure on the LEGS page.

Missed approach legs may be reviewed at any time on the LEGS page. The procedure is clearly identified in white. However, the procedure is not displayed on the MFD map until selected by the crew.

Both vertical and lateral guidance is provided. The FMS will not sequence into the legs of the missed approach until GA (Go Around) is selected. Manually setting the waypoint sequencing to AUTO will also allow the FMS to advance to the first waypoint of the missed approach as it crosses the runway threshold. There may be times when the pilot wishes to get into the missed approach before actually crossing over the runway. In this instance, the first waypoint of the missed approach procedure can be moved into the TO position and executed.

Altitude constraints are usually "AT OR ABOVE" for positioning legs and "AT" for holding waypoints. AT OR BELOW constraints may also be included to protect over flying traffic.

VNAV will not initiate a climb in a missed approach in order to protect against pulling the aircraft up and causing a hazardous loss of airspeed. Normal enroute climb speeds stored in the FMS are not used for the VNAV climb segments. Rather, the airspeed bug synchronizes with current airspeed. The pilot must select the climb mode and rate and set appropriate power. VNAV will capture and track any vertical constraints in the procedure as long as the altitude preselector is set higher than the constraint.

The switch to auto sequencing is verified on the top right hand line of the LEGS page. An alert, SEQ INHIB, indicating auto sequencing is inhibited, will also be displayed on the PFD under the NAV source.

Missed Approach Check List

Transitioning from a localizer approach:

1. Select Go-Around (GA)
2. Set power and configuration as required
3. Verify auto-sequence selected (LEGS PAGE)
4. Verify first waypoint of the missed approach is the TO waypoint
5. Select FMS as NAV SOURCE
6. Select appropriate lateral and vertical flight director modes on FCP
7. Engage autopilot, if desired

Transitioning from an FMS approach:

1. Select Go-Around (GA)
2. Set power and configuration as required
3. Verify auto-sequence is selected (LEGS PAGE)
4. Verify first waypoint of the missed approach is TO waypoint
5. Select desired lateral and vertical flight director modes on FCP Engage autopilot (if desired)

Chapter 15: Holds

A hold may be manually inserted in a flight plan or may be loaded, from the database, as part of a procedure. The pilot may set up holds at any fix on or off the flight plan or present position.

When there are no holds stored for the flight plan, pressing the HOLD *line select* or function key will present a LEGS page with the HOLD AT prompts along the bottom of the display. If there is a current hold in the flight plan, the planning page for the first hold will be displayed.

Holding at a flight plan waypoint simply uses that waypoint as the holding fix. Present position holds only require the pilot to press the PPOS line key.



HOLD PAGE - Figure 15.1

Following identification of the fix, a planning page will be displayed. The specifications of the hold are set on this page.

If the clearance is to “Hold southwest of the Cedar Rapids 180° radial” – all that needs to be entered is just that. *SW/180* entered into QUAD/RADIAL position will set up the proper inbound course and turns for the hold.

If the quadrant is not entered, the inbound course will default to the present course to the fix, if off the flight plan, or the inbound course, if on. The default turn direction is to the right and appropriate leg time or leg distance may be edited.

The maximum permitted airspeed for the hold will be displayed for reference only. The FMS will always annunciate a CHECK SPEED prior to entering the hold. Time to the fix will be calculated.

The *Expect Further Clearance* time from ATC is entered into the EFC line. When that time has expired, a warning, HOLD EFC EXPIRED will be displayed.

After the hold has been set up, the pilot should return to the LEGS page and clear any discontinuities, then EXECUTE. The FMS will calculate and provide guidance for the proper entry into the hold.

If the hold is the TO waypoint, the aircraft will proceed to the fix and enter the hold. If not, the FMS will continue to fly the flight plan until the hold is the TO waypoint, then enter the hold. Leg sequencing is inhibited when the aircraft enters the hold except when a hold is the transition for an approach.

Holding restrictions, other than the QUAD/RADIAL, may be edited at any time. Execute must always be pressed after any change.

If an approach contains a hold as an entry procedure, it will be automatically loaded on the hold page. The same hold may also be used as a normal ATC hold. Because it is an approach transition, exit will automatically arm. The exit is simply cancelled and the hold is flown normally.

There may be occasions when the same fix is used both for the approach transition and the missed approach point. In this case there will be two holds with the same identifier displayed on the hold pages.

Normally vertical guidance from the VNAV system is not available in a hold. The pilot must do any required altitude changes. However, a hold that is part of an approach procedure contains an additional waypoint for VNAV purposes. Prior to the fix on the inbound course the FMS inserts an INTC point. Often, the altitude of the hold is higher than the fix-crossing altitude. The VNAV system uses this point to compute the vertical path needed to complete the approach.

Exiting the HOLD

Once the aircraft has entered the hold an EXIT HOLD option will be presented. After selecting the exit option, EXIT ARMED will annunciate. Pressing EXECUTE will direct the aircraft to the fix, then exit the hold and on to the next waypoint in the flight plan.

If ATC requests an immediate departure from the hold, enter a DIRECT TO the desired waypoint on the LEGS page. When EXECUTE is pressed, the aircraft will turn towards the new TO waypoint.

Chapter 16: Fixes

The purpose of the FIX page is to establish a reference point along the track of the flight plan. For instance if ATC requests a “report abeam” report, that point is established using the fix page. The identifier for the reference fix is entered and ABEAM REF is selected. The FMS will display the abeam point on the MFD map and report the time, fuel and distance to the point on the fix page.

Any published or unpublished reference fix may be used. If a published fix is used, it is entered into the REF line on the CDU. If the fix is not published, the lat/lon for the desired reference fix may be entered.



FIX INFO PAGE - Figure 16.1

Once the reference fix is identified, the course, distance, time and fuel remaining for a *direct-to* course will be displayed and continually updated - similar to a DME.

Abeam

This option, as discussed above, will create a fix on the course of the airplane that is abeam, 90° to the FIX REF.

79Radial

Entering a radial from the reference waypoint, under the RAD/DIS legend, will establish a point on the course line that intersects with the radial. The FMS will calculate the distance, time and fuel from present position to that point.

Distance

Entering a distance from the reference waypoint, under the RAD/DIS legend, will establish a point where that distance will cross the projected track of the aircraft. Since the FMS draws a circle, with radius equaling the distance entered around the reference, there will typically be two intersections of the distance along the track.

Pressing EXECUTE is not required because a fix is not part of the flight plan, only a reference.

The fix location on the course line can be removed by using DELETE to remove either the ABEAM fix and/or the RAD/DIS fix. The reference waypoint and the radial/distance information remain.

Chapter 17: PFD Annunciations

Flight Director annunciations are placed on two lines below the selected nav source. The annunciations will only be shown if the FMS is the selected nav source. The first line of annunciation's flash for five seconds and then remains steady.

1st Line Annunciations

FMS DR (yellow)	Flight Management Computer is dead reckoning.
CHK POS (yellow)	Current position estimate may not meet the required accuracy.
IRS ONLY (white)	Position is derived solely from the Inertial Reference System.
POLR (white)	Aircraft is within 20 nm miles of the pole. FMS will fly straight and level until beyond 20 nm.

NO APPR (white)	Approach is not approved or approach has been disabled
GPS APPR (white)	Lateral and Vertical deviation scaling set at approach sensitivity - GPS approach enabled.
DEV CHG (white)	Lateral deviation scaling is being changed from terminal to approach sensitivity - GPS approach is enabled.
GPS TERM (white)	Lateral and Vertical deviation scaling set at terminal sensitivity.
APPR (white)	Lateral and Vertical deviation scaling set at terminal sensitivity and an RNAV approach is enabled.
TERM (white)	Lateral and Vertical deviation scaling set at RNAV terminal 0 sensitivity.
GPS ONLY (white)	Position is derived solely from GPS sensor. Message not displayed in terminal or approach phases if GPS approach is enabled.

2nd Line Annunciations

MSG (white/yellow)	Message on FMS CDU Clears when pilot presses MSG button.
HOLD (white)	Holding pattern active
OFST (white)	Flight plan offset in effect
ALT (yellow)	Rate of climb or descent is less than required to make the next as altitude constraint
SPD (yellow)	Current speed exceeds the speed restriction by more than 20 KIAS and VNAV is selected or exceeds holding speed by 10 KIAS two minutes before entering the hold
TOD (white)	Top of Descent – steady for 1 minute prior to reaching TOD flashing 5 seconds prior to TOD

BOC (white) Bottom of Climb – steady for 1 minute prior to reaching BOC
Flashing 5 seconds prior to reaching BOC

SEQ INHIB Automatic Sequencing of waypoints has stopped

There are two messages that can display in the center of the PFD HSI. Again the FMS must be the NAV source.

NO FLIGHT PLAN No flight plan in the FMS, TO waypoint must be entered

DISCONTINUITY Active leg is a discontinuity

There are four messages that may appear at the bottom of the MFD.

FMS NAV INVALID FMC cannot determine position from nav or dead (yellow - airborne) reckoning (white - ground)

FMS DR FMC is in dead reckoning (yellow)

FMS DR FOR 5 MIN FMC in dead reckoning for more than 5 minutes while (yellow) airborne.

CHK POS Unable to assure position accuracy (yellow)

Chapter 18: Operating Tips

Situational Awareness

Always know what to expect from the machine and the other pilot.

1. Notice the cues
2. Understand what they mean
3. Determine the expected result
4. Maintain feedback
5. Each element of the total system must know the other's intent
6. Ask questions of the machine, the other pilot, ATC, and yourself

Studies have shown that crews who ask more questions have a lower number of errors. In comparison, crews who do not ask many questions are not nearly as efficient and have considerably more errors.

Mode Awareness – Always Know:

What mode it is in?

What mode it will be in next?

What the expected action will be of a mode change

Recognize failures or inappropriate actions

Know how to validate the quality of a nav source and crosscheck FMS position and actions against IRS, GPS, and VOR/DME

EXECUTE Occasionally While Building a Flight Plan to “Save” Your Work

Build on the FPLN page

DELETE on the LEGS page

Edit on the LEGS page

When editing in a high work level environment, it may create less confusion to delete waypoints one at a time rather than several at a time.

Note:

A second press of many of the function buttons will return you to the previous page.

Did You Know?

During takeoff and climb-out, yellow FMS messages are not displayed for 2 minutes.
(The clock starts @ 60 knots.)

It makes for one less unnecessary distraction during takeoff.

Only FMS messages **NOT** critical to flight safety are inhibited.

Amber warnings critical to flight safety will always be displayed.

Data Entry

- Use care when making entries.
- If you have time to do something twice to get it right, that's more than enough time to do it once, correctly.

- Always have a written flight plan.
- Check the direction and distance for each waypoint on the LEGS page and make sure they are reasonable. Remember, read it like a book. Start at the top left and read across each line to the bottom.
- Double check entries or changes on the MFD before executing.
- Does it make sense? Does it look logical?
- Execute!

File This Away in the Noggin'

If there is more than one waypoint with the same name, the FMS presents a menu listing the closest one first on the list. Pressing the line key beside the desired waypoint selects it.

How Do I Delete a Flight Plan?

If on the ground, simply enter a new ORIGIN airport. The entire flight plan will be deleted. If in the air, enter an ORIGIN airport, only, into the second flight plan, then ACTIVATE, EXECUTE.

Problem – Approaches, Arrivals, Departures or Runway Menus Don't Display

Did you enter the originating and departing airports on the FPLN page? The FMS will also not be able to calculate time, fuel and VNAV solutions if you don't tell it where it is leaving from and where it is going. Also, deviation scaling is enabled with the insertion of an origin and destination airport.

It's Really Easy to Press the Wrong Line Key During Position Initialization

Remember – to initialize to an airport or pilot-defines waypoint, you press the right *line key* (lat/lon side) and to initialize to FMS, IRS, or GPS position use the left *line key* to load it to the scratchpad.

Problem – The Runway Update Option not Available on the LEGS Page

(No matter how many buttons you push).

You didn't enter the originating runway in the flight plan.

DEP/APP menu

Select a departing runway

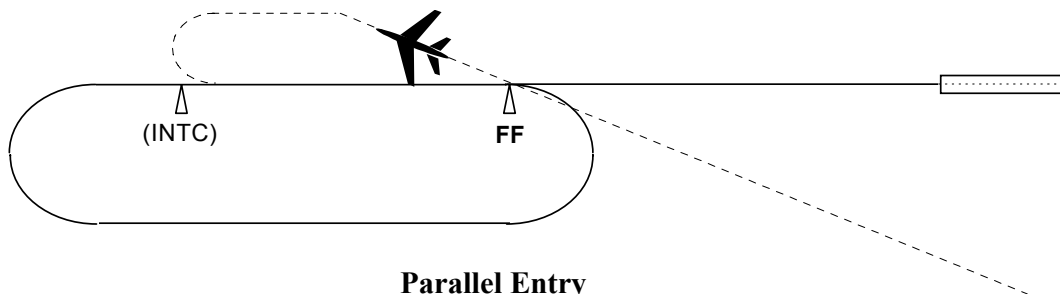
Execute

Note:

A runway update annunciation “completed” is only displayed “on-side.”

A Procedure Hold for an Approach is Identified on the LEGS Page by “HOLD TO.” A Normal Hold is Identified with “HOLD AT.”

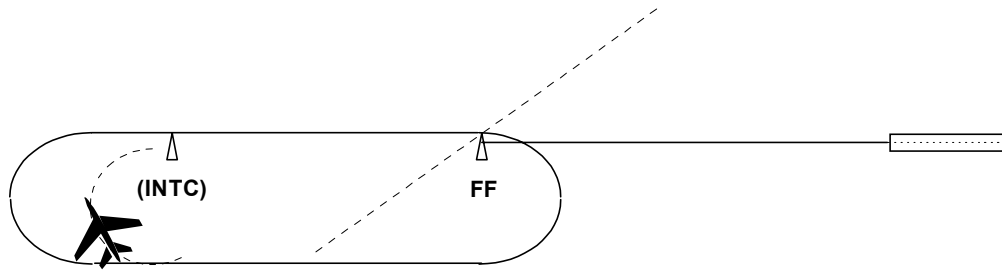
Hold Entry Differences (Or “Why Did it Do That?”)



Parallel Entry
Aircraft must cross the fix twice to “enter” hold

Parallel entry – the aircraft must cross the fix twice before the hold is active.

The aircraft will cross the fix, fly the parallel outbound, make the turn inbound and when it crosses the fix the second time the hold will become active. If you're flying a procedure hold for an approach and you wonder why you can't cancel the hold exit, wait for the second crossing of the fix.



Direct or Teardrop Entry
Aircraft must cross the fix only once to “enter” hold.

For teardrop and direct entries – the hold is active when the aircraft crosses the fix the first time.

Why Does the Entry Turn Arrow on the MFD Map Keep Changing Directions Prior to Entering a Hold?

When a hold is initially set up, the FMS looks at the predicted inbound course to set up the correct entry procedure. As the aircraft gets close to the hold fix, the FMS re-evaluates the correct entry depending, now, upon airplane heading. If the inbound course is near one of the dividing lines for the entry type, the arrow may change directions until just before entry.

Here’s a Rule “The FMS Will Not Allow You to set up a New Hold at the Same Fix.”

And here’s an exception – A missed approach procedure holding fix may be the same if it is entered from the database.

Using an Approach Procedure Hold as a Normal Hold

It’s OK to do it and works very well. If you expect the hold at a final fix will terminate in shooting the approach, the hold can be loaded as part of the approach. Of course there must be a published hold in the database. All the correct course headings and turn directions are there, you just need to confirm that’s what ATC really wants and make the appropriate edits.

An approach hold is designed to make *one turn and head for the barn*. Exit is automatically armed when the hold is entered. So, if you want to stay in the hold, the exit must be canceled. The catch? – Until you’re in the hold, it’s not obvious what is required to stay in the hold. Just

cancel the exit when it is armed. The hold will not be exited until the crew selects EXIT HOLD. Altitudes may be at the pilot or ATC's discretion. When it's time to shoot the approach, arm **EXIT HOLD**.

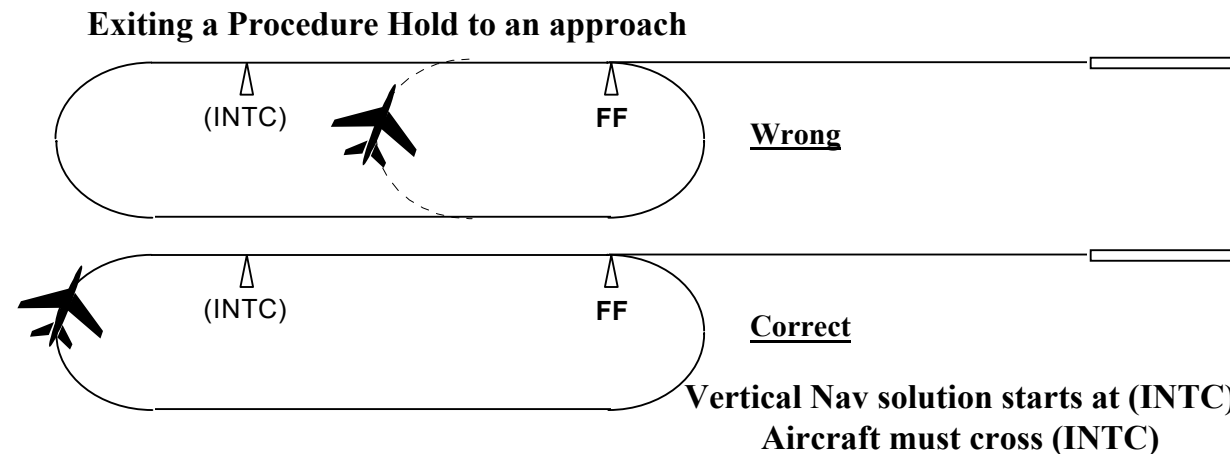
Vertical Nav is Not Normally Available in a Hold

Here's the exception – Approach holds allow a VNAV problem to be solved when EXIT HOLD is armed. The solution begins at the (INTC) waypoint.

Problem -- The Final Fix Does Not Sequence as the "TO" Waypoint While Exiting an Approach Procedure Hold.

You're probably manually "cutting the corner" without flying the full hold "racetrack." That's OK, but – when in the procedure hold the TO waypoint is "HOLD TO, (INTC)". You must cross the "(INTC)" waypoint before the FMS will sequence to the final fix. The distance shown on the PFD for the TO waypoint is to (INTC).

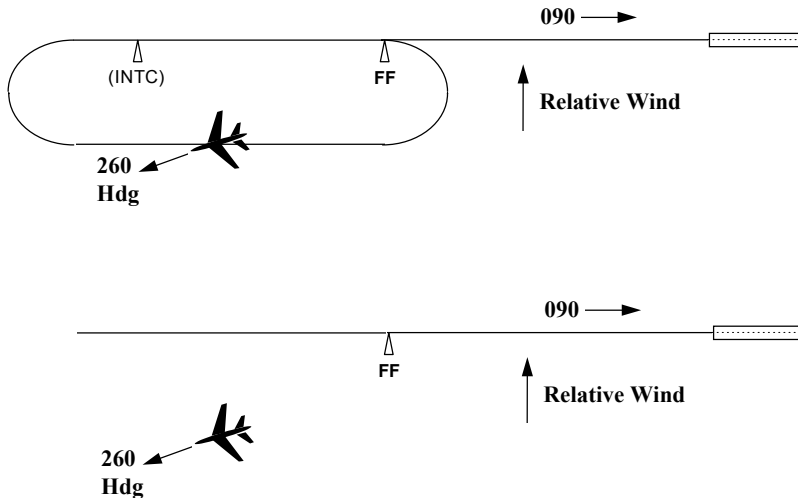
(In a normal hold the TO waypoint is always the hold fix. When EXIT HOLD is executed the aircraft will immediately head for the fix.)



So, if you want to cut the corner to hurry the approach along, first of all select HDG mode. Then perform a "Direct-To" edit and move the hold fix into the TO position. The correct inbound course will appear on the INTC CRS line. Press the INTC CRS line key to select the inbound course. Remember you have to press the key! In heading mode, manually turn the aircraft towards the inbound course.

Why Use Heading?

Because in NAV mode, if the aircraft is not on a course it will always turn in the direction that presents the smallest angle to the course. For a 180° turn, the airplane could go either way.



For example, if you are flying an out bound leg that is 180° from the inbound course to the right, when NAV is selected, the airplane may turn right – or, it may turn left. If, because of a wind factor, the aircraft heading is less than 180° from the left, the airplane will turn left, the long way around – it thinks it's closer.

A DME Arc May be Intercepted After the Entry Waypoint

Your position may be on either side of the arc.

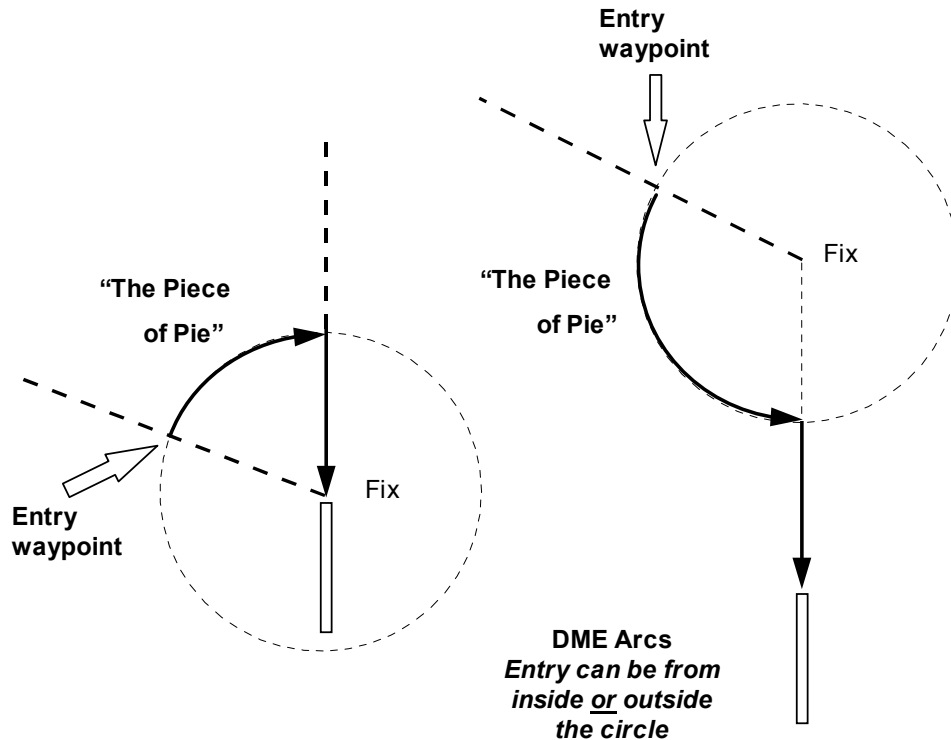
To set up the intercept:

Heading up FMS map must be displayed.

Move the entry waypoint to the FROM (top/cyan) position on the LEGS page. The FMS will draw a blind circle around the fix.

Select HDG mode and an appropriate heading for the intercept.

If left in NAV mode, the FMS may, depending upon the aircraft's position, intercept and track the arc anywhere on the blind circle.



Depending upon your location, the course deviation and heading displayed on the HSI may appear to be incorrect. Do not EXECUTE the move of the waypoint to the FROM position, or arm NAV or APPR until within the “piece of pie” and ATC has cleared you for the procedure. “Piece of pie” -- bounded by the end points of the arc.

VNAV Operation on Non-Precision FMS Approaches

“If it sounds like an ILS and looks like an ILS, therefore it must be.” But is it? A V-path, or Glide Path, is not defined by a “signal in space” like an ILS. Non-precision VNAV approach follows a geographic line that is based on baro altitude.

Make Sure You Understand Exactly What the Correct MDA is for Your Equipment, Conditions and Approach Type

- *Know the correct altimeter setting* – Make sure it is corrected for temperature in cold climates. All database and published altitudes are correct only under ISA conditions.

- Know how the FMS will “fly” the approach.
V-MDA Approach – Levels at the MDA, providing VNAV is armed.
RWY Approach – Vertical guidance terminates 50 above the runway threshold.
- Know the current armed and active modes, as well as what the corresponding annunciation’s mean. They are different from those for an ILS approach.
- Review the approach on the MFD, CDU and approach plate.
- You will also notice waypoints in the FMS Database that are not on the paper approach charts. There may even be waypoints not displayed on the LEGS page that appear on the printed approach chart, for example, waypoints between the final approach waypoint and the missed approach waypoint.

FMS approaches – V-MDA vs. RWY

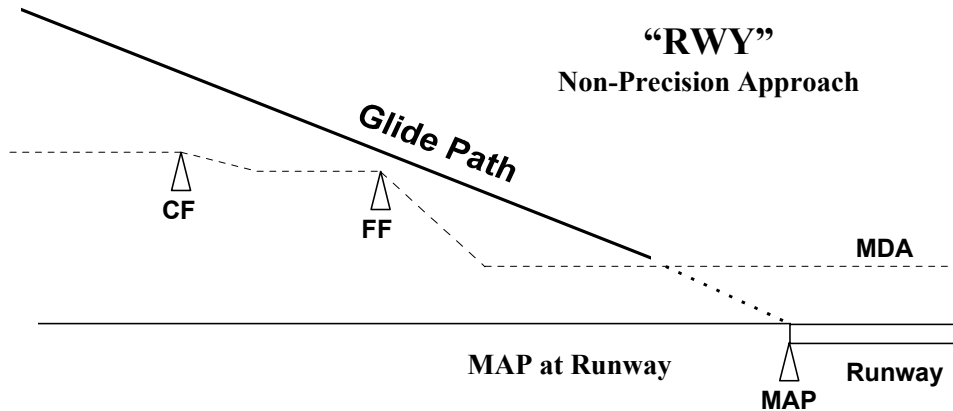
If coupled to the autopilot, one type of approach will level the airplane, the other will not.

V-MDA Approach

Missed approach point (MAP) is somewhere other than at a runway threshold, i.e. circling approach, VOR on field, etc. A V-MDA is displayed on the LEGS page above the MAP waypoint altitude constraint. The glide path is drawn down from the final fix, at a specified angle – typically three degrees-, to the MDA. A coupled approach will level the aircraft at the MDA constraint shown at the MAP waypoint on the LEGS page. The path angle and MDA may be changed. The MDA altitude presented on the CDU should be verified as correct for the conditions, equipment and approach. If not correct, the proper altitude must be entered.

NOTE:

If there is a step-down fix between the Final Fix and the MAP the path angle must not be changed.



RWY Approach

Missed approach point (MAP) is at or near the runway threshold. The MAP waypoint is identified on the CDU with an “RW” preceding the runway number and “RWY” is displayed as the altitude constraint. Pressing the line key beside RWY will show the altitude at which the glide path terminates (“usually” 50 feet above the threshold).

Typically, a 3° glide path is drawn up from the runway threshold to assure obstacle clearance.

It is generally flown like a glide slope, however; there is nothing to tell the flight director to stop the descent at MDA!

As Always, the Pilot has the Final Responsibility to Break Off an Approach to Assure Terrain and Obstacle Avoidance

Glide path angle and RWY altitude may not be changed.

The Inbound Course Displayed in the INTC CRS Line Doesn’t get Selected.

You’re doing a “Direct-TO” operation and wish to set up an inbound course to an approach fix. You didn’t enter the desired course because it was already presented on the INTC CRS line. Therefore you didn’t press the INTC CRS *line key*. What you ended up with was a “Direct-To” course from present position to the fix – and now you have to start over.

The correct inbound course appears (small font) on the INTC CRS line when setting up an inbound course into the first waypoint of an approach following a discontinuity.

You must always press the *line key* to select (large font) and load the course into the flight plan. Oh, by the way, there is an exception – you knew there would be. The correct inbound course to a runway extension waypoint for a visual approach is not automatically presented – it must be manually entered.

Problem – Tracking a Localizer While Ignoring the Glideslope

You are still a considerable distance from the airport and ATC wants you to intercept and fly the localizer inbound, but not descend. The active nav source is FMS, the preset source and course is the localizer. If you select APPR on the FCP the flight director will also see the glide slope, ignore the preselector and start down.

To hold altitude:

Manually select LOC as the NAV source.

Select NAV on the FCP.

When cleared for the approach, select APPR. You may need to manually start the aircraft towards the glideslope. Again the key is, in NAV mode, the flight director will honor the preselector and maintain altitude.

Final Course Heading on the CDU Doesn't Agree with the "Plate"

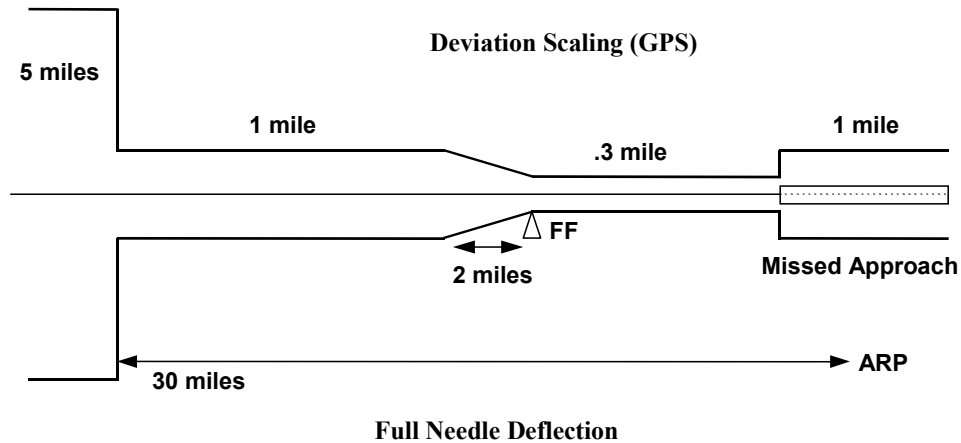
There may be times when a difference of 1-2° will appear. DO NOT change the heading! Use the heading entered by the database. Minor corrections are sometimes made in the database in order to get an approach to work correctly.

There are Times the FMS Final Course and Localizer Course do not Overlay Exactly

It's not uncommon to see the two courses off a bit. Remember a localizer is a signal in space and an FMS course is between two points. It's sometimes hard to believe but they will get you to the same place.

Speaking of Deviation Scaling...

When passing through any of the transition areas where the deviation scaling changes, you may see the vertical and lateral deviation indicators rapidly move. This movement will be more obvious if you are not exactly on course, laterally as well as vertically.



Course Accuracy is Better Using NAV Mode over the Heading Mode to Track the Dev Bar

Don't chase the Dev bar when there is a course change while crossing a waypoint. Follow the flight director. To make for smooth transitions, the flight director will always seem slow but be patient, follow the V-Bars, don't anticipate.

TOD Appears on Course Prior to the Final Fix on the MFD Map

The TOD is roughly placed on the map at a point 20 seconds before the descent actually begins. The airplane will not descend until at the final fix waypoint.

GP (Glide Path) Does not Arm When APPR is Pressed

The TO waypoint is not the final fix or APPR is not armed. GP, armed in white, will not appear unless the aircraft is on the leg into or out of the final fix. Pressing APPR when a waypoint other than the final fix is the TO waypoint will arm PATH. When the final fix becomes the TO waypoint, GP will automatically replace PATH.

Why Can't I Just Use NAV Mode to Fly an FMS Approach?

You can, it'll get you to the same place – however, NAV mode will honor the preselector, you must lower it to at least the MDA. APPR mode disregards the preselector once the Final Fix is the TO waypoint. At that point the preselector can be reset for a missed approach. All approaches should always be flown in APPR mode!

Need to Change an Approach? No sweat!

Press DEP/APP

Select the approach

Execute

Changing the NAV Source from LOC to FMS on a Missed Approach

NAV SOURCE selector knob rotation – Right-side is clockwise and left-side counter-clockwise.

Previously Passed or Edited Waypoints may be Retrieved from the History Pages

Pressing DIR, then PREV will show the last 15 waypoints. Pressing the *line key* beside it will load it as the “TO” waypoint. It's OK to use, and a very quick method, when you need to return to a previous “non-approach” waypoint. It's normally a nice shortcut, however, do not load an approach from the history pages! The sequence and altitudes may not be correct. If you need to reload an approach – use the Departure/Approach menu page.

How Do I Fly a Departure SID From the Flight Plan's Destination Airport?

SIDs are not offered as a menu choice for the destination airport. They are offered for an originating airport, however; the originating airport can't be changed while airborne.

Solution – make a second flight plan with the desired airport as the origin.

From the flight plan page:

Second flight plan

Insert ORIGIN airport

Activate

DEP/APP

Select SID

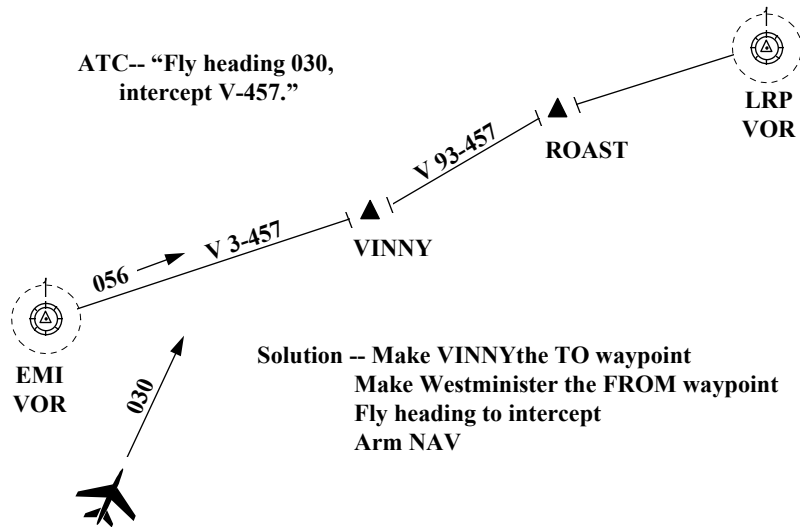
EXECUTE

DIRECT-TO appropriate waypoint

EXECUTE

To Get Back on Course After Diverting for a Thunderstorm (or???)

Enter the waypoint from the flight plan that immediately precedes your projected intercept point into the FROM position. Fly your own headings or ATC vectors for the appropriate intercept. Arm NAV.



You Selected an MFD Map Menu Item from the Wrong Side

If you typically switch seats in your flight operation, you'll choose right side from left and vice-a-versa. Menu page on each CDU has selections for left on left, and right on right.

Want to Know What the Direct Vertical Path is to a Waypoint?

Press the DIR button. As long as the angle is less than 6° , the vertical path angle and required vertical speed are displayed for each of the waypoints that have an altitude constraint. Of course, you already knew the Vertical Direct data for the active TO waypoint is displayed on the MFD text window by selecting the VNAV window from the MFD menu.

Now You Notice the Vertical Rate and Path Angle on the MFD do not Agree with Those Listed for the Waypoint on the CDU

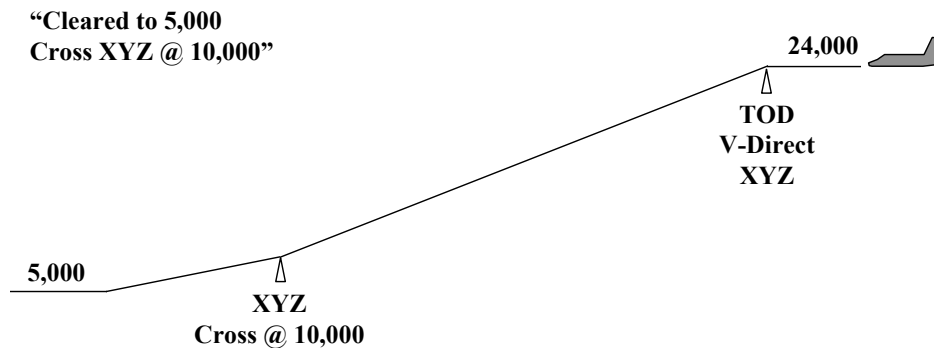
MFD vertical direct calculation is from present position. CDU vertical direct calculation is from present position plus 20 seconds.

A Radical Change in Baro Setting may Change the V-PATH

VNAV logic is based on the baro altimeter. A large baro change coming through FL180 will move the projected V-path.

VNAV Mode will not Continue a Descent Past a Final Altitude Constraint in the Flight Plan

Example: You're at FL240 and ATC directs "Cleared to 5,000, cross XYZ waypoint at 10,000." You lower the preselector to 5,000 feet, set up "vertical direct-to" 10,000 feet at XYZ waypoint and EXECUTE when you're ready to descend.



VNAV solution stops @ XYZ
Vertical mode and rate must be
selected to continue to 5,000

VNAV will descend the aircraft but will level at 10,000 feet because it does not see the preselector or another altitude constraint. The preselector functions only as a limiter, not a target. Once assured the aircraft will, in fact, be at 10,000 feet when it crosses the waypoint a vertical mode and rate must be selected in order to continue the descent to 5,000 feet. The modes should be selected prior to altitude capture by the autopilot.

Changing Up to Down and Down to Up on the CDU

Occasionally the arrows on the VNAV side of the LEGS page may be going the wrong direction. It may occur after a flight plan has been extensively edited. If the FMS doesn't think it'll work, the constraint altitude will be yellow. To change the arrow – Enter 'C' for climb and 'D' for descend. Press the appropriate *line select key* to make the change.

How Much Fuel is This Trip Going to Take?

If you check the MFD NAV data page while building the active flight plan, it tells you how much fuel you will have left when you arrive.

To find out how much fuel is required for the flight (origin to destination), create a second flight plan by copying the active. Add an expected arrival and approach to the flight plan to make the fuel calculation more accurate. Select the SEC FPLN from the MFD data menu. Total fuel required will be presented at the end of the flight plan on the second flight plan nav data page.

Entering Wind and Temperature Factors for Performance Predictions

If it's a short trip – wind and temp will not make much difference. However, if it's a long trip – especially if the high altitude winds are excessive or the temperatures are not near ISA – wind and temp will make a significant difference in the fuel and time calculations.



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