FLIGHT MANAGEMENT COMPUTER

TABLE OF CONTENTS

SUBJECT PAGE

FLIGHT MANAGEMENT COMPUTER 5

Overview 5
The FMCs 5
CDU 6

DISPLAY SCREEN 6

CDU Display 6
Title Line 6
Data Lines 6
Scratchpad 6
Line Select Keys 6
Annunciators 7
Function and Mode Keys 7

FLIGHT MANAGEMENT SYSTEM INTERNAL FUNCTIONS 8

Performance Management 8
Navigation Management 8
Guidance Management 9
Thrust Management 9

FMC DISPLAY PAGES ACCESSED WITH MODE KEYS 10

Overview 10
MENU Key 10
INIT REF Key 11
INIT/REF INDEX KEY DISPLAY DIAGRAM 12
RTE Key 13
DEP/ARR Key 13
EXEC Key 13
NEXT PAGE/PREV PAGE Keys 13
NAV RAD Key 14
PROG Key 14
VNAV Key 14

FLIGHT MANAGEMENT COMPUTER INITIALIZATION 16

Overview 16
Conventions 16
Required Entry Boxes 16
Crew Data Entry/Selection Lines 16
Down-selection/Up-selection 16

PRE-FLIGHT FMC INITIALIZATION PROCESS 17

Overview 17
IDENT Page 17
POS INIT Page 18
RTE Page 19
PERF INIT Page 20

BUILDING A FLIGHT PLAN 22

Overview 22
Conventions 22
RTE Page 22
Using Airways to define a route 23
A Defined Airway Segment 23
Using Navigation Database Waypoints 23
SELECT DESIRED WPT page 23
RTE Page Variable Modes 24
RTE LEGS Page 24
Maximum Number of Flight Plan Legs 26

DEFINING AND USING CUSTOM WAYPOINTS 27

Overview 27
Navigation Fix Entry 27
FMC Navigation Database Defined Waypoints 27
Along Track Waypoints 27
Place Bearing/Distance Waypoints 28
Course Intersection (Place Bearing/Place Bearing) Waypoints 29
Latitude/Longitude Waypoints 29
SELECT DESIRED WPT Page 30

FMC ARRIVAL/DEPARTURE PROCEDURES 32

DEP/ARR INDEX Page 32
DEPARTURES Page 32
ARRIVALS Page 33
Changing a SID/STAR/RWY 34

FMC FLIGHT PLAN MODIFICATION 35

Overview 35
Direct-To 35
Intercept Course 35
Inserting A Navigation Fix 37
Deleting a Navigation Fix: 37

FMC TAKEOFF PROCEDURES 39

Overview 39
THRUST LIM Page 39
TAKEOFF REF Page 40

FMC CLIMB OPERATIONS 43

Overview 43
CLB Page 43
FMC Climb Profile Logic 44
FMC Climb / MCP Altitude Selector Interaction 44
Constraint Deletion 45
Level Off/Resume Climb 45
Cruise Altitude Changes 45

FMC CRUISE OPERATIONS 46

Overview 46
CRZ Page 46
Step Climb Operations 48
Cruise Altitude Modification 49

FMC DESCENT OPERATIONS 50

Overview 50
CRZ Page 50
DES Page 50
DESCENT FORECASTS Page 51
Descent Profile Logic 52
FMC Descent / MCP Altitude Selector Interaction 52

FMC APPROACH PROCEDURES 53

Overview 53
APPROACH REF Page 53

FMC RADIO OPERATIONS 54

Overview 54
NAV RADIO Page 54
FMC Position Updating Logic 55

FMC FLIGHT REFERENCE AND CREW SUPPORT 56

Overview 56
POS REF Page 56
PROGRESS Pages 56
RTE DATA Pages 58
WINDS Page 59
SID/STARs 59
Minor SID/STAR differences 59

THIS PAGE INTENTIONALLY BLANK

FLIGHT MANAGEMENT COMPUTER

Overview: The 747-400 uses a fully integrated Flight Management System, in conjunction with other interfaced equipment such as the Autopilot Flight Director, Autothrottle and Navigation System provides a fully automatic, full regime flight control and information display system. The backbone of the FMS is the Flight Management Computer.

Boeing is currently in the process of upgrading the operating software for the 747-400 FMC/CDU. This simulation was built with the most current available information and may differences from earlier FMC simulations/manuals as a result.

The FMC takes input and sensory information from throughout the aircraft and is capable of providing flight control, navigation, thrust management, map display and performance optimization. The FMC provides output directly to the autoflight systems in the form of flight director steering commands, thrust queues and autoflight mode management.

The FMC is the central backbone of the entire FMS package on the 747-400, and interfaces with the following systems:

- Flight Control Computers (FCCs)
- Air Data Computer
- Fuel Quantity Indicating System
- Weight and Balance Computer
- VOR
- DME
- ILS/MLS Systems
- Inertial Reference System
- Digital Clock
- Autopilot Flight Director System
- Mode Control Panel
- FMC Database
- FMC/CDU (Crew inputs)
- Autothrottle Servo
- Electronic Interface Unit

In addition, the FMC provides commands or information directly to the following systems, although it does not receive information from these systems:

- Integrated Display System (PFD & ND)
- Electronic Engine Controls
- ADF
-

The FMC performs the following major functions.

- Flight Planning
- Navigation Computation
- Navigation Display
- Navigation Radio Tuning
- Guidance Commands (pitch, roll and thrust)
- Interface to Inertial Reference System (IRS)
- Performance Optimization
- Thrust Limit Calculation
- Autothrottle Control
- Polar Navigation Capability

The FMCs: The 747-400 FMS consists of two Flight Management Computers which are located in the electronics and equipment bay. Each FMC is comprised of five processors, and integrates data received from the air data sensors, crew input, navigation radios, engine and fuel sensory systems, inertial reference system and internal navigation database. This information is then used to provide steering commands to the autoflight systems in both roll and pitch modes, as well as to the autothrottle servos. Navigation and positional data is provided to the Navigation Display.

Each FMC is capable of receiving input independent of the other, and both systems will continually compare input/process results to ensure information consistency on both FMCs. If inconsistencies are detected, a resynchronization process is automatically initiated.

Flight crew interaction with the FMCs takes place via the FMC/CDU (Control Display Unit.) There are three CDUs located in the cockpit of the 747-400. One at the captains side of the throttle console, one at the first

officers side of the throttle console, and one located just aft of the throttles. Normal operation will see the captain and first officers using the CDUs at their individual stations, however the center CDU can be used by a crew member should one of the CDUs fail. The center CDU is usually responsible for managing ACARS functions in an automated fashion.

CDU: The CDU is comprised of a data display screen with six line select keys on each side of the screen. The data display screen shows 14 lines of data 24 characters wide. Numeric and Alphabetic keys are provided for crew input. Fifteen function and mode keys are provided to assist the crew in selecting and managing FMC functions.

CDU Display: The CDU display screen is comprised of 14 data lines capable of displaying 24 characters across in large or small font. The display is broken into three distinct areas.

Text in muted font indicates that the function is not available or cannot be modified by the user in the simulator.

Title Line: Top line of the display. Shows title of the current page display.

Data Lines: Six pairs of lines which contain data for the display page shown. Lines may also contain prompts for data input by the crew. The upper line in each line pair is called the Header Line, while the lower line is called the Data Line. Lines and line pairs are referenced by their association with the Line Select Keys (LSKs) on either side of the display. (Hence 1L, 4R, etc.)

Scratchpad: The last line of the display is a scratchpad which allows for alpha numeric input by the crew, or down-selection of FMC data from other lines.

Line Select Keys: The CDU display has six Line Select Keys (LSK) on each side of the screen in order to facilitate data input and manipulation. The keys are identified by their position relative to the display and their sequence from top to bottom. (e.g. The LSKs are identified as either Left or Right and are numbered from 1 to 6 starting at the top.)

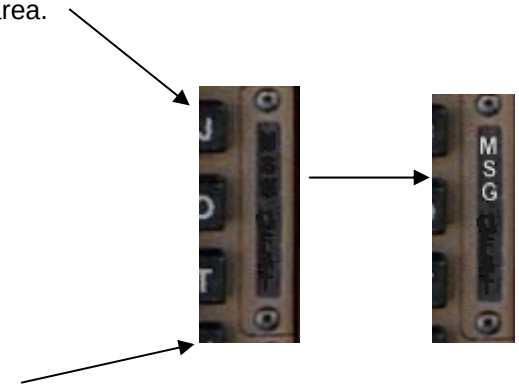
The LSKs are used for the following functions:

- Down-selection of data from a particular line to the scratchpad (if the scratchpad is empty.)
- Up-selection of data from the scratch pad to a data line.

- Access to data or function identified by LSK.

Annunciators: Two mode annunciators are modeled in the PMDG 747-400:

MSG: Illuminates when an FMC generated message is displayed in the scratchpad area.



OFST: Illuminates when a parallel offset path is in use.

Function and Mode Keys: The PMDG 747-400 FMC has fifteen function/mode keys located below the CDU display screen. These keys assist in the performance of a number of functions, including page selection and navigation of the FMCs function pages.

INIT REF: Accesses the initialization and reference pages.

RTE: Accesses the route pages.

DEP/ARR: Accesses the departures and arrivals procedure pages.

ATC: Function not modeled.

VNAV: Accesses the VNAV climb cruise and descent pages

FIX: Provides access to fix information pages.

LEGS: Accesses the legs pages.

HOLD: Provides access to the hold pages.

FMC/COMM: Function not modeled.

PROG: Accesses the progress pages.

EXEC: The execute command key for the FMS. The button contains a small lighted bar which will illuminate to indicate a modification has been selected and needs to be confirmed by pressing the execute key. Any page which has modification capability will also have an ERASE prompt to allow the crew member to cancel a selected modification. Selecting either the EXEC key, or pressing the LSK designated by the ERASE cursor will cause the lighted bar to extinguish.

MENU: Provides access other MCDU driven functions, such as ACARS. Key allows movement between FMC functions and ACARS.

NAV/RAD: Accesses the navigation radio tuning page.

PREV PAGE: Accesses individual pages of a multiple page display. (Route pages, for example, tend to be longer than one page.)

NEXT PAGE: Accesses individual pages of a multiple page display.

Two additional keys are located at the bottom of the numerical keypad which will be frequently used:

DEL: A single press of this key inserts the word DELTE into the scratch pad. Upload DELETE to an LSK in order to delete the information contained on that line.

CLR: Single presses of key will cause the last character in the scratchpad to be erased. A longer press of the key will erase entire contents of scratchpad.

.

FLIGHT MANAGEMENT SYSTEM INTERNAL FUNCTIONS

Performance Management: The Flight Management System (FMS) is capable of managing nearly all aspects of aircraft performance so as to optimize precision and economy of flight. The FMS is only capable of performing this function if it has been properly initialized at the beginning of flight.

The performance model used by the FMS takes into account fuel flow, engine data, altitude, gross weight of the aircraft, flaps, airspeed, Mach, temperature, vertical speed, acceleration and location within a programmed flight plan to determine the optimum performance for the aircraft at any given moment. Crew interface with the FMS comes via the FMC, primarily, but also by the Autopilot Mode Control Panel and flight controls.

The performance management modeling used by the FMS attempts to provide a least cost performance solution for all phases of flight, including climb, cruise and descent. The default cruise performance management setting is ECON, or economy cruise.

The airplane and engine data models are used to provide an optimum vertical profile for the selected performance mode. During the climb, an optimum Mach speed target and a corresponding thrust target are computed by the FMS, with the speed target transmitted to the vertical guidance function of the autoflight director system. The AFDS will then generate commands to the elevator in order to maintain the correct pitch for the required speed. Thrust setting commands are delivered to the autothrottle servos by the FMS, and used in conjunction with the pitch setting commands to maintain the optimum speed and climb as directed by the FMS.

During cruise, an optimum Mach setting is computed and thrust setting commands are delivered to the autothrottle.

During descent, a vertical path is computed based on the flight plan entered into the FMC. The FMS will evaluate expected wind conditions, aircraft speed, altitude, position relative to the planned end-of-descent point and any intermediate altitude or speed constraints between the aircraft and the end-of-descent point. This information will be passed to the AFDS for pitch based speed and vertical speed control and the autothrottles for vertical speed and thrust management. In ideal conditions, an idle thrust optimum descent profile is flown, however in many cases thrust and pitch will be varied to account for wind conditions or to ensure proper tracking of the vertical descent profile.

Navigation Management: The FMS automatically selects and tunes VHR Omni-Range (VOR) and Distance Measuring Equipment (DME) in order to constantly update the position and speed of the aircraft. This information is used in conjunction with the Inertial Reference System (IRS) to ensure accuracy in all phases of flight.

For properly equipped aircraft, the FMS will use GPS as a primary navigation information source unless GPS navigation accuracy is determined to be insufficient according to FMS navigation precision parameters.

The FMS will primarily attempt to combine GPS information, DME position information corrected for slant range and position from three Inertial Reference Units (IRUs). If no usable GPS or VOR/DME information is available, the FMS will monitor aircraft position based on IRS data only, until the aircraft is determined to be in a location where DME/VOR information is once again available for position and velocity cross checking and or GPS information becomes reliable.

The FMS navigation management system will also compute and provide true and magnetic track information, drift angle, magnetic variation for the current aircraft location and vertical flight path information.

The FMC automatically determines which VOR/DME combinations will yield the best

result given their position relative to the aircraft.

Guidance Management: Two-dimensional flight path management is available along an FMC programmed flight path in either the vertical navigation mode (VNAV) or lateral navigation mode (LNAV). Both of these modes are selected on the Mode Control Panel (MCP). When used together, the FMS is capable of providing fully integrated three dimensional flight path management along the FMC defined flight path.

The LNAV guidance function compares the airplane's position generated by the navigation function to the desired flight path according to the FMC programmed flight path. Steering commands are issued to the AFDS in order to keep the aircraft navigating correctly along the programmed route of flight.

In all phases of an LNAV managed flight, the FMS will monitor cross track error, which is defined as the lateral distance separating the aircraft from it's desired path of flight. Roll and steering commands are provided to the AFDS Flight Control Computers in order to correct the cross track error.

The FMS is capable of providing a great circle Direct-To track to any point on the FMC programmed flight path.

The VNAV guidance function controls the aircraft along the vertical flight path regime as defined by the FMC entered flight path and the aircraft's performance limitations.

The vertical navigation function takes positional data from the navigation function and the lateral navigation function (if selected) and compares it to the vertical profile as defined in the FMC entered flight plan. The vertical navigation function then provides pitch and thrust commands to the AFDS in order to maintain the proper vertical profile for the current phase of flight.

For vertical performance modes where vertical speed is unconstrained (most climbs) the VNAV system will provide pitch and thrust commands to the AFDS so as to maintain the most efficient climb based on the current thrust mode selected.

When speed is controlled by elevator input, the AFDS autothrottle will be given a target thrust setting by the vertical navigation function.

When vertical speed is controlled by elevator, aircraft speed will be managed by commands to the AFDS autothrottle to adjust thrust as necessary for the descent profile.

Thrust Management: The FMS thrust management function is capable of performing autothrottle control law calculations based on commands from the navigation function, as well as direct crew input from the FMC, throttle position, or AFDS autothrottle commands.

The autothrottle control law function provides automatic N1 equalization in all modes of flight, as well as thrust limit protection and N1 thrust requirement calculations to maintain MCP or AFDS required speed and thrust settings.

Autothrottle modes can be selected or overridden by the crew as required.

FMC DISPLAY PAGES ACCESSED WITH MODE KEYS

Overview: The PMDG 747-400 FMC has fifteen mode keys available on the FMC/CDU. These keys provide access to a number of functions within the FMC which will be used by the crew during various phases of flight.

MENU Key: The MENU key provides access to the FMC and other aircraft sub-systems which use the CDU for input or control. When pressed, the MENU key brings up the following display screen on the CDU:

Note that when press the menu key, you are presented with the FMC MENU page, and the title MENU is presented at the top of the page. The page title line will help you to understand where within the FMC function you are currently working.

This same page is the first page displayed by the FMC/CDU when power is initially provided to the aircraft. The MENU page allows the crew to select which FMS sub systems they wish to access within the CDU. The following options are currently available in the PMDG 747-400 FMC:

- FMC: Accesses FMC functions.
- ACARS: Accesses the ACARS system.
- EICAS CP: Reversion control of EICAS.

The FMC key will bring up the last displayed FMC page. The ACARS key will display the ACARS control page. The EICAS CP line select key will bring up the reversionary control page for the EICAS system.

The FMC and ACARS indicators will be followed by one of the following prompts:

<ACT> Indicates that the sub-system is currently active and operating.

<SEL> Indicates that the pilot has selected the sub-system but the MCDU has not yet established active communications with that sub-system.

There are four items displayed on the MENU display screen which are not currently modeled in the PMDG 747-400. If the LSK for these functions are pressed, the FMC/CDU will simply ignore the request as the functions are not available. These functions are listed below:

- SAT-M
- SAT-S
- ACMS
- CMC
- MEMORY
- EFIS CP

INIT REF Key: When pressed, the INIT REF key will provide access to one of the following pages:

- IDENT
- POS
- PERF
- THRUST LIM
- TAKEOFF
- APPROACH

The FMC will automatically display the page which is most appropriate for the current phase of flight. During the preflight phase, for example, the FMC will begin by displaying the IDENT or POS pages so as to allow the crew to begin initializing the FMC.

During the approach phase of flight, the FMC will automatically choose the APPROACH page, etc.

If the page displayed is not the page desired by the crew, pressing the LSK which has the <INDEX prompt (usually 6L) will return the CDU to the following screen:

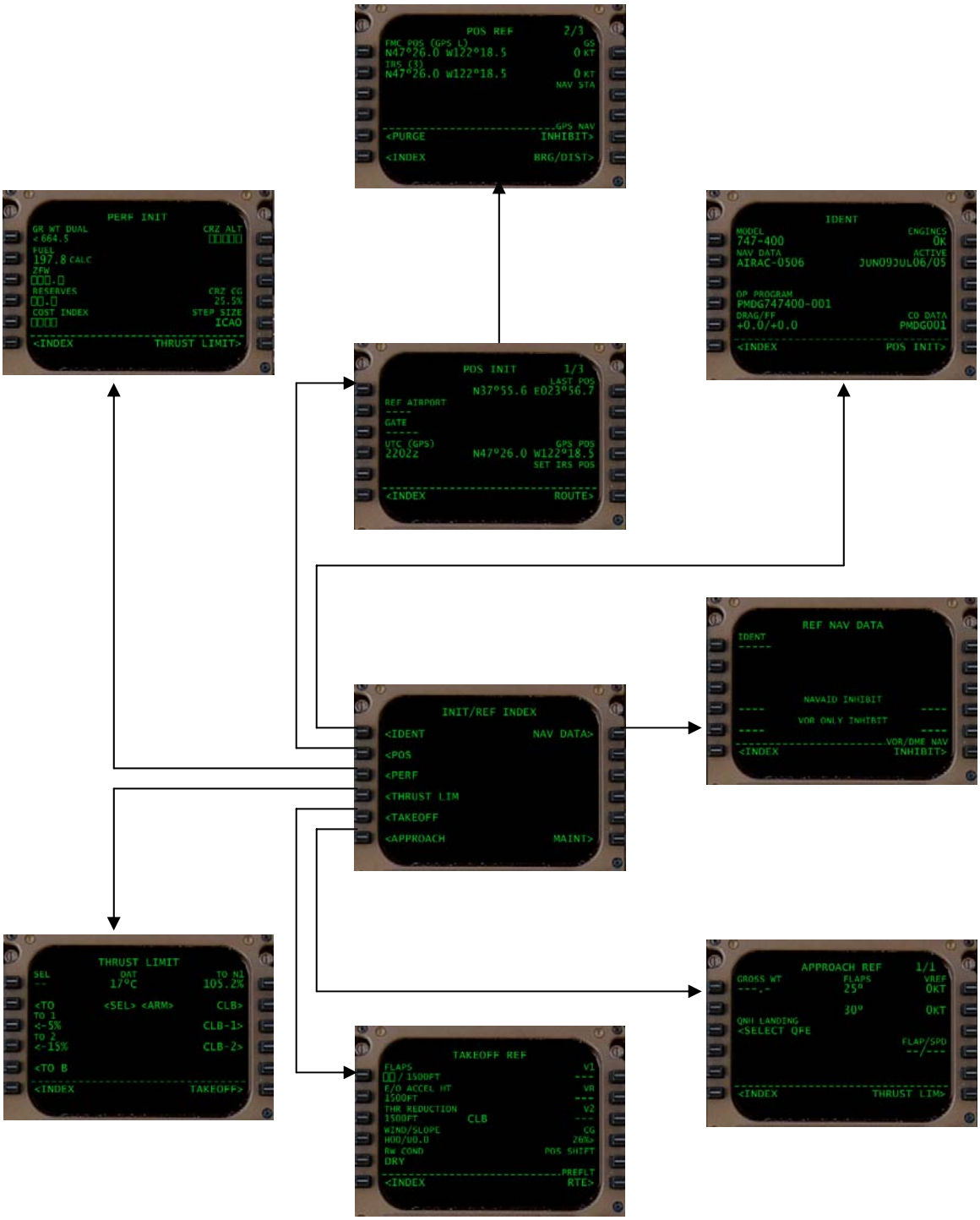
The INIT/REF INDEX page allows crew access to the following initialization and reference pages:

- IDENT: Aircraft identification and nav database verification page.
- POS: Position Initialization (on ground) or Position Reference page (in flight).
- PERF: (Located on page 2/2 of PERF page) Performance initialization page (Gross weight, Fuel Loading, Cost Index, etc.)
- THRUST LIM: Thrust performance mode selection page.
- TAKEOFF: Takeoff parameter reference and initialization page.
- APPROACH: Approach reference and initialization page.
- NAV DATA: Nav data reference page.

One function listed on the INIT/REF INDEX page is not currently modeled in the PMDG 747-400:

- MAINT

INIT/REF INDEX KEY DISPLAY DIAGRAM



RTE Key: When pressed, the RTE key provides access to the active route or modified active route page. If a route has not been activated by the crew, RTE 1 is automatically displayed.

The route being displayed is described by the title line of the RTE display, and can be any of the following:

RTE 1 or ACT RTE 1 or MOD RTE 1
- Route 1 was displayed.
- Route 1 is active.
- No route was activated.

RTE 2 or ACT RTE 2 or MOD RTE 2
- Route 2 was displayed.
- Route 2 is active.

DEP/ARR Key: The DEP/ARR key accesses the DEPARTURES and ARRIVALS pages and the DEP/ARR INDEX page.

These pages are used to select published departure procedures (Standard Instrument Departures, or SIDs) and published terminal arrival procedures, (Standard Terminal Arrivals, or STARs).

The DEP/ARR INDEX page allows the crew to select (using the appropriate LSKs) the appropriate DEP procedure, or an ARR procedure for either of two routes loaded into the FMC.

EXEC Key: The EXEC key is only active when the light bar contained within the key is illuminated. The key is used to confirm and changes to the vertical and lateral route plan.

At any time the EXEC key is active, an <ERASE prompt will appear on the CDU display in order to facilitate cancellation or deletion of a proposed action.

NEXT PAGE/PREV PAGE Keys: The NEXT PAGE and PREV PAGE keys are used in conjunction with CDU displays which occupy more than one page on the CDU display. Multiple page CDU displays are indicated by the use of page numbering in the upper right hand corner of the CDU display.

A wrap around feature is included so that if the NEXT PAGE key is pressed again when the current page is the last in the display,

(e.g. 5/5) then the first page of the display (1/5) will be displayed next. This feature also works for the PREV PAGE key.

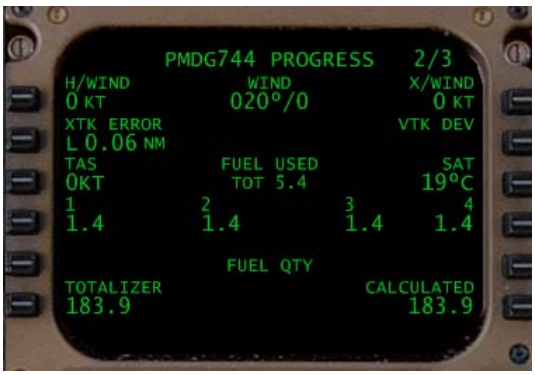
NAV RAD Key: The NAV RAD key accesses the NAV RADIO page, which allows the crew to monitor FMS automated navigation radio tuning, or to manually override the auto-tune sequence.

The NAV RAD page is allows the crew to monitor auto-tuning activity, or to manually tune a desired frequency for VOR1/VOR2, ADF1/ADF2 or the ILS.

A small 'A' next to a frequency indicates that the station has been auto-tuned for navigation verification. An 'M' indicates that the frequency is manually selected by the crew. Station identifier information appears in the center of the display, along with current redial TO the selected station.

Likewise, desired OBS course for a VOR can be manually entered by up-selecting a course from the scratch pad to either LSK 2L or 2R.

PROG Key: The PROG key accesses the flight PROGRESS pages. These pages provide navigation fix, distance to go, fuel, ETE, headwind/crosswind information, cross track and vertical track error, fuel totalizer and fuel usage information to the crew.



VNAV Key: The VNAV key accesses the vertical navigation profile pages. These pages are comprised of CLB (climb) CRZ

(cruise) and DES (descent) pages that are differentiated by their title lines.

Much like the INIT REF key, the FMC will automatically display the appropriate VNAV page for the current mode of flight. If other VNAV mode pages are needed, they may be accessed using the NEXT PAGE/PREV PAGE keys.

CLB VNAV PAGE:

VNAV CRZ PAGE:

VNAV DES PAGE:

FLIGHT MANAGEMENT COMPUTER INITIALIZATION

Overview: The flight management computer is easily the most complicated instrument on the flight deck of the 747-400. Proper initialization and usage of the FMC is a key part of crew member knowledge, and will greatly enhance both the accuracy and economy of aircraft operation.

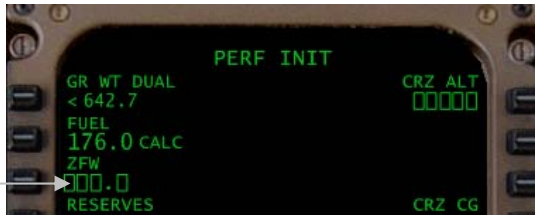
The FMC initialization and usage process is designed as a beginning to end process covering all phases of flight, with multiple options, alternative modes and information displays for each phase.

In order to facilitate effective learning of the FMC process, this manual divides FMC usage into nine specific flight regime/operating methods:

- Database Editing/Management
- Pre-Flight
- Flight Planning
- Takeoff
- Climb
- Cruise
- Radio
- Navigation
- Descent
- Approach

Conventions: Certain conventions should be recognized by crew members in order to input and manipulate data effectively in the FMC/CDU.

Required Entry Boxes: Boxes in any CDU display line indicate that information is required by the FMC in order to be properly initialized. Examples include Gross Weight, Startup Position, etc.



Crew Data Entry/Selection Lines: Dashed lines allow for crew entry of specific data which is unique to each individual flight, such as departure airport, destination airport, speed/altitude restrictions, flap acceleration heights, etc.

Down-selection/Up-selection: In order to facilitate the accurate and efficient transfer of data, a 'down-selection' capability is a key component of the FMC/CDU. By pressing the line select key adjacent to any line of data, that data is copied to the scratch pad. By then pressing an LSK you can up-select the information to another line.

For example, pressing LSK next to the GPS POS on the image above transferred the long position data to the scratchpad. Pressing the LSK next to SET IRS POS will up-select the position information to that line, fulfilling the need to update the IRS position data.

PRE-FLIGHT FMC INITIALIZATION PROCESS

Overview: When power is first applied to the aircraft, the FMC conducts a full self test and is then ready for crew preflight interaction. The preflight portion of FMC operation prepares the flight management system for flight by initializing parameters such as aircraft location, destination, weight, fuel load and flight plan.

IDENT Page: When first powered, the FMC will display the MENU page.

Pressing the LSK 1L key, (the <FMC prompt) will enter the FMC function area and display the IDENT page, as follows:

The IDENT page is described by the IDENT title page line at the top of the display screen. The data which appears on the IDENT page allows the crew to verify the accuracy of FMC operation for the known aircraft type, and cannot be changed from within the CDU. The data appearing on this page should not change on a regular basis, but it is important that this preflight check be accomplished in order to protect against system faults or improper system reloads during updates and/or changes to the FMC system or FMC database.

Line 6 at the bottom of the screen contains two prompts, <INDEX, which will display the INIT REF INDEX page, and POS INIT>, which will display the Position Initialization page of the FMC. During the preflight initialization, following the prompts in the 6R position will take the crew member through the entire initialization process.

The following information is provided on the IDENT page:

MODEL: The airplane model is displayed in line 1L.

ENGINES: The installed engine type is displayed in line 1R.

NAV DATA: The navigation database identifier and life cycle information is displayed on line 2 of the CDU. The AIRAC cycle and effective dates are shown here. If the database is out of date, an updated version can be downloaded from http://www.navdata.at.

OP PROGRAM: The operational program identifier is displayed in line 4L. This number is the part number of the FMC's software operations program. If both FMCs do not have the same software load the system will remain locked at the IDENT page.

DRAG / FUEL FLOW: Aircraft demonstrated drag adjustment (from norm) and the resultant demonstrated fuel flow adjustment (from norm) are displayed in 5L. This information is used on the actual aircraft to account for changes in the aircraft performance relative to it's original engineering specifications. It is not relevant to the simulator.

CO DATA: Company data identifier is displayed in line 5R.

POS INIT Page: The POS INIT page allows for position initialization of the Inertial Reference System (IRS). The POS INIT page is selected by pressing LSK at the POS INIT> prompt, or by selecting <POS INIT from the INIT/REF INDEX page.

The primary function of this page is to initialize the airplane's starting position for the Inertial Reference System. This is done by entering a "starting position" into the 6R LSK to satisfy the box prompts that indicate the IRS is in need of starting position data.

The fields displayed on the POS INIT page are as follows:

LAST POS: This reference position is the last recorded position of the aircraft at the time the aircraft was powered down, or at the time the brakes were last set. If determined to be applicable, this information can be down-selected via the scratchpad to satisfy the position initialization requirements of line 4R.

Crews are advised to use caution when down-selecting the LAST POS reference position, as it may contain accumulated IRS drift inaccuracy from the previous flight. In addition, if the aircraft has been towed to a new gate or moved while the IRS was not aligned, the reference position will be inaccurate.

Additionally, if the LAST POS data contains the shutdown information from a flight you ended at a different airport, it will have a significant negative impact on the performance of the FMC for your new flight.

We recommend the use of GPS position when available as it is generally considered to be most accurate and current.

REF AIRPORT: Entry of a reference airport ICAO code (International Civil Aviation Organization) will provide an IRS reference position to become available in 2R. This reference position can be down-selected via the scratchpad to satisfy the position needs of 4R if desired.

This can be easily accomplished by entering the ICAO airport code into the scratch pad:

Then up-select to the 2L LSK:

This will add the additional position information of the airport starting position to the right side of the CDU screen, thus providing a third option for position information for the FMC.

Note: To give a good example of why the LAST POS information should be used only when carefully checked, we shut the airplane down at the conclusion of a previous flight, then loaded the simulator at a different airport. Notice the vast difference in position information between the GPS position, AIRPORT position and the LAST POSITION displayed on this image!

GATE: The gate position reference allows the crew to select a Lat/Lon position reference based upon the gate at which the aircraft is currently parked. This function is dependant upon whether or not the gate position is included in the airport's SIDSTAR file.

SET IRS POS: The prompt boxes at 4R indicate that current aircraft position has not be initialized, or that any of the Inertial Reference Units are in the align mode. (If neither of these conditions is true, then 4R will be blank.)

To satisfy the prompt boxes at line 4R, the reference latitude/longitude position can be entered directly into the scratch pad, then line selected to 4R, or by -selection of the LAST POS or REF AIRPORT or GPS reference position via the scratch pad.

Once the position initialization process is satisfied, the POS INIT page will have three complete reference positions entered in lines 1R, 2R and 4R.

GMT: Line 5L displays the current time in GMT according to the airplane's clock.

POS INIT Completion: Once the POS INIT process has been completed, the <INDEX prompt at 6L will display the INIT/REF INDEX page, or the ROUTE> prompt at 6R will display the route pages.

RTE Page: The RTE page allows for entry of the origin, destination, company route name and flight number for the planned flight. The RTE page also allows the planned departure runway to be entered in order to facilitate proper use of Standard Instrument Departure procedures stored within the FMC database.

The RTE page is accessed either by pressing the RTE key on the FMC/CDU keypad or by selecting the ROUTE> prompt from the POS INIT page.

The fields displayed on the RTE page are as follows:

ORIGIN: The airport of origin for the flight. Valid entries include any four letter ICAO airport code.

DEST: Airport of destination. Valid entries include any four letter ICAO airport code.

FLT NO: Airline code and flight number. Valid entries are any alpha numeric combination not including + or -. The flight number will automatically be displayed on the PROGRESS page as well, and may be changed but not deleted. Entry of the flight number into the RTE page will automatically enter the flight number for both RTE 1 and RTE 2.

CO ROUTE: The title name of an FMC database stored Company Route. Entering a CO ROUTE in 2L will open this route for use.

RUNWAY: The runway prompt allows for selection of the departure runway. This will allow the FMC to properly plan navigation from the correct runway navigation point and offer the correct departure procedures for that runway.

RTE 2: Allows for entry and modification of second FMC memory stored route.

ACTIVATE: Upon completion of route selection, whether by CO ROUTE entry, or by manual flight planning (as described later), the route can be activated by selecting the ACTIVATE> key (6R) and pressing the lighted EXEC mode key on the FMC/CDU keypad.

PERF INIT Page: After completing the POS/INIT page, press the INIT/REF key. The FMC will take you to the next logical page in the FMC initialization sequence. This page is the PERF INIT page where some basic performance parameters for the flight are entered into the FMC.

The fields displayed on the PERF INIT page are as follows:

GR WT: Aircraft Gross Weight displayed in thousands of pounds or Kilograms. Immediately to the right of the prompt boxes on line 1L, the FMC Weight and Balance System (WBS) estimated aircraft weight is displayed in small font. GR WT can be confirmed either by entry via the scratch pad, or by selecting (confirming) the 1L WBS estimated figure.

A confirmed GR WT figure is displayed in large font, while an estimated or unconfirmed figure is displayed in small font.

It is possible to delete the GR WT figure in 1L, by selecting DEL, the pressing the 1L key. Deleting the 1L GR WT figure will cause the WBS gross weight figure to be entered into 1L in small font.

GR WT should always equal the aircraft zero fuel weight plus the total fuel weight.

FUEL: The FUEL indicator displays the current fuel weight loaded in thousands of pounds. The fuel weight will always be suffixed by one of the following:

- CALC: Fuel quantity has been calculated by the FMC using fuel flows. Prior to engine start- this value will always equal the quantity of fuel indicated by the Fuel Quantity Indicating System.
- SENSED: Fuel quantity is the FQIS value.
- MANUAL: Fuel quantity has been entered manually via the FMC.

If the FQIS is deactivated or inoperative, prompt boxes will alert the crew to enter fuel quantity manually in line 2L. Fuel quantity cannot be entered or deleted manually when SENSED is the current FUEL mode.

ZFW: The aircraft zero fuel weight is displayed in line 3L. Weight is displayed in the thousands of pounds, with an optional decimal point. Prompt boxes alert the crew that the ZFW must be entered manually, however confirmation of GR WT and FUEL fields will automatically update the ZFW field. ZFW figures will be displayed in small font until confirmed by LSK selection. **Note:** You can automatically populate the ZFW data by pressing the associated LSK.

RESERVES: The reserve fuel weight is displayed in line 4L. Prompt boxes alert the crew that a reserve fuel weight in thousands of pounds must be entered. If no weight is entered, a default value of 4000 pounds will be assumed.

The value entered for fuel reserves is used by the FMS to determine an insufficient fuel condition, and will also be used to calculate performance predictions for the flight.

Cost Index: The cost index number is a scale value from 00 to 99 (0000 to 9999 on actual aircraft) which helps to determine a level of economy for aircraft performance calculation.

Cost index is calculated as the aircraft operating cost divided by fuel cost. [($/hour aircraft operating cost) / (Fuel Cost in Cents/Pound)] A cost index of 00 will result in the maximum cost economy, with slow climb rates, maximum range cruise and slow descent speeds predicted by the FMC in order to minimize fuel burn. A high cost index will result in higher climb, cruise and descent speeds. The cost index is designed to provide a relative index of the cost of aircraft operation vs. time en-route.

CRUISE ALT: The planned cruise altitude is displayed in 1R. Entry is in feet.

CRZ CG: Displays the FMC calculated cruise Center of Gravity as a percentage of mean aerodynamic chord (Percent MAC).

STEP SIZE: The planned altitude step size is displayed in line 5R. The FMC will default to a standard ICAO step size of 2000 feet. This will result in proper cruise altitude clearance being maintained (e.g. odd flight levels while east bound, even flight levels while west bound.)

The crew may override the STEP SIZE by entering any value as a four digit multiple of 1000 from 0 to 9000. Entering a 0 value will result in no step climbs being made. If no steps are planned, it is important that 0 be entered in this field in order to accurately predict fuel consumption.

Deleting the pilot entered STEP SIZE will revert the figure back to ICAO.

BUILDING A FLIGHT PLAN

Overview: The capability of the FMS to perform complete 2D navigation in either the VNAN or LNAV mode and 3D navigation when these modes are used together is a powerful product of the FMC. In order to utilize this capability to its fullest extent, however, requires that the FMC have a complete and accurate route process programmed throughout the duration of the flight.

The ability of the crew to interact with the FMC, as well as their ability to understand and utilize its capabilities in congested airspace and during busy departure and arrival procedures will both enhance the safety of the operation and improve the accuracy to which the aircraft is flown.

Conventions: One of the most powerful flight planning features the FMC makes available to the crew is the stored FMC database of navaids, waypoints and intersections. For flight planning purposes, the crew is able to use nearly any geographically fixed navigation point, including fight plan defined waypoints such as latitude/longitude points, place/bearing/distance (PBD) waypoints, along-track waypoints, course intersection waypoints, runway extension waypoints, final approach fixes and latitude/longitude reporting points.

Flight plans can be entered into the FMC by manual entry, or by recalling a stored Company Route from the stored FMC database. Once entered, routes can also be saved and recalled in the future as company routes.

Two separate routes can be entered into the FMC, and the crew may switch between active routes while in flight. At all times, the crew should reference the title line of the RTE page to determine which route is currently selected as active.

RTE Page: The route page may be access using the RTE mode key or by select the ROUTE> prompt when displayed on the TAKEOFF REF, POS INIT or POS REF pages.

The RTE page is used to describe the planned route by origin, destination, flight number and, if available, company route name. The page is shown below, with the ICAO identifiers for ORIG and DEST already entered, as well as the airline code/flight number.

CO ROUTE: If a company route was previously stored for this flight, entry of the stored route name into line 3R via the scratchpad will automatically load the flight plan. This will eliminate the need to enter ORIG and DEST, as well as eliminate the need to program the route of flight in the RTE LEGS pages.

We have provided more than 350 routes covering various parts of the world. They are located in the Flight Simulator/PMDG/FLIGHTPLANS directory. Entering ADLBNE001, for example into the 3R LSK will automatically load a flight between Adelaide and Brisbane.

We regret that this version of the FMC does not currently have the ability to actively list all saved routes for easy display within the FMC itself. This is planned for future versions, however!

RWY: The origin airport planned runway can be entered into 3L Valid entries are RWxxY, where xx is the runway number and

Y is the runway designation of L, R or C as applicable.

Using Airways to define a route: Once the origin and destination have been entered it is time to begin defining the route of flight busing airways in order to minimize the amount of manual data entry conducted by the crew.

Airways are defined using the TO and VIA prompts as follows:

TO: This prompt, located on right side is where the name of fixes defining the starting and ending points of segments along the route are entered.

VIA: This entry describes *how* the airplane will reach the associated fix in the TO prompt. The VIA field may contain the following:

- DIRECT
- An airway segment (e.g.: J1, V305)
- A SID identifier (e.g. LOOP6)
- A SID with an enroute transition
- An approach segment identifier (e.g. ILS04R)
- APPR TRANS for approach transitions
- MISSED APPR for missed approach segments
- '- - - - -' indicating available for entry.

For example, the text DIRECT indicates that the airplane will navigate directly to the fix described under TO, but the name of an airway would indicate that the airplane is to follow a specific airway in order to reach the fix listed under TO.
And example of DIRECT to the SEA VOR is shown below:

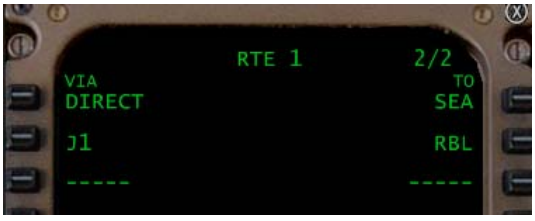
A Defined Airway Segment: A defined airway segment has pilot defined starting and ending waypoints. A defined airway segment is entered by inserting the airway identifier into the VIA field on the line that follows a TO field containing the airway segments starting waypoint.

Using our previous example of crossing SEA, we can use the SEA VOR as the starting point on a Defined Airway Segment the follows J1 from SEA to the RED BLUFF VOR located just north of Oakland, California.

To do this, we simply enter J1 into the scratch pad and upload to the 2L LSK:

This creates prompt boxes at the 2R LSK to indicate that we are expected to list a fix at which we expect to leave J1. Or, described another way, "where are we taking J1 TO?"

In our example, we will take J1 to the RBL VOR, so we upselect RBL to 2R.

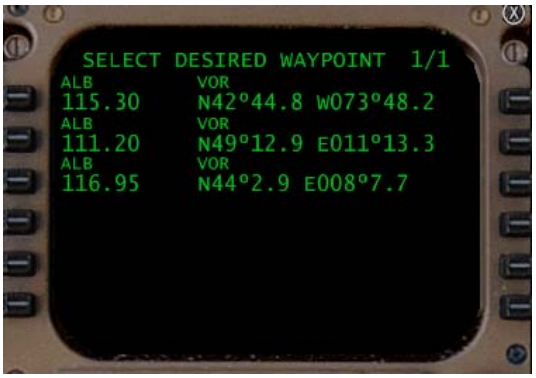


In the event that we were transitioning from J1 to J65, for example, we could upselect J65 to VIA and an exit point such as SMF to the TO column. This would instruct the FMC to build the flight plan along J1 until reaching RBL, then change to J65.

Using Navigation Database Waypoints: You can define the route of flight by individual waypoints contained within the database by entering and upselected a valid waypoint name into the TO prompt on the RTE page.

SELECT DESIRED WPT page: When entering a navigation fix, if an ambiguity results from the fact that more than one fix in

the database shares a common name, the FMC will present the crew with the SELECT DESIRED WPT page from which to select the correct/desired WPT.

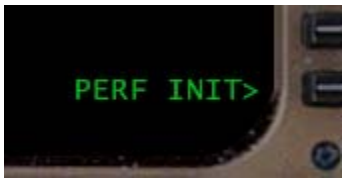


The VORs are ordered by distance from the fix prior to the entry selection, or the airplane's current position if no fixes have been entered. Pressing a left side LSK will select the desired item into the flight plan automatically.

RTE Page Variable Modes: Depending on the phase of flight, the RTE page will display one of three prompts at 6R.

ACTIVATE>: The ACTIVATE prompt is an alert to the crew that the route currently selected is not an active flight plan in the FMC. Selecting ACTIVATE (when the initialization process is complete, or during flight when deliberately changing between RTE 1 and RTE 2) will activate the selected route.

PERF INIT>: This prompt is shown in flight when a flight plan is currently active in the system. Selecting 6R will display the PERF INIT page.



OFFSET: During non-departure/approach phases of flight, the OFFSET prompt will become available at 6R. This prompt allows the crew to select a parallel flight track offset from their planned flight track by a crew specified distance. This procedure can be used for weather avoidance or offset flight track assignments from ATC. Valid entries are LXX (where XX is a distance figure between 1 and 99nm) or RXX or 0, to delete a selected OFFSET.

RTE LEGS Page: The RTE LEGS page is another area where manual entry of a flight plan may take place. The RTE LEGS page is used during the flight planning process to define the route of flight for the FMC on a waypoint by waypoint basis and in flight to perform operations such as a DIRECT-TO routing. The RTE LEGS page displays the individual legs of a flight plan as defined by their individual waypoints after the flight plan has been manually entered or selected using the CO ROUTE function or having been entered on the RTE page as described in the earlier section.

The RTE LEGS page is activated by pressing the LEGS key on the FMC/CDU keypad.

Page 1 of the RTE LEGS page is shown for the example KSEA-KSFO flight plan along J1 to RBL as described in the previous section.

The Title line of the page describes which route is currently being displayed on the RTE LEGS page. The upper right hand corner shows which page of the LEGS display is currently being shown. The NEXT PAGE and PREV PAGE keys are used to scan forward and back. Page 2/2 appears as:

At the bottom of the LEGS display, the <RTE 2 LEGS prompt allows the crew to display RTE 2 legs and waypoints if a RTE 2 has been programmed.

The ACTIVATE> prompt allows the crew to activate the current flight plan, if this has not already been done.

Course To Information: When navigation fixes are shown in the flight plan, the RTE LEGS page provides, for each fix, a course-to heading. This course heading will appear in lines 1L through 5L, and represents the course that must be flown in order to reach the next waypoint. The course displayed at the first displayed waypoint (1L) is the course from the airplane's current location to the first waypoint displayed. (In this example, a course of 223 degrees will take us to the SEA VOR.) All other course indications are the course that must be flown from the previous waypoint to the next waypoint in the flight plan.

Leg Distance Information: The center of the RTE LEGS display provides leg distance information for each leg of the flight plan. Once again, the distance displayed at 1L is the distance from the current aircraft position to the first navigation fix in the flight plan. All other distance indications represent the distance between the previous and next legs of the flight plan.

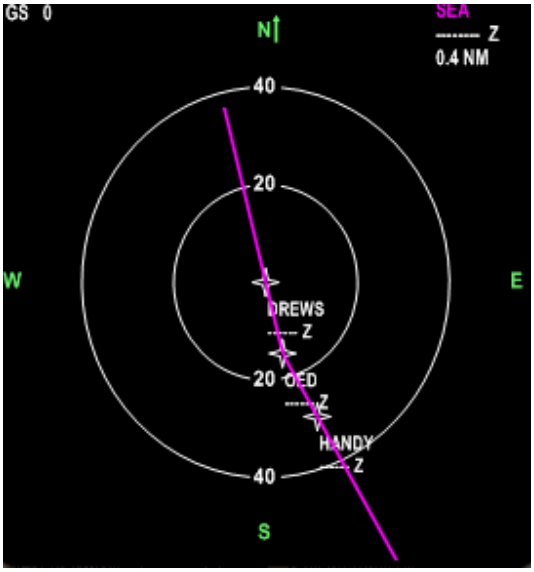
When the Navigation Display is in PLN mode, a <CTR> indicator will appear in the center column of the display as well.

The <CTR> indicator identifies which fix the flight plan is currently centered on when viewed in the PLAN mode on the navigation display.

The <CTR> indicator can be cycled through all points of the flight plan in order to display portions which may not be visible using the standard range display settings of the ND.

To follow the flight plan sequentially through all loaded waypoints, press the STEP> prompt at line 6R. This will move the <CTR> prompt to the next waypoint along the flight plan, and will update the navigation display appropriately as well.
The NEXT PAGE and PREV PAGE will cause larger jumps of the <CTR> indicator.

When in PLAN mode, the navigation display will appear as follows:



Note that the <CTR> prompt is next to DREWS intersection, which is displayed at the center of the navigation display.

This process can be used to validate the entry of a flight plan in the FMC.

Speed/Altitude Predictions or Constraints: When the FMC flight plan is fully initialized, the FMC will calculate a set of predicted altitude and speed values for each leg of the flight plan. These predictions appear in

small font in lines 1R through 5R. The FMS will provide these predicted altitude and speed values for each navigation fix unless the crew manually enters constraint values into the flight plan.

Constraint (or desired) values may need to be entered by the crew in order to adhere to published approach procedures or ATC clearances. Constraint values are entered by typing them manually into the scratchpad, then up-selecting them to the desired flight plan leg.

Altitude Constraints: The use of altitude constraints allows the crew to enter either ATC assigned waypoint/altitude constraints, or to program waypoint/constraints assigned by published approach procedures. Altitude constraints are entered by direct entry into the scratchpad, the up-selecting them to the desired line of the flight plan.

The available altitude constraints are as follows:

- AT constraints.
- AT OR ABOVE constraints.
- AT OR BELOW constraints.

AT constraints are used to indicate that the airplane must be at a specific altitude when crossing the associated fix. Entry of AT constraints can be in feet of flight level. (e.g. 18000 or FL180) AT constraints are simply entered into the scratchpad and up-selected to the desired navigation fix LSK.

AT OR ABOVE constraints are used to indicate that the airplane should cross the associated fix at a specific altitude, but may also cross at a higher altitude if the FMS calculates that it is more efficient to do so given the current flight disposition. The AT OR ABOVE altitude constraint can be entered in feet or flight level. (e.g. 18000 or FL180) AT OR ABOVE constraints are entered into the scratchpad in the format XXXXXA or FLXXXA and up-selected to the desired navigation fix LSK.

AT OR BELOW constraints are used to indicate that the airplane should cross the associated fix at a specific altitude, but my also cross at a lower altitude if the FMS calculates that it is more efficient to do so given the current flight disposition. The AT OR BELOW altitude constraint can be entered in feet or flight level. (e.g. 18000 or FL180) AT OR BELOW constraints are entered into the scratchpad in the format XXXXXB or FLXXXB and up-selected to the desired navigation fix LSK.

Speed Constraints: Speed constraints can be used by the crew to comply with ATC assigned speed constraints directly associated with a particular navigation fix. E.g. "Cross RBL at 300 knots."

Speed constraints must always be entered in association with an altitude constraint, and are entered numeric format from 100 to 400 knots Calibrated Air Speed, followed by the '/' indicator which separates the speed constraint from the altitude constraint. (e.g. 'XXX/FL180A')

ABOVE and BELOW modifiers are not possible for airspeed constraints.

Maximum Number of Flight Plan Legs: The RTE LEGS page is only capable of storing 120 legs per route. The capacity of both RTE 1 and RTE 2 combined allows for a complete flight plan entry of up to 240 legs if necessary.

If a crew member attempts to insert more than 120 legs in either route, the ROUTE FULL prompt will appear in the scratchpad, and the attempted entry will be discarded.

DEFINING AND USING CUSTOM WAYPOINTS

Overview: On of the most powerful features of the PMDG 747-400's FMC is the ability to define waypoints based upon the location of other, known fixes in the navigation database.

Making custom navigation fixes allows the crew to define a point anywhere in 3D space toward which the airplane can be navigated.

Navigation Fix Entry: Navigation fixes are entered into the left side of the RTE LEGS page individually via the scratchpad, or on the right side of the RTE page under a TO prompt. Navigation identifiers/Fixes can be comprised of the following:

- Airport
- Waypoint
- NDB
- VOR
- VOR/DME
- VORTAC
- DME/TACAN
- Runway
- Latitude/Longitude Points
- Place/Bearing/Distance Points (PBD)
- Along-track waypoints
- Course intersection waypoints
- Runway extension waypoints
- Final approach fixes

Navigation fixes can be entered into the RTE LEGS page in a number of formats. In most cases, crew members will navigate using existing navigation fixes such as published waypoints and VORs. These types of navigation fixes can be entered directly into the RTE LEGS page by name, and will be called from the stored FMC navigation database.

In some cases, however, it becomes necessary for crew members to provide unique navigation fixes or waypoints to the FMC in order to satisfy the changing ATC requirements, or in order to clearly define an unusual published approach for the FMS. In such cases, it is possible for the crew to define navigation waypoints in the FMC using position and altitude data relative to existing waypoint entries.

Currently, the PMDG 747-400s FMC is capable of accepting waypoints in the following formats:

- FMC Navigation Database Defined Waypoints/Fixes.
- Along Track Waypoints.
- Place Bearing/Distance Waypoints (PBDs)
- Latitude/Longitude Waypoints.
- Place Bearing/Place Bearing (Course Intersection) Waypoints

The process for entering these five types of waypoints is described below.

FMC Navigation Database Defined Waypoints: Navigation database defined waypoints can be directly entered into the left fields of the RTE LEGS page by entering the fix name into the scratchpad and up-selecting to the desired line. Valid entries are one to five character alphanumeric entries. If more than one navigation fix shares an identical name, the FMC/MCDU will display the SELECT DESIRED WPT page and the crew will be prompted to select the desired fix.

Navigation Database Defined Waypoints are useful when:

- Navigating along a specific route that is defined by navigation fixes.
- Navigating directly to a specific fix.

Along Track Waypoints: Along track waypoints are commonly used to mark a descent or climb restriction that is issued by ATC in reference to a navigation fix that exists along the route of flight.

Along Track Waypoints are the simplest of the custom waypoints, because they are entered exactly as issued by ATC.

For example, if ATC were to issue the following climb restriction, "descend and maintain FL180 25 miles from RBL VOR"

the crew simply enters the restriction into the FMC as an along track fix by using the following format:

FFF/#DD

(Note: The # above should be replaced with either a + or a – sign. + signifies beyond the waypoint while a – signifies before the waypoint.)

This, in this example, we would the following into the scratch pad:

Since we want this fix to *precede* RBL, we up-select the fix to the line containing RBL, and the FMC will insert the fix and move RBL down a line to accommodate the new, custom waypoint.

The along track waypoint that has been created is now listed in the flight plan using the format PPPss, where PPP is the first three letters of the fix name upon which the custom waypoint is based, and ss is a sequence number assigned by the FMC.

ATC issued speed and altitude restrictions can be entered on the right side of the display in a SSS/AAAAA format for speed/altitude.

Along Track Waypoints are useful when:

- ATC has defined some action or restriction along the route of flight that is based on a distance from/to a specific point in the flight plan.
- The crew wishes to define a point in 3D space along the path of flight such as a Descent point or visual approach point.

Place Bearing/Distance Waypoints: PBD waypoints can be entered into the left fields of the RTE LEGS page by entering the fix description into the scratchpad and up-selecting to the desired line. PBD waypoints work by describing a geographic point that is at a specific bearing and a specific distance from a navigation fix which is already defined in the flight plan or the FMC navigation database.

PBD waypoints come in handy when defining a point in space that is no currently a navigation fix. For example, if ATC were to request "after crossing RBL proceed direct to point 42 DME on the 280 radial of the HNW VOR" we can easily define this point in the FMC, thus simplifying our navigation solution.

The proper format for entering a PBD waypoint into the scratchpad is as follows:

PPPPPBBB.B/DDD.D

Where PPPPP is the existing navigation fix name (1 to 5 alphanumeric characters), BBB.B is the bearing and DDD.D is the distance. (The decimal place is considered to be optional for both bearing and distance.)

Thus, to define the point assigned by ATC, we enter the following into the scratchpad:

Up selecting this PBD waypoint will result in the fix being added to our flight plan in the same PPPss format as described above.

PBD bearing entries from 0 to 360 degrees and distance entries from 0 to 700 miles are valid.

Place Bearing Distance Waypoints are useful when:

- The crew must define a waypoint based upon a certain bearing and distance from any other point in the flight plan or navigation database.
- Constructing approaches by hand to simplify navigation to a VFR runway.
- Simplifying off-route navigation.

Course Intersection (Place Bearing/Place Bearing) Waypoints: Course Intersection waypoints, also known as Place Bearing/Place Bearing waypoints are fixes defined by the intersection of courses from two different fixes. The PB/PB waypoint garners it's name from the fact that the waypoint is being defined at a point which is one bearing from one place and one bearing from another.

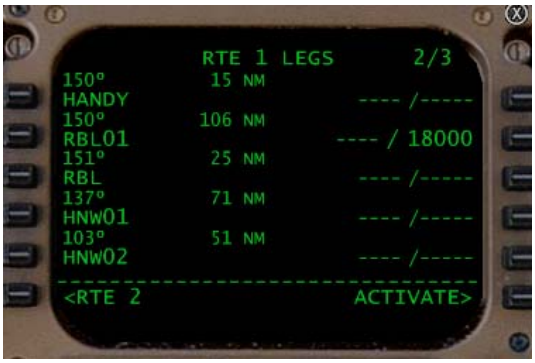
For example, if ATC asked that our flight plan to cross the intersection of the 120 radial from HNW and the 000 radio from MOD, we can define the point using a PB/PB waypoint.

The proper format for entering a PB/PB waypoint into the scratchpad is as follows:

XXXXXBBB.B/YYYYYBBB.B

XXXXX and YYYYY represent the existing navigation fixes which are being used to describe the PB/PB waypoint. BBB.B represents the bearing from each existing fix. The decimal point is optional in the bearing entries.

We then up-select this entry to our flight plan, and the new waypoint is added to our flight plan in the PPPss format. Note that since this is the second waypoint we have constructed using the HNW VOR, the sequence number is incremented.



A second example of the PB/PB in practical application comes from defining points along an approach path. If, for example, an approach or STAR has an altitude restriction that is based upon the intersection of a VOR radial across your path of flight, you can use a PB/PB waypoint to make the point appear visually on your flight plan along with the associated speed/altitude restriction.

PB/PB waypoints can be constructed using any fix in the flight plan or in the FMC navigation database.

PB/PB Waypoints are useful when:

- Navigating to a location that is defined by the intersection of two radials from other fixes.
- Defining crossing restrictions and/or speed restrictions that are based upon a radial from a fix crossing your route of flight.

Latitude/Longitude Waypoints: Latitude/Longitude waypoints are pilot entered waypoints defined by a specific geographic reference in a latitude/longitude format.

The proper format for entering a Latitude/Longitude waypoint into the scratchpad is as follows:

NXXXX.X/EXXXXX.X
SXXXX.X/WXXXXX.X

For example, entry for a latitude/longitude waypoint at the geographic location N78º 38.8' E120º 34.7' would be entered as follows:

The entry is then up-selected to the desired line in the RTE LEGS display, where it will be condensed for display in the route, as shown below. The expanded entry can be redisplayed on the scratchpad by pressing the associated LSK.

This type of entry is considered a "long format" Latitude/Longitude entry.

A short form entry is also available that follows the format:

NXXEXXX
SXXWXXX

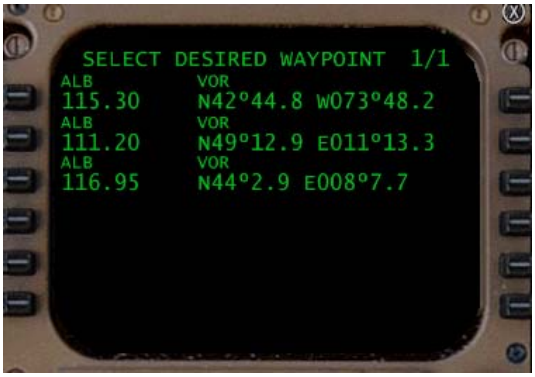
The position N47º 00.0' W93º 00.0' for example can be entered as:

Lat/Lon Waypoints are useful when:

- The route of flight is defined using lat/lon navigation points.
- The crew wishes to define lat/lon points as reporting points during oceanic crossings.

SELECT DESIRED WPT Page: In some cases, an ambiguity will occur when entering navigation data if more than one fix shares the same identifier. These types of ambiguities generally only occur with navigation aids that are located in vastly different geographic areas. Given the nature of the 747-400's range and the storage capability of the FMC navigation database, it becomes important for the crew to validate the navigation aids being entered to ensure accuracy.

The SELECT DESIRED WPT page (below) will be displayed in the event of a navigation fix name ambiguity:



All navigation aids with names identical to that entered in the FMC scratchpad will be displayed. In some cases, the crew member may need to use the NEXT PAGE/PREV PAGE keys to page through multiple displays in order to locate the desired fix.

Specific information related to each fix displayed on the SELECT DESIRED WPT page is provided in order to assist the crew member in selecting the appropriate fix.

Identifier and Fix Type: The identifier which was entered into the scratchpad will appear in small font at the beginning of each line on the display, followed by the fix type represented by each LSK.

Fix types available are as follows:

- ARPT
- DME
- ILS
- ILSDME
- LOC
- MLS
- MLSDME
- NDB
- TACAN
- VOR
- VORDME
- VORTAC
- WPT (waypoint)

Fix Frequency: When the fix type is a radio navigation aid, a frequency will be displayed in the appropriate line. Frequencies are displayed in lines 1L through 6L

Fix Position: The latitude/longitude position of the navigation fix is displayed in lines 1R through 6R.

The left or right LSK can be used to select the desired navigation fix from the SELECT DESIRED WPT page. Pressing any of the

LSKs will cause that navigation aid to be entered into the flight plan as normal.

FMC ARRIVAL/DEPARTURE PROCEDURES

DEP/ARR INDEX Page: The DEP/ARR INDEX page allows the crew to select published arrival and departure procedures at the origin and destination airports. STAR (Standard Terminal Arrival) and SID (Standard Instrument Departure) procedures are contained in the FMC's navigation database and can be used in conjunction with departures and approaches to the airports for which they exist.

PMDG has long had a strong partnership with PlanePath, the provider of the vast majority of SID/STAR procedures for the PMDG FMC. PlanePath takes one of the few known free access SID/STAR databases and produces a monthly update similar to the Navdata AIRAC cycle.

PlanePath's FMC database is updated on the downloads page of www.precisionmanuals.com on a monthly basis as the new procedures are provided by PlanePath.

A second repository of user designed procedures is available for download from www.navdata.at

We recommend that users check the various user sites for SID/STAR updates, as the existing database covers only a few thousand of the tens of thousands of procedures worldwide.

The DEP/ARR INDEX page is accessed by pressing the DEP/ARR key on the FMC/MCDU keypad.

The 1L, 3L and 6L keys allow for selection of SID procedures stored in the FMC SID database. Keys 1R through 4R and 6R allow for selection of STAR procedures stored in the FMC STAR database. The center of the display shows the crew entered or COMPANY ROUTE entered arrival and departure ICAO airport codes.

Additionally, the display is divided sections for RTE 1, RTE 2 and OTHER. The RTE 1 and RTE 2 sections allow selection of SID and STAR procedures for those respective routes. The OTHER sections allows for inspection of SID and STAR procedures at an airfield entered into the scratchpad.

DEPARTURES Page: Departure procedure selection is made by pressing the appropriate <DEP prompt from the DEP/ARR INDEX page. The <DEP prompt for the active route should be chosen unless the secondary route is being built. Pressing the <DEP prompt key will display a DEPARTURES page for the selected airport. The DEPARTURES page allows the crew to select the SID and associated runway to be used. A sample DEPARTURES page is shown below:

Runway: The available departure runways for the selected airport are listed down the right side of the screen. Pressing an associated LSK will cause all other runways to be removed from the screen and a <SEL> indicator will be placed next to the selected runway to indicate that it has been selected as the departure runway.

Selection of a departure runway before selection of a SID will also instruct the FMC to remove any SID procedures that do not originate from the selected departure runway.

Standard Instrument Departures: The SIDS are listed on the left side of the display at 1L through 5L. A SID can be selected by pressing the associated LSK. Once a SID is selected, a <SEL> indicator will appear next to the associated SID to indicate that it has been selected.

If the DEPARTURES page displayed is for the active route or for the airport of origin, selecting a SID or runway will automatically insert the appropriate fixes into the flight plan and update the runway selection on the RTE page. To alert the crew that these changes have been made, and to allow for verification, the EXEC key will illuminate. Pressing the EXEC key will confirm the selections, but a route discontinuity flag will be displayed in the RTE LEGS pages between the newly added SID and the previously programmed route.

Pressing the illuminated EXEC key will confirm the Runway and SID selections and make them active in the flight plan.

When the runway and SID are active in the flight plan, they will change to magenta on the navigation display, and the <SEL> indicators will change to <ACT>.

ARRIVALS Page: Arrival procedure selection is made by pressing the appropriate ARR> prompt on the DEP/ARR INDEX page.

There will always exist two ARR> prompts in order to account for the possibility that the flight may need to return to the departure field.

Selecting the ARR> prompt for KSFO will allow the selection of a STAR and eventually a runway for approach and landing.

Similar to the process used for runways and SIDs, it is important that crews understand that the selection of a STAR will cause the FMC to remove from view any runways that are not served by that STAR. Likewise, selecting an arrival runway will remove from view any STARs that do not connect to the selected runway.

Standard Terminal Arrival Route: The STARs are listed on the left side of the display at 1L through 5L. A STAR can be selected by pressing the associated LSK. Once a STAR is selected, a <SEL> indicator will appear next to the associated STAR to indicate that it has been selected by the crew.

Approaches: The available approaches for the selected airport and STAR are listed at 1R through 5R. Pressing the associated LSK will illuminate a <SEL> indicator on the selected approach to indicate that it has been selected by the crew.

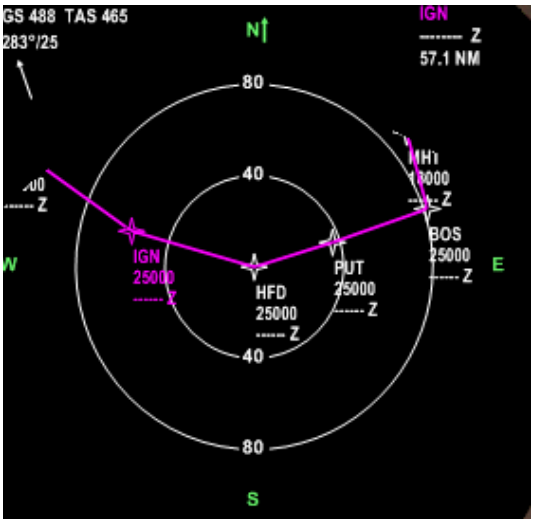
If the ARRIVALS page displayed is for the active route or for the airport of destination, selecting a STAR or an approach will automatically insert the appropriate fixes into the flight plan. To alert the crew that these changes have been made, and to allow for verification, the EXEC key will illuminate. Pressing the EXEC key will confirm the selections.

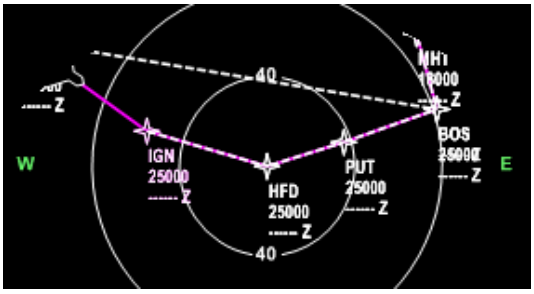
Selection of an ARRIVALS procedure does not need to be accomplished during the pre-flight process, but is included here for balance and clarity. Arrival procedures are normally selected during the initial approach planning phase of the flight.

Changing a SID/STAR/RWY: After selecting a SID/STAR or RWY, it may become necessary to change the procedure as a result of the changing ATC environment.

To effect the change, simply bring up the DEP/ARR page using the mode key, and press the LSK adjacent to the item you wish to change. This will repopulate the list of available options and allow a new selection.

It will be necessary to EXEC the changes in order to enter them into the flight plan.



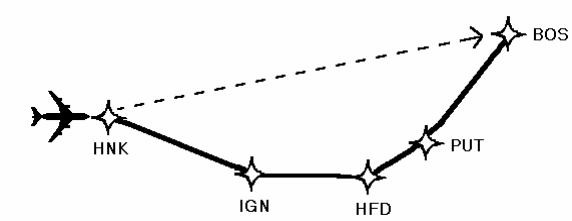


FMC FLIGHT PLAN MODIFICATION

Overview: During the course of a flight it often become necessary to adjust a flight plan in the FMC in order to keep it consistent with ATC clearances, shortened routings or route deviations. Using the appropriate FMC function entry to modify a flight plan greatly reduces crew workload when route of flight changes are necessary.

Direct-To: Direct-To flight plan entries instruct the FMC to fly a course direct to a particular fix. The fix may be part of the active flight plan, active modified flight path, or it may be off the intended path of flight.

Direct-To routings are useful for shortening the route of flight when ATC clearance is obtained to eliminate certain navigation fixes in a stored flight plan, as shown below:



A Direct-To routing is performed by displaying the ACT RTE LEGS page or the MOD RTE LEGS page, then entering the desired fix into the scratchpad. This can be done by manual entry, or be down-selecting the fix from the displayed flight plan.

After the desired fix has been entered into the scratchpad, it should be up-selected to 1L by pressing the LSK. This will create a MOD (modification) to the flight plan which will be visible in the FMC and on the navigation display. The flight plan will have been modified to eliminate the waypoints which are being bypassed in the Direct-To operation. If the Direct-To fix is the last fix in the active flight plan, a ROUTE DISCONTINUITY warning will be displayed by the FMC. This warning can be extinguished by selecting the appropriate approach fixes from the DEP/APP display, or by manually entering additional navigation fixes.

Pressing the EXEC key will confirm the change, or pressing <ERASE will cancel the Direct-To selection. Once the <EXEC key has been pressed, the FMS will be updated to fly Direct-To the desired fix.

Intercept Course: An intercept course is similar to the Direct-To operation. An intercept course instructs the FMC to intercept a particular course before flying that course directly to a station.

Intercept Course entries are useful for complying with SID and STAR transitions, or for complying with an ATC instruction such as, "fly heading 150 until intercepting the 290 degree radial to HFD, then fly direct HFD."

Any time ATC or published route procedures call for the crew to intercept a specific course or heading to/from a navigation fix, the Intercept Course entry can solve the navigation problem simply via the FMC.

An Intercept Course entry is performed by first displaying the ACT RTE LEGS or MOD RTE LEGS page, then entering the desired navigation fix into the scratchpad, or selecting it to the 1L position as a DIRECT.

Once the desired station has been entered into the scratchpad, it should be up-selected to 1L in the ATC RTE LEGS page.

This will change the RTE LEGS display to allow for an intercept course entry to be entered into 6R, as shown above.

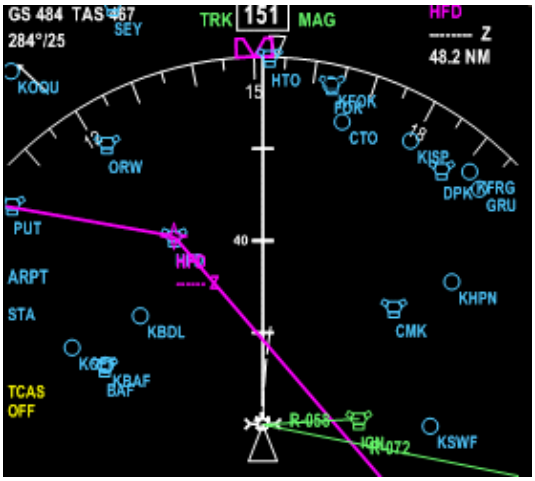
6R LSK will show the current aircraft ground track when it first appears. This line is used to enter the desired track TO the assigned fix.

In the current example, our flight has been instructed to fly a heading of 150 until intercepting the 290 radial. As such, we enter the inbound course of 110 degrees (290-180 = 110 on the inbound course!)

This will instruct the FMS to intercept the desired 290 radial TO the fix. The FMS will compute a great circle course between the current airplane location and the closest point of intercept to the desired course. The airplane will fly this computed course unless the crew overrides the computation be manually entering a heading.

In order to fly the 150 assigned heading to the intercept, set the HDG but to 150 and press the knob to trigger HDG SEL mode. Then re-arm LNAV.

Upon crossing the course, LNAV will turn and fly the course TO the fix as programmed.



Pressing the EXEC key will confirm the change, or pressing <ERASE will cancel the Intercept Course selection. Once the <EXEC key has been pressed, the FMS and flight plan will be updated.

If the crew wishes to fly a particular heading or ATC assigned course until intercept, this can be accomplished by selecting that heading in the MCP heading selector window and pressing the HDG knob.

If LNAV is armed, LNAV will engage and begin tracking the inbound course when the

aircraft approaches the intercept course entered into 6R.

Inserting A Navigation Fix: During flight it may become necessary to insert a new navigation fix into the flight plan in order to comply with ATC procedures or instructions.

This is accomplished by first displaying the RTE LEGS page for the active route (press the LEGS key on the FMC/CDU keypad.) The fix identifier can then be typed directly into the RTE LEGS page scratchpad, and up-selected to the desired line of the flight plan.

When up-selecting a navigation fix to an existing flight plan, the FMC will add the new fix to the line selected, and move all following navigation fixes down in the sequence. When inserting fixes into a flight plan, the FMC will display a set of prompt boxes in the line immediately following the new fix, along with the message ROUTE DISCONTINUITY. This alerts the crew that they must confirm for the FMC which navigation fix will follow the newly added fix.

In order to continue navigating normally, the route discontinuity must be removed by telling the FMC which fix is to follow the newly added fix.

To collapse flight plan and remove the discontinuity, down-select the desired fix to the scratch pad, then up-select it to the line with the prompt boxes for the route discontinuity.

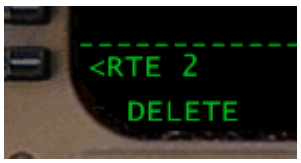
To confirm the continuation of the route, the waypoint identifier for the next fix in the desired route sequence should be down-selected to the scratchpad by pressing the associated LSK. This fix identifier can then be up-selected to the line containing the prompt boxes. The FMC will then re-sort the flight plan to allow the updated routing.

Pressing the EXEC key will confirm the change or pressing <ERASE will cancel the Intercept Course selection. Once the <EXEC key has been pressed, the FMS and flight plan will be updated.

Deleting a Navigation Fix: Navigation fixes can be deleted from the active flight plan using similar methods.

From the RTE LEGS page, use the NEXT PAGE/PREV PAGE keys until the desired fix is displayed on the page, then press the DEL key on the FMC/CDU keypad.

The DELETE prompt will appear in the scratchpad, indicating that the next LSK pressed will cause deletion of that associated flight plan navigation fix.



The desired fix can then be deleted by pressing the associated LSK. This will cause the FMC produce a modification to the active route which eliminates that fix from the flight plan.

When deleting fixes from a flight plan, the FMC will display a set of prompt boxes in the line immediately following the deleted fix, along with the message ROUTE DISCONTINUITY. This alerts the crew that they must confirm the route continuity at the point of the deleted navigation fix.

To confirm the continuation of the route, the waypoint identifier for the next fix in the desired route sequence should be down-selected to the scratchpad by pressing the associated LSK.

This fix identifier can then be up-selected to the line containing the prompt boxes. The FMC will then re-sort the flight plan to allow the updated routing.

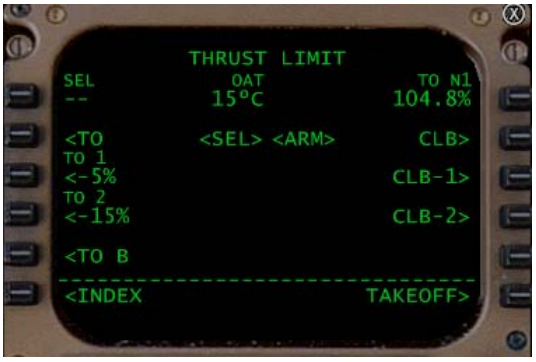
FMC TAKEOFF PROCEDURES

Overview: The FMC provides a number of functions to assist with the takeoff planning process. Specifically, the FMC is capable of taking input from the crew for calculating takeoff speeds, engine thrust limits, engine takeoff thrust derates and autothrottle management.

These features are used as part of the normal pre-takeoff process, and are described below.

THRUST LIM Page: The thrust limit page provides the crew with the ability to manually select the thrust modes which will be used by the FMS to provide thrust limits and thrust commands to the autothrottle servos.

The THRUST LIM page is displayed by pressing the THRUST LIM prompt when the INIT/REF INDEX page is displayed, or by pressing the 6R THRUST LIM> prompt from the PERF INIT page during pre-flight. A sample THRUST LIM page is shown below:



The THRUST LIM page displays three takeoff thrust limit options at lines 2L through 4L. Lines 2R through 4R display climb thrust limit options.

The top of the THRUST LIM display provides an entry point for a pilot-entered assumed temperature at 1L, a current outside air temperature reading in the center of line 1, and a Thrust Limit Mode indicator in line 1R.

Pilot Entered Assumed Air Temperature: The 1L key provides the crew with the ability to enter an assumed air temperature (SEL). Valid entries are one or two digit entries from 0 to 99. This field cannot be changed once the aircraft exceeds sixty five knots, or after autothrottle engagement. The field will be removed once the aircraft becomes airborne.

How is this used?: If planning a takeoff during a period of time when the temperature is changing rapidly, or if the airplane is currently parked in an area where the ambient temperature is expected to be different than the temperature encountered on the runway, it is prudent to enter the temperature that it is expected the takeoff will be conducted in.

For example, if the airplane is parked in the shade of a large hangar, but the runway is in direct sunlight on a hot day, it can be expected that there will be a performance impacting temperature difference between the current OAT (shown on the screen) and the assumed temperature.

Outside Air Temperature: The Air Data Computer measured OAT is displayed in the center of row 1.

Thrust Limit Mode: The currently selected thrust limit mode is displayed in small font in the header line for 1R. In addition, the N1% limit for this thrust mode is displayed in large font at 1R. If the thrust limit mode has been reduced by the assumed temperature entry, the thrust limit mode entry will be preceded by the "D-" derate indicator.

Following are the available thrust limit modes:

TO	Takeoff
TO 1	Takeoff 1
TO 2	Takeoff 2
GA	Go-Around
CON	Continuous
CRZ	Cruise
CLB	Climb
CLB 1	Climb 1
CLB 2	Climb 2

Takeoff thrust and Takeoff thrust Derates: Lines 2L through 4L show the available takeoff thrust limit modes which may be selected by the crew. In order, they are:

- TO: Takeoff is the normal takeoff thrust mode.
- TO 1: Takeoff 1 is the 5% derated takeoff thrust limit mode.
- TO 2: Takeoff 2 is the 15% derated takeoff thrust limit mode.

The takeoff thrust limit mode is selected by pressing the associated LSK. When a mode is selected, the <SEL> indicator will move to the associated line to indicate which mode is currently selected. In addition, the takeoff thrust limit mode will be displayed in 1R. Selecting either TO 1 or TO 2 will override any assumed air temperature figure entered into 1L by the crew.

Climb Thrust and Climb Thrust Derates: Lines 2R through 4R show the available climb thrust limit modes which may be selected by the crew. In order, they are:

- CLB: Climb is the normal climb thrust mode.
- CLB 1: Climb 1 the 10% derated climb thrust limit mode.
- CLB 2: Climb 2 is the 20% derated climb thrust limit mode.

The desired climb thrust limit mode is armed by pressing the associated LSK. When a mode is selected, the <ARM> indicator will move to the associated line to indicate which mode is currently armed.

If a derated takeoff thrust limit was selected, the FMC will automatically suggest an optimal climb thrust derate given current temperature or assumed temperature entries. This mode can be changed by simply selecting a different climb thrust mode.

In Flight Thrust Modes: When airborne, the THRUST LIM page will not display takeoff or climb thrust modes. These modes will be replaced by the in-flight thrust limit modes. These modes will be displayed in lines 1L through 3L of the THRUST LIM page, and are as follows:

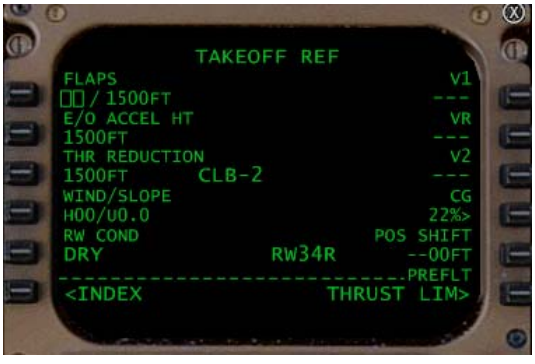
- GO AROUND: Go around thrust limit.
- CONTINUOUS: Continuous maximum allowable thrust limit.
- CRUISE: Cruise limit thrust .

Go around thrust is a limit mode provided for go around conditions, where high engine thrust settings are required for a short period of time.

Continuous thrust limit mode provides the highest thrust output possible from the engines in continuous operation. This mode is useful in situations involving a single engine failure while the aircraft is at high gross weights, or multiple engine failures at high cruise altitudes. This thrust limit mode will provide the highest thrust output possible without damaging the remaining engines.

Cruise thrust limit mode is the normal operating thrust limit mode for normal cruise flight operations.

TAKEOFF REF Page: The TAKEOFF REF page provides information pertaining to takeoff performance and settings. This information includes such settings as flap acceleration height, engine out acceleration height, thrust reduction height, runway slope and wind condition information, runway condition, takeoff speeds, trim and runway position shift information.



Flap Setting/Flap Acceleration Height: The planned flap setting (flaps 10 or flaps 20)

can be entered at line 1L, along with the desired flap acceleration height. If an invalid takeoff flap setting is entered manually at 1L, an error message will be generated. The takeoff flap setting must be correct in order for the FMC to generate the correct takeoff speeds.

The flap acceleration height is entered in feet, and indicates the altitude above field elevation at which the crew desires to begin acceleration to climb speeds. This information will be used by VNAV to decrease pitch and begin the acceleration process. Valid entries range from 400 to 9999 feet.

This height should take into consideration factors such as terrain elevation surrounding the departure airport, noise abatement requirements and the desire to have at least 1500 feet of altitude above airport elevation before reducing the initial climb rate in order to accelerate for flap retraction.

Engine Out Acceleration Height: The crew may manually select an engine-out acceleration height by entering the value into line 2L. This is the height at which the flight director and VNAV will begin to decrease pitch for acceleration and flap retraction in the event of an engine failure during takeoff. Valid entries range from 400 to 9999 feet.

This height should take into consideration factors such as terrain elevation surrounding the departure airport, as well as the ability of the airplane to climb effectively on 3 engines given the departure weight of the aircraft and the navigation procedure required to be flown after departure. This altitude will normally be slightly lower than the standard Flap Retraction/Acceleration height.

Thrust Reduction: The thrust reduction altitude described in 3L describes the altitude or flap setting at which thrust is reduced from the takeoff setting to the climb setting. This will occur automatically if VNAV and the autothrottle are engaged. The armed thrust mode, as selected in the THRUST LIM page, is displayed at the center of line 3. This indicates which thrust mode the FMC will use when it begins to reduce power from the initial takeoff setting.

Valid entries for thrust reduction can be any altitude between 400 and 9999 (feet above field elevation) or any flap position entry such as 1, 5. An entry of 5 will arm the thrust reduction to commence when the flaps are retracted past 5 degrees in flight.

Wind/Slope: Line 4L provides runway wind/slope information to enhance takeoff performance computations on sloped runways, or runways with a headwind/tailwind component. A headwind is described by the 'H' indicator, followed by the headwind component. A tailwind is denoted by the use of a 'T' indicator.

The FMC will use this information to adjust the calculated takeoff performance.

Runway upsweep and downslide is indicated by a U or a D respectively.

Runway Condition: Line 5L allows for pilot entry of the takeoff runway condition. This information is used by the FMC during the takeoff speed calculation process. Valid entries are DRY for dry and uncluttered runways, and WET for wet or cluttered runways.

Takeoff Speeds: V1, VR and V2 reference speeds are displayed in lines 1R through 3R. The speeds are initially displayed in small font, to indicate that they have been computed by the FMC based on pilot entered performance initialization.

The crew is responsible for validating the accuracy of these computed takeoff speeds by manually checking them against the manufacturer specified takeoff speeds.

Takeoff speed should be confirmed to the FMC by pressing each of the three LSKs individually after the speeds have been verified. Once confirmed, the speeds will be displayed in LARGE font.

Takeoff speeds can be overridden or manually entered by the flight crew if desired. Valid entries are any three digit number from 100 to 300.

If any changes are made to the takeoff performance initialization after the V1, Vr, V2 speeds have been selected, the FMC will automatically remove them and display a V SPEEDS DELETED warning. This is an indication to the crew that it is necessary to return to the TAKEOFF REF page and revalidate the takeoff performance.

Stabilizer Trim / Center of Gravity: The center of gravity and stabilizer trim settings are displayed on 4R. The CG value will be removed once the airplane is airborne.

Position Shift on Runway: Line 5R allows for pilot entry of an updated position along the planned departure runway. This procedure is used to update the FMS that the aircraft is not entering the takeoff roll from the threshold of the planned runway, and instead may be using an intersection departure. The position update function allows the pilot to enter a value representative of 'distance from actual runway threshold' to alert the FMS at the time the TO/GA switch is pressed.

This feature is not currently modeled in the PMDG 747-400.

FMC CLIMB OPERATIONS

Overview: The FMC provides a number of methods to assist the crew in planning, managing, and effecting a precise and economical climb regime of flight. The FMC accepts climb performance demands from crew member entries, and adjust aircraft performance via the FMS and autothrottle servos.

CLB Page: The climb page allows crew access to current and upcoming climb conditions and climb profile information. The active climb speed mode is always displayed in the CLB page.

The CLB page is accessed through the VNAV key on the FMC/MCDU keypad. A typical CLB page is shown below:

CRZ ALT: The cruise altitude is displayed at 1L with the header of CRZ ALT. The current cruise altitude is displayed if one has been selected and CLB is the active mode. If the current altitude is not displayed, 1L will contain prompt boxes which can be replaced by up-selecting the desired cruise altitude from the scratchpad.

Speed Mode: The currently selected cruise speed mode is displayed in small font at 2L, along with the selected Mach number and calibrated airspeed.

Modes displayed at 2L include:

- ECON SPD: Economy speed mode.
- SEL SPD: Manually selected speed mode.
- MCP SPD: MCP speed mode.
- LIM SPD CLB: Limit speed climb
- E/O SPD: Engine Out speed mode.

ECON CLB is the default climb mode, and will provide the best economy in the climb given the current aircraft configuration and cost index. The ECON CLB mode can be selected by pressing the <ECON prompt when the speed mode is not active.

SEL SPD mode is initiated whenever a speed restriction is being observed.

MCP SPD CLB is initiated by setting a speed in the MCP window and pressing the MCP speed knob.

LIM SPD CLB is active when the desired speed is greater than the maximum aircraft speed, or less than the minimum speed allowed for the current aircraft configuration. This mode is displayed when the FMS is preventing overspeed or stall buffet speeds from being flown.

E/O CLB is active when the ENG OUT> LSK has been pressed following an engine failure in the climb. E/O CLB will provide the best climb gradient speed given the current aircraft configuration.

Speed Transition: The speed transition is displayed in line 3L. The transition speed/altitude defaults to 250/10000, but will change to reflect a higher performance limit speed of the aircraft if aircraft speed performance is a factor due to high gross weights.

Speed Restriction: The SPD RESTR fields at 4L allow for manual crew entry of a speed/altitude restriction. Valid entries in this line follow the format:

SSS/AAAAA

Where SSS is the CAS speed restriction, and AAAAA is the valid altitude for the restriction.

Next Climb Constraint: Line 1R displays the next climb constraint called for by the FMC programmed flight plan. The header line for 1R shows 'AT' and the name of the next navigation fix. This line will be blank if no climb constraint exists at the listed navigation fix.

Climb constraints will be displayed in the SSS/AAAAA format, with the above or below modifier attached to the altitude.

Direct entry of a speed/climb constraint cannot be entered directly from this page, and must be entered in the RTE LEGS page.

Transition Altitude: Line 3R displays the transition altitude. This value defaults to 5000 feet MSL, but can be changed by up-selecting a new value from the scratchpad.

Maximum Climb Angle/Maximum Altitude: The speed which will yield the maximum climb angle given the current aircraft configuration is displayed in line 4L.

In the event of an engine failure, the MAX ANGLE speed will be replaced with the engine out maximum altitude figure for the current aircraft configuration.

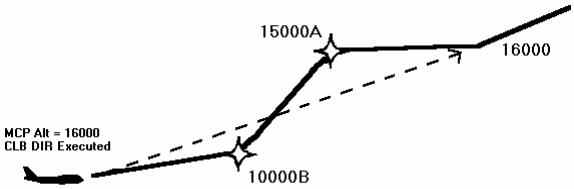
Engine Out Climb Mode: Selecting the ENG OUT> prompt at 5R will result in FMC calculation of engine-out speed schedules, performance predictions and guidance. When selected, the FMC will detect which engines are not operating, and adjust performance predictions and guidance accordingly. If the FMC detects that all engines are operating, then performance predictions for a single outboard engine failure will be used.

All Engine Climb Mode: If the ENG OUT> prompt was selected, it will be replaced with the ALL ENG> prompt. Selection of this prompt will return FMC calculations to an all engines operating mode.

Climb Direct: In cases where the altitude selected in the MCP altitude window exceeds an altitude restriction defined on the RTE LEGS page, the CLB DIR> prompt will be displayed at 6R. This prompt allows the crew to delete all climb restraints below the MCP selected altitude.

This feature can be used when the route of flight has programmed altitude climb constraints which are cancelled by an ATC command to "climb and maintain" a higher altitude.

When CLB DIR is selected, the EXEC light will illuminate to indicate that the action must be confirmed by the crew. When the EXEC key is pressed, the FMC will initiate a climb directly to the MCP entered altitude, and will cancel all altitude constraints between the airplane and the MCP selected altitude.



FMC Climb Profile Logic: The FMC is programmed for a default climb logic which will select a 250 knots or minimum clean airspeed for a climb to 10,000 feet, followed by an economy climb to cruise altitude. The crew may modify this climb profile via the RTE LEGS page.

In the event that the FMC cannot comply with the next altitude restriction programmed into the RTE LEGS page, (either due to rate of climb or speed related concerns) the prompt UNABLE NEXT ALT will be displayed.

FMC Climb / MCP Altitude Selector Interaction: The process which the FMC uses to process input from both the FMC programmed flight plan and the MCP Altitude Selector is called "Altitude Intervention." This process allows for deletion of altitude constraints using the MCP knob, as well as level off/resume climb operations.

Constraint Deletion: If the airplane is climbing, the pilot may select an altitude in the MCP altitude window that is between the current aircraft altitude and the programmed cruise altitude. Doing so will delete the next altitude constraint between the aircraft altitude and the MCP selected altitude. Subsequently pressing the MCP altitude knob will delete, one at a time, any additional altitude restrictions between the aircraft and the MCP selected altitude.

Level Off/Resume Climb: If the MCP altitude knob is set to an altitude that is lower than the programmed cruise altitude, the aircraft will level off at the MCP selected altitude. To resume the climb, a higher altitude should be dialed into the MCP altitude window and the MCP altitude knob should be pressed.

Cruise Altitude Changes: Cruise altitude changes can also be effected via the MCP altitude knob. Selecting a higher cruise altitude in the MCP altitude window and pressing the MCP altitude knob will automatically update the cruise altitude to the MCP altitude window selected altitude.

FMC CRUISE OPERATIONS

Overview: Use of the FMC for cruise flight greatly reduces en-route pilot workload, and simplifies the process of providing the greatest level of operating economy possible with the aircraft. The Cruise capabilities of the FMC include fuel management, engine out operations, VNAV cruise modes and altitude step climb operations.

CRZ Page: The CRZ page provides the crew with access to current and upcoming cruise profile information. Information displayed in the CRZ page includes the current commanded cruise altitude, cruise speed, N1% target settings, step climb size, next step to fix, next waypoint ETA and fuel, optimum and maximum cruise altitude and engine out cruise setting information.

A sample CRZ page is shown below:

Speed Mode: The active speed mode is displayed in the title line of the CRZ page display. The prefix ACT indicates that the cruise performance mode is active.

Cruise performance modes which may be displayed are as follows:

ECON: The economy cruise performance mode is the default cruise performance mode, and will yield the lowest aircraft operating cost based on the cost index selected. ECON cruise is only available when all engines are operating.

MCP: MCP selected speed cruise performance mode allows the pilot to select the cruise speed based on the MCP speed window setting. This mode is initiated by selecting a desired speed in the MCP speed window and pressing the MCP speed knob.

LIM SPD: The limit speed cruise performance mode is activated when the target speed exceeds either the upper or lower limits of the aircraft speed performance limitations envelope. Examples include overspeed or buffet margins. The LIM SPD indicator will be visible in any cruise operation where the FMC is providing speed envelope protection.

E/O: The Engine Out cruise performance mode provides the best cruise altitude performance in either the single engine out or double engine out operation. This mode is selected by pressing the ENG OUT> prompt after an engine failure in flight.

LRC: Long range cruise mode can be selected for long flights where speed is traded in order to maintain fuel efficiency for long range flight. To activate LRC, press the LRC prompt at 6L, then EXEC the change when the EXEC key illuminates.

Each of the cruise performance modes listed above will also use a VNAV cruise function in order to provide for vertical guidance. The current VNAV cruise mode is also displayed in the title line of the CRZ page, and the modes are as follows:

CRZ: Cruise operation is indicated when the airplane is in level flight with all engines operative.

CRZ CLB: Cruise climb is indicated when the airplane is climbing to a specified target altitude as defined by a step climb or MCP selected target altitude change.

CRZ DES: Cruise descent is indicated when the airplane is descending to a specified target altitude as defined by the FMC entered flight plan, or by a MCP selected target altitude change.

D/D: Drift down is indicated when the FMC begins a drift down procedure due to engine failure at high altitude. The D/D mode will remain as the active VNAV cruise mode until the maximum engine out altitude has been reached and the aircraft has leveled out.

Cruise Altitude: Line 1L of the CRZ page shows the current selected cruise altitude. This information will always be displayed unless a descent mode is activated. Prompt boxes in the CRZ ALT line indicate that crew entry of cruise altitude is required.

Cruise Speed: As long as an active cruise altitude is selected and the aircraft is not descending, line 2L of the CRZ page will display the current cruise mode in small font. The current target cruise speed will be in displayed in both CAS and Mach format using large font.

N1% Target: The N1% target is displayed in line 3L. This figure is calculated by the FMC as the target N1% setting based on current aircraft altitude, speed and gross weight.

Step Size: Line 4L displays the currently selected step size. The value of the step will reflect either a crew entered value or ICAO, for a default 2000 foot ICAO defined step size. This value can be changed directly be up-selecting a new, four digit integer that is a multiple of 1000.

If step climbs are not desired, a value of 0 should be entered into this field.

Step To Next Altitude: The next anticipated step fix is displayed in line 1R of the CRZ page. This information allows the crew to plan for upcoming step climb procedures. If the step climb was derived by the FMC based on the step size schedule, the altitude will be displayed in small font. If the step climb was pilot entered, it will appear in large font.

The Step To field cannot be manually updated until after the aircraft has passed the last planned step climb waypoint, or when an altitude is displayed on this line in small font.

Entries to this field are made in a standard altitude format into the scratchpad and up-selected to the appropriate line.

Step Climb Condition Indicator: Line 2L provides the crew with information related to upcoming step climb status. One of the following will be displayed in 2L:

NOW: Indicates that the aircraft has crossed the specified fix and a step climb to the next step altitude can be commenced.

AT: Indicates that a step climb to the step altitude entered in line 1R can take place at the specified location/fix.

AVAIL AT: Indicates that a step climb to the step altitude entered in line 1R cannot take place at the specified location/fix. This is most likely due to MAX ALT restrictions. The displayed DTG/ETA figures indicate when the planned step climb may be initiated.

TO T/D: Indicates that the aircraft is within 200 miles of the top-of-descent point. The displayed DTG/ETA is to the top-of-descent point.

TO AAAAA: Indicates that the airplane is more than 200 miles from the top-of-descent point, but that an engine out drift down procedure is in progress. AAAAA represents the new cruise altitude as calculated by the FMC.

NONE: Indicates that the FMC has determined that no step climb is necessary, or that no step climb should be made.

Next Waypoint ETA/Fuel: Line 3R displays the current ETA for crossing the next waypoint in the flight plan. This line also displays the expected fuel–on-board figure at the time of waypoint crossing. Fuel computations are made under the assumption that all intermediate step climbs will be performed as normal.

Optimum/Maximum Altitude: Line 4R displays the FMC computed optimum cruise altitude and maximum cruise altitude.

Optimum cruise is calculated based on current aircraft configuration, cost index, trip length and cruise mode.

Maximum cruise altitude is calculated based upon the highest usable altitude given the current aircraft configuration, thrust limits, cruise mode, buffet limits and maximum operating speed.

These figure will be automatically adjusted by the FMC in the event of an engine failure during the cruise portion of the flight.

Engine Out Cruise Operation: In the event of an engine failure in flight, selecting the ENG OUT> prompt at 5R will instruct the FMC to provide engine-out speed schedules, performance predictions and flight guidance.

In the event that the aircraft is above the maximum engine out altitude at the time of the engine failure, the cruise altitude will automatically be lowered to the engine out maximum altitude.

Step Climb Operations: The FMC provides computed step points and advisory step points for the crew. A step is executed by dialing the step altitude into the MCP altitude window and pressing the altitude knob. The FMC will then enter a cruise climb to the step altitude. No steps can be executed without pilot interaction.

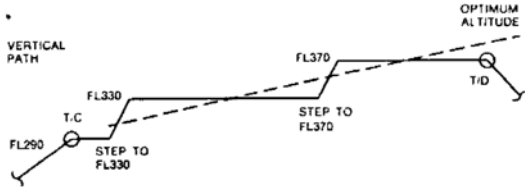
All performance predictions are based on the crew executing all planned and/or optimum step altitudes. If a step point is crossed and the step is not initiated, the performance predictions will assume that the crew will immediately initiate the step climb.

If the planned steps will not be made, a '0' should be entered into the 4L LSK (STEP SIZE) to provide accurate predictions for fuel remaining, top of descent, ETAs, etc.

The FMC computes altitude step points based on the entered step size which results in minimum trip cost for the economy cruise mode or minimum trip fuel consumption for the Long Range Cruise and selected speed cruise modes. The "step to" altitude will be the next ICAO standard altitude or step interval (2,000' for RVSM) but cannot exceed the maximum altitude at the step point.

There are some common misconceptions about how the FMC calculates step altitudes to use during the flight. When determining appropriate step climbs, the FMC calculates step to altitudes that are always greater than the optimum altitude.

This happens as a result of the optimization routines used to determine an operating altitude plateau that will provide an overall average optimum performance for the airplane during the course of the flight.



For example if your initial cruise altitude is FL260 and your step size is 2000 feet, the next step altitude is unlikely to be FL280. Instead, you will see FL3xx depending on aircraft weight and atmospheric temperatures. (There is only one very rare exception to this.)

In essence, while the FMC is automatically calculating step climbs it will construct a "ladder" using the cruise altitude you have entered for the flight plan and the STEP SIZE entered into the PERF or VNAV CRZ pages. (To stop auto-calculation of step climbs, enter a zero for step climb size.)

Example: If the initial cruise altitude is FL310 and STEP SIZE of 2,000 feet (ICAO climbs of 4,000 feet are almost never performed any longer!) the "ladder" will comprise flight levels FL310 (base), FL330, .., 450.

Once this ladder is constructed the FMC will mathematically work forward along the flight plan by first determining the optimum altitude at Top-Of-Climb, then the FMC will select as a first step candidate the first available step-to altitude that is above this optimum altitude.

This process will be repeated until sufficient steps are used to reach FL450 and so on or until the next step climb would be within 200 miles of the Top-of-Descent. This method will generally place the airplane slightly above optimum altitude at the conclusion of any step climb and as the airplane continues along the route of flight the computed optimum altitude based upon aircraft weight and performance factors will climb toward and eventually through the current aircraft altitude. Thus in theory, the airplane will spend half of it's time slightly above the optimum altitude and half of it's time slightly below optimum altitude, resulting in an average performance that closely approximates the continually sloping optimum altitude plane.

Obviously, having all engines running with optimal performance and having correctly input weight parameters to the FMC are the key parameters to effective step climb predictions.

Although step climb capability and step climb points are calculated by the FMC, the responsibility for actually performing the step climb rests with the crew.

Step climbs are executed by changing the MCP altitude window to reflect the desired new cruise altitude. Pressing the MCP altitude knob will cause the FMC to enter a cruise climb.

No step climbs can be executed without pilot interaction.

The FMC makes fuel and flight performance calculation based on the assumption that all step climbs will be made. If flight conditions preclude making the appropriate step climbs, the step climb indicator should be reset to 0 or fuel and time predictions will deviate from actual conditions.

There are two methods that can be used for computing and effecting step climbs.

Optimum Step Climb: The optimum step climb looks to gain the greatest benefit from airplane performance improvement as fuel weight is burned off. Because drift climbs are not practical in the controlled airspace environment, the FMC will attempt to average out aircraft performance by providing step climbs which will most closely approximate a drift climb.

The FMC will calculate the step points needed based on factors such as cruise performance mode and current aircraft weight, and will compute climbs based on ICAO step size or the step interval entered into the FMC.

The step climb will be calculated to the next step altitude, but cannot exceed the maximum altitude upon reaching that step point. No step climbs will be initiated within 200 miles of the top-of-descent.

Planned Step Climb: Planned step points are specified by the crew using crew entered modifications in the RTE LEGS page of the FMC. A planned step entry is made on the RTE LEGS page by entering the step altitude at a specific waypoint followed by 'S' to indicate a step point. The FMC will follow planned steps in the flight plan until no further planned steps are encountered. If the FMC determines that further step climbs can be made, they will be computed under the optimum step climb calculation described earlier.

Cruise Altitude Modification: The selected cruise altitude can be modified either by direct entry into the CRZ page, or by selecting a new altitude using the MCP altitude knob. (Pressing the knob will command the altitude change.)

If the MCP altitude is set to an altitude that is higher than the current cruise altitude, the cruise altitude will be updated to the new altitude. If the MCP altitude is set to an altitude that is lower than the current cruise altitude and the aircraft is more than 50 miles from the top-of-descent, the cruise altitude will be updated to the new altitude and a descent commenced.

If the MCP altitude is set to an altitude that is lower than the current cruise altitude and the aircraft is within 50 miles of the top-of-descent, an early descent will be initiated at a rate of 1250 fpm until the normal descent path is intercepted.

FMC DESCENT OPERATIONS

Overview: The FMC descent capabilities provide for descent planning and execution. A planned descent can only exist when a lateral route containing at least one descent constraint is active in the RTE LEGS page.

The descent planning features of the FMC allow the crew to set speed transitions, descent path restrictions, and waypoint dependent speed and altitude constraints.

CRZ Page: The CRZ page displayed when pressing the VNAV key on the FMC contains a single item to help crews maintain awareness of the beginning of descent phase. On line 3, the FMC will display a TO T/D to count down distance to the Top of Descent point for the flight.

DES Page: The descent page provides the crew with access to descent planning and information. The DES page is selected by pressing the VNAV key on the FMC/MCDU keypad. The NEXT PAGE/PREV PAGE keys may need to be used if the aircraft is still at cruise altitude. A sample DES page is displayed below:

The following information is provided on the DES page:

E/D AT: The End of Descent At information displayed in 1L describes the altitude and waypoint at which the descent is planned to end.

ECON SPD: Line 2L contains the descent speed mode information. The current descent speed mode is displayed in small font in the 2L header line. The descent speed is displayed in large font, in the CAS/Mach format.

Descent speed modes available are:

ECON DES: The economy descent mode will yield the lowest aircraft operating cost based on the entered cost index. The ECON DES mode will attempt to provide an idle thrust descent unless wind conditions encountered during the descent require thrust.

MCP SPD DES: The MCP selected speed descent mode is a pilot selected descent speed mode. To initiate this mode, the pilot pushes the MCP speed select knob. The speed of the descent can then be adjusted by selecting the desired speed in the MCP speed selector window.

LIM SPD DES: The limit speed descent mode becomes active in cases where the target descent speed exceeds the capabilities of the airframe in either the overspeed regime, or the stall buffet margin. The limit speed is flown by the vertical guidance function.

END OF DES: The prompt END OF DES is displayed in the descent speed mode line when the aircraft has passed the programmed end of descent constraint waypoint.

SPD TRANS: Line 3L displays the speed transition altitude. The line contains the transition speed, followed by the transition altitude in a SSS/AAAAA format. This field

may not be updated manually, but it may be deleted by pressing the FMC/MCDU DELETE key, then pressing 3L.

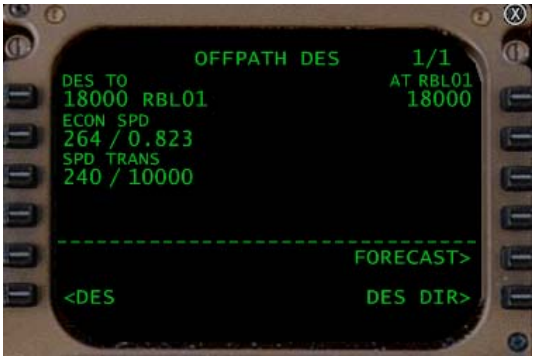
SPD RESTR: Line 4L provides the crew with the ability to enter an altitude dependent speed restriction. The line contains transition speed, followed by the transition altitude in a SSS/AAAAA format. The altitude entry must be an altitude below the cruise altitude, but above the End of Descent altitude.

AT: Line 1R contains the descent constraint waypoint as defined in the RTE LEGS page of the flight plan. The header line contains 'AT' followed by the navigation fix identifier to which the descent constraint is assigned. The constraint is displayed in the DES page exactly as it appears in the RTE LEGS page. The descent constraint cannot be updated or changed from the DES page, but it may be deleted. Deleting the constraint will remove it from the lateral route.

DES NOW: When the aircraft is not currently descending, but the MCP altitude selector is set below the current altitude, the DES NOW prompt will be displayed at 6R. The DES NOW> prompt deletes all climb/cruise constraints and commences an early descent. The rate of descent will be approximately 1250 feet per minute until the aircraft intercepts the originally planned vertical descent path which would have commenced at the top-of-descent mark.

DES DIR: When the aircraft is descending and the MCP altitude selector is set below the current aircraft altitude, the DES DIR> prompt will be displayed. Pressing the associated LSK will delete all altitude constraints between the aircraft and the MCP selected altitude and the FMC will command a descent to reach the MCP altitude. Upon reaching the MCP selected altitude, the vertical guidance function of the FMC will capture the originally computed vertical path for the remainder of the descent. Unless deleted or modified, all remaining descent constraints will be adhered to.

OFFPATH DES: The offpath descent page provides access to "Clean" and speed brake direct descent profiles if the crew does not wish to use the FMC calculated descent path. This page can be access through the <OFFPATH DES prompt in 6L of the DES page or DESCENT FORCASTS page.



DESCENT FORECASTS Page: The DESCENT FORCASTS page allows the crew to enter and use forecast values for wind, transition level, anti-ice settings and descent wind direction information. A sample DESCENT FORECASTS page is shown below:

The following information is provided on the DESCENT FORECASTS page:

TRANS LVL: The transition level for the destination airport is displayed in 1L. The transition level can be modified by up-selecting from the scratchpad.

ALT and WIND DIR/SPD: Lines 2 through 5 contain pilot entered wind direction and speed information for specific altitudes. Altitude entries can be entered and up-selected in either the FLAAA or AAAAA format. Wind direction and speed information can be entered and up-selected in a DDD/SSS format.

During the initial data entry, wind speeds must be entered in conjunction with wind direction. For subsequent entries, however, partial entries containing only a direction or only a speed update can be made.

Wind altitude speed and direction entries are made by the crew, and assist the FMC in computing the descent profile as defined in the flight plan.

Descent Profile Logic: The default descent profile logic is to effect an economy descent form cruise altitude to the transition altitude. After passing through the transition altitude, 240 knot descent is commanded. The crew may manually override the default descent profile through the use of speed and/or altitude constraints entered into the RTE LEGS page. The descent profile can also be modified using the MCP speed and/or altitude selector knobs. A combination of RTE LEGS entries and MCP selections can be used to adhere to ATC instructions, or to expedite the descent profile as needed.

During the descent, the aircraft will occasionally reach the descent limit speed regime while attempting to maintain the calculated vertical profile. This can occur as a result of headwinds or tailwinds, or wind forecasts not being entered correctly in the DESCENT FORCASTS page. The DRAG REQUIRED prompt is generally a good indication of a tail wind condition or descent overshoot, while the THRUST REQUIRED prompt generally indicates headwinds, or descent undershoot.

In cases of descent undershoot and overshoot, once the aircraft reaches the limit speeds (upper or lower limits) the vertical guidance function of the FMC will command the aircraft to depart the planned vertical profile while maintaining a descent that most closely follows the planned descent profile.

Adding drag or thrust as required will normally return the aircraft to the planned descent path.

FMC Descent / MCP Altitude Selector Interaction: The process which the FMC uses to process input from both the FMC programmed flight plan and the MCP Altitude Selector is called "Altitude Intervention." This process allows for deletion of altitude constraints using the MCP knob, as well as level off/resume descent operations.

Constraint Deletion: If the airplane is descending, the pilot may select an altitude in the MCP altitude window that is between the current aircraft altitude and the programmed end of descent altitude. Doing so will delete the next altitude constraint between the aircraft altitude and the MCP selected altitude. Subsequently pressing the MCP altitude knob will delete, one at a time, any additional altitude restrictions between the aircraft and the MCP selected descent altitude.

Level Off/Resume Descent: If the MCP altitude knob is set to an altitude that is between the current airplane altitude and the end of descent altitude constraint, the aircraft will level off at the MCP selected altitude. To resume the descent, a lower altitude should be dialed into the MCP altitude window and the MCP altitude knob should be pressed.

FMC APPROACH PROCEDURES

Overview: The FMC approach initialization process can assist in the effective transition from the descent to the approach and landing phase of flight. The FMC provides the crew with rapid approach calculations for weight/speed data and provides reference information for the touchdown.

APPROACH REF Page: The approach page provides the crew with information directly related to the final approach to landing process. A sample APPROACH REF page is shown below:

The following information is provided on the APPROACH REF page:

GROSS WT: Line 1L provides the current airplane gross weight in thousands of pounds unless the figure has been manually adjusted by the crew. Manual adjustment of the GROSS WT figure is accomplished by up-selecting a manually entered figure from the scratchpad. Valid entries are three digits with an optional decimal point. Crew entered GROSS WT values are used for predictive purposes only, and do not affect aircraft computation of actual gross weight.

Runway Length: Line 4L contains runway reference information to assist the crew in planning the touchdown and stopping phase of flight. The header line in 4L will display the ICAO airport identifier, followed by the runway number and L/C/R designator.

Runway length reference information is provided in large font in 4L, and is displayed in both feet and meters.

FLAPS/VREF: The Vref reference speeds for both the flaps 25 and flaps 30 settings are provided in lines 1R and 2R respectively. These Vref values are directly reported from the aircraft performance database, and will change as the GROSS WT figure in 1L changes.

FLAPS/SPEED: After reviewing the information contained in the APPROACH REF page, the crew can select the desired landing flap setting by down-selecting from either 1R or 2R, then up-selecting this information to 4R.

Additionally, the crew may manually enter a desired flap setting/Vref speed by entering the information into the scratchpad in the format FF/SSS.

If it becomes necessary to update the flap setting/speed entered into 4R, either the flap setting or the speed value may be updated individually. It is necessary, however, to enter them together initially.

The pilot selected flaps setting/Vref speed selector can be deleted by pressing the FMC/CDU DELETE key, the pressing 4R. This will cause the normal speed tape on the primary flight display to show both the flaps 25 and flaps 30 Vref speeds.

FMC RADIO OPERATIONS

Overview: The radio tuning function is almost entirely managed by the automated logic functions of the FMC. This alleviates the crew from having to manually tune successive radio navigation aids, and allows greater concentration to be placed on terminal navigation procedures, as well as traffic awareness. Understanding what the automated FMC navigation radio function can and cannot do, however, will help the crew to gain the most from the FMC radio tuning system.

NAV RADIO Page: The NAV RADIO page, displayed below, provides an overview of how the navigation radios are currently tuned, as well as the ability to manually tune the radios should the crew desire.

VOR L/R: Lines 1L and 1R provide frequency tuning information for the left and right VHF navigation radios. The currently tuned VOR station frequency is displayed in large font, along with the frequency identifier, if the FMC auto-tuning function was able to identify the VHF transmitter.

Directly between the frequency and station identifier information, a small font tuning indicator allows the crew to determine what type of tuning mode is currently being employed by each VHF radio.

A: Auto-selection. The FMC has automatically selected a navaid which will yield the best position and cross radial navigation update information due to it's position relative to the path of intended flight.

M: Manual selection. The displayed station or frequency was tuned manually be up-selecting the frequency from the scratchpad.

P: Procedure selection. This FMC selected navigation aid was selected because it is required by the active flight plan procedure. (Can be true of SIDs, STARs, Cruise flight or approach.)

R: Route selection. This FMC selected navigation aid was selected because it is the next VOR on the flight plan within 250 nautical miles of the airplane or the intended path of flight.

VOR navigation information can be updated manually in a number of formats.

- Navaid Identifier Name (NNNN)
- VOR/DME Frequency (FFF.FF)
- Frequency/Course (FFF.FF/CCC)
- Navaid Identifier/Course (NNNN/CCC)

A manual entry in the above formats will result in the closest matching navaid being tuned. If entered, the corresponding course information will be entered in 2L/R respectively.

If a manually entered VHR navaid is deleted, the corresponding VHF radio channel will revert to auto-tuning mode.

CRS: Line 2L and 2R each display the current navigation course information related to manual, procedure or route tuned navigation fixes in lines 1L and 1R respectively. This information is not displayed for autotuned navigation aids. Course information can be updated manually by up-selecting a three digit course from the scratchpad.

RADIAL: The current radial being received from the navigation fix tuned in either 1L or 1R is displayed in the center of line 2.

ADF L/R: Line 3L/R displays ADF tuning information. ADF frequencies are displayed in four digit format, and can be manually updated from the scratchpad if desired.

Course information cannot be selected when manually tuning ADF frequencies.

ILS-MLS: Line 4L displays the ILS or MLS station tuned by the FMC. When an ILS or MLS station is tuned, but is not currently active, the PARK indicator will be displayed adjacent to the ILS/MLS frequency identifier. The ILS frequency and front course information will be displayed for both manually and auto-tuned stations. This information will be displayed when the airplane is within 200 miles of the top of descent and the approach procedure is selected and entered in the RTE LEGS flight plan.

If an ILS or MLS frequency is manually tuned, auto-tuning capabilities of the ILS-MLS channel will be inhibited until the manually tuned station is deleted.

PRESELECT: Using the pre-select prompts at 6L and 6R, the crew may manually enter frequency/identifier/course entry combinations that may be required for use later in flight. This prevents the crew from having to continually re-enter manual navaid selection information to the scratchpad during the busy departure and approach process, but ensures that required navaids can quickly be made available should they be needed.

FMC Position Updating Logic: The FMC uses the auto-tuning process to update FMS position data throughout the course of a flight. By auto-tuning navigation fixes which the FMC determines will provide the best cross bearing information, the FMC is able to accurately triangulate the current aircraft position for continual update to the ND and the FMS.

Three different strategies are used by the FMC auto-tuning logic during this process.

DME/DME Tuning: (RHO-RHO) DME/DME updating uses the distance values obtained from two DME transmitters who's positions are known to the FMC. The FMC then performs time/range/intercept calculations on the data received from both DME transmitters in order to triangulate the current aircraft position.

VOR/DME Tuning: (RHO-THETA) VOR/DME updating uses the distance and bearing information from a single VOR/DME transmitter to update the current aircraft position to the FMS and the ND.

FMC FLIGHT REFERENCE AND CREW SUPPORT

Overview: The FMC is capable of providing the crew with information regarding the performance of the aircraft during flight, as well as supporting information which can help the crew to make informed and accurate decisions.

POS REF Page: The position reference page displays the current computed position and ground speed according to the FMC and each individual IRS flight control computer. The page also displays which navaids are currently being used by the FMC auto-tune system to provide position data to the FMC.

Page 2/3 FMC POS: Line 1L displays the current FMC computed aircraft position and the source of it's current position data. In the event the position update capability of the FMC fails or is inhibited, this line will be blanked by the FMC.

Page 3/3 IRS L/C/R: The IRS computed position for each of the three IRS flight control computers is displayed in lines 2L through 4L respectively. If data becomes unreliable from any of the three systems, the associated line will be blanked by the FMC.

RAD UPDATE: Pressing the <PURGE prompt at 5L deletes the current FMC computed position and replaces it with the current IRS computed position data. This may become necessary if it is determined that the FMC computed position has become corrupt or inaccurate. Pressing the <PURGE prompt once will display a <CONFIRM prompt, indicating that the purge sequence is armed and must be confirmed. Leaving the POS REF page before confirming the <PURGE selection will cancel the request.

GS: Lines 1R through 4R display the current computed ground speed according the FMC (1R) and each of the three IRS computers respectively (2R through 4R).

NAV STA: Line 5R displays the navaids which are being used by the FMC for position update and position computation. If the FMC is using VOR/DME or DME/DME stations for position update, the associated fix names will be displayed in 5R, else the display will be blanked.

PROGRESS Pages: The progress display occupies two display pages, and can be called up by pressing the PROG key on the FMC/MCDU.

The first progress display page is shown below. Note that the crew entered flight number, as well as the page reference information is contained in the title line of both pages.

LAST / ALT: Line 1L displays the identifier of the last navigation fix most recently over-flown. This line will be blank if there is no active flight plan programmed, the first leg is still being flown, or after flight completion. The ALT indicator in the center of line 1 shows the airplane altitude at the time of fix crossing.

ATA / FUEL: Line 1R displays the actual time of arrival at the last fix in the flight plan in the center of the display line. The right side of the display line shows the FMC computed fuel remaining figure at the time the fix was crossed.

TO / DTG: Lines 2L through 4L display the active navigation fix identifier (2L) the next fix in the programmed flight plan (3L) and the final destination (4L), as well as the FMC computed distance-to-go before reaching each of this respective locations.

ETA / FUEL: Lines 2R through 4R display the estimated time of arrival at the respective navigation points in each line, as well as the expected fuel-on-board when reaching that fix.

DEST: Line 4L can be used to check DTG, ETA and estimated FUEL on board for an alternate destination or an intermediate waypoint by up-selecting the appropriate destination or navigation identifier to 4L from the scratchpad. Alternate values entered to 4L are for informational purposes only and will not change any part of the active flight plan.

Leaving the displayed PROGRESS page will return 4L to the flight plan destination. This is a powerful tool for determining the expected enroute time and fuel burn for a diversion. If no modification has been made to 4L, DEST is displayed, which indicates that the destination shown matches the destination on the RTE page.

If an alternate airport identifier has been added to 4L, the prompt DIR TO ALTERNATE is displayed to indicate that the figures being displayed represent the FMC computed values for a flight directly from current position to the entered destination.

If a navigation fix contained in the active flight plan is entered into 4L, the prompt EN ROUTE WPT is displayed. This indicates that the fix entered is included in the active flight plan, and that the data displayed is the FMC expected values based upon a flight along the active flight plan.

Command Speed Mode: Line 5L shows the active VNAV command speed mode using small font in the header line. The current CAS/Mach number are displayed in large font. Line 5L will display any of the following modes:

- ECON SPD
- SEL SPD
- E/O SPD
- LIM SPD
- MCP SPD
- VREF+80

Next Constraint: Line 5R displays information related to the next constraint expected based on the RTE LEGS page entered flight plan and aircraft performance. This information is displayed in small font using the header line at 5R. Line 5R also displays in large font the estimated time of arrival at the next constraint, as well as the FMC computed distance-to-go to reach the constraint.

Values appearing in header line of 5R identify the type of constrain which will be encountered, and can be any of the following:

- TO STEP CLB: Step climb
- TO T/C Top of Climb
- TO T/D Top of Descent
- TO E/D End of Descent
- LEVEL AT Level flight attained during a VNAV driftdown.
- NOW The airplane has passed the most recent constraint.
- NONE No constraint active.

The second PROGESS page is reached by using the NEXT PAGE/PREV PAGE keys, and is displayed below:

Wind: Line 1 contains three wind indicators which display dynamically computed wind values from the FMC. H/WIND displays the aggregate headwind component, WIND displays the actual computed wind direction and speed, and X/WIND displays the crosswind component and direction. Crosswind component is denoted with an L or R for left and right, respectively.

Track Error: Line 2 displays both cross track error (XTK ERROR) and vertical track error (VTK ERROR) in nautical miles and feet.

XTK ERROR is displayed in nautical miles with a L and R designator to indicate that the aircraft has drifted left or right of course respectively. Distance values are displayed up to 99.9 nautical miles.

VTK ERROR is displayed in feet, with a + and – sign to indicate deviation above and below planned flight track. Vertical track error is displayed when the aircraft is in the descent phase of flight.

TAS / FUEL USED / SAT: Line 3 displays the current true air speed, the total fuel used by all four engines, and the current static air temperature.

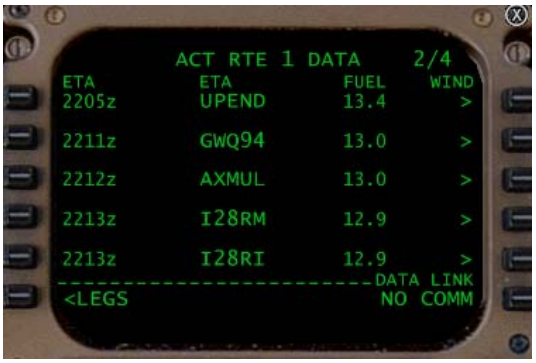
Individual Fuel Usage by Engine: The header line of line 4 displays an engine number for each engine. Immediately below that number, in large font, is the FMC computed fuel quantity used by each engine respectively.

Fuel Quantity Comparison: Line 6 provides a comparison between the fuel quantity measured using the Fuel Quantity Indicating System, (FQIS) and the FMC computed fuel remaining based on usage. Failure of either the FQIS or the fuel flow sensors will cause these values to be blanked in order to prevent erroneous comparison.

If the fuel values detected by the FQIS differ from the values computed by the FMC by more than 9,000 pounds, the FMC message, FUEL DISAGREE – PROG 2/2 will appear to alert the crew that PROGRESS page 2/2 needs to be examined.

When the page is selected after the FUEL DISAGREE message is displayed, two <use prompts located at 5L and 5R will prompt the crew to choose which fuel value should be used by the FMC to track fuel values for the remainder of the flight. Until a selection is made, the FMC will continue to use FMC calculated numbers. Both prompts will be blanked if the crew makes a manual fuel quantity entry into the PERF INIT page.

RTE DATA Pages: The RTE DATA page allows the crew access to ETA, computed fuel remaining and wind data for all programmed legs of the active flight plan. The RTE DATA page is displayed by selecting the RTE DATA> prompt from the RTE LEGS page.



The RTE DATA page is divided in to four columns. The entire remaining portion of the flight plan can be paged through using the NEXT PAGE / PREV PAGE keys on the FMC/MCDU keypad.

ETA: Estimated time of arrival at the associated fix given current flight progress according to the entered flight plan.

WPT: Each navigation fix remaining is displayed on a separate line. The name of each fix is displayed in this column in large font.

FUEL: The FMC computed fuel remaining upon reaching each associated fix is displayed in small font.

W>: Each navigation fix remaining in the flight plan is given it's own WINDS page, where the crew can examine wind conditions at the associated fix.

WINDS Page: The WINDS page allows for crew review of forecast wind and temperatures aloft at representative altitudes along the route of flight. The WINDS page is accessed using the W> prompt for each associated fix in the RTE DATA pages.

In order to model this system complete, it is necessary for us to implement a planned ACARS update to a future update/version of the PMDG 747-400 as this data is normally received by datalink in order to assist in flight planning while enroute.

You can manually enter wind data for your route of flight if it has been provided to you by a weather planning program or other device. If weather data is entered into the weather pages, it will be considered in the flight planning profile.

We do not consider this function to be fully operable, but it is available for you to interact with if you wish.

SID/STARs: The PMDG 747-400 is installed with approximately 1300 SID/STAR files that have been provided for your use by PMDG in cooperation with PlanePath.

The SID/STAR data is collected from publicly available sources that are not restricted by copyright and exported into a format that can be read by the PMDG FMC.

Some users may wish to program their own SID/STAR files for use with the PMDG 747-400. This is entirely possible even without programming skills!

Terry Yingling of PlanePath has provided a wonderful tutorial that will assist you in learning to produce SID/STAR files of your own. You can download this tutorial from the DOCUMENTATION section of www.precisionmanuals.com.

We are planning to make a repository for user produced SID/STAR files to compliment the files produced by PlanePath.

If you produce SID/STAR files of your own that you feel would be useful for others, please feel free to email them to sidstars@precisionmanuals.com and when we make this repository available, we will include it.

Minor SID/STAR differences: There are some minor differences in the performance of the 747-400 vs. our earlier 737 series airplanes. One difference involves the use of a VECTORS command in a SID during takeoff. Due to significant logic changes, the 747-400 FMC is not currently able to digest a VECTORS command at the beginning of a SID.

A simple work-around is to implement a climb to a DME/ALTITUDE at the beginning of the SID, then place the VECTORS portion of the SID after this climb/distance restriction. .

We are working to fix this for a future update, but it should not inhibit your use of SID/STARs if you follow the above recommendation.