# MCDONNELL DOUGLAS MD-11
# FMS AND MCDU

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<u>Note: This guide is not an FCOM and does not describe every single behavior of the system.</u>

# CONTENTS

## INTRODUCTION

The MD-11's Flight Management System (FMS) consists of two independent computers which are controlled by Multifunction Control and Display Units (MCDUs). There is one MCDU for the captain, one for the first officer, and one extra standby unit. The FMS provides guidance and navigation which can be coupled to the Auto Flight System or simply viewed by the pilot.

## FLIGHT PHASES

Flight phases are automatically selected throughout the flight. The selected phase affects information shown on each Multifunction Control and Display Unit (MCDU), behavior of the Auto Flight System, and behavior of certain other systems.

There are 7 flight phases:

- Preflight: Initial phase when power is applied, reactivates after engine shutdown
- Takeoff: Engages when throttles advanced for takeoff
- Climb: Engages at the set acceleration altitude
- Cruise: Engages when reaching set cruise altitude
- Descent: Engages when descending from set cruise altitude
- Approach: Engages when flaps are extended
- Rollout: Engages at main gear touchdown

If a step climb is performed, the cruise phase remains active. If a go-around is performed after touchdown, the system reverts to the approach phase. It is not possible to manually advance into a specific phase.

## THRUST LIMITS

Engine thrust limits are computed by the Full Authority Digital Engine Control (FADEC) system. Each engine has its own FADEC, which manages the thrust in accordance with thrust lever position, and commands from the Flight Management System (FMS).

There are 6 thrust limit modes:

- T/O: Takeoff
- T/O FLEX: Flexible takeoff
- G/A: Go around
- MCT: Maximum Continuous thrust
- CLB: Climb thrust
- CRZ: Cruise thrust

Thrust limits are usually automatically selected by the FMS, but can be overridden by the pilot using the THRUST LIMITS page of the Multifunction Control and Display Unit (MCDU).

The General Electric CF6-80C2D1F engine is controlled via N1 fan speed. The engine is rated at 61.5K thrust only.

The Pratt & Whitney PW4062 engine is controlled via Engine Pressure Ratio (EPR). EPR is an indicator of the thrust produced by the engine. The default rating mode is 60K, but 62K may be selected on the THRUST LIMITS page of the MCDU. Only T/O and G/A limits may operate in 62K mode.

When the thrust lever is moved, it commands an N1 (GE) or EPR (PW) target to the FADEC. This command is constrained by the FADEC to the highest thrust limit as well as the FADEC computed idle thrust limit. This ensures the FMS cannot limit pilot selectable thrust.

The Auto Thrust System (ATS) is constrained to the active thrust and idle limits.

During the preflight or takeoff flight phases, the T/O thrust limit is active by default. The T/O FLEX limit can be activated by entering a flex temperature into the MCDU. For PW engines, the 62K mode can be selected as long as T/O FLEX is not active.

When the climb thrust altitude is reached, the CLB thrust limit is activated. If no climb thrust altitude is set or computed, the CLB thrust limit will become active when the FMS transitions out of the takeoff phase.

When MCDU selected cruise altitude is reached, the CRZ thrust limit is activated. It remains activated even if a step climb occurs. It also remains active during the descent phase.

When the flaps are extended, the CLB thrust limit is activated.

If the Go Around button is pushed on the #2 throttle, the G/A thrust limit becomes active. It remains active until the Auto Flight System (AFS) leaves the Go Around mode.

## FMS SPD

FMS SPD mode allows the FMS to command the airspeed or mach number used by the Auto Flight System (AFS). More documentation will be added soon.

## MULTIFUNCTION CONTROL AND DISPLAY UNIT

The Multifunction Control and Display Unit (MCDU) is the interface between the pilot and the Flight Management System (FMS). There are three MCDUs in the cockpit. One for each pilot on the forward pedestal, and one backup standby unit on the aft pedestal. The MCDU is also used to control the CDFS and ACARS, which are not covered by this document.

## UNIT OVERVIEW



1) Line Select Keys (LSK)
   Selects or inserts data into the adjacent field.

2) Unit Display

3) Page Keys
   Selects the respective page.

4) Display Brightness Knob

5) Slew Keys
   Slews applicable pages in the direction of the arrow.

6) Next Page Key
   Goes to the next page. An arrow and page numbers are shown in the upper right corner of the display when a next page exists.

7) Alphanumeric Keys
   Types the respective character into the scratchpad

8) Clear Key
   If the scratchpad contains entered characters, the key performs a backspace. If a message is in the scratchpad, the key clears the message. Otherwise, the "CLR" character on the scratchpad is toggled.

## SCRATCHPAD

The scratchpad consists of the bottom most line of the display. Pressing any of the alphanumeric keys will type the respective character into this line. The CLR key can be used to remove the last character entered.

The scratchpad may also display messages from the FMS which can be removed using the CLR key. Once the message is removed, the next message will be shown, unless there are no more messages, at which point the scratchpad contents will revert to what was present before the message was displayed.

If the scratchpad is empty while the CLR key is pushed, the "CLR" character is shown in the scratchpad. Pushing the CLR key again will empty the scratchpad again.

## FIELDS AND LINE SELECT KEYS

Fields refer to locations where text is placed on the display. There are 6 rows and 3 columns. Fields are known as 1L through 6L for the left column, 1C through 6C for the center column, and 1R through 6R for the right column.

Data in fields can be shown in large or small font. An optional label is shown above some fields in small font.

A Line Select Key (LSK) is provided for each of the left or right columns of fields, and allows activation of commands and inserting or clearing data. Data in the center column fields are not normally accessible by LSKs.

An asterisk * indicates a command that can be activated by pushing the respective LSK. Pushing a command while the "CLR" character is shown in the scratchpad will perform the clear function of the command. If no clear function is available, "NOT ALLOWED" will be displayed.

Arrows < > indicate a page that can be accessed through pushing the respective LSK. Data in the scratchpad will not be cleared.

Boxes □ indicate a blank field which is requesting data entry. Dashes indicate a blank field, but not requesting data entry. Brackets [ ] indicate an optional blank field.

Some pages, such as F-PLN, can accept entry of data without showing an indication of allowable entry. This behavior will be described in the respective page's section.

Data can be entered by typing data into the scratchpad and then pressing the LSK adjacent to the desired field. If the format of the data is incorrect, "FORMAT ERROR" will be displayed. If the data exceeds the allowable entry range, "ENTRY OUT OF RANGE" will be displayed.

Certain fields perform special checking on entered values. Additional messages may be generated in these situations. For example, the FROM/TO field will validate that the ICAO's entered are valid and in the database. If they are not, "NOT IN DATA BASE" will be displayed.

Fields containing forward slashes indicate that it contains multiple properties. For example, the VOR1/CRS field contains both the frequency and course for the VOR1 radio. Entry is performed by following the slash format, in this case, "110.5/120".

Some multi-property fields allow entry of a single value at a time. For example, in the VOR1/CRS field, the frequency can be set by entering "110.5" or the course by entering "/120". The leading slash indicates the value should be entered into the second property. Single property editing is not supported on all two-property fields or for fields with more than two properties.

Data can be cleared by pushing the CLR key to display the "CLR" character, and then pressing the desired field's LSK. Some fields cannot be cleared after entry, and will display "NOT ALLOWED" if clearing is attempted.

Certain fields may have additional or special behavior. This behavior will be described in the respective page's section.

This section will cover MCDU pages related to the Flight Management System (FMS). Pages not listed are not currently simulated, but may be added in future versions of the aircraft.

## A/C STATUS

This page displays information about the FMS and its computers.

This page is displayed at power-up when "FMC" is selected on the MENU page. It can also be accessed from the REF page.

Pushing the → Page key will cause the second status page with additional information to appear. A subsequent push will return to the first status page.

The aircraft and engine type are displayed in the 1L and 1R fields. It must be verified correct before every flight. The OP PROGRAM software load must match between both MCDU's, especially the suffix.

The navigation database can be swapped by selecting the second database in field 4L. Doing so will cause a confirmation prompt to appear in the field 4R. Selecting this will swap the databases. This action clears the flightplan. Note that this function is for display purposes only, and does not affect the sim or database.

The PERF FACTOR can be adjusted by adjusting the factor in field 6L. This factor is used in aircraft performance computations. This function is not currently simulated.

The second status page has no editable fields.

## APPROACH

This page allows for viewing and selecting approach data.

This page is accessed by pushing the TO/APPR key while the climb, cruise, descent, approach, or rollout phases are active. It cannot be accessed in the preflight or takeoff phases.

Approach and reference speeds are computed and displayed in field 5L. Approach speed can be edited by entering the new speed into field 5L, which will be respected by FMS SPD if engaged. Reference speed cannot be edited.

Landing flap setting can be toggled between 35 and 50 degrees by selecting field 6L. The default is 35 degrees, and 50 degrees should only be used for very short runways or heavy payloads.

## CLOSEST AIRPORTS

This page allows information about various close by airports to be displayed. It is accessed from the REF INDEX page.

The 4 closest airports in the database will be displayed with their bearing and distance in lines 1L through 4L.

A fifth airport may be entered into field 5L in order to pull up its bearing and distance.

## F-PLN INIT

This page is used to initialize the flightplan and basic flight parameters.

This page is the first of three INIT pages, and is accessed by pushing the INIT key.

Pushing the → Page key will cause the WEIGHT INIT page to appear.

A stored Company Route can be inserted into field 1L. This feature will be used to allow external flightplan files to be loaded in a future version of the aircraft.

The departure and arrival airport ICAOs are inserted into field 1R. ICAOs are entered in Departure/Arrival format.

An alternate Company Route and ICAO can be optionally inserted into field 2L and 2R respectively.

The GNS position used for alignment of the Inertial Reference System can be adjusted by using the slew keys while on the F-PLN INIT page. The location of the "⇅" symbol determines whether the LAT or LONG will be adjusted. Selecting 3L or 4L will move the "⇅" symbol to LAT or LONG, respectively.

A flight number of any character combination can be entered into field 4L.

Cruise altitudes can be entered into field 5L. A single altitude can be entered by entering the flight level numbers in, for example, 300 for FL300. One or more step climbs can be selected by entering multiple altitudes, such as 300/320/340. Step climb is currently inoperative.

The ISA temperature will automatically be computed in field 6L when a cruise altitude is entered. In a future aircraft version, manual temperature and wind entry will be possible.

The cost index is entered into field 6L. This number is used to adjust the computation of ECON speeds and other performance data used for climb, cruise, and descent. A lower cost index will prefer minimal fuel usage, and a higher cost index will prefer higher speeds.

## FUEL INIT

This page is used to inform the FMS about refueling actions. This page is entirely optional and is not currently operable.

This page is the third of three INIT pages. It can be accessed by pushing the → Page key on the WEIGHT INIT page.

Pushing the → Page key again will cause the F-PLN INIT page to re-appear.

### IRS/GNS POS

This page allows for viewing Inertial Reference System (IRS) and Global Navigation System (GNS) data. It can be accessed by pushing the → Page key on the POS REF page.

Pushing the → Page key will cause the IRS STATUS page to appear.

This page has no selectable fields.

### IRS STATUS

This page displays the status of the Inertial Reference System. It can be accessed by pushing the → Page key on the IRS/GNS POS page.

Pushing the → Page key will cause the POS REF page to appear.

This page has no selectable fields.

### MENU

This page provides access to the various systems that the MCDU can interface with. It is accessed by pushing the MENU key. It also displays when the MCDU is powered up.

Each system can show either a request "<REQ>", or active status "<ACT>". Only one system may be active at a time on each MCDU.

If "<REQ>" is shown, pushing the LSK will acknowledge the request. Attempting to access pages via the page keys while a request is displayed will cause NOT ALLOWED to be displayed until the request is acknowledged.

"<ACT>" means the respective system is active on that MCDU and ready to be accessed.

### NAV RADIO

This page controls the navigation radios of the aircraft. It is accessed by pushing the NAV RAD key.

There are 2 VOR radios and 2 ADF radios. There are also 2 ILS radios that operate as one, and cannot be tuned independently.

VOR radios can be tuned by entering a frequency (MHz) and course into fields 1L or 1R. The ILS radio can be tuned by entering the frequency (MHz) and course into field 4L. Frequencies can be entered with or without a course.

ADF radios can be tuned by entering the frequency (KHz) into fields 3L or 3R.

There are two preselects which can be used to store a frequency and course for later use. These can be entered into fields 6L or 6R. Frequencies can be entered with or without a course.

Tuned frequencies can be cleared unless the Auto Flight System (AFS) is currently tracking the respective navaid.

When one of the VOR radios are tuned, the "VOR ARM" option appears in fields 2L or 2R, depending on which radio is tuned. Selecting it arms the VOR mode of the AFS.

When the ILS radios are tuned, the "LOC ONLY" option appears in field 5L. Selecting it arms the localizer only (no glideslope) mode of the AFS.

Any combination of VOR and ILS radios can be tuned at the same time, but only one can be armed for AFS tracking at a time.

Arm status can be canceled by using the clear function on the "VOR ARMED" or "LOC ARMED" commands. Once VOR or LOC ONLY has activated, it can only be cleared by selecting another lateral mode on the Flight Control Panel.

## PERF

PERF is made up of 3 separate pages for the climb (CLB), cruise (CRZ), and descent (DES) phases of flight.

When the PERF key is pushed, the climb page is displayed during the preflight, takeoff, or climb phases. The cruise page is displayed during the cruise phase only, and the descent page is displayed during the descent, approach, or rollout phases.

On the CLB or CRZ page, pushing the → Page key will display the PRESELECT pages. The rotation for the CLB page is: PERF CLB → PRESELECT CRZ → PRESELECT DES → PERF CLB.

The rotation for the CRZ page is: PERF CRZ → PRESELECT DES → PERF CRZ.

If the → Page key is pushed on the DES page, "NOT ALLOWED" will be displayed.

The title of the page includes ECON, MAX, or EDIT depending on the selected speed mode, which are set on this page for the corresponding phase.

ECON mode selects the FMS computed economy airspeed and mach number. Changeover between airspeed and mach number occurs automatically. This is the default mode. If another speed mode is selected, ECON can be re-engaged by selecting field 2L, or by pushing the FMS SPD button the Flight Control Panel while FMS SPD is already engaged.

MAX mode is available on the CLB and DES pages only. It selects the optimal speed for best climb or descent rates. MAX can be engaged by selecting field 3L.

EDIT mode allows the pilot to select the airspeed and/or Mach number used by FMS SPD for the corresponding phase. Either an airspeed, a mach number, or both can be inserted. If only an airspeed is inserted, the mach number will be set to MMO (Maximum Mach Operating speed). If only a mach number is inserted, the airspeed will be set to VMO (Maximum Operating speed). EDIT speed is inserted into field 4L. Once inserted, it cannot be cleared; the inserted speed will be retained with an asterisk if ECON or MAX is selected. This allows for simple future re-selection.

Transition altitude can be selected for the CLB and DES pages by inserting an altitude into field 6L. Flight level entry is not permitted.

## PERF PRESELECT

PRESELECT pages allow adjustment to parameters of a future phase's PERF page before the phase becomes active. There are PRESELECT pages for cruise (CRZ) and descent (DES).

These pages are accessed by pushing the → Page key from the PERF CLB or CRZ page.

Pushing the PERF key will immediately return to the active PERF page.

Behavior of the fields are identical to the above-described PERF pages.

## POS REF

This page allows for viewing position reference data. It is accessed from the REF INDEX page.

Pushing the → Page key will cause the IRS/GNS POS page to appear.

Field rows are populated with position information from the Inertial Reference System (IRS) and Global Navigation System (GNS).

Selecting one of the fields will toggle the frozen status. When frozen, the position will not be updated. Frozen status can be removed by selecting the field again.

The GNS can be toggled by selecting field 5R. When disabled, only the Inertial Reference System will be used for navigation.

## REF INDEX

This page is a menu that allows selection of other reference pages. It is accessed by pushing the REF key.

## SENSOR STATUS

This page allows for viewing FMS sensors that have failed. It is accessed from the REF INDEX page.

This page has no selectable fields.

When all sensors are working, nothing is displayed in any of the rows.

https://github.com/Octal450/MD-11

## TAKEOFF

This page allows for viewing and selecting takeoff data.

This page is accessed by pushing the TO/APPR key while the preflight or takeoff phases are active. It cannot be accessed in other phases.

Takeoff flex temperature can be entered into field 1L. It can also be cleared using the clear function on field 1L.

Packs can be selected on or off for takeoff by selecting field 2L. This affects performance data.

Takeoff flap setting is entered in field 3L. Flaps 10-25 is allowed. Flaps 28 can only be used if the aircraft has deflected ailerons equipped.

Slope and wind information are entered into field 2R. The runway slope value can be +/- 2 degrees, using "U" (up) and "D" (down) as alternatives to "+" and "-". For wind, the headwind or tailwind component uses "H" (headwind) and "T" (tailwind) instead of "+" and "-". Examples of valid entries for 0.5 degrees downward slope and 2 knots of headwind are "-0.5/2", "D0.5/H2", or any combination of these.

Outside air temperature can be entered into field 3R. Use the value from METAR/ATIS instead of the Engine and Alert Display. The entry must be followed by "C" for Celsius or "F" for Fahrenheit. Selecting field 3R with an empty scratchpad will toggle the unit.

Assuming weight and balance data, departure runway, and takeoff data have been entered, V1, VR, and V2 speeds are automatically calculated and displayed with an asterisk for confirmation in fields 4L, 5L, and 6L, respectively. Selecting each field will confirm the speed, removing the asterisk. V-speeds will then be displayed in magenta on the Primary Flight Display (PFD).

Selecting different takeoff settings (flex, flaps, packs) or changing the departure runway will cause the V-speeds to be recalculated, and they will need to be re-confirmed.

V-speeds can be overwritten or entered manually into fields 4L, 5L, and 6L. These speeds will be displayed in white on the PFD.

Climb thrust altitude is automatically set into field 4R to airport elevation + 1500 feet after the departure airport is entered. It can be overridden to any value above airport elevation + 1000 feet.

Acceleration altitude is automatically set into field 5R to airport elevation + 3000 feet after the departure airport is entered. It can be overridden to any value above airport elevation + 1000 feet.

Engine-out acceleration altitude is automatically set into field 6R to airport elevation + 800 feet after the departure airport is entered. It can be overridden to any value above airport elevation + 400 feet.

## THRUST LIMITS

This page allows for viewing and selecting engine thrust limits. It is accessed from the PERF or TAKEOFF pages.

Normally, thrust limits are automatically selected by the FMS, but they can be overridden by the pilot in manual mode. The title of the page reflects this status and will be either "AUTO THRUST LIMITS" or "MANUAL THRUST LIMITS".

During the preflight or takeoff flight phases, the T/O thrust limit is shown in field 1L.

Takeoff flex temperature can be entered into field 1R. This will cause the T/O FLEX thrust limit to be shown in the 2L field. If another thrust limit is selected, it will clear T/O FLEX.

Once the aircraft enters the climb phase, the T/O and T/O FLEX options are removed, and the G/A thrust limit is shown in field 1L.

The MCT, CLB, and CRZ thrust limits are displayed in fields 3L, 4L, and 6L, respectively.

Selecting a thrust limit will cause the system to enter MANUAL mode. In this mode, thrust limits must be selected manually throughout the flight. "SELECT AUTO" will be shown in field 4R. The limit will also be boxed in white on the Engine and Alert Display. Entering or clearing a flex temperature, or re-selecting T/O mode from T/O FLEX will not cause the system to enter MANUAL mode.

Pushing "SELECT AUTO" in field 4R will return the system to AUTO mode.

For Pratt & Whitney engines, the rating mode can be switched between 60K and 62K when T/O or G/A thrust limits are active by pushing the selection in field 3R.


## WEIGHT INIT

This page is used to enter aircraft weight and balance information. This information is used for performance computations.

This page is the second of three INIT pages. It can be accessed by pushing the → Page key on the F-PLN INIT page.

Pushing the → Page key again will cause the FUEL INIT page to appear.

The current sensed fuel is displayed in the UFOB area of field 1R.


Before Engine Start:
Taxi fuel can be entered into field 1L. This informs the FMS about the predicted fuel usage for taxiing.

UFOB can be copied into the BLOCK area of field 1R by pushing the LSK while the scratchpad is empty. Otherwise, block fuel can be entered manually.

Takeoff Gross Weight (TOGW) can be entered into field 2R, but it is strongly recommended to enter ZFW first and let this field calculate automatically.

<u>After Engine Start:</u>

The taxi fuel field is removed.

BLOCK is removed and the current sensed fuel is indicated in UFOB, along with the sensor indication "/FF+FQ".

TOGW is replaced by Gross Weight (GW). The difference between TOGW and GW is taxi fuel. Operation of the field is identical to TOGW.

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Zero Fuel Weight (ZFW) can be entered into field 3R. It is recommended to enter ZFW before TOGW. However, if BLOCK and TOGW have been entered beforehand, ZFW will be calculated automatically.

If either TOGW/GW or ZFW is edited after one has been calculated, the other field will be recalculated. If BLOCK is edited, either TOGW/GW or ZFW will be recalculated, whichever was last automatically calculated.

Takeoff Center of Gravity (TOCG) is entered into field 5R. This is primarily used for calculating the takeoff stabilizer trim.

Zero Fuel Weight Center of Gravity (ZFWCG) is entered into field 6R. This is used to compute the center of gravity throughout the flight.

A shortcut in the sim is provided for entering TOGW/GW, ZFW, TOCG, and ZFWCG. It functions similarly to the BLOCK fuel shortcut mentioned earlier for the real aircraft. Pushing the LSK while the scratchpad is empty will insert the correct value into the scratchpad. This value can then be inserted into the field by pushing the LSK again.