ACRONYMS

A/B or AB	AirBrakes
ACM	Airbrake Control Manifold
ACMU	Actuator Control and Monitoring Unit
ADI	Attitude Director Indicator
ADS	Air Data System
AHRS	Attitude and Heading Reference System
AOA	Angle Of Attack
AOS	Angle of Sideslip
ASP	Auto-throttle Speed Protection
BCU	Brake Control Unit
BU	Back Up
CB	Circuit Breaker
CAS	Crew Alerting System
DFDR	Digital Flight Data Recorder
DP	Dynamic Pressure
EBHA	Electrical Backup Hydraulic Actuator
EP	Electro Pump
FCC	Flight Control Computer
FCS	Flight Control System
FCL	Flight Control Laws
FDC	Flight Data Concentrator
FBW	Fly By Wire- refers to the technology
HSEBU	Horizontal Stabilizer Electronic Backup Unit
HSECU	Horizontal Stabilizer Electronic Control Unit
HSI	Horizontal Situation Indicator
HSSU	Horizontal Stabilizer Sensor Unit
HSTA	Horizontal Stabilizer Trim Actuator
HUD	Head Up Display
IRS	Inertial Reference System
LH	Left Hand
MAIC	Maintenance and Avionics Interface Computer
MAU	Modular Avionics Unit
MFCC	Main Flight Control Computer
MMO	Mach Maximum Operating
OP	Overhead Panel
PCU	Power Control Unit
PFCS	Primary Flight Control System - refers to the system

PMA	Permanent Magnetic Alternator
PS	Static Pressure
PSP	Pitch Speed Protection
PTY	PrioriTY
RA	Radar Altimeter
RH	Right Hand
RTO	Reject Take-Off
SELMON	SELection and MONitoring unit
SF	Slats Flaps
SFAU	Slats Flaps Airbrakes Control Unit
SFCC	Secondary Flight Control Computer
SFCI	Secondary Flight Control Interface
SPPCU	SPoiler Power Control Unit
SSPC	Solid State Power Controllers
TCS	Touch Control Steering
THS	Tail Horizontal Stabilizer
TOGA	Take Off Go Around
VMO	Velocity Maximum Operating (Maximum Operating Speed)
WOW	Weight On Wheel

INTRODUCTION

The Flight Control System description is decomposed in:

- Primary Flight Control System, which allows controlling the trajectory of the airplane. Primary Flight Control System include:
  - Ailerons,
  - Tail Horizontal Stabilizer,
  - Elevators,
  - Rudder,
  - Spoilers.
- Secondary Flight Control System, which allows aerodynamic configuration optimization. The secondary Flight Controls System include:
  - Slats System,
  - Flaps System,
  - Airbrakes System (including aibrakes and spoilers panels).

Information can be found in the following ATA sub-chapters:

- ATA 27_1: Primary Flight Control System,
- ATA 27_2: Slats System,
- ATA 27_3: Flaps System,
- ATA 27_4: Airbrakes System.

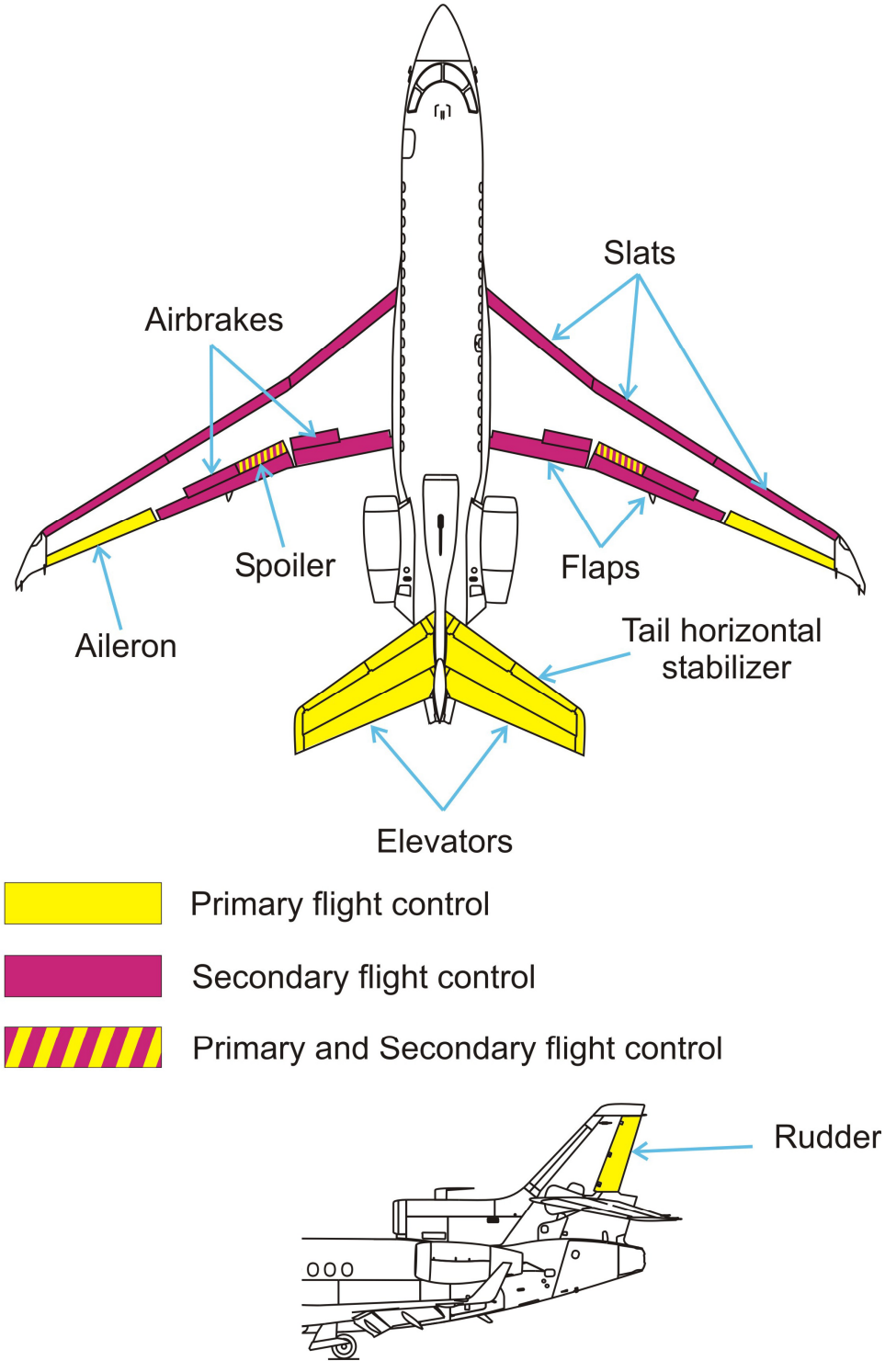


FIGURE 02-27-05-01 - PRIMARY AND SECONDARY FLIGHT CONTROL

INTRODUCTION

The Falcon 7X airplane is fitted with a Primary Flight Control System (PFCS) controlling the airplane attitude on the three axis according to pilot or Flight Director input commands by way of 8 primary flight control surfaces:

- Two ailerons,
- Two elevators,
- One rudder,
- A trimable Tail Horizontal Stabilizer,
- Two spoilers.

Fly By Wire technology is used for Primary Flight Control System, which provides:

- Protections against over speed, stall and structural overstress,
- Stability augmentation,
- Auto trim function,
- Pilot controls adaptation,
- Aerodynamic configuration optimization.

Primary Flight control surface position orders are:

- Electrically commanded,
- Performed by actuators (either hydraulically or electrically powered).

FLIGHT DECK OVERVIEW

CONTROLS

Crew manual control of the Primary Flight Control system is performed via:

- The sidestick,
- The priority pushbutton,
- The pedals,
- The manual trims available und,er some flight or failure conditions.

A switch located on the sideledge next to each pilot sidestick allows position control of the pedals.

Primary Flight Control System can also be commanded by the Flight Director (FD) when AutoPilot (AP) is engaged.

INDICATIONS

Cockpit indications related to the Primary Flight Control System are displayed:

- On the PDU for trims positions,
- On the FCS synoptic page for control surfaces and trims positions,
- In the ENG-CAS window for CAS messages,
- In the STATus synoptic / FAULT tab for fault messages.

Aural alerts are provided by the PFCS in some failure cases.

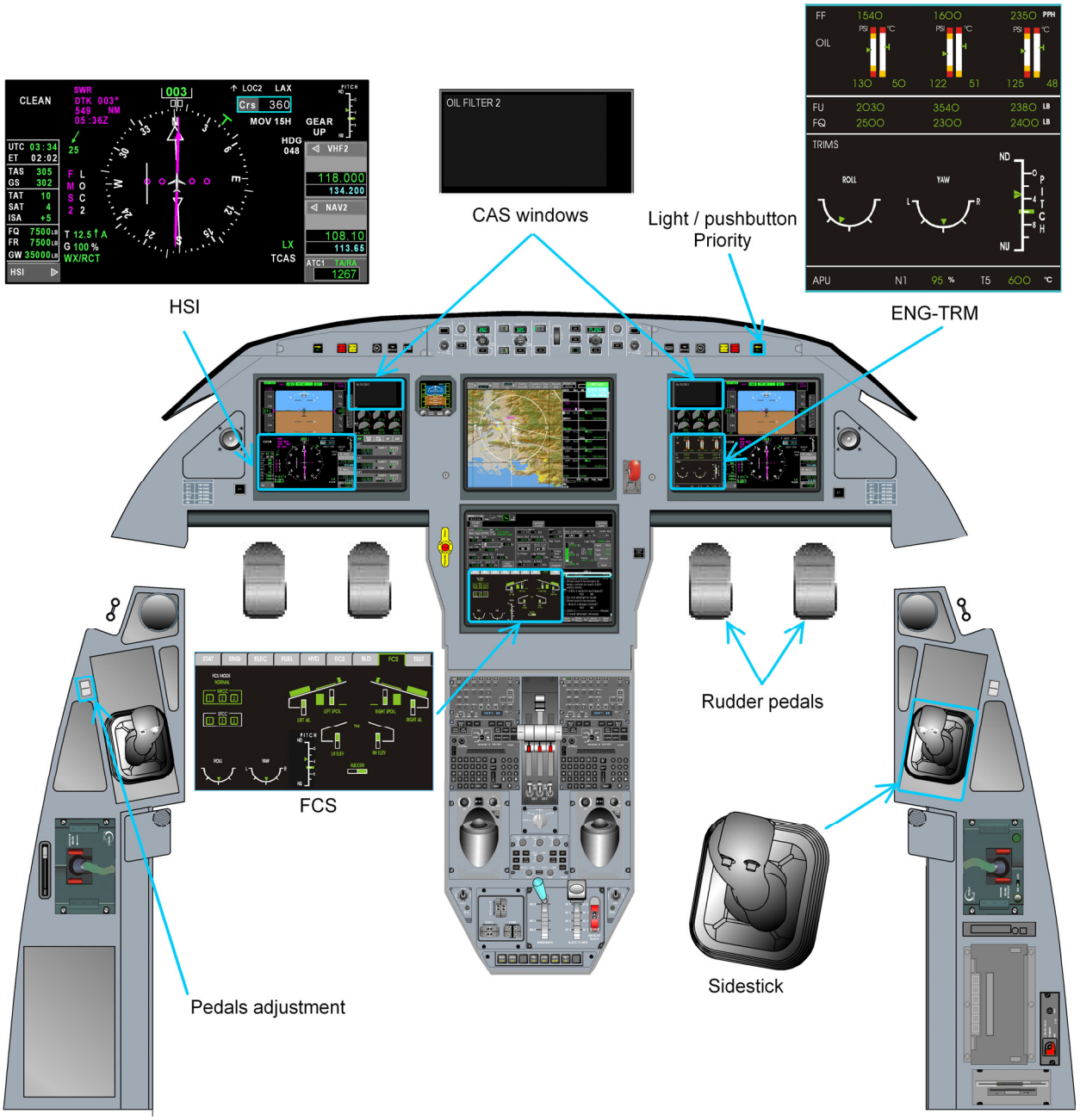


FIGURE 02-27_1-05-00 - FLIGHT DECK OVERVIEW

GENERAL

The Primary Fight Control System (PFCS) architecture is based on six main functionalities:

- Data collection:
  - From sensors (IRS, AHRS, RA, ADS,…),
  - From pilots controls,
  - From the Flight Director if the AutoPilot is engaged,
- Calculation of control surfaces commands by the main and secondary Flight Control Computers,
- Selection of Flight Control Computer for control surface commands and transmission of commands to actuators,
- Actuation of flight control surfaces by the actuators,
- Monitoring of actuators,
- Data exchanges with avionics.

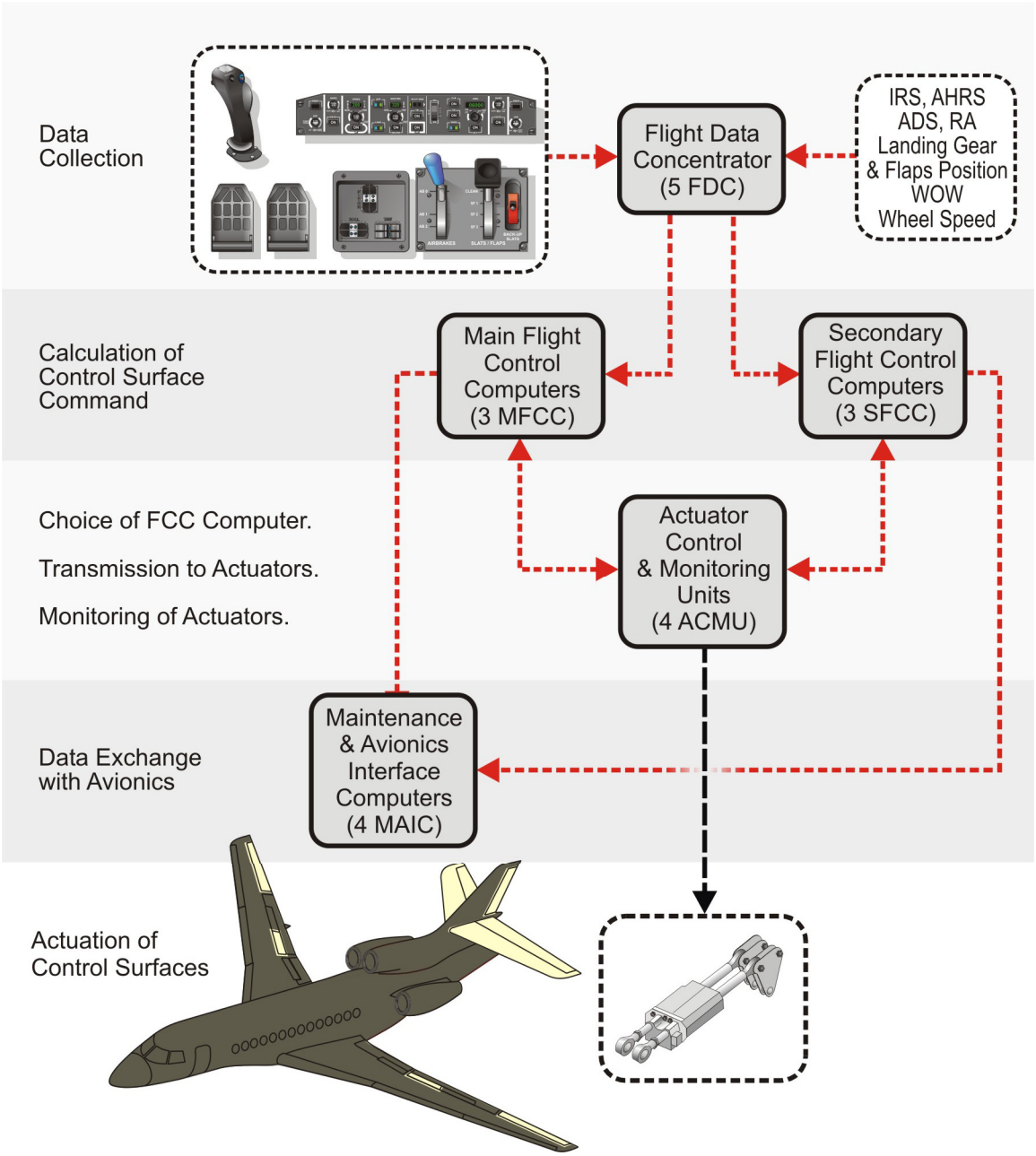


FIGURE 02-27_1-10-00 FUNCTIONALITIES OF PFCS COMPUTERS

These six main functionalities are performed by five different types of computers and by servo actuators:

Data collection:

=> Performed by five (5) Flight Data Concentrators (FDC).

Calculation of control surfaces commands:

=> Function performed by:

- Three (3) Main Flight Control Computers (MFCC) in normal conditions, or
- Three (3) Secondary Flight Control Computers (SFCC) in case of failure of the three MFCC.

Selection of FCC for the control surfaces commands and transmission and slaving of commands to actuators (after),

=> Functions performed by four (4) Actuator Control & Monitoring Units (ACMU).

Actuation of Flight Control surfaces,

=> Function performed by the actuators.

Monitoring of actuators

=> Functions performed by the four (4) Actuator Control & Monitoring Unit (ACMU).

Data exchanges with avionics,

=> Function performed by four (4) Maintenance & Avionics Interface Computers (MAIC).

➢ *Refer to PFCS Control for additional information on each computer.*

ADDITIONAL SAFETY FEATURE

In case all MFCC and all SFCC have failed, an analog computer is used, with direct control of the Horizontal Stabilizer and Spoilers through the pitch trim and rudder pedals.

The back-up mode uses internal sensors.

This mode is a temporary mode only used during computer reset.

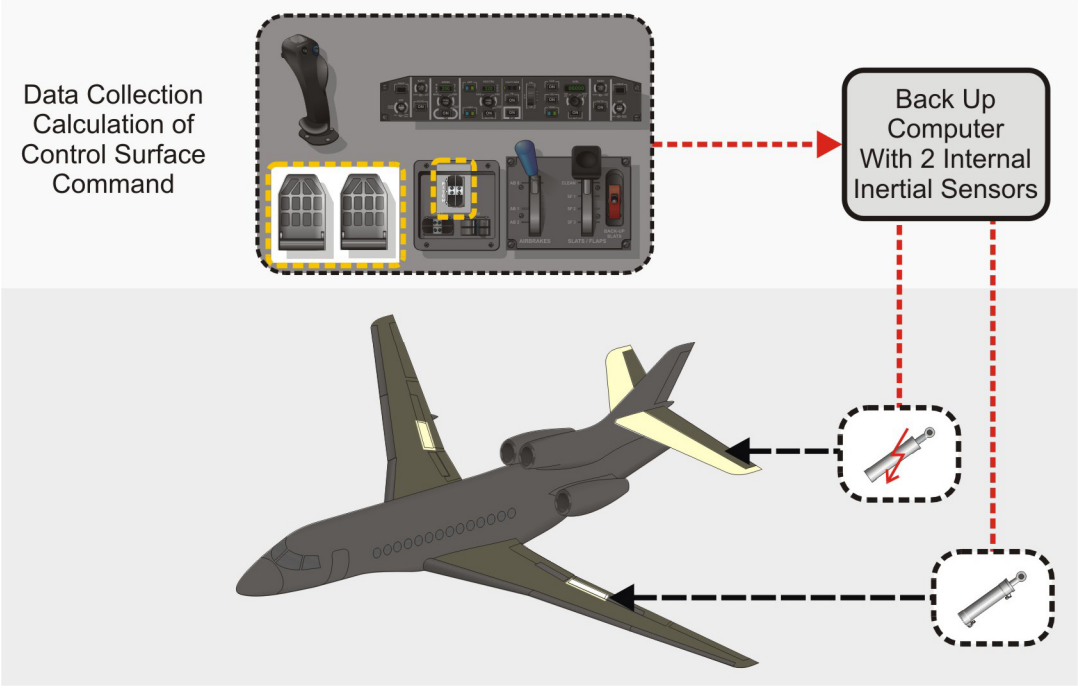


FIGURE 02-27_1-10-01 BACK UP CONTROL OF THE AIRPLANE

PRIMARY FLIGHT CONTROL SYSTEM DESCRIPTION

FLIGHT DATA CONCENTRATORS (FDC)

The PFCS includes 5 Flight Data Concentrators.

Each FDC collects the data received from the different sensors and pilots controls, and provide these data to the Flight Control Computers.

MAIN AND SECONDARY FLIGHT CONTROL COMPUTERS (MFCC AND SFCC)

The PFCS includes 3 MFCC and 3 SFCC.

The MFCC and SFCC perform the calculation of the Control Surface Commands, based on Flight Control Laws available.

The Flight Control Laws (FCL) requires flight control surface movement to achieve the expected behavior of the airplane depending on pilot inputs and airplane movement. The Flight Control Laws available depend on the status of airplane sensors and actuators. Three different types of Flight Control Laws are defined: named "Normal", "Alternate" and "Direct Laws". The non degraded FCL provide a higher level of safety and comfort and lower level of piloting workload compared to degraded FCL.

All MFCC and SFCC are active at the same time, MFCC being normally in control. The SFCC will be automatically in control in case of loss of all 3 MFCC.

The three different types of FCL are available within the MFCC.

MFCC are dual lane computers:

- Lane A is in control,
- Lane B performs monitoring.

Only the lowest level of FCL (named "Direct Laws") is available within the SFCC.

SFCC are single lane computers.

MFCC and SFCC send the computed control surface commands to the ACMU.

➢ *Refer to Flight Control Laws section for a description of functions available in the different types of Flight Control Laws.*

ACTUATOR CONTROL AND MONITORING CONTROL UNIT (ACMU)

The PFCS includes 4 ACMU.

Each ACMU receives data from all MFCC and SFCC. The ACMU would consider as invalid any MFCC for which channel A and B send inconsistent data. In addition, the ACMU would consider as invalid any MFCC (respectively SFCC) that would send data inconsistent with the data received from other MFCC (respectively SFCC).

Each ACMU sends orders to some of the servo actuators, and slaves the servo actuators to that order.

The monitoring of the actuators allows failure detection of control surfaces.

MAINTENANCE AND AVIONICS INTERFACES COMPUTER (MAIC)

The PFCS includes 4 MAIC.

Each MAIC receives data from MFCC and SFCC, as well as from the avionics.

Each MAIC provides status of Flight Control Laws, Computer, and actuator status for the elaboration of displays, CAS messages and aural alerts.

Each MAIC receives Flight Director data from the MAU for AP guidance.

Each MAIC provides parameters to other systems including FD, AT, DFDR.

Therefore some failures of the PFCS could impact other systems.

PRIMARY FLIGHT CONTROL SURFACES

GENERAL

The Primary Flight Control surfaces are actuated by electrical or electro-hydraulic servo actuators:

SURFACE	TYPE & NUMBER OF ACTUATORS	POWER SOURCE OF ACTUATOR
Horizontal Stabilizer	1 actuator with 3 motors	Electrical
Left and right elevators	2 actuators on each elevator	Electro-hydraulic
Left and right ailerons	1 dual actuator on each aileron	Electro-hydraulic
Left and right spoilers	1 actuator for each spoiler	Electro-hydraulic Includes a local accumulator and electrically driven hydraulic generator for redundancy [EBHA - Electric Back Up Hydraulic Actuator]
Rudder	1 dual actuator	Electro-hydraulic

SOURCES

The electrical power supply uses by FCS are labeled E1, E2, E3 and E4.

ELECTRICAL	HYDRAULIC
- Four +28V electric power supplies: o E1, powered by Permanent Magnet Alternator (PMA) driven by No 1 engine, o E2, powered by PMA driven by No 2 engine, o E3, powered by LH essential bus, o E4, powered by RH essential bus.	- Three hydraulic systems: A, B and C with possible local pressure generation for spoilers

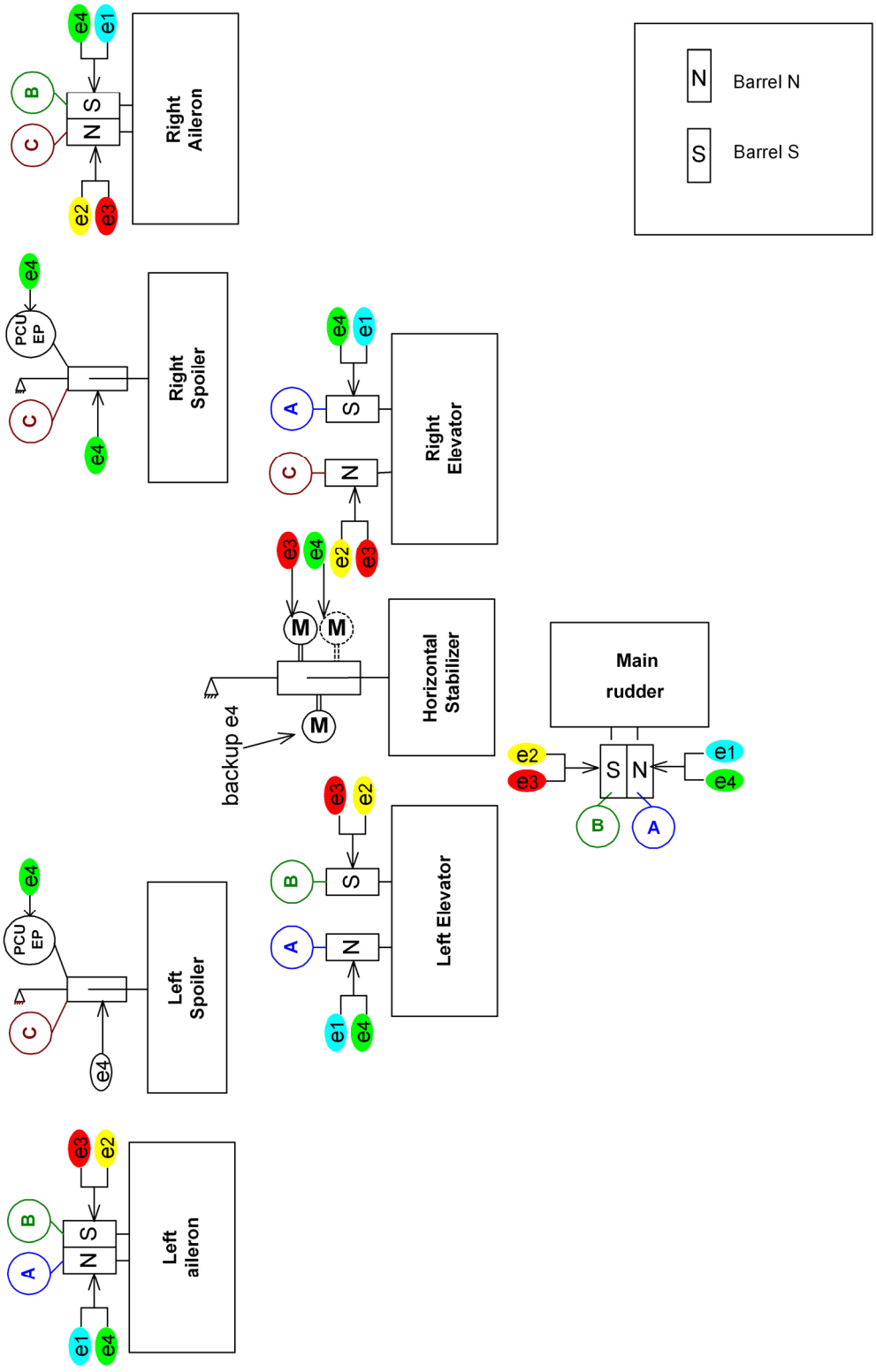


FIGURE 02-27_1-10-02 - PRIMARY FLIGHT CONTROL ARCHITECTURE

PRIMARY FLIGHT CONTROL SYSTEM FUNCTIONS

The main functions provided by the PFCS are:

- Stability augmentation,
- Auto trims,
- Manual trims,
- Protections (structural overstress, overspeed, stall, excessive attitude)
- Aerodynamic configuration optimization,
- Pilot control adaptation.

STABILITY AUGMENTATION

The stability augmentation function aims at providing a good level of static and dynamic stability to the airplane on each axis.

Stability augmentation on the pitch axis

On the pitch axis, the stability augmentation function enables:

- The augmentation of the static margin,
- The augmentation of pitch damping,
- De-rotation at touch down: on ground at landing, a pitch down order through the elevator is introduced, depending on Airbrakes extension, in order to create a de-rotation when stick is released.

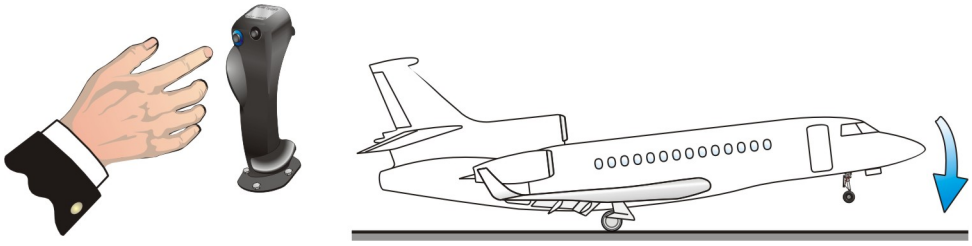


FIGURE 02-27_1-10-03 -DE ROTATION AT TOUCH DOWN

Stability augmentation on the roll axis

On the roll axis, the stability augmentations function enables:

- The reduction of induced roll during side-slipping,
- The increase of the roll damping,
- The recovery of a positive static spiral stability above 35° of bank angle.

With regard to the "positive static spiral stability above 35° of bank":

- If sidestick is released to neutral above 35° of bank, the airplane bank angle is automatically gently driven back to 35°,

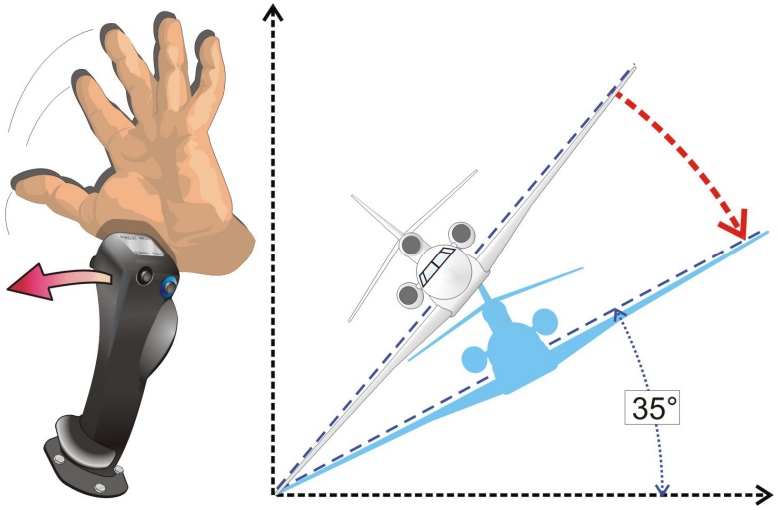


FIGURE 02-27_1-10-04 - ABOVE 35° OF BANK, STICK FREE, BANK ANGLE IS REDUCED

- While if sidestick is released to neutral below 35° of bank, the airplane roll rate is maintained to zero (refer to roll Autotrim).

Stability augmentation on the yaw axis

On the yaw axis, the stability augmentation function enables:

- Dutch roll damping (the natural aircraft has a low dutch roll damping).

AUTOTRIMS AND TRIMS

Autotrim on the pitch axis

In flight (above 50 ft RA): pitch autotrim maintains, stick free, a zero flight path angle variation.

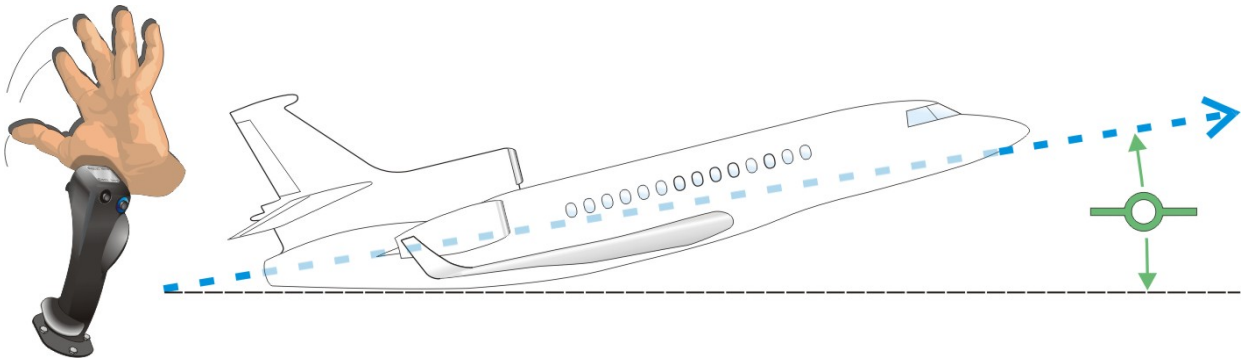


FIGURE 02-27_1-10-05 - IN CRUISE, STICK FREE, FLIGHT PATH IS MAINTAINED

During flare (below 50 ft RA): the auto trim and THS position are frozen.

Autotrim on the roll axis

Roll autotrim functions aim at:

- Providing a compensation for large or small asymmetries (fuel unbalance or failure of Ailerons / Spoilers / Airbrakes)

The roll autotrim maintains:

- Stick free: with the bank angle within ±35°, the roll rate is maintained to zero.

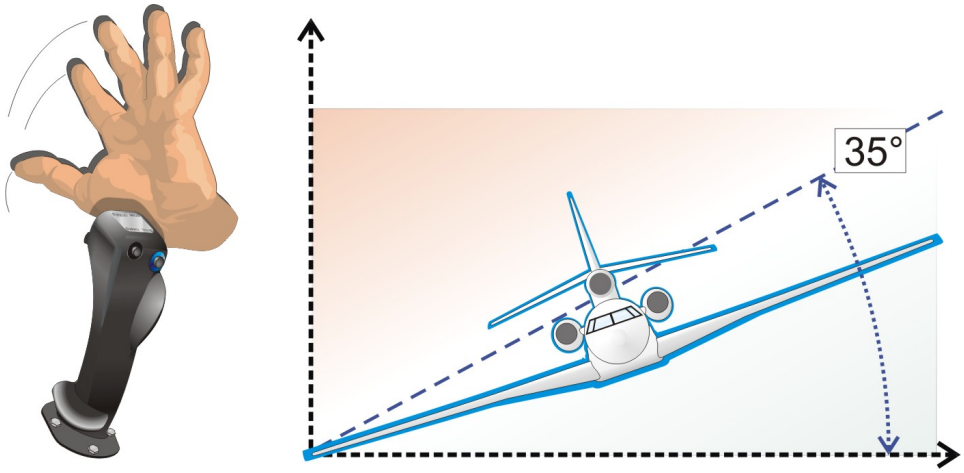


FIGURE 02-27_1-10-06 - BELOW 35° OF BANK, STICK FREE, ROLL RATE ANGLE IS ZERO

Autotrim on the yaw axis

Yaw autotrim functions aim at:

- Compensating small asymmetries (fuel unbalance for example)
- Providing a partial compensation of lateral engine failure.

The yaw autotrim maintains:

- Pedal free: a zero body axis lateral acceleration.

NOTE

Autotrims allow the airplane to come back within a short period to a stabilized condition after a perturbation. They do not permit to cancel the effect of perturbation and to come back to initial flight conditions which was present prior to the perturbation.

For small perturbation in manual flight, it would be recommended to wait for PFCS corrections before the pilot provides command inputs, in order to avoid useless piloting workload.

For example, if stick free, the airplane bank angle was 15° and a turbulence increases the bank angle:

- The roll auto trim will counteract the effect of the turbulence within a short period,
- The bank angle reached before the compensation by the roll auto trim might be 17°,
- This new bank angle of 17° will be maintained.

Manual trims

Pitch manual trim is only available:

- On ground or
- In case of loss of pitch autotrim.

For example, the loss of Radar Altimeter would induce the loss of pitch auto trim, and therefore the use of manual trims.

Roll manual trim is only available:

- In case of direct laws.

Yaw manual trim:

- Is provided to the pilot event in normal operation of the PFCS (normal laws),
- In order to enable lateral equilibrium stick and pedals free in case of engine failure.

THS POSITION

On ground below 60 kt, the THS is automatically positioned at -6° for take off when flaps are extended (detected through flaps position) and at 0. deg when flaps are retracted.

This automatism is interrupted if the pilot commands manually pitch trim. It is restored on ground by a transition between flaps retracted and flaps extended with Vc < 60 kt.

PROTECTIONS

Structural overstress protection

This function aims at providing, when aerodynamically reachable:

- A maximum reachable load factor (the minimum between 3 g and of the load factor leading to structural limit) upon emergency stick action leading to reach the aft stop,
- -1 g load factor, flaps retracted, or 0 g load factor, flaps extended, upon emergency stick action leading to reach the hard forward stop,
- This function also allows to reach a predictive (0.2 g) load factor upon an instinctive action leading the stick to reach the soft forward stop.

On the yaw axis, this function prevents exceeding limit loads on the vertical fin in static conditions and, as much as possible, in dynamic conditions.

Speed and stall protections

The PFCS provides overspeed protection as well as stall protection even when the AutoPilot (AP) is not engaged.

➢ *Refer to ATA 22_3 "Speed and stall protections" for a description of these protections."*

Excessive attitude protection

The excessive attitude protection function aims at preventing the airplane from exceeding pitch angle:

- 25° pitch angle for speed below 100 kt to 35° pitch angle for speed above 250 kt with sidestick on its aft stop,
- -18° pitch angle for speed below 100 kt down to -28° pitch angle for speed above 250 kt with sidestick on the forward stop.

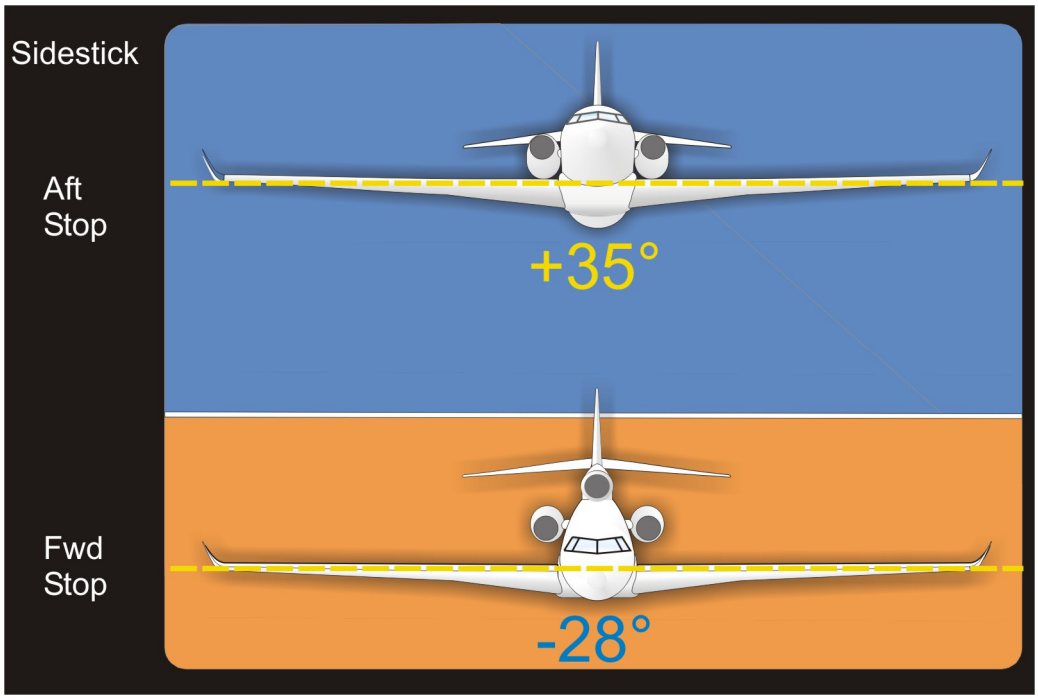


FIGURE 02-27_1-10-09 - EXCESSIVE ATTITUDE PROTECTION

AERODYNAMIC CONFIGURATION OPTIMISATION

This function aims at adapting airplane aerodynamic controls to pilot orders and flight conditions for:

- Drag minimization / maximization,
- Lift maximization.

PILOT CONTROL ADAPTATION

This function aims at reaching a good level of pilotability through homogenization of airplane response to pilot controls.

FLIGHT CONTROL LAWS

GENERAL

When the Primary Flight Control System (PFCS) is operating nominally, all the functions are available.

The PFCS failures may result from failures of:

- The sensors used as inputs for the PFCS computers,
- The PFCS computers and data transmission between them,
- The aerodynamic surfaces actuation (including slats and spoilers).

In order to minimize the number of degraded modes from the pilot point of view, the different status of the PFCS after failures are gathered into three modes:

- NORMAL laws: full functionality is provided,
- ALTERNATE laws:
  - Handling characteristics similar to NORMAL laws around 1g,
  - In order to be conservative, all the protections are considered as lost, although some of them may still be active,
  - This mode is automatically entered when NORMAL laws cannot be supported due to failure in computation, servo-actuators, sensors or interfacing system.
- DIRECT laws:
  - Implementing the functions enabling safe flight and landing (similar to a conventional airplane in the restricted flight envelope),
  - This mode is automatically entered when NORMAL / ALTERNATE laws cannot be supported due to failures in computation, servo-actuators, sensors or interfacing system.

AVAILABILITY OF FCL IN MFCC AND SFCC

The MFCC can support:

- Normal laws,
- Alternate laws,
- Direct laws,

Transition from one mode to the other with MFCC in control will depend on the status of:

- Sensors used as inputs,
- FDC, or malfunction of MFCC,
- The aerodynamic surfaces actuation (including slats, and spoilers).

The SFCC can only support:

- Direct laws (similar to MFCC direct laws).

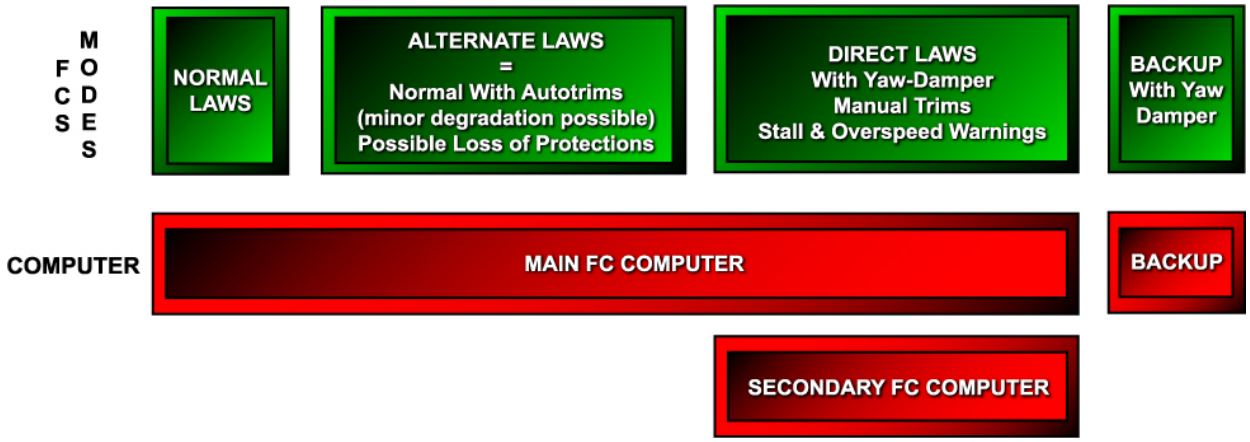


FIGURE 02-27_1-10-10 - AVAILABILITY OF FCL IN MFCC AND SFCC

TRANSITION OF FCL

Depending on the PFCS mode and/or failure of the actuators, procedures and limitations of the flight domain have to be restricted in order to:

- Provide a sufficient level of pilotability according to the status of the system,
- Enable an acceptable transition in case of a subsequent failure leading to another degradation in the system.

AVAILABILITY OF FUNCTIONS IN THE DIFFERENT FCL

The following table presents the availability of main PFCS functions according to the Flight Control Laws. Availability of "aerodynamic optimization" and "pilot control adaptation" is provided in the "Description supplementary information" section.

CODE	AVAILABILITY OF THE FUNCTION
Yes	The function is available in the active control laws
Potentially	The function is potentially available. In order to be conservative, it should be considered that the function is lost.
No	The function is not available in the active control laws

	AVAILABILITY OF FUNCTION DEPENDING ON ACTIVE CONTROL LAWS		
FUNCTIONS	**NORMAL LAWS**	**ALTERNATE LAWS**	**DIRECT LAWS**
Pitch stability augmentation	Yes	Yes	No
Roll stability augmentation	Yes	Yes	No
Yaw stability augmentation	Yes	Yes	Yes
Pitch, roll, yaw autotrim	Yes	Potentially	No
Yaw manual trim	Yes (1)	Potentially	Yes (1)
Pitch manual trim	Yes on ground or if Pitch Auto trim inoperative	Potentially	Yes (1)
Roll manual trim	No	No	Yes (1)
Protections	Yes	Potentially	No
AutoPilot inner loop	Yes (1)	Potentially	No

(1) Some failures might lead to the loss of these functions, but the system will not revert to a lower level of Flight Control Laws.

BACKUP MODE

In addition to the three modes previously presented, a fourth one is added called the BACKUP mode.

The condition leading to this mode is loss of all MFCC and SFCC or complete loss of hydraulic. Unlike the NORMAL, ALTERNATE and DIRECT laws, the BACKUP mode is foreseen to be operated temporarily while the crew attempts to recover one of the higher level modes.

BACKUP mode consists in direct commands using:

- Pitch trim dedicated sensors, actuated by the manual trim control, to activate the tail horizontal stabilizer (THS) actuator,
- Pedals dedicated sensors to control the spoilers.

CONTROL SURFACES USED IN THE DIFFERENT FCL

LONGITUDINAL CONTROL IN NORMAL, ALTERNATE AND DIRECT LAWS

For longitudinal control, the following control surfaces are used:

- Primarily Elevators for the short term actions or when the Horizontal Stabilizer (HS) reaches maximum position for trims,
- Horizontal Stabilizer for long term actions (trims),
- Ailerons and Spoilers for THS load alleviation.

Load alleviation consists in limiting elevators deflection to limit loads on the THS. This function, active above 300 kt, uses the ailerons above 1.3 g and the spoilers above 1.6 g.

Commands for longitudinal control are received

- From longitudinal inputs on sidesticks,
- From the longitudinal FD mode,
- From the pitch auto or manual trims when available.

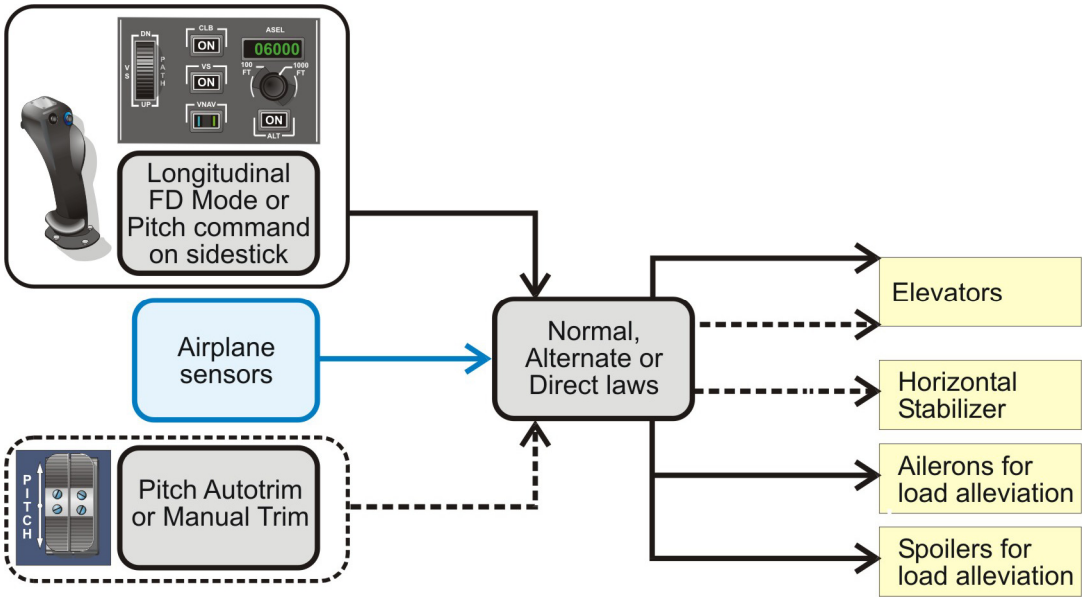


FIGURE 02-27_1-10-12 - LONGITUDINAL CONTROL

LATERAL CONTROL IN NORMAL, ALTERNATE AND DIRECT LAWS

For lateral control, the following control surfaces are used:

- primarily Ailerons,
- Spoilers,
- Rudder for turn coordination.

Pitch autotrim will be activated when available to maintain flight path during roll maneuvers. In this case, no pilot pitch input is required to maintain the flight path during turns.

Commands for lateral control are received

- From lateral inputs on sidesticks,
- From the lateral command of horizontal FD mode,
- From the roll auto or manual trims when available.

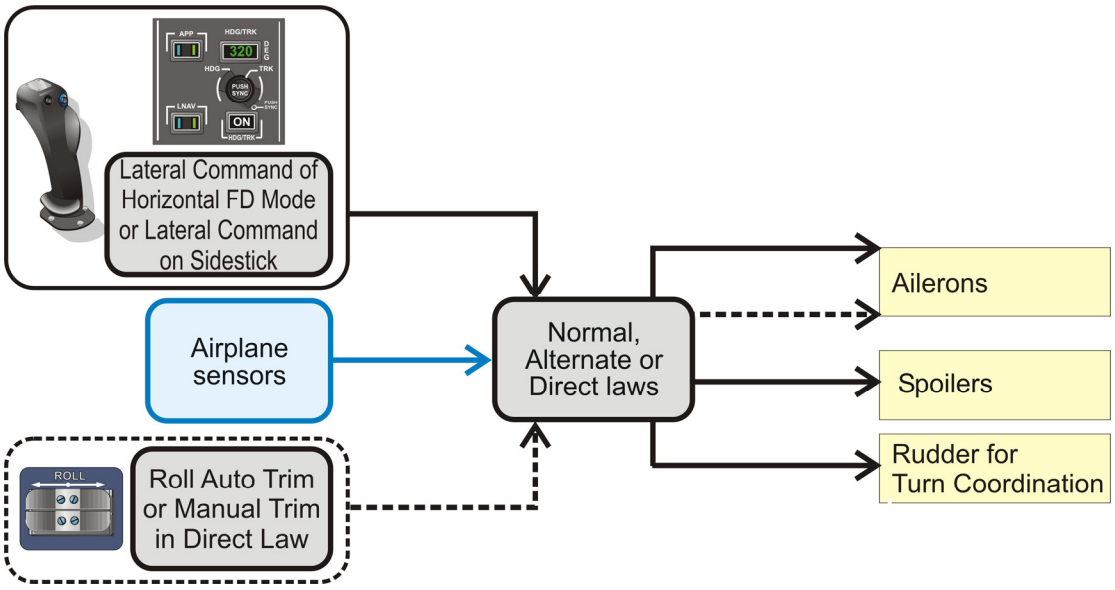


FIGURE 02-27_1-10-13 LATERAL CONTROL

YAW CONTROL IN NORMAL, ALTERNATE AND DIRECT LAWS

In flight

For yaw control in flight, the following control surfaces are used:

- Rudder,
- Ailerons.

Commands for longitudinal control are received

- From the pedals,
- From the yaw auto or manual trims when available.

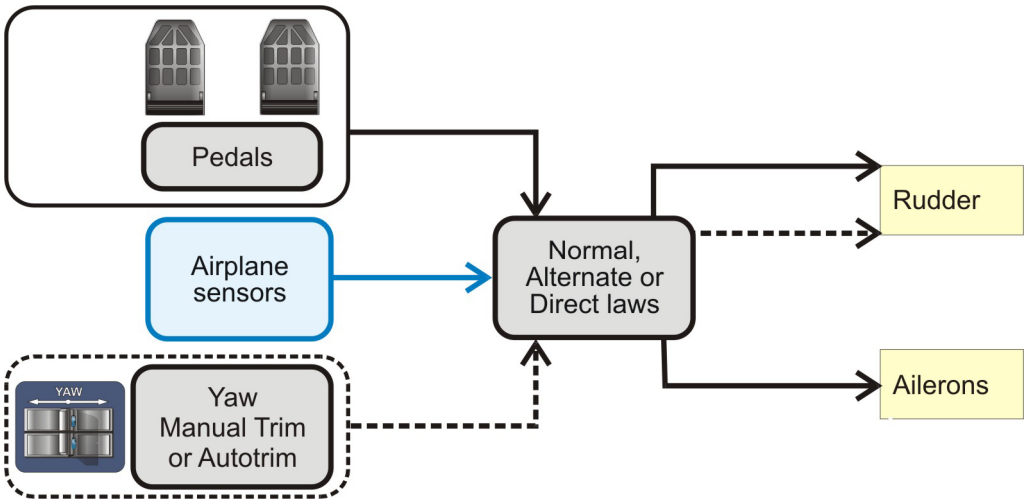


FIGURE 02-27_1-10-14 YAW CONTROL IN FLIGHT

On ground

For yaw control on ground, spoilers might be used in addition to Rudder, and Ailerons, in case of engine failure.

➢ *Refer to ATA 32_3 for Nose Wheel Steering description.*

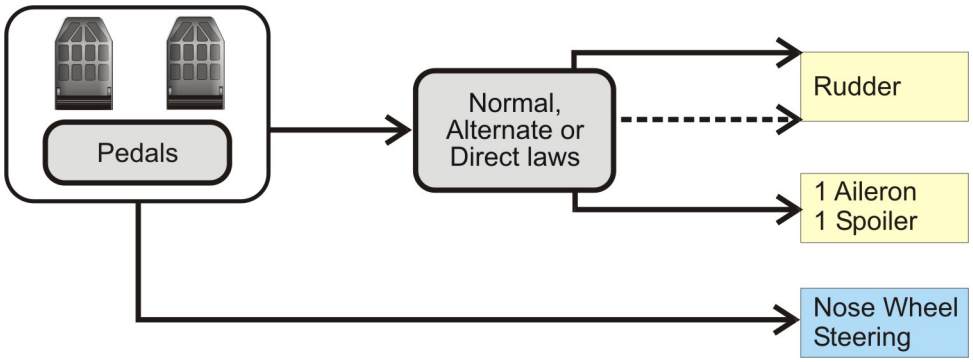


FIGURE 02-27_1-10-15 YAW CONTROL ON GROUND

LONGITUDINAL CONTROL IN BACKUP MODE

For longitudinal control in BACKUP mode:

- Horizontal Stabilizer is used,
- Commanded by manual pitch trim.

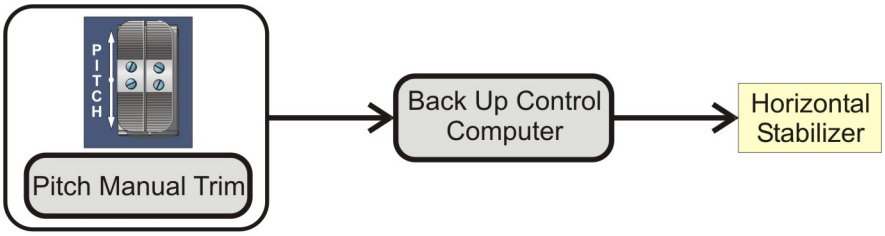


FIGURE 02-27_1-10-16 LONGITUDINAL CONTROL IN BACK UP MODE

LATERALCONTROL IN BACKUP MODE

For lateral control in BACKUP mode:

- Spoilers are used
- Commanded by pedals.

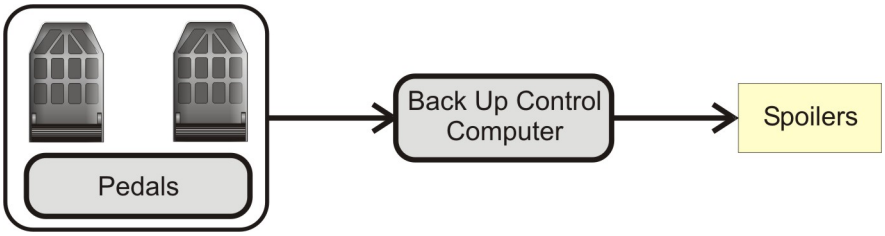


FIGURE 02-27_1-10-17 LATERAL CONTROL IN BACK UP MODE

YAW CONTROL IN BACKUP MODE

There is no direct control on yaw axis in BACKUP mode.

DESIGN PRINCIPLES

The Flight Control System was designed considering the following design principles:

- The FBW technology was selected in order to improve safety by :
  - Preventing the airplane from exceeding the safe flight envelope while reaching maximum airplane performance,
  - Allowing instinctive reaction in emergency situation,
  - Reduce pilot workload by:

    Having common airplane handling characteristics throughout the flight envelope,

    Enhancing airplane stability.
- With regard to the Primary Flight Control System architecture:
  - Experience from military aircraft was used to design PFCS architecture and Flight Control Laws,
  - The Flight Control Laws computers control all types of flight control surfaces to ensure maximum redundancy,
  - Two different types of digital Flight Control Laws computers are used for control of the PFCS, and an additional analogical backup computer has been added, in order to ensure dissimilarity. This additional back up computer is not required from a quantitative System Safety Analysis point of view.
  - For each type of Flight Control Laws computer (MFCC and SFCC), three identical modules are implemented in order to ensure maximum redundancy even in case of dispatch with one module failed,
  - In case of all generators failure, PFCS is still powered by two dedicated electrical sources - engine driven PMA, and the Ram Air Turbine,
  - In case of all engines failure, the PFCS is powered by the Ram Air Turbine,
  - Multiple data sources are used in order to ensure maximum redundancy even in case of dispatch with one module failed,
- With regard to the use of spoilers for roll control:
  - Imposed by the high wing span,
  - Due to the position of ailerons, aerodistorsion at high speed limits the ailerons efficiency,
  - Necessary to counteract dissymetric failures of ailerons or airbrakes (important induced roll due to the wing span and control surfaces area).
- With regard to Flight Control Laws:
  - All transitions to degraded flight control laws are automatic,
  - Flight control laws are designed to ensure smooth transitions to a lower level of flight control laws,
  - The Flight Control panel only permits upgrading the type of flight control laws if the system is capable.

LOCATION OF EQUIPMENT

GENERAL

The MFCC, SFCC, ACMU, MAIC, BU and SFCI (used for automatic control of slats and airbrakes) are modules installed in the four PFCS racks, as follows:

- MFCC: in the LH front FBW rack,
- SFCC and SFCI: in the RH front FBW rack,
- FDC and MAIC: split between the two forward FBW racks,
- ACMU modules: split between the two rear FBW racks.
- BU modules: in one rack.

➢ *Refer to ATA 27_2 Slats and 27_4 Airbrakes for a description of SFCI.*

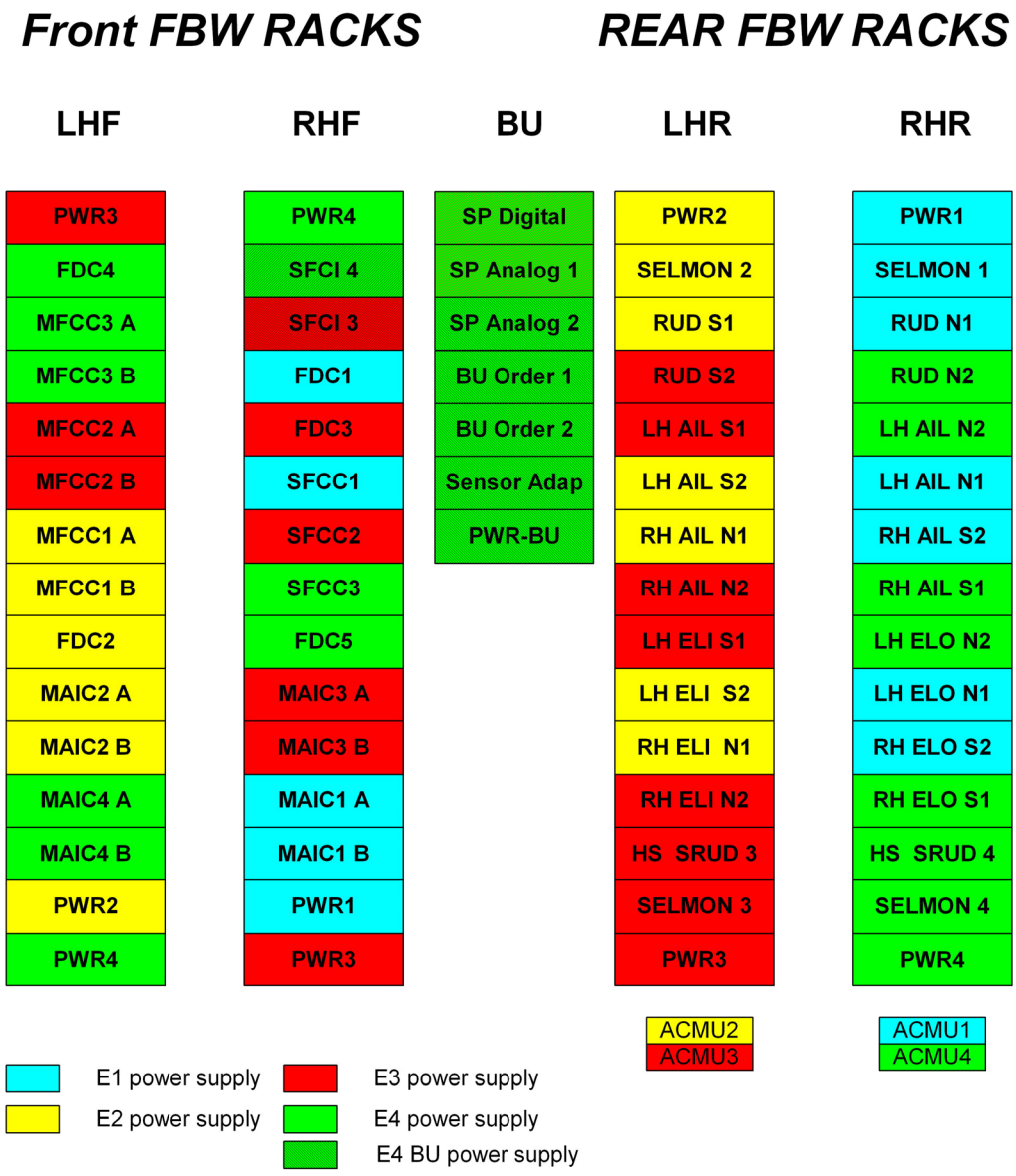


FIGURE 02-27_1-15-00 - MODULES REPARTITION IN FBW RACKS

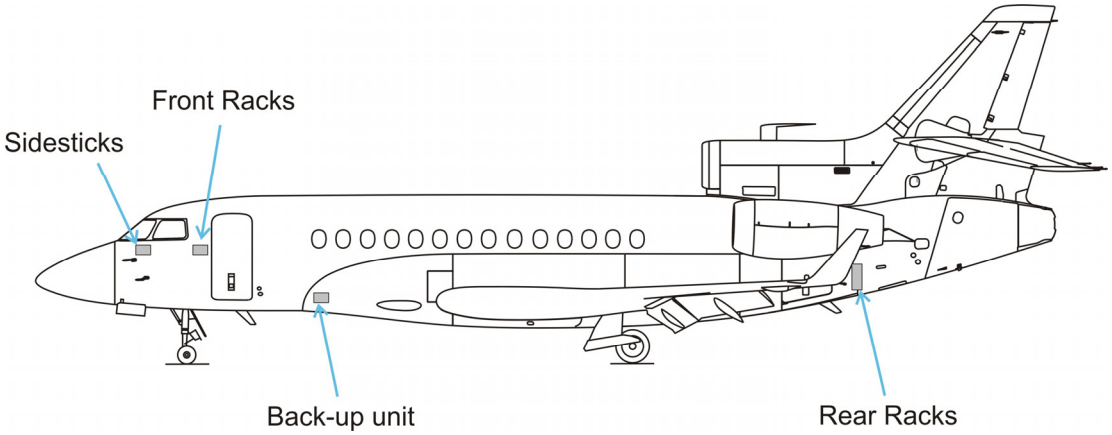


FIGURE 02-27_1-15-01 - PFCS EQUIPMENT LOCATION SIDE-VIEW

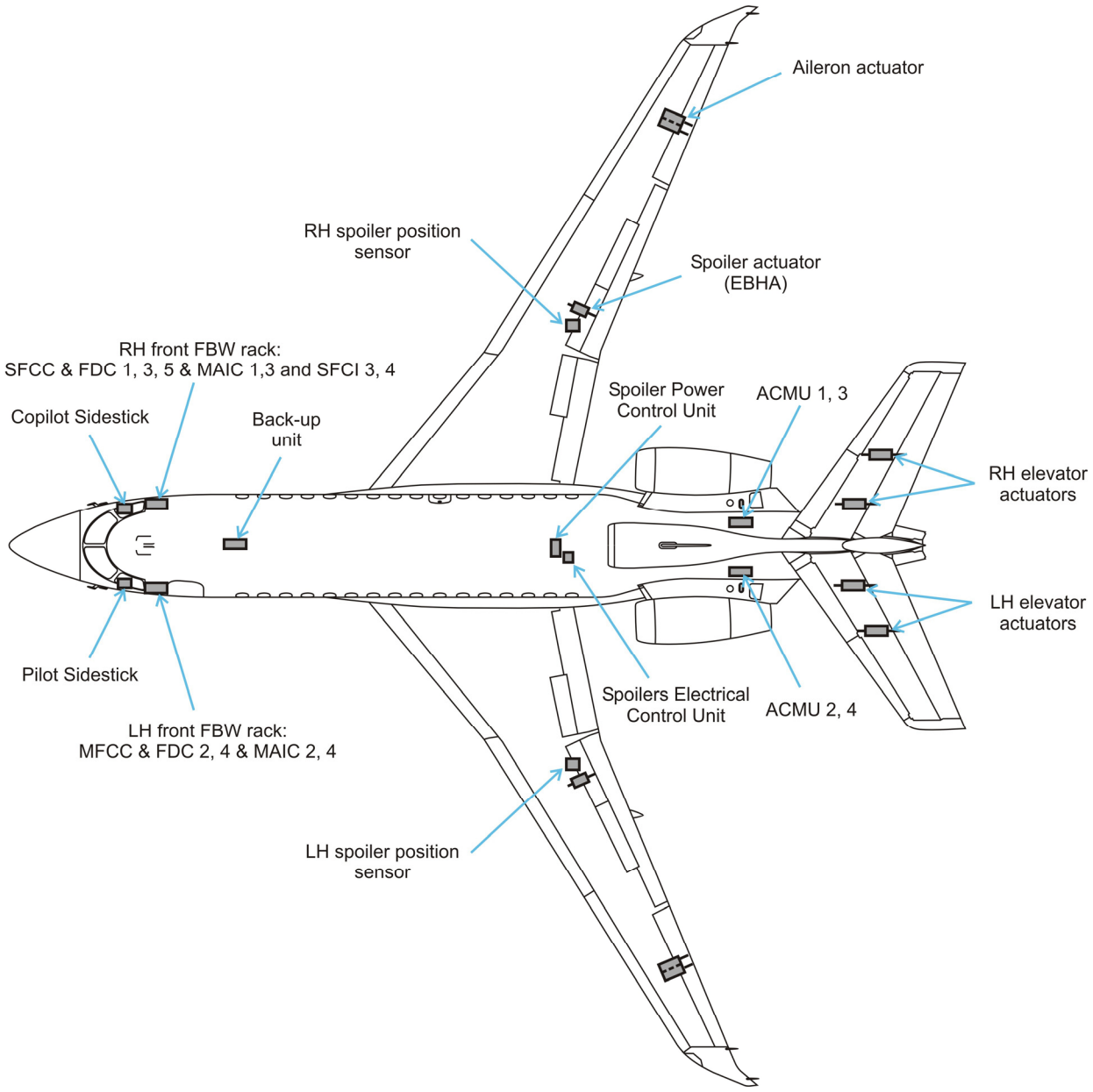


FIGURE 02-27_1-15-02 - PFCS EQUIPMENT LOCATION TOP VIEW

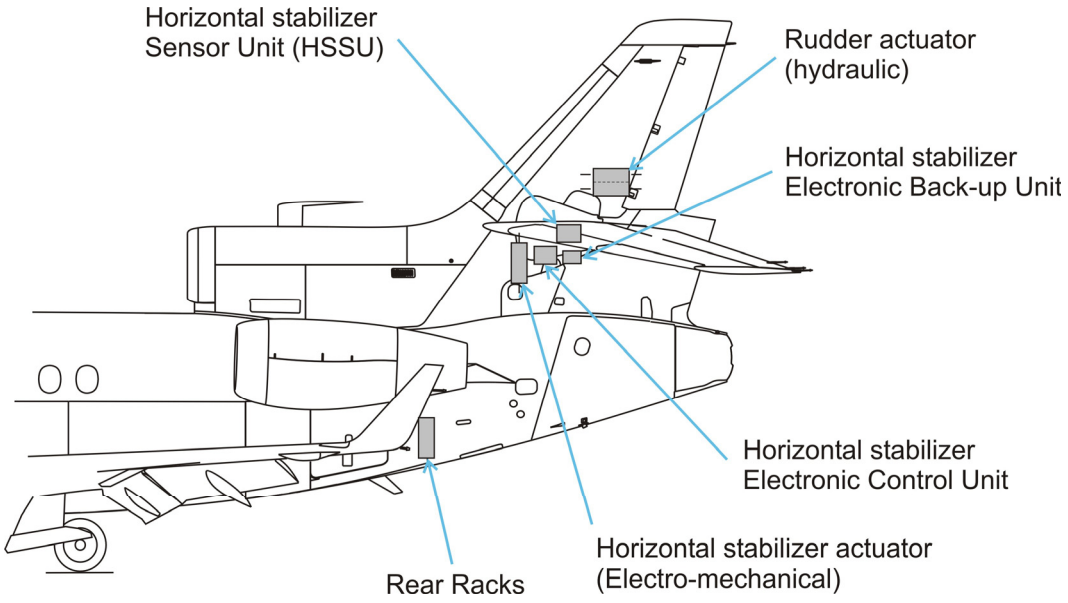


FIGURE 02-27_1-15-03- PFCS EQUIPMENT LOCATION REAR SIDE-VIEW

ELECTRICAL POWER SUPPLY

The following paragraph describes the power supply and the electrical protections of the different equipment of the Primary Flight Control.

The electrical protection is provided:

- Either by Solid State Power Controllers (SSPC),
- Or by Circuit Breakers (CB).

➢ *Refer to ATA 24 – ELECTRICAL POWER for additional information.*

EQUIPMENT	POWER SUPPLY	TYPE OF PROTECTION
LH FRONT RACK (MFCC1 & FDC2 & MAIC2)	E2: PMA2	Fuse
LH FRONT RACK (MFCC2)	E3: LH ESS bus	CB
LH FRONT RACK (MFCC3 & FDC4 & MAIC4)	E4: RH ESS bus	CB
RH FRONT RACK (SFCC1 & FDC1 & MAIC1)	E1: PMA1	Fuse
RH FRONT RACK (SFCC2 & FDC3 & MAIC3)	E3: LH ESS bus	CB
RH FRONT RACK (SFCC3 & FDC5)	E4: LH ESS bus	CB
BACKUP UNIT	RH ESS bus	Fuse
LH REAR RACK	E2: PMA2	Fuse
LH REAR RACK	E3: LH ESS bus	SSPC
RH REAR RACK	E1: PMA1	Fuse
RH REAR RACK	E4: RH ESS bus	CB
HSECU	LH ESS bus	CB

TRANSITION BETWEEN FLIGHT CONTROL LAWS

Depending on the PFCS mode and/or failure of the actuators, procedures and limitations of the flight domain have to be restricted in order to:

- Provide a sufficient level of pilotability according to the status of the system,
- Enable an acceptable transition in case of a subsequent failure leading to another degradation in the system.

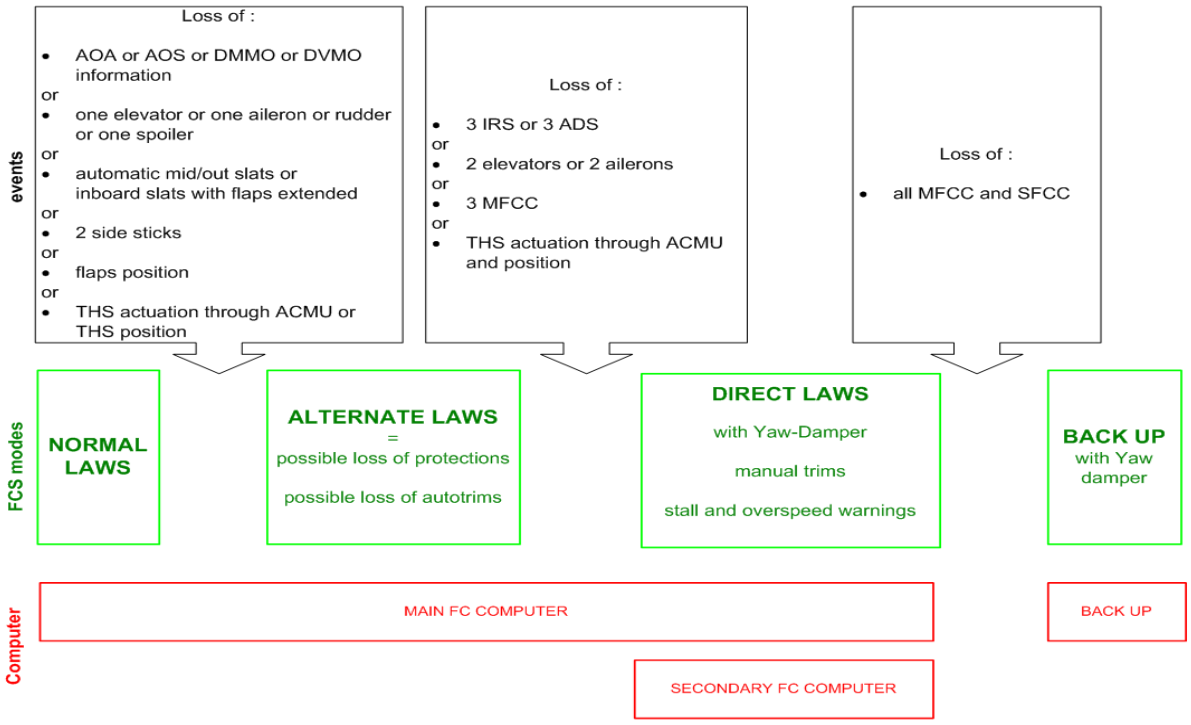


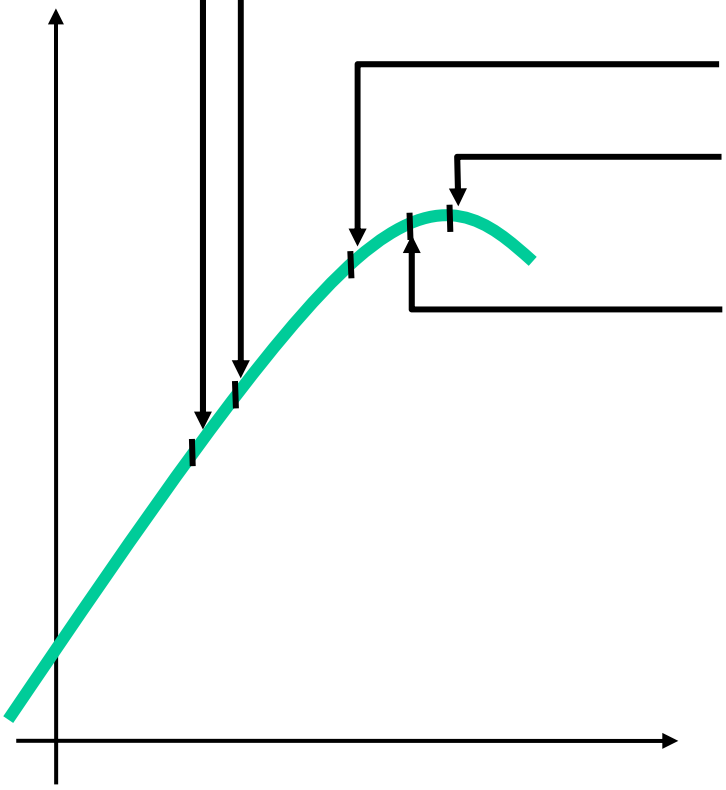
FIGURE 02-27_1-15-04 - TRANSITIONS BETWEEN MODES IN CASE OF FAILURE

PRIMARY FLIGHT CONTROL SYSTEM FUNCTIONS

This paragraph provides additional information on "Stall protection", "Aerodynamic configuration optimization" and "pilot controls adaptation" functions.

LOSS OF CONTROL PROTECTION - STALL PROTECTION

The following graph shows the characteristic Angles Of Attack at low speed.



- α_{Vref} : AOA in straight flight at Vref
- $\alpha_{max\ stick\ to\ neutral}$: maximum AOA with stick to neutral in straight flight (speed stability recovered above this AOA)
- $\alpha_{1.3g\ at\ Vref}$: AOA at Vref at 1.3g
- α_{stall} : maximum lift = 19.5°
- α_{limit} : maximum AOA with stick on its aft stops (16, 17° in normal law)

$\alpha_{stall\ warning}$: AOA above which stall warning is announced. It is set :

- Between α_{limit} and α_{stall} in normal laws mode (19°)
- Above $\alpha_{1.3g\ at\ Vref}$ in case of loss of AOA protection (16°, 17° in alternate or direct laws)

Angle of Attack α

FIGURE 02-27_1-10-05 - LOSS OF CONTROL PROTECTIONS

AERODYNAMIC CONFIGURATION OPTIMISATION

This function aims at adapting airplane aerodynamic controls to pilot orders and flight conditions (drag minimization / maximization, lift maximization,…).

Aerodynamic configuration optimization includes:

- In clean configuration: automatic extension of middle and outboard slats in order to increase maximum lift angle of attack,
- In slats/Flaps configuration:
  - Retraction of inboard slats at high angle of attack in order to increase deep stall margins,
  - Retraction of inboard slats in SF1 to increase Anti Ice system efficiency.
- Use of spoilers for the airbrake function in order to maximize lift reduction,
- Automatic airbrakes retraction orders (for inboard and outboard airbrakes, and for spoilers in airbrake function) at high angle of attack and during Take-Off / Go-Around manoeuvre,
- Automatic reduction of airbrake authority according to AOA for spoilers,
- Automatic airbrake extension after landing for spoilers,
- Control surfaces deflection optimization (use of symmetric ailerons deflection for lift coefficient optimization).

PILOT CONTROLS ADAPTATION

This function aims at reaching a good level of pilotability through homogenization of airplane response to pilot controls. It includes:

- Pilot commands shaping,
- Pitch airplane response homogenization according to flight conditions and airplane configuration,
- Roll and yaw airplane response homogenization with respect to the flight condition and airplane configuration,
- Roll coordination in turn.

FUNCTION AVAILABILITY SYNTHESIS

The following table presents the availability of the "Aerodynamic configuration optimization" and "pilot controls adaptation" functions according to the flight control laws.

CODE	AVAILABILITY OF THE FUNCTION
Yes	The function is available in the active control laws
Potentially	The function is potentially available. In order to be conservative, it should be considered that the function is lost.
No	The function is not available in the active control laws

	AVAILABILITY OF FUNCTION DEPENDING ON ACTIVE CONTROL LAWS		
FUNCTIONS	NORMAL LAWS	ALTERNATE LAWS	DIRECT LAWS
Aerodynamic configuration optimization	Yes	Potentially	Potentially
Pilot controls adaptation	Yes	Yes	Potentially

INPUTS USED BY THE PFCS COMUTERS

The main inputs used by the PFCS computers are:

- Pilot commands:
  - Stick (roll and pitch axis),
  - Rudder pedals,
  - Pitch, roll and yaw manual trim,
  - Airbrakes command (continuous command and boolean command),
  - Sidestick priority switches,
  - AP quick disconnect and Touch Control Steering (TCS),
  - Throttle Take Off or Idle position,
- ADS sensors providing:
  - Angle of attack (AOA),
  - Angle of sideslip (AOS),
  - Static pressure (PS),
  - Dynamic pressure (DP),
  - ΔVMO /ΔMMO,
- IRS and AHRS sensors providing inertial information:
  - Body rates (p, q, r),
  - Body accelerations (gx, gy, gz),
  - Body angles (theta, phi),
  - Ground speed (Vz, Vg)
- Aerodynamic surfaces positions:
  - Flaps,
  - Horizontal stabiliser,
  - Inboard slats position.
- Main and nose landing gear weight on wheels.
- Avionics information provided by MAU:
  - Flight Director information (flight path angle and bank angle command, engagement requirement),
  - Number of the ADS displayed to the pilot flying,
  - Radio altimeter height,
  - Landing gear extension status.
- Airbrakes automatic retraction command in case of TOGA maneuver and automatic extension on ground,
- Actuators failure detection: THS, rudder, elevators, ailerons and spoilers actuation failures,
- Computers (Main or Secondary) controlling the airplane,
- Wheel speeds for the de-rotation function.

PRIMARY CONTROL SURFACES AND ACTUATORS

GENERAL

A set of electro-hydraulic and electric actuators performs the actuation of the 8 primary control surfaces and spoilers:

- 7 electro-hydraulic servoactuators:
  - right and left ailerons: 1 servoactuator on each side,
  - right and left elevators: 2 servoactuators on each side,
  - rudder: 1 servoactuator,
- 1 electric actuator: horizontal stabilizer and associated electrical control unit (HSECU for the first HSTA motors, HSEBU for the HSTA BU motor),
- 2 spoilers (using airplane Hydraulic or a local Backup Hydraulic) and their associated electrical control unit (SPPCU).

ELEVATORS

Each elevator is attached to and operated by two servo actuators, one inboard actuator and one outboard actuator. These servo actuators are each powered by one of the three independent hydraulic systems:

- LH elevator: outboard servo actuator: hydraulic system A,
- LH elevator: inboard servo actuator: hydraulic system B,
- RH elevator: inboard servo actuator: hydraulic system C,
- RH elevator: outboard servo actuator: hydraulic system A,

Each elevator servo-actuator is a single barrel hydraulically powered linear actuator displacing the control surface in response to electrical position command signals issued from two ACMU (one in control at a time).

Each elevator has 3 operational modes:

- Active: the barrel remains in the active mode until switching-off commanded by the ACMU,
- Centered: the barrel does not respond to commands from the ACMU. The actuator piston rod is first centered, then maintained in its middle position by the hydraulic pressure. This mode is automatically engaged when the 2 electrical control channels of the actuator are switched-off and the conjugated actuator of the same surface is lost due to electrical or hydraulic failures. The engagement logic is merely hydraulic.
- Damped: the barrel does not respond to commands from the ACMU. The piston is allowed to move, but at a restricted rate which provides flutter damping.

In normal operating conditions:

- The 2 barrels of the 2 actuators of each elevator will be active simultaneously, with half pressure thanks to pressure reducers,
- At a time, each barrel is electrically controlled by only one ACMU channel.

In case one barrel failed, full pressure is applied on the remaining barrel.

TAIL HORIZONTAL STABILIZER

The Tail Horizontal Stabilizer (THS) performs the following functions:

- Actuation of the horizontal stabilizer by automatic or manual orders during flight,
- Position holding of the horizontal stabilizer.

The THS consists of the following:

- A Horizontal Stabilizer Trim Actuator (HSTA) composed of a ball screw driven via a gearbox with three electrical motors,
- A Horizontal Stabilizer Electronic Control Unit (HSECU) composed of the electronics for two channels (Channel 3 and Channel 4) driving two independent brushless motors/brakes,
- A Horizontal Stabilizer Electronic Backup Unit (HSEBU) composed of the electronics for a single channel (Backup) driving a brush motor/brake,
- A Horizontal Stabilizer Sensor Unit (HSSU) used for Flight Control Laws and slaving of the THS.

AILERONS

Each aileron is attached to and operated by one servo actuator powered by two of the three independent hydraulic systems (hydraulic systems A and B for LH aileron, hydraulic systems B and C for RH aileron).

Each aileron servo actuator is a hydraulically powered linear actuator displacing the control surface in response to electrical position command signals issued from two ACMU.

Each actuator consists of two hydraulically independent barrels installed next to each other and bolted together.

Each barrel has 2 operational modes:

- Active: the barrel remains in the active mode until switching-off commanded by the ACMU,
- Damped: the barrel does not respond to commands from the ACMU. The piston is allowed to move, but at a restricted rate which provides flutter damping. This mode allows the other barrel of the actuator to continue to operate the surface at a rate sufficient for airplane control.

In normal operating conditions:

- The 2 barrels of the aileron actuator are active simultaneously,
- At a time, each barrel is electrically controlled by only one ACMU channel.

SPOILERS

The spoilers are located between the inboard and outboard airbrakes.

The Spoiler Control System performs the following functions:

- Actuation of the spoilers according to the flight control laws,
- Position holding of the two spoilers (without supply or command, spoilers are maintained retracted).

The PFCS issues orders to provide:

- Additional roll capability inside the operating flight envelope,
- Pitch and yaw control,
- Airbrake function.

RUDDER

The rudder is attached to and operated by one servo actuator powered by the two independent hydraulic systems.

The actuator consists in two hydraulically independent barrels installed next to each other and bolted together. It has 3 operational modes:

- ACTIVE: a barrel remains in the active mode until switching-off commanded by the ACMU,
- BY-PASSED: a barrel remains in the by-passed mode as long as the other one remains in the active mode. The piston of the by-passed barrel is allowed to move at a restricted rate which allows the active barrel to continue to operate the surface at a rate sufficient for airplane control,
- DAMPED: the barrel does not respond to commands from the ACMU. The two barrels are simultaneously in the damped mode. The piston is allowed to move, but at a restricted rate which provides flutter damping.

In normal operating conditions:

- Unlike the aileron actuator, the 2 barrels of the rudder actuator are successively active,
- At a time, each barrel is electrically controlled by only one ACMU channel.

ACTUATORS CONDITION IN BACK UP MODE

In this mode, ailerons and rudder are in damped mode and elevators are hydraulically centered.

CONTROLS

SIDESTICKS

The Falcon 7X is fitted with two sidesticks for pitch and roll control. The two sidesticks are independent (they are not mechanically linked), and provide artificial feeling function on the two axis.

The force feedback is only provided by mechanical elements (spring, fluid damper,…).

The main functions of the sidesticks are to:

- Measure the pilot order through two directions (pitch and roll),
- Transmit the pilot orders to the Flight Control System,
- Add a force threshold at zero when the autopilot is engaged.

Each sidestick includes 4 pushbuttons:

- AP / PTY,
- TCS: Touch Control Steering,
- HUD DCT or EVS if M618 is installed on the airplane,
- MIC: Radio alternat.

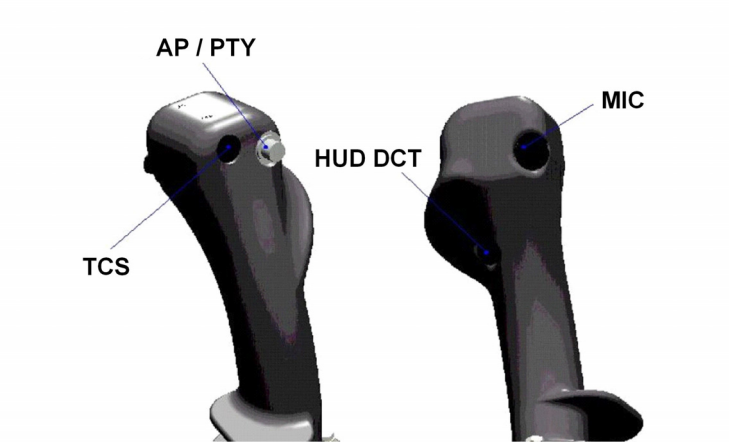


FIGURE 02-27_1-20-00 - LH SIDESTICK

Normal operation

On pitch axis:

- A given sidestick displacement provides a given G load,
- The sidestick includes soft stops in nose down direction, before the hard stop.

On roll axis:

- A given sidestick displacement will always provide the same roll rate,
- Maximum displacement will provide a roll rate of 40°/s,
- The sidestick force law is asymmetrical taking into account an ergonomic consideration.

AutoPilot engaged

When the AutoPilot is (AP) engaged:

- Sidesticks are restrained in neutral position by means of an electromagnetic devices adding a supplementary force threshold to disengage,
- Sidestick commands are inhibited as long as the effort exerted on the sidestick are below this force threshold,
- The AutoPilot is disengaged as soon as the deflection of the stick on one or both axis exceeds the value corresponding to the force threshold or other disengagement: then the force feedback law return to normal mode.

Sidestick dual input warning and priority logic

In case of dual inputs from left pilot and right pilot on the sidestick, aural and tactile alerts are generated. Tactile alert is made by a vibrating device within the handgrip.

Pilots use the priority pushbutton located on the handgrip when needed.

PRIORITY PUSHBUTTON

Sidestick priority pushbutton allows the crew members to select which of the left pilot or right pilot, or both control the airplane. .

Two cases can be possible:

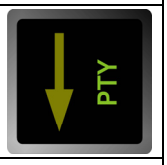
- Only one pilot operates a sidestick (the other being free at neutral position): the corresponding deflection command constitutes the input signal driving the PFCS.
- Each pilot operates its sidestick in the same or opposite direction: both pilots inputs are algebraically summed. In this case, an aural message "DUAL INPUT" and a tactile warning warn the crew members of both pilots flying situation.

At any time, a pilot can deactivate the other pilot sidestick by depressing and keeping pressed his priority pushbutton. In this priority situation:

- A green indicator is lighted in front of the pilot whose stick is activated,
- An amber indicator is lighted in front of the pilot whose stick is deactivated,
- Aural warning “Priority Left” (respectively “Priority Right”) is triggered when the left pilot (respectively the right pilot) has taken the priority and the side-stick of other pilot is deflected.

If the priority pushbutton is depressed for more than 30 seconds the PFCS will latch the current priority state, allowing the priority pushbutton to be released without loosing priority. At any time, a deactivated stick can be reactivated by momentarily pressing its priority pushbutton.

When the autopilot is engaged, first depress on a priority pushbutton disengage it and second depress acknowledge the AutoPilot disengagement warning.

CONFIG.	LEFT SIDE				RIGHT SIDE				AURAL WARNING
	SIDESTICK	TAKEOVER P/B	PRIORITY LIGHT	TACTILE WARNING	SIDESTICK	TAKEOVER P/B	PRIORITY LIGHT	TACTILE WARNING	
LEFT PILOT FLYING (WITHOUT PRIORITY)	Deflected	Not Depressed			Neutral free	Not Depressed			
RIGHT PILOT FLYING (WITHOUT PRIORITY)	Neutral free	Not Depressed			Deflected	Not Depressed			
BOTH PILOTS FLYING	Deflected	Not Depressed		X	Deflected	Not Depressed		X	"DUAL"

CONFIGURATION	LEFT SIDE				RIGHT SIDE				AURAL WARNING
	SIDESTICK	TAKEOVER P/B	PRIORITY LIGHT	TACTILE WARNING	SIDESTICK	TAKEOVER P/B	PRIORITY LIGHT	TACTILE WARNING	
CASE 1 LEFT PILOT FLYING WITH PRIORITY	Deflected	Depressed	PTY		Deflected	Not Depressed	PTY		"PRIORITY LEFT"
CASE 2 LEFT PILOT WITH PRIORITY	Deflected	Depressed	PTY		Neutral	Not Depressed	PTY		
CASE 3 RIGHT PILOT FLYING WITH PRIORITY	Deflected	Not Depressed	PTY		Deflected	Depressed	PTY		"PRIORITY RIGHT"
CASE 4 RIGHT PILOT FLYING WITH PRIORITY	Neutral	Not Depressed	PTY		Deflected	Depressed	PTY		

RUDDER AND BRAKE PEDALS

Each pilot and copilot pedals are arranged in a Rudder and Brake Pedals Assembly (RBPA) which provide:

- Primary yaw control,
- Roll control in Back up mode,
- Nose wheel steering control,
- Braking control,
- Adjustment of null position of pedal to accommodate aircrew preferences.

The pilot and co-pilot rudder pedals are mechanically linked so that each pilot is always aware of the flight crew input, and either has the option of adding to, or countering the other's rudder pedal input if the situation arises. A re-centering/feel mechanism produces artificial feel for the pilots, and causes the pedal set to return to neutral after the pilot input.

The rudder pedal command is normal intuitive yaw command in accordance with rudder pedal deflection.

Braking function and nose wheel steering are also normal intuitive actions.

The pedal assemblies can be independently adjusted by means of an electric motor, to accommodate for human size.

FIGURE 02-27_1-20-01 - RUDDER AND BRAKE PEDALS

ADJUSTMENT OF PEDALS

A switch located on the sideledge next to each pilot sidestick allows position control of the pedals.

Adjustment of the pedals is achieved by means of a brush DC motor, which varies the length of the links that attach the pedal support beams to the transfer yoke. In addition, a mechanical backup with a crank is provided.

TRIM UNIT

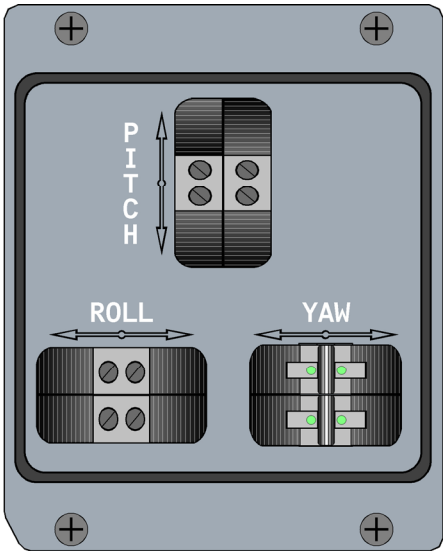
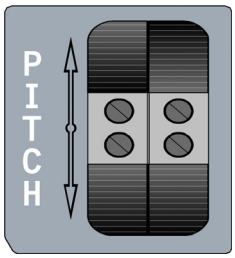
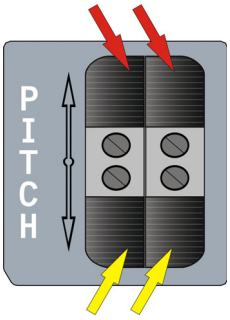
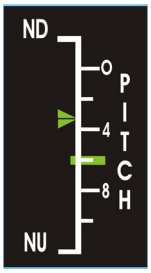
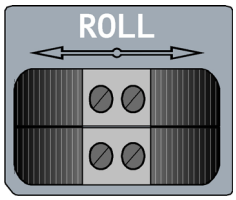
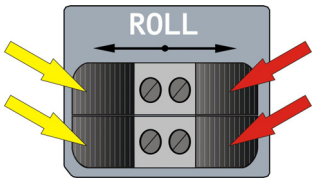
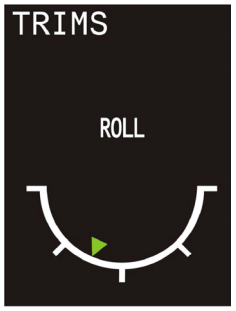
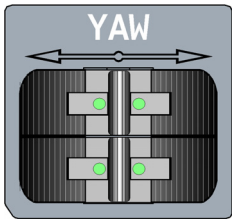
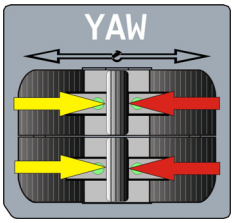
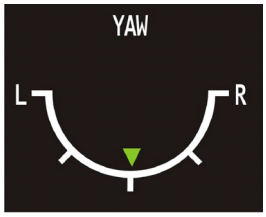


FIGURE 02-27_1-20-02 - TRIM UNIT

SYNTHETIC TABLES

CONTROL	FUNCTION	TO ACTIVATE TO DEACTIVATE	SYNOPTIC
	Activates nose-up or nose-down the tail horizontal stabilizer (push both halves of the switch) Normal laws: Active on ground If Pitch Auto Trim not available or in Direct laws: Active on ground & flight		
	Activates left or rightroll trim (push both halvesof the switch) Normal laws: Not active Direct laws: Active on ground & flight		
	Activates left or right yaw trim (push both halves of the switch) Normal / Alternate/ Direct laws: Active on ground & flight		

OVERHEAD PANEL

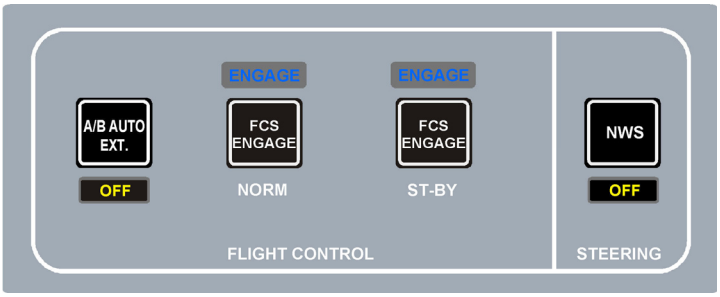


FIGURE 02-27_1-20-03 – FLIGHT CONTROL OVERHEAD PANEL

The goal of the FCS engage pushbuttons is to reengage either set of MFCC or set of SFCC computer when a computer is declared as valid and not in control (standby), or an actuator control channel after an automatic recovery of the failure.

The two pushbuttons have the same functionality.

When the pilot depresses the FCS engage pushbutton, the blue ENGAGE light is lighted to indicate that the pushbutton has been depressed.

By procedure, if the normal pushbutton has no impact on the PFCS, the crew shall try to use the other stand-by pushbutton.

INDICATIONS

Related PFCS indications are displayed:

- In the FCS synoptic page (FCS surfaces positions and trims positions),
- In the ENG-TRM window (ROLL, YAW and PITCH trims positions),
- In the HSI window (PITCH)
- In the TEST page for FCS test,
- In the ENG-CAS window for CAS messages,
- In the STATus synoptic / FAULT tab for fault messages.

FCS SYNOPTIC PAGE

The FCS synoptic page displayed the following information:

- The active FCS mode,
- MFCC and SFCC computers status,
- Trims position,
- Positions of all control surfaces except for the flaps.

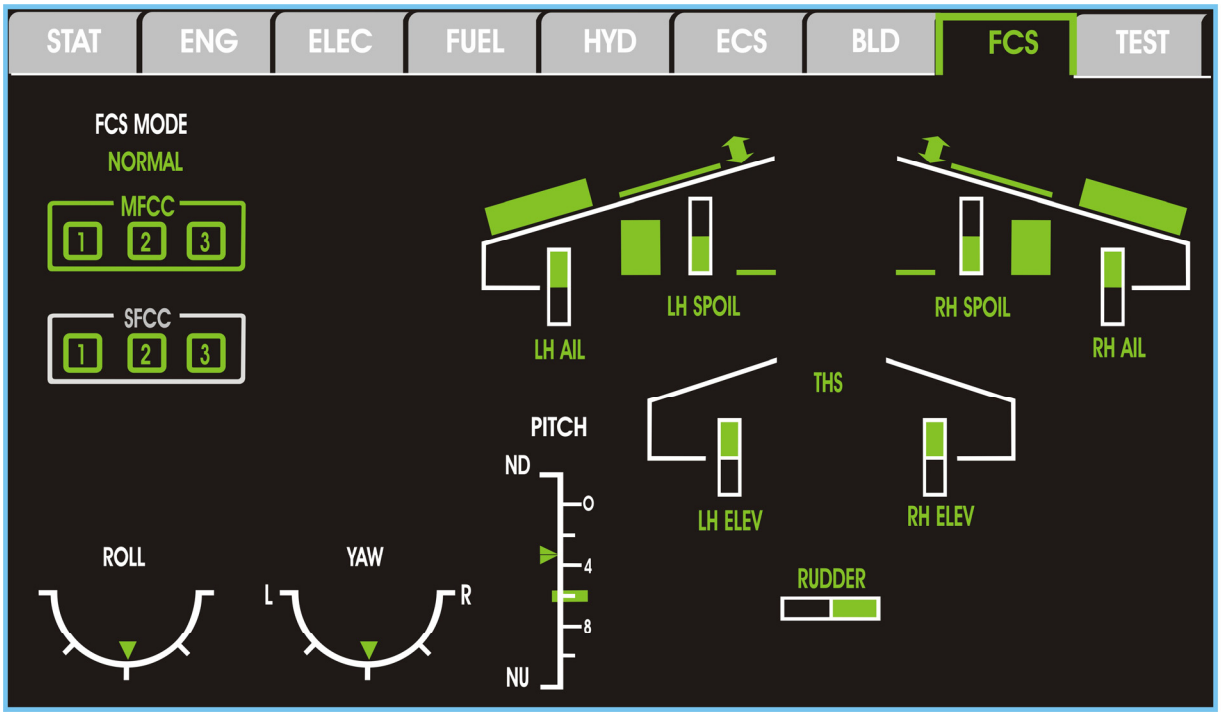


FIGURE 02-27_1-20-04 - FCS SYNOPTIC PAGE

Active FCS mode

The FCS mode currently engaged is displayed above the computer status. The display is a green label: NORMAL or ALTERNATE or DIRECT or BACK-UP

Computer status

Each PFCS computer is symbolized by a square whose color is:

- Green when the computer is properly operating,

- Else amber.

The rectangle around the computers enables to provide the computer set status:

- For MFCC:
  - The rectangle is green when at least one MFCC computer is operating and valid,

  - It is amber else.

- For SFCC:
  - The rectangle is grey when the SFCC are valid but not in control,

  - It is green when they are operating and in control;

  - It is amber when the SFCC are failed.

Trims positions

It is a repeater of the display available in ENG-TRM window.

Roll and yaw trim indication is performed in percentage of the full trim authority, full scale is 100% authority.

Authority varies according to flight conditions as follows:

- Roll: 50% of side stick authority : 12 - 14 ° ailerons,
- Yaw: 90% of pedals authority limited to 13.5° (at max speed or Mach, authority is 4°).

Positions of control surfaces

The right part of the synoptic is devoted to provide the positions of all control surfaces except the flaps (removed for clarity). The positions are displayed with bar graphs, except the slats and airbrakes (pictogram).

Name of the control surface is displayed in:

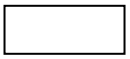
- Green in normal condition: 

- Green surrounded by amber rectangle, when the surface actuator operation is degraded: 

- Amber when the surface actuator is failed: 

- White when the status is unknown: 

The following pictograms are used for slats and airbrakes:

- when retracted,
-  when extended,
-  when moving.

The pictogram is green for normal operation or amber for abnormal operation.

If surface position is invalid the pictogram is replaced by an amber cross:. 

ENG-TRM WINDOW

The display of the ENG-TRM window occurs:

- On crew members requests,
- Or crew members action on trim unit,
- Or as soon as one trim position exceeds a normal threshold.

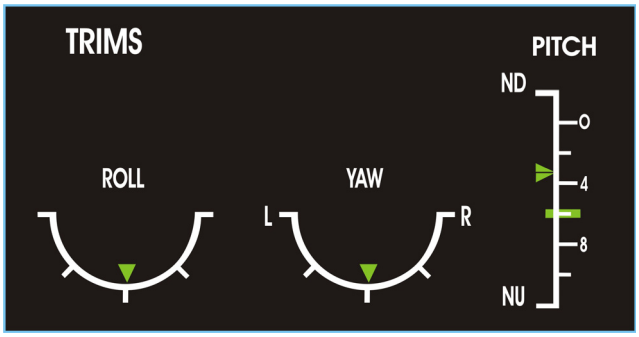


FIGURE 02-27_1-20-05 - ENG-TRM WINDOW - TRIMS POSITIONS

NOTE

In cruise, after trimming the airplane, it is usual to have aileron and rudder trim indicators not centered (due to airplane asymmetry).

HSI WINDOW

Horizontal stabilizer position is also permanently displayed in the top RH corner of the HSI window.

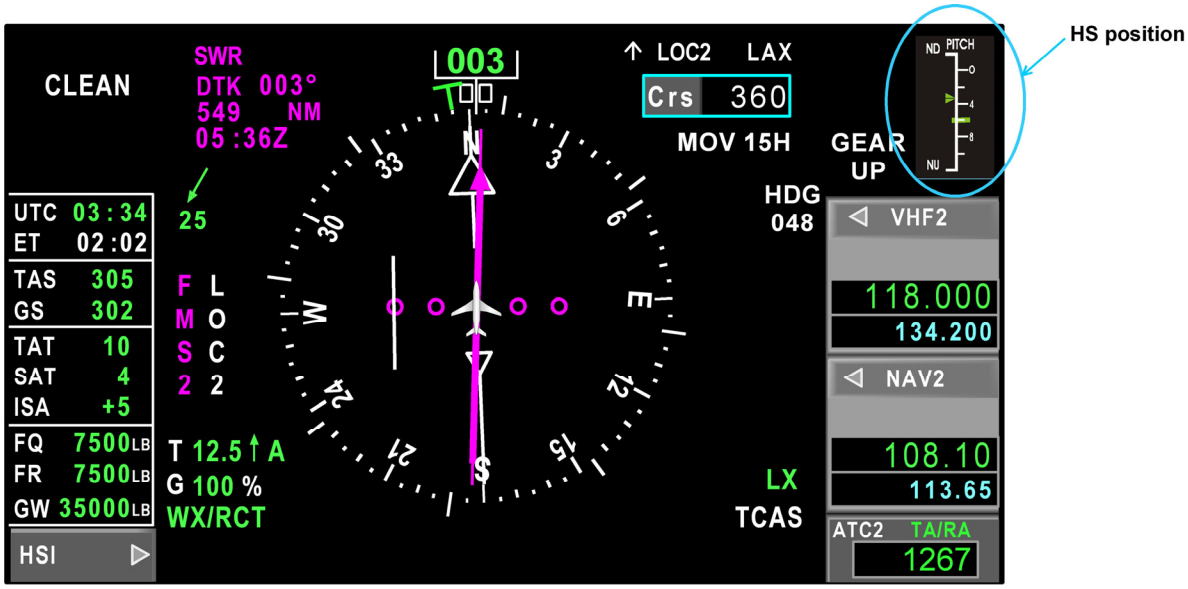


FIGURE 02-27_1-20-06 - HSI WINDOW DISPLAY

TEST SYNOPTIC

The FCS test allows to:

- Test the integrity of the flight controls,
- Compute the dispatch condition following the failures.

This test is triggered via the FCS soft key available on the TEST synoptic page. This test is only authorized on ground.

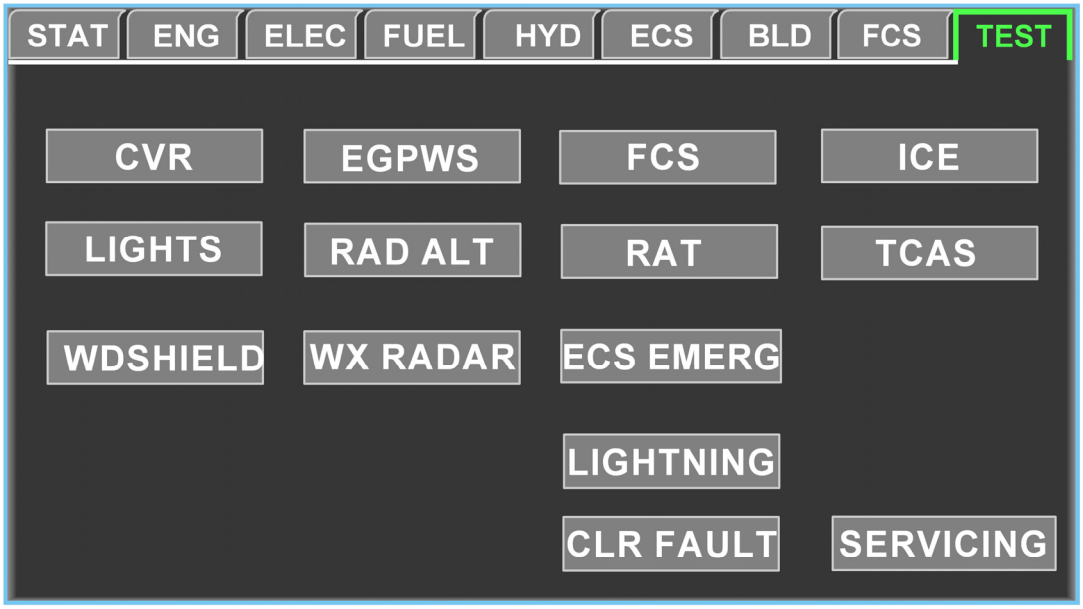


FIGURE 02-27_1-20-07 - TEST SYNOPTIC PAGE

To initialize the test, the crew members should select FCS soft key until **FCS: TEST IN PROGRESS** CAS message is displayed.

During the test, the control surfaces are moving and a transient **FCS: MID OUT RETRACT FAIL** CAS message is displayed.

The test is finished when **FCS: TEST IN PROGRESS** CAS message disappears.

If the **FCS: TEST FAILED** CAS message is displayed the test is failed, else the test is passed.

During the test, a second select of the FCS soft key stopped the test.

If the test is not performed before the taxi phase of flight, the **FCS: TEST NOT PERFORMED** CAS message is displayed during this phase.

No supplementary information to be provided on controls and indications at present time.

SYSTEM MONITORING

The following parameters of the Primary Flight Control System are monitored:

- Validity of the different computers,
- Active Flight Control Laws,
- Jamming of a control surface,
- Status of THS runaway protection device described in the "Mechanical Protection" paragraph,
- Temperature in the vicinity of the aft racks of the PFCS.

ACTIVE PROTECTIONS

TRANSITIONS OF FLIGHT CONTROL LAWS

Depending on airplane sensors available, the MFCC revert automatically to lower level Flight Control Laws.

The ACMU continuously monitor the outputs of the three MFCC and three SFCC, and if necessary vote out one, two, or all three MFCC or SFCC.

OVERHEAT PROTECTION

Cooling air from the ECS is used in order to cool the forward and aft FBW racks.

- *Refer to ATA 21_1 DESCRIPTION - SUPPLEMENTARY INFORMATION for additional information.*

MECHANICAL PROTECTIONS

HORIZONTAL STABILIZER RUNAWAY PROTECTION

"No back" is the primary device which holds the Horizontal Stabilizer Trim Actuator in position.

In case of "no back" failure, there is a potential risk of unwanted movement (due to aerodynamic effort) of the HSTA if the crew uses the manual trim.

This failure is indicated by **69 FCS: THS PROT FAIL** CAS message.

The uphold of the HSTA position depends on the capability of the backup motor to counteract the aerodynamic force. If the crew does not use the manual trim, position is hold by the brake.

No supplementary information to be provided on system protections at present time.

ELECTRICAL SOURCE ON GROUND

A dedicated feature enables to power the PMA converter when the engines are stopped, by supplying it by the normal airplane electrical generation.

This function is to be used only during on-ground maintenance operations.

Two switches located on the maintenance panel allow to use this function:

- TEST E1,
- TEST E2.

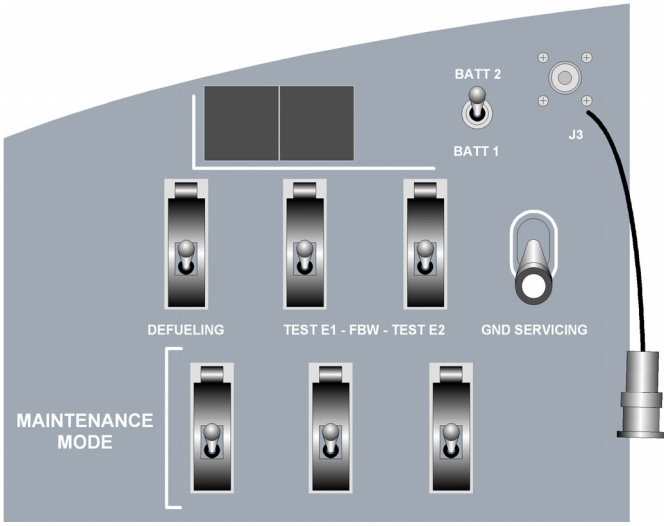


FIGURE 02-27_1-40 - MAINTENANCE PANEL

An internal monitoring system elaborates a discrete fed to the avionics system and signaling that the PMA is in maintenance mode (supplied by the airplane electrical generation). This raises a dedicated caution CAS message.

INTRODUCTION

The Falcon 7X airplane is fitted with six slats, three slats per half-wing:

- One inboard slat,
- One middle slat,
- One outboard slat.

The leading-edge slats are electrically controlled and hydraulically actuated.

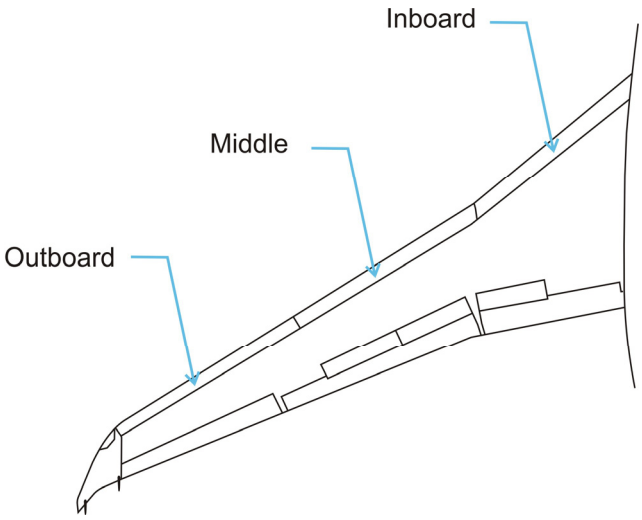


FIGURE 02-27_2-05-00 - LEADING-EDGE SLATS

There is no optional equipment associated with the slats system.

FLIGHT DECK OVERVIEW

CONTROLS

Crew control of the slats is performed via:

- The SLATS/FLAPS handle,
- The BACK-UP SLATS switch.

Both of these controls are located on the Pedestal.

INDICATIONS

Cockpit indications related to Slats system are displayed:

- On the left hand corner of the HSI, on the PDU for slats position,
- On the FCS synoptic page (Slats position),
- On placard markings in front of each pilot for the limitations,
- In the ENG-CAS window for CAS messages,
- In the STATus synoptic / FAULT tab for fault messages.

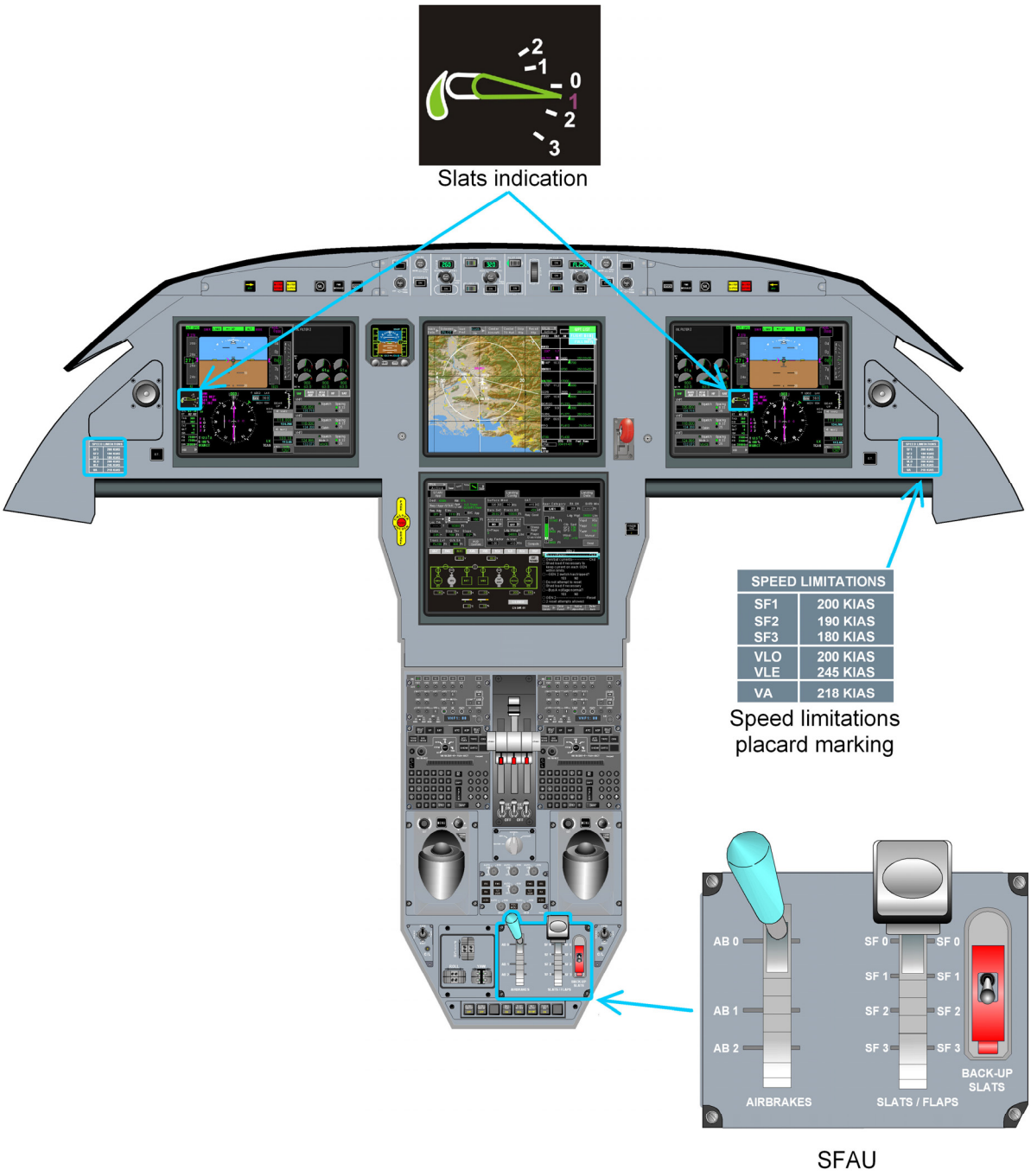


FIGURE 02-27_2-05-01 - FLIGHT DECK OVERVIEW

GENERAL

The Slats Control System performs the following functions:

- Actuation of the six slats based on:
  - Normal pilot order,
  - Back up pilot order (applicable to middle and outboard slats),
  - Automatic order.
- Position holding of the six slats,
- Monitoring of the position of the six slats.

Each slat surface is fitted with:

- Two actuators for middle and outboard slats for
  - Normal operation,
  - Back up extension.
- One actuator for inboard slats.

Hydraulic A is used for normal slats operation (all slats).

Hydraulic system B is used for back up slats extension (middle and outboard slats only).

SLATS CONTROL

Control of the Slats is manual or automatic.

PILOT COMMANDED SLATS OPERATION

During pilot commanded operation of the slats:

- In normal operation, control of the slats is performed:
  - By two Secondary Flight Controls Interface (SFCI3 and SFCI4 located in front FBW rack) modules which receive the Slats Flaps handle signal (4 positions: CLEAN, SF1, SF2, and SF3),
  - The electrical command signal from the SFCI is sent to the Slats Control Manifold (SCM), which provides hydraulic power to the slats.
- In slats back up operation, control of the slats is performed:
  - By a direct electrical command signal from the Slats BACK-UP SLATS switch, located on pedestal, to the Slats Control Manifold (SCM), which provides hydraulic power to the slats.

AUTOMATIC SLATS OPERATION

Automatic operation of the Slats:

- Is commanded by the Primary Flight Control System (PFCS), which provides command signal to the SCM through SFCI modules.

PFCS automatic slats function consists in:

- Configuration protection:
  - Normal slats extension is inhibited above 210 kt,
  - Slats retraction is inhibited by the PFCS if the flaps are extended.
- Stall protection:
  - In clean configuration: extension of middle and outboard slats at AOA=9°,
  - If inboard slats were extended, inboard slats are retracted at AOA=26°.
- Anti-ice system optimization:
  - In SF1 position, under some speed and AOA conditions, the inboard slats will retract.

➢ *Refer to Description - Supplementary Information section for additional information on Anti-ice optimization automatic control.*

PRINCIPAL DIAGRAM

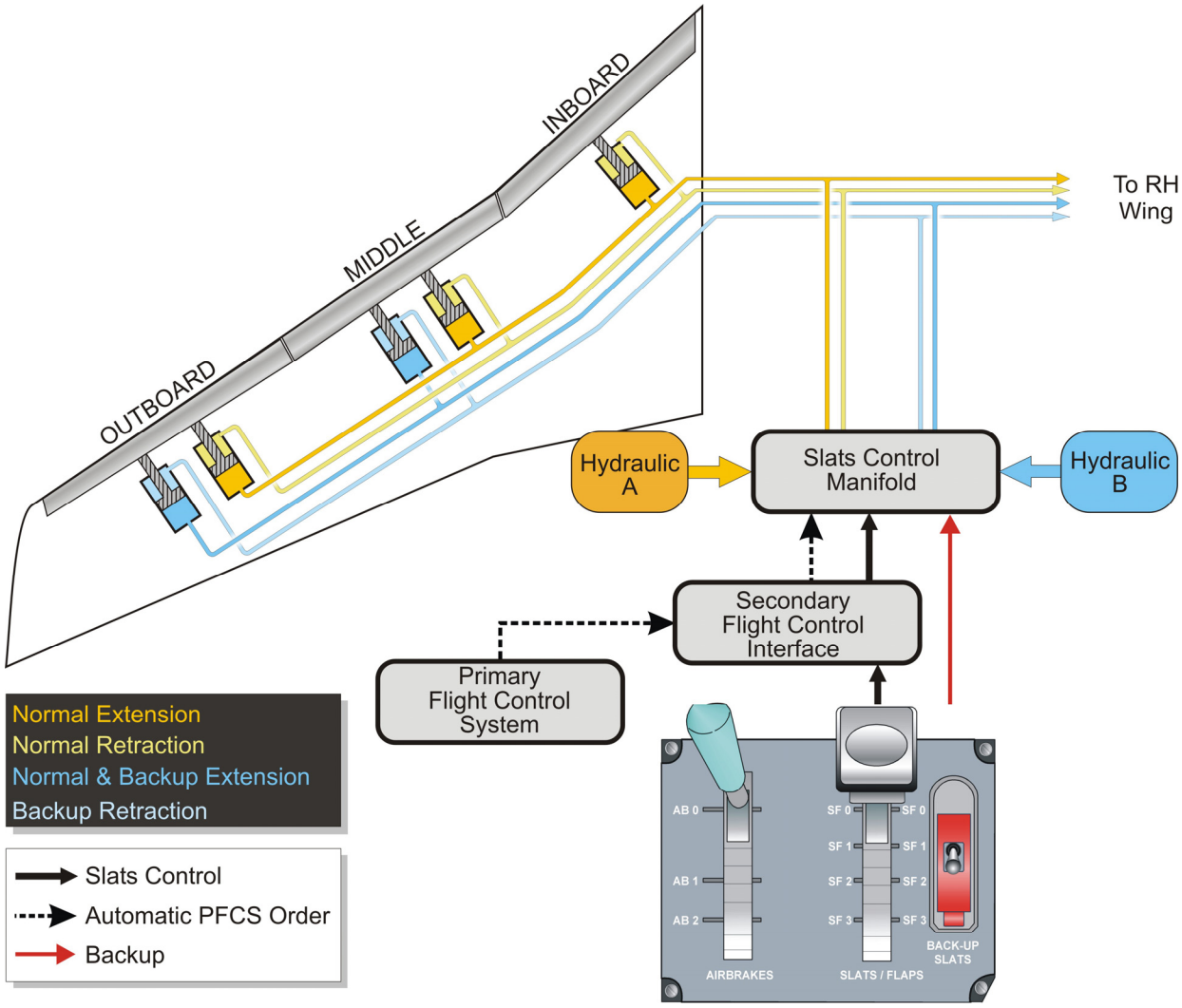


FIGURE 02-27_2-10-00 - SLATS PRINCIPLE DIAGRAM

SLATS FLAPS AIRBRAKES UNIT

The SFAU is located within the aft section of the cockpit pedestal. The unit comprises one lever assembly which is the interface for the crewmembers to command flaps and slats deployment, and a separate lever assembly which is the interface for the flight crew to command the airbrakes. A back-up slat switch is also included with a guard to prevent inadvertent operation.

The SFAU allows to manually controlling the slats position in normal and back-up mode:

- In normal mode:
  - Control handle in "SF0" position: the slats (outboard, middle, inboard) are in retracted position,
  - Control handle in "SF 1" position: the slats are extended, first outboard and middle and then inboard.
- In back-up mode:
  - Selecting BACK-UP SLATS control switch to the extension position causes outboard and middle slats to extend,
  - Retraction of outboard and middle slats is possible by resetting the BACK-UP SLATS control switch.

SLATS CONTROL MANIFOLD

The SCM provides the hydraulic control of six normal actuators (inboard, middle and outboard) and four backup actuators (middle and outboard).

The SCM is divided into two parts, one powered by hydraulic system A (normal control) and the other powered by hydraulic system B (backup control).

SECONDARY FLIGHT CONTROLS INTERFACE

Each SFCI includes two hardware lanes A & B and do the functions that follow :

- Transmits orders to the SCM,
- Receives the automatic orders, the flaps retracted information and manual slats extension enable signal from the PFCS,
- Receives information from all the transducers,
- Gives the slats positions to the PFCS,
- Receives normal pilot order from the SFAU,
- Transmits the middle and outboard slats extended information to the SFAU.

SEQUENCING

The sequencing between the middle and outboard slats and the inboard slats is electrically controlled by the SFCI.

During normal operation, middle and outboard slats are extending simultaneously.

With regard to inboard versus middle and outboard slats:

- For extension:
  - The middle and outboard slats extend first,
  - Then the inboard slats.
- For retraction:
  - The inboard slats retract first after flaps retraction,
  - Then the middle and outboard slats.

DESIGN PRINCIPLES

- With regard to the slats characteristics:
  - The wings are fitted with three slats due to the length of the wing span,
  - The limitation in altitude of slats and flaps is related to the absence of flight test at high altitude (as the use of slats and flaps is not necessary in altitude),
  - The back-up slats actuators also have hydraulic pressure in the retraction chamber to avoid extension of slats in case of negative Gs at high speed,
  - Slats are fitted with hooks to allow the adapation of the slats shape to the bent wing profile.
- Sequencing of the slats was determined to:
  - Avoid overlapping of inboard slats over middle slats,
  - Avoid deep stall (inboard slats retraction at AOA=26°).

LOCATION OF COMPONENTS

The SFCI modules are modules installed in the in the RH front FBW rack.

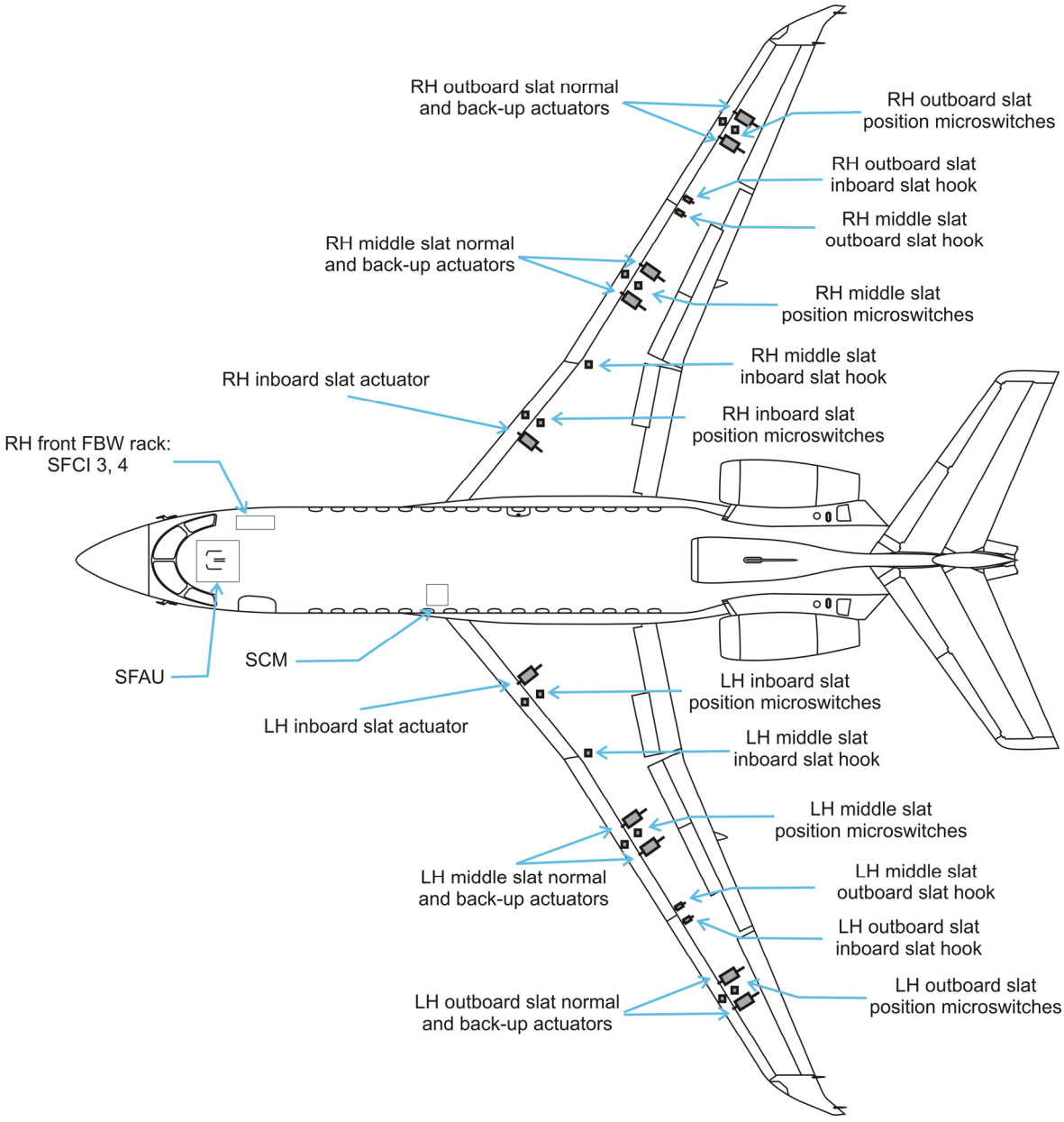


FIGURE 02-27_2-15-00 - LEADING-EDGE SLATS SYSTEM LOCATION OF EQUIPMENT

ELECTRICAL POWER SUPPLY

The following paragraph describes the power supply of the different equipment of the slats system.

Electrical protection is provided:

- Either by Solid State Power Controllers (SSPC) ,
- Or by Circuit Breakers (CB).

➢ *Refer to ATA 24 - ELECTRICAL POWER for additional information.*

EQUIPMENT	POWER SUPPLY	TYPE OF PROTECTION
SFAU	LH ESS	CB
SFAU BACKUP	RH ESS	CB
SFCI 3	LH ESS	CB
SFCI 4	RH ESS	CB

SLATS DETAILED DESCRIPTION

When retracted, middle and outboard slats are hold back at each end by a slat hook in order to adapt slat shape to the bent wing profile.

The locking is ensured by the rod of a double effect jack which pulls a dog to contact a tooth fixed on the external slat track.

When the hydraulic fluid flows to the retraction chamber of the jack, the slat hook locks.

When the hydraulic fluid flows to the extension chamber of the jack, the slat hook unlocks.

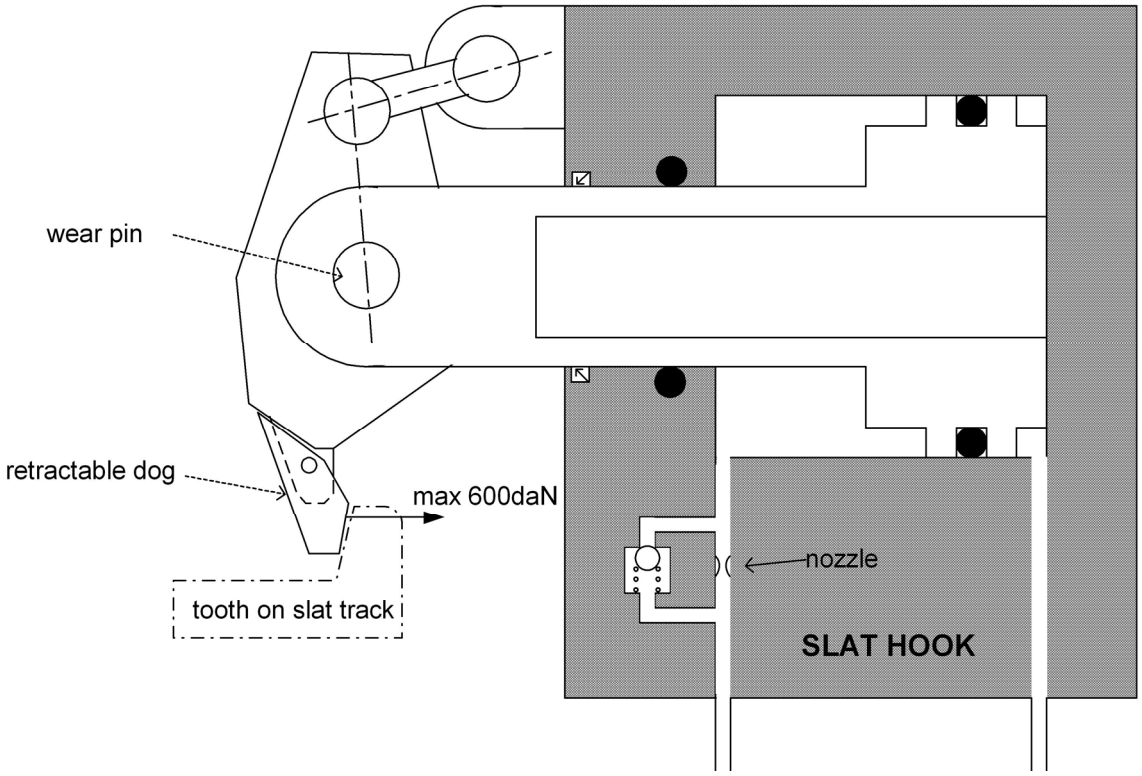


FIGURE 02-27_2-25 - SLAT HOOK

SLATS CONTROL - DETAILED DESCRIPTION

ANTI-ICE SYSTEM OPTIMIZATION

Conditions for inboard slats retraction for Anti-ice system optimization are:

- SF1 position, and
- Speed above 165 kt, and
- Throttle not in Take Off position, and
- AOA conditions< 7°.

Automatic control is cancelled when:

- Flap position is greater than 15°, (SF2 or SF3) or
- Speed is below 155 kt, or
- Throttle in Take Off position, or
- AOA exceeds 8°.

CONTROLS

Manual control of the Slats is performed via:

- The SLATS / FLAPS handle,
- The BACK-UP SLATS switch.

Both of these controls are located on the "Slats Flaps airbrakes Control Unit", on the pedestal.

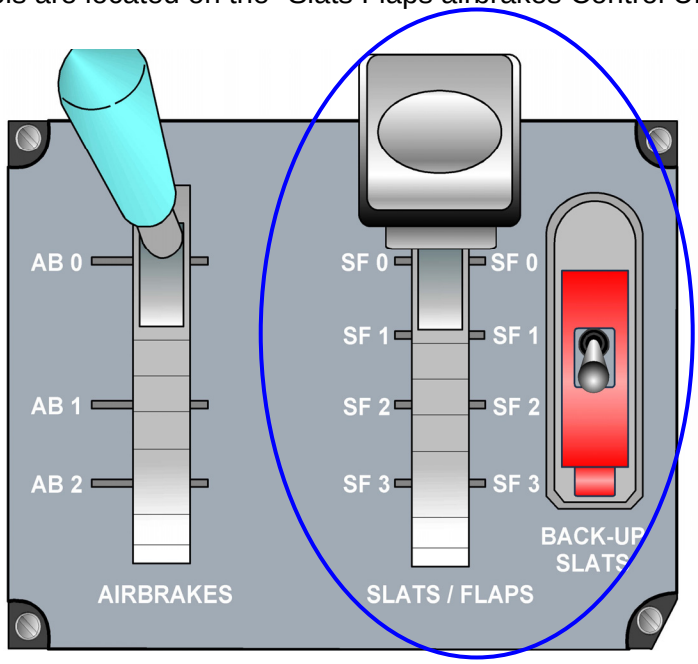
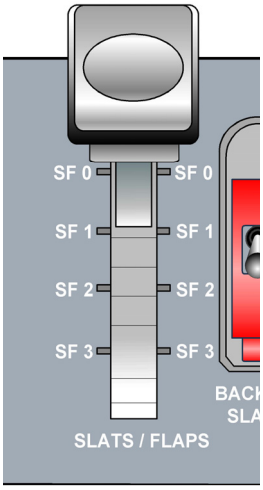
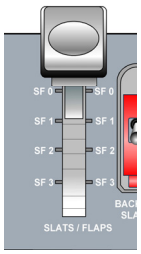
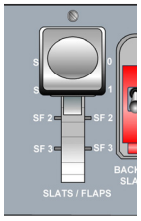
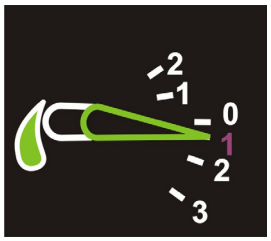
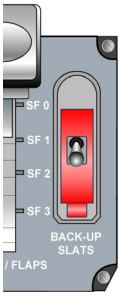
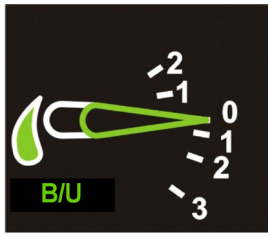


FIGURE 02-27_2-20-00 - SLATS FLAPS AIRBRAKES UNIT

CONTROL	FUNCTION	TO ACTIVATE TO DEACTIVATE	SYNOPTIC
	Sets Slats / Flaps to CLEAN notch. (Slats + Flaps retracted)		
	Sets Slats / Flaps to first notch SF1. (Slats + Flaps 9°)		
	Extends the Middle and Outboard slats in backup mode.		

INDICATIONS

Indications related to Slats are displayed:

- In the PDU for slats flaps position indicator,
- In the FCS synoptic page (Slats surfaces position),
- On the placard markings for slats flaps limitations,
- The ENG-CAS window for CAS messages,
- STATus synoptic / FAULT tab for fault messages.

PDU INDICATION

Slap, flap and airbrake positions are displayed in the top LH corner of the HSI window.

FIGURE 02-27_2-20-01 - HSI WINDOW DISPLAY

General

Slat / flap / airbrake symbols are displayed as long as:

- There is one slat, one flap or one airbrake panel extended (including untimely or non-commanded surface movement), or
- There is a secondary flight controls CAS message displayed, or
- One of the secondary flight controls is in automatic control (AUTO, A/B AUTO RET, A/B DISARM),
- Or Slats BACKUP is active.

The slat / flap / airbrake symbols are replaced by a white CLEAN label if:

- The airplane is in the CLEAN configuration,
- No secondary flight controls CAS message appears, and
- No secondary flight controls label is in automatic control

Airplane in CLEAN configuration,

No flight
control CAS message.

No secondary flight
control is in automatic control.

The CLEAN white label will be removed if:

- The airplane altitude is above 18,000ft, and
- The CLEAN label has been displayed for 15 s.

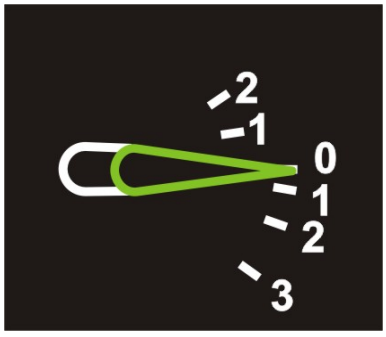
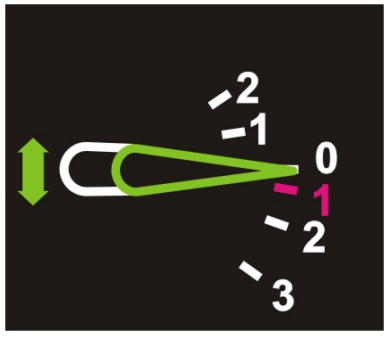
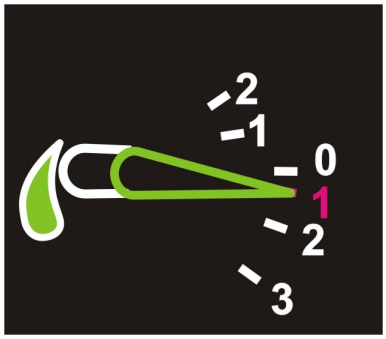
Airplane altitude above 18,000ft.

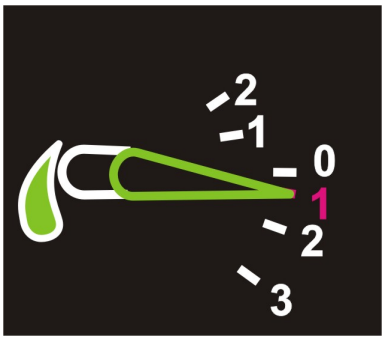
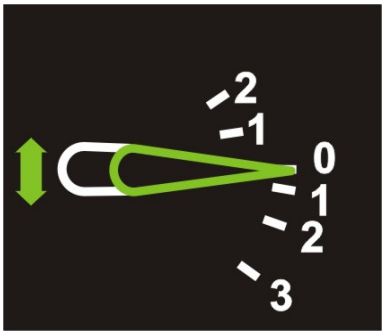
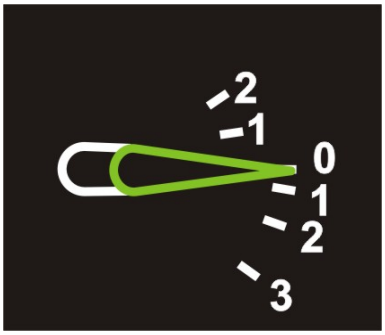
CLEAN label has been
displayed for 15 s.

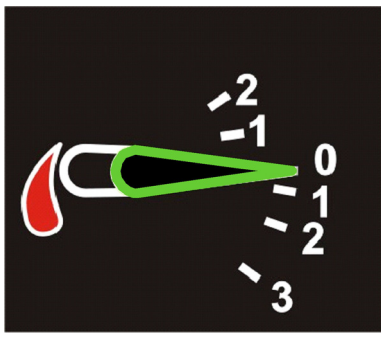
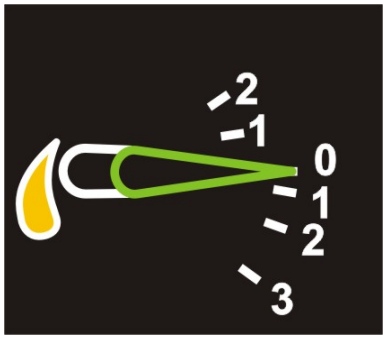
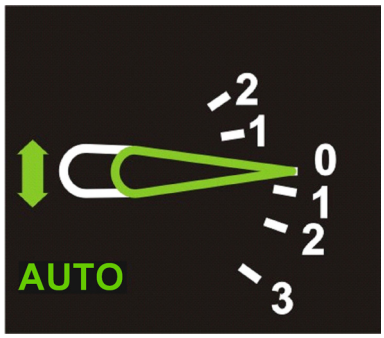
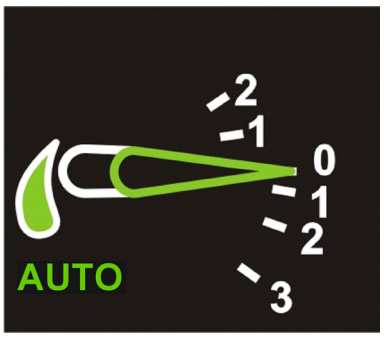
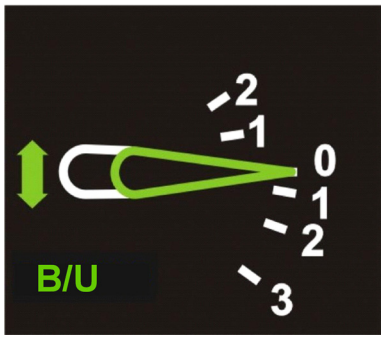
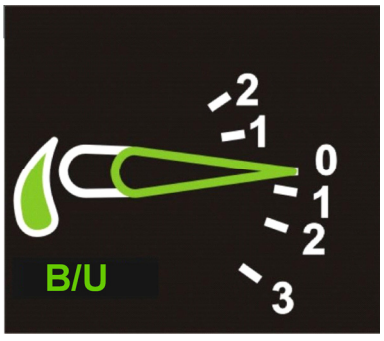
Slat symbol

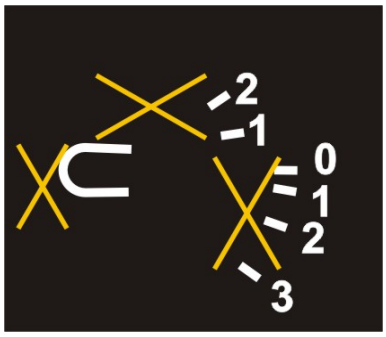
On the PDU, slats are symbolized by a drop, of different color /steady or flashing depending on the type of operation.

The slats symbol on the PDU is related to middle and outboard slats position only. The inboard slats are displayed in FCS synoptic page.

SLATS EXTENSION SEQUENCE		
		
Control handle in CLEAN notch: - Middle and outboard slats retracted, - Slats drop symbol is not displayed, - Flaps retracted, - Flaps green symbol in position 0.	Control handle moved to SF1 notch: - Slats extend, Flaps extend to Position 1, - Slats green arrow symbol flashes, - Flaps green symbol moves to position 1, - Flaps position 1 tick mark displayed in magenta.	Inboard and outboard Slats are extended: - Slats drop symbol comes green filled and steady, - Flaps are extended in position 1, - Flaps green symbol steady in position 1, - Flaps position 1 tick mark displayed in magenta.

SLATS RETRACTION SEQUENCE		
		
Control handle in SF1 notch: - Middle and outboard slats extended, - Slats drop symbol is green filled, - Flaps green symbol steady in position 1, - Flaps position 1 tick mark displayed in magenta.	Control handle moved to CLEAN notch: - Slats and flaps retract - Slats green arrow symbol flashes. - Flaps green symbol moves to position 0 - Flaps position 1 tick mark displayed in white	Both slats retracted: - No slats symbol is displayed. - Flaps retracted: - Flaps green symbol steady in position 0

SLAT MALFUNCTION, AUTOMATIC AND BACKUP OPERATIONS	
	
No take-off due to slats: Slat symbol is flashing red. The configuration is not allowed for take-off.	Discrepancy between slats control and one of the middle or outboard slat position, or SFCI failures.
	
Automatic slats movement.	Slats automatically extended.
	
Backup slats movement.	Slats extended by backup system

INVALID DATA

Slat / flap / airbrake indications are not valid.

FCS SYNOPTIC

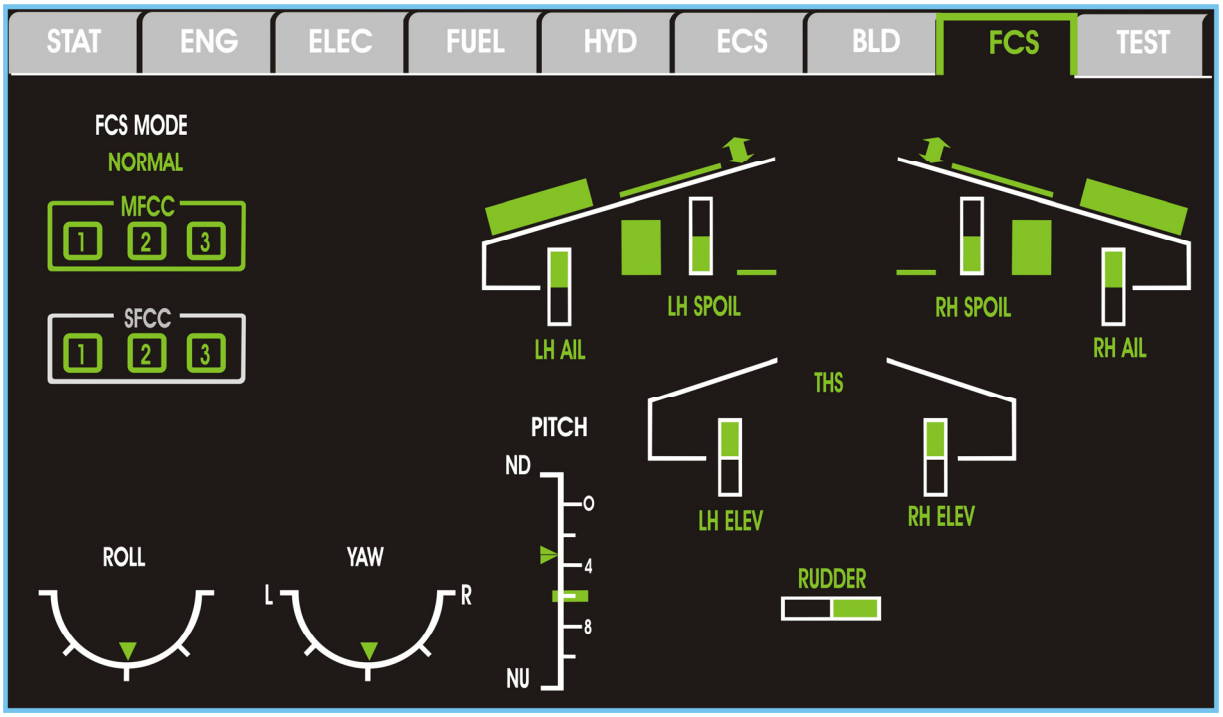
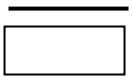


FIGURE 02-27_2-20-02 - FCS SYNOPTIC PAGE

The right part of the synoptic is devoted to provide the positions of all control surfaces except the flaps (removed for clarity).

The positions of all slats are displayed with pictograms:

-  when retracted,
- when extended,
-  when moving.

The pictogram is green for normal operation or amber for abnormal operation.

If surface position is invalid the pictogram is replaced by an amber cross:. 

PLACARD MARKINGS

The "SPEED LIMITATIONS" placard reminds the speed limitations for VFE, for the different slats and flaps configurations.

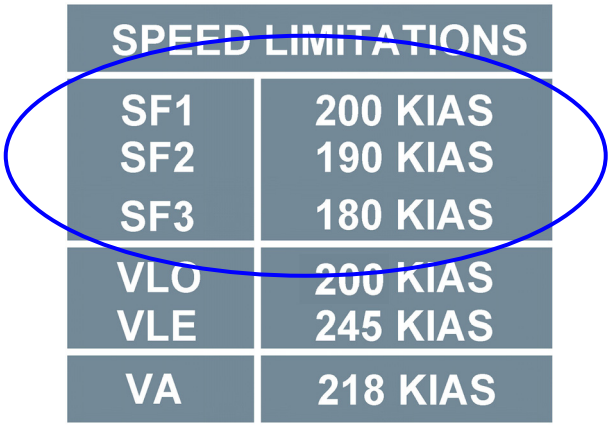


FIGURE 02-27_2-20-03 - SPEED LIMITATIONS PLACARD MARKINGS

No supplementary information to be provided on Controls and Indications at present time.

SYSTEM MONITORING

The following parameters are monitored:

- Slats position compared to control handle position or automatic order (would trigger an indication and a CAS message).

➢ *Refer to the "Indications" section for a description of the indications and to CODDE 2 for a complete list of CAS messages.*

ACTIVE PROTECTIONS

The following protections are provided by the PFCS:

- Inhibition of slats extension at high speed,
- Inhibition of slats retraction while the flaps are extended.

No supplementary information to be provided on System protections at present time.

Slats system does not require any ground operation.

INTRODUCTION

The flap assembly aims at increasing the lift at low speeds, typically during take-off and approach phases of flight.

The Falcon 7X airplane is fitted with four flaps, two double slotted flaps per half-wing:

- An inboard flaps,
- An outboard flaps.

The flaps are electrically controlled and hydraulically actuated.

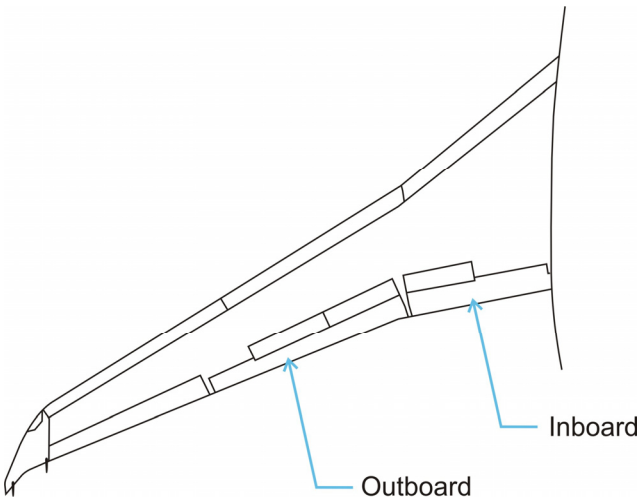


FIGURE 02-27_3-05-00 - FLAPS

There is no optional equipment associated with the flaps.

FLIGHT DECK OVERVIEW

CONTROLS

Crew control of the flats is performed via:

- The Slats / Flaps handle, located on the pedestal

INDICATIONS

Cockpit indications related to flaps system are displayed:

- On the left hand corner of the HSI, on the PDU for Flaps position,
- On placard markings in front of each pilot for the limitations,
- On the ENG-CAS window for CAS messages and white configuration messages,
- On the STATus synoptic / FAULT tab for fault messages.

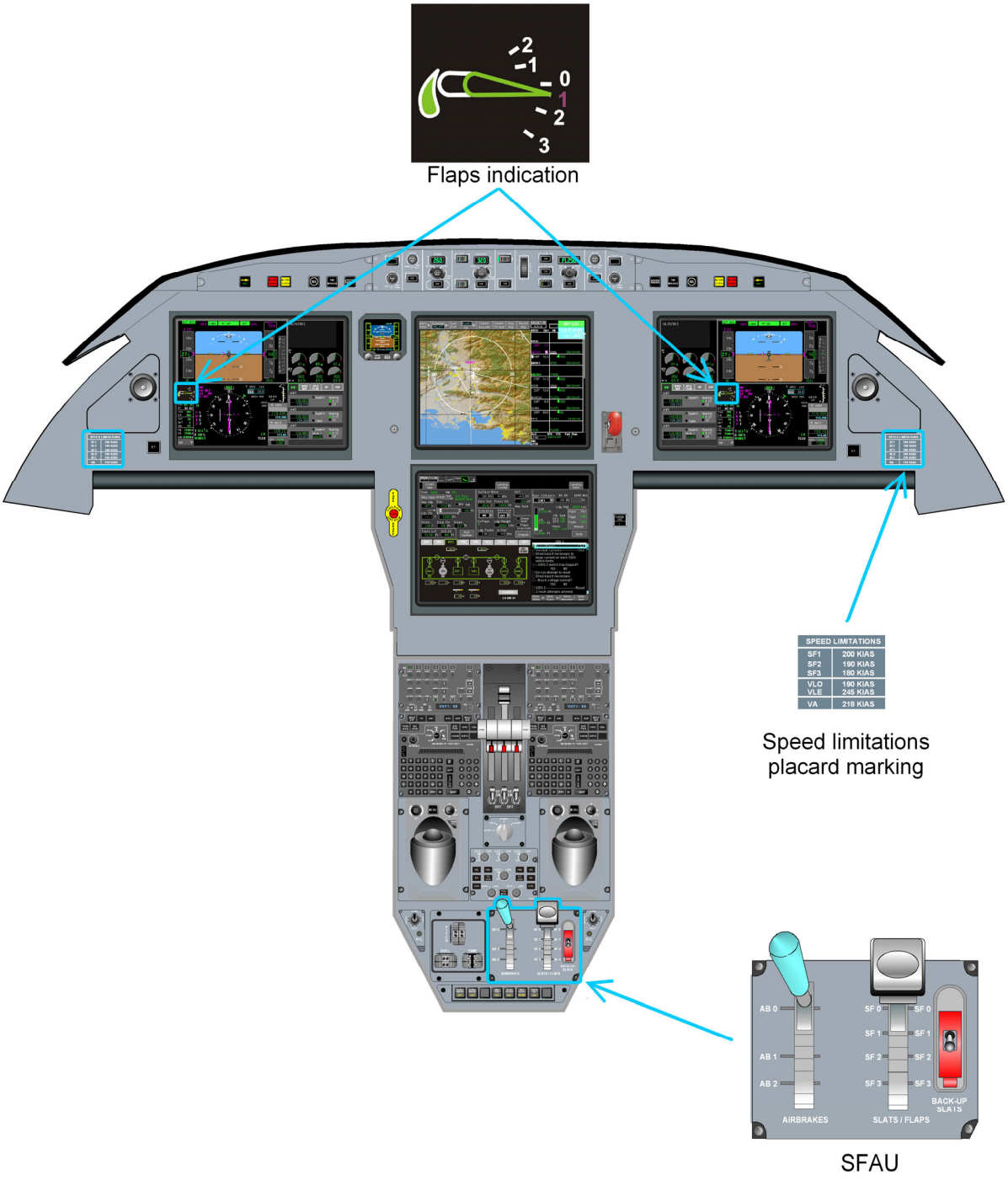


FIGURE 02-27_3-05-01 - FLIGHT DECK OVERVIEW

GENERAL

The flaps control system performs the following functions:

- Actuation of the four flaps based on pilot order,
- Position holding of the flaps.

There are four normal configurations of the system:

- SF0 (Slats / Flaps fully retracted),
- SF1 (Slats extended / Flaps 9°),
- SF2 (Slats extended / Flaps 20°),
- SF3 (Slats extended / Flaps 40°).

Except during takeoff and landing the flap surfaces are fully retracted to provide a minimum drag (clean wing) configuration.

Each flap surface:

- Is supported on three tracks,
- Is actuated by two actuators.

Hydraulic B is used for operation of the flaps.

FLAPS CONTROL

Control of the flaps is performed by the SFAU (Slats Flaps and Airbrake Unit), providing a command signal to a Power Drive Unit (PDU).

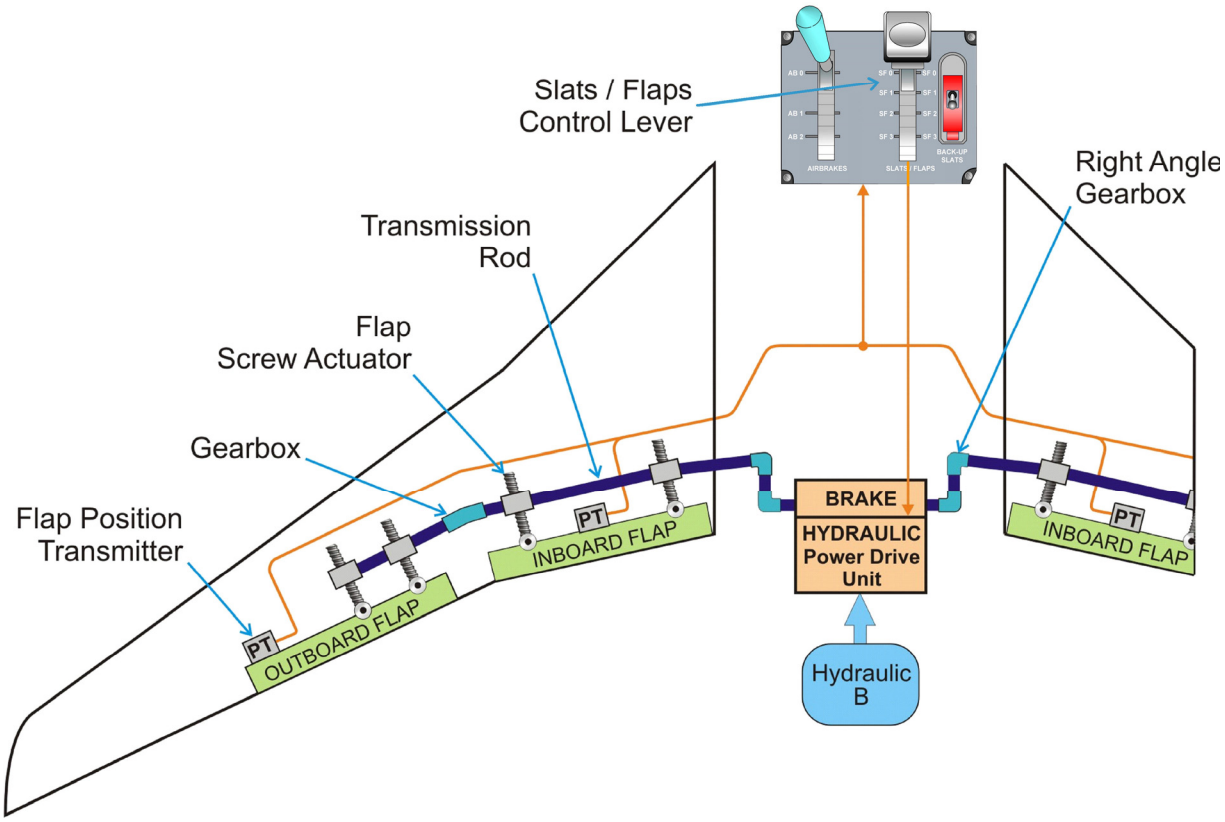


FIGURE 02-27_3-10-00 - FLAPS SYSTEM

POWER DRIVE UNIT

The Power Drive Unit (PDU) receives extension, retraction and brake release commands from the SFAU.

The PDU utilizes hydraulic power from the hydraulic B system to rotate the transmission tubes and produce the required movement of the flap.

The power drive unit also includes a brake that holds the system at the commanded position.

SLATS FLAPS AIRBRAKES UNIT

The SFAU is located within the aft section of the cockpit pedestal. The unit comprises one lever assembly which is the interface for the crewmembers to command flaps and slats deployment, and a separate lever assembly which is the interface for the flight crew to command the airbrakes. A back-up slat switch is also included with a guard to prevent inadvertent operation.

Dual redundant potentiometers within the slats / flaps lever assembly translate movement of the lever between the four available positions, into electrical signals that are processed within the SFAU. Then the SFAU generates a demand to the PDU for flap movement depending on the commanded flap position and the actual flap position from the position sensors. The SFAU also provides indication of flap equipment failures including lever failure, flap asymmetry and flap overrun

SEQUENCING

The sequencing of flap operation is controlled as follows:

- Both flap surfaces are commanded simultaneously thanks to mechanical transmission,
- For extension and retraction:
  - The flaps can only be extended after the outboard and middle slat sections have been fully deployed.
  - The flaps retract before any slats retracting.

DESIGN PRINCIPLES

With regard to flaps system architecture:

- Each flap surface is actuated by two actuators,
- One actuator is enough to maintain the position of the flap surface,
- Flaps extensions are impossible if the outboard and inboard slats are not fully extended.

LOCATION OF COMPONENTS

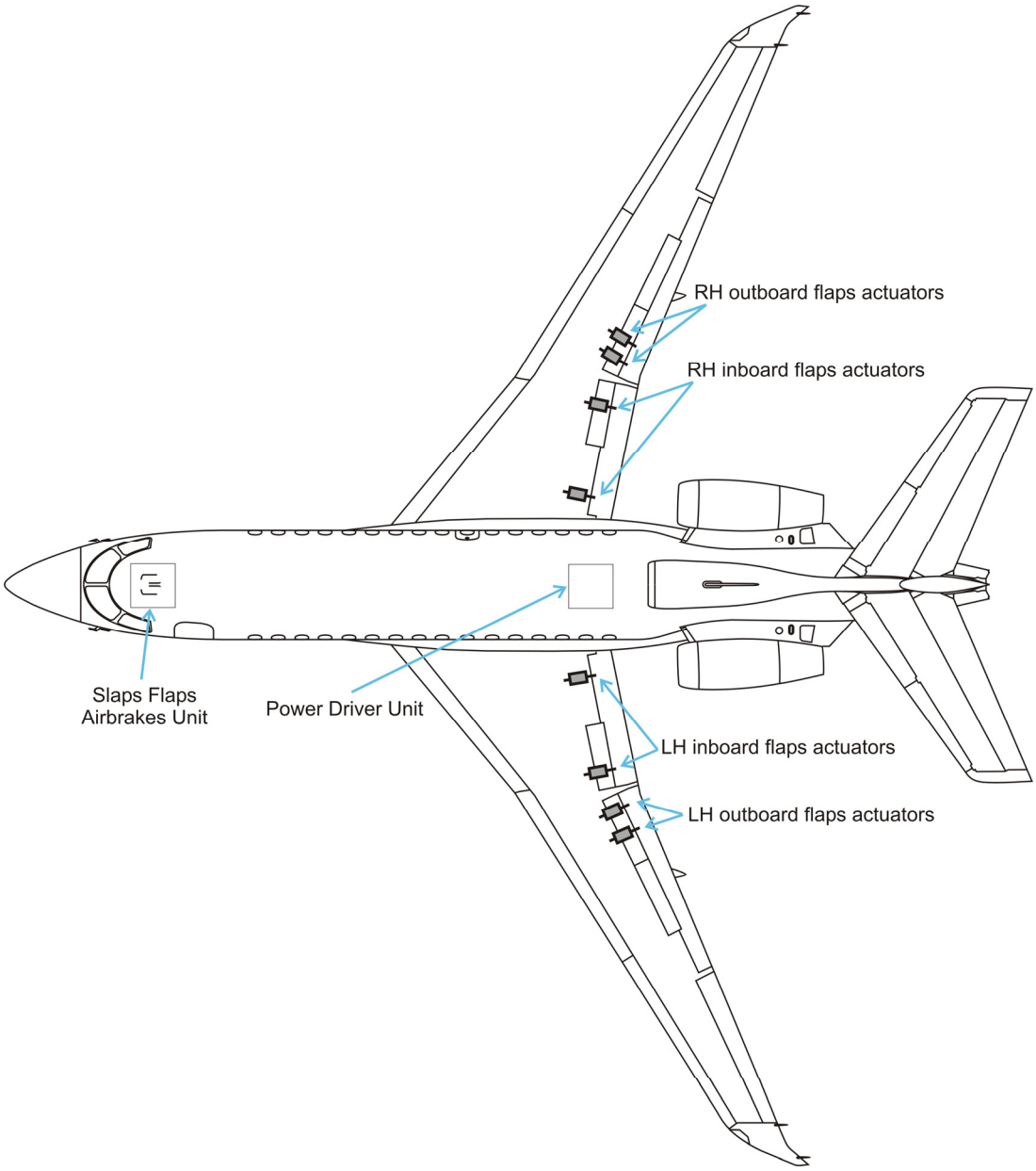


FIGURE 02-27_3-15-00 – FLAPS EQUIPMENT LOCATION

ELECTRICAL POWER SUPPLY

The following paragraph describes the power supply of the different equipment of the flaps system.

Electrical protection is provided:

- Either by Solid State Power Controllers (SSPC) ,
- Or by Circuit Breakers (CB).

➢ *Refer to ATA 24 – ELECTRICAL POWER for additional information.*

EQUIPMENT	POWER SUPPLY	TYPE OF PROTECTION
SFAU	LH ESS	CB

CONTROLS

Control of the flaps is performed via the Slats / Flaps handle, located on the SFAU, on the pedestal.

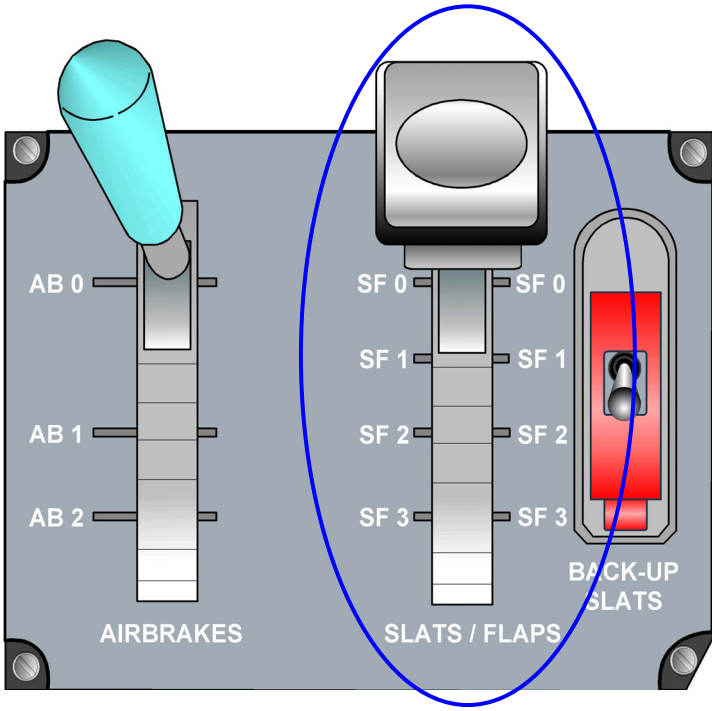
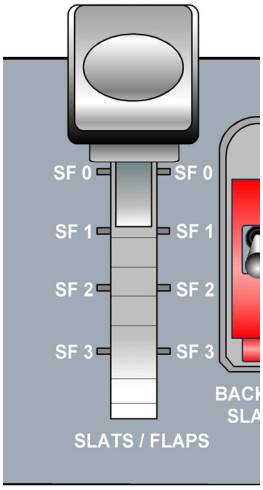
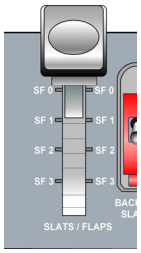
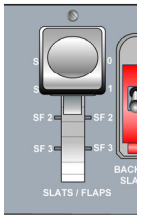
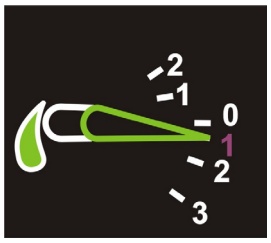
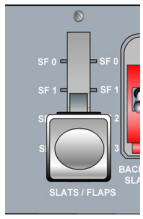
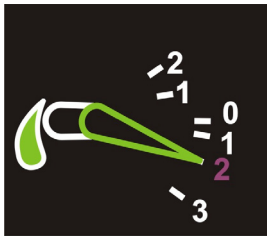
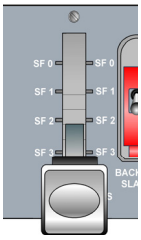
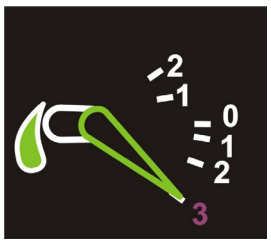


FIGURE 02-27_3-20-00 - SLATS FLAPS AIRBRAKES UNIT

SYNTHETIC TABLE

CONTROL	FUNCTION	TO ACTIVATE TO DEACTIVATE	SYNOPTIC
	Sets Slats / Flaps to SF0 notch. (Slats + Flaps retracted)		CLEAN
	Sets Slats / Flaps to first notch SF1. (Slats extented + Flaps 9°)		
	Sets Slats / Flaps to the second notch SF2. (Slats extended + Flaps 20°)		
	Sets Slats / Flaps to the third notch SF3 (Slats extended + Flaps 40°)		

INDICATIONS

Indications related to flats are displayed:

- In the PDU for slats flaps position indicator,
- On the placard markings for slats flaps limitations,
- On the ENG-CAS window for CAS messages,
- On the STATus synoptic / FAULT for fault messages.

PDU INDICATION

Slap, flap and airbrake positions are displayed in the top LH corner of the HSI window.

FIGURE 02-27_2-20-01 - HSI WINDOW DISPLAY

General

Slat / flap / airbrake symbols are displayed as long as:

- There is one slat, one flap or one airbrake panel extended (including untimely or non-commanded surface movement), or
- There is a secondary flight controls CAS message displayed, or
- One of the secondary flight controls is in automatic control (AUTO, A/B AUTO RET, A/B DISARM),
- Or Slats BACKUP is active.

The slat / flap / airbrake symbols are replaced by a white CLEAN label if:

- The airplane is in the CLEAN configuration,
- No secondary flight controls CAS message appears, and
- No secondary flight controls label is in automatic control.

Airplane in CLEAN configuration,

No flight control CAS message

No secondary flight control is in automatic control.

The CLEAN white label will be removed if:

- The airplane altitude is above 18,000 ft, and
- The CLEAN label has been displayed for at least 15 s.

Airplane altitude above 18,000ft

CLEAN label has been displayed for at least 15 s

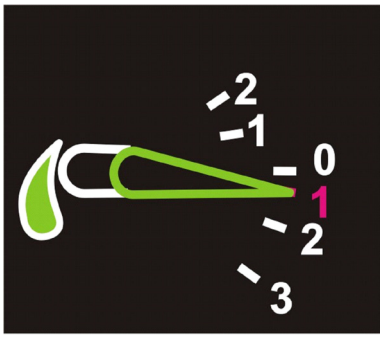
FLAPS SYMBOL

On the PDU, Flaps are symbolized by a conic shape, of different color /steady or flashing depending on the type of operation.

The flaps symbol is related to inboard and outboard flaps position. All flaps are supposed to be in same position, otherwise a CAS message would be triggered.

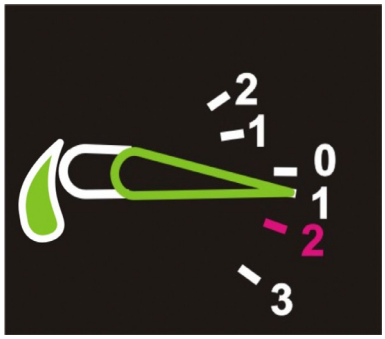
Flap handle position is shown on the indicator as a magenta tick mark ad label (0, 1, 2 or 3) (corresponding to the "target color code").

FLAPS EXTENSION FROM SF1 TO SF2
(FROM CLEAN TO SF1: IDENTICAL TO SLAT EXTENSION)



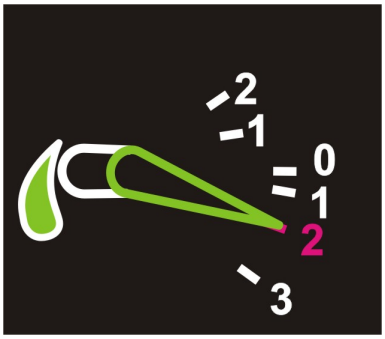
Control handle in SF1 notch:

- Flaps extended to a deflection angle of 9°. Slats are extended (drop green filled),
- Flaps green symbol steady in position 1,
- Flap position tick mark and label 1 displayed in magenta.



Control handle moved to SF2 notch:

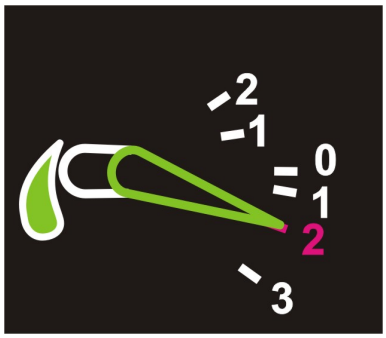
- Flaps extend to position 2,
- Flaps green symbol moves to position 2,
- Flaps position tick mark and label 2 displayed in magenta.



When flaps reach the position of 20°:

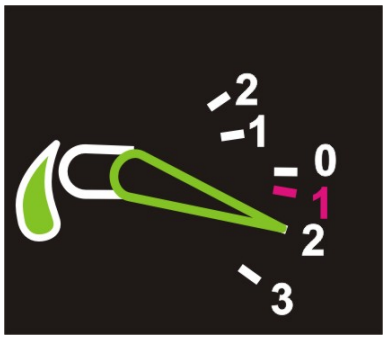
- Flap symbol is in position 2,
- Flaps position tick mark and label 2 displayed in magenta.

FLAP RETRACTION FROM SF1 TO SF2
(FROM SF1 TO CLEAN: IDENTICAL TO SLAT EXTENSION)



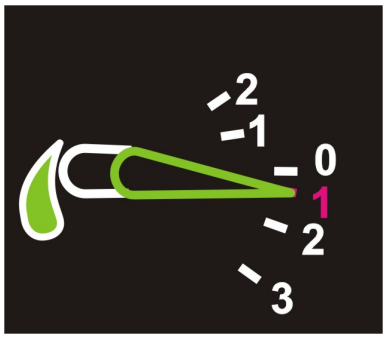
Control handle in SF2 notch:

- Flap symbol is in position 2,
- Flaps position tick mark and label 2 displayed in magenta.



Control handle moved to SF1 notch:

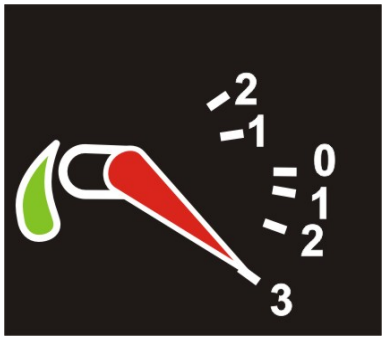
- Flaps retract to position 1,
- Flaps green symbol moves to position 1,
- Flaps position tick mark and label 1 displayed in magenta.



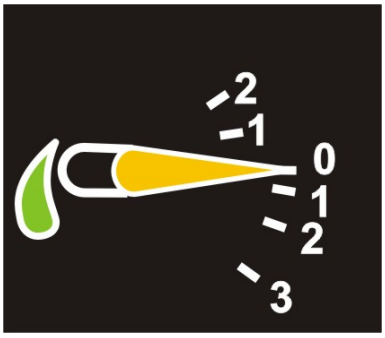
When flaps reach the position of 9°:

- Flap symbol is in position 1,
- Flaps position tick mark and label 1 displayed in magenta.

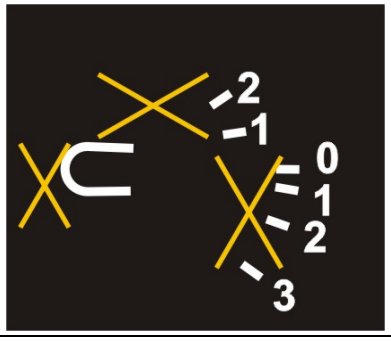
FLAPS WRONG CONFIGURATION AND MALFUNCTION



No take-off due to flaps:
flap symbol is flashing red.
The configuration is not allowed for take-off.



Flap failure.

INVALID DATA

Slat / flap / airbrake indications are not valid.

WHITE CONFIGURATION MESSAGES

The system provides the following verification of configuration:

- For Take Off configuration: during taxi, if the slats and flaps are not selected in one of the authorized Take Off configuration, the message **TO CONF: FLAPS MISCONFIG** is displayed,
- For Approach configuration: below 1,000 ft, if the slats flaps are not selected in SF3 position, the message **LDG CONF: FLAPS NOT FULL** is displayed,
- After a Go Around: in flight, if the slats and flaps are still selected in SF3 position 10 seconds after the Go Around pushbutton was triggered, the message **CONF: FLAPS MISCONFIG FULL** is displayed.

NOTE

After landing, the **TO CONF: FLAPS MISCONFIG** message is inhibited during 5 minutes. Therefore, if a Take Off is performed within 5 minutes after landing, the crew should not expect this message, even if the Flaps configuration is not appropriate for Take Off.

PLACARD MARKINGS

The "SPEED LIMITATIONS" placard reminds the speed limitations for VFE, for the different slats and flaps configurations.

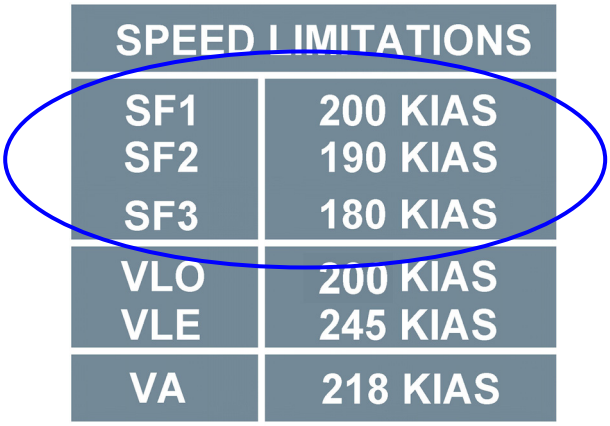


FIGURE 02-27_3-20-02 - SPEED LIMITATIONS PLACARD MARKINGS

No supplementary information to be provided on Controls and Indications at present time.

SYSTEM MONITORING

The flap system provides monitoring of the following parameters:

- Flap asymmetry between left and right wings.

➢ *Refer to the "Indications" section for a description of indications and to CODDE 2 for a complete list of CAS messages.*

ACTIVE MONITORING

The system is arranged to provide symmetric actuation of the surfaces. Asymmetric movement of the flap will be detected by the position sensors. Detection of asymmetric flap movement causes:

- Flaps movement to stop.

Each actuator includes a shear pin that provides some protection for both the actuator and the flap surface in the event of a system or track jam.

No supplementary information to be provided on System protections at present time.

Flaps system does not require any ground operation.

INTRODUCTION

The airbrake assembly aims at increasing airplane drag in order to slow down the airplane. They can be operated either on ground or in flight.

The Falcon 7X is fitted with six airbrake panels, three airbrake panels on each wing:

- 1 outboard panel,
- 1 middle panel,
- 1 inboard panel.

The middle panels are also used for roll, pitch and yaw control and are called spoilers.

➢ *Refer to 27_1 paragraph.*

Airbrakes are electrically controlled and hydraulically actuated.

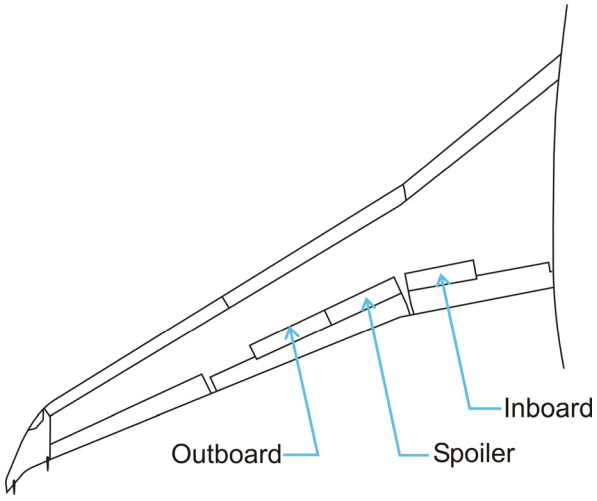


FIGURE 02-27_4-05-00 - AIRBRAKES AND SPOILERS PANELS

There is no optional equipment associated with Airbrake system.

FLIGHT DECK OVERVIEW

CONTROLS

Crew control of Airbrakes is performed via:

- The airbrake handle, located on the pedestal,
- The "A/B AUTO EXTEND" de-selection pushbutton on the Overhead Panel (OP).

INDICATIONS

Cockpit indications related to Airbrakes are displayed:

- On the speed tape of the ADI, on the PDU,
- On the left hand corner of the HSI, on the PDU for airbrakes position,
- On the FCS synoptic page (Airbrakes/spoilers surfaces positions),
- On the ENG-CAS window for white configuration and failure CAS messages,
- On the STATus synoptic / FAULT tab for fault messages.

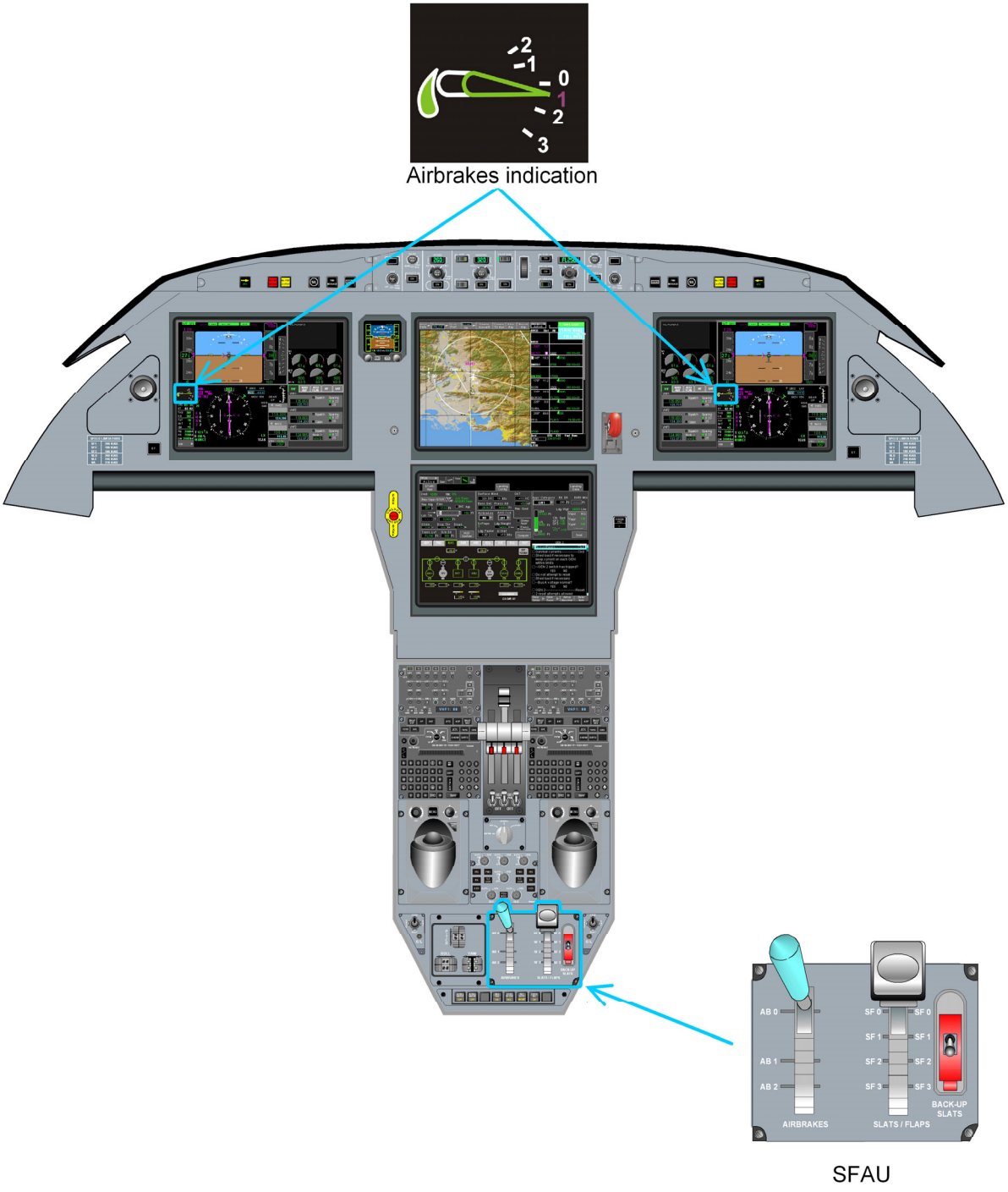


FIGURE 02-27_4-05-01 - FLIGHT DECK OVERVIEW

GENERAL

The airbrakes control system performs the following functions:

- Actuation of the six airbrakes panels based on:
  - Normal pilot order,
  - Automatic order.
- Position holding of the airbrakes,
- Monitoring of the position of the airbrakes.

Airbrakes and spoilers surfaces are fitted with:

- A hydraulic actuator for each spoiler.
- A two-position hydraulic actuator for each inboard and outboard panel.

Hydraulic B is used for inboard and outboard airbrakes operation.

Hydraulic C is used for spoilers operation.

AIRBRAKES AND SPOILERS CONTROL

Control of the airbrake and spoiler panels is manual or automatic. The automatic control has priority over the manual control.

PILOT COMMANDED AIRBRAKES OPERATION

Manual control is used for:
- Progressive extension / retraction of spoilers,
- Extension / retraction of Inboard and outboard airbrake panels.

Spoilers (Airbrake handle between position 0 and 1)

Progressive manual control of the airbrakes spoilers is performed:
- By a control unit named Slats Flaps and Airbrakes Unit (SFAU), providing analog electrical signal to the Primary Flight Control System (PFCS),
- The PFCS combines this signal with automatic airbrake commands to control the spoiler actuators.

Inboard and outboard airbrakes (Airbrake handle in position 2)

Control of the airbrake outboard and inboard panels is performed:
- By a control unit named SFAU , providing directly electrical command to the Airbrake Control Manifold,
- Hydraulic power is then applied to the actuators.

AUTOMATIC AIRBRAKES OPERATION

Automatic control is used for:
- Roll, pitch and yaw control and load alleviation for spoilers,
- Automatic extension of all airbrake and spoiler panels on ground:
  - At landing,
  - During Rejected Take-Off (RTO) (manual extention is however required in this case in addition to the automatic extension).
- Automatic retraction of all airbrake and spoiler panels in flight:
  - For stall protection,
  - During go-around,
- Automatic retraction of inboard airbrakes panels in flight when flaps are not retracted.

Automatic commands are:
- Triggered by the Brake Control Unit (BCU) command for ground automatic extension,
- Elaborated by the Primary Flight Control System for all automatic flight functions,
- Named Airbrake "Auto-deploy" and "Auto-retract" commands.

Inboard and outboard airbrakes

Control of the airbrake outboard and inboard panels is performed as follows:

- Order is elaborated by the BCU (auto extension) or by the PFCS (auto extension or auto retraction),
- Electrical order is transmitted to the Secondary Flight Control Interface (SFCI) and consolidated in SFCI,
- The SFCI provide command signal to the SFAU,
- Electrical command is finally transmitted to the Airbrake Control Manifold (ACM),
- Hydraulic power is then applied to the actuator.

Spoilers

Control of the spoiler panels as an airbrake function is performed as follows:

- Order is elaborated by the BCU (auto extension) or by the PFCS (auto extension or auto retraction),
- Electrical order from the BCU is transmitted to the SFCI and consolidated in SFCI,
- The SFCI provides command signal from the BCU to the PFCS,
- Hydraulic power is then applied to the actuator based on PFCS order.

Each spoiler position is sensed and sent back to the PFCS for closed loop position control.

AIRBRAKE CONTROL MANIFOLD

The ACM converts electrical signals in hydraulic flow to the inboard and/or outboard airbrake actuators depending on airplane configuration.

ACTUATORS

A single differential-area hydraulic actuator drives each of the four inboard and outboard airbrake panels. Each actuator is fitted with a mechanical lock to hold the airbrake in the retracted position, even in case of hydraulic loss.

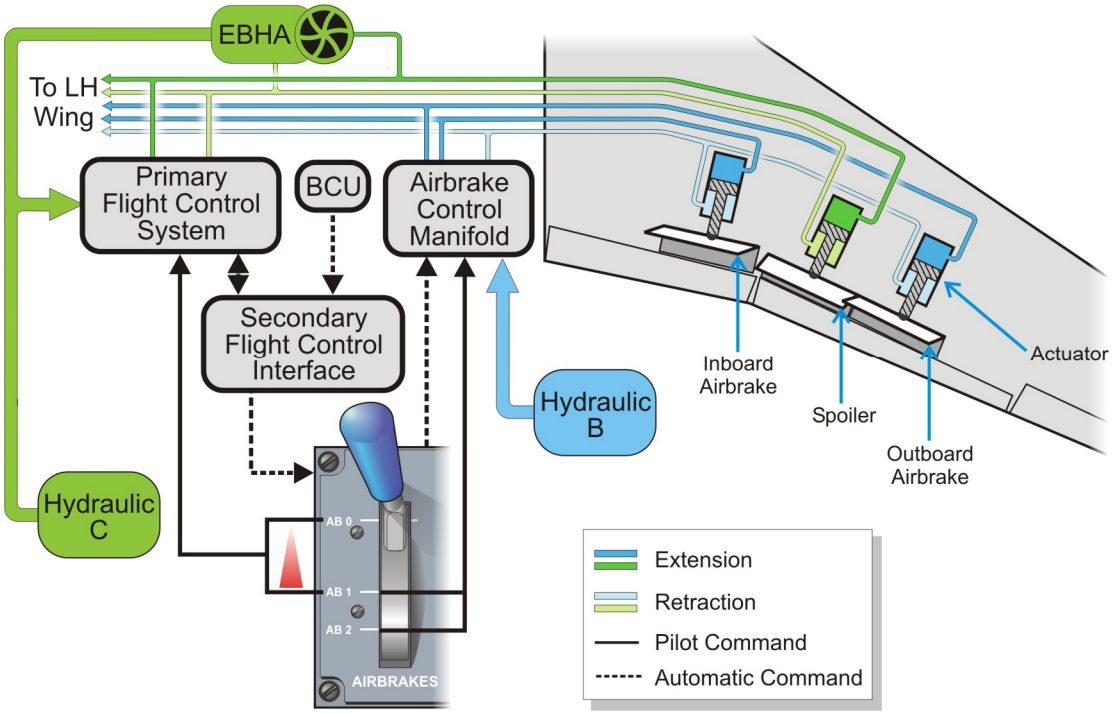


FIGURE 02-27_4-10-00 - AIRBRAKE AND SPOILERS SCHEMATICS

DESIGN PRINCIPLES

With regard to airbrake system architecture:

- Inboard and outboard airbrake panels are fitted with locks in order to avoid untimely extension of airbrakes in case of hydraulic failure, because of the criticality of airbrake untimely extension,
- Inboard airbrake actuators are commanded through the same solenoid valve and outboard airbrake actuators are also commanded through the same solenoid valve, thus limiting the risk for asymmetric extension or retraction,
- Inboard and outboard airbrake pairs are commanded separately using different SFAU channels.

LOCATION OF COMPONENTS

The SFCI modules are modules installed in the in the RH front FBW rack.

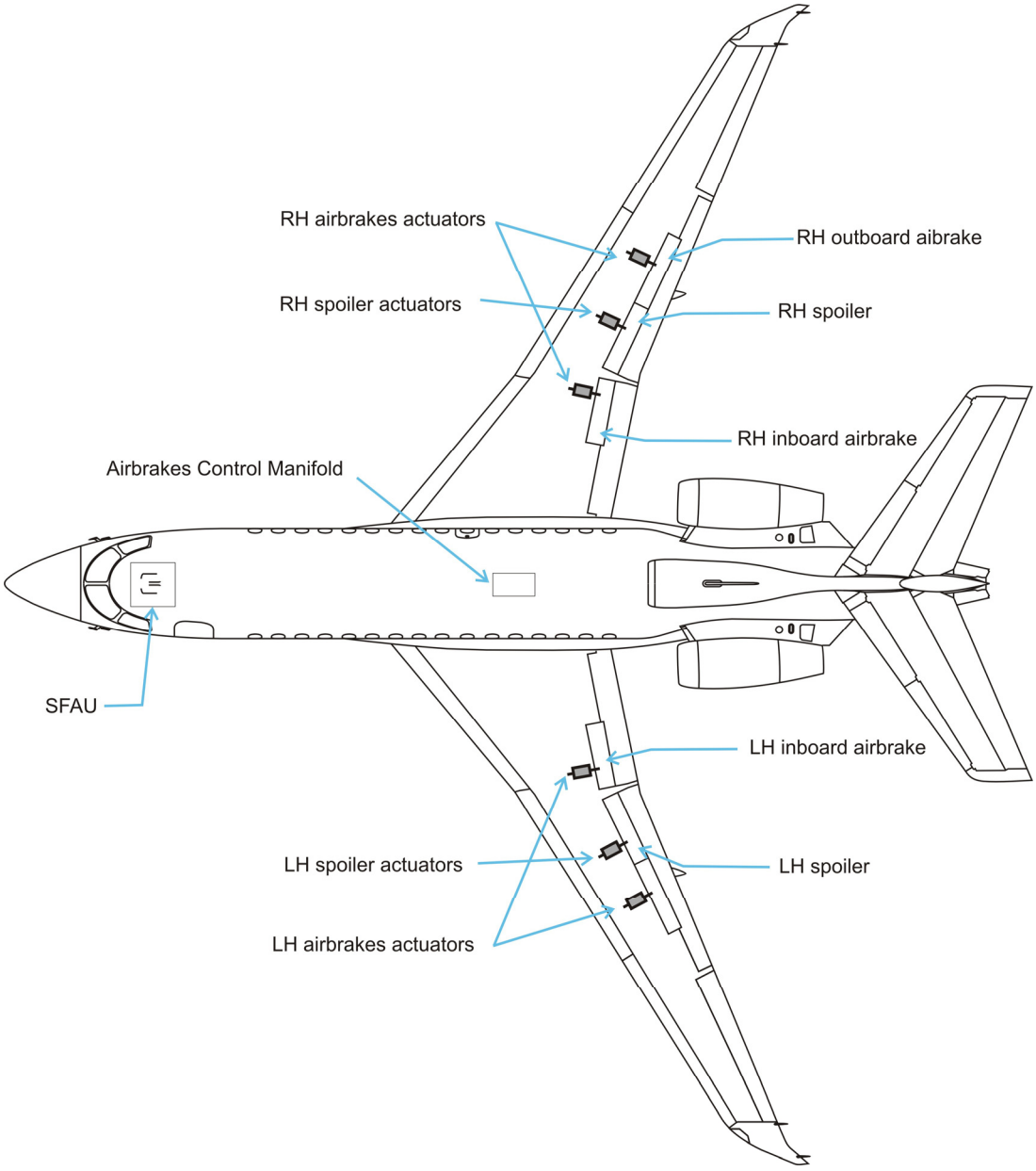


FIGURE 02-27_4-15-00 - AIRBRAKES SYSTEM LOCATION OF EQUIPMENT

ELECTRICAL POWER SUPPLY

Following paragraph describes the power supply of the different equipment of the airbrakes system.

Electrical protection is provided:

- Either by Solid State Power Controllers (SSPC),
- Or by Circuit Breakers (CB).

➢ *Refer to ATA 24 – ELECTRICAL POWER for additional information.*

EQUIPMENT	POWER SUPPLY	TYPE OF PROTECTION
SFAU	LH Ess bus	CB
SFCI 3	E3: LH ESS bus	CB
SFCI 4	E4: LH ESS bus	CB

AUTOMATIC AIRBRAKE OPERATION

At landing, automatic extension of airbrakes is inactivated when all four wheel speeds are lower than 20kt or 40 s after touch down.

During an RTO, automatic extension of airbrakes is inactivated when all four wheel speeds are lower than 20kt or when brake pedal depression has decreased below 20%.

CONTROLS

Control of the airbrakes is performed via:

- The airbrake handle, located on the pedestal,
- The A/B AUTO EXTEND pushbutton on the Overhead Panel.

AIRBRAKE HANDLE

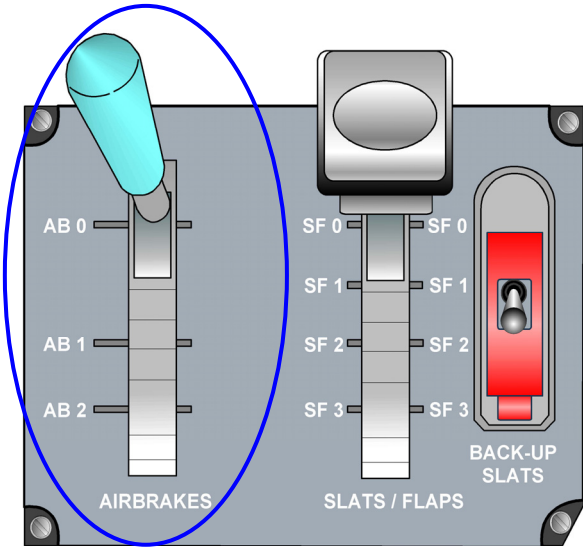
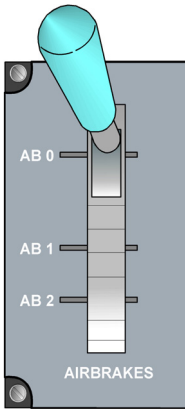
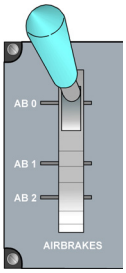
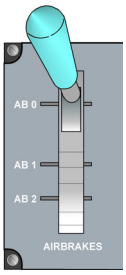
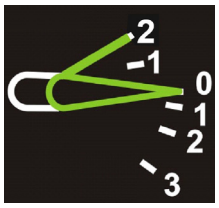
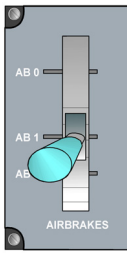
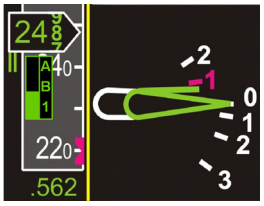
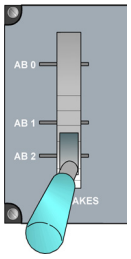
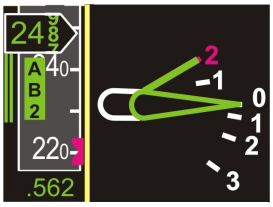
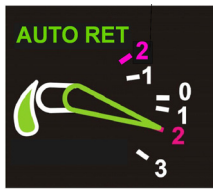
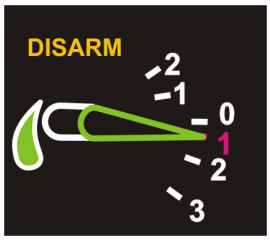


FIGURE 02-27_4-20-00 - SLATS FLAPS AIRBRAKES UNIT

CONTROL	FUNCTION	TO ACTIVATE TO DEACTIVATE	SYNOPTIC
	Airbrakes to AB 0 notch: - airbrake panels, slats and flaps retracted		
	Airbrakes to AB 0 notch: - AB and/or spoiler automatically commanded (spoiler panels deployed depending on automatic PFCS control)		 **AUTO EXTENSION**
	Between AB 0 and AB 1: - Progressive spoilers deployment (maximum deflection in AB1 depends on airspeed, angle of attack, and flaps position)		
	Sets airbrakes to AB 2: - inboard and outboard airbrake panels deployed		  **AUTO RETRACTION**

A/B AUTO EXTEND PUSHBUTTON

CONTROL	FUNCTION	TO ACTIVATE TO DEACTIVATE	SYNOPTIC
	Disarms automatic airbrake extension	 AUTO EXT mode is on	No specific indication
		 AUTO EXT mode is OFF	

INDICATIONS

Related FCS indications are displayed:

- In the FCS synoptic page (FCS surfaces positions and trims positions),
- In the HSI window (Slat / flap / airbrake symbols),
- In the ADI window (airbrake indication),
- The ENG-CAS window for white configuration and failure CAS messages,
- STATus synoptic / FAULT tab for fault messages.

FCS SYNOPTIC

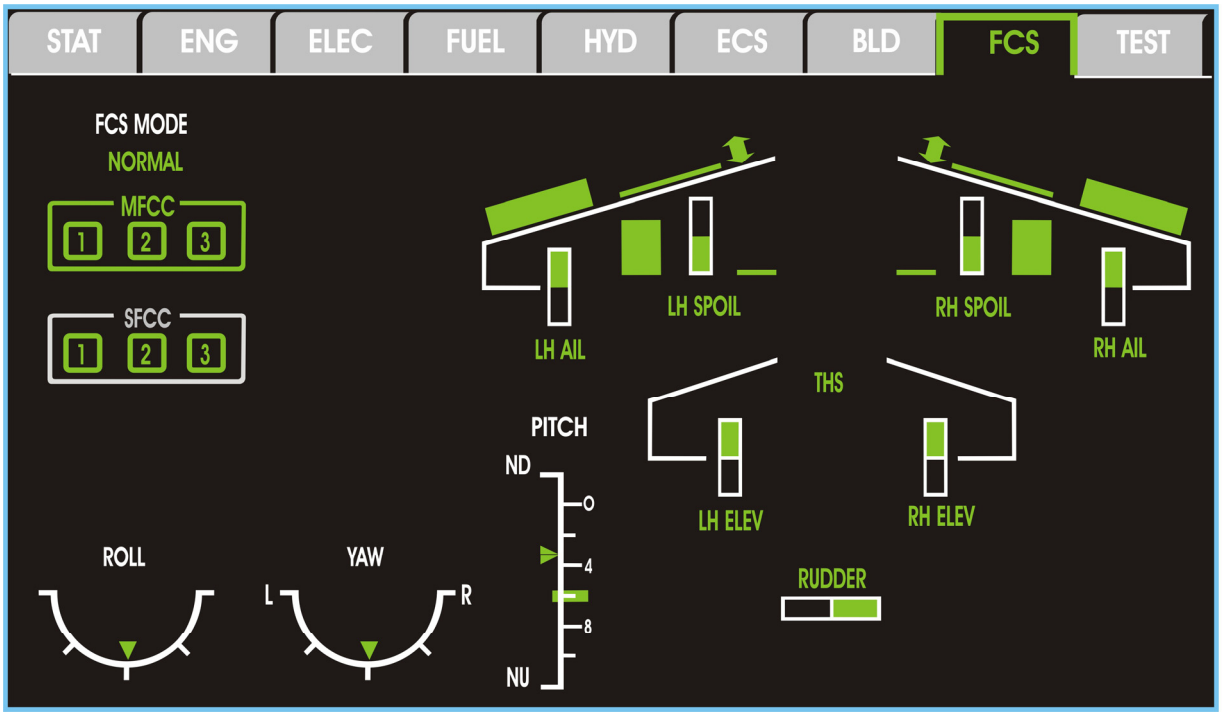


FIGURE 02-27_4-20-01 - FCS SYNOPTIC PAGE

Airbrake panel symbol is displayed at the trailing edge of the wing symbol.

Each airbrake panel shall have a dedicated symbol:

- Airbrake inboard and outboard panel are retracted:
  - o No failure of the panel is detected: 
  - o Panel failure is detected: 
- Airbrake inboard and outboard panel are extended:
  - o No failure of the panel is detected: 
  - o Panel failure is detected: 

In case of the panel switch position is invalid, an amber 'X' is displayed: 

HSI WINDOW

Horizontal stabilizer position is also permanently displayed in the top left-hand corner of the HSI window.

Slat/flap position indicator

FIGURE 02-27_4-20-02 - HSI WINDOW DISPLAY

Slap, flap and airbrake positions are displayed in the top LH corner of the HSI window. Several symbols and labels can be displayed in this dedicated area according to the following rules:

- Slat / flap / airbrake symbols are displayed as long as:
  - There is one slat, one flap or one airbrake panel extended (including untimely or non-commanded surface movement), or
  - There is a secondary flight controls CAS message displayed, or
  - One of the secondary flight controls is in automatic control (AUTO, A/B AUTO RET, A/B DISARM),
  - Or slats backup is active.
- The slat / flap / airbrake symbols are replaced by a white CLEAN label if:
  - The airplane is in the CLEAN configuration,
  - No secondary flight controls CAS message appears, and
  - No secondary flight controls label is in automatic control.

Airplane in CLEAN configuration,

No flight control CAS message,

No secondary flight control is in automatic control.

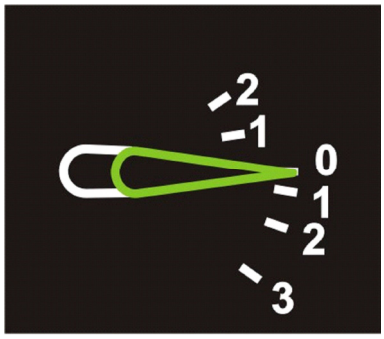
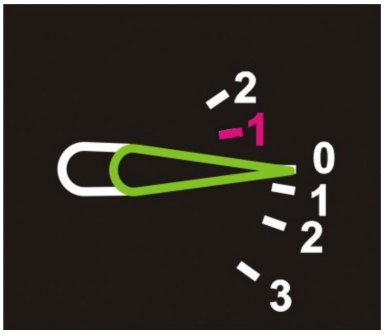
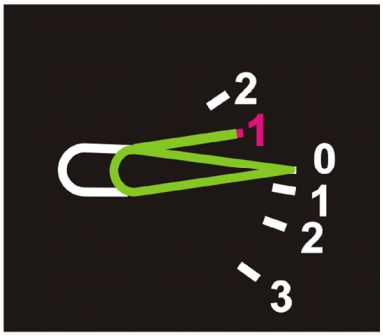
- The CLEAN white label will be removed if:
  - The airplane altitude is above 18,000 ft, and
  - The CLEAN label has been displayed for at least 15 s.

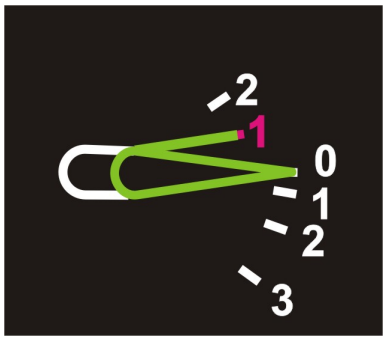
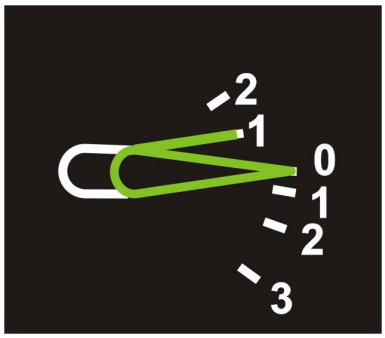
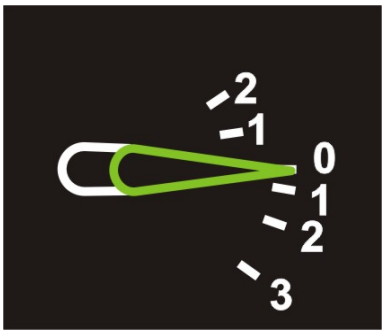
Airplane altitude above 18,000ft and

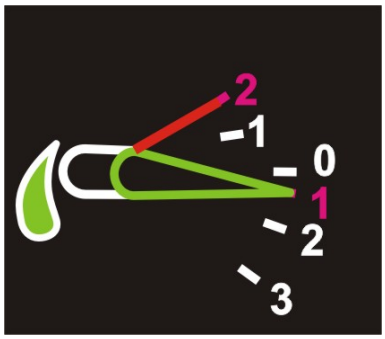
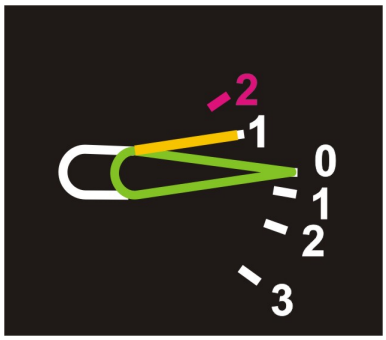
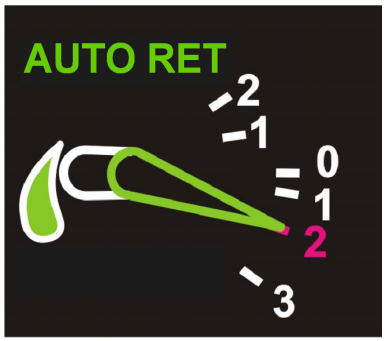
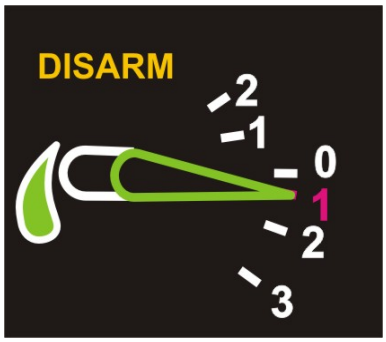
CLEAN label has been displayed for at least 15 s

Flap handle and airbrake handle positions are shown in the indicator as a magenta tick mark (1, 2 or 3 for flaps indication, 1 or 2 for airbrakes indication).

Airbrake symbol description

AIRBRAKES EXTENSION (FROM AB0 TO AB1)		
		
Control handle in notch 0. Airbrakes are retracted and airbrake symbol is not displayed.	Control handle moved to notch 1: selecting the control handle to notch 1 causes tick mark and label 1 to be displayed in magenta.	When airbrakes are deployed, airbrake symbol is displayed in position1. Tick mark and label 1 are displayed in magenta.

AIRBRAKE RETRACTION (FROM AB1 TO AB0)		
		
Control handle in notch 1: airbrakes are deployed, airbrake symbol is displayed in position 1. Tick mark and label 1 are displayed in magenta.	Control handle moved to notch 0: selecting the control handle to position 0 causes tick mark and label 1 to be displayed in white.	When airbrakes are retracted, airbrake symbol is no more displayed.

AIRBRAKES MALFUNCTION AND AUTOMATIC OPERATIONS	
	
No take-off: airbrake symbol is flashing red. The configuration is not allowed for take-off.	Airbrake failure.
	
Automatic retraction (stall protection)	Airbrakes in DISARM mode: no automatic extension.

ADI WINDOW

The airbrake indication is also displayed in airspeed tape as a reminder.

This indication is performed with airbrakes AB1 and AB2 annunciation displayed vertically under the airspeed readout.

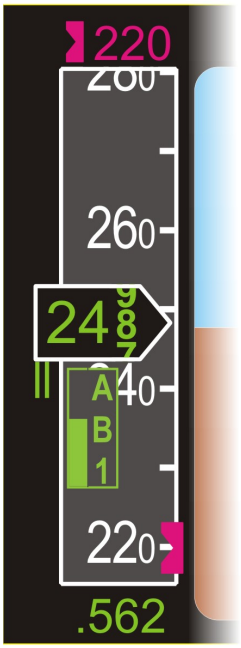
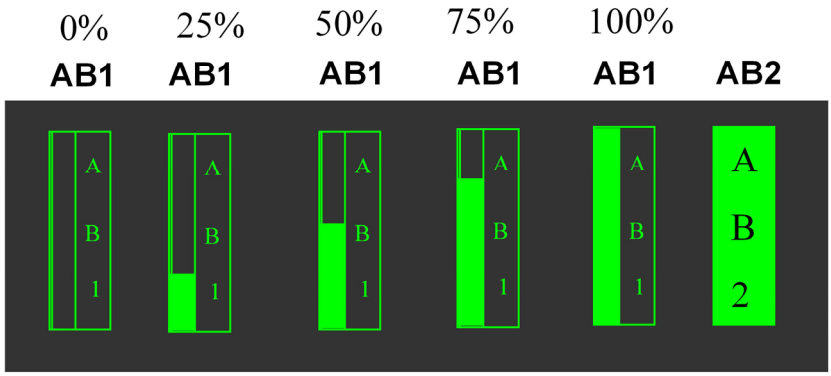


FIGURE 02-27_4-20-03 - AIRSPEED TAPE WITH AIRBRAKES POSITION 1

AB2 annunciation is displayed if one inboard or outboard panel is not retracted,

AB1 annunciation is displayed if one spoiler is not retracted. AB1 annunciation is displayed progressively depending on airbrake lever position from AB 0 to AB 1, as illustrated below:



AB1 and AB2 annunciation color is:

- In red reverse video blinking if the CAS message **NO TAKE OFF** is enabled due to airbrakes,
- In amber reverse video if one of the airbrake caution CAS messages is triggered,
- In green reverse video otherwise.

The amber or green reverse video is blinking if Thrust Director ASP mode (Auto-throttle Speed Protection) or Flight Director PSP mode (Pitch Speed Protection) is active

WHITE CONFIGURATION MESSAGES

The system provides following verification of configuration:

- For Take Off configuration: during taxi, if the Airbrakes are not selected in AB0 configuration, the message **TO CONF: A/B MISCONFIG** is displayed.

No supplementary information to be provided on Controls and Indications at present time.

SYSTEM MONITORING

The airbrake system provides monitoring of the following parameters:

- The airbrake position in compared to the control handle position or automatic order ,
- Validity of orders provided by the SFAU to the ACM.

➢ *Refer to the "Indications" section for a description of indications and to CODDE 2 for a complete list of CAS messages.*

ACTIVE PROTECTIONS

Inboard airbrake panels are automatically retracted when flaps are not retracted in flight.

MECHANICAL PROTECTIONS

Inboard and outboard airbrake panels are fitted with locks in order to avoid untimely extension of airbrakes in case of hydraulic failure.

No supplementary information to be provided on System Protections at present time.

Airbrakes system does not require any ground operation.