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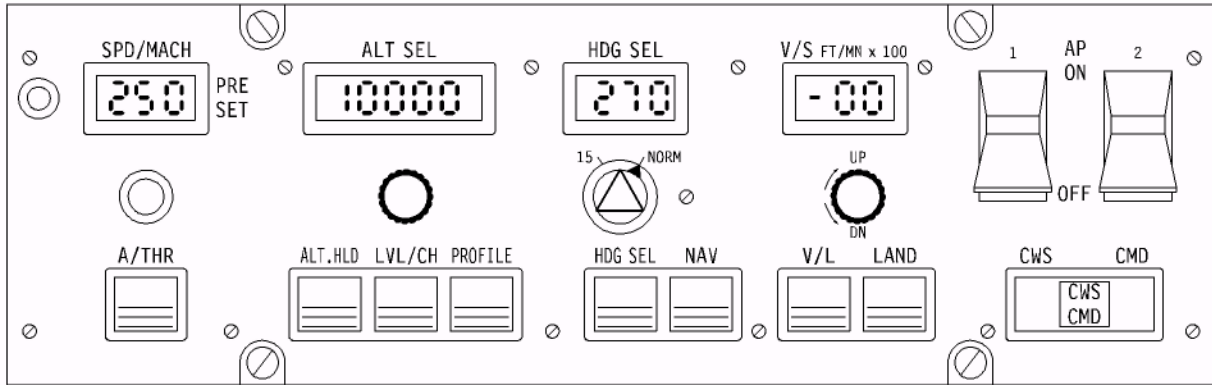
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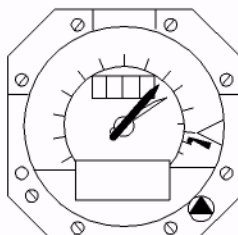
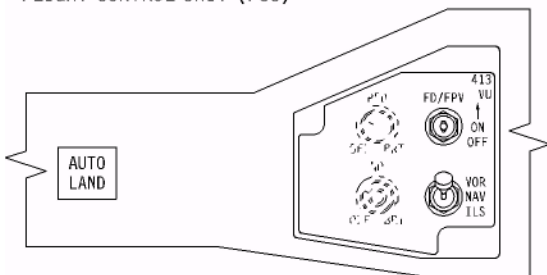
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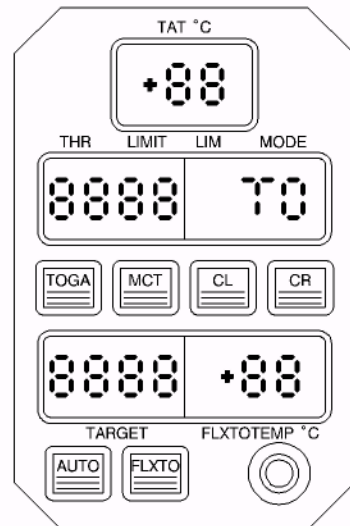
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FLIGHT CONTROL UNIT (FCU)

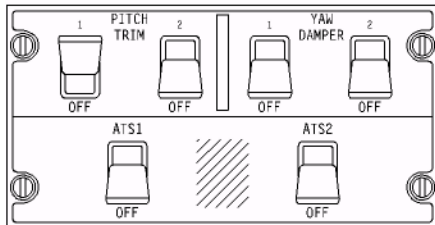


EPR (OR N1) INDICATORS

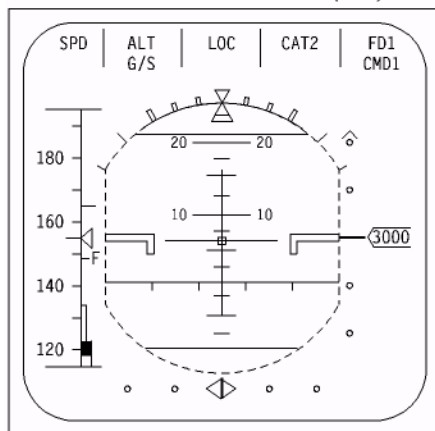


THRUST RATING PANEL (TRP)

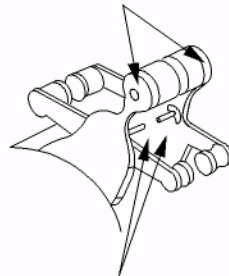
PITCH TRIM/YAW DAMPER/ATS ENGAGEMENT UNIT



PRIMARY FLIGHT DISPLAY (PFD)

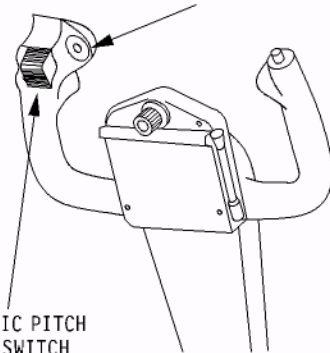


A/THR-THR L INSTINCTIVE DISCONNECT PUSHBUTTON SWITCHES



GO LEVERS

AP INSTINCTIVE DISCONNECT PUSHBUTTON SWITCH



ELECTRIC PITCH TRIM SWITCH (ROCKING LEVER)

**GENERAL**

- The Automatic Flight System (AFS) can be used:
  - for guidance only, in manual flying (FD only) or in control wheel steering (AP engaged in CWS mode),
  - or
  - for automatic control of the selected flight path targets (AP engaged in CMD mode).
- The AFS fully integrates the Auto Pilot/Flight Director functions (AP/FD) and the Auto Throttle functions (A/THR).
- **At any time, the pilot can select the desired level of automation, revert to the AP/FD basic modes or to manual flying.**
- The AFS is designed to :
  - control the aircraft on the selected flight path (AP/FD vertical and lateral guidance),
  - control the aircraft speed (AP/FD or A/THR),
  - control the engine thrust (A/THR).
- Pilot inputs to the AFS are performed via :
  - the Flight Control Unit (FCU),
  - the FMS CDU,
  - the Thrust Rating Panel (TRP),
  - the throttle Go-levers,
  - the control column, control wheel and rudder pedals, when the AP is engaged in CWS mode.
- The AFS consists of :
  - 2 Flight Directors (FD 1 and FD 2),
  - 2 Autopilots (AP 1 and AP 2),
  - 2 Autothrottle Systems (ATS 1 and ATS 2).
- The AFS includes the following computers :
  - 2 Flight Control Computers (FCC) :
    - FCC1 for AP1/FD1,
    - FCC2 for AP2/FD2.
  - 2 Thrust Control Computers (TCC) to :
    - compute the engine thrust limit for any flight phase,
    - control the associated Autothrottle System.
  - 2 Flight Augmentation Computers (FAC),
  - 2 Yaw Dampers,
  - 2 Pitch Trim .
- The AFS integrates peripheral data from the :
  - FCC, TCC, FAC, FCU, TRP,
  - FMS Control Display Unit (CDU),
  - Flight Management Computer (FMC),
  - IRS, ADC, VOR, ILS, Radio Altimeters,
  - Throttle Lever Angle (TLA) position and Go-levers,
  - ATS and AP instinctive disconnect pushbuttons switches,
  - engines,
  - Slats Flaps Control Computer (SFCC, for slats/flaps position),
  - Electronic Flight Control Unit (EFCU, for control wheel position),
  - landing gear position detectors (for the ground/flight condition).

**AFS COMPUTER REDUNDANCY**

- The AFS computers are duplicated in order to provide the required level of system redundancy.
- Each computer consists of two independent processing channels (command and monitor channels) assuring all the functions dedicated to the computer.
- The computations performed by the command and monitor channels are permanently compared.
 

In case of disagreement between the two channels, the affected function or computer is disabled before it may affect the aircraft guidance.
- In operational terms, such a self-monitored system is referred to as being **Fail Passive**.
- For precision approach and go-around, as soon as the second AP is engaged, if the active system fails, the second system takes over automatically.

**Autoflight System**
**AFS - General**

- In operational terms, this system redundancy provides a **Fail Operational** capability.

**ELECTRIC POWER SUPPLY**

- AFS computers are electrically supplied :
  - temporarily :
    - at aircraft power-up, for computer self test,
    - when performing the annunciator lights test,
  - continuously :
    - when one PITCH TRIM lever is in the engaged position,
- or
- when one engine is started.
- The AFS computers are electrically supplied, as follows :

	AC	DC
FCC 1	AC ESS BUS	DC ESS BUS
FCC 2	AC BUS 2	DC NORM BUS
FCU		DC ESS BUS DC NORM BUS
TCC 1	AC BUS 1	DC NORM BUS
TCC 2	AC BUS 1 AC BUS 2	DC ESS BUS

- AFS power supply is cut off when both engines are shutdown (both PITCH TRIM levers disengaged).

**AFS ARCHITECTURE**

- The main design principles of the AFS architecture are:
  - the AFS fully integrates the Auto Pilot/Flight Director (AP/FD) and the Auto Throttle (A/THR) functions,
  - for each AP/FD mode, an A/THR mode is automatically associated (paired).
  - the AP/FD can be used without the A/THR (i.e. with manual thrust setting).
  - the A/THR can be used in manual flying.

- the AFS operates in response to the pilot selections.

however, in some cases, the AFS operates automatically according to built-in protection features .

- pilot selections and peripheral data are processed together to provide :
  - guidance orders in pitch and roll, (FD bars),
  - aircraft speed control,
  - engine thrust control.
- AP/FD modes are armed or engaged either manually by the pilot (selections on FCU) or automatically (Go-levers activation, mode transitions or mode reversions).
- ATS modes are automatically selected in accordance with the engaged AP/FD vertical mode.
- the crew can monitor the AP/FD and ATS modes status on the Flight Mode Annunciator (FMA) which is displayed in the upper part of each PFD (Primary Flight Display).
- the engaged FD modes do not change upon AP engagement (transition from manual flying using the FD) and disengagement (reversion to manual flying using the FD).
- AP/FD1 and AP/FD2 work in parallel and provide guidance orders which are represented by the FD bars position. FD1 is displayed on PFD 1 and FD2 on PFD2.
- the FD guidance orders (FD bars commands) can be executed :
  - manually by the pilot with AP OFF or with AP engaged in CWS mode (Control Wheel Steering) mode,
  - automatically by the AP if engaged in CMD (Command) mode.
- at any time, the pilot can revert to manual thrust control by pressing the ATS instinctive disconnect pushbutton on either throttle lever and to manual flying by pressing the AP instinctive disconnect pushbutton on the control wheel.



- AP engagement conditions include all the FD engagement conditions plus specific additional conditions.

In case of loss of any engagement condition due to an equipment failure :

- if the FD1 (2) is lost, the AP1 (2) is lost consequently,
- if the AP1 (2) is lost, the FD1 (2) may remain engaged (for example, in case of loss of the green hydraulic system, the AP1 is lost but the FD1 remains operative).

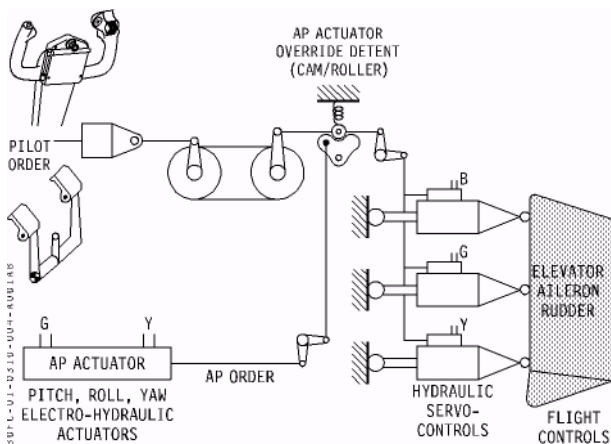
## Autoflight System AFS - General

### AFS - PILOT INTERFACE

- The cockpit equipments associated to the use of the AFS are :
  - PITCH TRIM/YAW DAMPER/ATS engagement unit,
  - Flight Control Unit (FCU),
  - Primary Flight Display (PFD) including :
    - Flight Mode Annunciator (FMA),
    - FD bars.
  - AP instinctive disconnect pushbuttons,
  - ATS instinctive disconnect pushbuttons,
  - Go-levers,
  - Thrust Rating Panel (TRP) and EPR/N1 indicators,
  - FD/FPV switches,
  - VOR/NAV/ILS selectors,
  - ILS control panel,
  - local warnings.

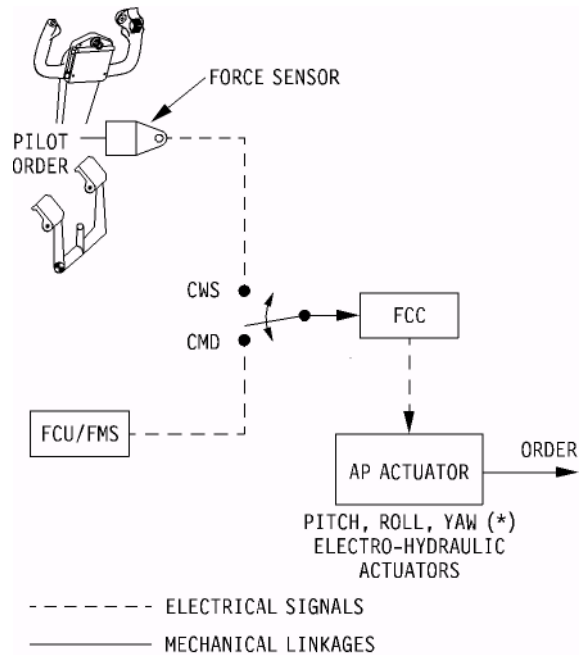
### AP CONNECTION TO FLIGHT CONTROLS

- The primary flight controls are actuated by hydraulic servo controls which are commanded either mechanically in manual flying or by the AP actuators if the AP is engaged.



- With the AP engaged (in CMD or CWS), the AP electro-hydraulic actuators are electrically commanded via the FCC.

The AP yaw actuator is active only when the AP is engaged in CMD and slats are extended.

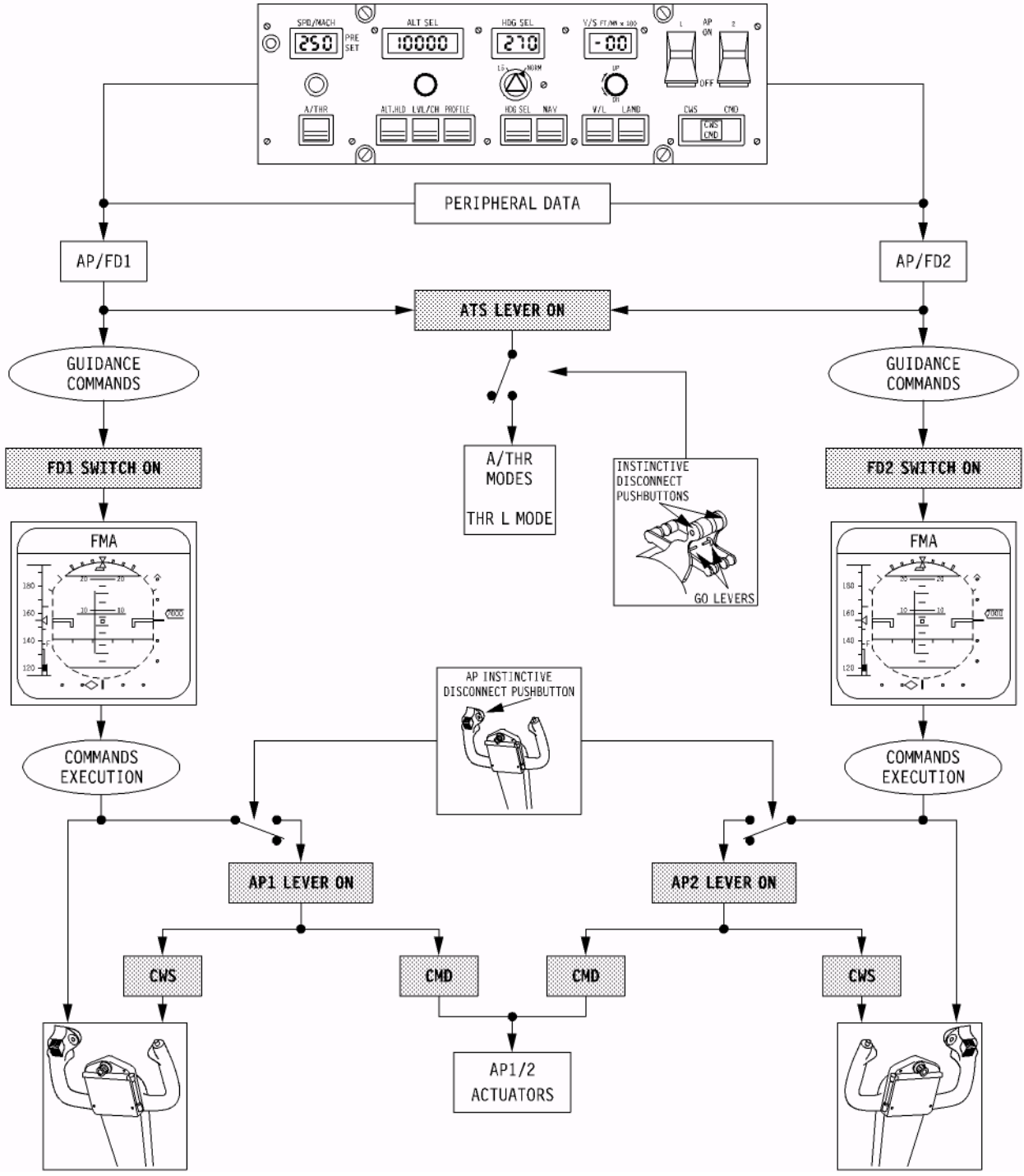


(\*) YAW CHANNEL IS ACTIVE ONLY WHEN AP IS ENGAGED IN CMD, WITH SLATS EXTENDED.

- The AP electro-hydraulic actuators are hydraulically powered as follows :
  - AP1 actuators : Green hydraulic system.
  - AP2 actuators : Yellow hydraulic system.
- When flight controls are commanded by AP actuators, feedback movement is provided to the control column, control wheel and rudder pedals.
- Each AP actuator is fitted with a safety detent device (cam/roller), which provides the possibility to override the actuator in case of an AP hardover (illustration to be considered for education purposes only, it does not reflect the actual hardware).

PILOT ACTIONS

### PILOT SELECTIONS



**Autoflight System****AFS – Mode Definition****AFS MODES**

- The AFS guidance associates :
  - AP/FD vertical and lateral modes,
  - a paired A/THR mode.
- For landing and go-around, the AP/FD uses combined modes which associate a vertical mode and a paired lateral mode.
- The selection of the AP/FD modes is performed on the FCU, the status of the corresponding vertical and lateral modes, as well as of the associated A/THR mode, is indicated on the Flight Mode Annunciator (FMA) located in the upper part of the Primary Flight Display (PFD).

**AP/FD BASIC MODES**

- The basic vertical mode of the AP/FD is the V/S mode.  
Upon engagement, the V/S mode maintains the current aircraft vertical speed.
- The basic lateral mode of the AP/FD is the HDG mode.  
Upon engagement, the HDG mode maintains the current aircraft heading.
- At AFS computer power-up, the FD engages the basic modes.

**ENGAGED VERSUS ARMED MODES**

- Some AP/FD modes can be armed before being engaged. ATS modes can only be engaged.
- A mode is armed, following a manual or automatic selection, until the conditions for engagement are met.  
During the arming phase, the mode is displayed in blue in the second or third line of the FMA.

- A mode is engaged when it is used by the AFS.

When engaged, the mode is displayed in green in the first line of the FMA.

An automatic transition from armed to engaged occurs when the required engagement conditions are met (e.g. : glide slope capture in approach, transition from G/S blue to GS\* green).

**MODE TRANSITIONS**

- A mode transition is a manual or automatic change-over from one mode to another mode which occurs as the result of :
  - a pilot action (e.g. : mode selection on FCU), or
  - a prior pilot selection involving several modes in sequence (e.g. : in altitude capture, the vertical mode changes from SPD to ALT\* then to ALT)

**MODE REVERSIONS**

- A mode reversion is a manual or automatic change-over from one mode to another mode which occurs as the result of :
  - a pilot action (e.g. intentional disengagement of a mode, by pressing the corresponding pushbutton switch on the FCU, thus resulting in a manual reversion to the associated basic mode), or
  - a system built-in condition (e.g. automatic LVL/CH to V/S mode reversion), or
  - a failure or temporary loss of the engaged mode.
- Reversions due to the failure or temporary loss of the engaged mode are indicated by the flashing of the associated FD bar and by the FMA annunciation (reversion to the associated basic mode, i.e. V/S or HDG).

**Note : Mode transitions and reversions are described, for each individual AP/FD and A/THR mode, in the respective description and operation section.**

**AP/FD VERTICAL MODE AND A/THR MODE PAIRING**

- The engagement of an AP/FD vertical mode automatically engages the associated A/THR mode, provided the A/THR is engaged, e.g. :
  - Upon engagement of the AP/FD V/S mode, the A/THR SPD mode engages :
    - AP/FD adjusts the pitch attitude (using the elevator) to maintain the selected V/S and,
    - A/THR adjusts the engine thrust to maintain the selected speed.
  - In Level Change (LVL/CH), the AP/FD SPD mode engages and the A/THR THR mode (in climb) or RETARD mode (in descent) engages :
    - AP/FD adjusts the pitch attitude (using the elevator) to maintain the selected speed.
    - A/THR maintains the engine thrust limit (in climb) or idle (in descent),

**ATS MODES**

The ATS and A/THR can be engaged in the following modes :

<b>FMA indications</b>	<b>Mode</b>	<b>Mode function</b>
<b>MAN THR</b> <i>(Amber)</i>	Manual Thrust	ATS is armed but no A/THR mode is engaged, throttle levers must be set manually.
<b>THR</b>	Thrust	Maintains the Thrust Limit (THR LIM) as selected and displayed on the TRP.
<b>THR</b> <i>(Blue)</i>	Thrust Armed	Autothrottle system is declutched during takeoff, but remains armed in order to re clutch after takeoff (refer to section 1.03.23 A/THR THR mode).
<b>SPD</b>	Speed	Maintains the selected speed.
<b>MACH</b>	Mach	Maintains the selected Mach number.
<b>P.THR</b>	Profile Thrust	Maintains the Thrust Limit/Target Thrust directed by the FMS, as indicated on the TRP (TRP in AUTO).
<b>P.SPD</b>	Profile Speed	Maintains the target speed directed by the FMS.
<b>RETARD</b>	Retard	Reduces throttle levers to 5° throttle lever angle (TLA), then the Autothrottle system declutches (A/THR blue).
<b>A/THR</b> <i>(Blue)</i>	A/THR Armed	Autothrottle system is declutched but remains armed in order to re clutch at level -off.
<b>THR L</b>	Thrust Latch	Sets and maintains the Thrust Limit (THR LIM), as selected and displayed on the TRP, following the activation of the angle-of-attack protection (alpha-floor).

**AP/FD VERTICAL/LATERAL/COMBINED MODES**

- The AP/FD can be engaged in the following modes :

**VERTICAL modes**

<b>FMA Indication</b>	<b>Mode</b>	<b>Mode function</b>	<b>Associated A/THR mode</b>
<b>V/S</b>	Vertical Speed	Acquires and maintains the selected V/S.	SPD or MACH
<b>SRS</b>	Speed Reference System	Maintains a reference speed for takeoff or go-around.	THR
<b>SPD</b>	Speed	Maintains the selected speed.	THR (climb) RETARD (descent)
<b>MACH</b>	Mach	Maintains the selected Mach number.	THR (climb) RETARD (descent)
<b>ALT</b> <i>(Blue)</i>	Altitude hold Armed	Arming phase of ALT mode.	In accordance with the engaged vertical mode
<b>ALT*</b>	Altitude hold Capture	Capture phase of ALT mode.	SPD or MACH
<b>ALT</b>	Altitude hold	Maintains the selected altitude.	SPD or MACH
<b>G/S</b> <i>(Blue)</i>	G/S Armed	Arming phase of GS mode.	In accordance with the engaged vertical mode
<b>GS*</b>	G/S Capture	Capture phase of GS mode.	SPD
<b>GS</b>	G/S Track	Tracks the Glideslope beam.	SPD
<b>P.CLB</b> <i>(Blue)</i>	Profile Climb Armed	Arming phase of P.CLB mode.	In accordance with the engaged Pitch mode.
<b>P.CLB</b>	Profile Climb	In PROFILE mode, maintains the climb speed and path directed by the FMS.	P.THR
<b>P.ALT</b>	Profile Altitude hold	In PROFILE mode, maintains the selected altitude.	P.SPD
<b>P. DES</b> <i>(Blue)</i>	Profile Descent Armed	Arming phase of P. DES mode.	In accordance with the engaged vertical mode
<b>P.DES</b>	Profile Descent	In PROFILE mode, maintains the descent speed, flight path or vertical speed directed by the FMS.	P.THR then RETARD or P.SPD

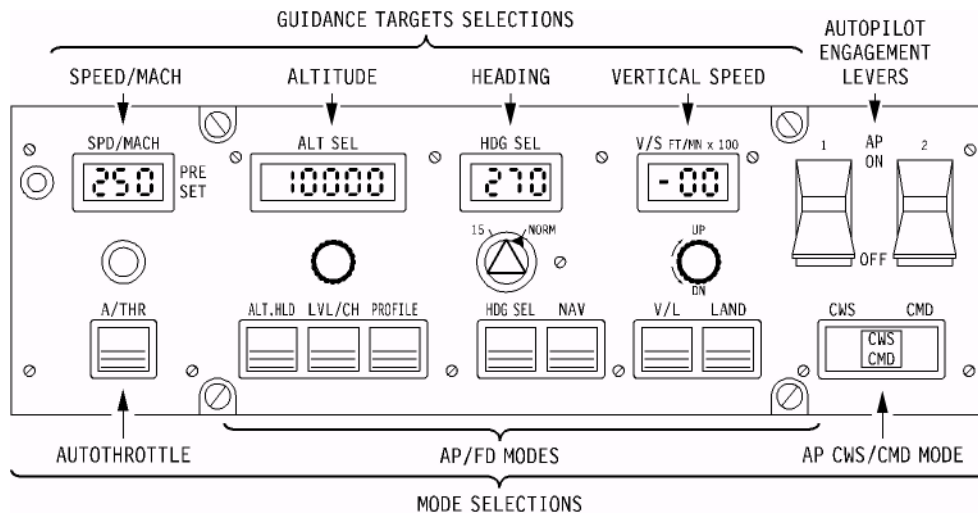


**LATERAL modes**

<b>FMA Indication</b>	<b>Mode</b>	<b>Mode function</b>
<b>HDG</b>	Heading	Maintains the present aircraft heading.
<b>HDG/S (Blue)</b>	Heading Select Armed	Arming phase of HDG/S mode (only when HDG/S is armed for take-off).
<b>HDG/S</b>	Heading Select	Acquires and maintains the selected heading.
<b>RWY</b>	Runway	Tracks the selected localizer course to maintain the runway centerline during takeoff up to 30 ft (then NAV, HDG/S or HDG engages automatically).
<b>NAV (Blue)</b>	Navigation Armed	Arming phase of NAV mode.
<b>NAV</b>	Navigation	Maintains the FMS F-PLN track.
<b>VOR (Blue)</b>	VOR Armed	Arming phase of VOR mode.
<b>VOR*</b>	VOR Capture	Capture of the selected VOR radial/course.
<b>VOR</b>	VOR Track	Tracks the selected VOR radial/course.
<b>LOC (Blue)</b>	Localizer Armed	Arming phase of LOC mode.
<b>LOC*</b>	Localizer Capture	Capture phase of LOC mode.
<b>LOC</b>	LocalizerTrack	Tracks the selected Localizer course.

**COMBINED modes**

<b>FMA Indication</b>	<b>Mode</b>	<b>Mode function</b>	<b>Associated A/THR mode</b>
<b>LAND</b>	Land Track	Localizer and glideslope tracking below 400 ft RA.	<b>SPD</b>
<b>FLARE</b>	Flare	Flare and runway alignment guidance.	<b>SPD then RETARD</b>
<b>ROLL OUT</b>	Rollout	Derotation and roll out guidance.	<b>MAN THR</b>
<b>GO AROUND</b>	Go Around	Go-around guidance, using SRS and HDG modes.	<b>THR</b>

**GENERAL**


- The FCU is the main interface between the flight crew and the AFS in order to :
  - engage the A/THR and the AP,
  - engage AP/FD modes,
  - select guidance target values.

**BASIC PRINCIPLES**
**Arming/engagement :**

- A mode can be armed or engaged by pressing the corresponding pushbutton switch or (for LVL/CH, HDG SEL and V/S modes only) by pulling the corresponding selector knob.

**Disarming/disengagement :**

- If a mode is armed or engaged, pressing its pushbutton switch a second time disarms or disengages the mode.  
A mode cannot be disengaged by pulling the corresponding setting knob a second time.

Engaging a new mode disengages the mode which was previously engaged.

**Selector knobs :**

- Turning a selector knob clockwise increases the target value and turning anticlockwise decreases the target value.

**Pushbutton switches :**

- The pushbutton switches control the corresponding mode.

The pushbutton switches include three green bars which illuminate green when the corresponding mode is engaged.

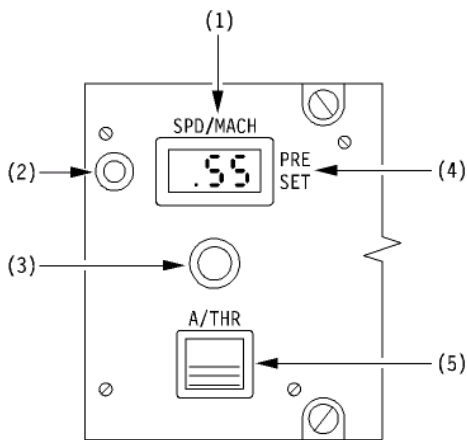
- Disengaging a mode by pressing the related pushbutton switch causes a reversion to the corresponding basic mode :
  - if the vertical mode is disengaged, V/S engages,
  - if the lateral mode is disengaged, HDG engages.

**FCU INITIALIZATION**

- During cockpit preparation, when the FCU is electrically supplied (by engaging either pitch trim lever) all windows, except SPD/MACH, are initialized in accordance with the present aircraft parameters (e.g.: 100 kt, 500 ft, 350°, 00 ft/min).

**Note 1 :** 700 kt is the minimum value for the SPD/MACH display window.

**Note 2 :** If aircraft data are missing or invalid, the displayed data are 100 kt, 5000 ft, 000° and "- - -" in the V/S display window.

**FCU DESCRIPTION**

**(1) SPD/MACH window**

- Displays the target or pre set speed/Mach number.
- When PRE SET light is extinguished, the target speed/Mach (used by either A/THR or AP/FD) is displayed. When PRE SET light is illuminated, the pre-set speed/Mach is displayed.
- "---" is displayed when PROFILE mode is engaged.

**Note 1: Range of displayed values :**

- SPD : 100 kt to 399 kt IAS
- MACH : .01 to .99

**Note 2:** The target speed (selected by the pilot or computed by the FMS, when in PROFILE mode) is also displayed on the PFD speed scale.

**(2) SPD/MACH switch-over button**

- Pressing the SPD/MACH switch over pushbutton switches the SPD/MACH display from the selected SPD to the present MACH or from the selected MACH to the present SPD.
- At 25,400 ft an automatic switching occurs from SPD to MACH in climb and from MACH to SPD in descent.
- If a SPD or MACH has been PRE SET, the automatic SPD/MACH switching occurs at the corresponding air speed/Mach number cross-over altitude.

**(3) SPD/MACH selector knob**

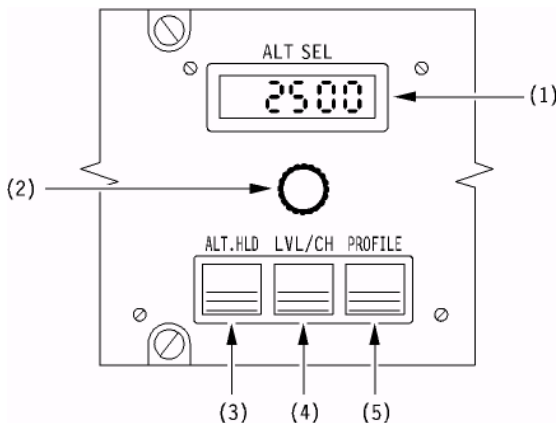
- Turning the SPD/MACH setting knob selects the Speed/Mach target value (1 kt/0.01 Mach per click).
- The SPD/MACH selection is confirmed by cross checking the blue index on the Primary Flight Display (PFD) speed scale.
- Pressing the knob illuminates the PRE SET light, and allows a speed or Mach to be preset. If PRE SET is already illuminated, pressing the knob again cancels the preset speed/Mach (PRE SET light extinguishes).
- Pulling the knob while PROFILE mode is engaged, causes a manual reversion to selected modes :
  - if in level flight, PROFILE mode disengages and SPD mode (A/THR) and ALT mode (AP/FD) engage. The speed/Mach window synchronizes on the present aircraft speed or Mach.
  - if in climb or descent, PROFILE mode disengages and LVL/CH engages. The speed/Mach window synchronizes on the present aircraft speed/Mach.

**(4) PRE SET light**

- The PRE SET light illuminates when SPD/MACH setting knob is pressed. The speed or Mach set in the SPD/MACH window is the preset value (not the active speed or Mach)

**(5) A/THR pushbutton switch**

- Pressing the A/THR pushbutton switch engages or disengages the A/THR.
- The three green bars illuminate when the A/THR is engaged.


**(4) LVL/CH pushbutton switch**

- Pressing the LVL/CH pushbutton switch engages or disengages the LVL/CH mode.

**(5) PROFILE pushbutton switch**

- Pressing the PROFILE pushbutton switch engages or disengages the PROFILE mode.

**(1) ALT SEL window**

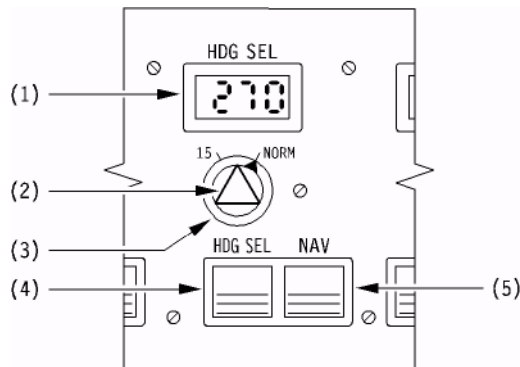
- Displays the selected target altitude.

**(2) ALT SEL selector knob**

- Pressing the knob changes the altitude setting increment per click from 1000 ft to 100 ft. Pressing the knob a second time reverts to 1000 ft increment.
- Turning the ALT SEL selector knob selects the altitude target value.
- The ALT SEL selection is confirmed by cross checking the blue target altitude on the Primary Flight Display (PFD) altitude scale.
- Pulling the knob, if a new target altitude is selected in the ALT SEL window, results in the following :
  - LVL/CH engages,
  - If in PROFILE mode, a climb or descent is initiated,
  - If already in LVL/CH or PROFILE climb or descent, pulling this knob has no effect.

**(3) ALT. HLD pushbutton switch**

- Pressing the ALT. HLD pushbutton switch engages an immediate level-off (ALT green on FMA).

**Autoflight System**
**Flight Control Unit (FCU)**

**(1) HDG SEL window**

- Displays the selected target heading.

**(2) HDG SEL selector knob (inner knob)**

- Pushing the HDG SEL selector, if HDG/S mode is not engaged, synchronizes the heading in the HDG SEL window with the present aircraft heading.

If HDG/S mode is already engaged, pushing the selector knob has no effect.

- Pulling the knob, if HDG/S is not engaged, engages the HDG/S mode. If HDG/S mode is already engaged, pulling the knob has no effect.
- Turning the knob selects the desired target heading (1° per click)
- The HDG/S mode engagement is confirmed by the FMA annunciation (HDG/S green) and by the illumination of the HDG SEL pushbutton on the FCU.
- The HDG SElection is confirmed by cross-checking the position of the blue index (or the blue heading value) on the Navigation Display (ND) heading scale.

**(3) Bank Angle Limit selector (outer knob)**

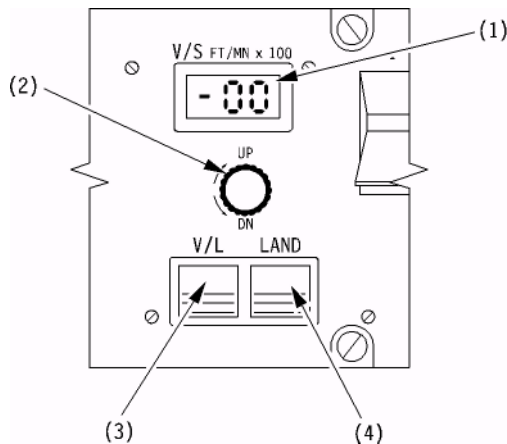
- The outer knob selects the bank angle limit :
  - NORM position : the bank angle is limited to 30° in HDG/S mode and to 25° in VOR mode.
  - 15 position : the bank angle is limited to 15° (this limitation is active only in HDG/S and VOR modes).

**(4) HDG SEL pushbutton switch**

- Pressing the HDG SEL pushbutton switch engages or disengages the HDG/S mode.

**(5) NAV pushbutton switch**

- Pressing the NAV pushbutton switch engages or disengages the NAV mode.

**Autoflight System**
**Flight Control Unit (FCU)**

**(1) V/S window**

- Display the selected vertical speed target.
- " --- " is displayed if V/S mode is not engaged.

**(2) V/S selector knob**

- Turning the V/S selector knob selects the desired vertical speed target (100 ft/mn per click).
- Pushing the knob has no effect.
- Pulling the knob engages the V/S mode. If V/S mode is already engaged, pulling the knob has no effect.
- If the V/S mode is not engaged, turning this knob initially synchronizes the displayed V/S with the present aircraft V/S, but does not engage the V/S mode.

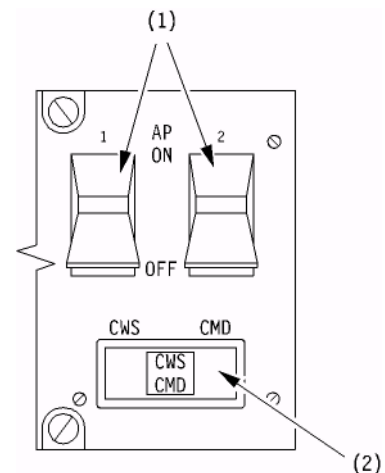
If the V/S mode is not engaged by pulling the V/S knob or by deselecting the engaged vertical mode within 10 seconds, the displayed V/S is cleared from the V/S window.

**(3) V/L pushbutton switch**

- Pressing the V/L pushbutton switch arms or engages VOR or LOC mode.

**(4) LAND pushbutton switch**

- Pressing the LAND pushbutton switch arms or engages the GS and LOC modes for an ILS approach.

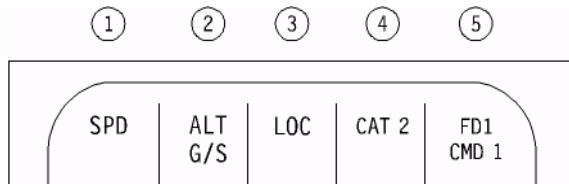

**(1) AP engagement levers**

- Setting an AP engagement lever to ON allows to engage the corresponding AP, provided the AP engagement conditions are met.
  - ON : AP is engaged.
  - OFF : AP is disengaged.
- Only one AP lever can be engaged at a time, except when LAND mode is armed on the FCU or in GO AROUND mode, then both AP can be engaged simultaneously in CMD.

**(2) AP CWS/CMD switch-over pushbutton**

- Pressing the AP CWS/CMD pushbutton switches the AP from CWS to CMD mode or from CMD to CWS. The corresponding light (CWS or CMD) illuminates to indicate the selected mode.



**Autoflight System**
**Flight Mode Annunciator (FMA)**
**FLIGHT MODE ANNUNCIATOR (FMA)**
**FMA design principle and display :**

**FMA colour codes :**

- The following colour codes are used to indicate the status of the AP/FD and A/THR modes, on the FMA :



- The FMA is the main interface between the flight crew and the AFS in order to :
  - confirm the engagement of the selected A/THR and AP/FD modes (together with the illumination of the corresponding pushbutton switch on the FCU),
  - confirm, at any time, the status of the A/THR and AP/FD modes (e.g. in order to identify and callout any mode transition or reversion).
- Together with the FCU, the FMA provides feedback to the flight crew regarding the AFS operation :
  - flight crew **inputs** to AFS : **FCU** (and FMS CDU when in PROFILE / NAV mode),
  - **AFS feedback** to flight crew : **FMA** (together with other **PFD** and **ND** data).
- The FMA is divided into 5 separate columns :
  - column 1 : **ATS modes**,
  - column 2 : **AP/FD vertical modes**,
  - column 3 : **AP/FD lateral modes**,
  - column 4 : **Category of the landing capability:**  
CAT1 / CAT2 / CAT3
  - column 5 : **FD engagement status :**  
FD1 / FD2 (first line)  
  
**AP mode engagement status :**  
CMD1 / CMD2 / DUAL / CWS1 /  
CWS2 (Second line).
  - AP/FD **combined modes** are displayed in columns 2 and 3, used as a single column.

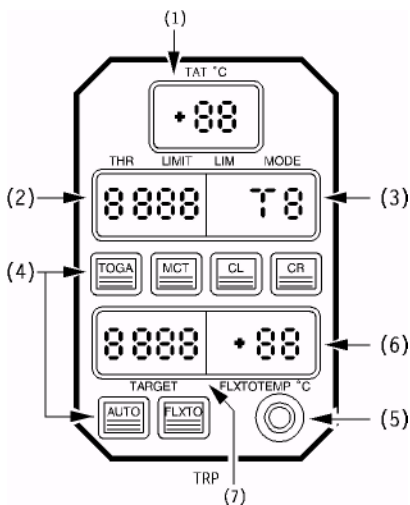
In column 1, second line, blue is used for THR and A/THR and amber is used for MAN THR.

In column 5, second line, white is used for CMD1 / CMD2 / DUAL and amber for CWS1 / CWS 2.

## Autoflight System

## Trust Rating Panel (TRP)

### THRUST RATING PANEL (TRP)



#### (1) TAT (Total Air Temperature) window

- Displays the TAT.
- Dashes are displayed in case of TAT computation failure.

#### (2) THR LIMIT window

- Displays the thrust limit value for the mode displayed in the LIM MODE window.
- The value is N1 (GE engine) or EPR (PW engine).
- Dashes are displayed in case of :
  - thrust limit computation failure,
  - TRP failure.

#### (3) LIM MODE window

- Displays the thrust limit mode selected either manually or automatically :
  - TOGA, MCT, CL or CR.

#### (4) Thrust limit mode selection keys

- Pressing a key selects the corresponding thrust limit mode.
- When a key is pressed, the three bars illuminate green.

- The selection of a new mode deselects the mode which was previously selected.

#### (5) FLX TO TEMP selector knob

- Turning the FLX TO TEMP selector knob selects a flexible temperature (assumed temperature) for reduced takeoff thrust (1°C per click).

- If a FLEX TO TEMP lower than the TAT is selected, the TARGET window becomes dashed.

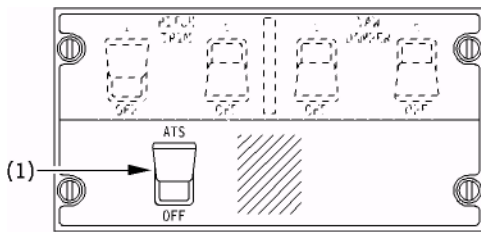
#### (6) FLX TO TEMP °C window

- Indicates the selected flexible temperature (in °C).

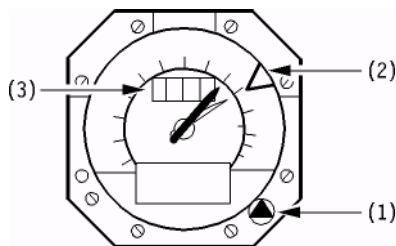
#### (7) TARGET window

- Displays the thrust target value.
- The displayed value is expressed in terms of N1 (GE engine) or EPR (PW engine) and depends on the flight phase and mode selection, as summarized hereafter :

TARGET window	Condition
FLX TO thrust	For takeoff, if FLX TO key is pressed and a FLX TO TEMP (greater than TAT) is selected
Thrust limit (as in THR LIMIT window)	A/THR engaged in THR mode A/THR not engaged and AP/FD in LVL/CH climb or SRS
Blank	A/THR engaged in SPD/MACH mode A/THR is declutched
I-L-	In LVL/CH descent, in conjunction with RETARD mode engagement. In PROFILE descent, if FMS requires idle thrust
FMS target thrust	In PROFILE climb or descent
Dashes ( - - - )	In PROFILE cruise If a FLEX TO TEMP lower than TAT is selected

**ATS PANEL**

**(1) ATS arming lever**

- Up : The Autothrottle system (ATS) is armed.  
Lever remains latched up as long as ATS arming conditions are met.
- OFF : ATS is disarmed. Autothrottle functions are not available (including Alpha floor protection).

**N1 (GE) or EPR (PW) INDICATORS**


**Note :** For detailed description of the N1 (EPR) indicator, refer to the section **POWER PLANT - INDICATING**.

**(1) Thrust limit selector knob**

- Pressed in : normal position.
- Pulling and turning the knob selects manually the desired thrust limit value (if no TRP data is available).

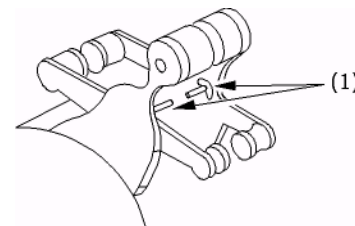
**(2) Thrust limit index (orange bug)**

- Indicates the THR LIMIT value displayed on the TRP or manually selected by the selector knob.

**Note :** In automatic mode (knob pressed in), the orange index is driven directly by the TCC and indicates zero in case of TCC failure.

**(3) Digital thrust limit indication**

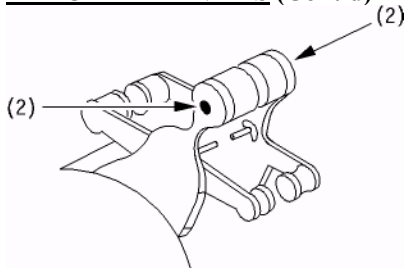
- Displays the thrust limit value only if the thrust limit is manually selected by pulling and turning the selector knob (1).
- In automatic mode (selector knob pressed), the counter is blank (covered).

**THROTTLE LEVERS**

**(1) Go-levers**

- Go-levers are located under and between the throttle levers,
  - With slats extended, triggering either go-lever results in the following :
    - **on ground (take-off initiation) :**  
AP/FD engages in SRS mode for vertical guidance and in RWY, HDG/S or HDG (depending on crew selection) for lateral guidance.  
A/THR engages in THR mode.
    - **in flight :**  
AP/FD engages in GO AROUND mode (combined mode associating the SRS mode for vertical guidance and the HDG mode for lateral guidance).  
A/THR engages in THR mode.
  - With slats retracted in flight, triggering either go-lever engages the THR L mode but does not change the engaged AP/FD vertical and lateral modes.

**Note :** If the A/THR - THR mode is engaged, triggering the go-levers has no effect.

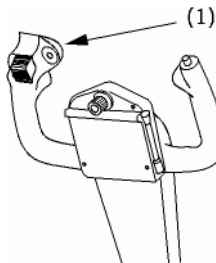
**THROTTLE LEVERS (Cont'd)**



**(2) A/THR or THR L instinctive disconnect pushbuttons**

- Pressing either one of the two red pushbutton switches disengages the A/THR or the THR L mode , if engaged.

**CONTROL WHEEL**



**(1) AP instinctive disconnect pushbutton**

- Pressing the AP instinctive disconnect pushbutton, on either control wheel, disengages the autopilot, if engaged.
- Pressing either AP instinctive disconnect pushbutton a second time cancels the AP disconnect warnings.

**ANGLE-OF-ATTACK, SELECTED SPEED AND THRUST LIMIT PROTECTION**

- The level of protection provided by the ATS-A/THR is summarized in the following table :

ATS LEVER	A/THR	FMA	PROTECTION LEVEL
Disarmed	-	blank	No protection
Armed	Disengaged	MAN THR	Alpha-Floor protection
Armed	Engaged	A/THR blue THR, SPD P.THR, P.SPD RETARD	Alpha-Floor protection  Selected speed protection Thrust limit protection

**Alpha-Floor protection**

- If the aircraft angle-of-attack exceeds a given value (as defined in the table hereafter), the ATS Thrust Latch mode engages (THR L annunciation on the FMA) in order to automatically apply the thrust limit (THR LIMIT), as selected on the TRP (unless the THR mode is already engaged).
- The Alpha-Floor protection is activated at an angle-of-attack which depends on the Slats/Flaps lever position :

S/F LEVER	ANGLE-OF-ATTACK
0/0	8°5
15/0, 15/15, 20/20	14°5
30/40	11°5

- The activation of the Alpha-Floor protection is not accompanied by an AP/FD nose down order (the engaged AP/FD vertical mode remains engaged with the associated pitch command).  
Crew action is necessary for pitch attitude recovery.
- Alpha Floor protection is available provided :
  - one ATS lever is armed,
  - the altitude is above 100 ft RA.
- The THR L mode can be disengaged by pressing either ATS instinctive disconnect pushbutton .

**speed protection**

- The speed protection is available, whenever a target speed is selected, to protect the aircraft against underspeed or overspeed :
  - **underspeed** : if a speed lower than VLS is selected on the FCU, the AFS maintains VLS,
  - **overspeed** : if a speed higher than V<sub>MAX</sub> is selected on the FCU, the AFS maintains V<sub>MAX</sub>,
- The FCU speed selection protection is available provided the ATS lever is armed and :
  - the FD is followed manually (AP OFF or engaged in CWS mode), or
  - the AP is engaged in CMD.

**Thrust limit protection**

- If the Thrust Limit Computation is available, the A/THR automatically limits the engine thrust to the thrust limit (THR LIMIT) value corresponding to the LIM MODE selected on the TRP.
- If the Thrust Limit Computation is not available (e.g. TCC failed), provided the N1 (GE engines)/ EPR (PW engines) limit is manually set on the N1/EPR indicators, the thrust limit protection remains available in A/THR SPD/MACH mode.

**WINDSHEAR WARNING AND GUIDANCE**

- The windshear detection system is operative :
  - at takeoff and go around : from the ground up to 1000 ft RA,
  - in approach : from 1000 ft RA down to 50 ft RA.
- If a windshear is detected, the windshear warning is triggered.
- If the slats are extended, when either go-lever is triggered, the AP/FD provides a specific vertical guidance (FD pitch bar command) for recovery.
- The windshear warnings consists in :
  - a red "WINDSHEAR" warning displayed in the sky part of the PFD (for 15 seconds minimum),
  - a voice "WINDSHEAR" warning repeated three times.

**Note 1: Windshear warnings can be tested by the ANN LT "TEST" or "AUTO TEST".**

**Note 2: When windshear warnings are triggered, GPWS warnings are inhibited.**

- The AP/FD vertical guidance (in SRS or GO AROUND mode progressively adopts the following survival strategy :
  - control of airspeed (selected speed + 10 kt) as long as a positive vertical speed is maintained,
  - control of altitude as long as airspeed is above stick-shaker speed,
  - control of speed above stick-shaker speed as long as required.

During recovery, a 21.5° maximum pitch attitude target may be commanded (instead of 17.5° in normal conditions).

**AP AUTOMATIC DISENGAGEMENT**

- When engaged in CMD, the AP automatically disengages if a force greater than a given value is applied on the control wheel in pitch (i.e. in an attempt to override the AP operation in pitch).
- For detailed information regarding the following functions and safety features, refer to the section AUTOPILOT - CMD mode :
  - Supervisory Control Wheel Operation,
  - AP actuator override,
  - AP automatic disengagement.

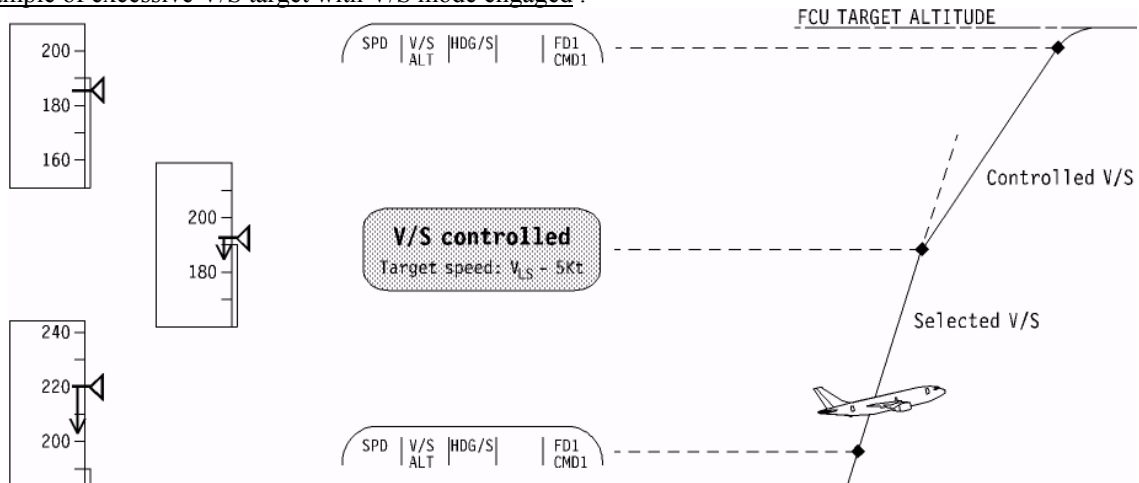


**SPEED PROTECTION IN V/S, LVL/CH, ALT\* OR PROFILE MODES**

- With the AP/FD engaged in V/S, LVL/CH, ALT\*, or PROFILE modes the speed protection protects the aircraft against :
  - **underspeed** in climb with a target speed down to **VLS - 5 kt.**
  - **overspeed** in descent with target speed up to **VMAX + 4 kt.**
- The authority of the guidance in the protection has been increased to ensure a better protection against a too large speed excursion out of the normal flight envelope (in case of high headwind or tail wind gradients, for example).
- The guidance system authority is limited to a level off. This means that if the thrust available is too low to maintain a vertical speed in climb at **VLS - 5 kt**, the aircraft will stop climbing, but will not descend to maintain the speed. Thus, the speed will slowly decrease. Similarly, if the requested vertical speed cannot be maintained due to high speed, the aircraft will reduce the vertical speed to maintain **VMAX+4kt**. This may lead to a level off.
- If the target speed of **VLS - 5 kt** cannot be maintained, the autopilot will disconnect at **VLS - 10 kt**. Before AP disconnection, the speed protection has been effective during several seconds and has contributed to reduce the pitch attitude and the deceleration rate. The aircraft is then at a reasonable pitch attitude with a slow deceleration rate and is easy to recover manually.

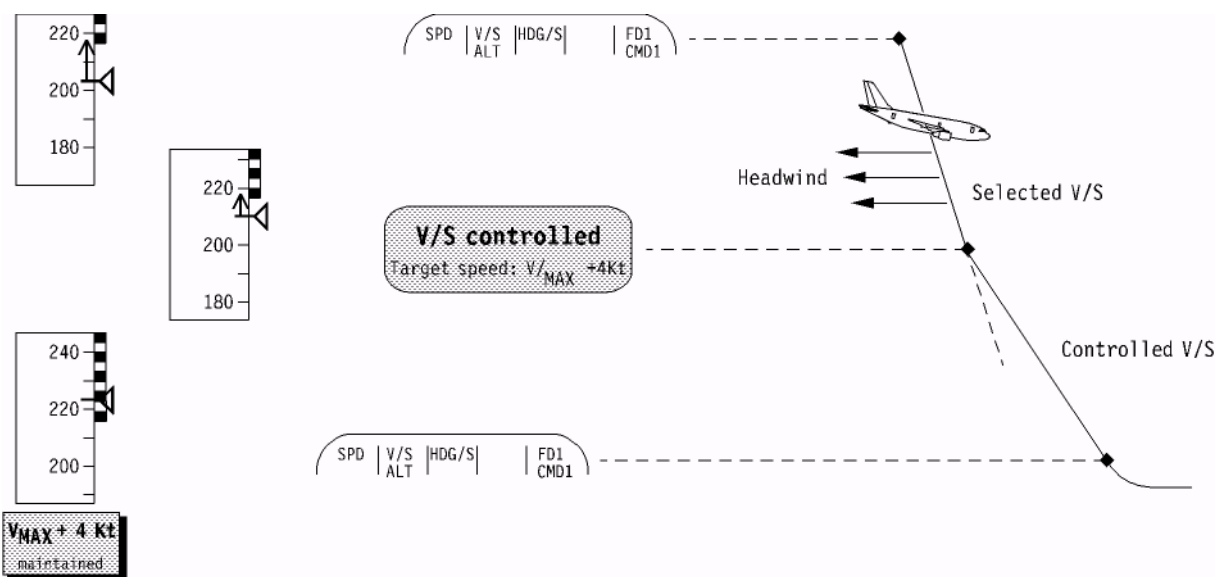
**Note : When flying manually, the flight director gives orders to follow the speed protection guidance. The crew reaction must be firmer than in normal flight, without being aggressive as the expected g-load variation can go up to 0.3 g.**

- Example of excessive V/S target with V/S mode engaged :



At low speed, in ALT\* or V/S mode, if the AFS cannot maintain the requested vertical speed (selected V/S), the aircraft will depart from the commanded trajectory as the AP/FD gives orders to maintain a vertical speed (controlled V/S) which avoid flying below  $V_{LS} - 5kt$ .

- Example of headwind in approach with V/S mode engaged :



If the AFS cannot maintain the requested vertical speed, the AP/FD will avoid speed or Mach overshoot in case of high acceleration (strong headwind).

**Note :** When reaching  $V_{MAX}$ , the target speed guidance value is about the same as the overspeed warning. The overspeed warning may be activated when stabilized on the guidance target speed or in case of turbulence.

**FUNCTION**

- The Auto Throttle System (ATS) provides the following functions :
  - Computation (TCC) and display (TRP) of the thrust limit for the selected limit mode,
  - Autothrust (A/THR) to acquire and maintain :
    - a selected speed or Mach number, or
    - a selected thrust limit or target thrust, or
    - the idle thrust.
  - Angle-of-Attack protection ( $\sigma$ -floor protection) by applying automatically the thrust limit corresponding to the limit mode selected on the TRP (Thrust Latch mode - THR L).

**ENGAGEMENT AND OPERATION**

- Provided the ATS is electrically supplied, the TCC computes the thrust limit for each thrust limit mode.
- The ATS is armed by arming the ATS engage lever. The ATS lever can be armed provided :
  - The TCC is operative,
  - At least 1 FAC is operative,
  - At least 1 ADC is operative.
- Provided the ATS is armed, the THR L protection is available and the A/THR can be engaged.
- When A/THR is engaged, the engine thrust is automatically controlled (as a function of the active AP/FD mode).
- When A/THR is not engaged, the engine thrust must be manually controlled (as directed by the amber MAN THR annunciation on the FMA).

**FMA INDICATIONS**

- The ATS mode status is displayed in the first column of the FMA.

**ATS CONNECTION TO THROTTLE LEVERS**

- The ATS system consists of :
  - a computation (TCC) and display (TRP) part, in order to compute and display the applicable thrust limit or thrust target,
  - a driving part in order to move the throttle levers which, in turn, transmit the thrust command to the engines.
- The ATS driving part consists of the following electro-mechanical components :
  - a single electrical servo-motor (ATS actuator),
  - two coupling units (clutches).
- With any A/THR mode or with THR L mode engaged, both throttle levers are driven at a constant speed rate.

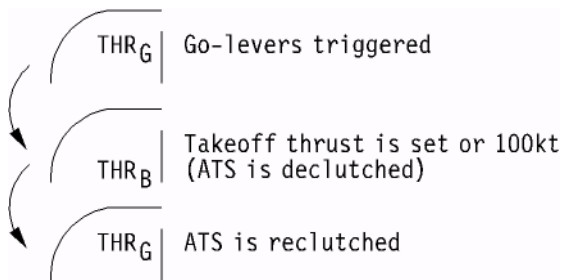
The throttle levers speed rate (in  $^{\circ}$  / second) depends on the flight phase and AP / FD mode as follows :

- In GO AROUND (whether engaged in flight or after touchdown) :  $8^{\circ}$  / second,
  - In any other mode :  $3^{\circ}$  / second.
- As soon as the thrust command is reached, the ATS either declutches the coupling units or stops the actuator, as follows :
    - **At takeoff :**
      - In order to enable each engine to reach the required takeoff thrust the ATS actuator operates until both engines have reached the takeoff thrust.
      - Coupling units are declutched individually, when the associated engine reaches the takeoff thrust.
      - When both engines have reached the takeoff thrust or at 100 kt at the latest, both coupling units are declutched.
      - The ATS declutch is annunciated on the FMA (THR blue).

**Autoflight System**
**General**

- The ATS is reclutched (both coupling units reclutched) when either :
  - \* the landing gear is selected UP, or
  - \* a new THR LIMIT mode is selected on the TRP.

- The FMA modes transition sequence is as follows:



- The ATS declutch during the takeoff phase is intended to prevent any uncommanded thrust change during the takeoff roll and initial climb.

**- In flight :**

- During climb (A/THR - THR or P.THR mode) or cruise (A/THR - SPD or P.SPD mode), the coupling units remain clutched but the ATS actuator stops operating as soon as the leading engine reaches the thrust target.

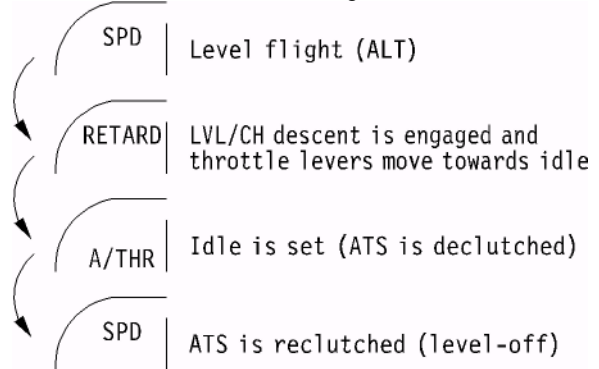
The above operating logic applies to a thrust increase as well as to a thrust reduction.

- In LVL CH descent (A/THR - RETARD mode), the ATS coupling units are declutched simultaneously when idle is set (A/THR blue annunciation on FMA).

The ATS coupling units are reclutched when either :

- reaching the selected altitude, (ALT\* mode engagement), or
- another vertical mode is selected.

The FMA modes transitions sequence is as



- With A/THR engaged in any mode or with THR L mode engaged (e.g. following the activation of the angle-of-attack protection), when moving either throttle lever manually :

- the autothrottle coupling unit temporarily declutches to enable manual throttle lever adjustment (e. g. in case of thrust asymmetry requiring a throttle stagger),
- when the throttle lever is released, the autothrottle coupling unit reclutches,
- the resulting throttle stagger, if any, is maintained.

**THRUST LIMIT COMPUTATION**

- The thrust limit value for the thrust limit mode selected on the TRP is computed by the TCC in N1 (for GE engine) or EPR (for PW engine). The value is displayed on the TRP THR LIMIT window as well as on the N1 or EPR indicators (amber bug).
- The thrust limit is computed for all flight phases and is permanently displayed.
- The following thrust limit modes can be selected on the TRP:
  - TOGA      Take-Off/Go-Around thrust,
  - MCT      Maximum Continuous Thrust
  - CL        Maximum Climb thrust,
  - CR        Maximum Cruise thrust,
  - FLX TO   Flexible (reduced) Take-Off thrust,
  - AUTO     FMS selects the Thrust Limit mode (MCT, CL or CR) and Target Thrust.

- When the TCC/TRP are initially powered, the TOGA mode is automatically selected.
- The Thrust Limit for the selected mode is continuously computed, and will change as conditions require (airspeed, temperature, altitude, etc...).
- To compute the thrust limit, the TCC uses data from the ADC (e.g.: altitude, speed/Mach, TAT) and bleed air status (e.g.: anti-ice valves open or closed, packs on or off).

**THRUST LIMIT SELECTION:**

<b>Illuminated key</b>	<b>LIM MODE</b>	<b>Manual selection</b>	<b>Automatic selection</b>
TOGA	TO	On ground only, by pressing the TOGA key.	On ground when aircraft is electrically powered.
FLX TO	TO	On ground only, by pressing the FLX TO key.	Not applicable.
TOGA	GA	In flight, by pressing the TOGA key.	In flight, when S/F lever is moved from 0/0 to 15/0.
MCT/CL/CR	MCT/CL/CR	By pressing MCT, CL or CR key.	Not applicable.
AUTO	MCT/CL/CR	Not applicable	When PROFILE mode engages, if altitude is greater than 1500 ft RA.
AUTO	GA	Not applicable	In flight, upon slats extension, if at least 1 AP/FD is engaged in PROFILE mode.

**Autoflight System****Auto Thrust (A/THR) - General****FUNCTION**

- The A/THR :
  - acquires and maintains the selected thrust limit or thrust target,
  - acquires and maintains the selected speed or Mach number,
  - retards the throttles to idle during initial descent.
- The A/THR controls the engine thrust in response to inputs from the FCU or FMS.

**ENGAGEMENT AND OPERATION**

- Provided the ATS lever is armed, the A/THR can be engaged :
  - manually, by pressing the A/THR pushbutton switch,
  - or
  - automatically, at takeoff or for go-around by triggering either Go-lever.

On the ground, it is not possible to engage the A/THR by pressing the A/THR pushbutton switch.

- The A/THR can be engaged in :
  - THR mode,
  - SPD/MACH mode,
  - RETARD mode.
- When the A/THR is engaged, the A/THR pushbutton switch illuminates and the engaged A/THR mode is displayed on the FMA.

**DISENGAGEMENT**

- A/THR disengages (but the ATS remains armed) :
  - **in flight** :
    - when the A/THR pushbutton switch is pressed,
    - or
    - when pressing either instinctive disconnect pushbutton
    - or
    - when THR L mode engages, following the activation of the angle-of-attack protection.
  - **on the ground** :
    - when the ground spoilers are extended (at landing or in case of rejected takeoff),
    - or
    - when one engine is in reverse thrust,
    - or
    - when both engines are at idle, unless GA mode is engaged,
    - or
    - if MCT, CL, or CR mode is selected on the TRP, with IAS below 60 kt.
- When the A/THR is disengaged, the thrust must be manually controlled.  
MAN THR is annunciated in amber on the FMA, for crew awareness.



**Autoflight System**
**A/THR Modes**
**THRUST MODE**
**FUNCTION**

- The thrust mode acquires and maintains :
  - the thrust limit selected on the TRP (THR mode), or
  - the FLEX TO target thrust (THR mode), or
  - the target thrust computed by the FMS (P. THR mode).
- In THR (P.THR) mode, the A/THR acquires and maintains the THR LIMIT (TARGET) displayed on the TRP.

The speed target selected on the FCU (managed by the FMS) is maintained by the AP/FD by adjusting the pitch attitude, using the elevators.

**ENGAGEMENT AND OPERATION**

- The THR mode automatically engages with the AP/FD SRS, SPD (LVL/CH climb) and GO AROUND modes.
- The P.THR mode automatically engages with the AP/FD PROFILE mode (P.CLB and initial phase of P.DES).
- In flight, in THR mode, the A/THR compares the thrust limit or target thrust with the engine which exhibits the higher thrust. When this engine reaches the target thrust, both throttle levers stop moving.

**CAUTION**

In case of a throttle lever jamming, whenever the ATS commands a thrust change, only the free throttle lever moves leading to a thrust asymmetry and to a possible flight path deviation.

- When a thrust reduction is commanded, the ATS commands the free throttle lever to retard, until the idle position (in the worst case).
- When a thrust increase is commanded, the ATS commands the free throttle lever to advance until the target thrust is reached.

**Cont'd**
**Cont'd**

Should such a throttle levers and thrust asymmetry be observed, the A/THR must be disconnected (using the instinctive disconnect pushbutton switch) and symmetric thrust must be restored manually.

Refer to the THROTTLE (LEVER) JAM procedure for detailed procedural recommendations.

**SPEED/MACH MODE**
**FUNCTION**

- The speed/Mach mode acquires and maintains :
  - the speed or Mach number target selected on the FCU (SPD or MACH mode), or,
  - the target speed or Mach number computed by the FMS (P.SPD mode).

**ENGAGEMENT AND OPERATION**

- SPD/MACH mode automatically engages and disengages in association with AP/FD V/S, ALT, GS or LAND mode.
  - P.SPD mode automatically engages and disengages in association with AP/FD PROFILE mode (P.ALT).
- If a speed is selected on the FCU with the SPD mode engaged, pressing the SPD/MACH switch-over pushbutton causes the present Mach to be displayed. The engaged mode also changes to MACH. Switch-over from Mach to speed is also possible.
- With AP/FD OFF (e.g. manual flying using FPV), the A/THR can be engaged but only in SPD/MACH mode.

**RETARD MODE****FUNCTION**

- The RETARD mode retards the throttle levers to idle (5° throttle lever angle).

**ENGAGEMENT AND OPERATION**

- The RETARD mode engages :
  - in LVL/CH descent, until the throttles levers reach the idle position (then the ATS coupling units are declutched and A/THR blue is annunciated on the FMA),
  - in FLARE mode (at 30 ft),
  - in PROFILE descent (P.DES).

**Note : In PROFILE descent, RETARD green remains displayed as long as idle thrust is required.**

**Note : When RETARD is engaged with LVL/CH or PROFILE, the throttles can be manually stopped at any desired intermediate position.**

- When the throttle levers reach idle, or if levers are manually stopped while retarding, RETARD mode disengages and the ATS declutches (A/THR blue on the FMA).

**Autoflight System**
**Thrust Latch (THR L) Mode**
**FUNCTION**

- The Thrust Latch (THR L) mode acquires and maintains the thrust limit (THR LIMIT) selected on the TRP.
- The THR L mode is primarily associated with the activation of the angle-of-attack protection (Alpha-Floor).

**ENGAGEMENT AND OPERATION**

- Provided that the ATS lever is armed, the THR L mode automatically engages either,
  - if the Alpha-Floor protection is activated,
  - or
  - if the go-levers are triggered in flight, with slats retracted.

**Note:** if slats are extended, triggering the go-levers engages the AP/FD- GO AROUND mode and the A/THR - THR mode.

- THR L engagement is not possible if the A/THR is engaged in THR mode (indeed, the thrust limit is already commanded and set).
- THR L engagement :
  - **does not change the engaged AP/FD vertical mode** (i.e. no angle-of-attack and speed recovery vertical guidance is associated to the THR L mode), and
  - **disengages the A/THR.**
- THR L engagement is indicated on the FMA :



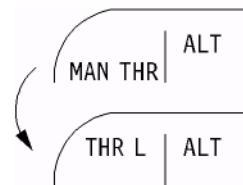
- THR L is green and **steady** if THR L is engaged by the **Alpha-Floor protection**, and flashes when the aircraft exits the Alpha-Floor condition.
- THR L is green and **flashing** if THR L is engaged by the in-flight activation of **go-levers** with slats retracted.

**DISENGAGEMENT**

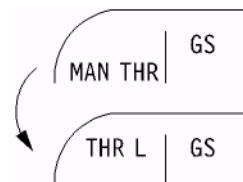
- THR L can be disengaged :
  - by pressing either ATS instinctive disconnect pushbutton (A/THR can then be re-engaged, when desired),
  - or
  - by pressing the A/THR pushbutton (to re-engage A/THR).

**MODE TRANSITIONS**

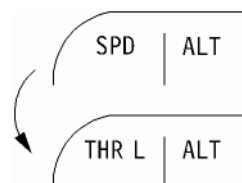
- Depending on the flight phase, the following typical mode transitions can be observed :
  - in level flight with manual thrust, if alpha-floor is activated :



- in glide slope tracking with manual thrust, if alpha-floor is activated :



- if go-levers are triggered with slats retracted :



**Autoflight System**
**Response to Peripheral Equipment  
Failure**

<b>EQUIPMENT LOST</b>	<b>ATS ARMED, A/THR or THR L ENGAGED</b>
Engine 1 or 2	No effect.
FADEC (MODE FAULT)	ATS disarms and cannot be re-armed.
TROTTLE FAULT (loss of both throttle lever angle signals)	ATS disarms and cannot be re-armed.
ADC 1	ATS disarms. ADC 2 takes over automatically and ATS can be re-armed.
ADC 1 and 2	ATS disarms, re-arming is not possible.
FAC 1 or 2	No effect.
FAC 1 and 2	ATS disarms, re-arming is possible.
Radio Altitude 1 and 2	A/THR RETARD mode does not engage at 30 ft for flare.
FCU	ATS disarms. ATS re-arming is possible. A/THR re-engagement is not possible. THR L mode is available (by go-levers activation, in clean configuration).
FMC 1 or 2	ATS disarms upon AP/FD disengagement if the master FMC fails. ATS can be re-armed.

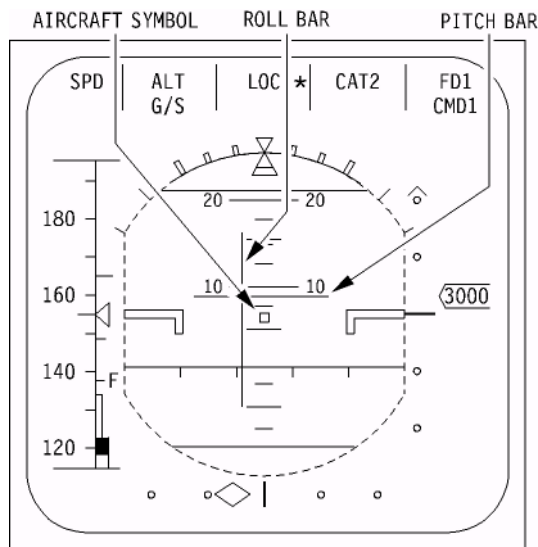
<b>EQUIPMENT LOST</b>	<b>ATS ARMED</b>	
	<b>A/THR in SPD/MACH mode</b>	<b>• A/THR in THR mode, or • THR L engaged</b>
IRS 1	ATS disarms if SPD/MACH mode is engaged. ATS re-arming and A/THR re-engagement is possible after ATT/HDG switching to SYS3.	No effect.
TRP	No effect, provided the thrust limit is set manually on the thrust indicators.	ATS disarms. ATS can be re-armed but A/THR cannot be re-engaged.
TCC - Thrust limit computation	No effect.	ATS disarms.

**Autoflight System**
**Flight Director**
**FUNCTION**

- The Flight Director (FD) provides vertical and lateral guidance in manual flying as well as with an AP engaged in CWS.

**OPERATION**

- The FD includes :
  - the pitch command bar (horizontal bar),
  - the roll command bar (vertical bar).
- Pitch and roll bar positions indicate the pitch and roll **corrections** to be applied to acquire and maintain the selected or computed flight path.



- When a bar is centered on the aircraft symbol, there is no more correction to be applied on this axis.
- If the FD bars are not followed on purpose, it is recommended to switch OFF both FD.

**CAUTION**

In LVL/CH descent, if a level-off is performed before capturing the target altitude (pitch bar not followed), the ATS remains declutched with thrust set at idle.

A pilot action is then required for thrust setting (engagement of ALT mode or manual thrust control).

**FD ENGAGEMENT CONDITIONS**

- The FD 1 and 2 are engaged and displayed on the PFD provided the following conditions are met :

FD 1	FD 2
- FD/FPV 1 switch ON - FCC 1 operative - ADC 1 operative - FAC 1 or 2 operative - IRS1and(2or3)operative - FCU operative - Landing gear data available	- FD/FPV 2 switch ON - FCC 2 operative - ADC 2 operative - FAC 1 or 2 operative - IRS 2and(1or3) operative - FCU operative - Landing gear data available

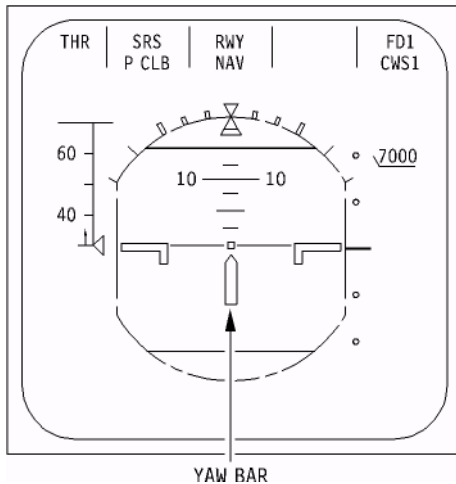
- On the ground, FDs initially engage in the basic modes (V/S and HDG).

**FD BARS DISPLAY**

- FD bars can be cleared from the PFD display :
  - by switching the FD/FPV to OFF,
  - by selecting the FPV display.
- With no AP engaged or with AP engaged in CWS, if FD bars are cleared or if FPV is selected :
  - the A/THR can be used in SPD mode only,
  - on the FMA, columns 2 and 3 are blank.
- With AP engaged in CMD, if FD bars are cleared or if FPV is selected, the FMA does not change.

**YAW BAR**

- A yaw bar (vertical arrow) is automatically displayed instead of the FD roll bar :
  - at takeoff when the RWY mode engages,
  - at landing in FLARE mode, when passing 30 ft, and in ROLL OUT mode.



- The guidance provided by the yaw bar depends on the flight phase (AP/FD lateral mode) as follows :
  - at takeoff (RWY mode) : guidance along the runway center line up to 30 ft, using the LOC signal,
  - at landing (FLARE mode) : guidance for alignment with the runway center line.
  - during ROLL OUT mode : guidance to recover (as required) and keep the runway centerline.

**FD FAILURE**

- If any of the FD display conditions is lost (except the FD/FPV switch position), the associated FD disengages, and :
  - The affected FD bars disappear,
  - A red "FD 1" (or 2) message appears on the sky of the affected PFD.
- At the time of the FD failure, the associated FMA is :
  - cleared, if no AP is engaged,
  - cleared, if the associated AP was engaged (this AP disengages simultaneously),
  - not affected, if the AP opposite to the failed FD is engaged (for example, FD 1 failed with AP 2 engaged).

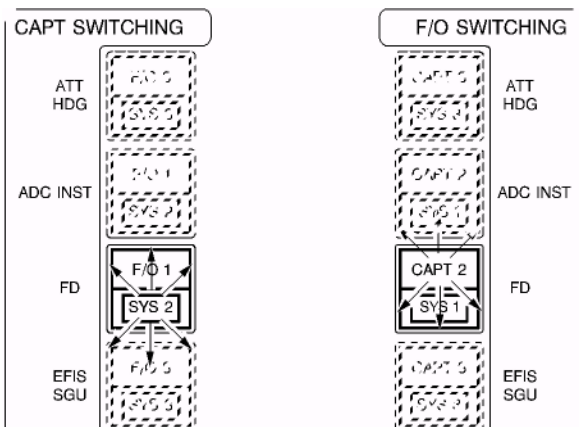
**Autoflight System**
**Flight Director**
**FD SWITCHING**

- In case of FD failure, the remaining FD orders can be displayed on both PFD simultaneously.
- In case of FD 1(2) failure, the FD 2(1) orders can be displayed on the affected side by pressing the FD push button switch on the CAPT(F/O) SWITCHING panel.
- For example, in case of FD 1 failure, when the CAPT FD pushbutton switch is pressed :
  - SYS 2 illuminates white on the CAPT SWITCHING panel and,
  - CAPT/2 illuminates green on the F/O SWITCHING panel (this notifies the F/O that the captain is sharing FD 2).

**Note 1:** The initial configuration can be recovered by pressing the CAPT FD pushbutton switch a second time.

**Note 2 :** It is not possible to cross-display the FD commands: if the Captain has selected FD SYS 2, the F/O cannot select SYS 1 simultaneously.

Likewise, the CAPT cannot select FD SYS 2 if the F/O has already selected SYS 1.



- FD 2 commands are now displayed on both the F/O and CAPT PFD,
- "FD 2" (white) is displayed on both FMA,
- the red "FD 1" message is cleared from the CAPT PFD.



**Autoflight System**
**Autopilot - General**
**FUNCTION**

- The Autopilot (AP) can be engaged in two different modes :
  - Control Wheel Steering (CWS),
  - or
  - Command (CMD).
- In CWS mode, the pilot manually flies the aircraft and controls the pitch and roll flight controls through the AP actuators.  
The rudder is directly controlled by the pilot.  
The vertical and lateral guidance is provided by the FD bars.
- In CMD mode, the AP takes full automatic control of the aircraft in pitch, roll and yaw to follow the selected flight path. The yaw (rudder) is only controlled with slats extended.

**ENGAGEMENT CONDITIONS**

- The AP can be engaged in CWS or CMD provided the following conditions are met :

AP 1	AP 2
- flight/ground signal available	- flight/ground signal available
- Aircraft airborne since at least 4 s (*)	- Aircraft airborne since at least 4 s (*)
- Bank angle $\leq 45^\circ$	- Bank angle $\leq 45^\circ$
- FCC 1 operative - FCU operative	- FCC 2 operative - FCU operative
- Pitch, Roll, Yaw (*) AP actuators available	- Pitch, Roll, Yaw (*) AP actuators available
- ADC 1 operative	- ADC 2 operative
- FAC 1 or 2 operative	- FAC 1 or 2 operative
- IRS1 and (2 or 3) operative	- IRS2 and (1 or 3) operative
- Pitch Trim 1 or 2 engaged	- Pitch Trim 1 or 2 engaged
- Yaw Damper 1 or 2 engaged	- Yaw Damper 1 or 2 engaged
- Hydraulics : green and (blue or yellow) systems operative	- Hydraulics : yellow system operative

(\*) conditions not necessary for CWS mode.

- On the ground, with engines running, only CWS mode can be engaged.

When selected in flight, the AP directly engages in CMD mode. To engage the CWS mode, the CWS/CMD switch-over pushbutton must be pressed.

The pushbutton must be pressed a second time to revert to CMD mode.

- In CWS, only one AP can be engaged at a time.  
In CMD, two APs can be engaged in approach (after selection of LAND mode on FCU) and in go-around.
- If one AP is engaged, the engagement of the second AP disengages the first engaged AP (except in CMD after selection of LAND mode on the FCU or in GO AROUND mode).
- In case of AP change-over, the vertical and lateral modes engaged with the first AP remain engaged for the other AP.

**DISENGAGEMENT CONDITIONS**

- The AP can be manually disengaged by **pressing the AP instinctive disconnect pushbutton** (if both AP are engaged, both AP disengage simultaneously).

It is also possible to disengage the AP by setting the associated AP lever to the OFF position.

- When engaged in CMD, the AP automatically disengages if a force greater than a defined threshold is applied in pitch on the control column .
- The AP automatically disengages if any engagement condition is lost, except for the 45°-bank-angle condition.
- Disengagement of the AP simultaneously triggers :
  - the AP OFF warning on the PFD,
  - the aural warning (CAVALRY CHARGE).
  - the flashing of the two red AUTO LAND warning lights, if LAND green is annunciated on FMA and altitude is below 200 ft RA.

Visual and aural warnings can be cancelled by pressing either AP instinctive disconnect pushbutton.

**Note : At the time of the AP disengagement, the modes engaged for AP guidance remain engaged for FD guidance.**

**OPERATION**

- The Control Wheel Steering (CWS) mode enables manual flying through the AP (i.e. through the Flight Control Computer - FCC - and the AP pitch and roll actuators).

Yaw control is not concerned by CWS operation.

- When the AP is engaged in CWS, the present aircraft pitch attitude and bank angle are maintained.
  - The aircraft pitch attitude and bank angle can be changed by pilot inputs on the control column and control wheel.
- When CWS inputs are released, the new pitch attitude and bank angle are maintained.
- The CWS mode can be used for :
    - take-off and departure maneuvering,
    - approach and landing.
  - In CWS mode, the FD orders must be followed by the pilot in order to acquire and maintain the selected flight path and targets.
  - In CWS mode, the THS is controlled by the Electric Trim (rocking levers) or by the Autotrim (refer to chapter 1.09.13 - PITCH CONTROL) as follows :

- aircraft on the **ground** :

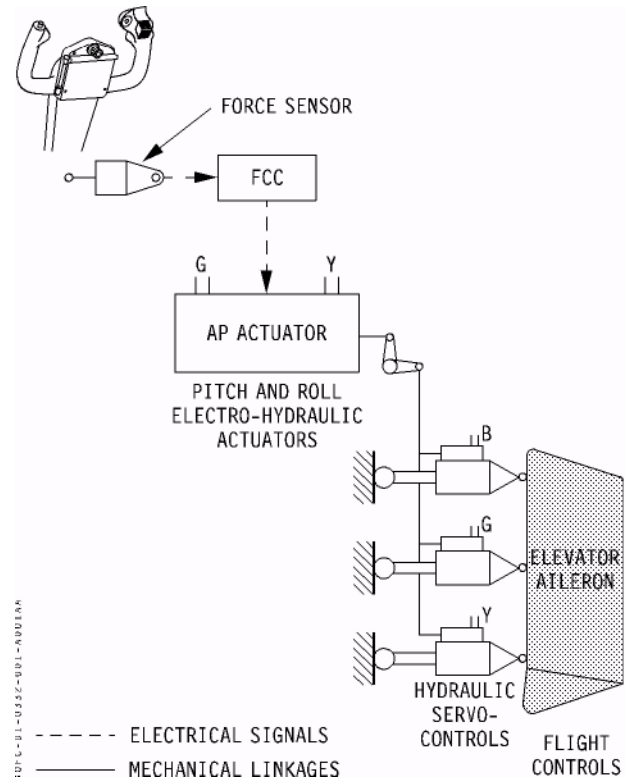
- the Electric Trim is active,
- the Autotrim is inhibited.

- aircraft in **flight** :

- the Electric Trim is active,
- the Autotrim is active 5 seconds after liftoff, but is inhibited whenever the Electric Trim (rocking levers) is used.

- **the Electric Trim has always priority over the Autotrim.**

- The inputs on the control column and control wheel are sensed by force sensors (dynamometric rods), processed by the FCC and transmitted to the AP pitch and roll actuators.



- In CWS mode, the control column and control wheel displacement reflects the deflection of the associated flight control surfaces (i.e. the result of the pilot input).
- In CWS mode, the Alpha trim protection is available (in clean configuration) as soon as a pitch force is applied on the control column and detected by the force sensors.

**ENGAGEMENT**

- The CWS mode can be used from brakes release to the complete aircraft stop at landing.
- The CWS mode is optimized for takeoff and arrival maneuvering, in cruise the use of CMD mode is recommended.
- The CWS mode can be engaged :
  - on the ground, by engaging one AP (the AP engages automatically in CWS mode),or
  - in flight, with AP engaged in CMD, by pressing the CWS/CMD switch-over pushbutton on the FCU.
- The engagement of the CWS mode is confirmed by the FMA annunciation (CWS 1 or 2) and by the illumination of the CWS light on the CWS/CMD switch-over pushbutton on the FCU.
- When in CWS mode, the second AP cannot be engaged.

**DISENGAGEMENT**

- The CWS mode can be disengaged by :
  - pressing the CWS/CMD switch-over pushbutton to engage the CMD mode,or
  - pressing the AP instinctive disconnect pushbutton on the control wheel to disengage the AP.
- In CWS, there is no automatic disengagement by stick force on the control column or control wheel (in CWS mode, the pilot cannot work against the AP but works through the AP).

**Autoflight System**
**Speed/Mach PRE SET**
**FUNCTION**

- The PRE SET feature allows the pilot to pre-select a speed or Mach number which will become the next target speed or Mach.

**Note :** PRE SET is not available in PROFILE mode.

**PRESETTING A SPEED OR MACH :**

- A speed or Mach can be preset by :
  - Pushing the SPD/MACH setting knob.

The PRE SET light illuminates (to indicate that the value displayed in the SPD/MACH window is a PRE SET value).

- Setting the desired preset speed or Mach in the SPD/MACH window.

**Note :** On the ground (i.e. during the cockpit preparation) the PRE SET function is operative only if the altitude selected on the FCU (ALT SEL window) is greater than the aircraft present altitude.

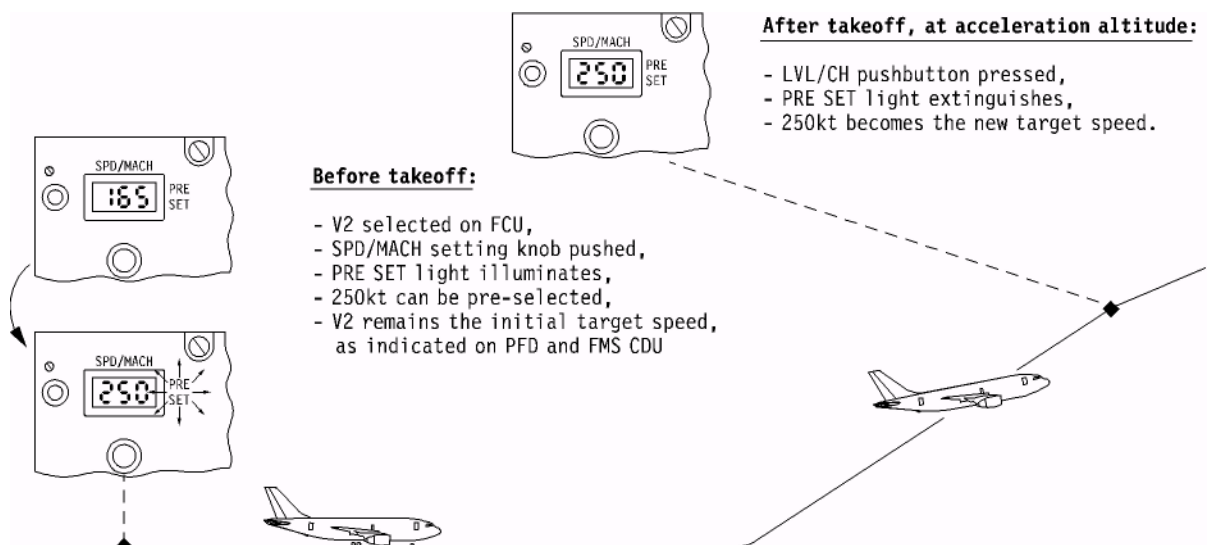
**ACTIVATION OF THE PRE SET SPEED OR MACH**

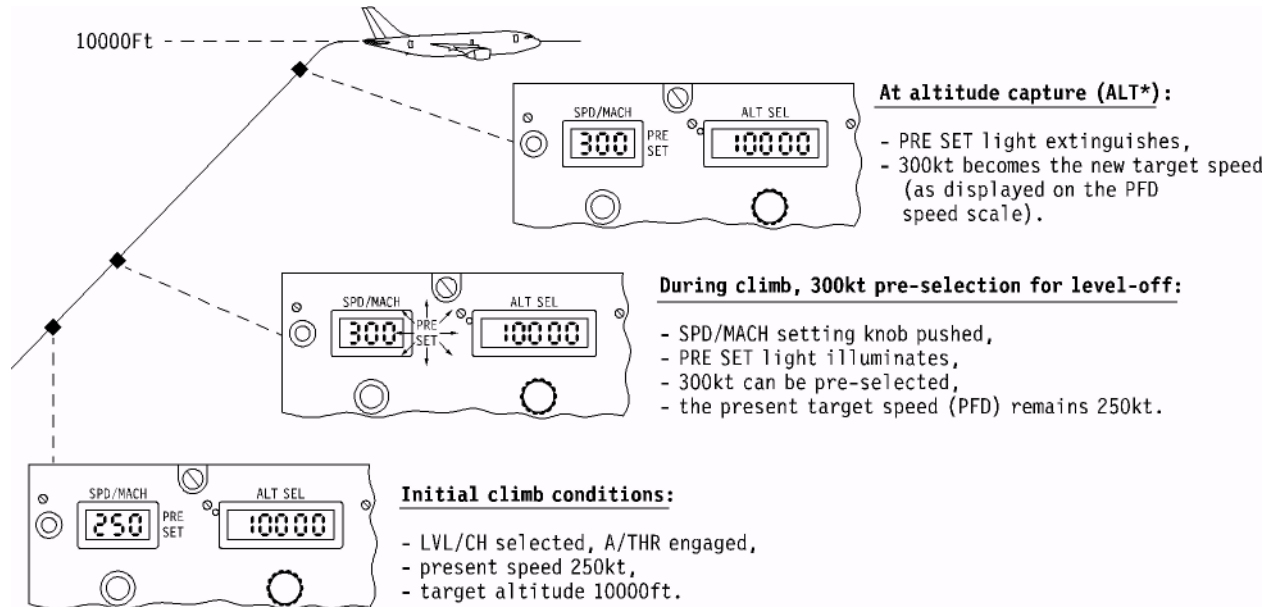
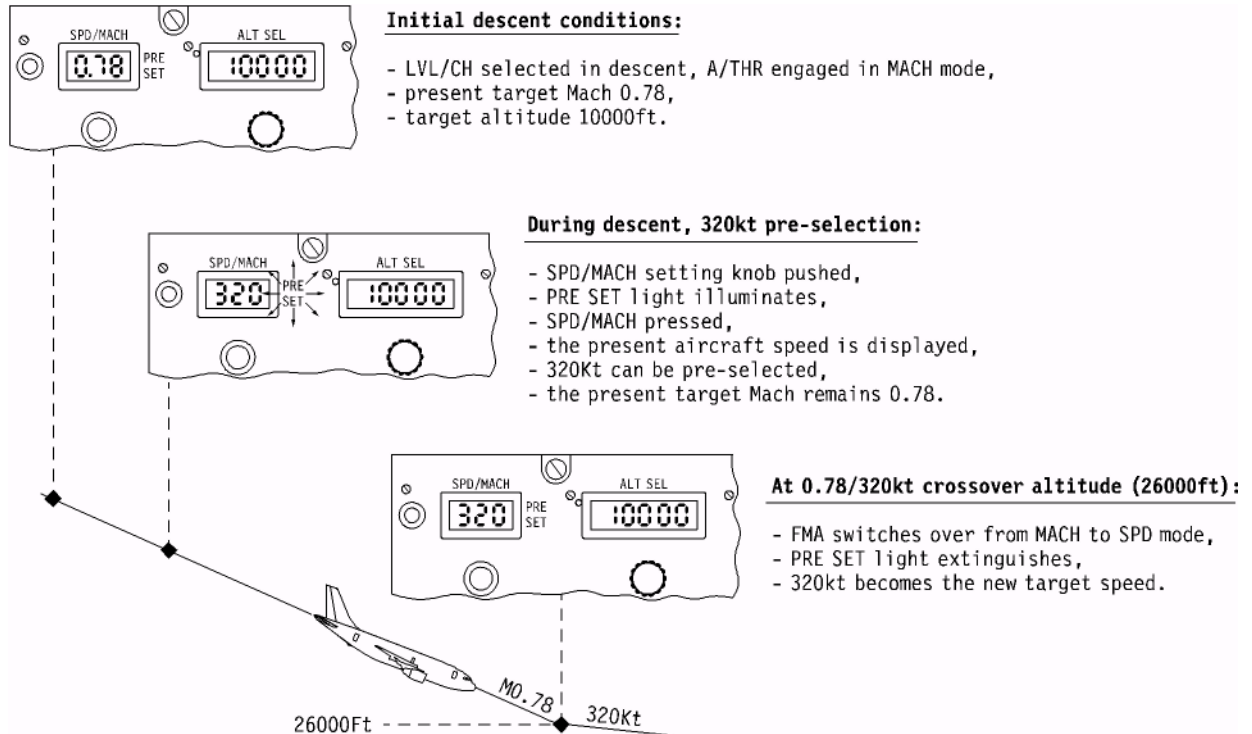
- The preset speed or Mach becomes the active target speed or Mach when either :
  - LVL/CH or ALT mode is selected, or
  - at ALT\* engagement.
- For a speed to Mach intercept :
  - If a Mach is preset while climbing in SPD mode the preset Mach becomes the target Mach at the speed/Mach crossover altitude. MACH mode engages.
- For a Mach to speed intercept :
  - If a speed is preset while descending in MACH mode, the preset speed becomes the target speed at the Mach/speed crossover altitude. SPD mode engages.

**PRE SET DE-ACTIVATION**

- The PRE SET speed/Mach can be de-activated at any time by pushing the SPD/MACH setting knob a second time.

The PRE SET light extinguishes and the active target speed (or Mach) is displayed in the SPD/MACH window.

**PRE SET activation after takeoff at LVL/CH selection :**


**PRE SET activation at altitude capture (ALT\*):**

**PRE SET activation to intercept a SPD from a MACH:**


**Autoflight System**
**Takeoff Modes**
**COMBINED MODES FOR TAKEOFF**

- For takeoff the AFS combines an A/THR, a vertical and a lateral AP/FD mode, as follows :
  - A/THR mode : THR mode,
  - Vertical AP/FD mode : SRS mode,
  - Lateral AP/FD mode : RWY, HDG/S or HDG mode.

**Note : SRS is also the vertical guidance mode in GO AROUND mode.**

**ENGAGEMENT CONDITIONS OF TAKEOFF MODES**

- AFS takeoff modes are :
  - available on ground with :
    - no AP engaged, but at least one FD engaged, or
    - at least one FD engaged and one AP in CWS mode,
  - and engages when either go-lever is triggered, provided :
    - slats are extended at 15° or more.

**SRS MODE (Speed Reference System)**

- The SRS mode acquires and maintains :
  - With 2 engines operating :
    - The FCU selected speed + 10 kt (the selected speed is V2 at takeoff and VAPP in Go-around).
  - With 1 engine inoperative :
    - The FCU selected speed or the existing speed at the time of the engine failure, whichever is higher.
- After triggering the go-levers, the pitch bar is set at 10° nose-up. During rotation, the bar moves toward the SRS pitch target.
- The SRS guidance law includes :
  - a pitch attitude guidance limit in order not to exceed an 18° pitch attitude,
  - a vertical speed protection to ensure a minimum

100 ft/mn rate of climb.

**Note : At low aircraft weight, low airfield elevation and/or low OAT (high thrust/weight ratios) the AP/FD may momentarily exceed the 18° target before establishing a stabilised pitch attitude.**

- The SRS mode remains engaged until :
  - ALT\* mode engagement or ALT. HLD mode selection, in case of low altitude level-off,
  - or
  - LVL/CH mode selection,
  - or
  - PROFILE mode engagement,
  - or
  - V/S mode selection.
- If windshear is detected, the SRS mode provides pitch guidance as described above, until V/S reaches zero, then the following survival strategy is adopted :
  - A slightly positive V/S is maintained until speed decreases to slightly above Vss,
  - then, speed is maintained slightly above Vss, allowing an altitude loss as required to maintain Vss.

**Note : In windshear conditions the pitch attitude guidance target may be significantly greater than that expected for a normal takeoff.**

**RWY MODE (Runway)**

- In RWY mode, a yaw bar replaces the FD roll bar for lateral guidance on the localizer centerline. (refer to section - FLIGHT DIRECTOR).
- RWY mode is available provided the runway ILS frequency and course are selected and signals are valid.
- The RWY mode engages if the aircraft heading is less than 10° away from the selected ILS/LOC course when the go-levers are triggered.

When the RWY mode is engaged, if the aircraft heading departs by more than 40° from the selected ILS/LOC course, the RWY mode disengages.



**Autoflight System**
**Takeoff Modes**
**OPERATION:**

- When either Go-lever is triggered, and provided the ATS is armed:
  - if the departure ILS or LOC frequency and course are selected, the FMA annunciation is :



- if the departure ILS or LOC frequency and course are not selected, the FMA annunciation is :



or



**Note 1:** ALT mode is armed in readiness to capture the initial selected altitude.

**Note 2:** HDG/S or NAV mode can be armed before takeoff and will automatically engage at 30 ft.

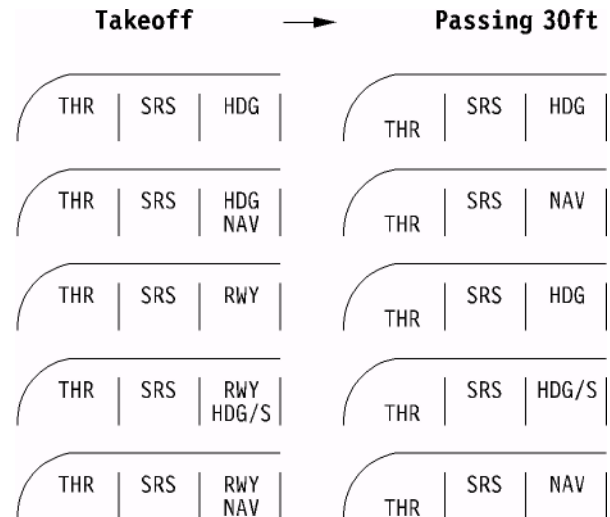
**Note 3:** If HDG mode is engaged for takeoff, the FD roll bar remains centered while on ground. After lift-off, the FD roll bar provides guidance to maintain the present aircraft heading.

- RWY mode automatically disengages at 30 ft. The Yaw bar is replaced by the roll bar.
- When the SRS mode disengages, the SPD/MACH window synchronizes on the **current aircraft speed** if the current speed is higher than the selected target speed (i.e. V2 or VAPP), **except** if a PRE SET speed has been selected.
- For thrust control during takeoff, refer to chapter - ATS CONNECTION TO THROTTLE LEVERS.

**LATERAL MODE TRANSITION AT 30 FT**

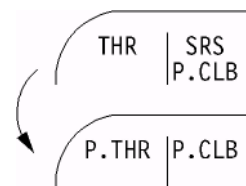
- At 30 ft, depending on the lateral mode selected and armed at takeoff, the typical automatic lateral mode transitions are presented hereafter (before landing gear retraction and A/THR reclutch):

**Note:** the A/THR mode transition occurs during the takeoff roll.

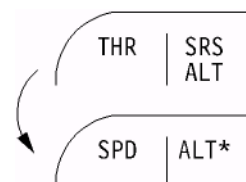

**VERTICAL MODE TRANSITIONS**

- Depending on the vertical mode armed for takeoff, the automatic vertical mode and A/THR mode transitions sequence is as follows:

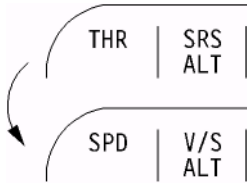
- at thrust reduction altitude, if PROFILE is armed :



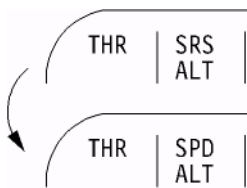
- at altitude capture (i.e. low altitude level-off) :



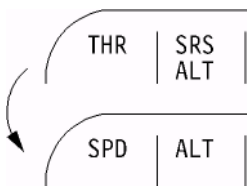
- A manual mode transition can be initiated by selecting another vertical mode.  
The possible mode transition sequences are : - If V/S mode is selected :



- If LVL/CH mode is selected :



- If ALT. HLD mode is selected :



**Autoflight System**
**Vertical Speed Mode**
**FUNCTION**

- The Vertical Speed mode (V/S) or Level Change mode (LVL/CH) can be used for climb or descent.
- V/S is the basic vertical mode of the AP/FD.
- The V/S mode allows to climb or descent while maintaining :
  - a selected V/S,
  - the selected speed (A/THR in SPD or MACH mode).
- If the selected target speed and V/S cannot be maintained simultaneously, **maintaining the target V/S has priority.**

**ENGAGEMENT**

- V/S mode can be engaged by :
  - setting a new altitude target, then
  - pulling the V/S knob (this synchronizes the vertical speed window on the present aircraft vertical speed), then
  - setting the desired vertical speed.

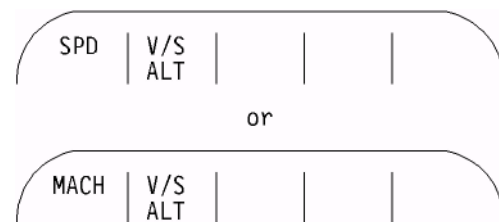
It is also possible to set the desired vertical speed before pulling the V/S knob.
- V/S speed mode engagement is confirmed by the FMA annunciation.
- V/S mode engages automatically:
  - on the ground, at the AFS power up,
  - when an FD is selected ON while no AP is engaged or no FD is displayed,
  - if an AP is engaged in CMD while its associated FD is not displayed or not operative,
  - if any engaged vertical mode (ALT. HLD, LVL/CH, PROFILE) is disengaged by pressing its associated pushbutton a second time,
  - if LAND mode is deselected between GS\* and LAND green on FMA (refer to LAND MODE - MODE REVERSION).
  - when the AP/FD re-engages following an AP/FD temporary disengagement (both FD bars flash for 10 seconds).

**OPERATION**

- It is recommended to use V/S mode for step climb or descent of 2000 ft or less.
- At V/S mode engagement, the AP/FD synchronizes on the present vertical speed and acquires the selected V/S.
- In V/S mode, the AP/FD adjusts the pitch to maintain the vertical speed and the A/THR adjusts the engine thrust to maintain the speed.
- To maintain the selected V/S, the speed may :
  - decrease down to  $VLS + 5$  kt, in climb,
  - increase up to  $V_{MAX}$ , in descent.

If  $VLS + 5$  kt (in climb) or  $V_{MAX}$  (in descent) is reached, an automatic mode reversion from V/S to LVL/CH occurs (refer to the paragraph MODE REVERSIONS, hereafter, for detailed illustration).

- V/S mode engagement arms the ALT mode to capture the selected altitude.
- In V/S mode, the FMA annunciation is :

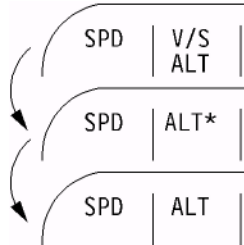


- While in V/S mode, the selected target altitude, speed and vertical speed can be changed at any time.
- In approach, V/S mode can be engaged with a negative vertical speed while the selected altitude is above the present aircraft altitude (e.g. descent from the Final Descent Point to the MDA, during a non-precision approach).

<b>Autoflight System</b>	<b>Vertical Speed Mode</b>
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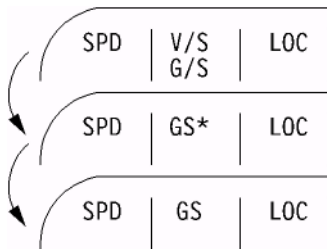
### MODE TRANSITIONS

- When capturing the target altitude, the automatic mode transition sequence is :



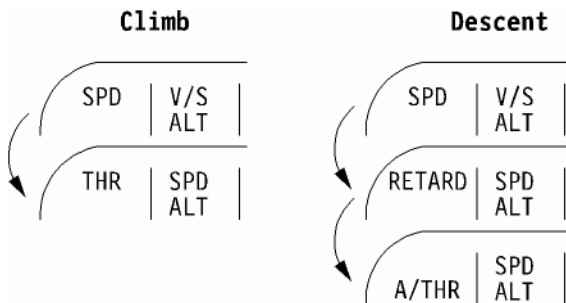
**Note :** If the FCU target altitude is within 100 ft of the present aircraft altitude when V/S mode is selected, V/S will initially engage but immediately disengages because ALT\* engages.

- In approach, with LAND mode selected on FCU, when capturing the glide slope from above, the automatic mode transition sequence is :

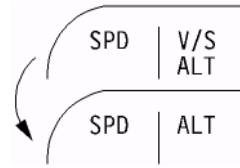


- A manual mode transition can be initiated by the pilot by selecting another vertical mode. The transition sequence is :

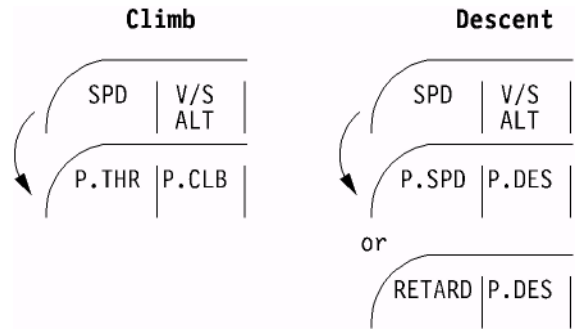
- If LVL/CH mode is selected :



- If ALT. HLD mode is selected :



- If PROFILE mode is selected :



### MODE REVERSIONS

- In V/S mode, if the selected vertical speed is excessive and the selected speed cannot be maintained, an automatic mode reversion occurs to LVL/CH to prevent the aircraft from reaching the speed limits (VLS or VMAX).

- The mode reversion is indicated by :

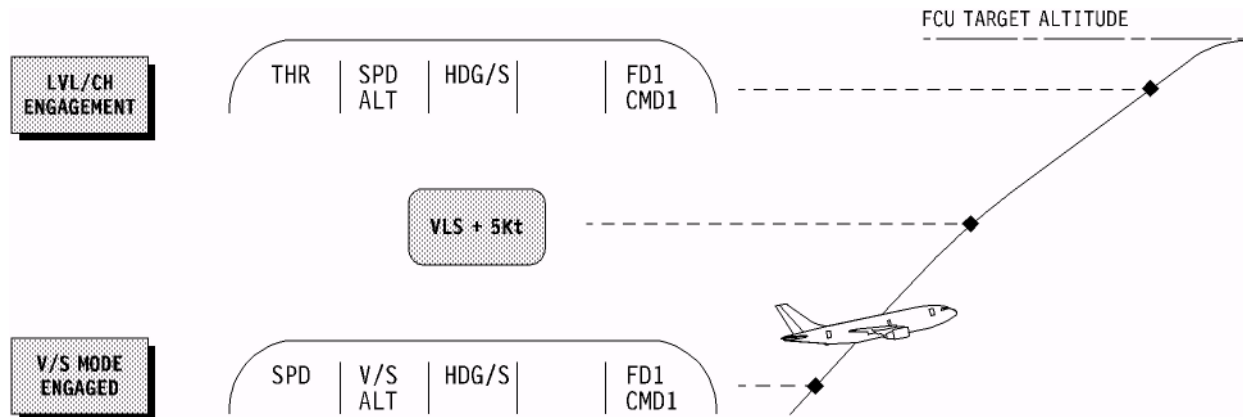
- the FMA annunciation,
- the illumination of the LVL/CH pushbutton,
- the V/S window which becomes "---".

(Cont'd)

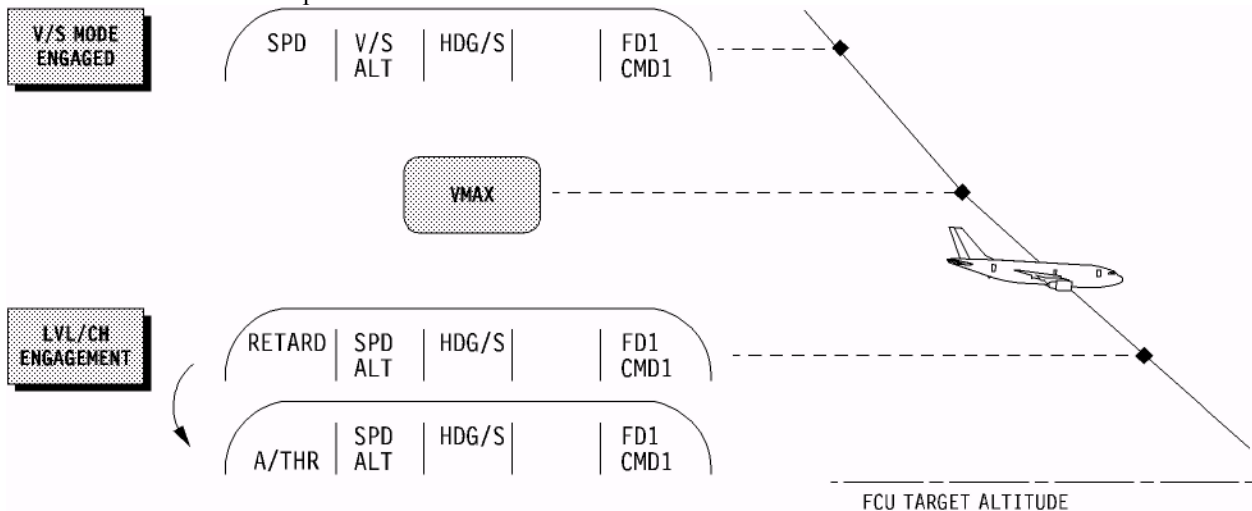
Autoflight System	<b>Vertical Speed Mode</b>
-------------------	----------------------------

**MODE REVERSIONS (Cont'd)**

- In climb, the A/THR SPD mode increases the thrust up to the thrust limit, if required, in order to maintain the selected speed.
  - If VLS+ 5 kt is reached and if the selected altitude is above the present aircraft altitude, a mode reversion occurs from V/S to LVL/CH climb.
  - The thrust is maintained at the thrust limit, and the AP/FD decreases and adjusts the vertical speed to maintain the selected speed.



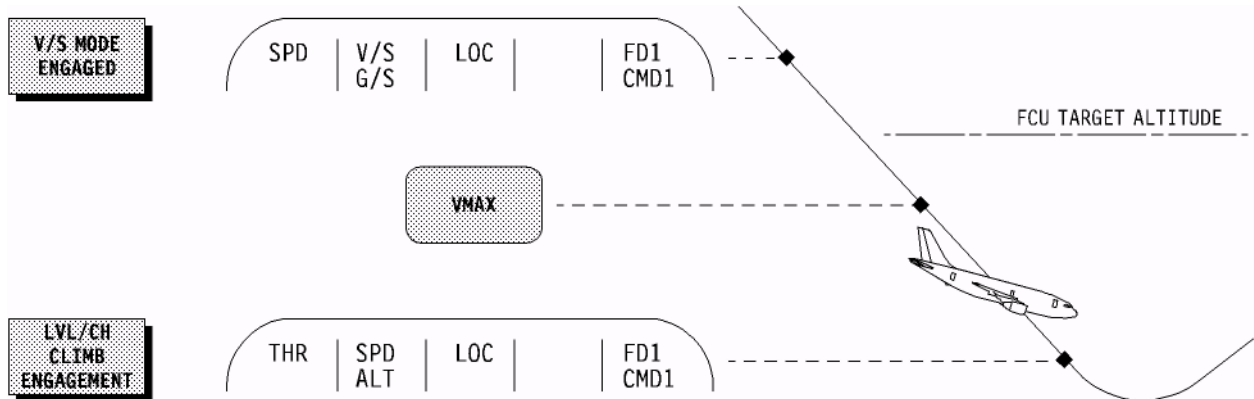
- In descent, the A/THR SPD mode reduces the thrust down to idle, if required, in order to maintain the selected speed.
  - If VMAX is reached and if the FCU selected altitude is below the present aircraft altitude, a mode reversion occurs from V/S to LVL/CH descent.
  - The thrust is maintained at idle (throttle levers declutch) and the AP/FD decreases and adjusts the vertical speed to maintain the selected speed.



(Cont'd)

**MODE REVERSIONS (Cont'd)**

- If VMAX (e.g. VFE or VLE) is reached and if the selected altitude is above the present aircraft altitude (e.g. while **capturing the glide slope from above**), a mode reversion occurs from V/S to LVL/CH **climb**.
- The thrust is set at the TRP THR LIM value (TOGA if slats are extended) and the AP/FD commands a climb to the selected altitude, with the speed selected on the FCU (SPD window) as target speed.



**Autoflight System**
**Level Change**
**FUNCTION**

- The LVL/CH mode enables to climb or descend at :
  - the selected target speed (AP/FD in SPD or MACH mode),
  - with the engine power set at the thrust limit for climb (A/THR in THR mode with CL or CR thrust limit selected on the TRP) or at idle for descent (RETARD mode).

**ENGAGEMENT**

- LVL/CH climb or descent can be engaged by :
  - Selecting a new altitude and,
  - Pushing the LVL/CH pushbutton or pulling the ALT SEL knob.
- LVL/CH climb engages if the selected altitude is above the present aircraft altitude and LVL/CH descent engages if the selected altitude is below the present aircraft altitude.

LVL/CH engages only if the selected altitude and the aircraft present altitude differ by 250 ft or more.

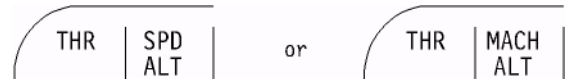
- LVL/CH engagement is confirmed by the FMA annunciation and by the illumination of the LVL/CH pushbutton.
- In climb or descent with PROFILE mode engaged, a manual reversion to LVL/CH mode can be performed by pulling the SPD/MACH setting knob.

The SPD/MACH window synchronizes on the present aircraft speed.

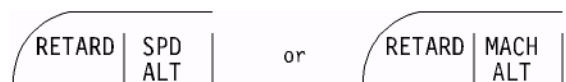
**OPERATION**

- It is recommended to use LVL/CH for step climb or descent exceeding 2000 ft.
- In LVL/CH, the AP/FD maintains the selected target speed by adjusting the pitch.
- LVL/CH engagement arms the ALT mode (in readiness to capture the new selected altitude).

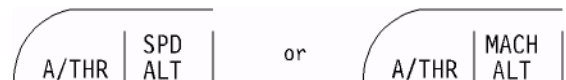
- In LVL/CH climb, the FMA annunciation is :



- In LVL/CH descent, the FMA annunciation is initially :



The A/THR commands idle thrust. When idle thrust is set, the FMA annunciation changes to :

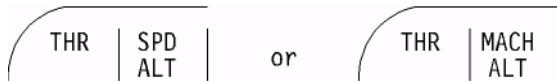


- While in LVL/CH :
  - The selected target altitude and speed/Mach can be changed at any time.
  - If the target speed/Mach is below VLS or above VMAX/MMO, the AFS maintains VLS or VMAX/MMO.

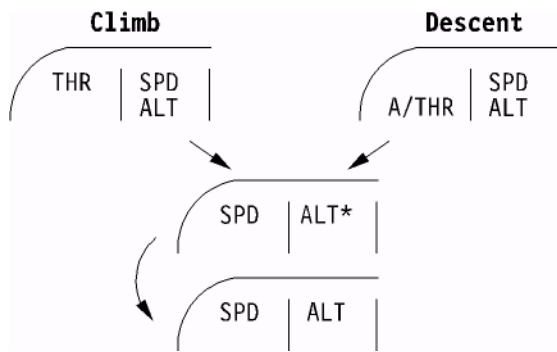


### MODE TRANSITIONS

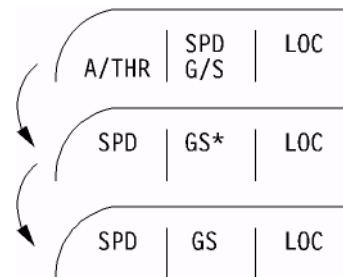
- The transition from SPD to MACH or from MACH to SPD occurs :
  - at the Speed/Mach crossover altitude, if PRE SET has been activated,
  - at 25,400 ft if PRE SET is not activated.



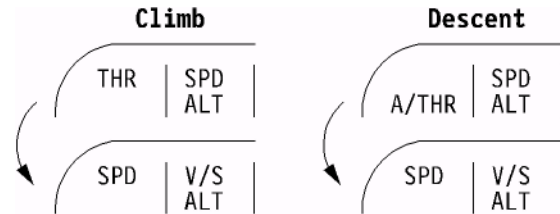
- When capturing the selected target altitude, the automatic mode transition sequence is :



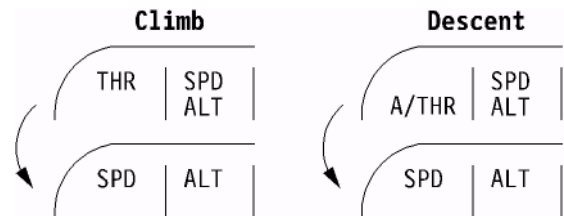
- In approach, with LAND mode armed on the FCU, when capturing the glide slope, the automatic mode transition sequence is :



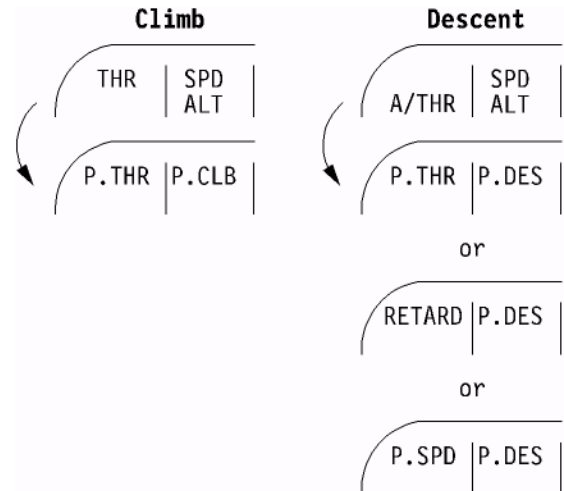
- A manual mode transition can be initiated by selecting another vertical mode. The possible transition sequences are as follows : - If V/S mode is selected :



- If ALT. HLD mode is selected :

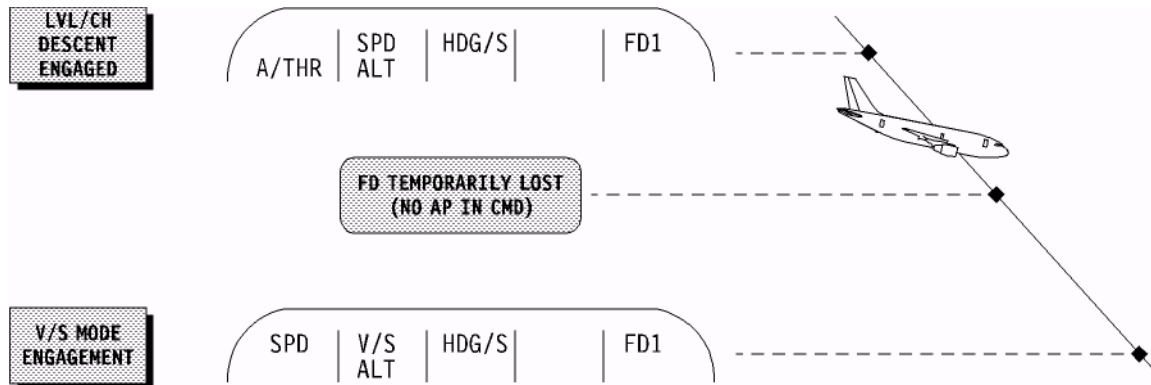


- If PROFILE mode is selected :



**MODE REVERSIONS**

- In LVL/CH climb or descent, a manual mode reversion to V/S mode can be initiated by pressing the illuminated LVL/CH pushbutton.
- In LVL/CH (climb or descent), an automatic mode reversion to V/S mode occurs if no AP is engaged in CMD and the FD is temporarily lost. V/S mode engages after FD recovery.



**Autoflight System**
**Altitude Mode**
**FUNCTION**

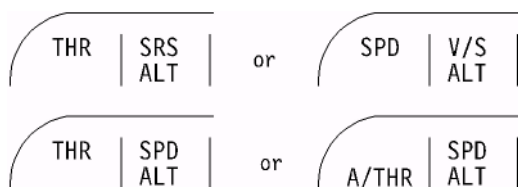
- The altitude (ALT) mode captures and maintains an altitude which is :
  - the FCU selected altitude in climb or descent, or
  - the immediate level-off altitude if the ALT. HLD pushbutton is pressed during climb or descent.
- During altitude capture and hold, the A/THR adjusts the engine thrust to maintain the selected speed (A/THR in SPD or MACH mode), provided that the A/THR was previously engaged.

**ENGAGEMENT**

- The altitude mode has three successive phases to capture and maintain a selected altitude :
  - arming phase (ALT blue on FMA),
  - capture phase (ALT\* green on FMA),
  - hold phase (ALT green on FMA).

**Arming phase**

- ALT mode arms automatically when :
  - a climb or a descent mode is engaged (SRS or V/S mode engaged or LVL/CH or GO AROUND selected), and
  - a target altitude is set.
- The FMA annunciation is :

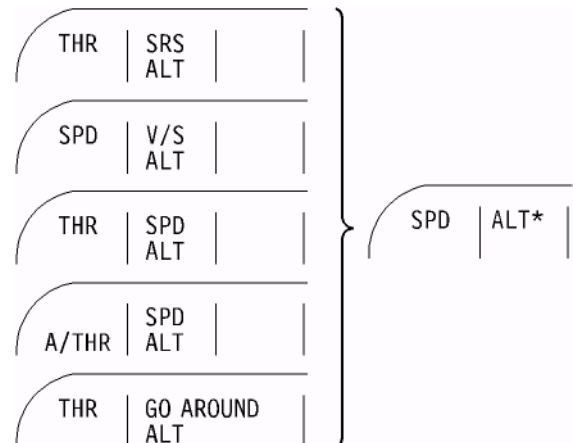

**Altitude Capture phase**

- ALT\* mode automatically engages when the aircraft is in the capture range of the selected target altitude.

The capture range varies depending on the aircraft vertical speed (the capture range increases with increasing vertical speed).

For example, in LVL/CH with 2000 ft/mn vertical speed, ALT\* engages approximately 700 ft before the selected altitude.

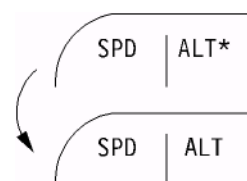
- ALT\* mode engagement is confirmed by the FMA and by the illumination of the ALT. HLD pushbutton.
- The FMA transition sequence is :



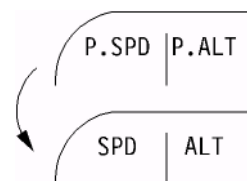
- On the FCU, the LVL/CH pushbutton extinguishes and the ALT. HLD pushbutton illuminates.

**Altitude hold phase**

- ALT mode engages when the aircraft reaches the selected altitude.
- ALT mode engagement is confirmed by the FMA.
- The FMA transition sequence is :

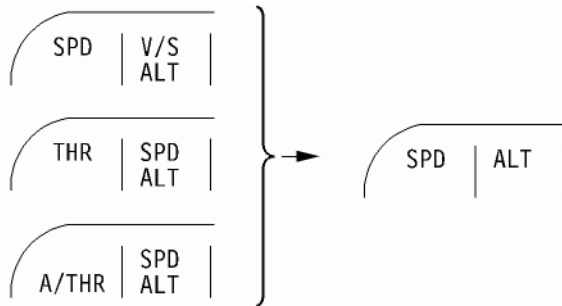


- In cruise, with PROFILE mode engaged (P. ALT), a manual reversion to the ALT mode can be performed by pulling the SPD/MACH knob.



**Autoflight System**
**Altitude Mode**
**IMMEDIATE LEVEL-OFF IN CLIMB OR DESCENT**

- In climb or descent, an immediate level-off can be performed by pressing the ALT. HLD pushbutton.
- The AP/FD engages directly in ALT mode (the altitude capture phase is suppressed).
- The FMA transition sequence is :


**OPERATION**

- When ALT is armed or engaged, the selected target altitude can be changed at any time.

Depending on when the new altitude selection is performed, the system operates as follows :

- If the target altitude is changed while ALT is armed (ALT blue) :
  - the aircraft climbs or descends towards the new selected target altitude.
- If the target altitude is changed during capture phase (ALT\* green) :
  - If the new target altitude is within the capture range , ALT\* remains engaged and the new altitude is captured.
  - If the new target altitude is beyond the capture range, an automatic reversion from ALT\* to V/S mode occurs (refer to MODE REVERSION paragraph).
- If the target altitude is changed during the altitude hold phase (ALT green) :
  - ALT remains engaged. The AP/FD will not climb or descend to the new selected target altitude until another vertical mode (i.e. : V/S, LVL/CH, P.CLB or P.DES) is selected.

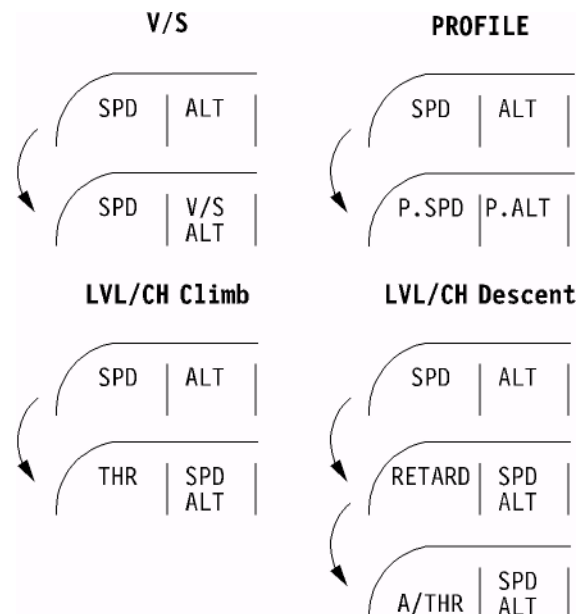
- If flying manually in ALT mode with only the FD displayed, and an AP is then engaged in CMD :
  - if the current altitude is within 250 ft of the selected target altitude, the AP/FD will capture and hold the target altitude (ALT\* then ALT mode),
  - if the current altitude is more than 250 ft away from the target altitude, the AP/FD will maintain the current altitude.

**MODE TRANSITIONS**

- In approach, with LAND mode selected on FCU, when capturing the glide slope, the automatic mode transition sequence is :

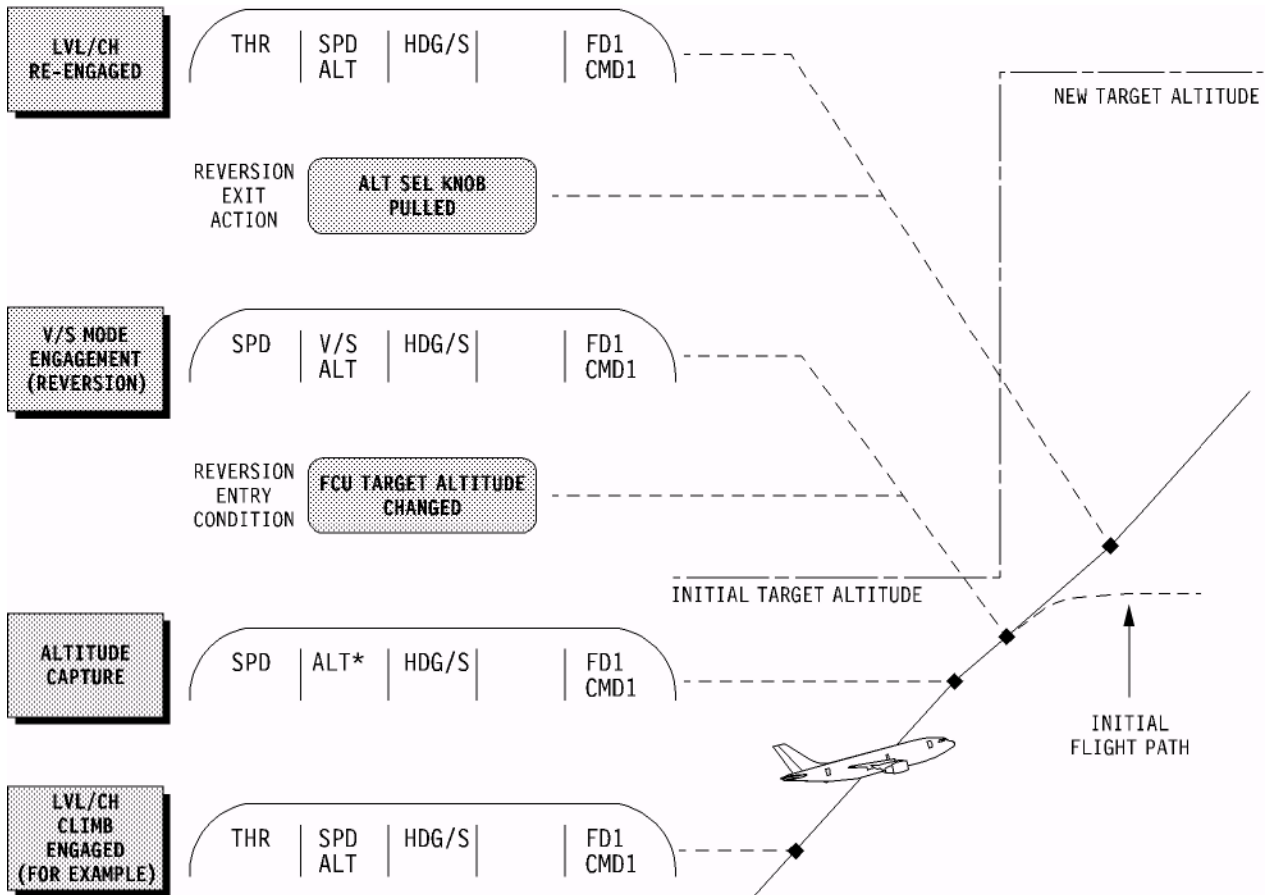


- A manual mode transition can be initiated by selecting another vertical mode, such as V/S, LVL/CH or PROFILE :



**MODE REVERSIONS**

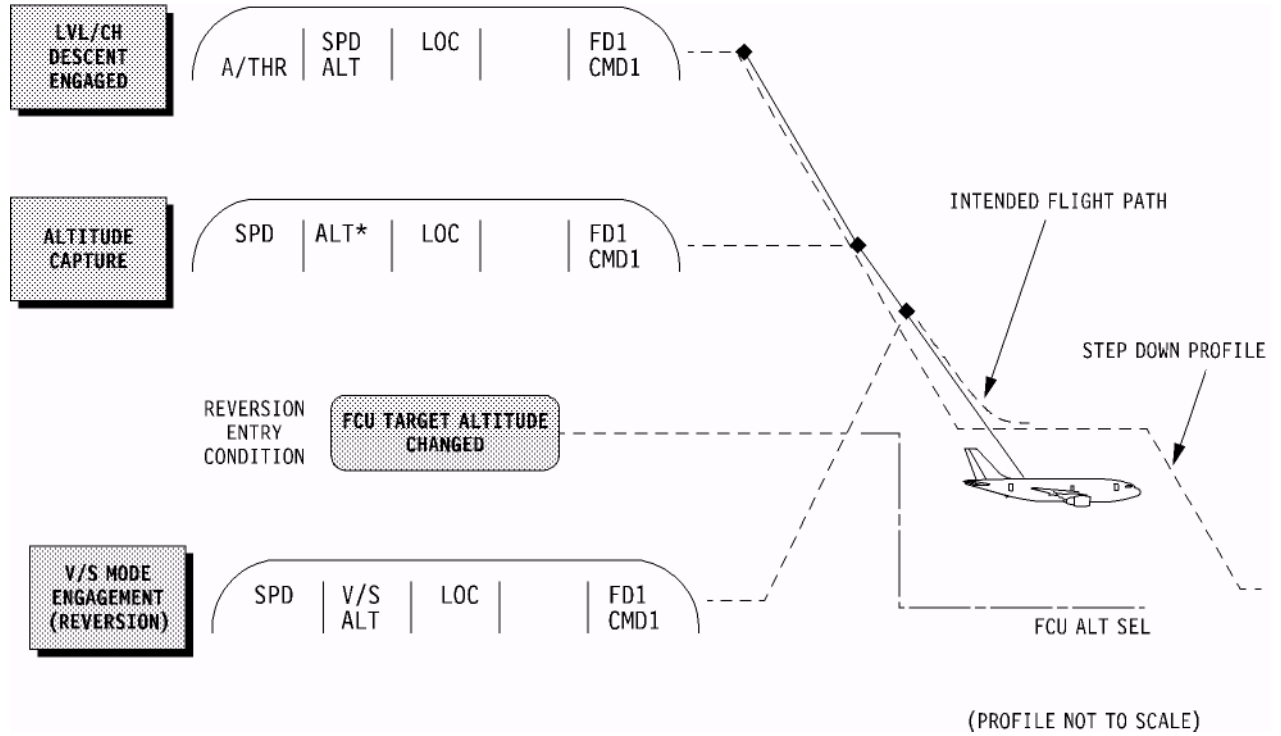
- In ALT\* or ALT mode, a mode reversion to V/S occurs if the illuminated ALT. HLD pushbutton is pressed.
- In ALT\* mode, an automatic mode reversion from LVL/CH to V/S occurs if :
  - the target altitude is changed (e.g. if the aircraft has been cleared to a higher (altitude), and
  - the aircraft is out of the capture range of the new target altitude, and
  - the ALT SEL knob is not pulled.



- Following the mode reversion :
  - the aircraft maintains the present aircraft vertical speed,
  - the FD pitch bar flashes for 10 seconds,
  - ALT is armed again (ALT blue),
  - ALT. HLD pushbutton extinguishes.
- The V/S mode remains engaged until the ALT SEL knob is pulled or until the LVL/CH pushbutton is pressed (re-engagement of the LVL/CH mode).

**MODE REVERSIONS (Cont'd)**

- A similar automatic mode reversion from LVL/CH to V/S occurs in descent or during a step-down approach if the target altitude is changed while in ALT\* (e.g. if the aircraft has been already cleared to a lower altitude, and the change of FCU target altitude to the next step-down altitude is expedited while still in ALT\*):



## Autoflight System

## Heading Mode

### FUNCTION

- The Heading (HDG) mode is the basic lateral mode of the AP/FD.
- HDG mode maintains the present aircraft heading at mode engagement.
- When HDG engages, if the present aircraft bank angle is :
  - less than 5°, the HDG mode maintains the present aircraft heading,
  - more than 5°, the AP/FD levels the wings, then maintains the heading which is achieved when the bank angle passes 5°.

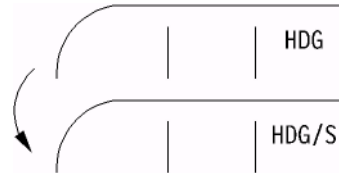
### ENGAGEMENT AND OPERATION

- There is no pushbutton to engage HDG Mode.
- HDG mode engages :
  - On the ground, at AFS power up,
  - When an FD is selected ON with no AP engaged or no FD displayed.
  - If an AP is engaged in CMD while its associated FD is not displayed.
  - If NAV mode is selected after LOC\*.
  - If any other lateral mode (HDG/S, VOR or LOC) is disengaged by pressing its associated pushbutton a second time.
  - If LAND is deselected, between LOC\* and LAND green on FMA (refer to section LAND MODE - MODE REVERSIONS).
  - When the AP/FD re-engages following an AP/FD temporary disengagement (both FD bars flash for 10 seconds).
  - When GO AROUND mode engages (but HDG green is not indicated on the FMA).
- The HDG mode engagement is indicated on the FMA only (no indication on the FCU).

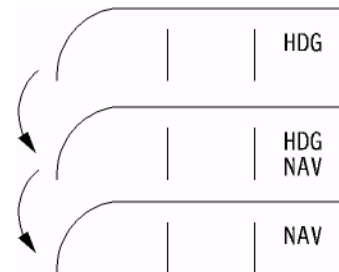
### MODE TRANSITIONS

- A manual mode transition from HDG to another lateral mode occurs when the pilot selects any lateral mode on the FCU. The FMA transition sequence is as follows :

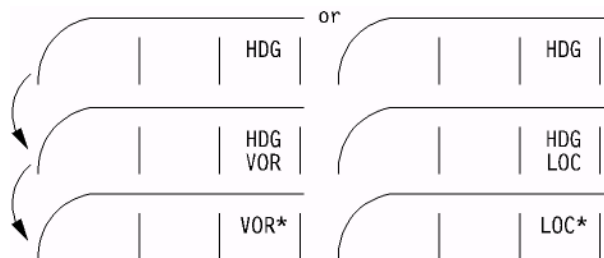
- If HDG SEL mode is selected :



- If NAV mode is selected :



- If V/L mode (VOR or LOC mode) is selected :



- If LAND mode is selected, the transition with LOC mode is the same as when LOC mode is selected by pressing the V/L pushbutton.

- An automatic mode transition occurs from HDG to NAV, at 30 ft, if NAV is armed for takeoff.



**Autoflight System**
**Heading Select Mode**
**FUNCTION**

- The Heading Select mode (HDG/S) acquires and maintains the selected heading.

**ENGAGEMENT AND OPERATION**

- HDG/S mode can be engaged by :
  - pulling the HDG SEL knob, or
  - pressing the HDG SEL pushbutton.
- HDG/S can be engaged using the recommended **Push-Pull-Turn** technique :
  - **Push** the HDG SEL knob to synchronize the HDG SEL window on the present aircraft heading, then
  - **Pull** the HDG SEL knob to engage the HDG/S mode, then
  - **Turn** the HDG SEL knob, in the direction of the desired turn, to select the desired heading.

The heading selection is confirmed by cross-checking the blue index on the Navigation Display (ND) heading scale.

**Note :** With HDG/S engaged, the aircraft turns in the same direction the HDG SEL knob is turned (even if a turn of more than 180° is selected).

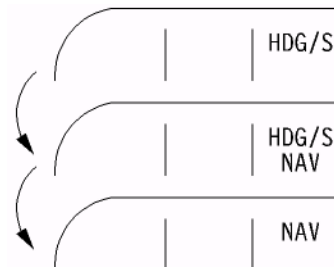
**This design feature and the above operating technique voids the possibility of initiating turns in the unintended direction.**

- If the HDG SEL window is not synchronized on the present aircraft heading or if the desired heading is selected before engaging the HDG/S mode, when HDG/S engages, the aircraft turns in the shortest direction towards the selected heading.
- HDG/S mode engagement is indicated on the FMA and on the FCU by the illumination of the HDG SEL pushbutton.
- While in HDG/S mode, the heading can be changed at any time by selecting the desired heading.
- Before takeoff, if RWY mode is used, HDG/S mode may be armed for climb out.

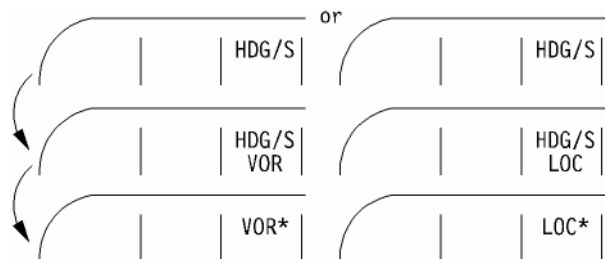
**MODE TRANSITIONS**

- A manual mode transition from HDG/S to another lateral mode occurs when the pilot selects any lateral mode on the FCU. The FMA transition sequence is as follows :

- If NAV mode is selected :



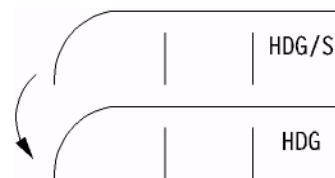
- If V/L mode (VOR or LOC mode) is selected :



- When LAND is selected, the transition with LOC mode is the same as when LOC mode is selected by pressing the V/L pushbutton.

**MODE REVERSION**

- A manual mode reversion from HDG/S to HDG (basic lateral mode) occurs if the pilot presses the HDG SEL pushbutton a second time.



**Autoflight System**
**VOR Mode**
**FUNCTION**

- The VOR mode captures and tracks a selected VOR radial/course.
- The VOR mode is to be used for enroute navigation only.
- For capturing and tracking the final approach course of a VOR or VOR-DME approach, the HDG SEL mode must be used together with VOR or VOR-DME raw data.
- The HDG SEL mode and VOR/VOR-DME raw data should also be used to capture and track a VOR radial/course whenever slats are extended and the distance to the VOR is less than 30 nm.

**ENGAGEMENT AND OPERATION**

- VOR mode has three successive phases to capture and track a selected VOR radial :
  - arming phase (VOR blue on FMA)
  - capture phase (VOR\* green on FMA)
  - tracking phase (VOR green on FMA).
- VOR mode can be armed by pressing the V/L (VOR/LOC) pushbutton in the following configurations :
  - both FD are displayed (no AP engaged) and :
    - both VOR/NAV/ILS switches are in VOR, or one in VOR and the other in NAV,
    - VOR frequency/course are set on both VOR control panels.
  - one AP in CMD and :
    - the inside VOR/NAV/ILS switch is in VOR,
    - VOR frequency/course are set on the inside VOR control panel (at least).
- It is not possible to engage VOR mode if LAND mode is selected on FCU.
- When VOR mode is armed, the AP/FD uses the support of another lateral mode to guide the aircraft towards the capture point of the VOR radial. This mode can be HDG, HDG/S or NAV.

- For correct capture of the VOR radial/course, the intercept angle must not exceed :
  - 90°, if the distance to the VOR station is higher than 30 NM,
  - 30°, if the distance to the VOR station is less than 30 NM.

- VOR mode automatically engages the radial capture phase (VOR\*) when the aircraft is in the capture range of the VOR radial.

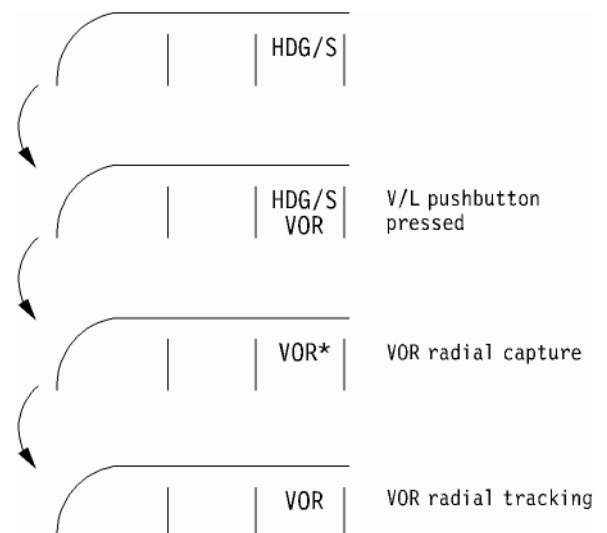
VOR mode automatically engages the radial tracking phase (VOR) when the aircraft reaches the selected VOR radial.

- In VOR\* and VOR modes, the AP Supervisory Override function is available.
- In VOR mode, the bank angle is limited at 25° with the HDG SEL outer knob in the NORM position, or at 15° with the knob in the 15 position.

These bank angle limitations are valid in manual flying following FD orders or with the AP engaged in CMD.

- VOR mode arming and engagement is indicated by the FMA annunciation and by the illumination of the V/L pushbutton.

A typical FMA transition sequence is :

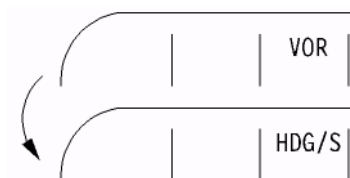


**Autoflight System**
**VOR Mode**

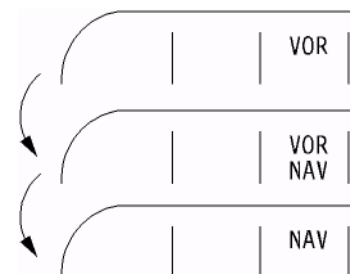
- If one VOR receiver fails while in the arming phase (VOR blue on FMA), the VOR mode disarms on the affected side.
- If one VOR receiver fails while in the capture (VOR\*) or tracking (VOR green) phase :
  - If the onside AP/FD is engaged, the AP/FD disengages,
  - If the opposite AP/FD is engaged, the AP/FD remains engaged in VOR mode.

**MODE TRANSITIONS**

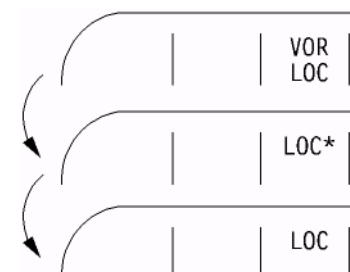
- A manual mode transition can be initiated by selecting another lateral mode. The FMA transition sequence is as follows :
  - If HDG/S mode is selected :



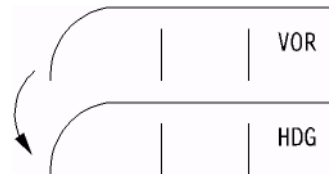
- If NAV mode is selected :



- If LAND mode is selected :


**MODE REVERSIONS**

- A manual mode reversion from VOR to HDG (basic lateral mode) occurs if the V/L pushbutton is pressed a second time.



- If a go-around is initiated while in VOR\* or VOR mode, GO AROUND mode engages using HDG mode for the lateral guidance.

**Note : in GO AROUND mode, HDG is not indicated on the FMA.**

**Autoflight System**
**LOC Mode**
**FUNCTION**

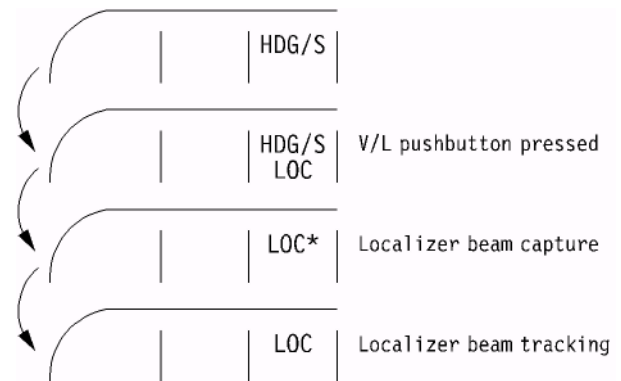
- The LOC (localizer) mode captures and tracks a localizer beam.
- LOC mode can be used for localizer-only approaches, or if the ILS glideslope is out of service or unreliable.

**ENGAGEMENT AND OPERATION**

- LOC mode has three successive phases to capture and track a localizer beam :
  - arming phase (LOC blue on FMA)
  - capture phase (LOC\* green on FMA)
  - tracking phase (LOC green on FMA)
- LOC mode can be armed by pressing the V/L (VOR/LOC) pushbutton while in the following configurations :
  - both FD are displayed (no AP engaged) and :
    - at least one VOR/NAV/ILS switch is in the ILS position,
    - the ILS or LOC frequency and course are set on the ILS control panel.
  - one AP in CMD and :
    - the onside VOR/NAV/ILS switch is in the ILS position,
    - the ILS or LOC frequency and course are set on the ILS control panel.
- LOC mode automatically arms when LAND pushbutton is pressed provided an ILS frequency and a course have been set on the ILS control panel (refer to APPROACH AND LANDING – LAND mode).
- When LOC mode is armed, the AP/FD uses the support of another lateral mode to guide the aircraft towards the capture point of the localizer beam. This mode can be HDG, HDG/S or NAV
- LOC mode automatically engages the capture phase (LOC\*) when the aircraft is in the capture range of the localizer beam.

- LOC mode automatically engages the tracking phase (LOC green) when the aircraft reaches the localizer beam.
- In LOC\* mode, the AP Supervisory Override function is available.
- LOC arming and engagement is confirmed by the illumination of the V/L pushbutton, and by the FMA.

A typical FMA transition sequence is :



**Note 1 :** During the localizer capture phase (LOC\*) the bank angle can reach 30°, irrespective of the bank angle limit selector position.

**Note 2 :** The maximum intercept angle for capturing a localizer is 115°.

**Note 3 :** If one ILS receiver (or LOC channel) fails while in the arming phase (LOC blue on FMA), the LOC mode disarms on the affected side.

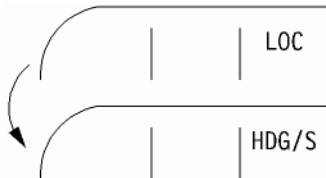
**If one ILS receiver (or LOC channel) fails while in the capture (LOC\*) or tracking (LOC green) phase :**

- If the onside AP/FD is engaged, the AP/FD disengages,
- If the opposite AP/FD is engaged, the AP/FD remains engaged in LOC mode.

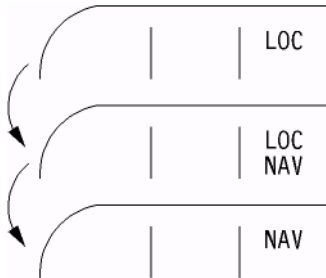
**Note 4 :** If the on-ground localizer transmitter fails while in LOC\* or LOC mode (no signal received by both aircraft ILS receivers), the LOC scale and FD roll bar flash on both PFD.

**Autoflight System**
**LOC Mode**
**MODE TRANSITIONS**

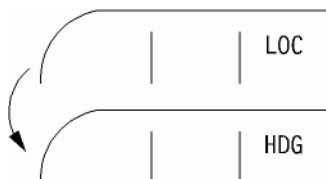
- A manual mode transition can be initiated by the pilot by selecting another lateral mode. The FMA transition sequence is as follows :
  - If HDG/S mode is selected :



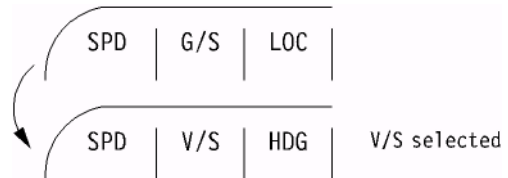
- If NAV mode is selected :


**MODE REVERSIONS**

- A manual mode reversion from LOC to HDG (basic lateral mode) occurs if the V/L pushbutton switch is pressed a second time.



- A manual mode reversion from LOC to HDG occurs when LAND mode is selected and the pilot :
  - presses the LAND pushbutton switch,
  - or selects another vertical mode.



- If a go-around is initiated while in LOC\* or LOC mode, GO AROUND mode engages using HDG mode for the lateral guidance.

**Note : in GO AROUND mode, HDG is not indicated on the FMA.**

**LOC BACK COURSE APPROACH**

- The LOC mode cannot be used to fly a back-course ILS or LOC approach.
- During a LOC BACK CRS approach, the FD guidance or the AP guidance (if engaged in CMD mode) is reversed.
- A LOC BACK CRS approach can be conducted with the AP in CMD but using the HDG SEL and V/S modes.
- During a LOC BLACK CRS approach, the LOC deviation must be monitored on the ND only (in ROSE or ARC mode).

**Autoflight System**
**VOR/LOC Mode Selection**
**VOR/LOC MODE SELECTION LOGIC**

- The V/L pushbutton controls the engagement of the VOR and LOC modes.
- Whether VOR or LOC mode arms/engages depends on the position of the two VOR/NAV/ILS switches, and on which FD and AP are engaged (refer to the tables 1, 2 and 3 below for details).

**TABLE 1**

- This table is applicable :
  - if both FD are displayed (no AP engaged) and LAND mode is not selected on FCU,
  - or if both AP are engaged in CMD and GO AROUND mode is engaged.
- If VOR/NAV/ILS switches are not in the same positions, VOR mode has priority over NAV mode, and LOC mode has priority over VOR and NAV modes.
- VOR or LOC mode arming/engagement when the V/L pushbutton is pressed is as follows :

VOR/NAV/ILS switch position		Mode	Remark
One side	Other side		
VOR	VOR	VOR	See Note 1
VOR	NAV	VOR	VOR arms on both PFD
VOR	ILS	LOC	See Note 2
NAV	NAV	No effect	
NAV	ILS	LOC	LOC arms on both PFD
ILS	ILS	LOC	

**Note 1 :** Once VOR mode is armed or engaged, if either VOR/NAV/ILS switch is changed from VOR to ILS, the associated FD will disengage (FD bars are cleared and the red FD warning is displayed).

**Note 2 :** The FD associated with the VOR/NAV/ILS switch which is in the VOR position disengages (FD bars are cleared and the red FD warning is displayed). This FD re-engages after its VOR/NAV/ILS switch is set to ILS or NAV.

**Note 3 :** If VOR or LOC mode is selected when both AP are in CMD in GO AROUND mode, AP2 disengages.

**TABLE 2**

- This table is applicable if :
  - one AP is engaged in CMD,
  - and both FD are displayed.
- Priority is given to the VOR/NAV/ILS switch associated with the engaged AP.
- VOR or LOC mode arming/engagement when the V/L pushbutton is pressed is as follows :

VOR/NAV/ILS switch position		Mode	Remark
Side of engaged AP	Other side		
VOR	VOR	VOR	
VOR	NAV	VOR	
VOR	ILS	VOR	See Note 1
NAV	VOR	No effect	
NAV	NAV	No effect	
NAV	ILS	No effect	
ILS	VOR	LOC	See Note 2
ILS	NAV	LOC	
ILS	ILS	LOC	

**Note 1 :** When VOR mode engages, if one VOR/NAV/ILS switch is in the ILS position, the onsite FD disengages and will re-engage after the switch is set in the VOR position.

**Note 2 :** When LOC mode engages, if one VOR/NAV/ILS switch is in the VOR position, the onsite FD disengages and will re-engage after the switch is set in the ILS position.

**Note 3 :** VOR mode does not engage if LAND mode is selected on FCU.

**TABLE 3**

- This table is applicable if LAND mode is selected on FCU and :
  - both AP are engaged in CMD,
  - and/or both FD are displayed.
- LOC mode arming/engagement when the V/L pushbutton is pressed is as follows :

**Note : VOR mode cannot be engaged under the above conditions.**

VOR/NAV/ILS switch position		Mode	Remark
One side	Other side		
ILS	ILS	LOC	See Note 1
ILS	VOR	LOC	See Note 2
ILS	NAV	LOC	See Note 3
NAV	NAV	No effect	
NAV	VOR	No effect	
VOR	VOR	No effect	

**Note 1 : AP2 disengages but FD2 remains engaged (in LOC mode). AP/FD1 remain engaged (in LOC mode).**

**Note 2: The AP/FD associated with the VOR/NAV//LS switch set to VOR disengages.**

**Note3 : The AP/FD associated with the VOR/NAV/ILS switch set to NAV remains engaged (in LOC mode).**



**Autoflight System**
**Land Mode**
**FUNCTION**

- The LAND mode selection on the FCU provides vertical and lateral guidance during an ILS approach to capture and track the localizer and glide slope beams.
- In the final phase of the approach, the LAND mode provides flare and alignment guidance (FLARE mode) and roll out guidance (ROLL OUT mode) for automatic landing and roll out.
- The A/THR mode associated with the LAND mode is the SPD mode.
- The LAND mode selection :
  - arms simultaneously then engages a vertical mode (GS) and a lateral mode (LOC) for capturing and tracking the ILS beam,
  - engages successively combined (vertical and lateral) modes (LAND, FLARE and ROLL OUT) for the final approach and landing.

**ENGAGEMENT AND OPERATION**

- During approach, LAND mode can be selected by pressing the LAND pushbutton provided :
  - Radio Altitude (RA) is above 400 ft.
  - an ILS frequency and course have been set on the ILS control panel (irrespective of the VOR/NAV/ILS switch position).
- LAND mode selection is indicated by the FMA annunciation (G/S blue and LOC blue) and by the illumination of the LAND pushbutton.
- When LAND pushbutton is pressed, GS and LOC modes arm and start their respective capture phases when within their respective capture ranges.
- Selecting the VOR/NAV/ILS switch to ILS allows to display on the onside PFD and ND the LOC and GS deviation indexes.

If the VOR/NAV/ILS switch has been left in VOR or NAV when LAND mode is selected, an amber "ILS" message flashes on the onside PFD (to remind the crew member to set the VOR/NAV/ILS switch in the ILS position).

- Once LAND mode has been armed, both AP can be engaged in CMD.

**Note 1 : With LAND mode armed and one AP engaged in CMD, the DC bus tie contactor (connecting the DC NORM BUS and the DC ESS BUS) automatically opens in order to assure an independent electrical power supplies for the AP/FD 1 and 2.**

**In case of DC bus tie contactor failure to open, the landing capability does not change from CAT2 to CAT3 after the engagement of the second AP (but no audio alert is provided).**

**Note 2 : Below 700 ft AGL, the ILS frequency and course selector knobs are disabled.**

**Note 3 : If FPV is used for the approach, FD bars automatically replace the FPV when FLARE mode engages or if a go-around is initiated.**

- If LAND is deselected by pressing the pushbutton a second time, the FD bars flash during 10s.

**MODES ASSOCIATED WITH LAND MODE**
**LOC mode**

Refer to section LOC MODE for LOC mode description.

**GLIDE SLOPE (GS) mode**

- The GS mode captures and tracks the ILS glide slope.
- GS mode has three successive phases :
  - arming phase (G/S blue on FMA),
  - capture phase (GS\* green on FMA),
  - tracking phase (GS green on FMA).
- GS mode arming and engagement is indicated on the FMA only.
- When GS mode is armed, the AP/FD uses the support of a pilot-selected vertical mode to guide the aircraft towards the capture point of the glide slope beam. This intercept mode can be V/S, LVL/CH, ALT or PROFILE.

**Autoflight System**
**Land Mode**

- GS mode automatically engages the capture phase (GS\*) when the aircraft is in the capture range of the glide slope and engages the tracking phase (GS green) when the aircraft is stabilized on the glide slope.
- **GS\* can engage only if LOC\* or LOC green is engaged**
- In GS\* mode, the AP Supervisory Control Wheel Operation is available.
- The A/THR mode associated to the GS mode is SPD.

**LAND mode (LAND green on FMA)**

- LAND mode is a combined mode which engages at 400 ft AGL or below provided GS and LOC modes are engaged in tracking phase (GS and LOC green on FMA).

The guidance in LAND green mode is similar to GS green and LOC green.

- Once engaged, LAND mode is latched and cannot be disengaged except by engaging the GO AROUND mode.
- LAND mode engagement is indicated on the FMA only (LAND green).
- For safety reasons, in LAND mode, all FCU controls are inhibited except :
  - the SPD selector knob,
  - the AP engagement levers (to engage the second AP in CMD, if desired),
  - the CWS/CMD switch-over pushbutton.

**Note : Switching from CMD to CWS is possible only when one AP is engaged.**

- The A/THR mode associated to the LAND mode is SPD.

**FLARE mode**

- The FLARE mode is a combined mode which provides :
  - vertical guidance for flare and touchdown (using a flare control law defined in terms of vertical speed).

- lateral guidance for the alignment of the aircraft with the runway center line (by comparing the aircraft magnetic heading provided by the IRS with the runway heading / course selected on the ILS control box).

**Note : In cross-wind conditions, the aircraft is maintained wings level (i. e. without sideslip but with a crab angle).**

- FLARE mode typically engages at 50 ft RA (the FLARE mode engagement is adjusted as a function of the aircraft vertical speed). Engagement is indicated on the FMA (FLARE green).
- In manual landing, at 30 ft RA, the FD roll bar is replaced by the yaw bar.
- The A/THR mode associated to the FLARE mode is initially SPD, then RETARD at 30 ft RA.

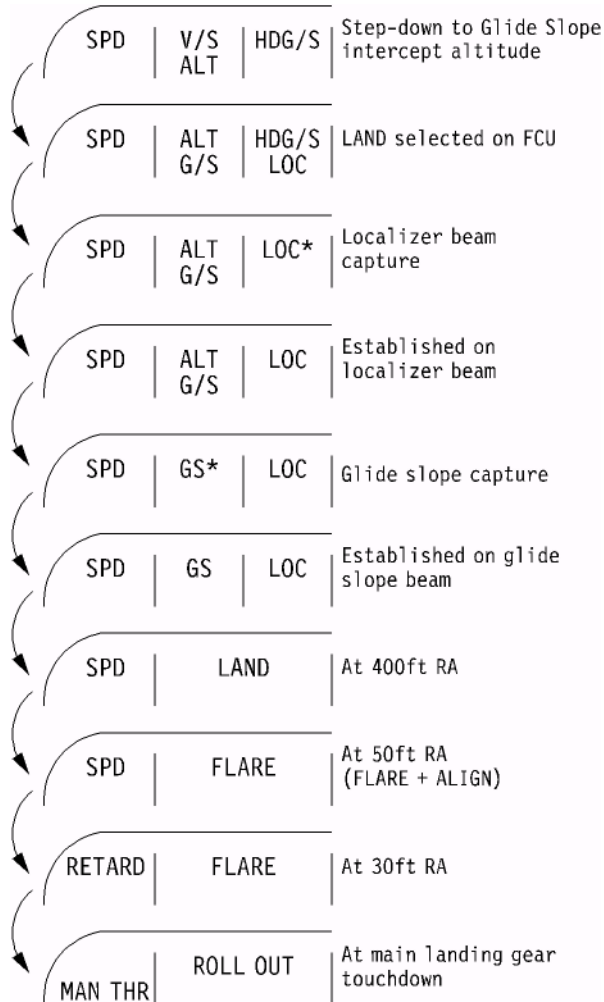
**ROLL OUT mode**

- The ROLL OUT mode is a combined mode which provides :
  - Lateral guidance for tracking of the runway centerline (using the IRS magnetic heading, the runway heading / course selected on the ILS control box, the yaw rate and the localizer deviation),
  - vertical guidance for lowering the nose landing gear (derotation).
- ROLL OUT mode engages at main landing gear touchdown and is annunciated on the FMA.
- When ROLL OUT mode engages, the A/THR disengages (MAN THR on FMA).
- The ROLL OUT mode remains active until the aircraft complete stop.
- On the ground during taxi-in, the ROLL OUT mode remains displayed on the FMA as long as the FD is displayed.

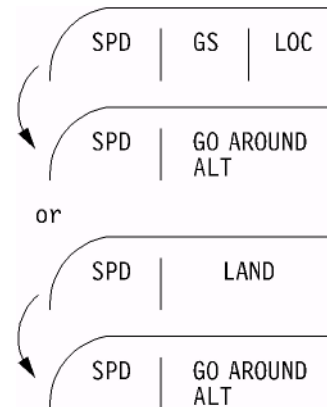
The ROLL OUT mode disengages if a go-around is initiated after touchdown or, at the latest, when takeoff modes are engaged.

### MODE TRANSITIONS

- During approach and landing, the typical automatic mode transitions sequence is as follows :



- With GS and LOC modes armed, both modes can be simultaneously disarmed by :
  - pressing the LAND pushbutton switch again (the support modes remain engaged),
  - selecting either another vertical mode or another lateral mode,
  - selecting GO AROUND mode (i.e. by triggering either go-lever).
- At any time of the approach, the pilot can engage the GO AROUND mode (SRS/HDG guidance), the corresponding FMA transition sequences are as follows :

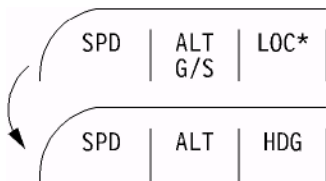


**Autoflight System**
**Land Mode**
**MODE REVERSIONS**

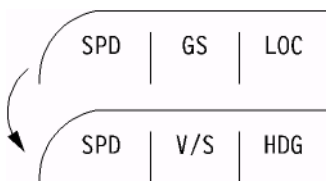
- Following LOC\* engagement and before LAND green mode engagement, a manual mode reversion can be performed by :

- pressing the LAND pushbutton a second time :

- LOC\* or LOC disengages and HDG engages (basic mode).
- if G/S is armed, G/S disarms (the vertical support mode remains engaged).

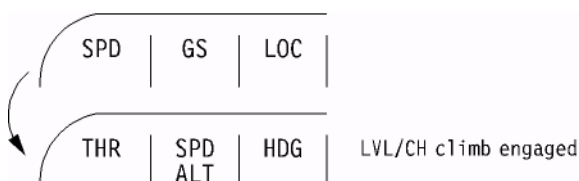


- if GS\* or GS is engaged, GS disengages and V/S engages (basic mode).



- selecting another **vertical mode** :

- the vertical mode engages,
- a lateral mode reversion to HDG mode occurs.



- selecting another **lateral mode** :

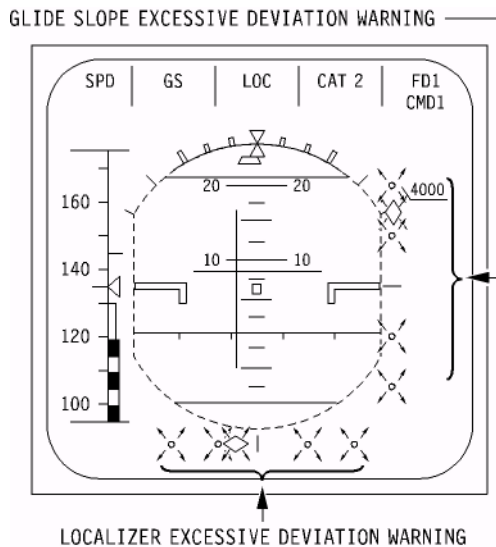
- the lateral mode engages,
- if G/S is armed, G/S disarms (LAND pushbutton switch extinguishes)



- if GS\* or GS is engaged, a vertical mode reversion occurs to V/S mode.



- An automatic mode reversion to basic modes (V/S and HDG) occurs if both radio altimeters fail or if both ILS receivers fail.

**Autoflight System**
**Land Mode**
**WARNINGS**
**Excessive deviation from localizer or glide slope**


- If the VOR/NAV/ILS switch is in the ILS position, the PFD/ND glide slope and/or localizer index and scale flash to warn the crew of excessive localizer or glide slope deviation :
  - The LOC excessive deviation warning (flashing LOC index and scale on PFD and ND) is triggered, above 15 ft RA, if LOC deviation exceeds 1/3 dot.
  - The G/S excessive deviation warning (flashing G/S index and scale on PFD and ND) is triggered, above 100 ft RA, if G/S deviation exceeds 1 dot.

The above warnings are triggered only in LOC green or GS green phases, with CAT 2 or CAT 3 landing capability indicated on FMA.

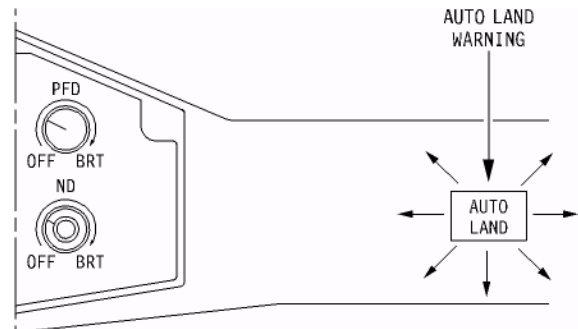
- In either GS or LOC tracking phase (GS green or LOC green on FMA), the ILS transmitter (ground station) failure is annunciated as follows :
  - localizer transmitter failure :
    - LOC excessive deviation warning and flashing FD roll bar, and
    - AUTO LAND warning, if below 200 ft RA.

- glide slope transmitter failure :

- G/S excessive deviation warning and flashing FD pitch bar, and
- AUTO LAND warning, if below 200 ft RA.

**AUTO LAND Warning**

- The AUTO LAND warning consists of two red AUTO LAND lights flashing on the glareshield panel.



- The warning is triggered simultaneously with one of the following conditions :
  - GS and/or LOC excessive deviation warning,
  - AP OFF warning,
  - long flare (aircraft not on the ground 15 seconds after passing 50 ft RA),
  - a difference greater than 15 ft is detected between the Radio Altimeters 1 and 2.
- The warning is triggered, below 200 ft RA, only in LAND green mode with CAT 2 or CAT 3 landing category capability.
- The AUTO LAND warning can be cancelled by :
  - triggering either Go-lever (i.e. initiating a Go-Around), or
  - pressing the AP instinctive disconnect pushbutton twice (the first action disengages the AP, the second action cancels the AP OFF and AUTO LAND warnings).

**Warning test**

- LOC and G/S excessive deviation warnings and both AUTO LAND warning lights can be tested by pressing either AUTO LAND light.

**Autoflight System**
**Land Mode**
**Landing capability downgrade**

- If the landing capacity category is downgraded (CAT 3 downgraded to CAT 2 or CAT 2 downgraded to CAT 1 or in case of loss of CAT 1 capability) an audio triple-click warning sounds.

**LANDING CAPABILITY**

- When LAND mode is selected on FCU, a landing capability category (CAT 1, CAT 2 or CAT 3) determined by the status of the aircraft's equipment, is displayed in the fourth column of the FMA.
- In addition to the arming conditions for LAND mode, the following table lists the equipment and systems which must be operational for respective landing capability categories :

Capability → Equipment ↓	CAT 1	CAT 2	CAT3
AP/FD	1 FD or 1 AP in CMD	1 AP in CMD	2 AP in CMD + 1 FD
A/THR			Engaged in SPD mode
ILS receiver	№1 for FD 1 №2 for FD 2	№1 and №2	№1 and №2
PFD (Primary Flight Display)	№1 for FD 1 №2 for FD 2	№1 and №2	№1 and №2
IRS (Inertial Reference System)	№1 and (№2 or 3) for FD 1 №2 and (№1 or 3) for FD 2	№1 and (№2 or 3) for AP 1 №2 and (№1 or 3) for AP 2	№ 1 and №2 and №3
Radio Altimeters	№ 1 for FD 1 № 2 for FD 2	№ 1 for AP 1 № 2 for AP 2	№1 and №2
Hydraulic Systems		G and (B or Y) for AP 1 Y only for AP2	G and B and Y
Electrical Power	GEN1 or GEN2 or APU GEN	GEN1 or GEN2 or APU GEN	2 GEN (GEN1 or GEN2 or APU GEN)
Yaw Damper		№1 or №2	№1 and №2
Pitch Trim		№1 and №2	№1 and №2
FWC (Flight Warning Computer)		№1 for AP 1 №2 for AP 2	№1 and №2

- Below 100 ft RA, the CAT 3 landing capability is latched.

The disconnection of one AP or the loss of the A/THR - SPD mode, or the loss of any required equipment, does not cause a downgrading of the landing capability category.

**FAULT ACCOMODATION/REVERSION**

- If one ILS or Radio Altimeter receiver fails, the onside AP/FD disengages. The other AP/FD remains engaged in LAND mode.

The same logic applies for any equipment failure which causes the loss of the ROLL OUT mode.

- If both Radio Altimeters or both ILS receivers fail, LAND mode disengages (reversion to basic V/S and HDG modes), both AP disengage (AP OFF warning), FD bars flash for 10 seconds and the landing capability downgrade warning (triple-click) is triggered.

The same logic applies for any failure which causes the disengagement of both AP/FD.

- In GS green or LOC green mode (tracking phase), the non-reception of the glide slope or localizer signal causes :

- the activation of the glide slope or localizer excessive deviation warning,
- the flashing of the pitch or roll FD bar,
- the AUTO LAND warning activation (if below 200 ft RA).

- If the DC BUS Tie Contactor fails to open (no AP1 and AP2 electrical power segregation), the second AP can be engaged but the landing capability category will be CAT2 only.



**Autoflight System**
**GO AROUND Mode**
**FUNCTION**

- The GO AROUND mode is a combined mode that provides vertical and lateral guidance for go-around :
  - The vertical guidance mode is SRS.
  - The lateral guidance mode is HDG.

On the FMA, GO AROUND is displayed, but SRS and HDG are not.

**Note:** For SRS mode, refer to section - TAKEOFF MODES

- The A/THR mode associated to the GO AROUND mode is THR.

**ENGAGEMENT AND OPERATION**

- GO AROUND mode is engaged by triggering the Go-levers :
  - If the Go-levers are triggered in flight :
    - GO AROUND mode engages provided the SLATS/FLAPS handle is in the 15/0 position (or more extended).
    - If a GO AROUND is initiated with the AP engaged in CMD and the aircraft touches down during the go-around maneuver, the AP remains engaged in CMD and GO AROUND mode.
  - If the Go-levers are triggered within 30 seconds after touchdown :
    - following a manual landing, GO AROUND mode engages,
    - following an automatic landing, GO AROUND mode does not engage.
  - If the Go-levers are triggered more than 30 seconds after touchdown (with slats at 15° or more), TAKEOFF modes activate, and the AP disengages (if engaged).

**Note :** If Go-levers are triggered in flight with the slats/flaps lever in 0/0 position, the ATS Thrust Latch mode (THR L on FMA) engages but the AP/FD guidance does not change.

- GO AROUND mode engagement is indicated on the FMA only.

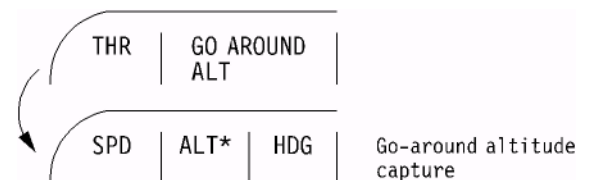
- If both AP were in CMD for the approach, both stay engaged during the go-around, as long as GO AROUND mode remains engaged.

**Note 1:** The GA thrust limit on the TRP is automatically selected when slats are selected to 15/0, and at least one AP/FD is engaged.

**Note 2 :** If the FPV is displayed on the PFD when GO AROUND mode engages, it is automatically replaced by the FD bars.

**MODE TRANSITIONS**

- An automatic mode transition occurs (GO AROUND mode disengages) when the aircraft reaches the go-around altitude. Altitude capture (ALT\*) and HDG mode engage.

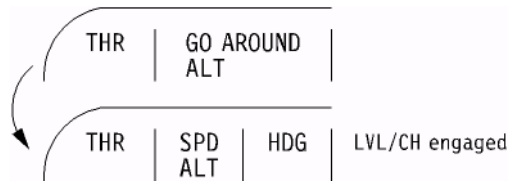


- When GO AROUND mode disengages, AP2 disengages if both AP were engaged.
- A manual mode transition occurs if a **new vertical mode** is engaged (V/S, ALT, LVL/CH, ALT\* or PROFILE when in NAV) :
  - GO AROUND mode disengages,
  - the selected vertical mode engages,
  - the HDG mode is annunciated on the FMA (but was already engaged for the go-around lateral guidance),
  - the A/THR mode associated with the selected vertical mode engages.

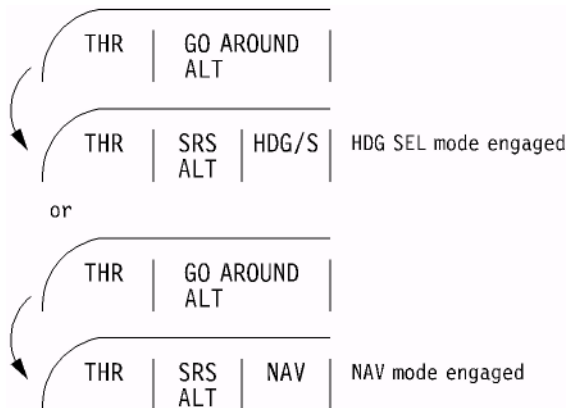


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**Autoflight System**
**GO AROUND Mode**


- A manual mode transition occurs if a **new lateral mode** is engaged (HDG SEL, NAV) :
  - GO AROUND mode disengages,
  - the SRS mode is annunciated on the FMA (but was already engaged for the go-around vertical guidance),
  - the selected lateral mode engages,
  - the A/THR THR mode remains engaged.



**Note :** The V/L and LAND modes must not be used to manually disengage the GO AROUND mode.

**Autoflight System**
**Profile Mode**
**FUNCTION**

- The PROFILE mode couples the Flight Management System (FMS) to the AP/FD and to the A/THR (AUTO mode on TRP) for vertical guidance along the FMS vertical flight plan (F-PLN).
- In PROFILE mode, the vertical guidance orders and the thrust are computed by the Flight Management Computer (FMC) and executed by :
  - the AP/FD ( P.CLB, P.ALT, P.DES modes ) for maintaining the required speed, altitude, flight path or vertical speed,
  - the A/THR ( P.THR, P.SPD, RETARD modes ) for maintaining the required thrust or speed.
- The PROFILE mode may be used without the A/THR being engaged (i.e. with MAN THR setting).

**ENGAGEMENT AND OPERATION**

- The PROFILE mode can be armed (at takeoff) or engaged at any time by pressing the PROFILE pushbutton.
- When PROFILE mode is armed at takeoff (P.CLB blue on FMA), PROFILE (P.THR / P.CBL green on FMA) automatically engages at the thrust reduction altitude (i.e. at 1500 ft AGL or higher, as set in the FMS TAKEOFF page).
- If not initially armed, PROFILE mode can be manually engaged after passing the thrust reduction altitude at any time during climb (P.CLB on FMA), cruise (P.ALT on FMA) and descent (P.DES on FMA).
- When PROFILE mode is engaged, altitude changes are initiated by setting the new cleared altitude on the FCU, and by pulling the ALT SEL knob.
- When PROFILE mode engages,
  - the SPD/MACH window is dashed (speed/Mach is controlled by the FMS, the FMS target speed is indicated on the PFD speed scale by the blue index),
  - the TRP AUTO key illuminates (TRP thrust limit is controlled by the FMS).

- In climb or descent the TRP TARGET window displays the FMS-computed target thrust.
- The A/THR modes associated to the PROFILE mode are :
  - P.THR in climb and for descent initiation, to maintain the target thrust commanded the FMS,
  - P.SPD in cruise to maintain the target speed commanded by the FMS or in descent if speed or altitude constraints have to be achieved,
  - RETARD during idle descent.
- PROFILE mode arming/engagement is indicated on the FMA and by the illumination of the PROFILE pushbutton switch.
- The operating envelope of the PROFILE mode is from 1500 ft AGL at takeoff to :
  - GS capture (GS\*), for a precision approach, or
  - the Final Approach Fix (FAF) or the Final Descent Point, for non-precision approach.
- **PROFILE mode is not allowed for use on final approach (i.e. after the FAF or the Final Descent Point or 1000 ft AGL, whichever is earlier).**
- In PROFILE mode, the speed is controlled to remain between VLS (Green Dot, if in ECON mode) and below VMAX.

**DISENGAGEMENT**

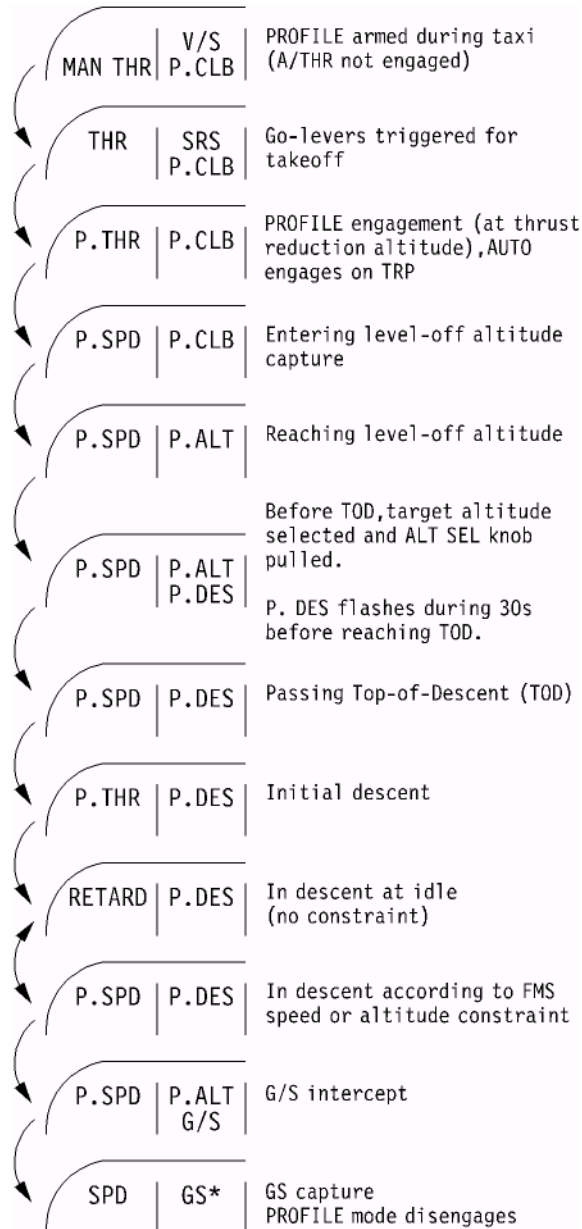
- The PROFILE mode is disengaged by pulling the SPD/MACH knob (SPD/MACH window synchronizes on the present aircraft speed).  
Pulling the SPD/MACH knob results in a manual reversion from **managed modes to selected modes** :
  - LVL/CH mode in climb or descent,
  - ALT mode in level flight.
- The SPD knob can then be turned to select the desired target speed.

## Autoflight System

## Profile Mode

### MODES TRANSITIONS

- The automatic mode transitions sequence over a complete flight conducted in PROFILE mode, is as follows :

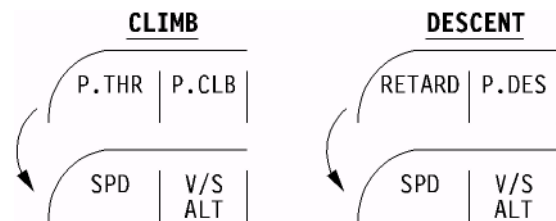


- The altitude capture range (automatic transition from P.THR / P.CLB to P.SPD / P.CLB) varies depending on the aircraft vertical speed (the capture range increases with increasing vertical speed).

In PROFILE climb with 2000 ft/mn vertical speed, the capture phase is initiated approximately 300 ft before the selected altitude.

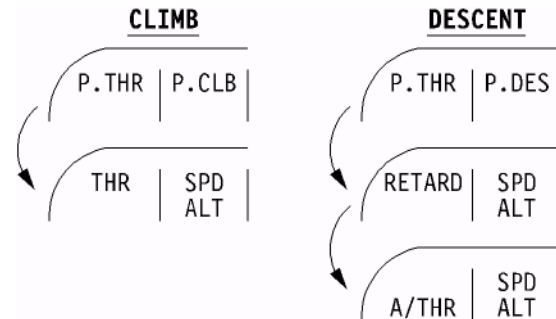
- A manual mode transition can be initiated by selecting another vertical mode, the transition sequence is as follows :

- If V/S mode is selected by pulling the V/S knob :



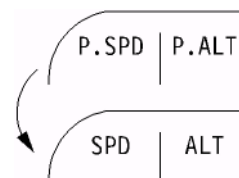
- If LVL/CH mode is selected by :

- pulling the SPD/MACH knob in climb or descent,
- or by pressing the LVL/CH pushbutton.



- If ALT HLD mode is selected by :

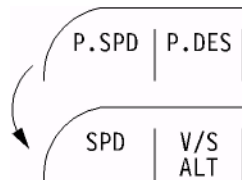
- pulling the SPD/MACH knob in level flight,
- or by pressing the ALT.HLD pushbutton.



**MODE REVERSIONS**

- A manual mode reversion from PROFILE to V/S (basic vertical mode) can be performed by pressing the PROFILE pushbutton.

The FMA mode reversion sequence is as follows :



- In descent, automatic reversions from RETARD/ P.DES to P.SPD / P.DES or from P.PSD / PDES to RETARD / P.DES occur when speed or altitude constraints have to be met or if the airspeed is below or above defined guidance limits.

- In P.DES mode, depending on the prevailing constraint or condition, the vertical guidance :

- maintains the computed flight path (Path), or
- maintains the computed target speed (SPD), or
- maintains the present aircraft vertical speed (V/S).

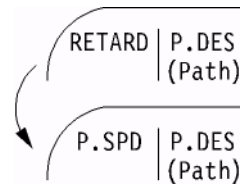
In the FMA illustrations provided hereafter, (Path), (V/S) or (SPD) indicates the applicable guidance

- but is not displayed on the FMA.

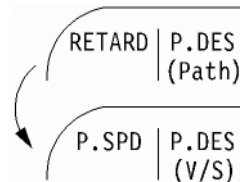
- An automatic reversion from RETARD / P.DES to P.SPD / P.DES occurs if :

- an ALT CSTR must be met,
- a SPD CSTR must be met,
- IAS is greater than the target speed + 20 kt,
- IAS is lower than the target speed - 20 kt,
- IAS is lower than Green Dot - 10 kt.

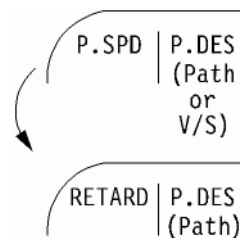
The FMA mode reversion sequence is as follows :



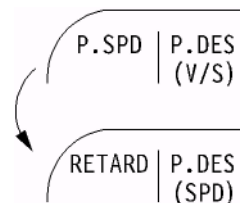
- An automatic mode reversion from RETARD / P.DES to P.SPD / P.DES occurs if a revision of the F-PLN is performed (as temporarily, the FMS cannot refer to any flight profile reference for flight path guidance) :



- When the conditions requiring a tight speed control (P.SPD mode) no longer exist, an automatic reversion from P.SPD / P.DES to RETARD / P.DES occurs :

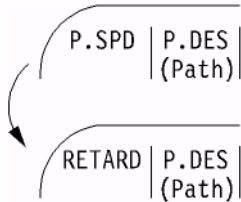


- An automatic reversion from P.SPD / P.DES to RETARD / P.DES occurs if the airspeed exceed VMO - 5 kt, when in IMM DES :



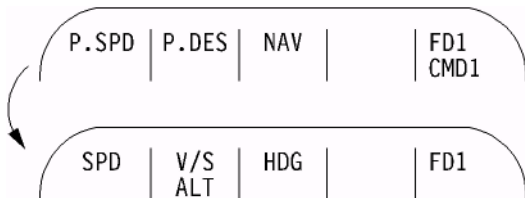
**Autoflight System**
**Profile Mode**

- A similar automatic reversion from P.SPD / P.DES to RETARD / P.DES occurs if :
  - IAS is greater than the target speed + 15 kt,
  - or
  - IAS is greater than VMAX - 2 kt



- An automatic mode reversion from PROFILE to V/S mode occurs if the FMC associated to the engaged AP fails.

The AP disengages, the FD remains engaged in V/S mode.



**Autoflight System**
**NAV Mode**
**FUNCTION**

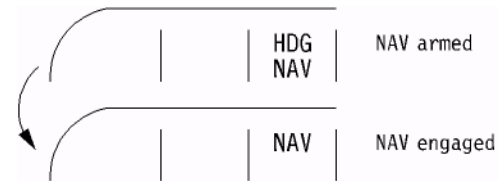
- The NAV mode couples the Flight Management System (FMS) to the AP/FD for lateral guidance along the FMS lateral flight plan (F-PLN).

**ENGAGEMENT AND OPERATION**

- The NAV mode can be armed or engaged (NAV blue or NAV green on FMA) by pressing the NAV pushbutton.
- If the NAV mode is armed for takeoff, NAV automatically engages when passing 30 ft AGL.
- If not armed before takeoff, NAV mode can be manually engaged after passing 30 ft at any time, provided there is an active leg in the FMS F-PLN.
- In flight, when the NAV pushbutton is pressed :
  - NAV immediately engages if the aircraft is within the capture band of the active leg (i.e. if the present aircraft track is within 10 nm from the FMS active F-PLN leg),
  - NAV arms if the present aircraft track is more than 10 nm away from the active leg, then NAV engages when the aircraft enters the capture band of the active F-PLN leg.
- When NAV is armed (NAV blue on the FMA), the AP/FD uses the support of another lateral mode (HDG, RWY, HDG/S or VOR) to guide the aircraft towards the capture band of the active F-PLN leg.  
At the capture point, NAV mode engages ( NAV green on FMA) and the aircraft is guided towards the active F-PLN leg with a 45° intercept angle.
- When NAV mode is engaged, the HDG SEL window displays the last manually selected heading.
- To capture or maintain the FMS course in NAV mode, the bank angle is determined by the FMS regardless of the position of the Bank Angle Limit selector.

**Note :** With NAV mode engaged or disengaged, it is always possible to view the FMS flight plan course, and the aircraft's position relative to this course, on the ND, by selecting MAP or PLAN on the EFIS control panel.

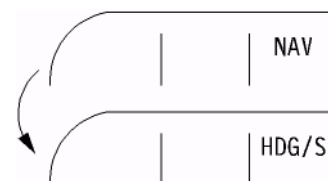
- NAV mode arming and engagement is annunciated on the FMA and is indicated on the FCU by the illumination of the NAV pushbutton switch.



- The operating envelope of the NAV mode is from 30 ft AGL at takeoff to :
  - LOC capture (LOC\*) for a precision (ILS) approach or for a LOC-only approach,
  - MDA-MDH for other types of non-precision approaches.

**MODE TRANSITIONS**

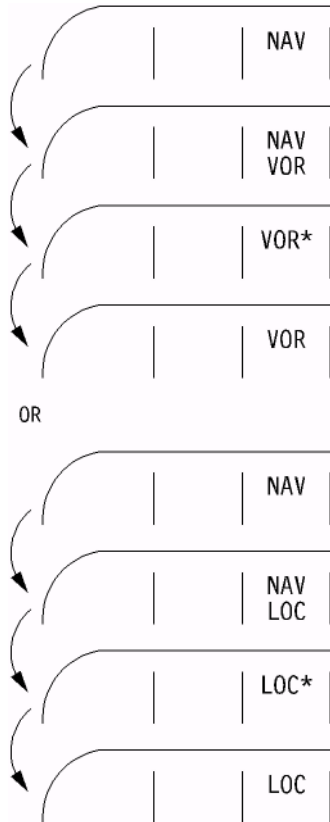
- A manual mode transition can be initiated by selecting another lateral mode, the transition sequence is as follows :
  - If HDG/S mode is selected :



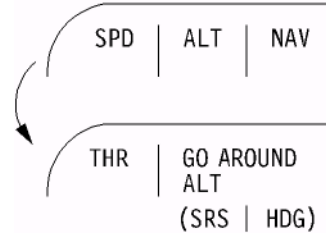
## Autoflight System

## NAV Mode

- If V/L (VOR/LOC) mode is selected :

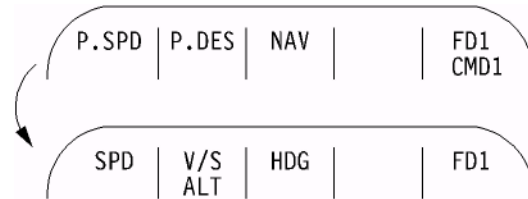


- An automatic mode reversion from NAV mode to HDG mode occurs if a go-around is initiated, however HDG is not indicated on FMA :



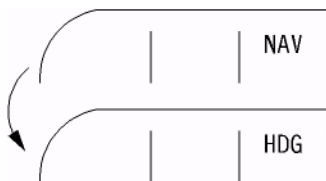
- An automatic mode reversion from NAV mode to HDG mode occurs if the FMC associated to the engaged AP fails.

The AP disengages, the FD remains engaged in HDG mode.



### MODE REVERSIONS

- A manual mode reversion from NAV mode to HDG mode (basic lateral mode) occurs if the NAV pushbutton is pressed a second time.



- When in NAV mode, if a given heading has to be maintained (e.g. upon ATC request) a manual reversion from NAV mode to HDG/S mode can be performed by using the Push-Pull-Turn technique (refer to section - HEADING SELECT MODE)