AIRCRAFT TYPE COURSE:

AIRBUS A320

CATEGORY B1

FOR TRAINING PURPOSES ONLY

ATA 27 FLIGHT CONTROLS

FOR TRAINING PURPOSES ONLY

GENERAL

FLIGHT CONTROLS SYSTEM COMPONENT LOCATION

SYSTEM OVERVIEW

The control is achieved through the following conventional surfaces.

PITCH

Two elevators and the Trimmable Horizontal Stabilizer (THS) achieve the pitch control. Elevators are used for short-term activity. The THS is used for long-term activity.

ROLL

Roll control is achieved by one aileron and spoilers 2 to 5 on each wing, numbered from wing root to wing tip.

YAW

The rudder does the yaw control. The rudder is used during cross wind take-off and landing, and in case of engine failure (thrust asymmetry). The yaw damper function controls the rudder for Dutch roll damping and turn coordination.

SPEED BRAKES

The speed brake function is used in flight to increase the aircraft drag. Spoilers 2 to 4 are used. Roll orders and speed brake orders are added with priority given to the roll function.

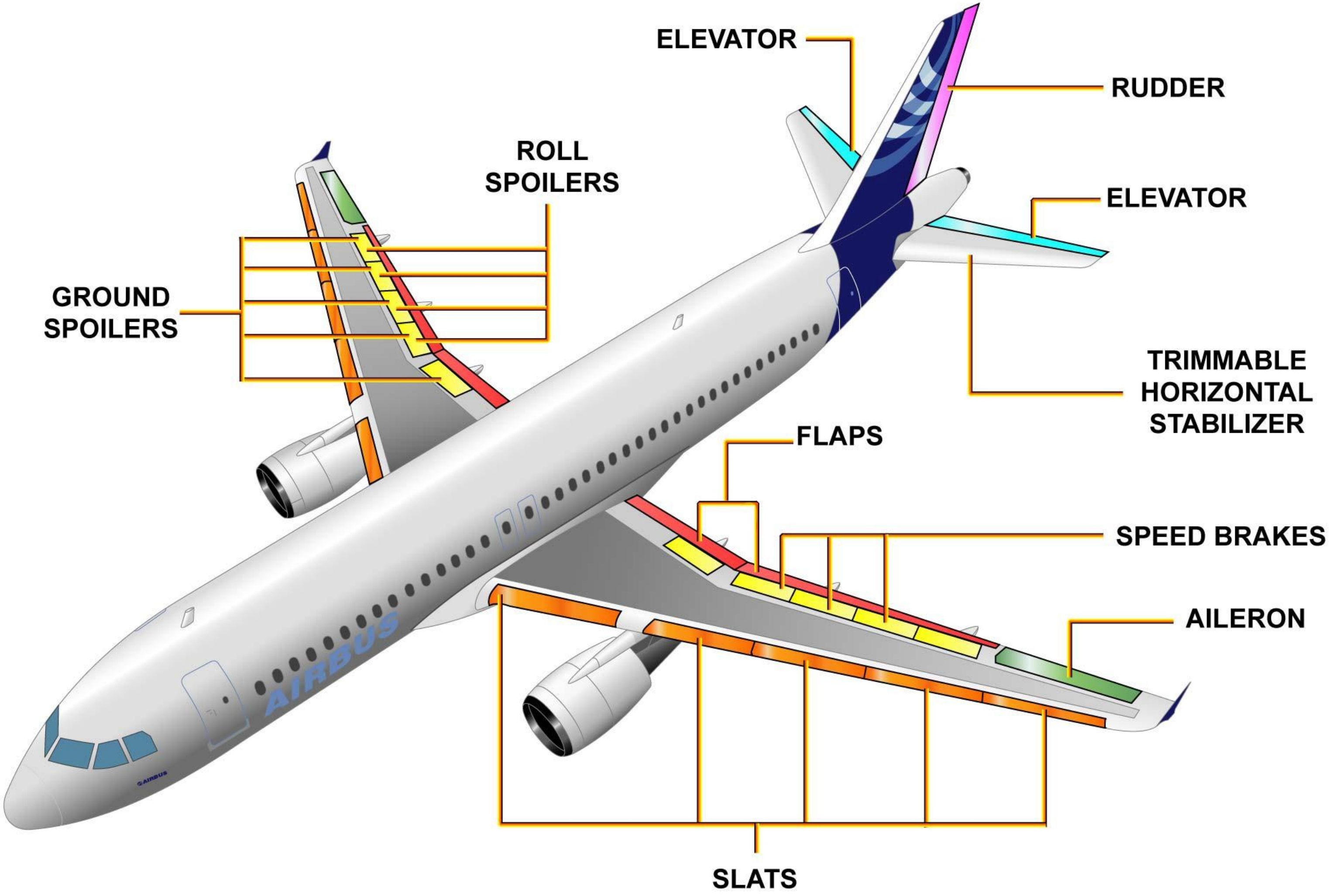
GROUND SPOILERS

The ground spoiler function is used to destroy the lift during landing and in case of aborted take-off. All spoiler panels are used.

AILERON DROOP

The aileron droop function increases the lift on the part of the wing which has no flaps. The ailerons are deflected downwards when the flaps are extended.

SYSTEM OVERVIEW – PITCH - AILERON DROOP



FLIGHT CONTROLS SYSTEM COMPONENT LOCATION

SYSTEM OVERVIEW (continued)

HIGH LIFT

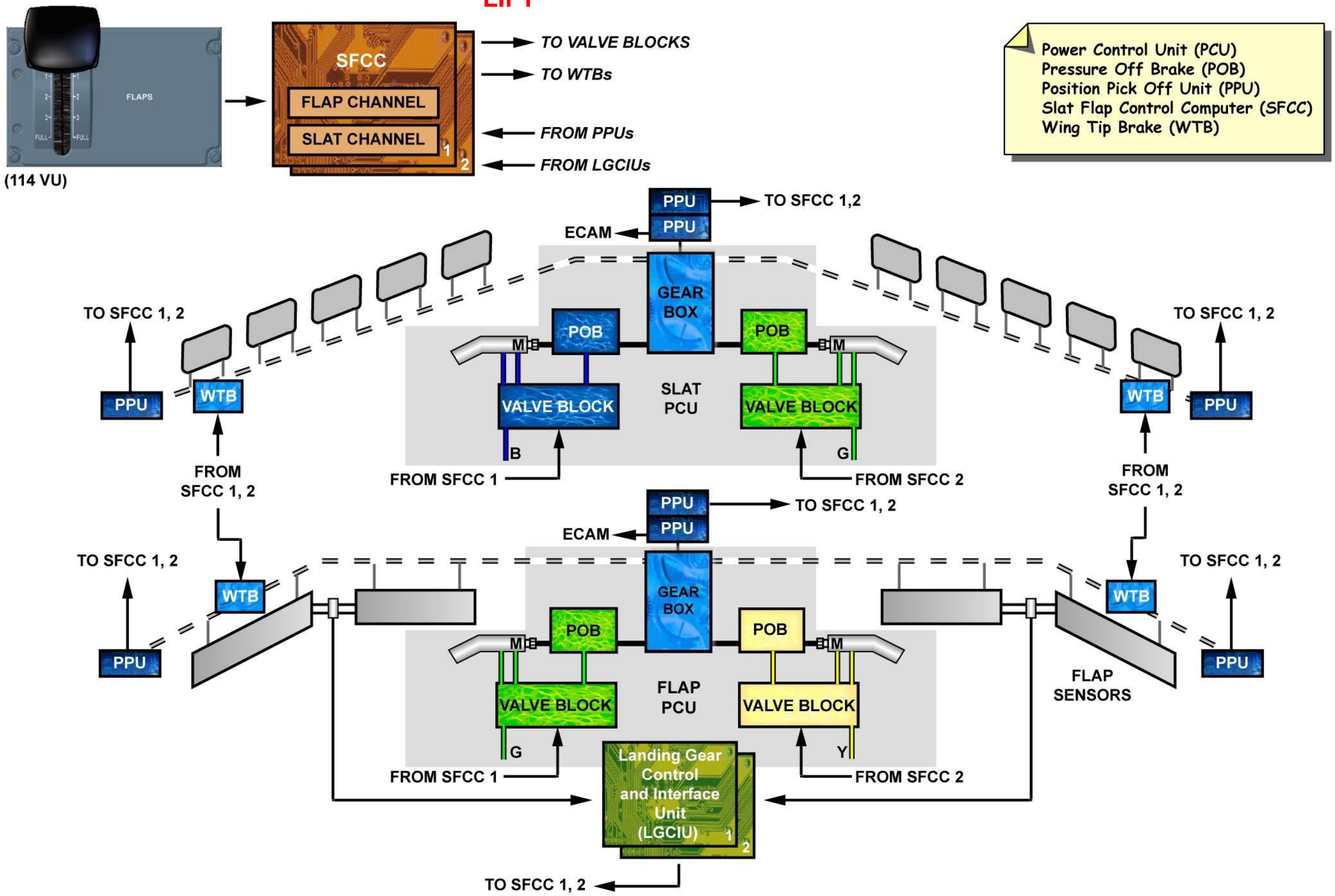
Slats and flaps achieve the high lift function. There are two flaps, inboard and outboard, and five slats on each wing, numbered from wing root to wing tip. The A321 has double slotted flaps.
The slats and flaps are electrically controlled and hydraulically operated. Two Slat Flap Control Computers (SFCCs) do the control and monitoring. Each computer has one slat and one flap channel. The slat and flap systems are similar.
A Power Control Unit (PCU) drives each system with two hydraulic motors coupled to a differential gearbox. Torque shafts and gearboxes transmit the mechanical power to the actuators, which drive the surfaces.

Each motor is powered by a different hydraulic system and has its own valve block and Pressure Off Brake (POB). Valve blocks control the direction of rotation and the speed of their related PCU output shaft. The POB locks the transmission when the slat and flap surfaces have reached the selected position or if hydraulic power fails.
Wing Tip Brakes (WTBs) are given in order to stop and lock the system when major failures are detected. They are hydraulically activated and can only be reset on ground.
Position Pick-Off Units (PPUs) send slat and flap position feedback to the SFCCs and ECAM.

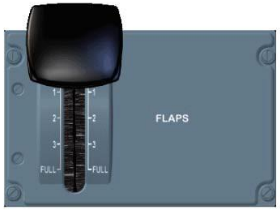
Flap sensors installed between inboard and outboard flaps inhibit further flap operation when a flap attachment failure is detected. The signal is sent to the SFCCs via the Landing Gear Control and Interface Units (LGCIU). To prevent an aircraft stall, slats cannot be fully retracted at high angles of attack or low speeds (Alpha/speed lock function).

The FLAPS lever has five positions: 0, 1, 2, 3 and FULL. Two configurations correspond to position 1: Configuration 1 and Configuration 1+F. These are selected as shown on the graphic. The flaps lever selects simultaneous operation of the slats and flaps. The five lever positions correspond to the surface positions as shown on the graphic.

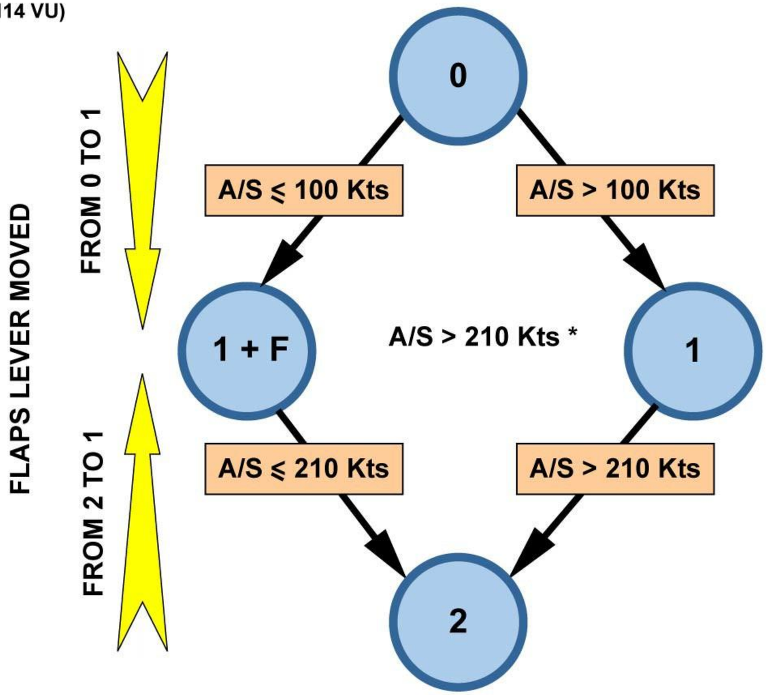
SYSTEM OVERVIEW - HIGH LIFT



SYSTEM OVERVIEW - HIGH LIFT



(114 VU)



* When config. 1 + F is selected flaps retract to 0° automatically at 210 knots (before the airspeed reaches VFE).

This chart is applicable for SA aircraft equipped with CFM engines:

POSITION	SLATS	FLAPS	INDICATION ON ECAM
0	0	0	
1	18	0	0
		10	1 + F
2	22	15	2
3	22	20	3
FULL	27	35	FULL

For SA aircraft equipped with IAE or PW engines, the FLAP position FULL is 40°.

FLIGHT CONTROLS SYSTEM COMPONENT LOCATION

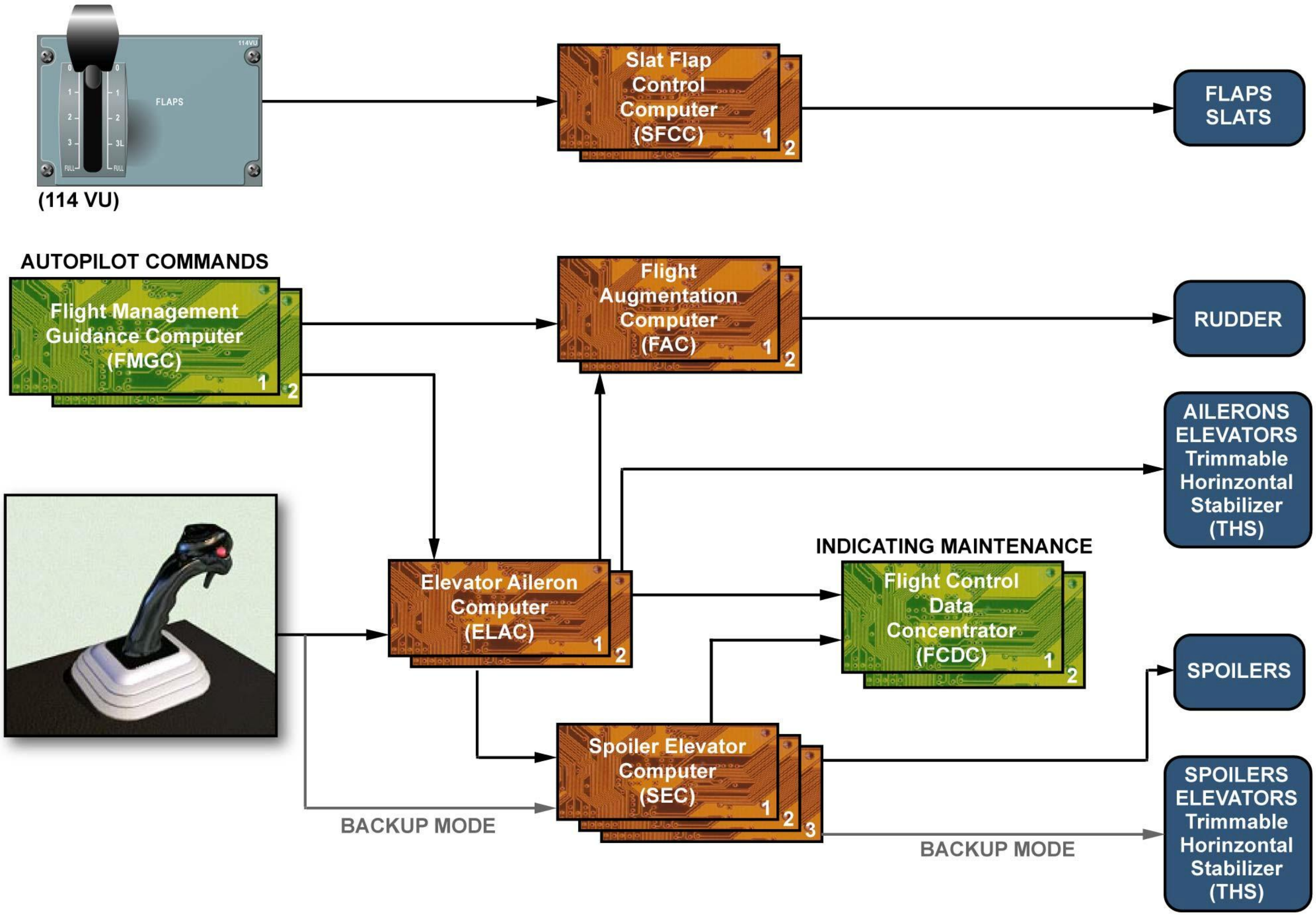
SYSTEM OVERVIEW (continued)

COMPUTERS

A computer arrangement permanently controls and monitors the flight control surfaces, it also records and stores faults.
This arrangement includes:

- 2 Elevator Aileron Computers (ELAC) for pitch and roll control,
- 3 Spoiler Elevator Computers (SEC) for pitch and roll control,
- 2 Flight Augmentation Computers (FAC) for yaw control,
- 2 Flight Control Data Concentrators (FCDC) for indication and maintenance tests,
- 2 Flight Management Guidance Computer (FMGC) for autopilot commands,
- 2 Slat Flap Control Computers (SFCC) for slat and flap control.

SYSTEM OVERVIEW - COMPUTERS



FOR TRAINING PURPOSES ONLY

FLIGHT CONTROLS SYSTEM COMPONENT LOCATION

SYSTEM OVERVIEW (continued)

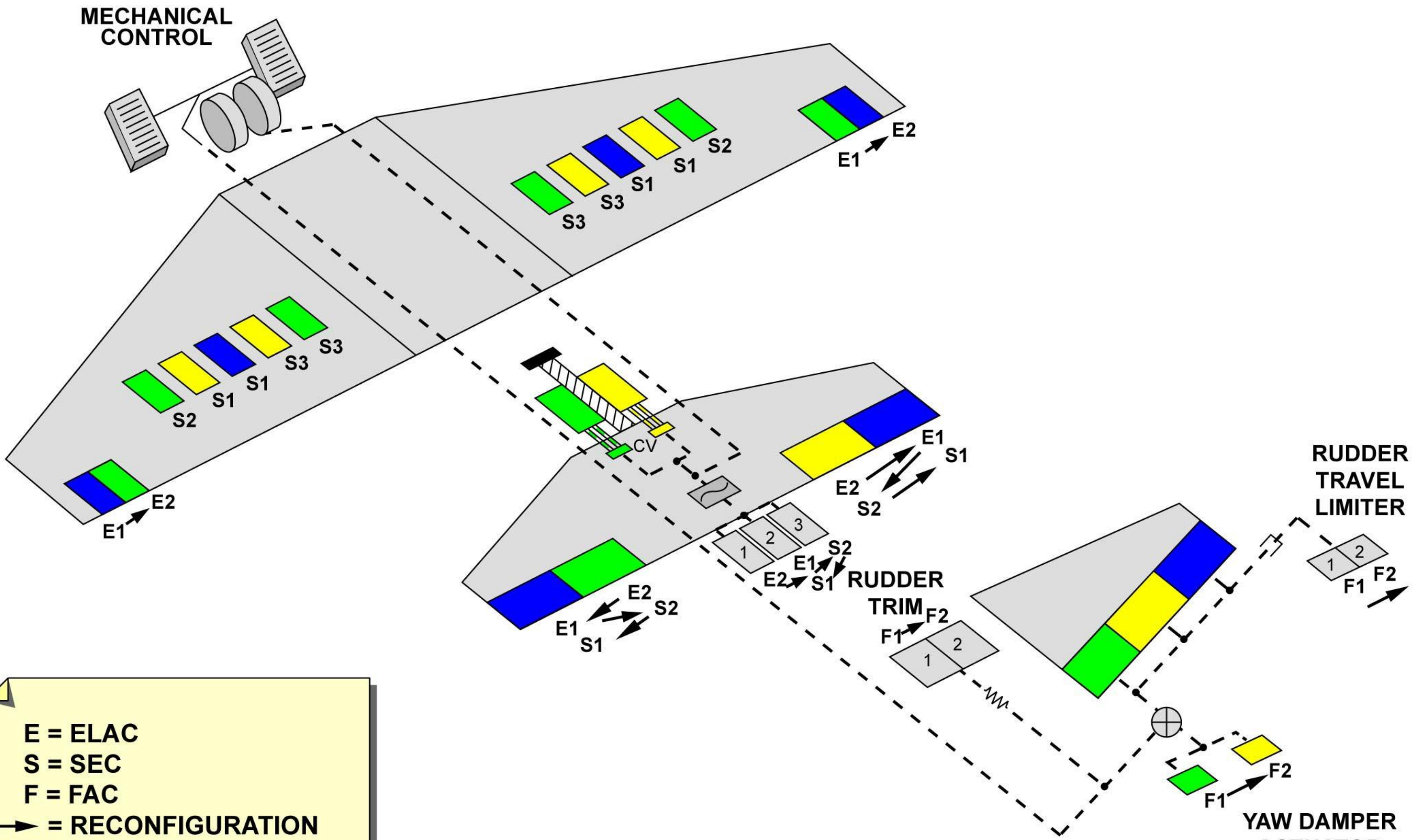
ACTIVE SERVO CONTROLS

There are two servo controls for each aileron, for each elevator and for the yaw damping function. In normal configuration, one servo control actuates the surface. It is called active servo control. The second, which follows the surface deflection, is in damping mode. When only manual pitch trim is available, the centering mode is applied to the elevators. The actuators are hydraulically maintained in neutral position.

RECONFIGURATION PRIORITIES

In normal configuration, the following computers do the servoloop control. The arrows indicate the actuation reconfiguration priorities in case of computer failure or loss of hydraulic circuits.

SYSTEM OVERVIEW - ACTIVE SERVO CONTROLS & RECONFIGURATION PRIORITIES



E = ELAC
S = SEC
F = FAC
→ = RECONFIGURATION PRIORITIES

FOR TRAINING PURPOSES ONLY

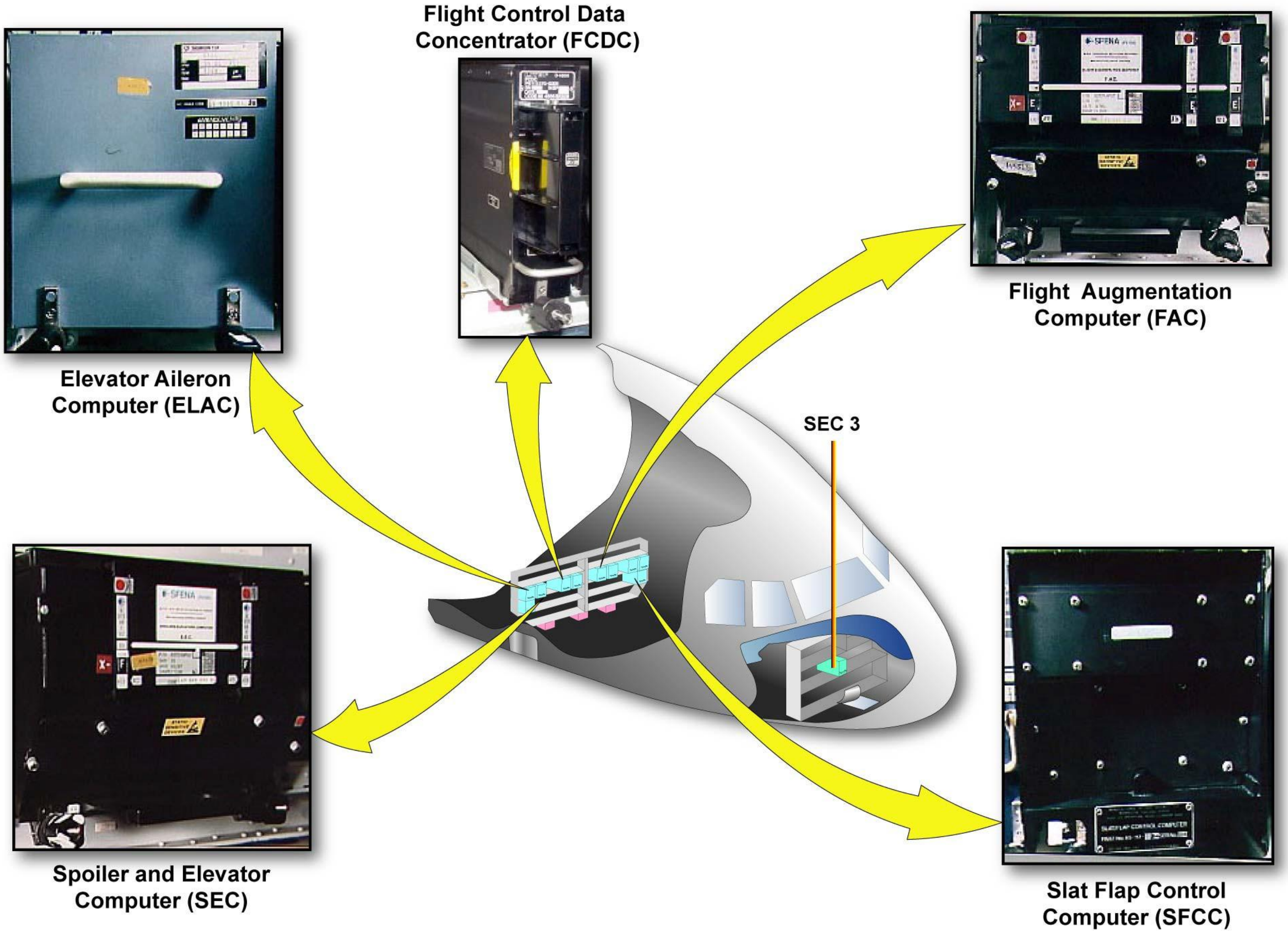
FLIGHT CONTROLS SYSTEM COMPONENT LOCATION

COMPONENT LOCATION

COMPUTERS

All the flight control computers are located in the avionics compartment.

COMPONENT LOCATION - COMPUTERS



SIDE STICK DESCRIPTION/OPERATION

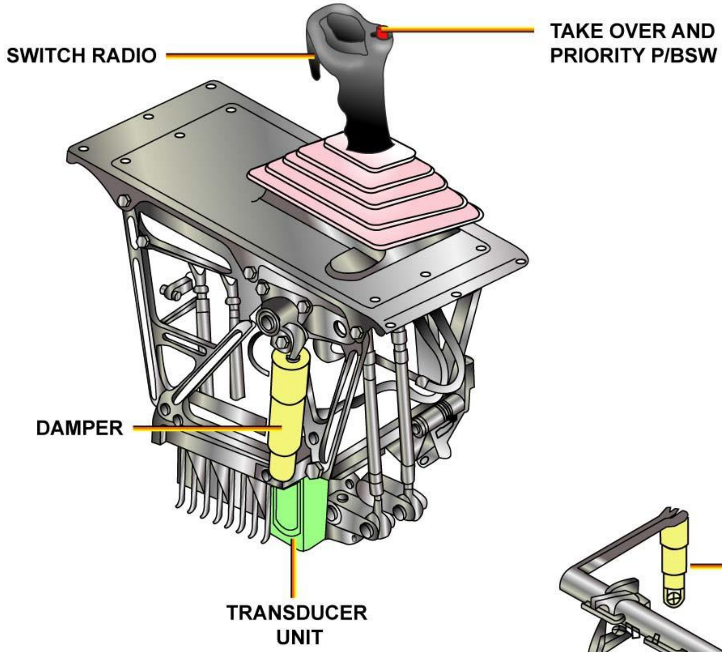
GENERAL

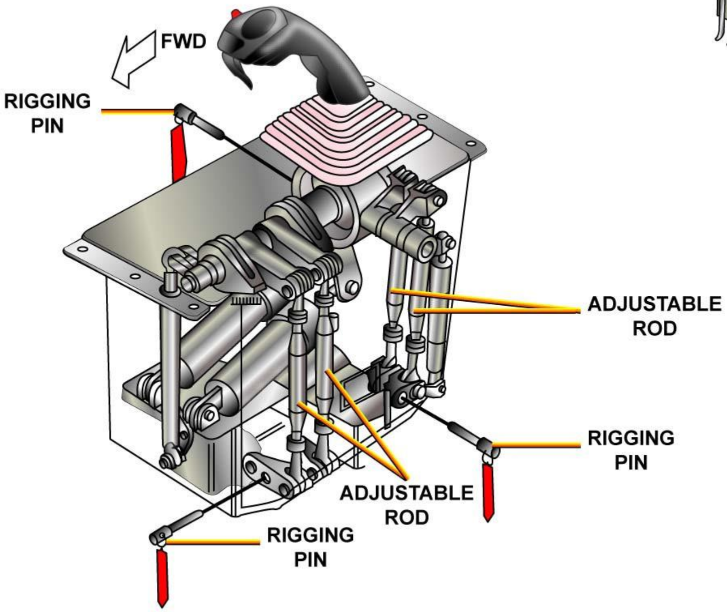
The main function of the side sticks is to transmit to the Electrical Flight Control System (EFCS) the lateral and longitudinal manual control orders in the form of electrical signals, depending on the position of the hand grip. It also generate the related artificial feel loads using spring rods, springs and dampers.
In autopilot mode, a solenoid is energized in order to keep the side sticks in the neutral position. By doing this, the solenoid provides a higher load level in order to prevent any unwanted switching to the manual control mode, while keeping the possibility to override the autopilot if required. A thermoformed polycarbonate casing houses the mechanical assembly to prevent the penetration of foreign matter, which could jam the moving parts.

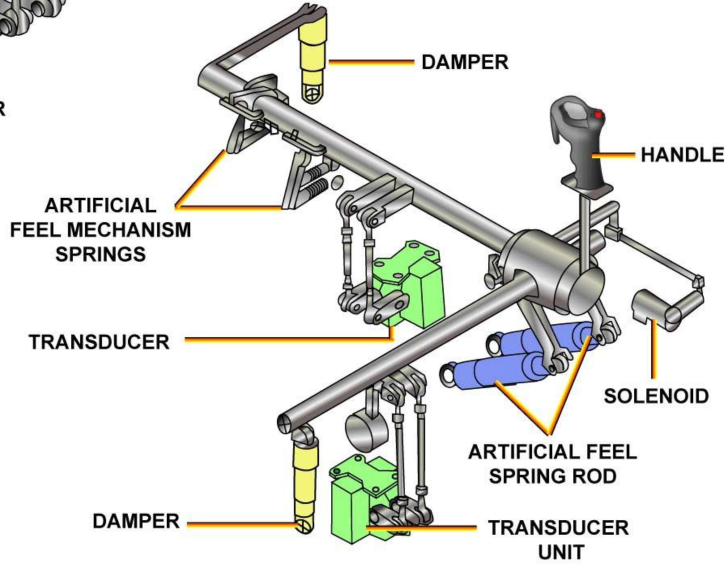
Two identical transducer units are associated to each computer, one for roll control, another one for pitch control. A transducer unit comprises sets of potentiometers driven by a duplicate mechanism and connected to the EFCS computers via connectors. Ring pins can be installed for adjustment.

WARNING: During handling, make sure that the side stick assembly stays in vertical position. There is a risk of skydrol leakage from dampers.

GENERAL


SWITCH RADIO
TAKE OVER AND PRIORITY P/BSW
DAMPER
TRANSDUCER UNIT


FWD
RIGGING PIN
ADJUSTABLE ROD
RIGGING PIN
ADJUSTABLE ROD
RIGGING PIN


DAMPER
HANDLE
ARTIFICIAL FEEL MECHANISM SPRINGS
TRANSDUCER
SOLENOID
ARTIFICIAL FEEL SPRING ROD
DAMPER
TRANSDUCER UNIT

SIDE STICK DESCRIPTION/OPERATION

SIDE STICK AND PRIORITY LOGIC

Side sticks, one on each lateral console, are used for manual pitch and roll control. They are springloaded to neutral. When the autopilot is engaged, a solenoid-operated detent locks both side sticks in the neutral position. If the pilot applies a force above a given threshold (5daN in pitch, 3.5 daN in roll), the autopilot disengages and the side stick unlocks and sends an input to the computers. The hand grip includes 2 P/Bs: An autopilot disconnect/side stick priority P/B and a push-to-talk button.
Side stick priority logic: When only one pilot operates the side stick, his demand is sent to the computers. When the other pilot operates his side stick, in the same or opposite direction, both pilot inputs are algebraically added. The addition is limited to single-stick maximum deflection.

NOTE: In the event of simultaneous inputs on both side sticks (2° deflection off the neutral position in any direction), the two green SIDE STICK PRIORITY lights, on the glareshield, come on and the "DUAL INPUT" voice message activates.

A pilot can deactivate the other side stick, and take full control by pressing and keeping pressed his takeover P/B. For latching the priority condition, it is recommended that the takeover P/B be pressed for more than 40 seconds. The takeover pushbutton can then be released without losing priority. However, a deactivated side stick can be reactivated at any time, by momentarily pressing either takeover P/B. If both pilots press their takeover P/Bs, the last pilot to press their P/B will have priority.

NOTE: If an autopilot is engaged, any action on a takeover P/B will disengage it.

In a priority situation, a red light will come on, in front of the pilot whose side stick is deactivated. A green light will come on, in front of the pilot who has taken control, if the other side stick is not in the neutral position (to indicate a potential and unwanted control demand).

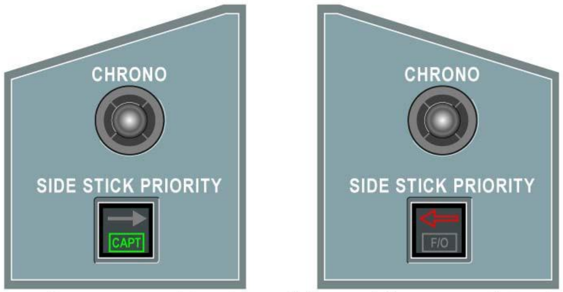
NOTE: If one stick is deactivated on ground, at takeoff thrust application, the takeoff «CONFIG» warning is triggered.

SIDE STICK AND PRIORITY LOGIC

Normal operation: Only one side stick is deflected.

\+ "DUAL INPUT" Aural message

The Captain and First Officer inputs are algebraically summed. The maximum resulting input is limited to a full deflection input of a single side stick.



\+ "PRIORITY LEFT" Aural message

The Captain presses his side stick pushbutton, while the First Officer moves his side stick. The Captain gains the priority.

FLIGHT CONTROL LAWS

PRINCIPLE

A side stick or an autopilot sends an electrical signal to the flight control computers for an aircraft maneuver. The flight control computers process the demand and send it to the control surfaces. The processing uses pre-set limitations and instructions called LAWS. In normal law, regardless of the pilots' input, the computers will prevent excessive maneuvers and make sure the safe envelope is not exceeded in pitch and roll axes. The rudder control is designed as on a conventional aircraft.

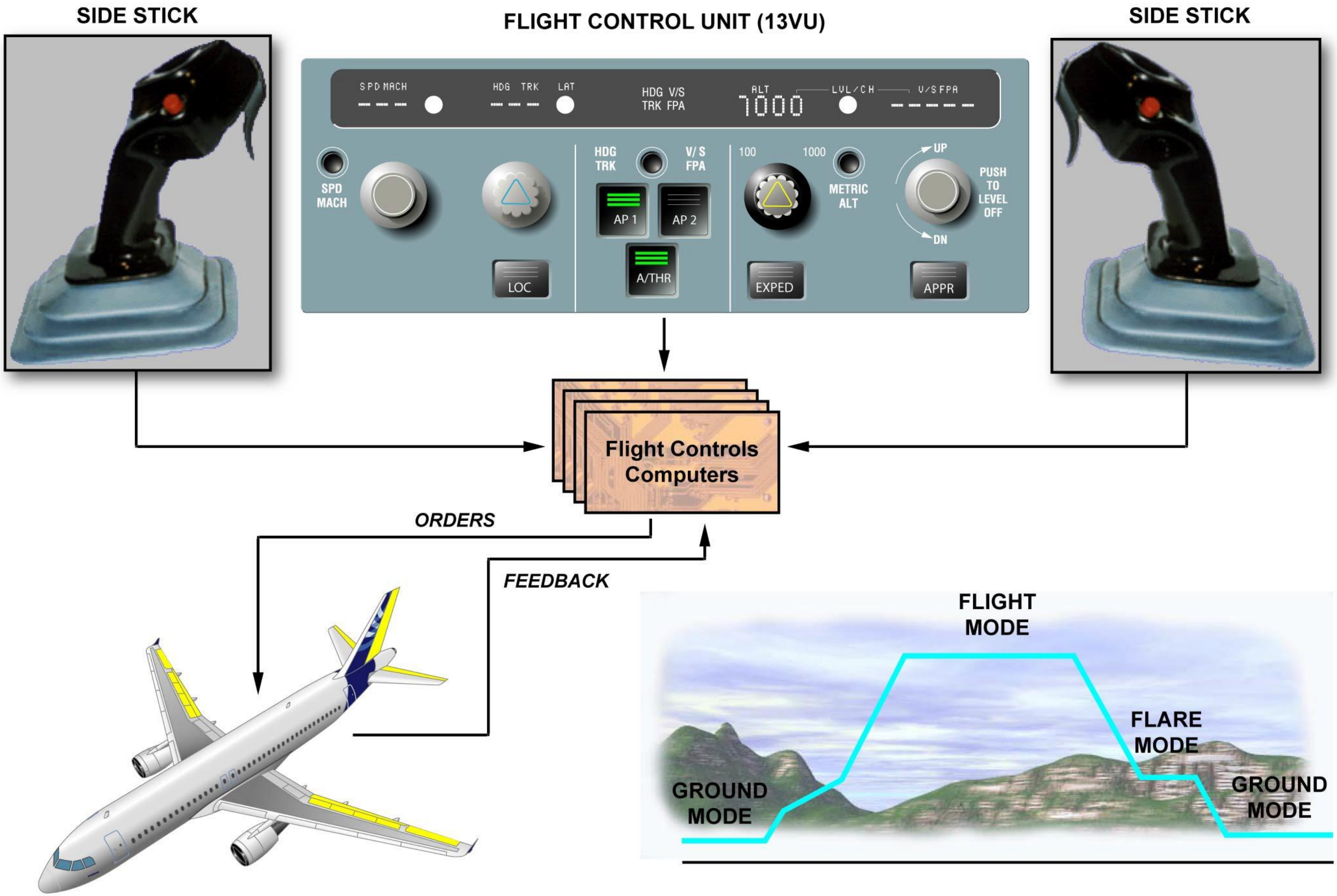
Normal law is modified depending on the phase of flight. It operates in 3 modes:

• Ground mode: operates on the ground when the aircraft is electrically and hydraulically powered. There is a direct relationship between the side stick and the control surfaces.
• Flight mode: operates in the air after a gradual transition from ground mode just after lift-off,
• Flare mode: modifies the flight mode to give a conventional "feel" to the landing phase.

In normal LAW, when the aircraft is in flight mode, the control surface deflection is not directly proportional to the side stick deflection. A side stick deflection gives a rate demand to the flight control computers, which set control surface deflection to meet the rate demand.

For the same side stick input, the control surface deflections will be large at low speed and small at high speed.
A side stick input is a rate of roll demand in roll and a load factor (g) demand in pitch. Yaw control is conventional.
The response information is fed back to the flight control computers. The computers process this feedback and adjust the control surface deflection to ensure that the maneuver rate demand is achieved accurately. This means that control surface deflections may be altered with no change in side stick position.
When in flight mode, if you wish to perform a descending left turn for example, you must set the required attitude and then return the side stick to neutral. The neutral side stick position requires zero rates of pitch and roll. The flight control computers will maintain the set attitude until you use the side stick to ask for an attitude change. During the entire maneuver, there is no need for pilot trim inputs.

PRINCIPLE


SIDE STICK
FLIGHT CONTROL UNIT (13VU)
SIDE STICK
SPD MACH
HDG TRK
LAT
HDG V/S
TRK FPA
ALT
LVL/CH
V/S FPA
7000
SPD
MACH
HDG
TRK
V/S
FPA
100
1000
METRIC
ALT
UP
PUSH
TO
LEVEL
OFF
DN
AP 1
AP 2
A/THR
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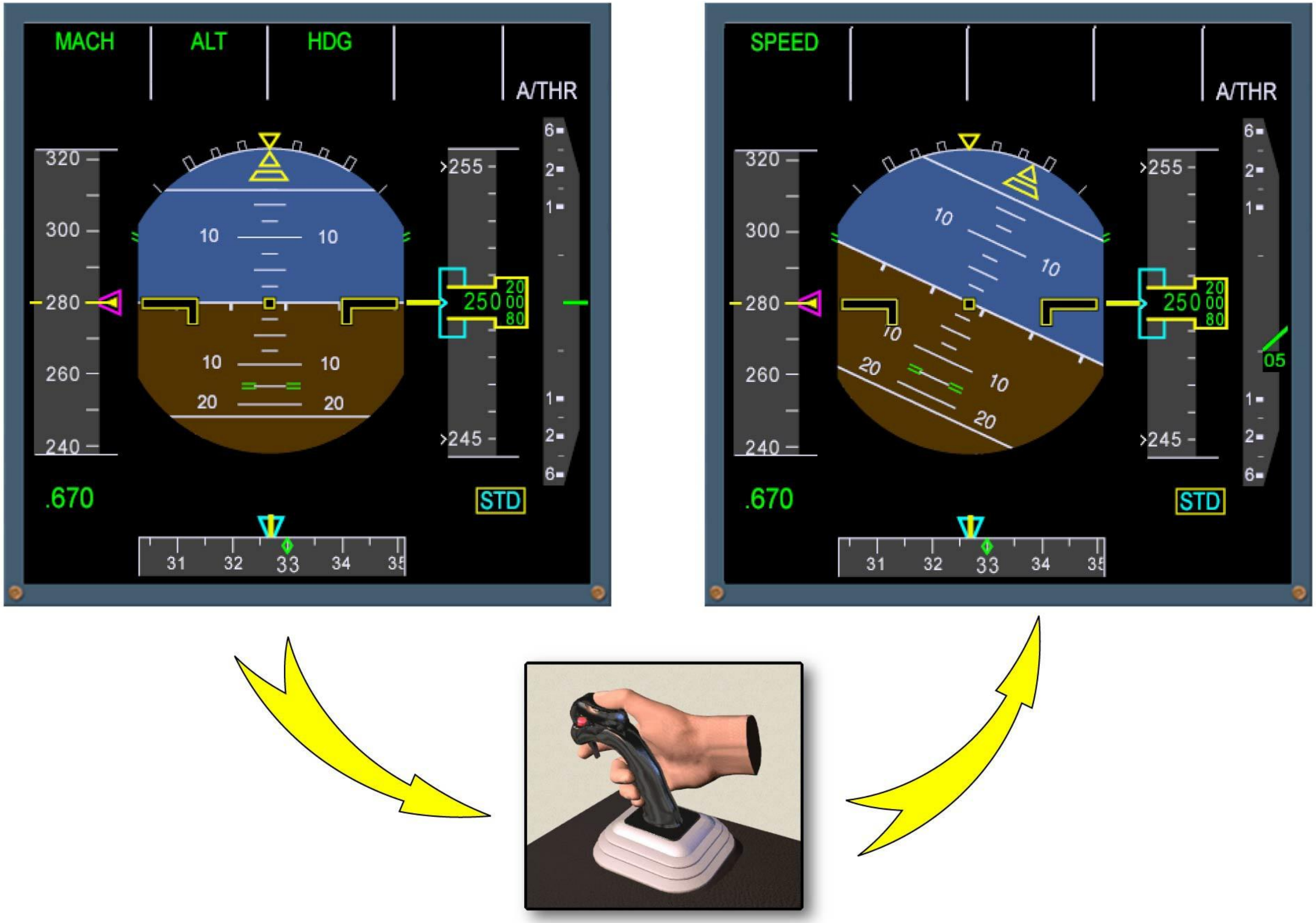
MODE
GROUND
MODE

PRINCIPLE



FLIGHT CONTROL LAWS

NORMAL LAW

Normal law provides a number of airborne pitch protections.
They are:
- Load factor limitation,
- Pitch attitude protection,
- High angle of attack protection,
- High speed protection.

In lateral control, there is only one protection, which is for bank angle.

NOTE: Turn co-ordination and "Dutch roll" damping are automatically provided in normal law.
Pilot inputs on the rudder pedals are not required.

LOAD FACTOR LIMITATION

Load factor limitation prevents structural overstress by a limitation of the control surface deflections through the flight control computers. Full side stick movement is always available.
The load factor is automatically limited to:
- (+) 2.5 g to (-) 1 g in clean configuration,
- (+) 2 g to 0 g in other configurations.

NORMAL LAW - LOAD FACTOR LIMITATION

FLIGHT CONTROL LAWS

NORMAL LAW (continued)

PITCH ATTITUDE PROTECTION

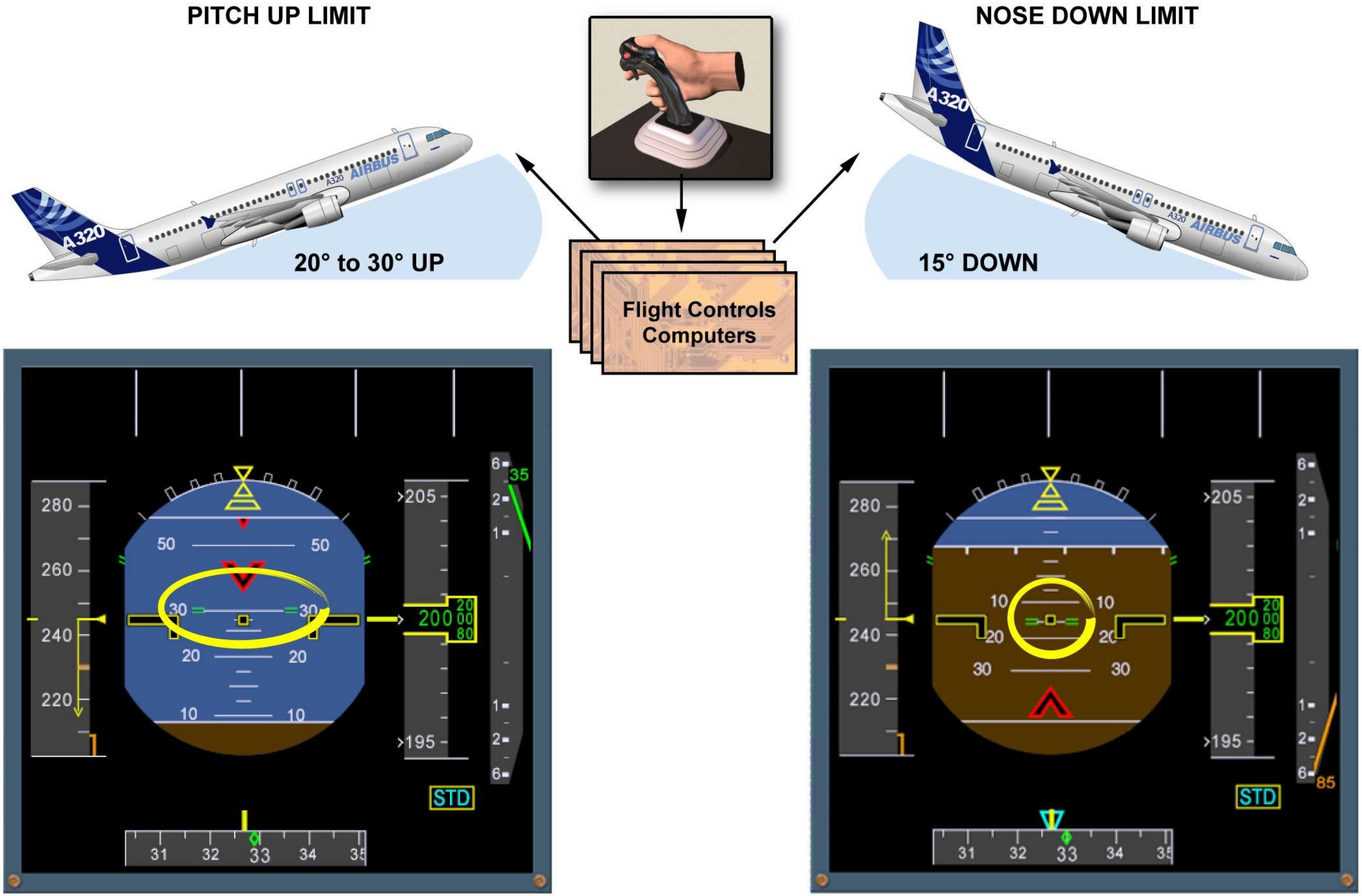
If the aircraft reaches the pitch attitude protection nose up limits, then the flight control computers will override pilot demands and keep the aircraft within the safe flight limits.

The pitch attitude protection limits are shown as small green dashes on the Primary Flight Display (PFD).

The pitch up values are different depending on the aircraft configuration and speed between 30 and 20 degrees up.

The nose down limit is 15 degrees.

NORMAL LAW - PITCH ATTITUDE PROTECTION



FLIGHT CONTROL LAWS

NORMAL LAW (continued)

HIGH ANGLE OF ATTACK PROTECTION

The high Angle Of Attack (AOA) protection is designed to prevent a stalling of the aircraft and to ensure optimum performance in extreme maneuvers, for example windshear or Enhanced Ground Proximity Warning System (EGPWS) warning recovery.
This protection takes priority on all others. This protection displays information on the side of the PFD speed scale.
Under normal law, when the angle of attack becomes more than PROT, the system changes from normal mode to protection mode:
The side sticks controls directly an angle of attack.

NOTE: V PROT and V MAX may be different because they are G-load sensitive.

When the speed decreases, V PROT reaches VLS, which is the lowest speed that can be selected with the autothrust engaged.
A low energy warning, repeated every 5 seconds, indicates to the pilot that the aircraft energy becomes lower than a threshold. Under this threshold, the thrust must be increased to recover a positive flight path angle through pitch control.

The low energy warning is available in the following conditions:
- Above 100 ft RA and
- Below 2,000 ft RA and
- In conf 2, 3, FULL and
- Not in TOGA, ...

NORMAL LAW (continued)

HIGH ANGLE OF ATTACK PROTECTION (continued)

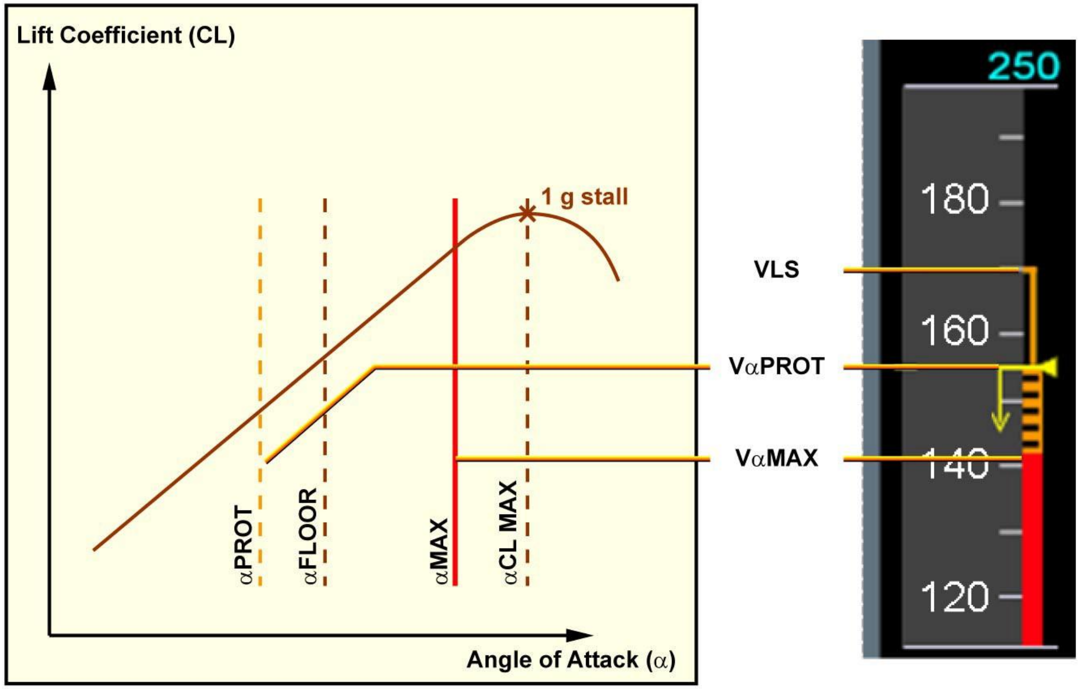
With autothrust inoperative or not engaged, the speed can reduce to the first level of AOA protection, V PROT, which is shown at the top of the amber / black band (barber pole).
If engaged, the autopilot will disconnect. Nose up pitch trim is inhibited below V PROT.

The flight control computers will maintain V PROT if the side stick is released.
The floor protection is usually available from lift-off down to 100 ft RA.

A/THR is automatically activated and commands TOGA thrust when the aircraft angle of attack is above a pre-determined threshold.
This is indicated by an "A FLOOR" indication on the Flight Mode Annunciator (FMA) and also on the Engine Warning Display (EWD).
If the pilots override V PROT with the side stick, the speed can reduce to V MAX.

In normal law, the flight control computers will maintain V MAX, even if a pilot holds a side stick fully aft.
In this protection range, the normal law demand is modified and side stick input is an AOA demand, instead of a load factor demand.
If the pilot releases the side stick at V MAX, the speed will return to V PROT and will be maintained.

NORMAL LAW - HIGH ANGLE OF ATTACK PROTECTION

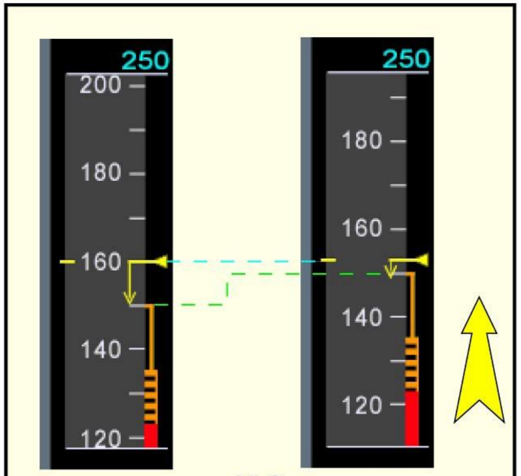


VLS : Lowest speed that can be selected

VαPROT: speed related to αPROT

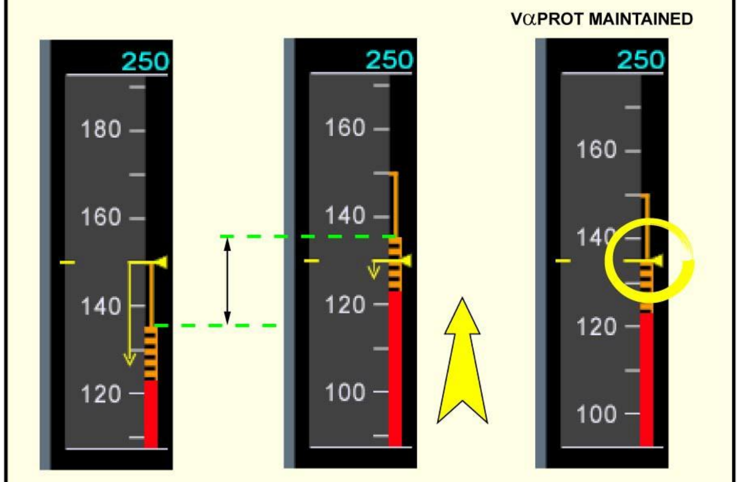
VαMAX: speed related to αMAX

NORMAL LAW - HIGH ANGLE OF ATTACK PROTECTION

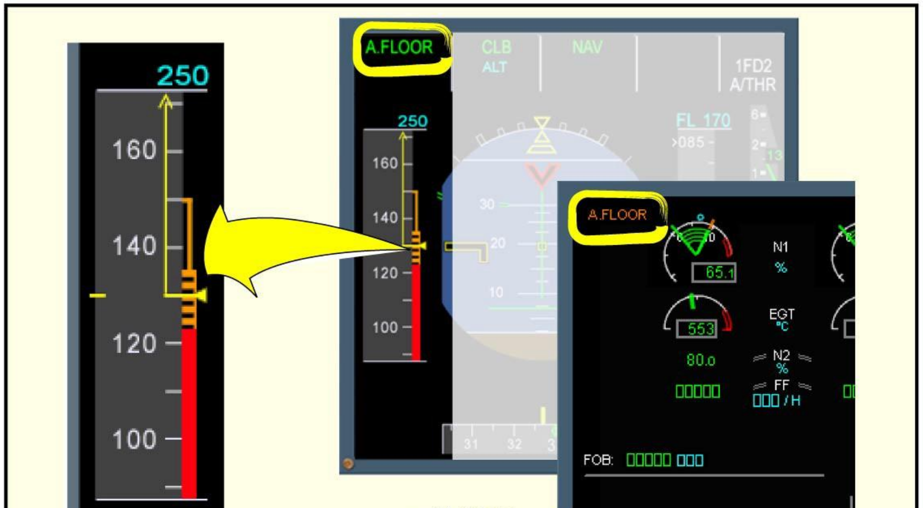


VLS

PFD



VαPROT



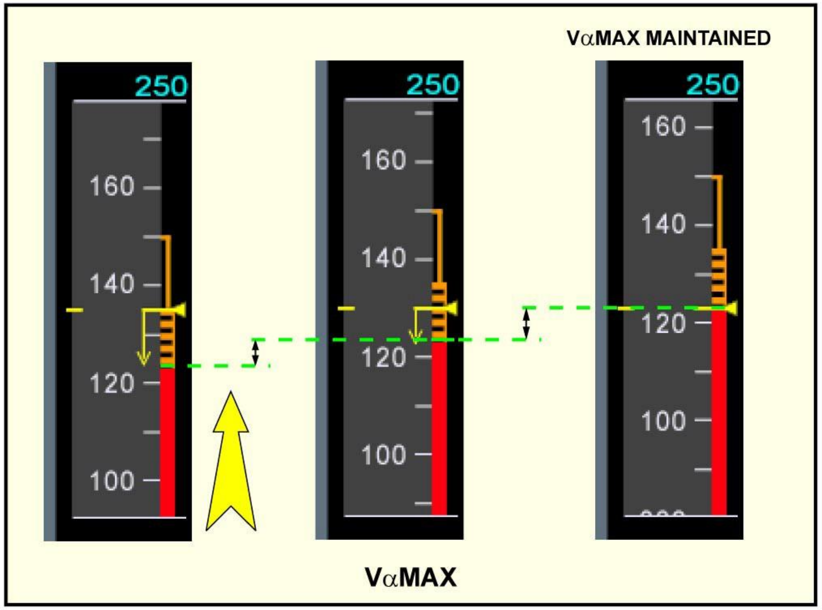
α FLOOR

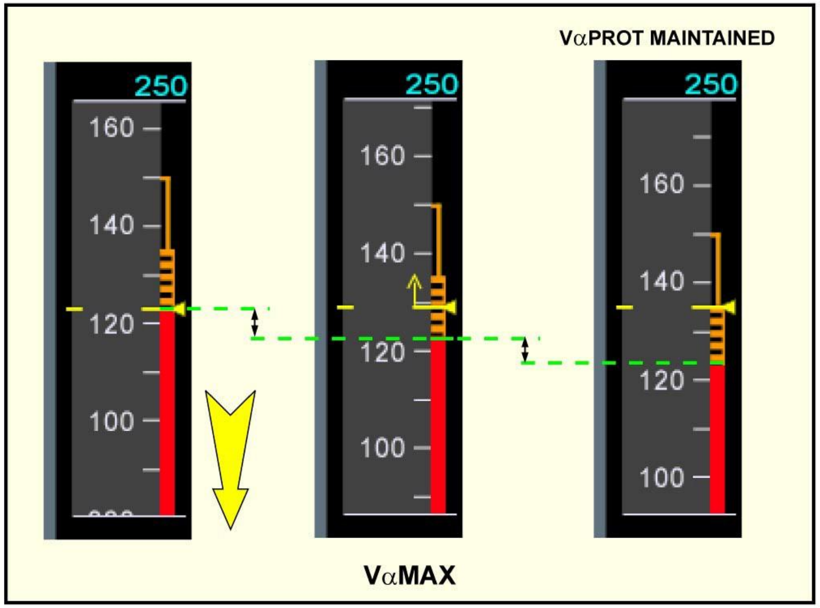
EWD

NORMAL LAW - HIGH ANGLE OF ATTACK PROTECTION

ACTIVATED

RELEASED





FOR TRAINING PURPOSES ONLY

FLIGHT CONTROL LAWS

NORMAL LAW (continued)

HIGH SPEED PROTECTION

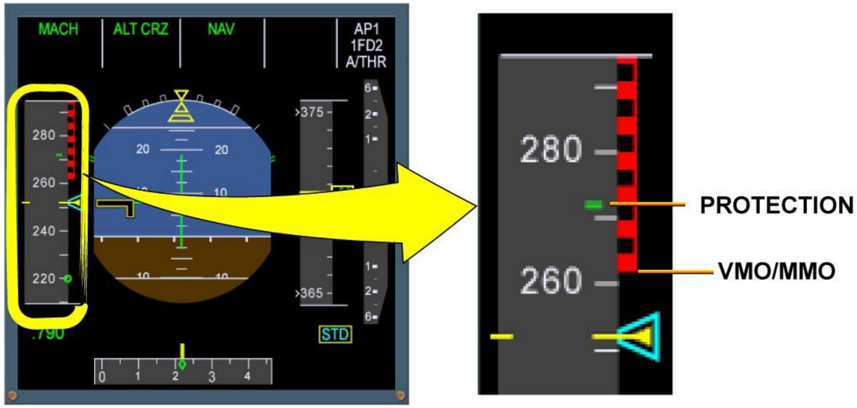
The high speed protection is designed to prevent the aircraft from exceeding maximum speed.
These protection limits are displayed on the PFD speed scale. VMO/MMO is shown at the bottom of the red/black barber pole. Green dashes indicate the speed at which the protection is activated. When the airspeed/Mach increases above VMO/MMO, an overspeed ECAM warning is triggered (refer to Autoflight chapter).

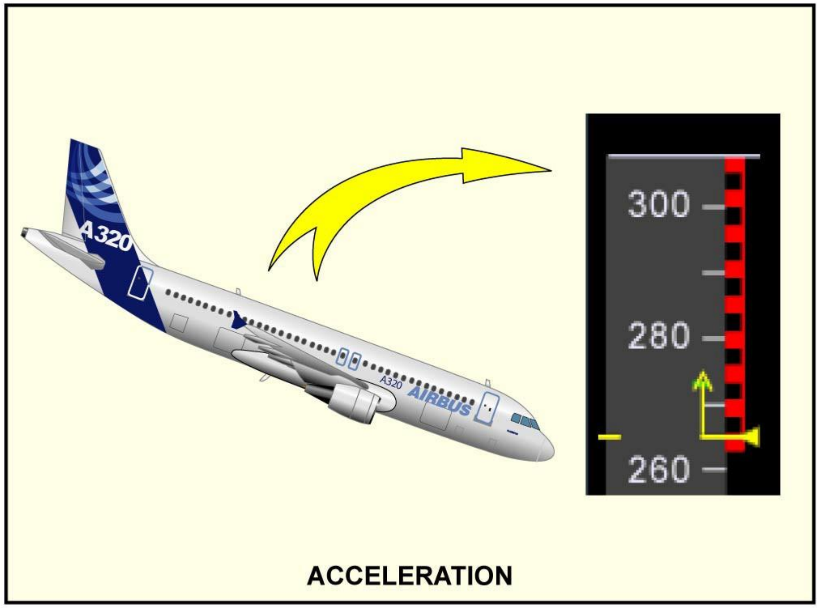
If the airspeed/Mach increases to the protection activation speed:

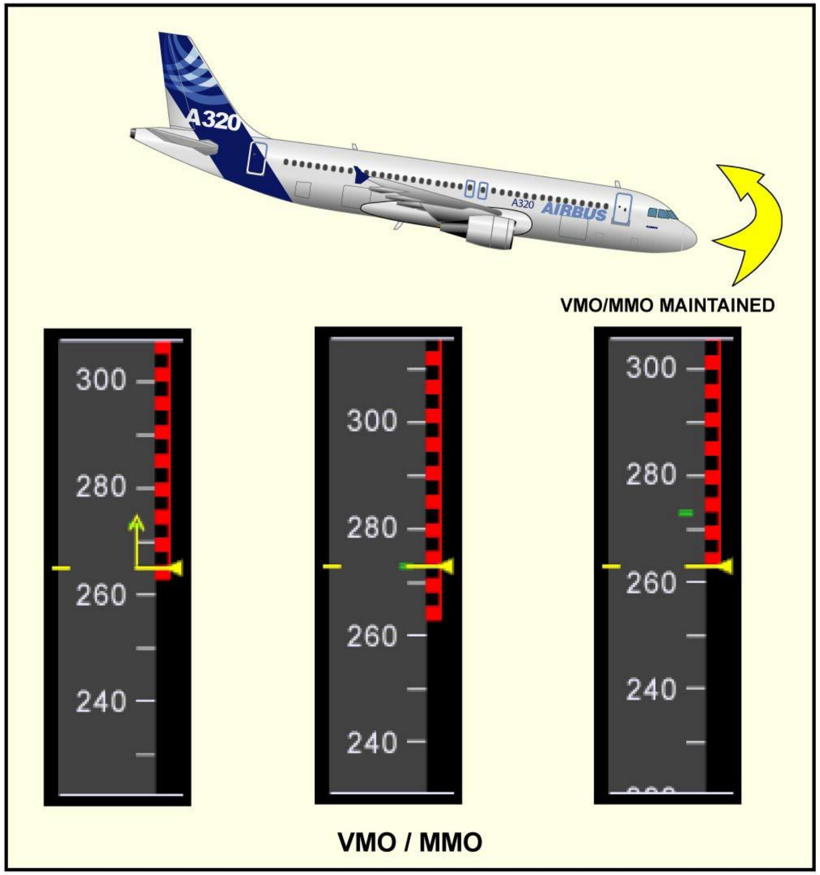
- the autopilot disengages and,
- the flight control computers send a pitch up command to the control surfaces to prevent more acceleration.

The side stick authority is reduced, but the flight control computers will permit this speed to be exceeded momentarily for maneuvering if necessary.
With stick released, the speed will return to VMO/MMO.

NORMAL LAW - HIGH SPEED PROTECTION







FLIGHT CONTROL LAWS

NORMAL LAW (continued)

BANK ANGLE PROTECTION

Under normal law, bank angle protection limits the angle of bank to 67 degrees, shown by green dashes on the PFD.
If the pilot holds full lateral side stick, the angle of bank will increase and maintain 67 degrees.
The Flight Director (FD) on the PFD will disappear if the angle of bank exceeds 45 degrees.
If the side stick is released at any time when the bank angle exceeds 33 degrees, the aircraft will return to and maintain a 33 degrees bank angle.
The FD will be displayed again on the PFD when the angle of bank reduces to less than 40 degrees.
The autotrim is inhibited above 33 degrees.

With the angle of attack protections active:

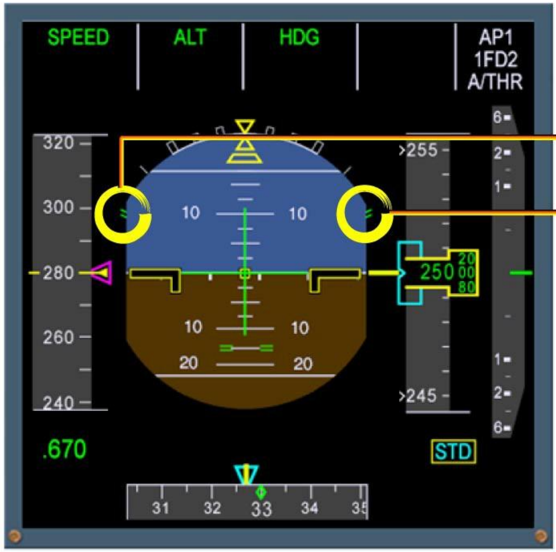
- The bank angle is limited to 45 degrees and no more.

With the high speed protection active:

- The system maintains a positive spiral stability to 0 degree bank angle, so that if the side stick is released, the aircraft returns to wing level.

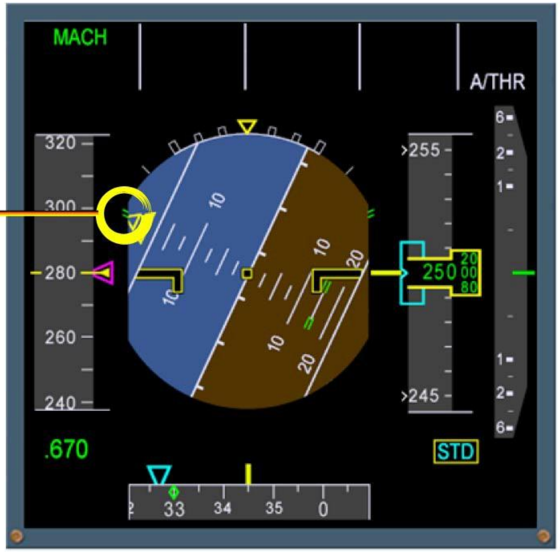
The bank angle limit is also reduced from 67 to 40 degrees.

NORMAL LAW - BANK ANGLE PROTECTION



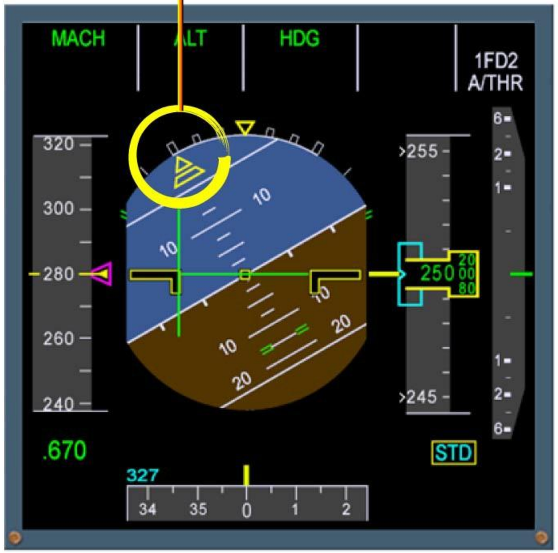
BANK ANGLE LIMITS

BANK ANGLE LIMIT EXCEEDED



33° BANK ANGLE

FD BARS DISAPPEARED



ROLL/YAW

ROLL CONTROL NORMAL D/O

SIDESTICK
The sidestick sends electrical orders to the ELevator Aileron Computers (ELACs) and Spoiler Elevator Computers (SECs).

ELAC
There are two ELACs: ELAC 1 normally controls the ailerons, with ELAC 2 as back-up. In case of failure of ELAC 1, ELAC 2 will automatically take control.

SEC
Using orders coming from the ELACs, each SEC sends orders to one or two pairs of spoilers, without back-up.

FAC
Flight Augmentation Computer (FAC) 1, with FAC 2 as back-up, transmits turn coordination orders for the rudder.

FMGC
When the autopilot is engaged, the Flight Management and Guidance Computer (FMGC) sends roll commands to the ELACs and the FACs, and to the SECs through the ELACs via ARINC 429 data buses.

AILERONS
There are two electrically-controlled hydraulic actuators per aileron, one in active mode and the other in damping mode. The left blue and right green actuators are controlled by ELAC 1 and the other two actuators by ELAC 2. All aileron actuators revert to damping mode in case of a double ELAC failure or green and blue hydraulic low pressure.

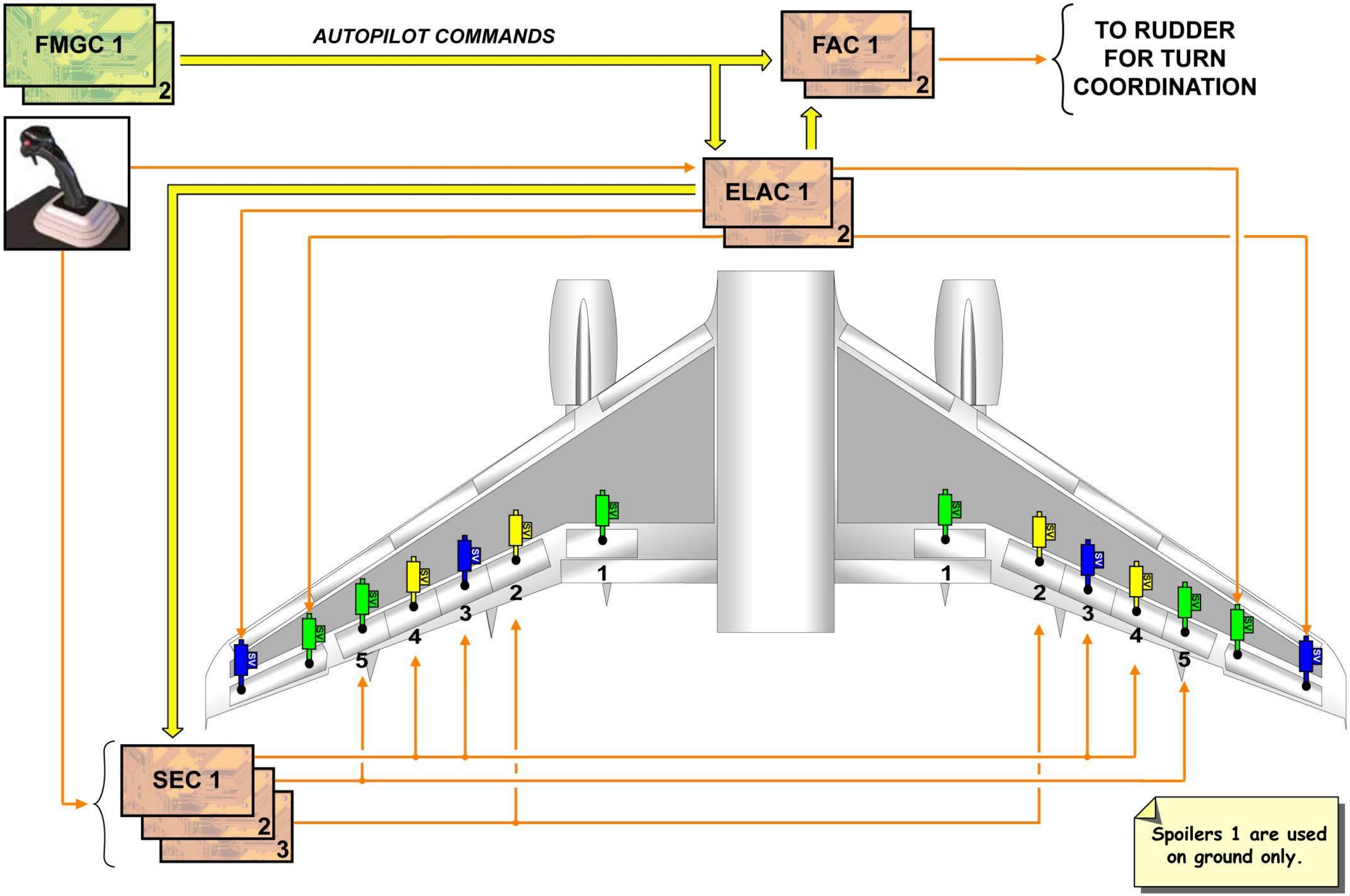
SPOILERS

Each spoiler is powered by one hydraulic actuator. Surfaces are automatically retracted if a fault is detected by the monitoring system or if there is no electrical supply.

In case of loss of hydraulic power supply:
• if retracted, the surface remains retracted,
• if not retracted, the surface will maintain existing deflection to the zero hinge moment position or less if pushed down by aerodynamics.

NOTE: Spoilers 1 are not used for roll control.

SIDESTICK - SPOILERS



ROLL CONTROL ABNORMAL OPERATION

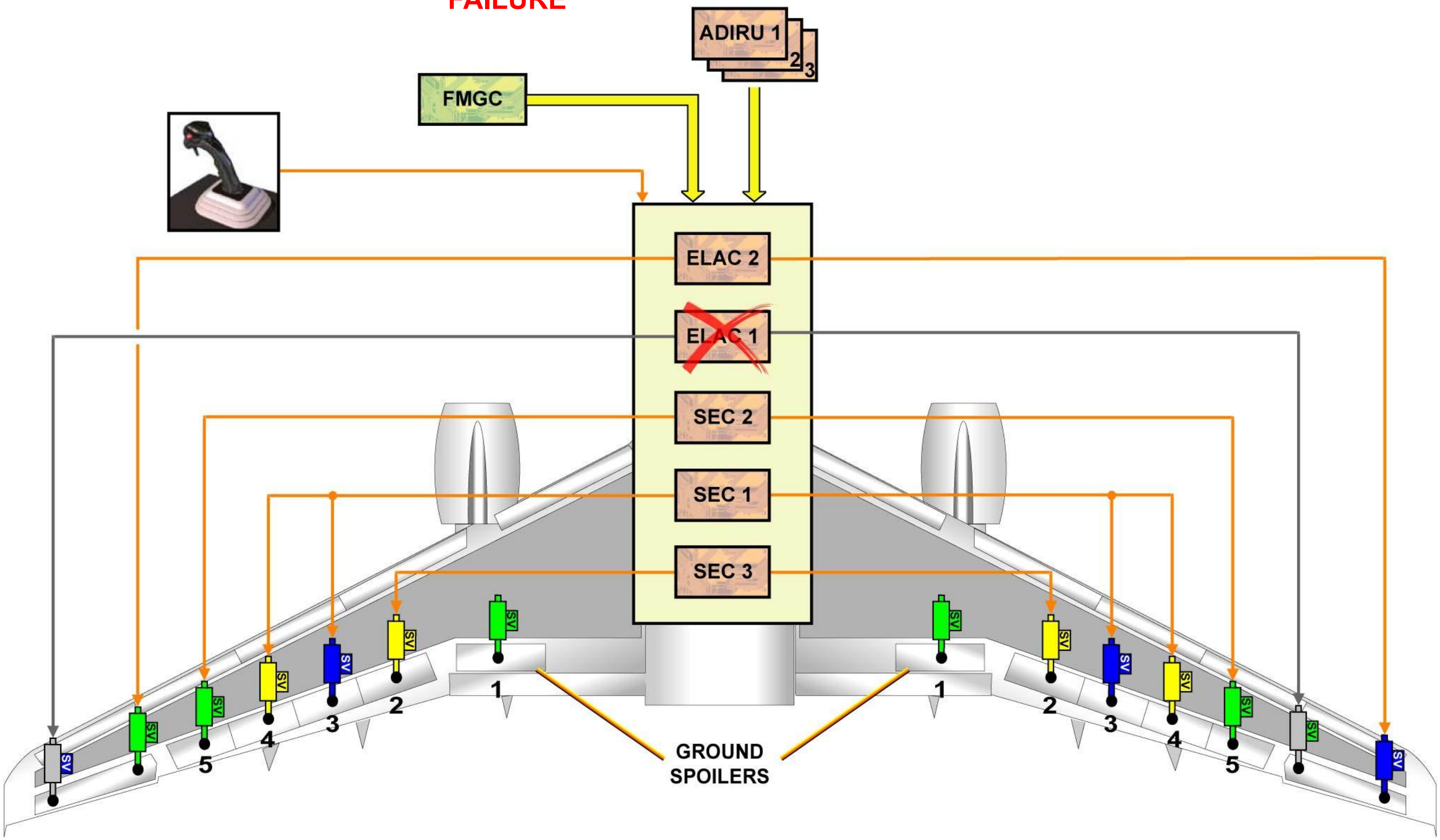
COMPUTER FAILURES

A computer failure can engage a lateral abnormal configuration.

ELAC 1 FAILURE

The loss of ELevator Aileron Computer (ELAC) 1 leads to select ELAC 2 active. ELAC 2 computes the lateral orders in normal law and transmits them to the Spoiler Elevator Computer (SEC) for the roll spoiler.

COMPUTER FAILURES - ELAC 1 FAILURE



ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

FOR TRAINING PURPOSES ONLY

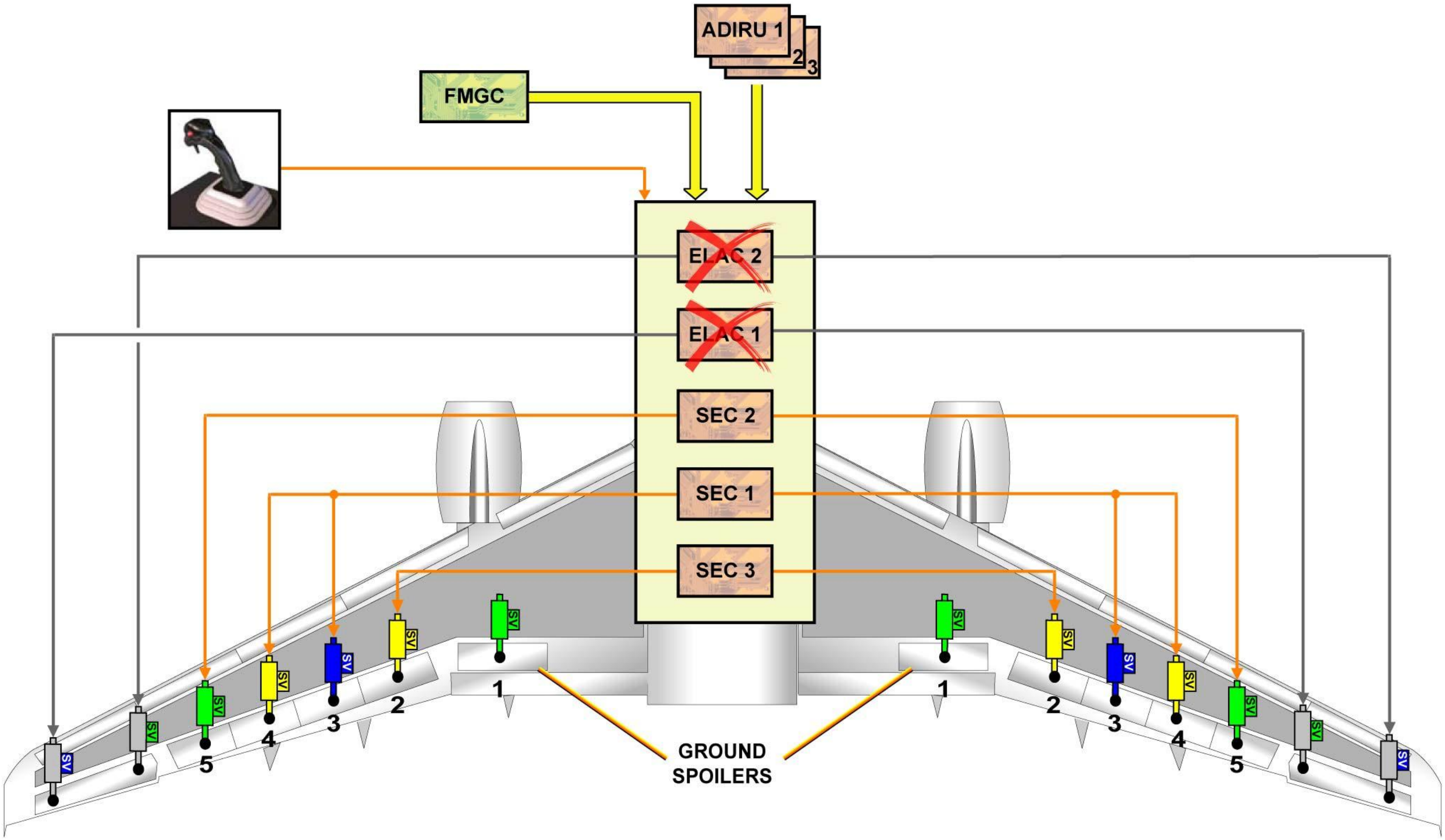
ROLL CONTROL ABNORMAL OPERATION

COMPUTER FAILURES (continued)

ELAC 1+2 FAILURE

In case of loss of both ELACs only spoilers are available.
The SECs control the roll in direct law and the yaw damping function normal law is lost.

COMPUTER FAILURES - ELAC 1+2 FAILURE



ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

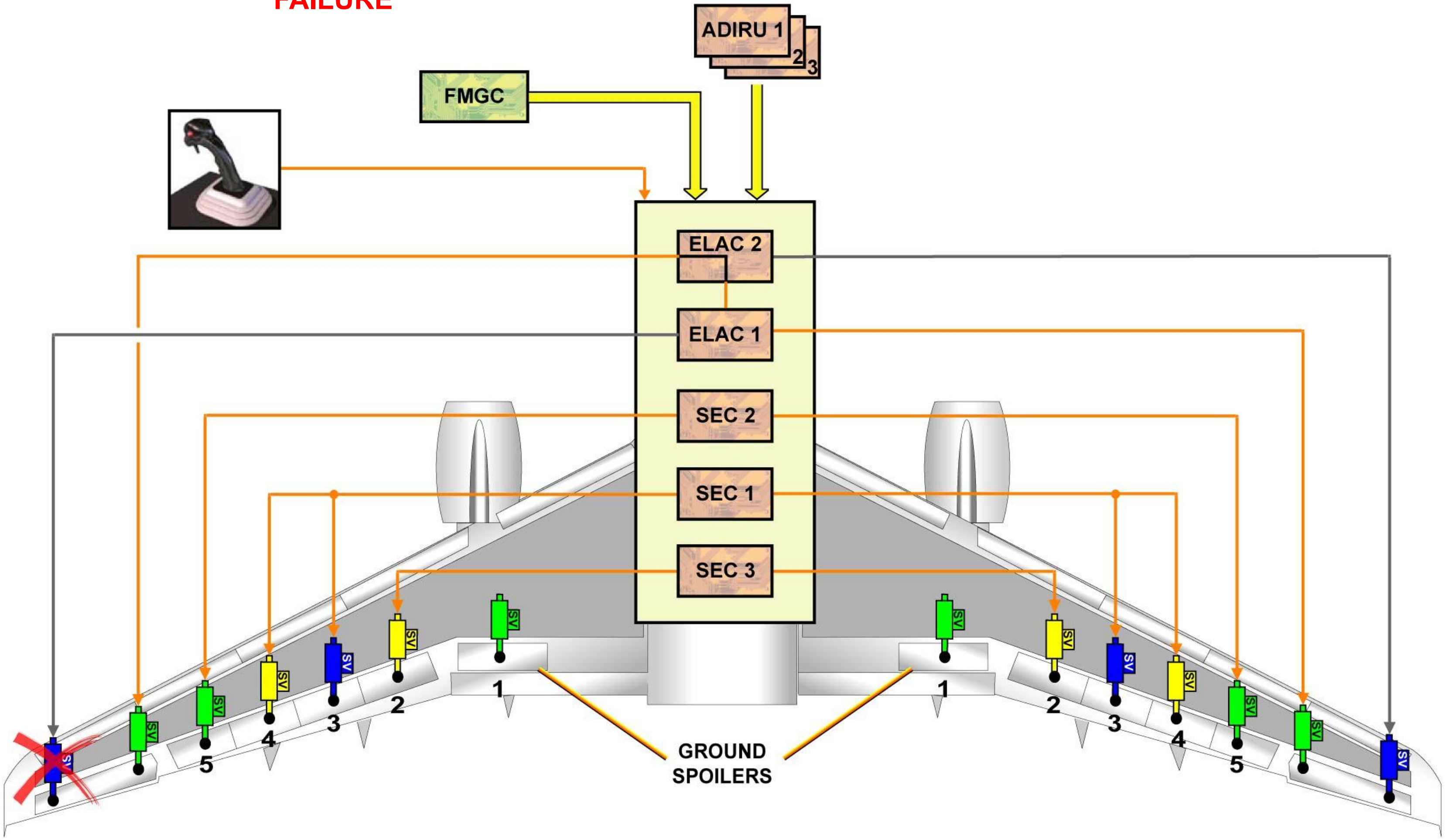
ROLL CONTROL ABNORMAL OPERATION

SERVO CONTROL FAILURES

AILERON SERVO CONTROL FAILURE

In case of failure of one aileron servo control, the second one takes over and is controlled by the other ELAC. In this example, ELAC 1 still computes the orders and ELAC 2 is in slave mode.

SERVO CONTROL FAILURES - AILERON SERVO CONTROL FAILURE



ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

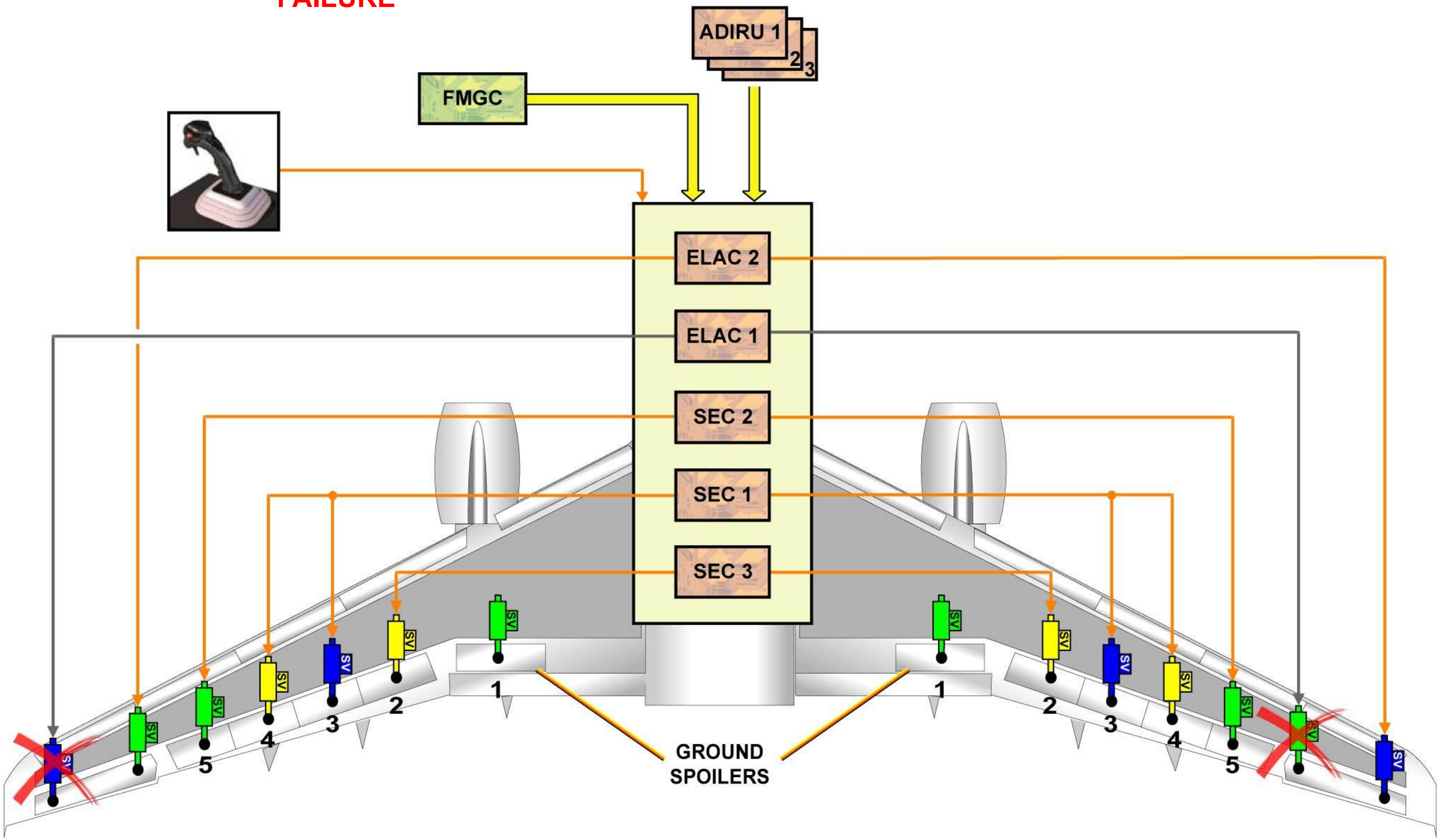
ROLL CONTROL ABNORMAL OPERATION

SERVO CONTROL FAILURES (continued)

ELAC 1 SERVO CONTROLS FAILURE

In case of failure of both ELAC 1 servo controls, then ELAC 2 does the computation and controls its servo controls.

SERVO CONTROL FAILURES - ELAC 1 SERVO CONTROLS FAILURE



ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

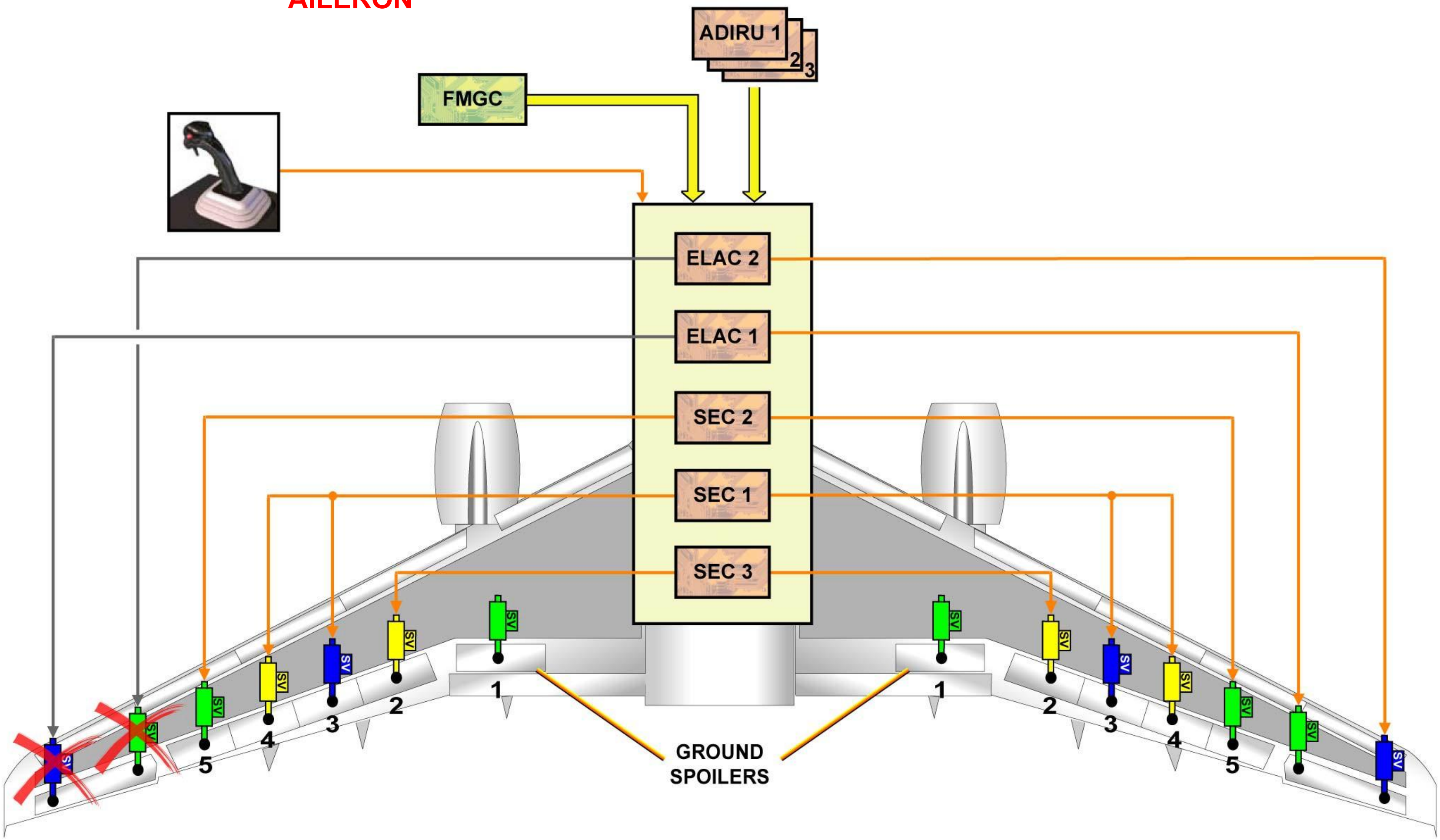
ROLL CONTROL ABNORMAL OPERATION

SERVO CONTROL FAILURES (continued)

FAILURES ON THE SAME AILERON

In case of failure of both servo controls of the same aileron, the other aileron is still operated.

SERVO CONTROL FAILURES - FAILURES ON THE SAME AILERON



ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

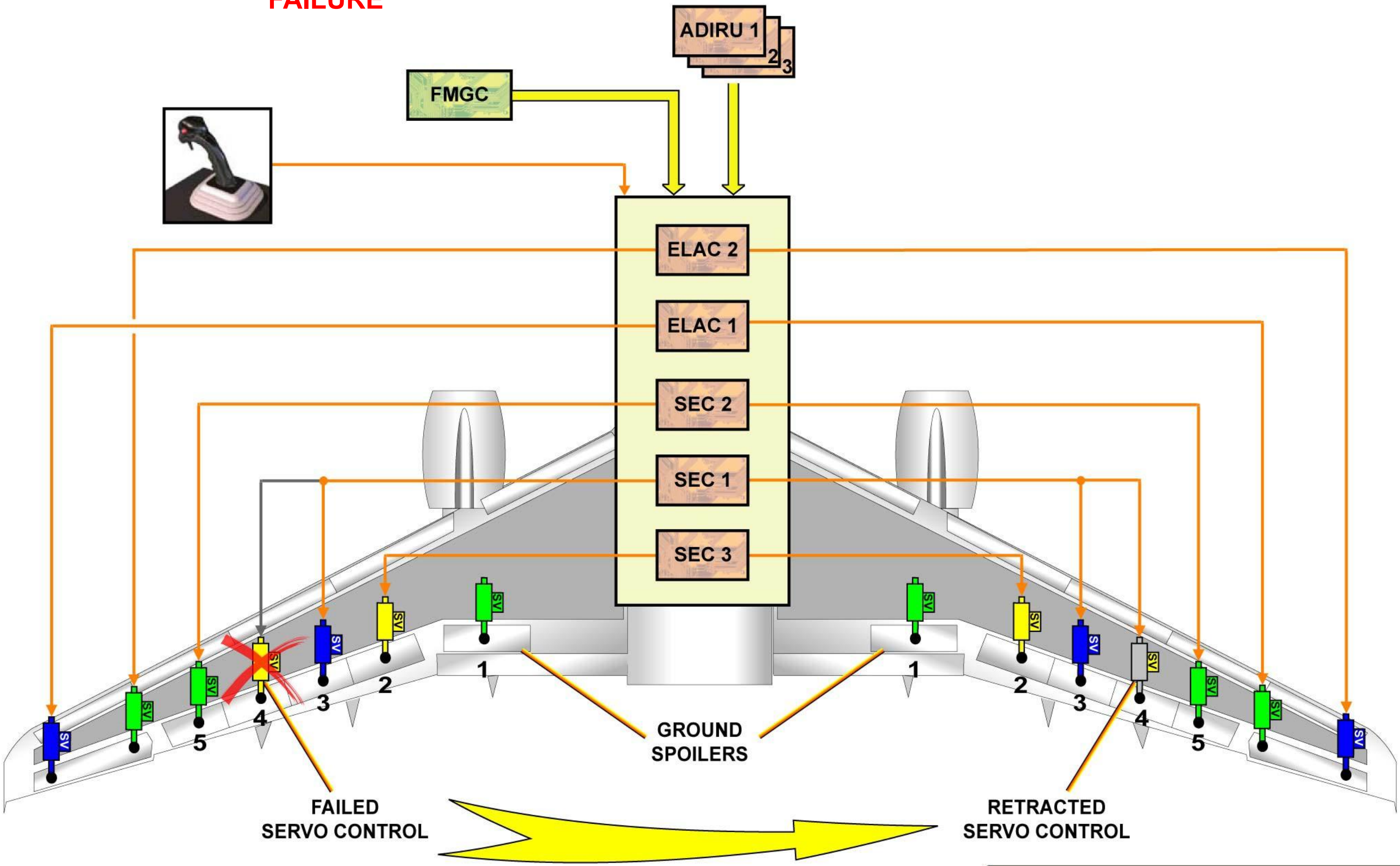
ROLL CONTROL ABNORMAL OPERATION

SERVO CONTROL FAILURES (continued)

SPOILER SERVO CONTROL FAILURE

In case of failure of a spoiler servo control, the opposite surface is retracted.

SERVO CONTROL FAILURES - SPOILER SERVO CONTROL FAILURE



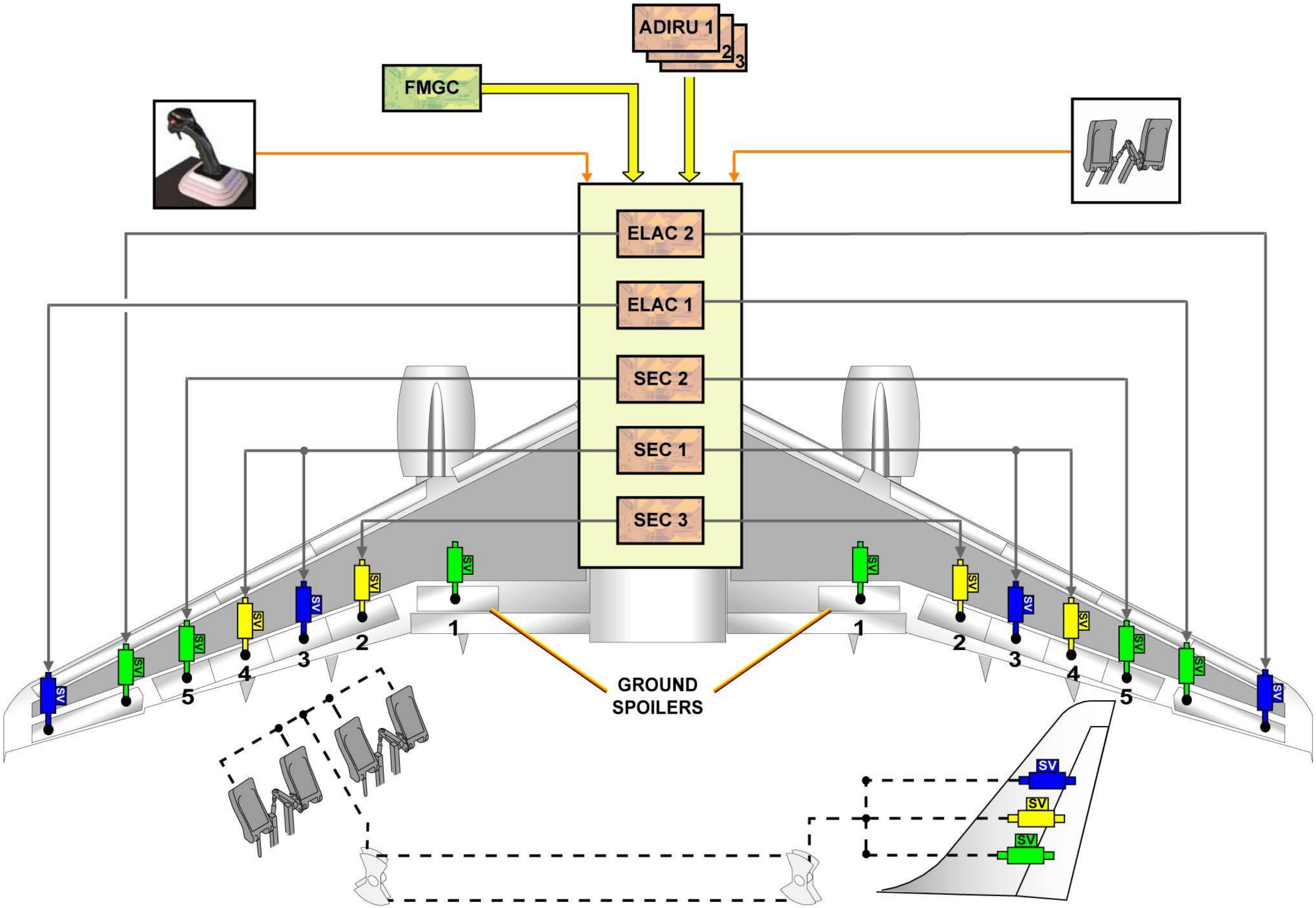
ADIRU: Air Data/Inertial Reference Unit
FMGC: Flight Management and Guidance Computer

ROLL CONTROL ABNORMAL OPERATION

ELECTRICAL FAILURE

In case of total electrical loss, induced roll is obtained by using the rudder pedals, which have a mechanical control.

ELECTRICAL FAILURE



YAW CONTROL NORMAL D/O

GENERAL

The yaw control is done by the rudder, with a maximum deflection of 25° for the A320 and A321, and 30° for the A318 and A319. The rudder is operated by three moving body servocontrols with a common mechanical input.

RUDDER PEDALS

The two pairs of rudder pedals are connected together. They are linked by a cable loop to the mechanical summing point which in turn is connected to the hydraulic rudder actuators via a differential unit.

Mechanical rudder control is always available from the rudder pedals. The pedal position signals are sent to the ELevator Aileron Computers (ELACs) by the transducer (XDCR) unit. If installed, the Force Transducer Unit (FTU) is used to measure pilots forces applied on the pedals. This information is not used in flight control system but transmitted to the Flight Control Data Concentrator (FCDC) to be recorded by the Digital Flight Data Recorder (DFDR).

ELAC

In flight, the ELACs transmit the yaw damping and turn coordination to the Flight Augmentation Computers (FACs) for rudder deflection. There is no feedback to the pedals for yaw damping and turn coordination.

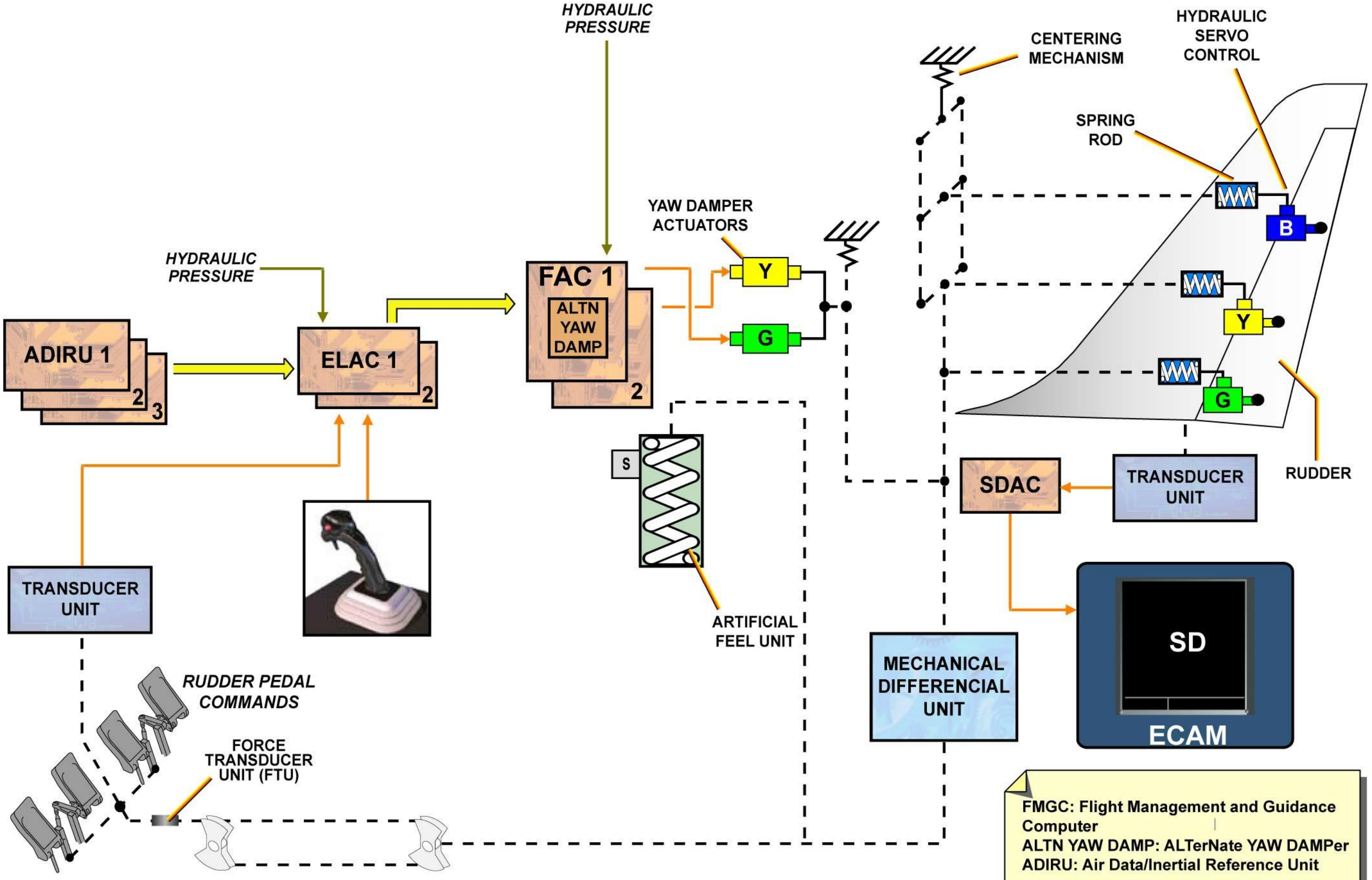
FAC

The two FACs control the yaw damper servo controls. FAC 1 has priority. FAC 2 is in hot stand-by.

RUDDER

The rudder is powered by three hydraulic actuators operating in parallel. The position of the rudder is transmitted to the System Data Acquisition Concentrator (SDAC) through a position XDCR unit. This position is shown on the lower display unit of the ECAM.

GENERAL - RUDDER



FMGC: Flight Management and Guidance Computer
ALTN YAW DAMP: ALTerNate YAW DAMPer
ADIRU: Air Data/Inertial Reference Unit

YAW CONTROL NORMAL D/O

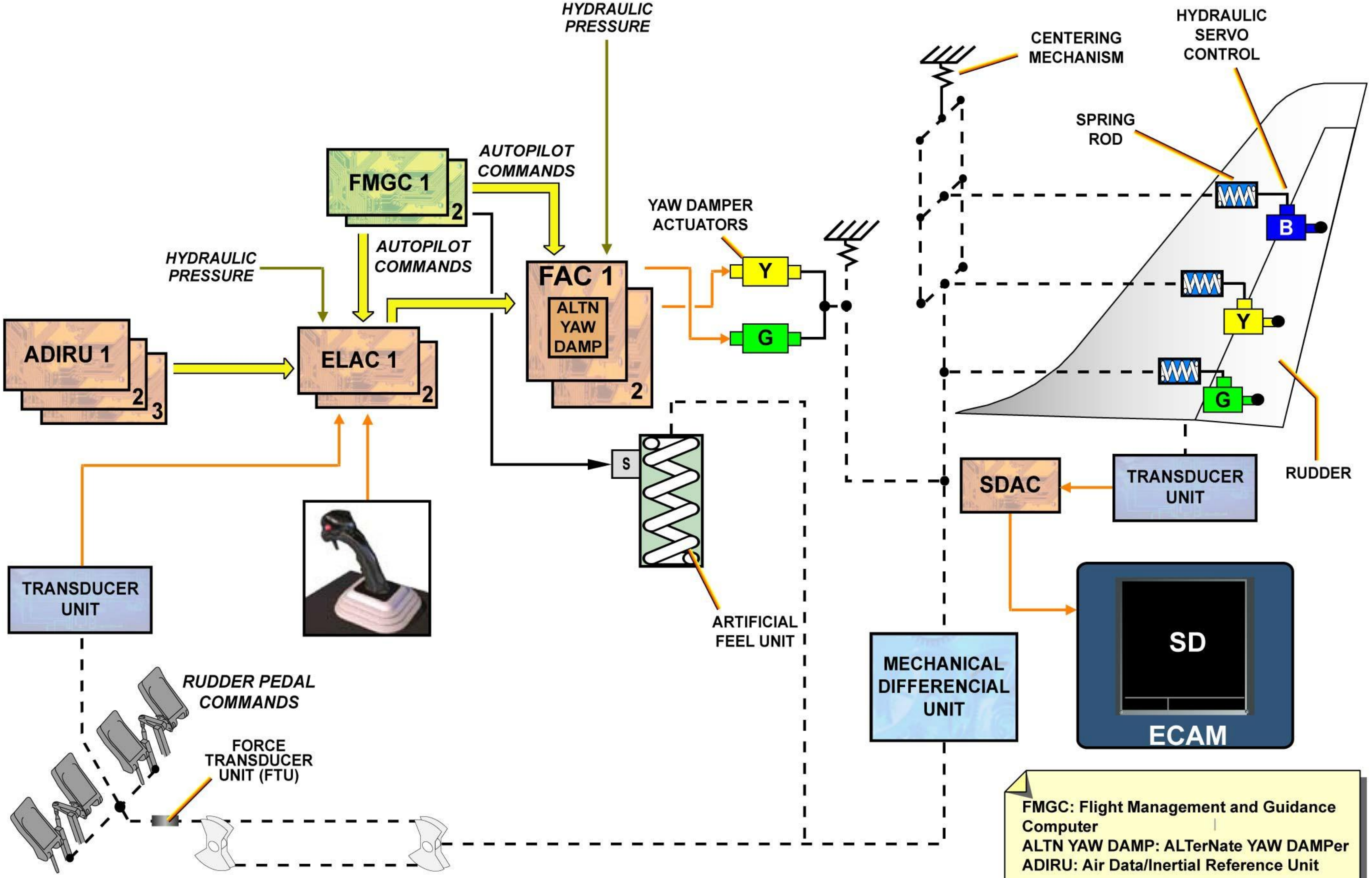
FMGC

When the autopilot is engaged, the Flight Management and Guidance Computers (FMGCs) send commands to the FACs for rudder trimming, yaw control and yaw damping function. The FMGCs energize the artificial feel stiffening solenoid to increase the threshold of the rudder artificial feel and to avoid unintentional autopilot disconnection.

YAW DAMPING

The yaw dampers servo activation controls are connected to the rudder hydraulic actuators through a mechanical differential unit: each servo actuator is controlled by its related FAC. No feedback to the rudder pedals is given thanks to the differential unit.

FMGC & YAW DAMPING



FMGC: Flight Management and Guidance Computer
ALTN YAW DAMP: ALTerNate YAW DAMPer
ADIRU: Air Data/Inertial Reference Unit

FOR TRAINING PURPOSES ONLY

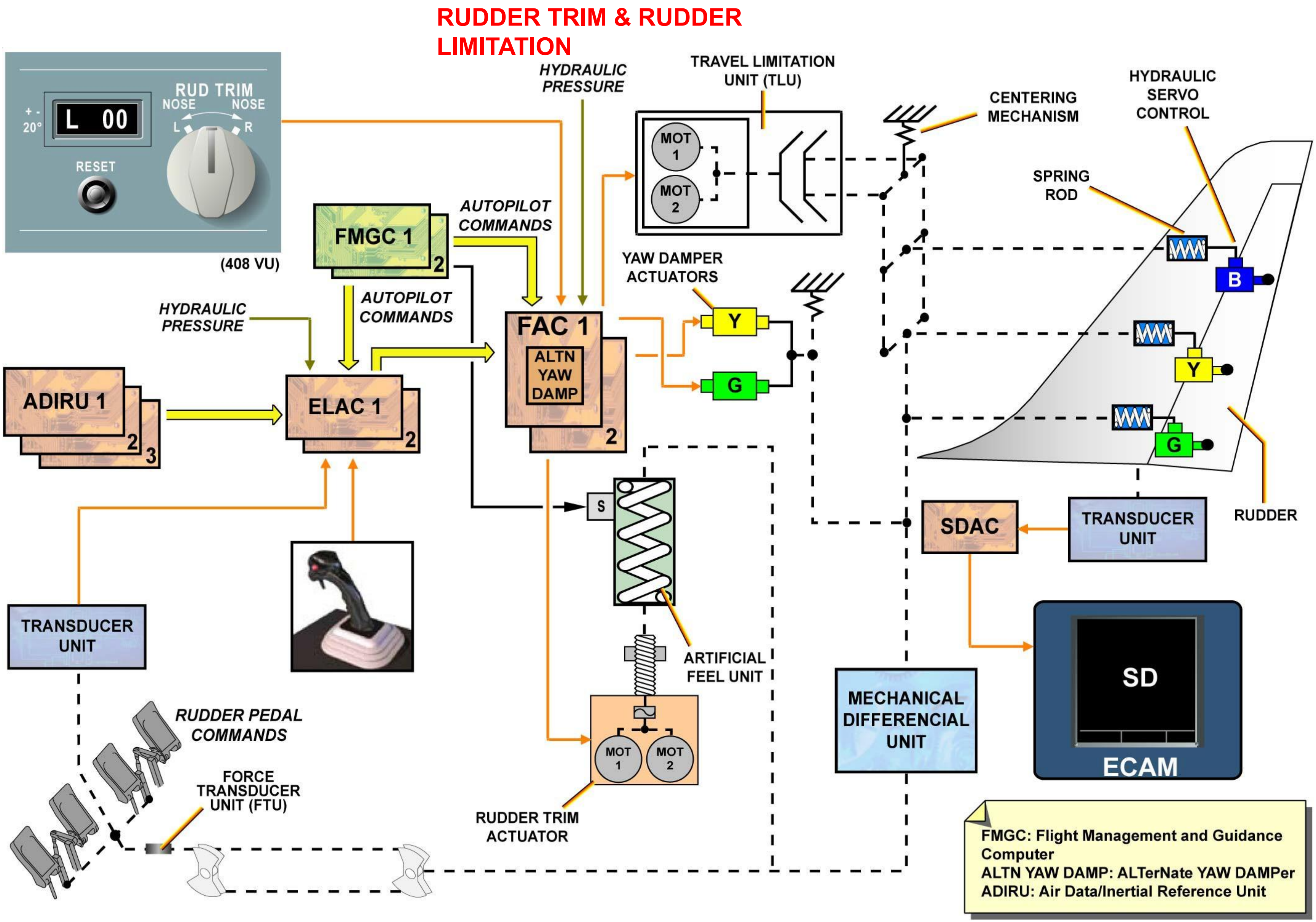
YAW CONTROL NORMAL D/O

RUDDER TRIM

The rudder trim is achieved by one or two electric motors at a time, each controlled by its associated FAC. In manual flight, the pilot can apply rudder trim at 1°/sec from the RUDder TRIM rotary switch.
Also, an asymmetry compensation function is available in case of lateral asymmetry, and a yaw automatic trim is active for lateral asymmetry and engine failure compensation at 5°/sec.
Trimming causes rudder pedal movement.

RUDDER LIMITATION

Rudder deflection limitation is achieved by a variable stop unit driven by one or two electric motors at a time. Each motor is controlled by its associated FAC. The rudder deflection becomes limited as speed is increased.



FMGC: Flight Management and Guidance Computer
ALTN YAW DAMP: ALTerNate YAW DAMPer
ADIRU: Air Data/Inertial Reference Unit

FOR TRAINING PURPOSES ONLY

YAW CONTROL ABNORMAL D/O

ALTERNATE LAW

The alternate yaw damper law computed in the Flight Augmentation Computer (FAC) becomes active if the roll normal law fails. Turn coordination is no longer available.

The alternate yaw damper law also becomes active in these cases:

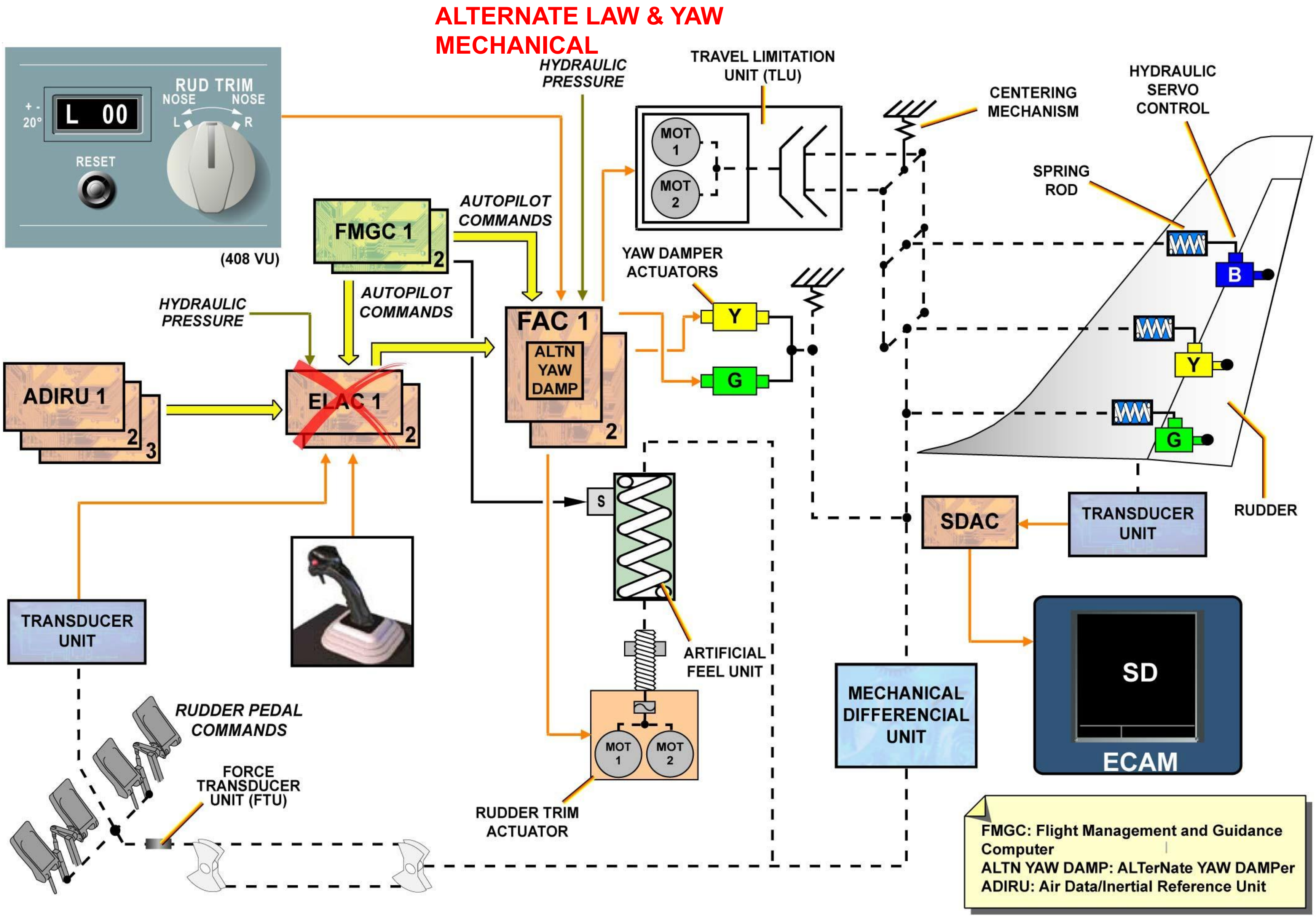
- two Air Data References (ADRs) or two Inertial References (IRs) or two ELevator Aileron Computers (ELACs) or both ailerons or all spoilers fail or blue+green hydraulic low pressure or of pitch normal law is lost,
- the alternate law in FAC 1 is active with the emergency electrical supply (emergency generator running),
- the yaw damper authority is limited to +/- 5° rudder deflection.

YAW MECHANICAL

The mechanical rudder control, which is available at all times, must be used following the failures shown below:

- two FACs or three ADRs or three IRs or green+yellow hydraulic low pressure or electrical power on batteries only.

NOTE: In case of a dual FAC failure, a specific channel in each FAC selects the rudder.



FOR TRAINING PURPOSES ONLY

AILERON SERVO CONTROL OPERATION

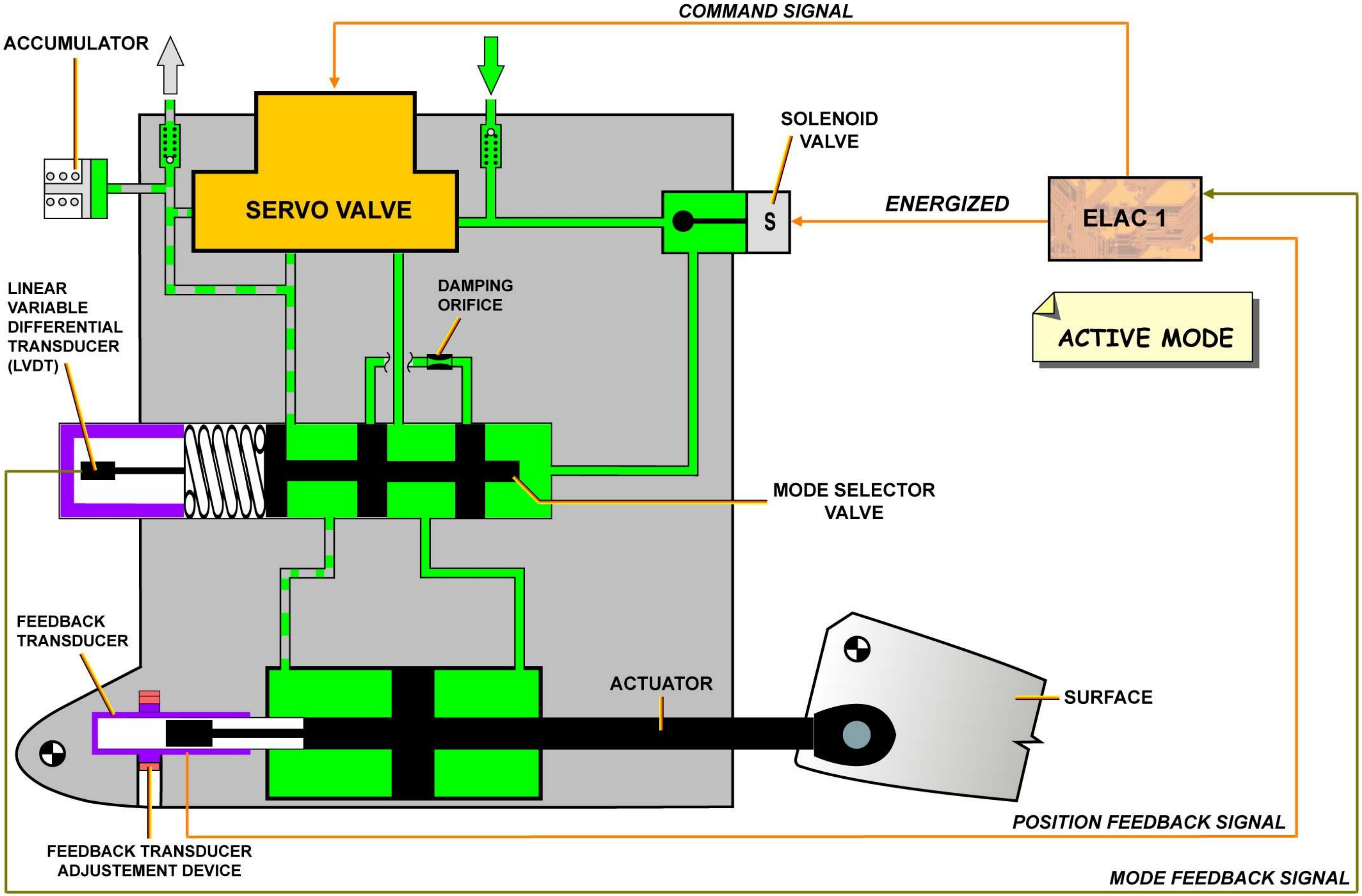
GENERAL

Each aileron is equipped with two identical electro-hydraulic servo-controls.
These servo-controls have two modes:
- the active mode
- the damping mode.

ACTIVE MODE

In the active mode, the solenoid valve is energized by the Electrical Flight Control System (EFCS). This enables the HP fluid to flow and to put the mode selector valve in the active position. The two chambers of the actuator are thus connected to the servo-valve control lines. Theservo-control is then in the active mode. The Linear Variable-Differential Transducer (LVDT) supplies an electrical signal to the ELAC, which identifies this change of state. The feedback transducer (also called LVDT) gives the servo-loop feedback.

GENERAL & ACTIVE MODE



AILERON SERVO CONTROL OPERATION

DAMPING MODE

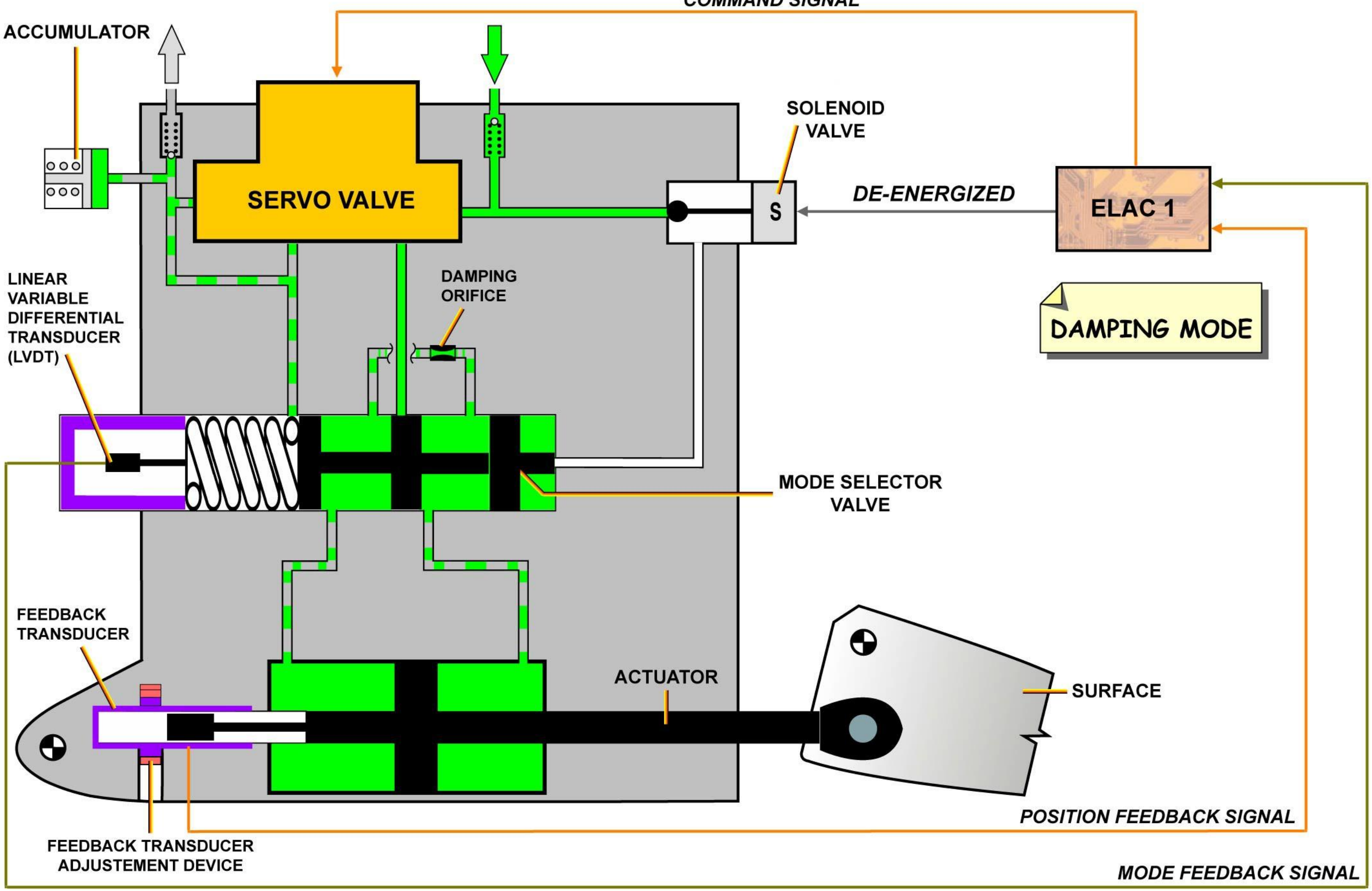
In damping mode, the actuator follows the control surface movements. In this configuration, the solenoid valve is de-energized and the mode selector valve moves under the action of its spring. The two chambers of the actuator are thus interconnected through the damping orifice. The LVDT identifies this change of state and transmit it to the EFCS.
The fluid reserve allows to hold the volume of fluid in the actuator chambers:
- if the temperature of the hydraulic fluid changes or,
- if there is a leakage.

The fluid reserve is permanently connected to the return line of the servo-valve.

MAINTENANCE AND RIGGING FACILITIES

After replacement of the servo-control, it is necessary to adjust the feedback transducer (LVDT). It is necessary to get an equal voltage in the secondary winding (electrical zero) when the aileron is in neutral position. This is done through an action on the feedback transducer adjustment device located on the actuator.

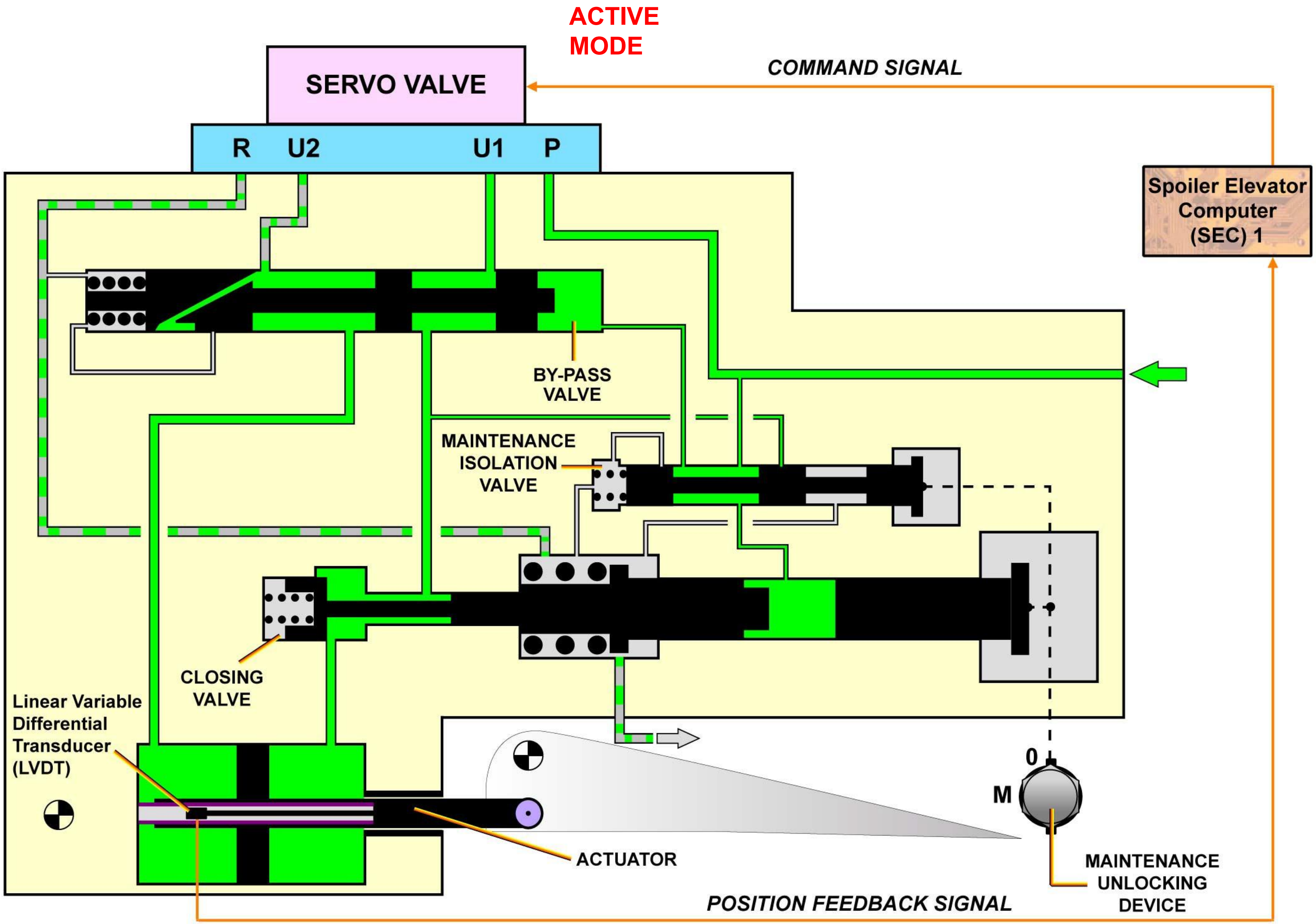
DAMPING MODE & MAINTENANCE AND RIGGING FACILITIES



SPOILER SERVO CONTROL OPERATION

ACTIVE MODE

In active mode the spoiler servo control actuator is hydraulically supplied. According to the command signal to the servo valve the spoiler surface will extend or retract. The feedback transducer Linear Variable Differential Transducer (LVDT) provide(s) the servo loop feedback.

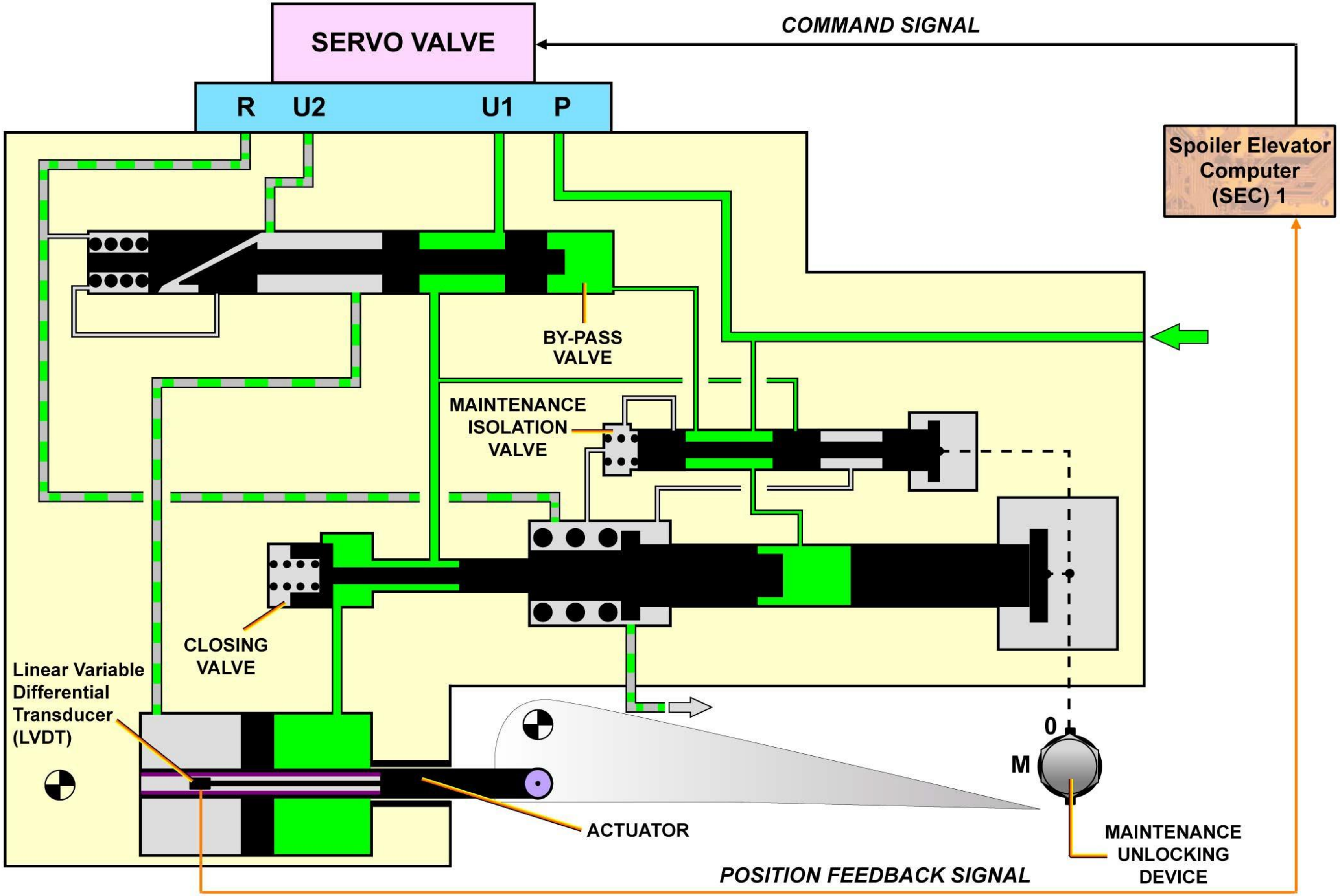

ACTIVE
MODE
COMMAND SIGNAL
SERVO VALVE
R
U2
U1
P
Spoiler Elevator
Computer
(SEC) 1
BY-PASS
VALVE
MAINTENANCE
ISOLATION
VALVE
CLOSING
VALVE
Linear Variable
Differential
Transducer
(LVDT)
0
M
ACTUATOR
MAINTENANCE
UNLOCKING
DEVICE
POSITION FEEDBACK SIGNAL

SPOILER SERVO CONTROL OPERATION

BIASED MODE

The servo-control actuator is pressurized. Due to an electrical failure the command signal is lost. The biased servo valve pressurizes the retraction chamber. The spoiler actuator stays pressurized and the spoiler remains retracted.

BIASED MODE

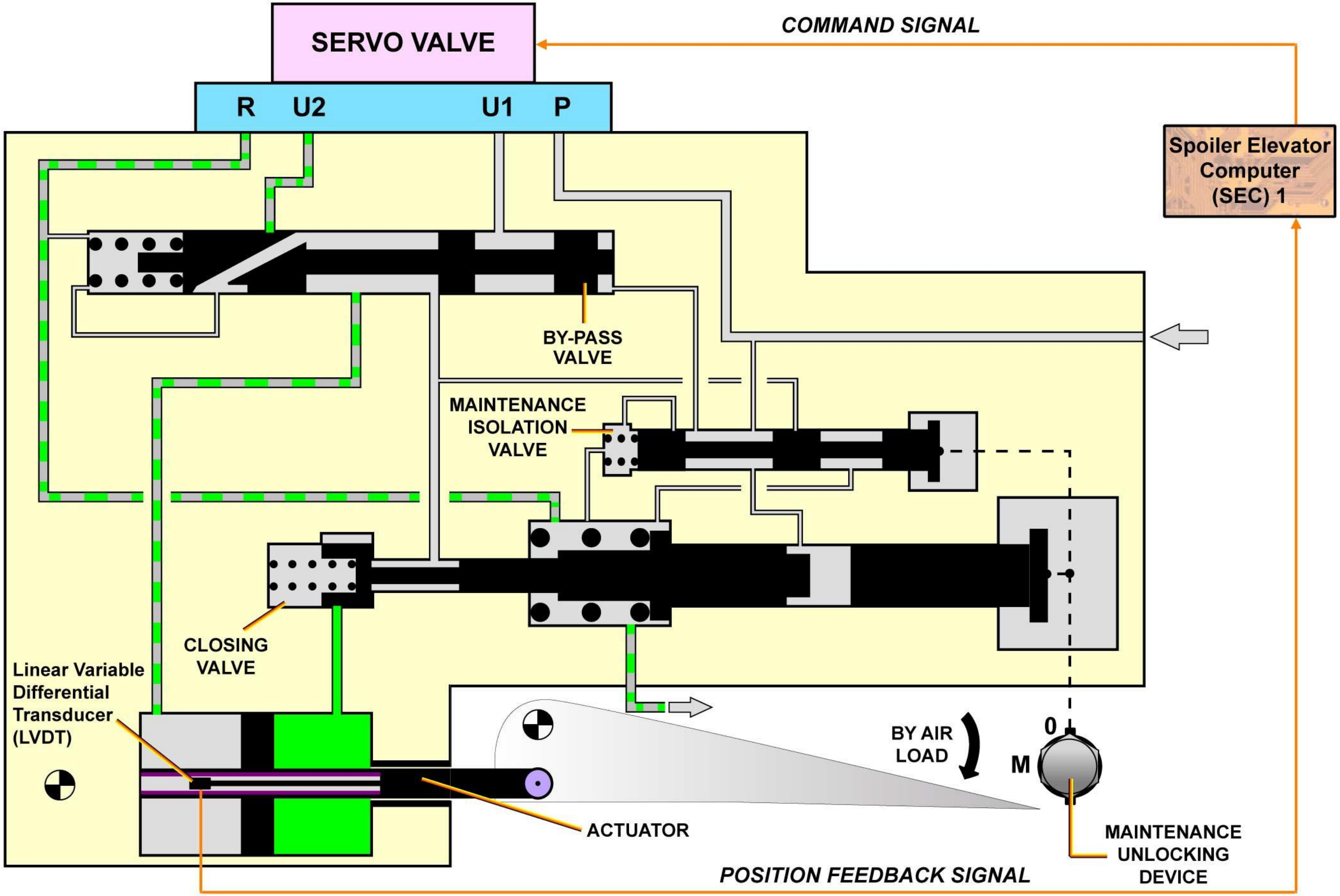

SERVO VALVE
COMMAND SIGNAL
R
U2
U1
P
Spoiler Elevator Computer (SEC) 1
BY-PASS VALVE
MAINTENANCE ISOLATION VALVE
CLOSING VALVE
Linear Variable Differential Transducer (LVDT)
ACTUATOR
0
M
MAINTENANCE UNLOCKING DEVICE
POSITION FEEDBACK SIGNAL

SPOILER SERVO CONTROL OPERATION

LOCKED MODE

In locked mode, the hydraulic pressure is lost. The closing valve closes the retraction chamber. The surface can only be moved towards the retracted position, pushed by aerodynamical forces.

LOCKED MODE

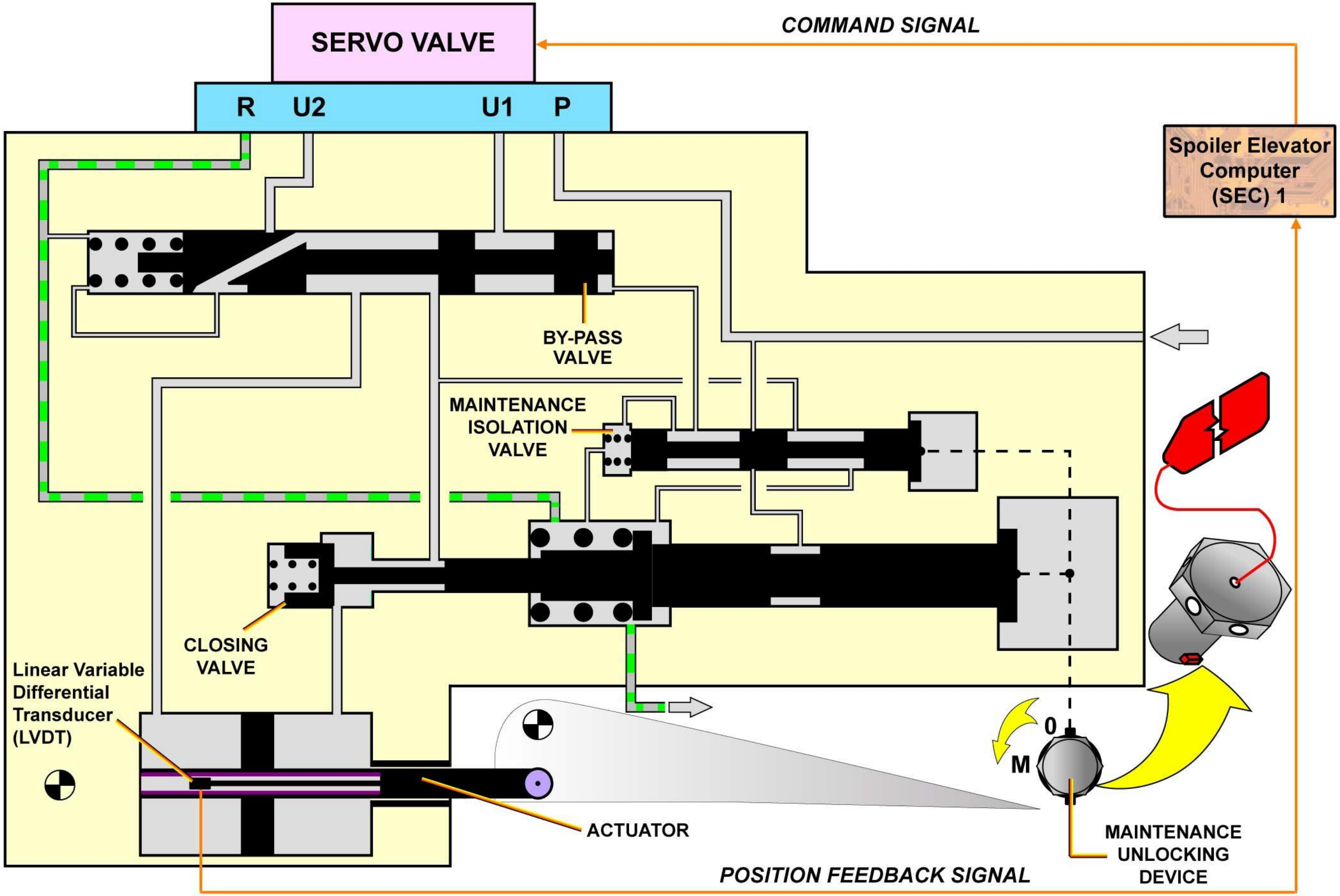

SERVO VALVE
COMMAND SIGNAL
R
U2
U1
P
Spoiler Elevator Computer (SEC) 1
BY-PASS VALVE
MAINTENANCE ISOLATION VALVE
CLOSING VALVE
Linear Variable Differential Transducer (LVDT)
BY AIR LOAD
0
M
ACTUATOR
MAINTENANCE UNLOCKING DEVICE
POSITION FEEDBACK SIGNAL

SPOILER SERVO CONTROL OPERATION

MANUAL MODE

To be unlocked, the servo control actuator must be depressurized. The maintenance unlocking device can be engaged thanks to a key equipped with a red flame. This tool cannot be removed when the servo control is in maintenance mode. Once the maintenance unlocking device is engaged the spoiler surface can be raised manually for inspection purposes.

MANUAL MODE


COMMAND SIGNAL
SERVO VALVE
R
U2
U1
P
Spoiler Elevator Computer (SEC) 1
BY-PASS VALVE
MAINTENANCE ISOLATION VALVE
CLOSING VALVE
Linear Variable Differential Transducer (LVDT)
ACTUATOR
0
M
MAINTENANCE UNLOCKING DEVICE
POSITION FEEDBACK SIGNAL

RUDDER TRIM ACTUATOR

GENERAL

The rudder trim actuator is installed on the rudder system, in the tail area and it's or are one of the mechanical inputs of the rudder servo controls. The rudder trim actuator enables the zero force position of the artificial feel and trim unit to be adjusted.

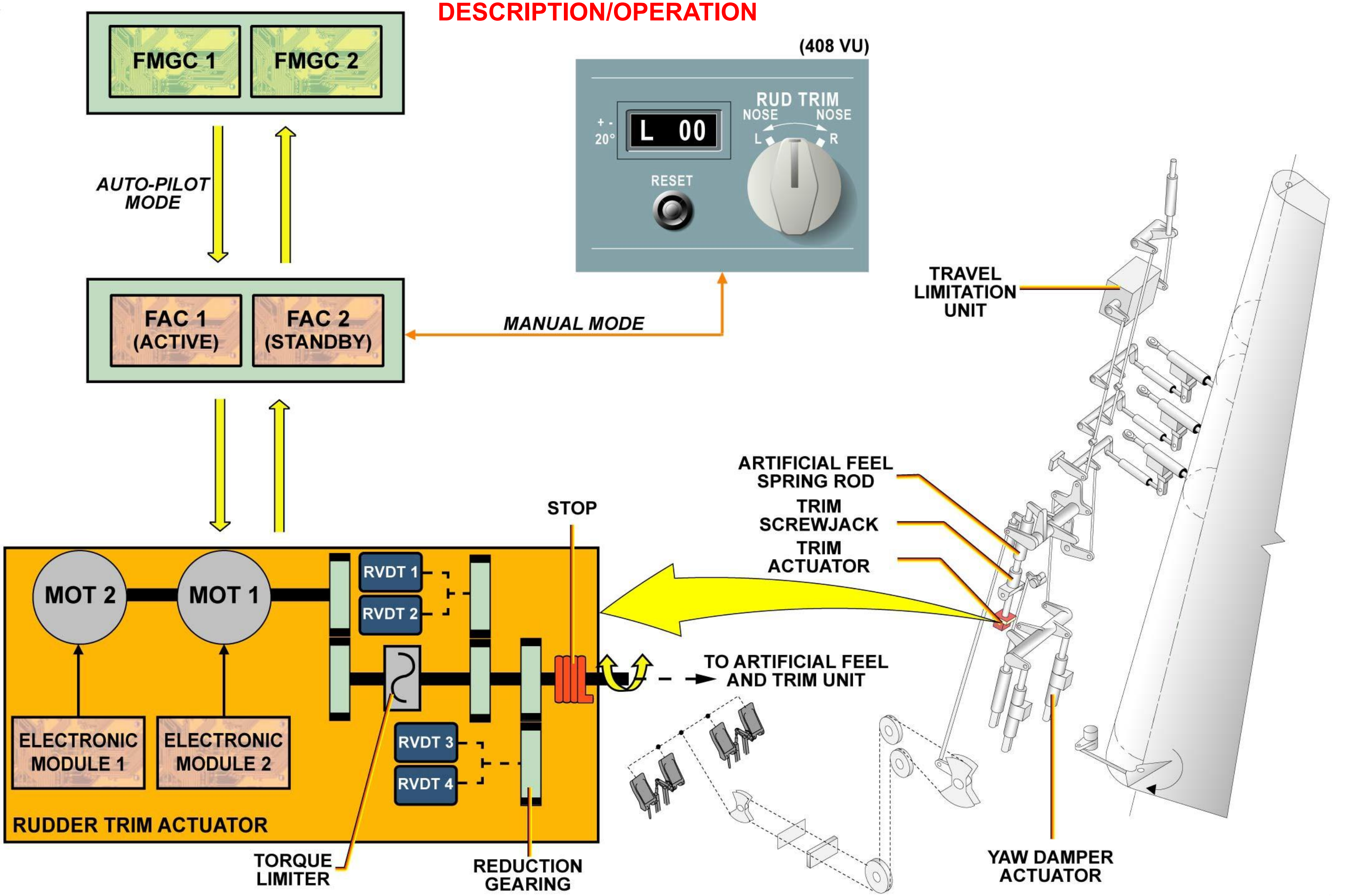
CONTROLS

The rudder trim actuator is an electromechanical unit, which converts the electrical input from the Flight Augmentation Computers (FACs) into a rotation of its output shaft. The rudder trim actuator can be controlled either by the RUDder TRIM control switch located in the center pedestal of the cockpit, in manual mode, or by the Flight Management & Guidance Computers (FMGCs) in AP mode. In both cases orders are sent via the FACs. In automatic control, the rudder trim function controlled by the FAC, fulfills the generation and the accomplishment of the engine failure recovery function. In this case, the engine failure compensation slow law orders are sent to the rudder trim actuator. The AP also provides signals, which validate the detection of engine failure as a function of the engine rating.

DESCRIPTION/OPERATION

The rudder trim actuator has two DC motors, installed on the same shaft. Each one is controlled by one independent electronic module, with only one motor operating at a time, via FAC1 or 2. The motors permanently coupled to a reduction gear, drive the output shaft, via a torque limiter. Then the output shaft drives four Rotary Variable Differential Transducers (RVDTs), transmitting the output shaft position signal to the FACs.

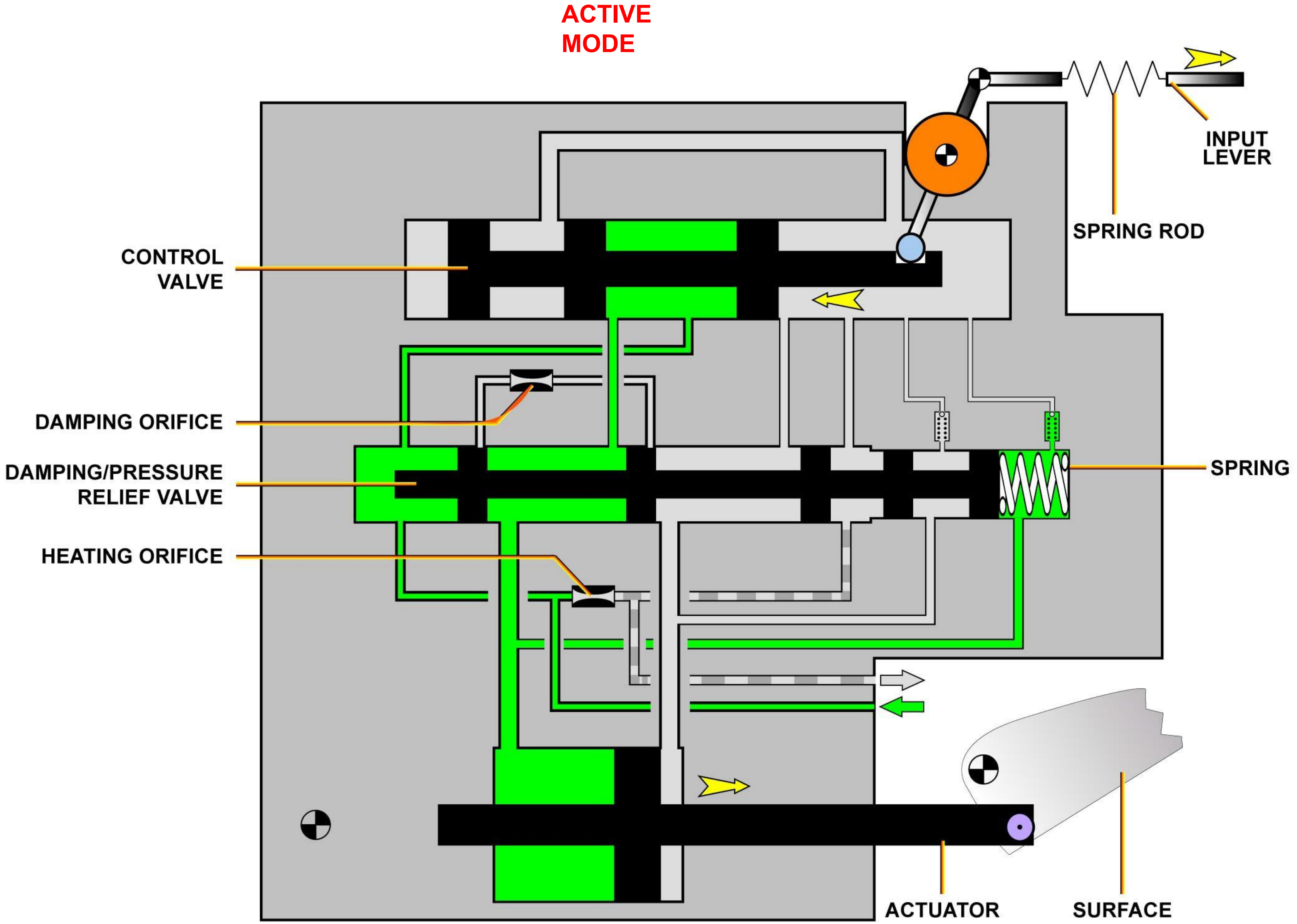
GENERAL - DESCRIPTION/OPERATION



RUDDER SERVO CONTROL OPERATION

ACTIVE MODE

When the rudder servo control actuator is in active mode, the actuator moves to the right or to the left according to the control valve position. The high pressure is connected to the return via the heating orifice; this fulfills the permanent heating leakage.

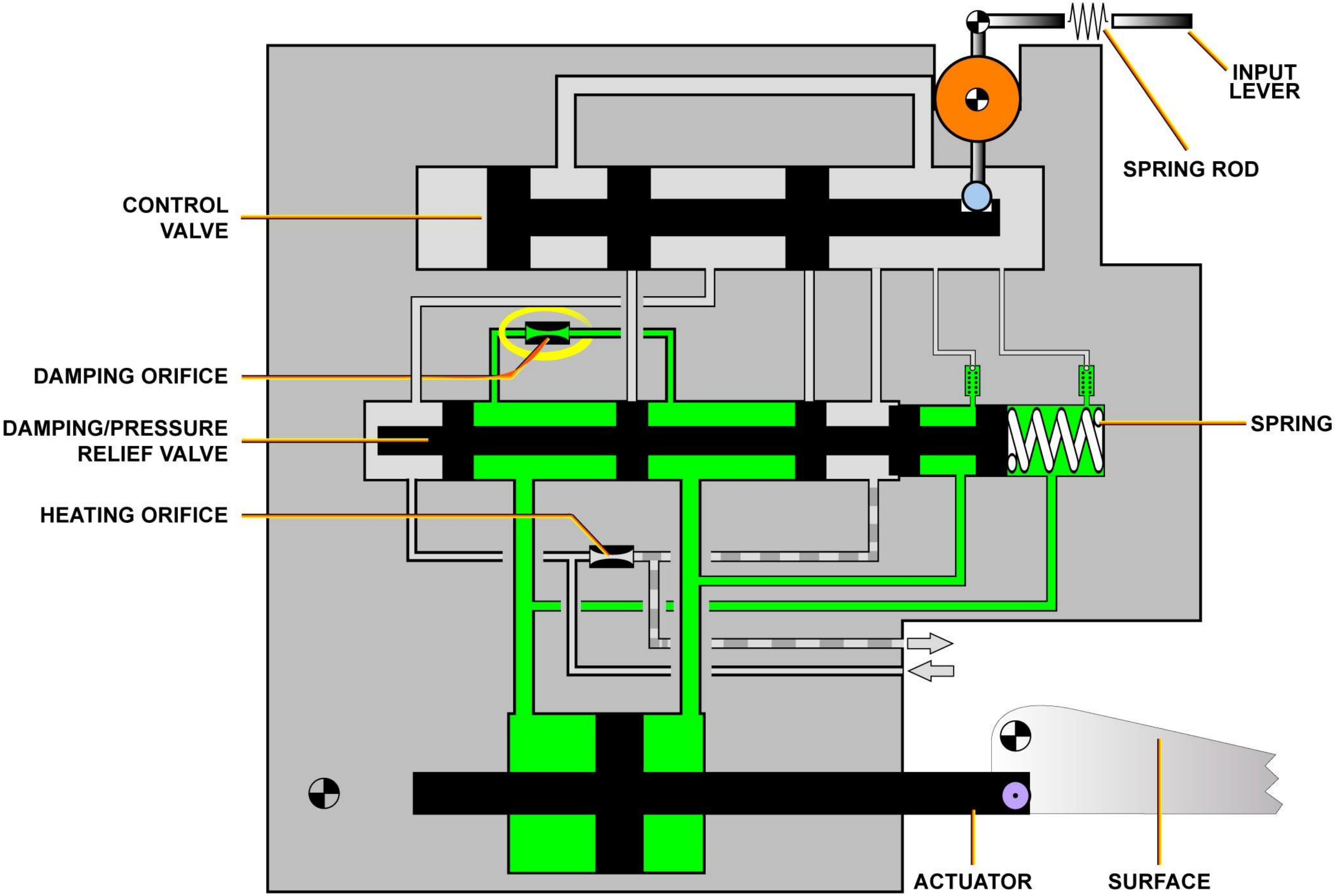

ACTIVE
MODE
INPUT
LEVER
SPRING ROD
CONTROL
VALVE
DAMPING ORIFICE
DAMPING/PRESSURE
RELIEF VALVE
SPRING
HEATING ORIFICE
ACTUATOR
SURFACE

RUDDER SERVO CONTROL OPERATION

DAMPING MODE

The rudder servo control actuator changes to damping mode, as soon as the hydraulic pressure supply is cut. When the servo control is depressurized, the spring sets the damping and pressure-relief valve to the bypass position, and the hydraulic fluid goes from one chamber to the other via the damping orifice.

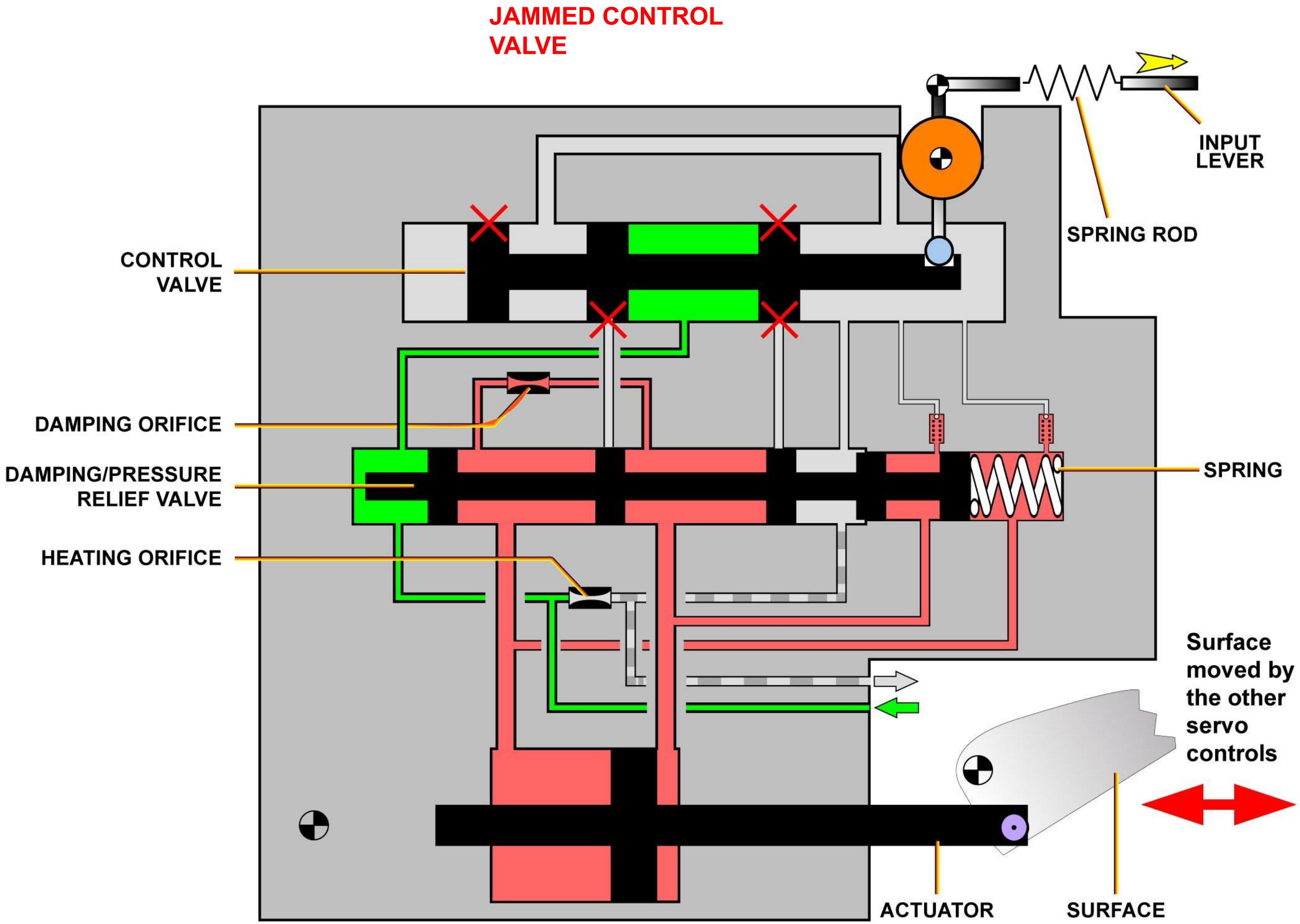
DAMPING MODE



RUDDER SERVO CONTROL OPERATION

JAMMED CONTROL VALVE

If the control valve jams, the rudder servo control actuator follows the rudder surface movement, ensured by the other rudder servo controls. Rudder locking or runaway in the event of a servo control valve jamming is prevented by a spring rod and pressure relief valve arrangement.


JAMMED CONTROL VALVE
INPUT LEVER
SPRING ROD
CONTROL VALVE
DAMPING ORIFICE
DAMPING/PRESSURE RELIEF VALVE
SPRING
HEATING ORIFICE
Surface moved by the other servo controls
ACTUATOR
SURFACE

RUDDER LIMITER OPERATION

LOW SPEED CONFIGURATION

Under 160 kts the stops are in low-speed configuration. Full input/output lever movement to the rudder servo control is available.

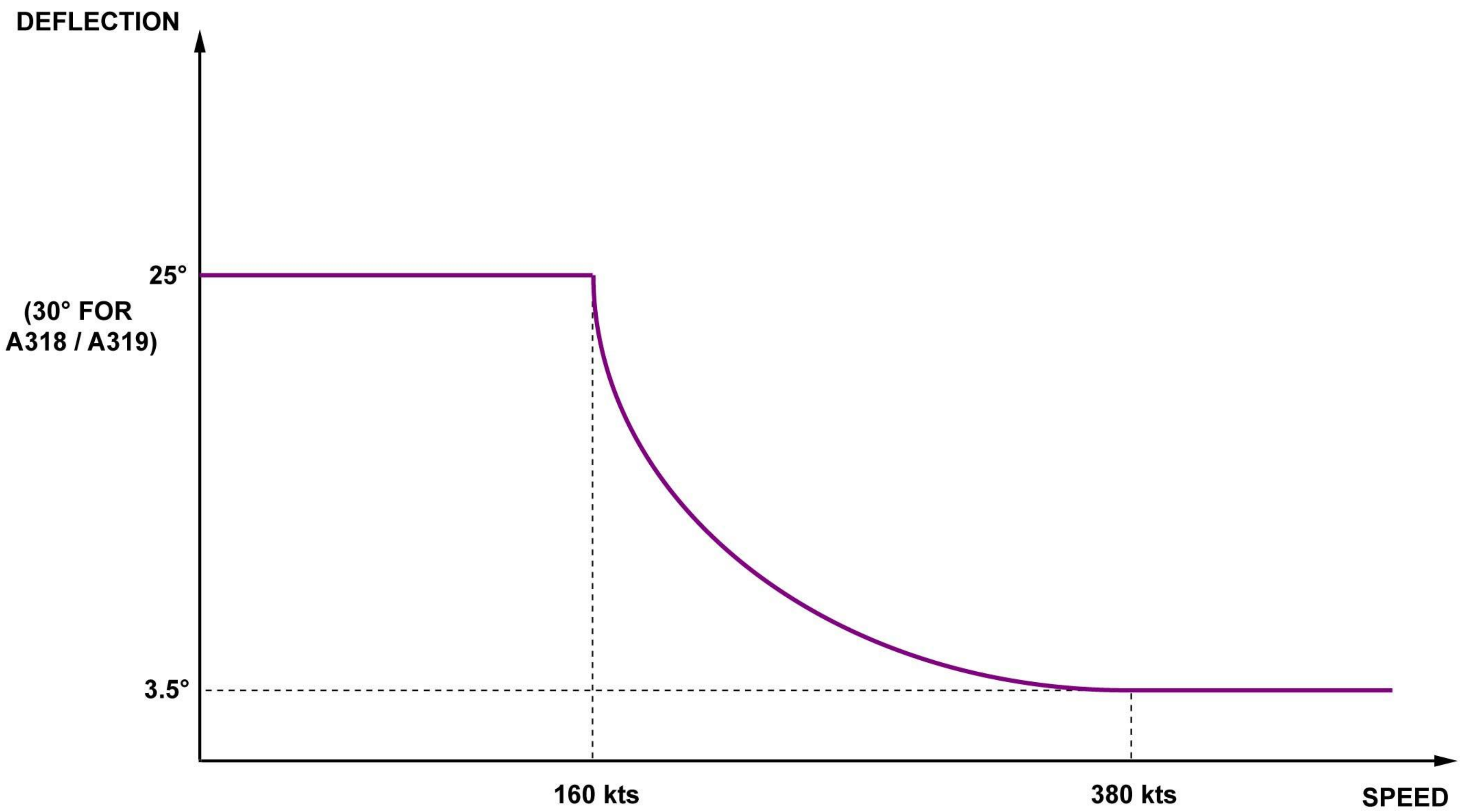
VARIABLE LIMITATION

Between 160 and 380 kts the rudder deflection is limited as a function of speed. The corresponding law is computed by the Flight Augmentation Computers (FACs).

HIGH SPEED CONFIGURATION

Above 380 kts the stops are in high-speed configuration. Only limited input/output lever movement to the rudder servo control is available.

LOW SPEED CONFIGURATION - HIGH SPEED CONFIGURATION



RUDDER LIMITER OPERATION

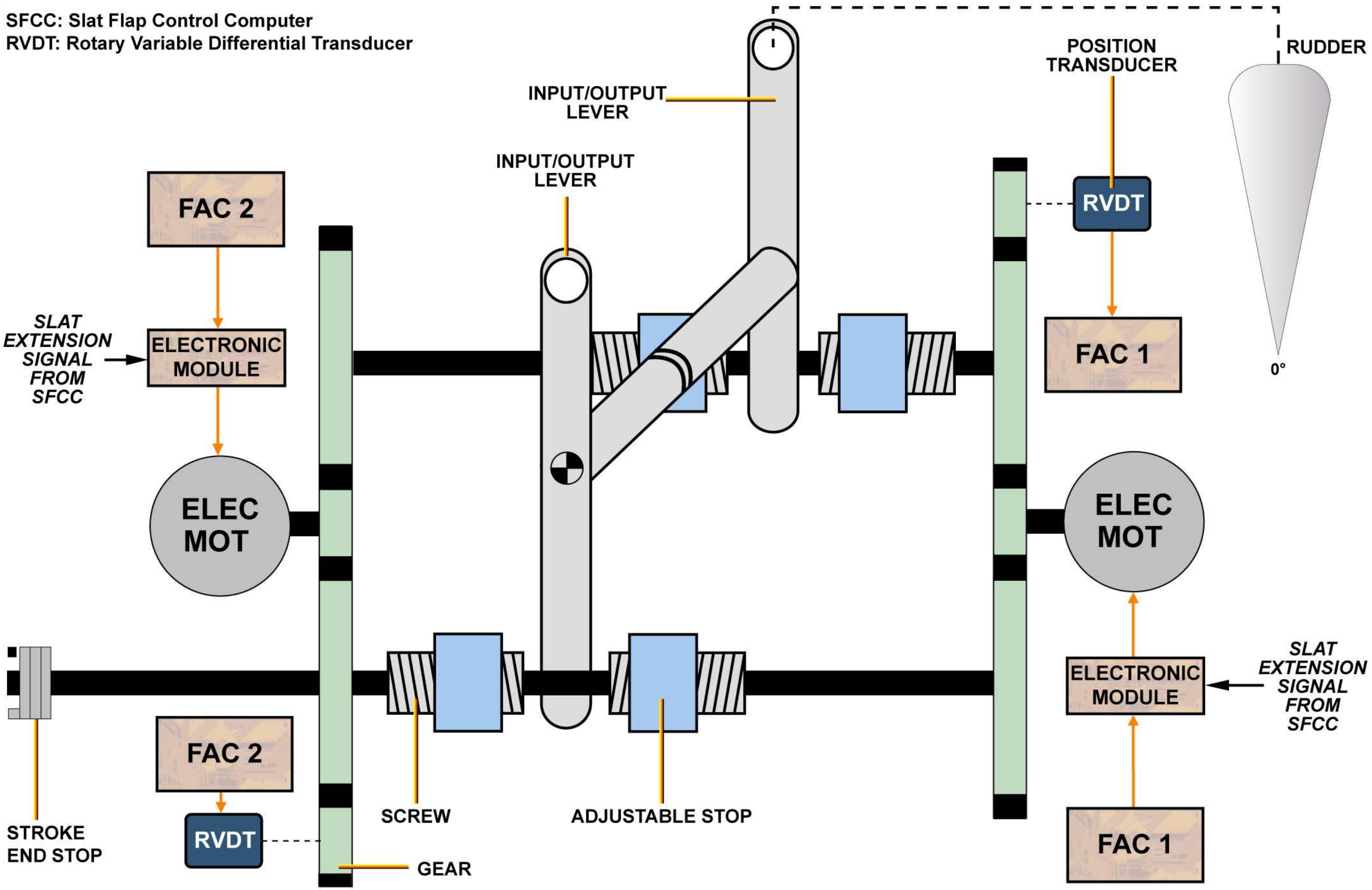
TRAVEL LIMITATION UNIT

The mechanical design of the Travel Limitation Unit (TLU) is such that a single mechanical failure (rupture or disconnection) cannot cause the loss of the travel limitation function. The TLU has two brushless electric motors separately controlled by an electronic assembly. Each motor drives two screws via a reduction gear and permits the symmetrical linear displacement of two nuts used as adjustable stops. A non-locking rotary stop limits the stroke of one of the screw/nut assemblies which are irreversible. There are two levers on each connection shaft; one is connected to the input rod and the other is used as a punctual stop. The movement of each screw is transmitted to a Rotary Variable Differential Transducer via the reduction gear which permits to indicate the position of the variable stop.

NOTE: To prevent icing, there is a heating system which includes two coils and their regulating thermostats.

TRAVEL LIMITATION UNIT

SFCC: Slat Flap Control Computer
RVDT: Rotary Variable Differential Transducer



RUDDER LIMITER OPERATION

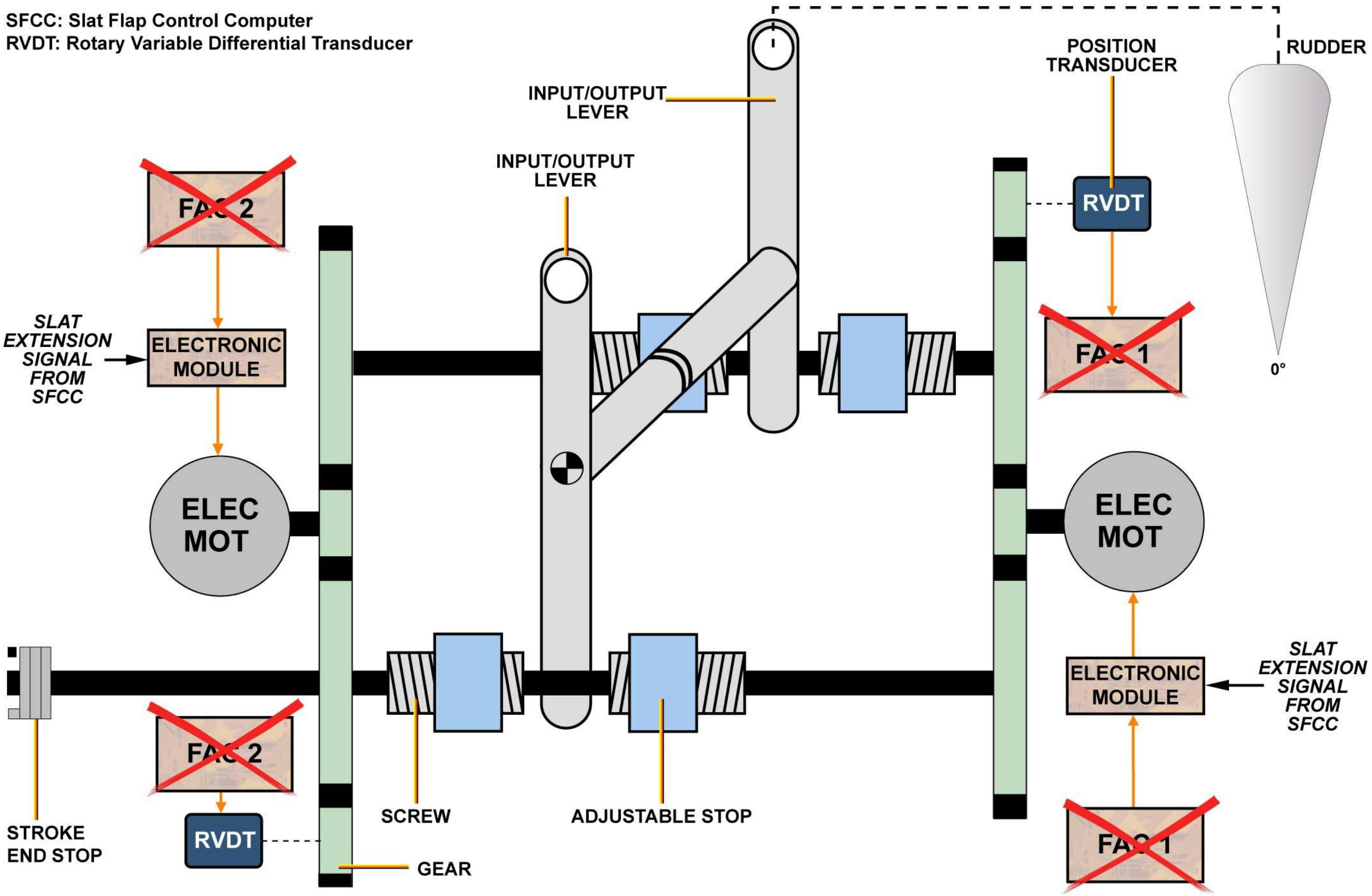
FAC

If both FACs fail, the rudder travel limitation value is frozen immediately. In this case, an emergency control brings back the stops to the low speed configuration (maximum possible deflection of the rudder) when slats are extended.

NOTE: To bring back the stops to the low speed configuration, the motors are used as 2-phase asynchronous motor energized by 26V 400 Hz power. This control mode is achieved when the coil of a specific relay (each motor has a relay) is energized for a period of 30 s approximately. This time is sufficient to bring back the stops to the low speed configuration.

FAC

SFCC: Slat Flap Control Computer
RVDT: Rotary Variable Differential Transducer



YAW DAMPER SERVO ACTUATOR OPERATION

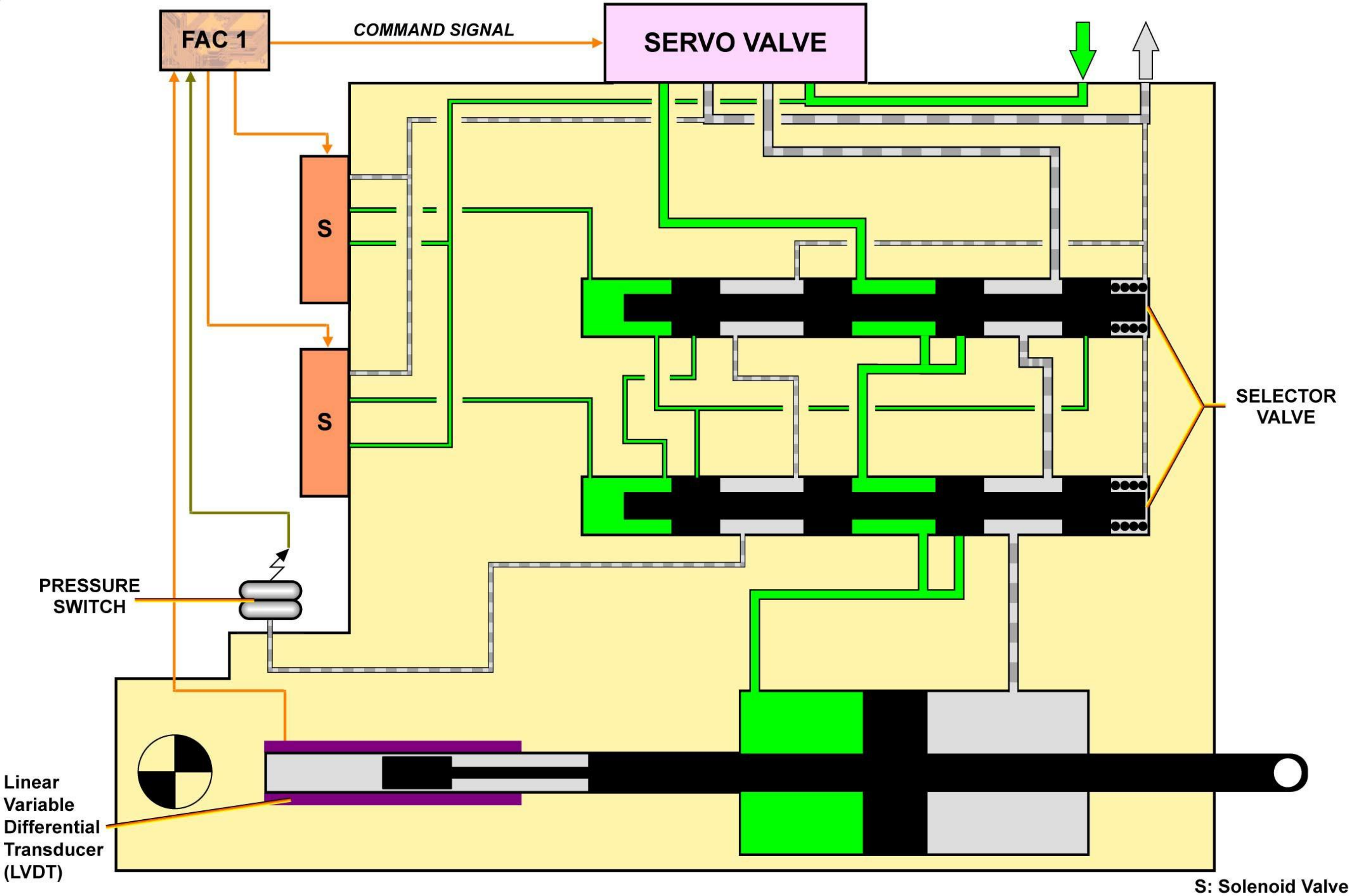
ACTIVE MODE

The actuator is in active mode when both solenoid valves are energized; the hydraulic pressure and the servo valve are available. The two selector valves are connected to the servovalve outputs and allow the servo actuator to operate in active mode. In this case the pressure switch is not activated. The feedback transducer of the Linear Variable Differential Transducer (LVDT) type supplies the servo loop feedback information to the Flight Augmentation Computers (FACs). FAC 1 controls and monitors the green servo actuator and FAC 2 the yellow one. Only one yaw damper at a time is in active mode, the other one is in a by-pass mode.

MONITORING

A pressure switch installed on to the servo actuator detects any different position between the selector valves.

ACTIVE MODE & MONITORING



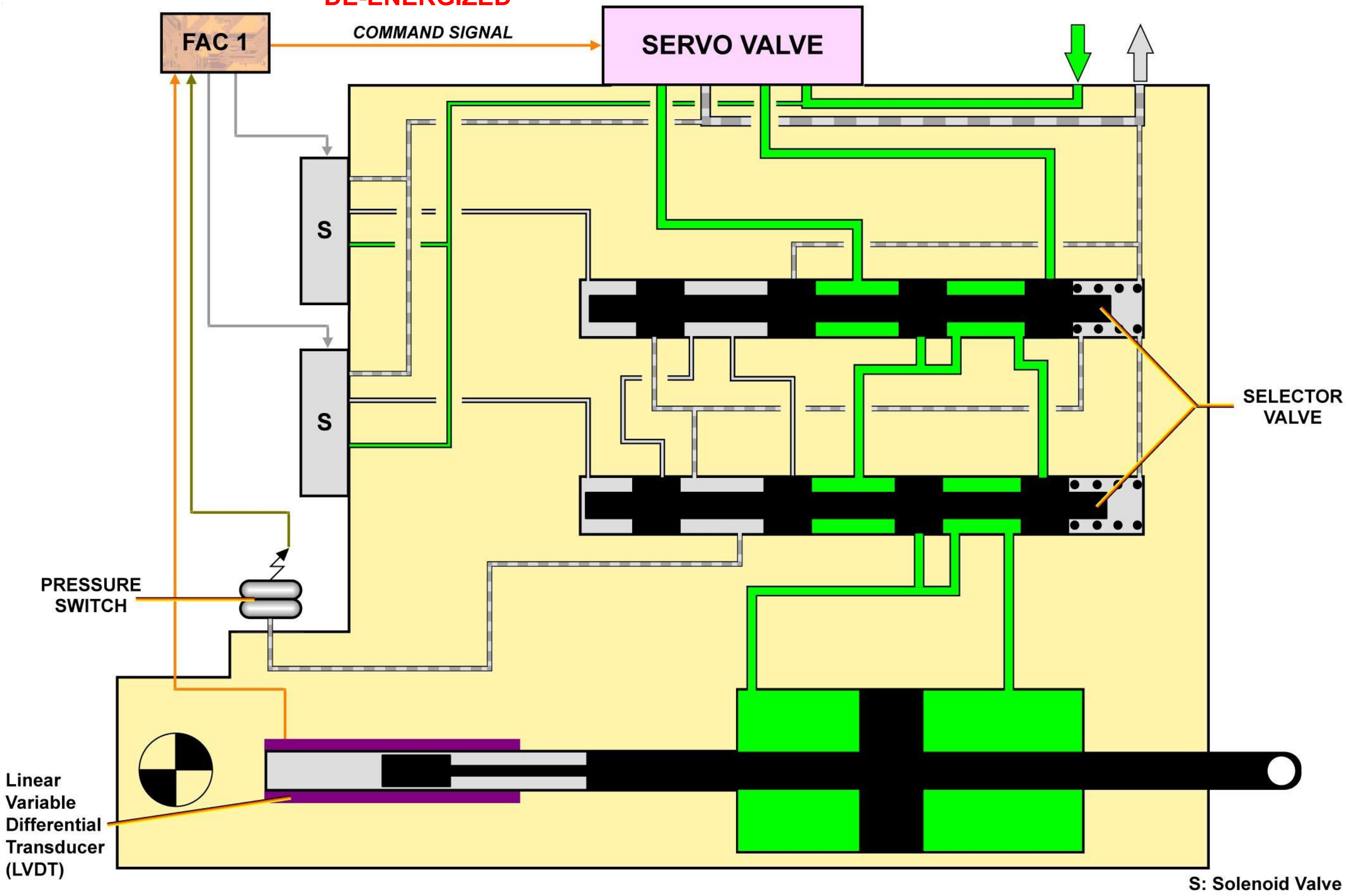
YAW DAMPER SERVO ACTUATOR OPERATION

BYPASS MODE

BOTH SOLENOID VALVES DE-ENERGIZED

The two-solenoid valves are de-energized and the associated selector valves are set to the bypass mode under the action of their spring. The two-piston chambers are, in this case, interconnected. The pressure switch is not activated.

BYPASS MODE - BOTH SOLENOID VALVES DE-ENERGIZED



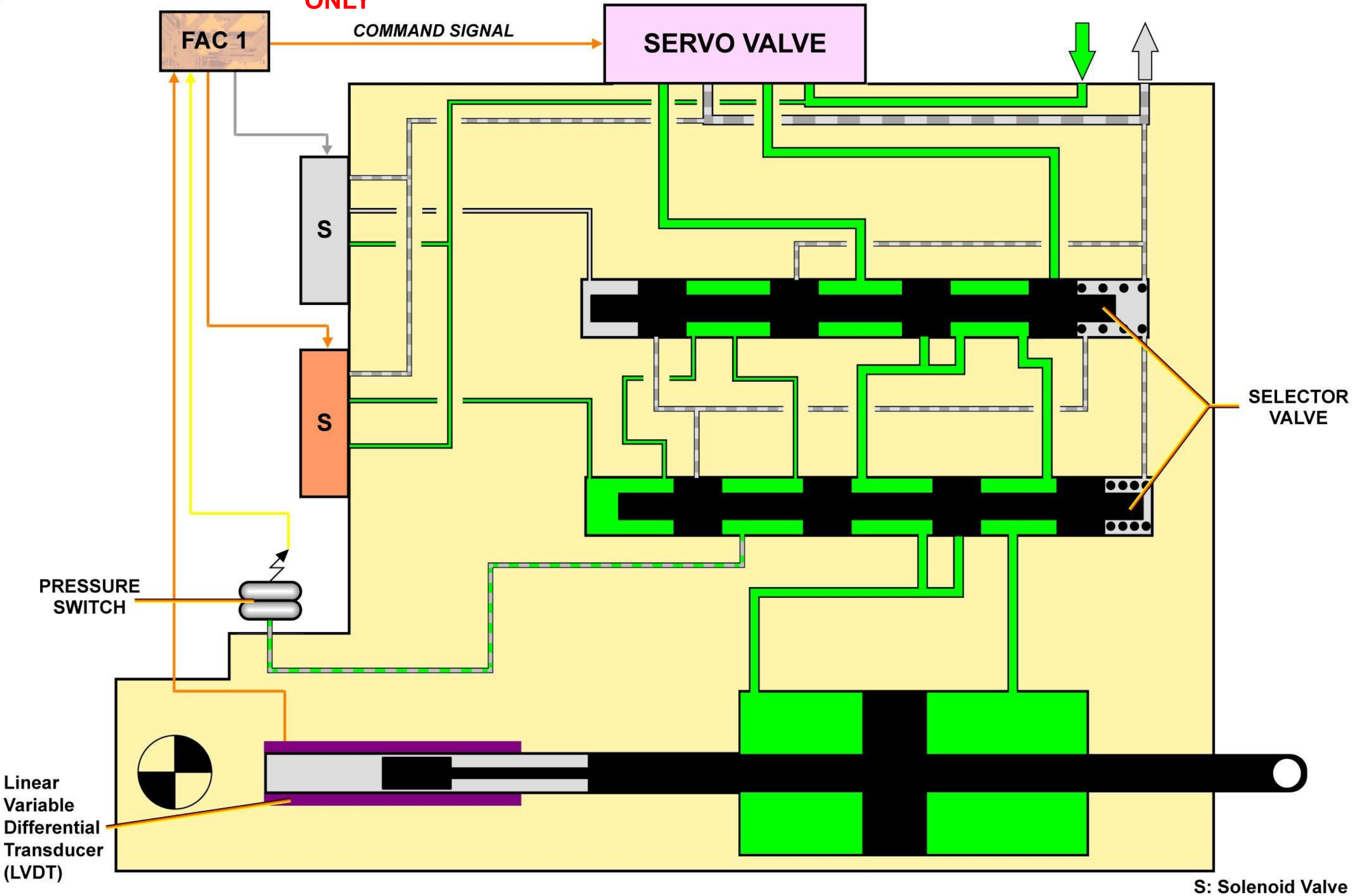
YAW DAMPER SERVO ACTUATOR OPERATION

BYPASS MODE (continued)

ONE SOLENOID VALVE DE-ENERGIZED ONLY

In case of a single electrical failure causing one selector valve to be in bypass mode, the other being in active mode, the result lies in the interconnection of the two actuator chambers, thus the actuator is in bypass mode. In this way, by means of the pressure switch, which is now connected to the supply pressure, this abnormal configuration is indicated to the FACs.

BYPASS MODE - ONE SOLENOID VALVE DE-ENERGIZED ONLY



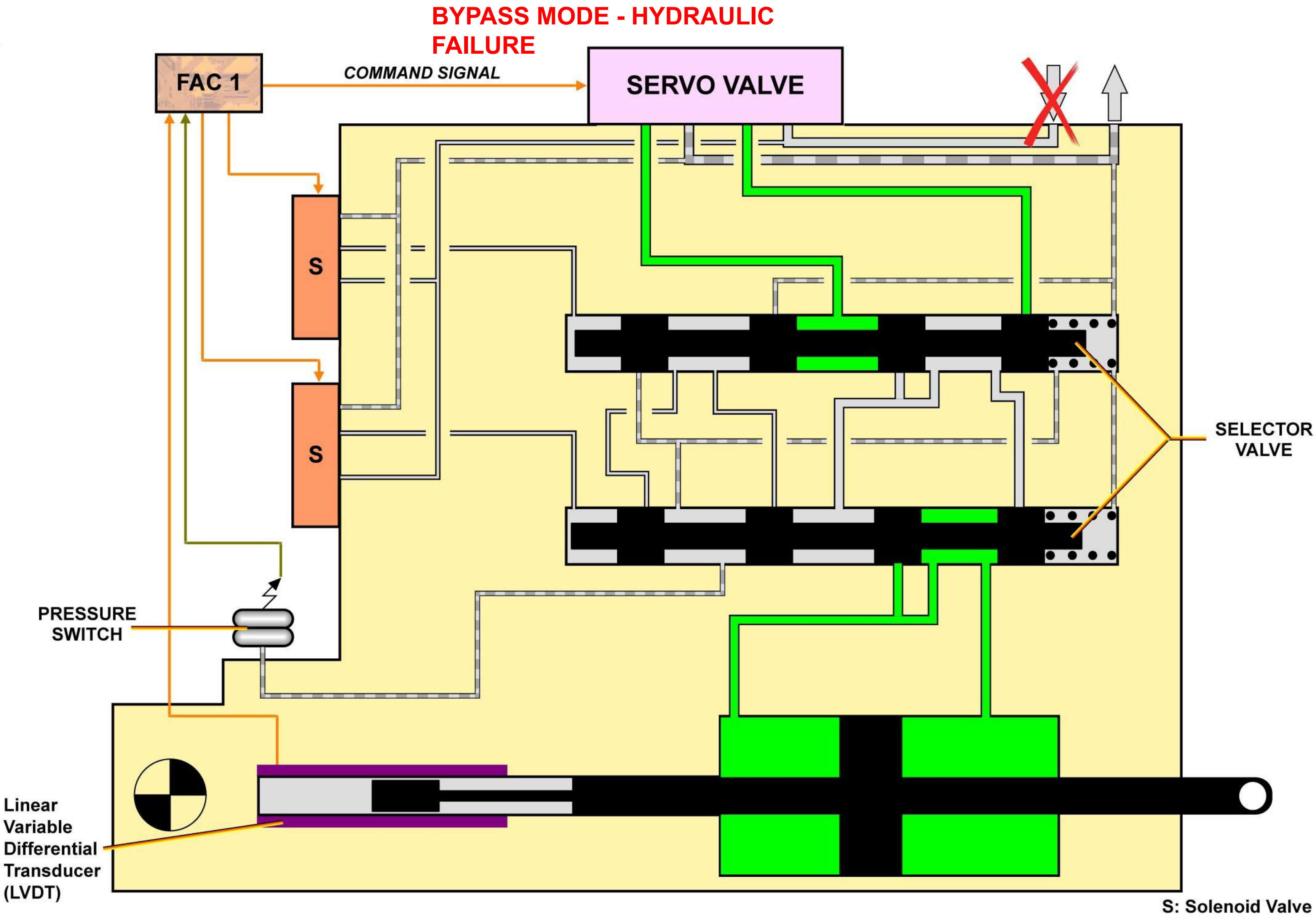
S: Solenoid Valve

YAW DAMPER SERVO ACTUATOR OPERATION

BYPASS MODE (continued)

HYDRAULIC FAILURE

With no hydraulic pressure, the two selector valves are set, under the action of their spring, in bypass mode, thus the two chambers of the piston are interconnected. In this case, the pressure switch is not activated.


BYPASS MODE - HYDRAULIC FAILURE
FAC 1
COMMAND SIGNAL
SERVO VALVE
S
S
SELECTOR VALVE
PRESSURE SWITCH
Linear Variable Differential Transducer (LVDT)
S: Solenoid Valve

SPEED BRAKE & GROUND SPOILER D/O

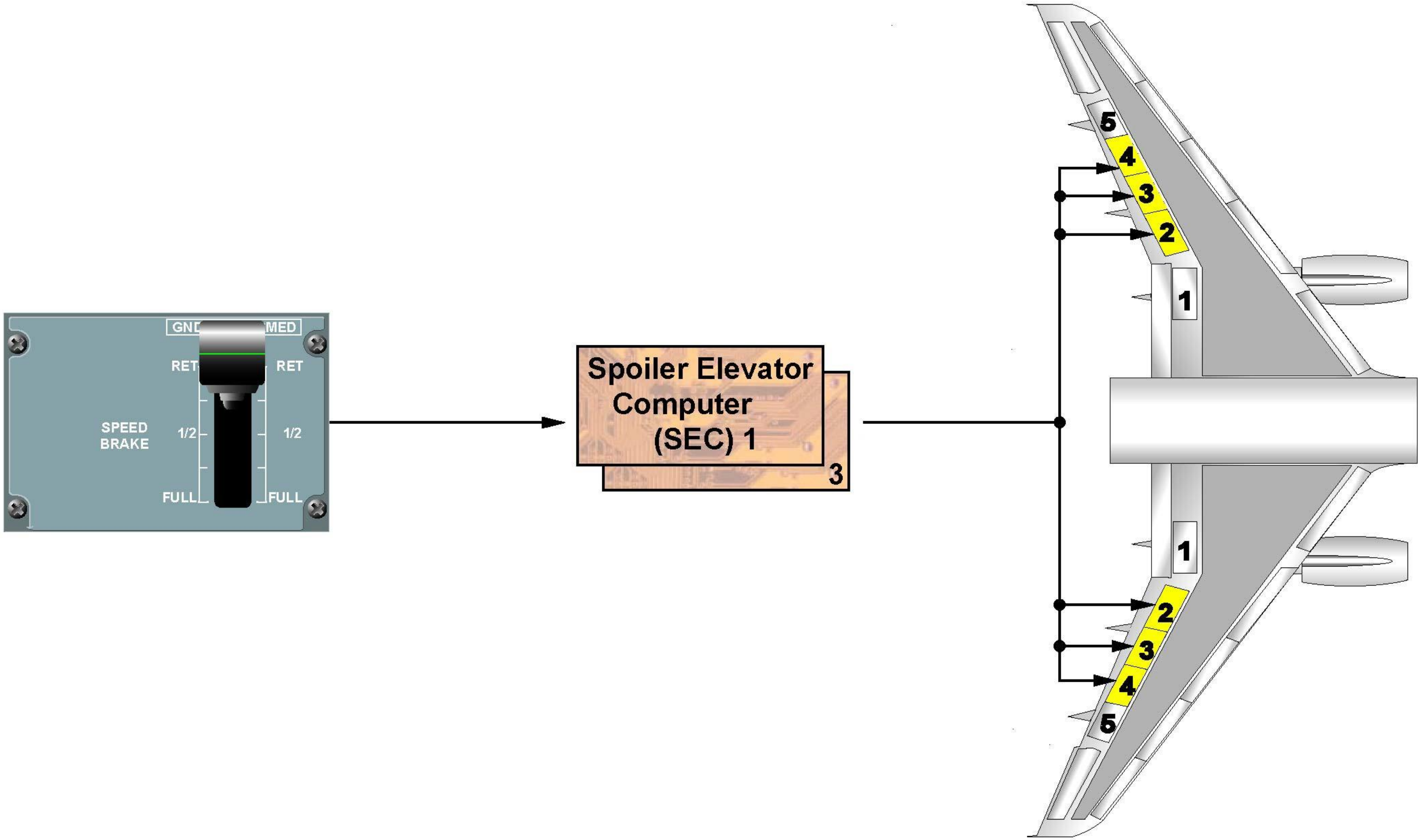
SPEED BRAKE FUNCTION

The speed brake function is commanded in the flight phase following a pilot's action on the speed brake lever. The speed brakes can be driven by Spoiler and Elevator Computers (SECs) 1 and 3, and supplied from the hydraulic system. The surfaces ensuring this function are spoilers 2 thru 4. When one surface is not available on one wing, the symmetrical one, on the other wing, is inhibited. The switching to alternate or direct laws does not affect the speed brake function.

The different priorities of this function are:

- the roll order has priority over the speed brake function. When the sum of roll and speed brake commands, relative to one surface, is greater than the maximum possible deflection, the symmetrical surface is retracted until the difference between the two surfaces is equal to the roll order,
- if the Angle-Of-Attack (AOA) protection is activated with speed brakes extended, the speed brakes are automatically retracted.

SPEED BRAKE FUNCTION



SPEED BRAKE & GROUND SPOILER D/O

SPEED BRAKE LOGIC

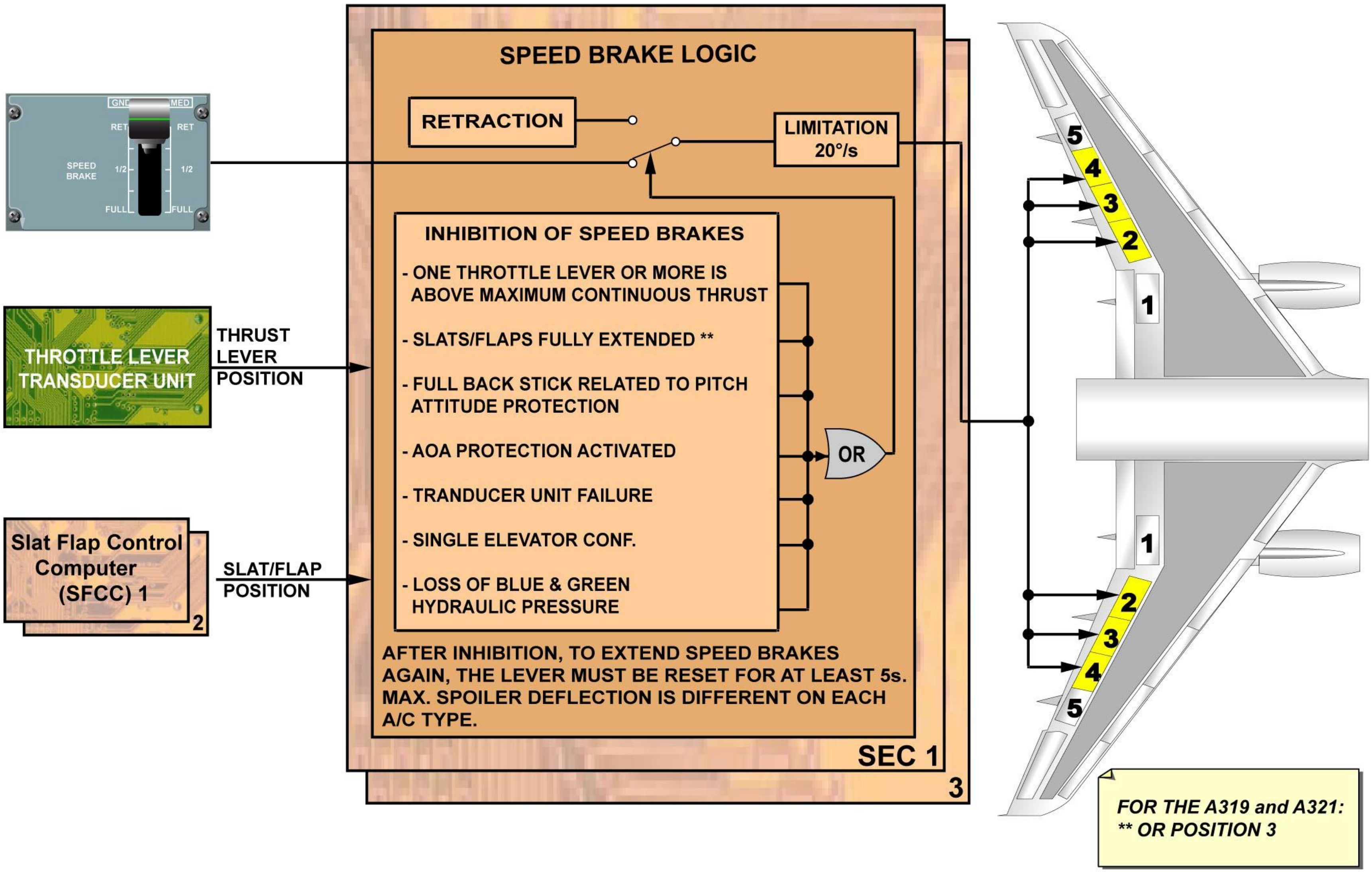
The speed brake control lever sends commands to the speed brakes. The SECs receive the information from the Slats and Flaps Control Computers (SFCCs) and the throttle lever transducer unit. Speed brake extension is inhibited in the conditions given below:

- failure of SEC 1 and 3,
- failure of left or right elevator (only spoilers 3 & 4 are inhibited),
- Angle-Of-Attack (AOA) protection is available,
- in FLAP FULL configuration (A320) or FLAP FULL or position 3 (A319/A321).

If speed brakes are extended, they automatically retract and stay retracted until the inhibition condition stops and the lever is reset. The SECs control a steep-approach function.

NOTE: For a steep-approach landing, on an A318, the SECs control the deflection of speed brakes No. 4, 3 and 2, to a maximum angle of 30°, 30° and 0° respectively. For a go-around, the maximum speed brake rate is 20°/s.

SPEED BRAKE LOGIC

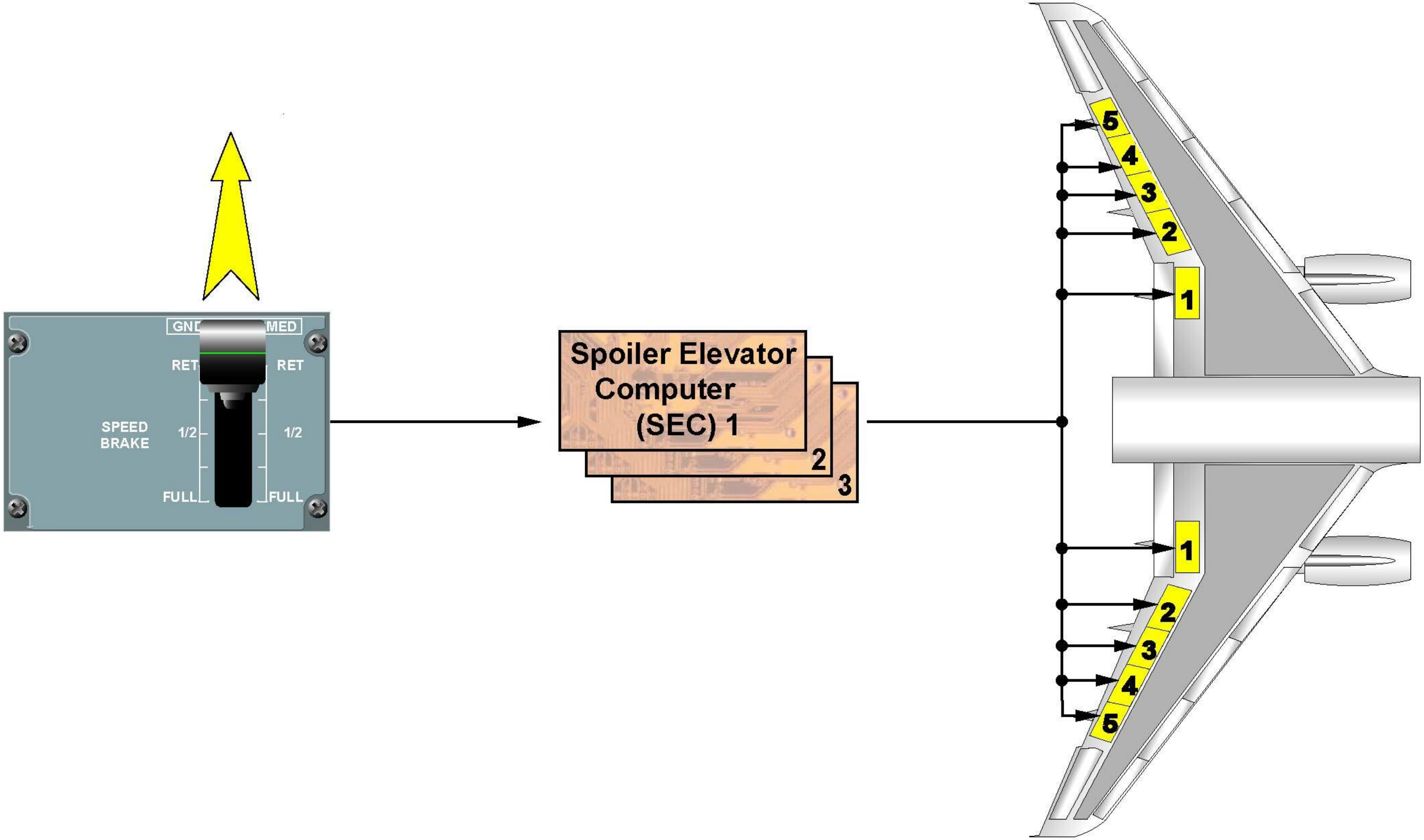


SPEED BRAKE & GROUND SPOILER D/O

GROUND SPOILER FUNCTION

When the logic conditions which determine the lift dumper extension are fulfilled, a deflection order is sent to spoilers 1 to 5, to 10º or 50º extension depending on the state of both Main Landing Gear (MLG) legs, compressed or not. Ground spoilers are armed when the speed brake control lever is pulled up, in manual mode. Moreover, a pitch pre-command at ground spoiler extension/retraction avoids induced pitch effects, in normal or AP mode. The ground spoiler function is automatic.

GROUND SPOILER FUNCTION



SPEED BRAKE & GROUND SPOILER D/O

GROUND SPOILER LOGIC

The ground spoiler control is entirely automatic. Achieved by the spoilers 1 to 5. The maximum deflection is 50° with a deflection rate of 30°/second.

The ground spoilers are armed:

• when the speed brake control lever is pulled up into the ARMED position.

Ground spoilers automatically extend when armed:

• both thrust levers at forward idle and both MLG touch down (Flight / Ground transition),

• or during Take Off (TO) run at speed greater than 72 knots (kts) and both thrust levers retarded at forward idle.

Ground spoilers automatically extended (not armed):

• when both MLG touch down and reverse is selected on at least one engine (remaining engine at idle),

• or during TO run speed greater than 72 kts and reverse is selected on at least one engine (remaining engine at idle).

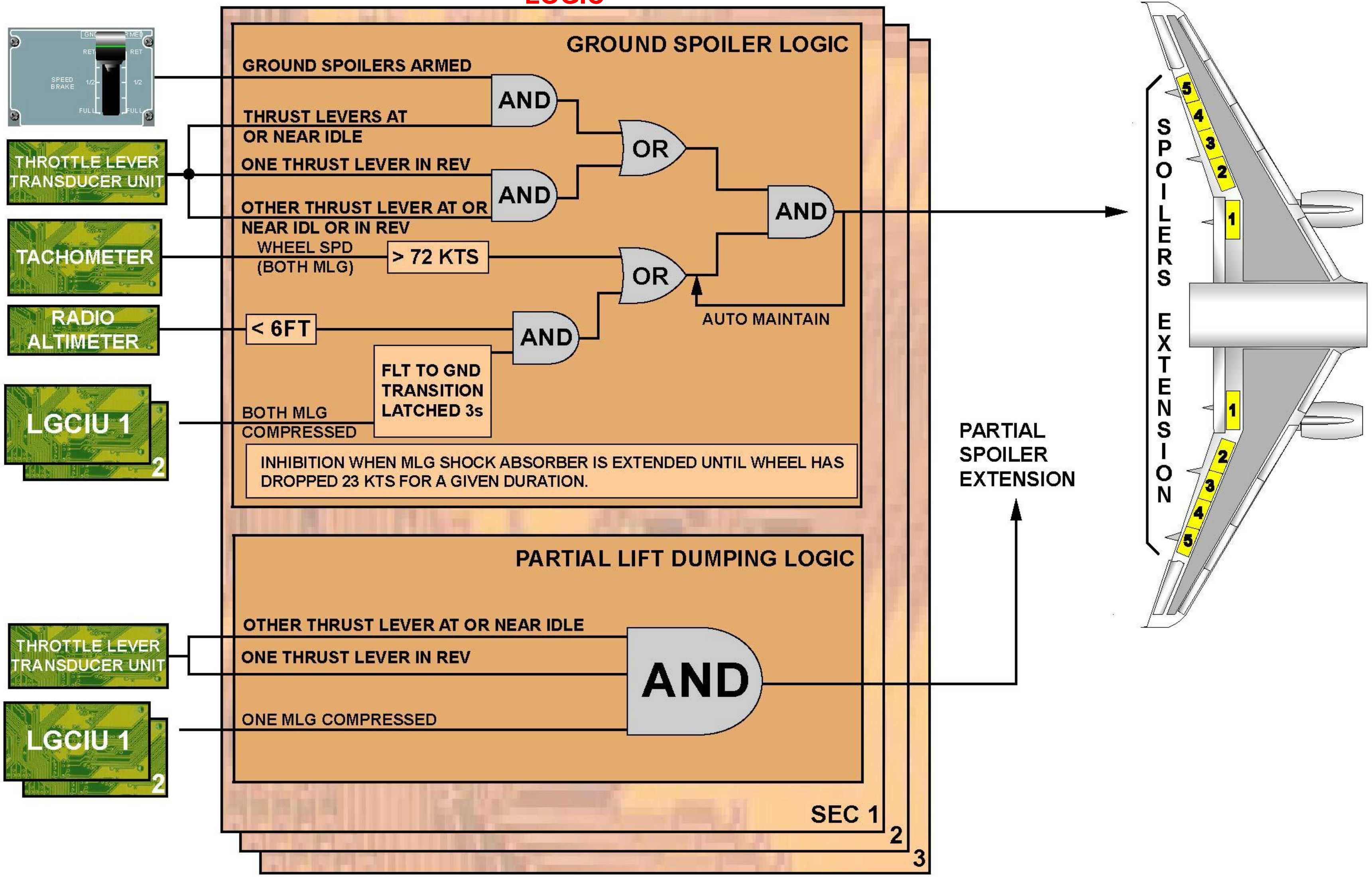
Ground spoilers partially extend:

• when reverse is selected on at least one engine (remaining engine at idle) and one MLG is compressed.

This partial extension (10°), by decreasing the lift, will ease the compression of the second MLG, and consequently will lead to the normal ground spoiler extension.

NOTE: The speed brake handle will not move during spoiler deflection or retraction. The spoiler position will be displayed on the lower ECAM display WHEEL page.

GROUND SPOILER LOGIC



FOR TRAINING PURPOSES ONLY

PITCH

PITCH CONTROL NORMAL D/O

SIDE STICK
The side stick sends electrical orders to the ELevator Aileron Computers (ELACs) and Spoiler Elevator Computers (SECs).

ELAC
There are two ELACs. ELAC 2 normally controls the elevators and Trimmable Horizontal Stabilizer (THS) with ELAC 1 as a backup. In case of ELAC 2 failure, ELAC 1 automatically takes over.

SEC
In case of dual ELACs failure, SEC 1 or 2 automatically takes over pitch control.

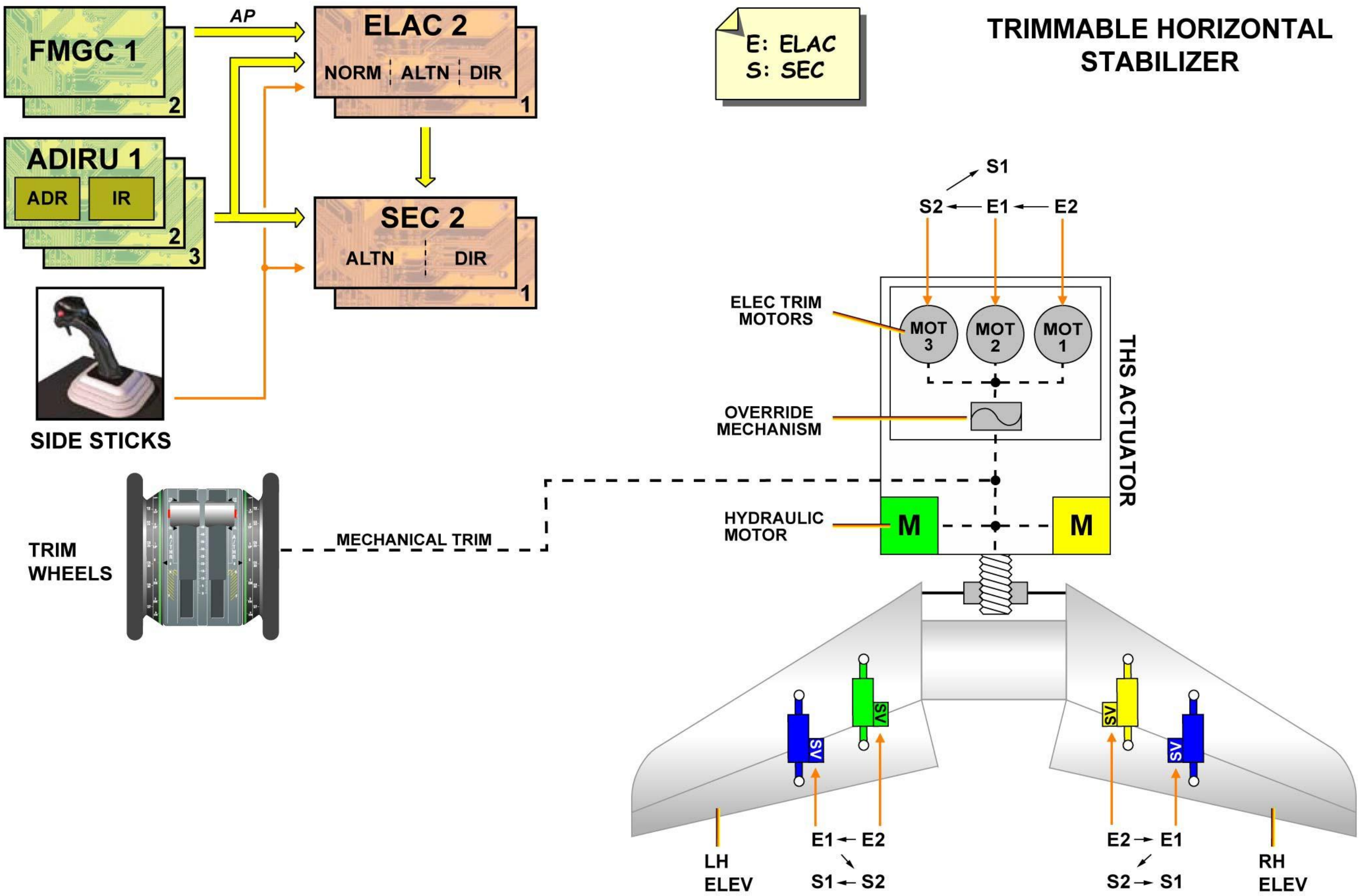
FMGC
When the Autopilot (AP) is engaged, the Flight Management and Guidance Computer (FMGC) sends AP commands to the ELACs.

ELEVATORS
Each elevator is powered by two actuators, one in active mode, and the other in damping mode with automatic changeover in case of failure. Both actuators become active in case of large pitch demands. ELAC 2 controls the green and yellow actuators and ELAC 1 controls the blue actuators.

THS
The THS is positioned by a screw actuator driven by two hydraulic motors, which are controlled by one of the three electric motors. One electrical trim motor is operative at a time, and the other two are in standby. Motor 1 is controlled by ELAC 2, motor 2 by ELAC 1 or SEC 1, and motor 3 by SEC 2.

TRIM WHEELS
The mechanical trim, which has priority over the electrical trim, is operated from the manual trim wheels.

SIDE STICK - TRIM WHEELS



PITCH CONTROL ABNORMAL D/O

ALTERNATE LAW

If the normal law of the ELevator Aileron Computer (ELAC) 2 fails, the control goes to the ELAC 1.
If the normal law of both ELACs fails, the alternate law takes over. The failures lead to an activation of the alternate law with reduced protections.

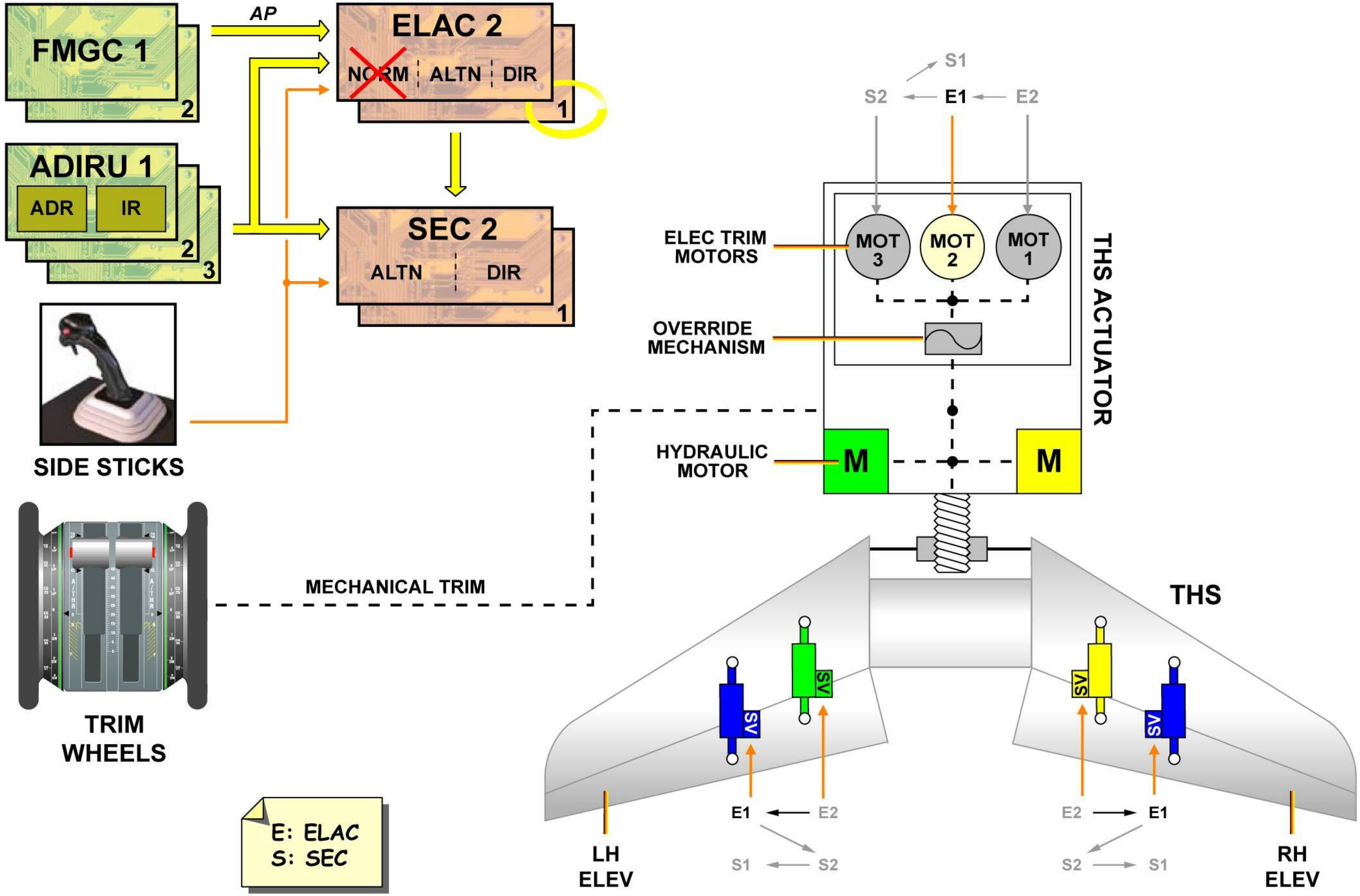
IN ELAC WITH PROTECTIONS

Alternate law with reduced protections including load factor and stability augmentation, is active in ELAC 1 or 2 in case of either:
- double self-detected Air Data Reference (ADR) or Inertial Reference (IR) failure,
- 2nd not self-detected ADR failure,
- double hydraulic failure blue and green or yellow and green,
- loss of roll normal law,
- alternate law active in ELAC 1 with emergency electrical supply.

IN ELAC WITHOUT PROTECTIONS

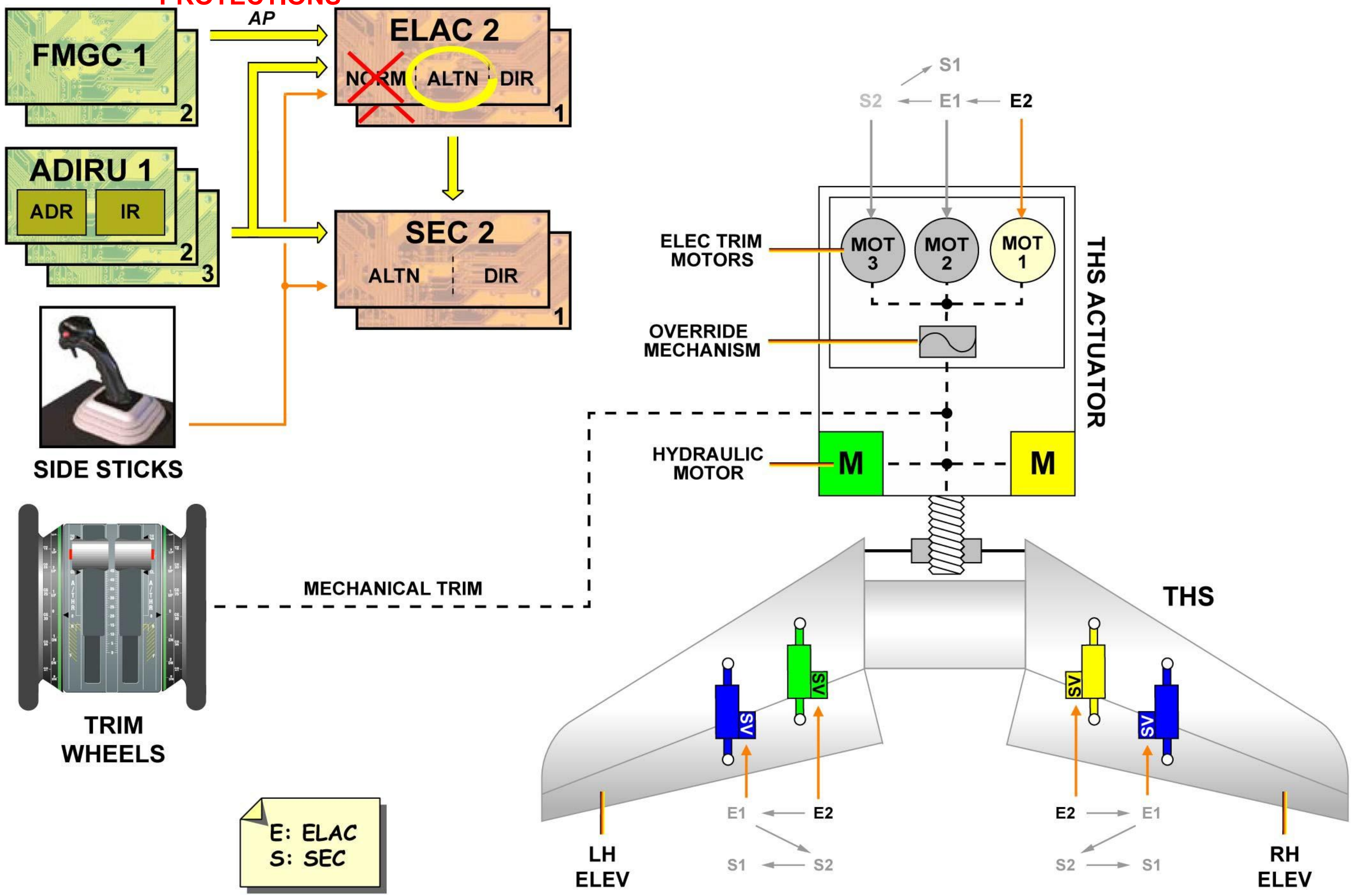
Depending on the failures, the pitch channel can switch to an alternate law without protections. Alternate law without protection including stability augmentation lost and load factor protection retained, is active in ELAC 1 or 2 in case of either:
- 2nd not self-detected ADR failure,
- triple ADR failure.

ALTERNATE LAW - IN ELAC WITH PROTECTIONS & IN ELAC WITHOUT PROTECTIONS



FOR TRAINING PURPOSES ONLY

ALTERNATE LAW - IN ELAC WITH PROTECTIONS & IN ELAC WITHOUT PROTECTIONS



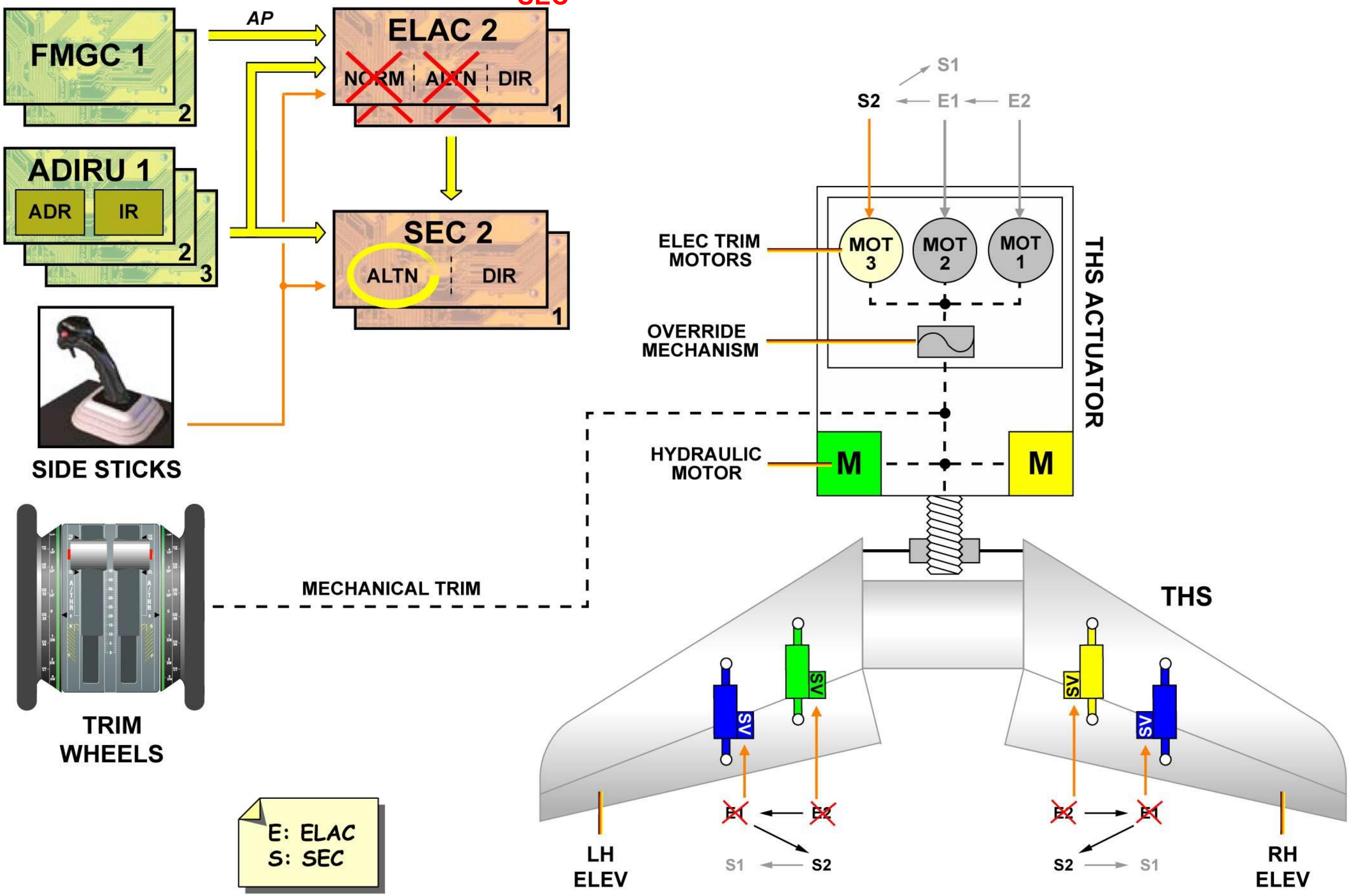
PITCH CONTROL ABNORMAL D/O

ALTERNATE LAW (continued)

IN SEC

After a double ELAC failure, alternate law with or without stability augmentation, becomes active in the Spoiler Elevator Computer (SEC).

ALTERNATE LAW - IN SEC



PITCH CONTROL ABNORMAL D/O

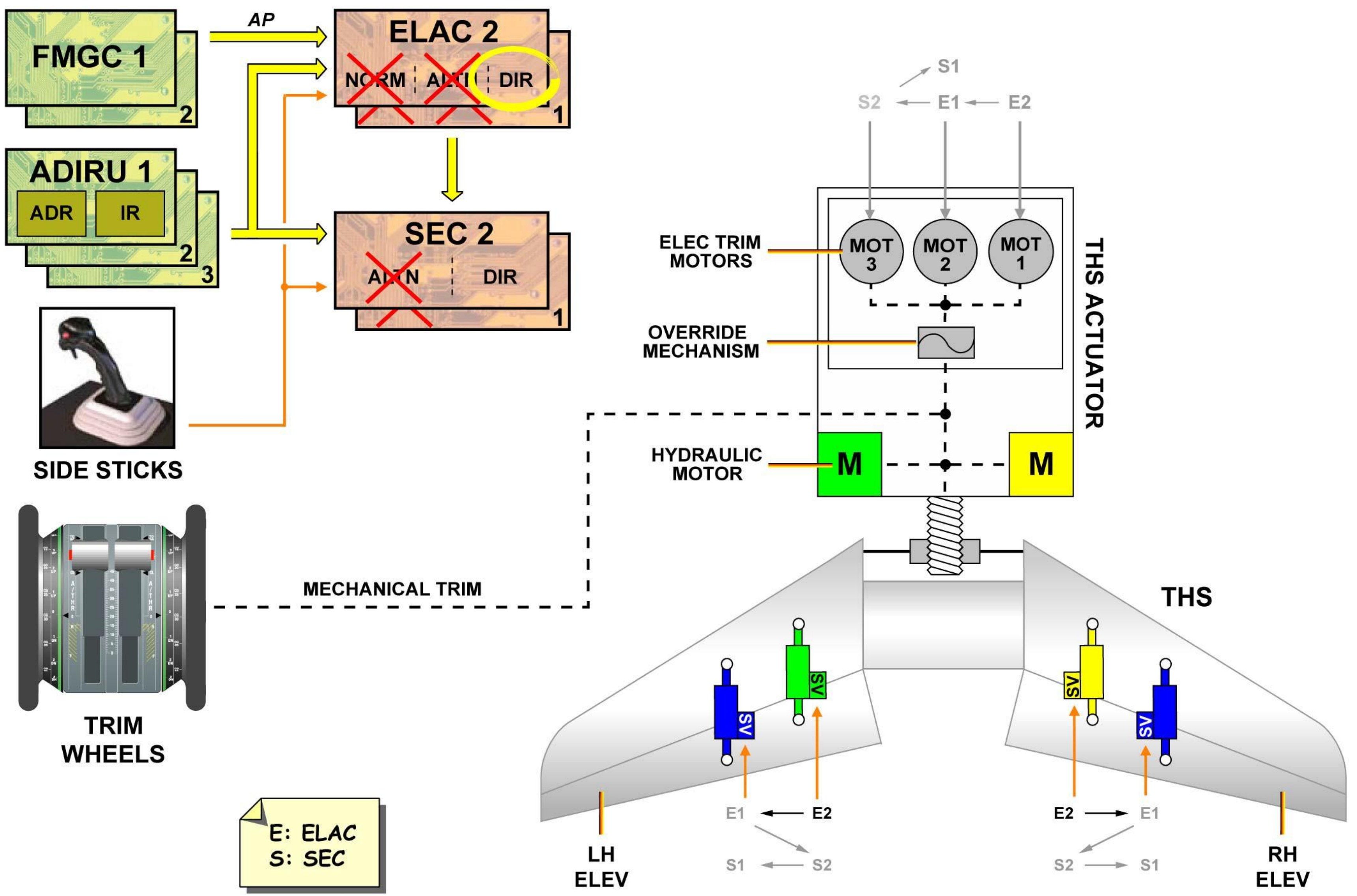
DIRECT LAW

If the alternate law is lost, the direct law computed in ELAC 1 or 2 becomes active.
The pitch direct law is active in case of either:

- dual IR failure,
- triple IR failure,
- failure of the RA.

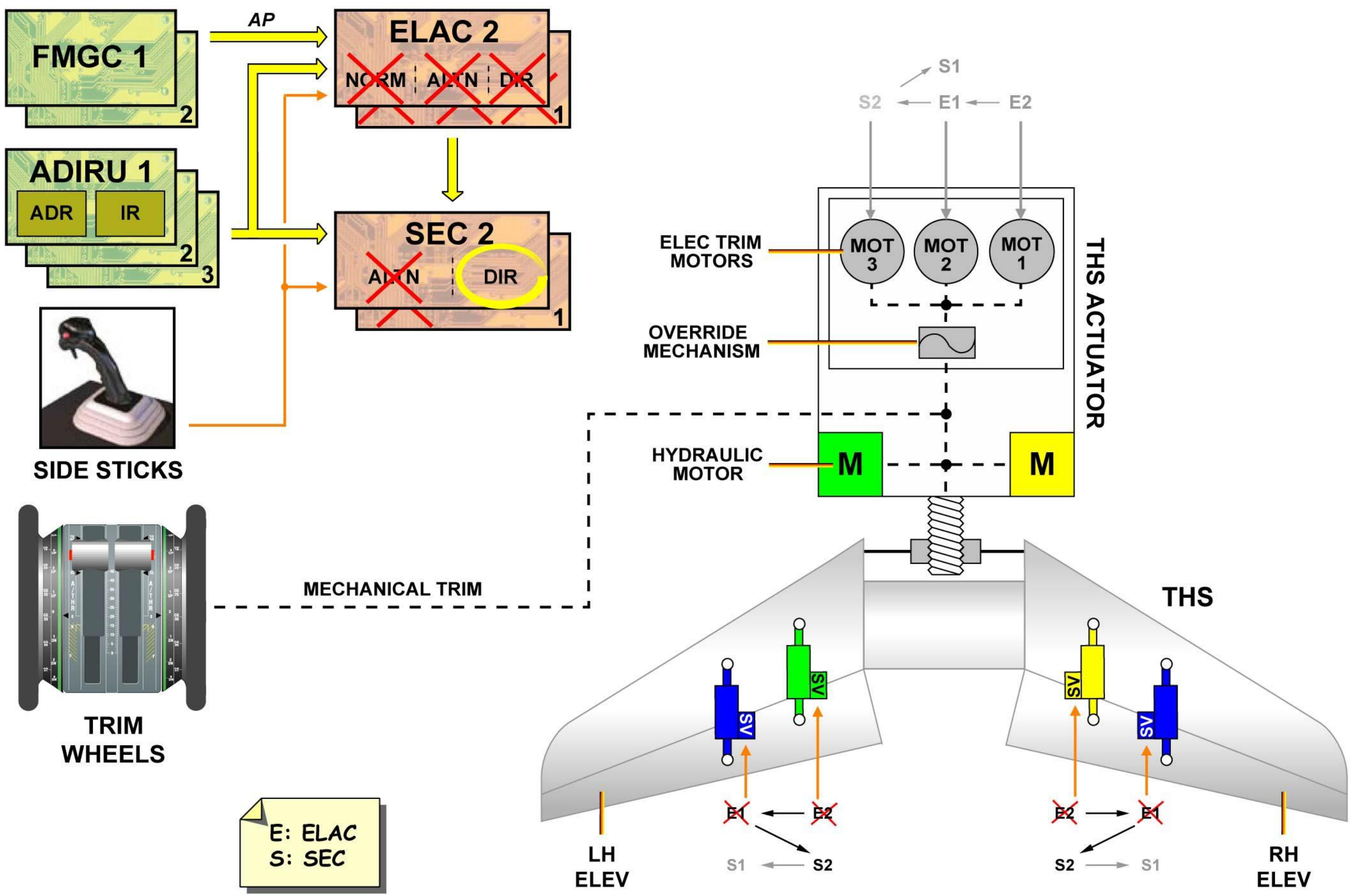
The auto trim is lost and the crew has to use the mechanical trim.
In case of loss of both ELACs when the alternate law is already lost, the direct law computed in SEC 1 or 2 becomes active.

DIRECT LAW



FOR TRAINING PURPOSES ONLY

DIRECT LAW

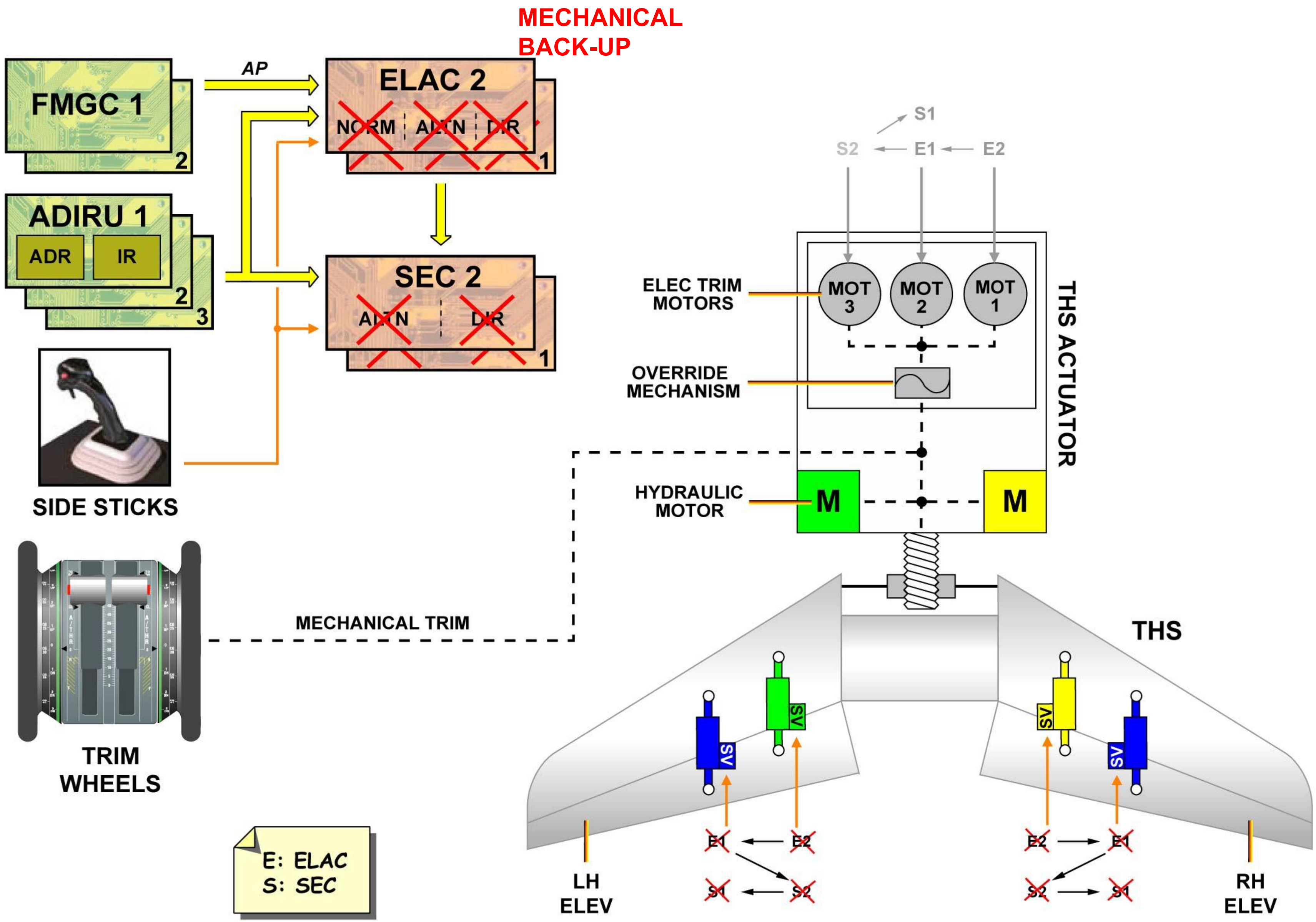


FOR TRAINING PURPOSES ONLY

PITCH CONTROL ABNORMAL D/O

MECHANICAL BACK-UP

In case of total electrical failure or loss of all computers, pitch control can be achieved by the mechanical trim system. The four elevator actuators are in centering mode.

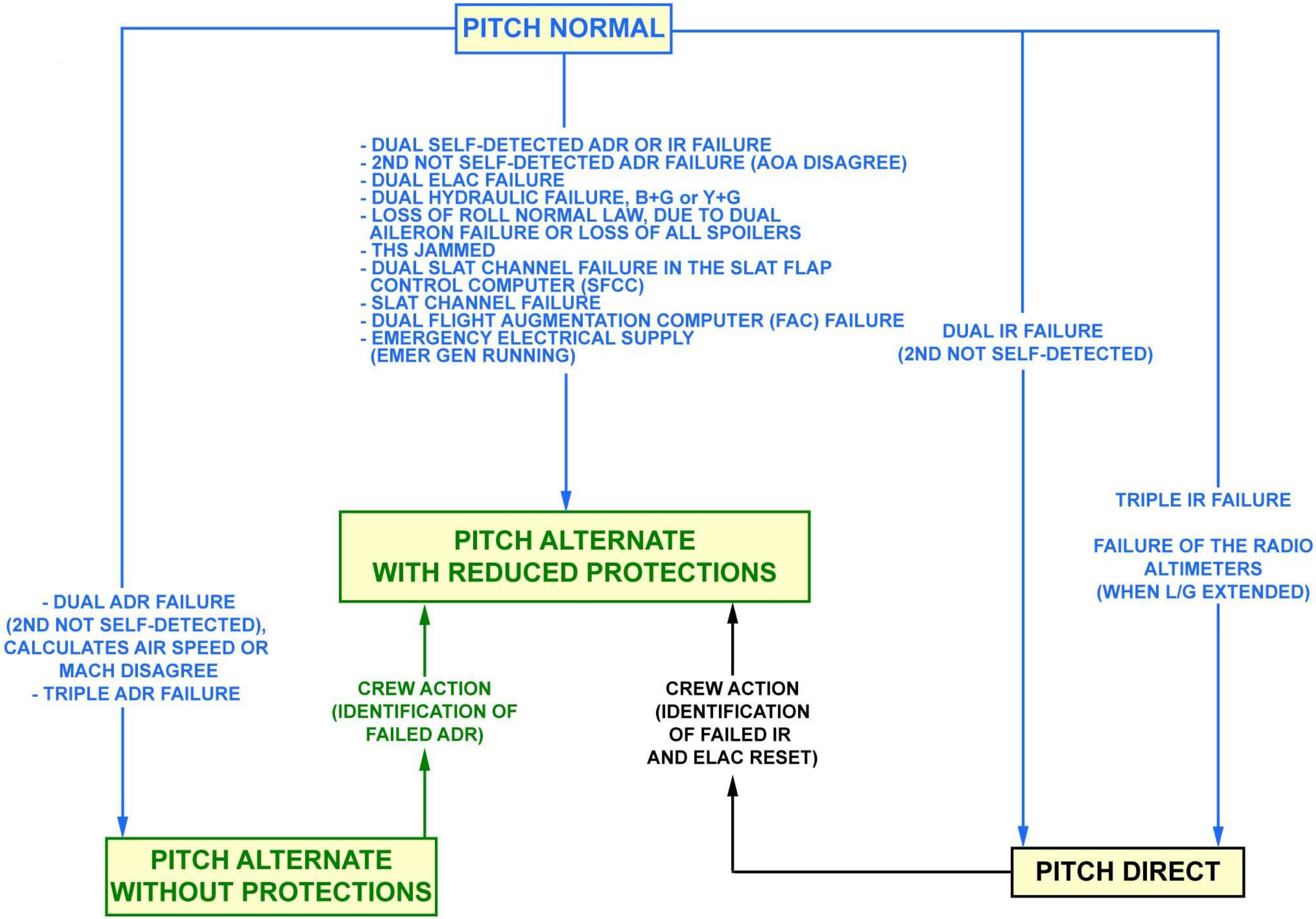

MECHANICAL
BACK-UP
AP
FMGC 1
2
ELAC 2
NORM
ALTN
DIR
1
ADIRU 1
ADR
IR
2
3
SEC 2
ALTN
DIR
1
SIDE STICKS
TRIM
WHEELS
MECHANICAL TRIM
E: ELAC
S: SEC
S1
S2
E1
E2
ELEC TRIM
MOTORS
MOT
3
MOT
2
MOT
1
THS ACTUATOR
OVERRIDE
MECHANISM
HYDRAULIC
MOTOR
M
M
THS
SV
LH
ELEV
RH
ELEV

PITCH CONTROL ABNORMAL D/O

PITCH LAW RECONFIGURATION

This diagram summarizes the pitch law reconfiguration.

PITCH LAW RECONFIGURATION

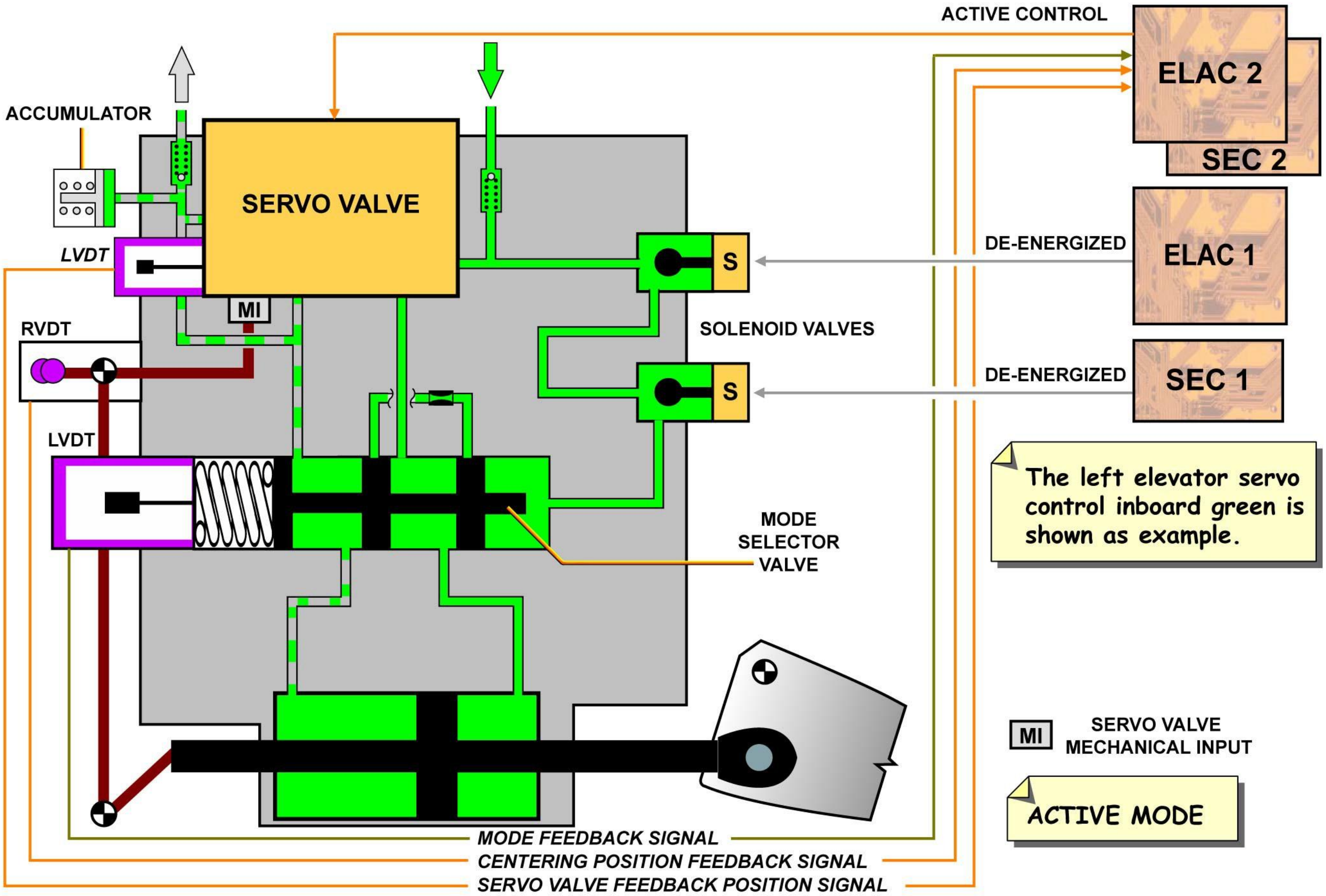


ELEVATOR SERVO CONTROL OPERATION

ACTIVE MODE

When the elevator servo control is in the active mode, it is pressurized and both solenoid valves are de-energized. The servo valve is controlled by one computer at a time.

ACTIVE MODE

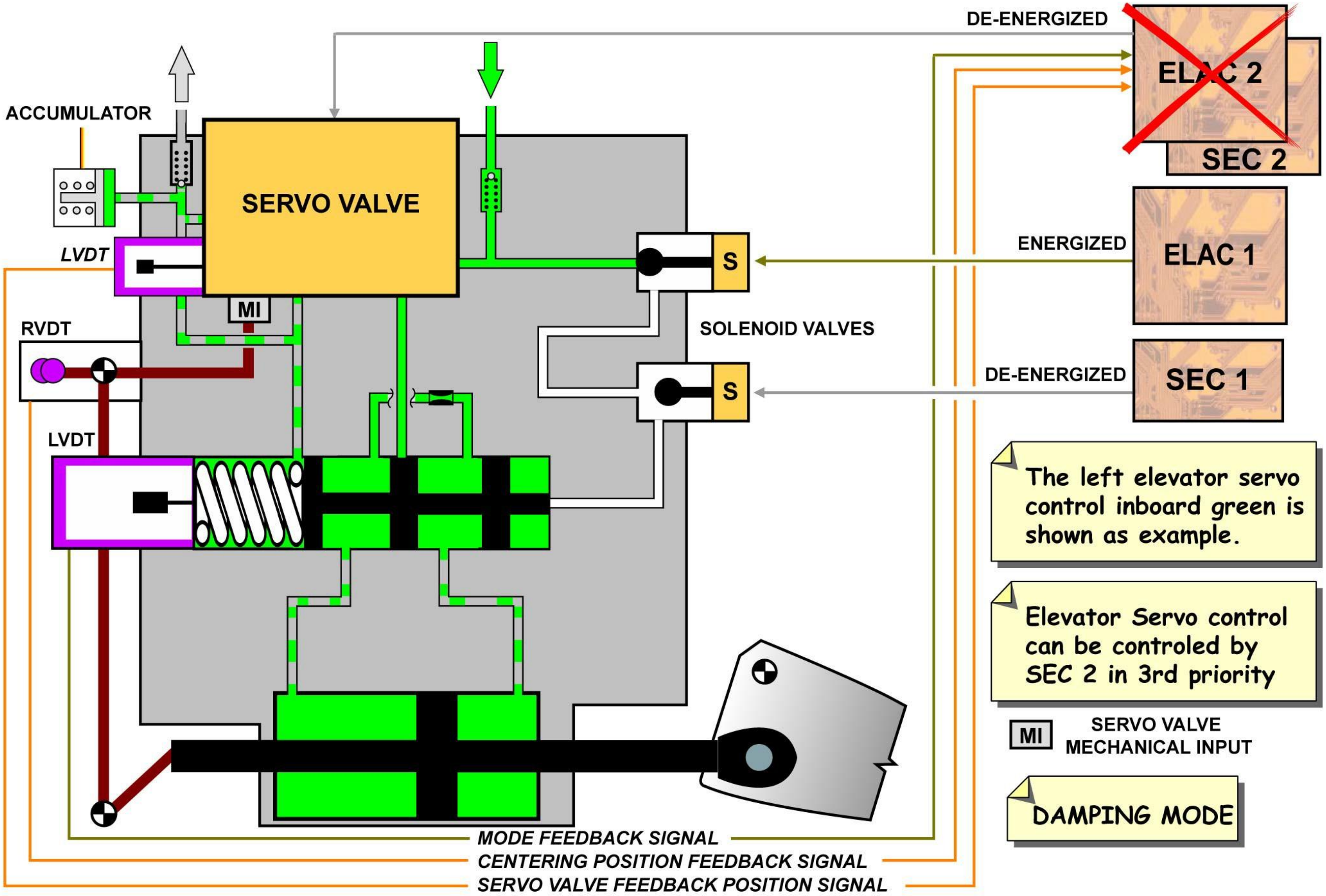

ACTIVE CONTROL
ELAC 2
SEC 2
ACCUMULATOR
SERVO VALVE
LVDT
MI
RVDT
DE-ENERGIZED
ELAC 1
S
SOLENOID VALVES
DE-ENERGIZED
SEC 1
S
LVDT
MODE
SELECTOR
VALVE
The left elevator servo control inboard green is shown as example.
MI
SERVO VALVE
MECHANICAL INPUT
ACTIVE MODE
MODE FEEDBACK SIGNAL
CENTERING POSITION FEEDBACK SIGNAL
SERVO VALVE FEEDBACK POSITION SIGNAL

ELEVATOR SERVO CONTROL OPERATION

DAMPING MODE

In case of a computer failure (e.g. ELAC2 failure), the related solenoid valve is energized by the other computer and the elevator servo control is in the damping mode as it is the actuator that is depressurized. This causes the interconnection of the two actuator chambers through the damping orifice.

DAMPING MODE



The left elevator servo control inboard green is shown as example.

Elevator Servo control can be controled by SEC 2 in 3rd priority

MI SERVO VALVE MECHANICAL INPUT

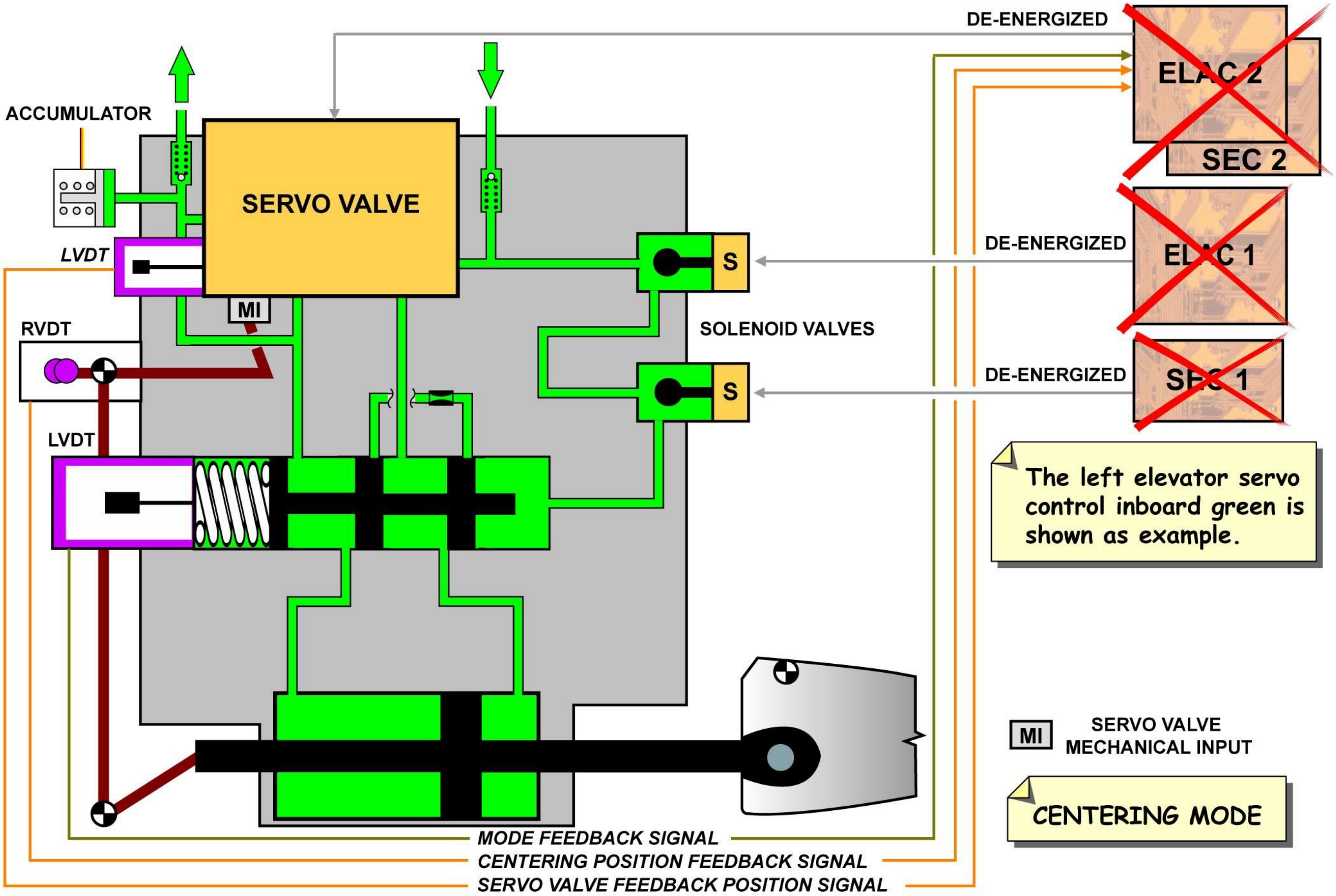
DAMPING MODE

ELEVATOR SERVO CONTROL OPERATION

RE-CENTERING MODE

When the elevator servo control is in the re-centering mode, it is pressurized, the solenoid valves and servo valve are de-energized, the servo valve is centered to the neutral position by its mechanical input. Due to the centering device, the servo control actuator is maintained hydraulically in its neutral position.

RE-CENTERING MODE



FOR TRAINING PURPOSES ONLY

THS ACTUATOR OPERATION

THS DESCRIPTION

HYDRAULIC MOTORS

Both hydraulic motors drive the ball screw actuator through a power differential gearbox. It moves up or down a ball nut on which the Trimmable Horizontal Stabilizer (THS) surface is mounted.

VALVE BLOCKS

One valve block is given for each hydraulic motor.

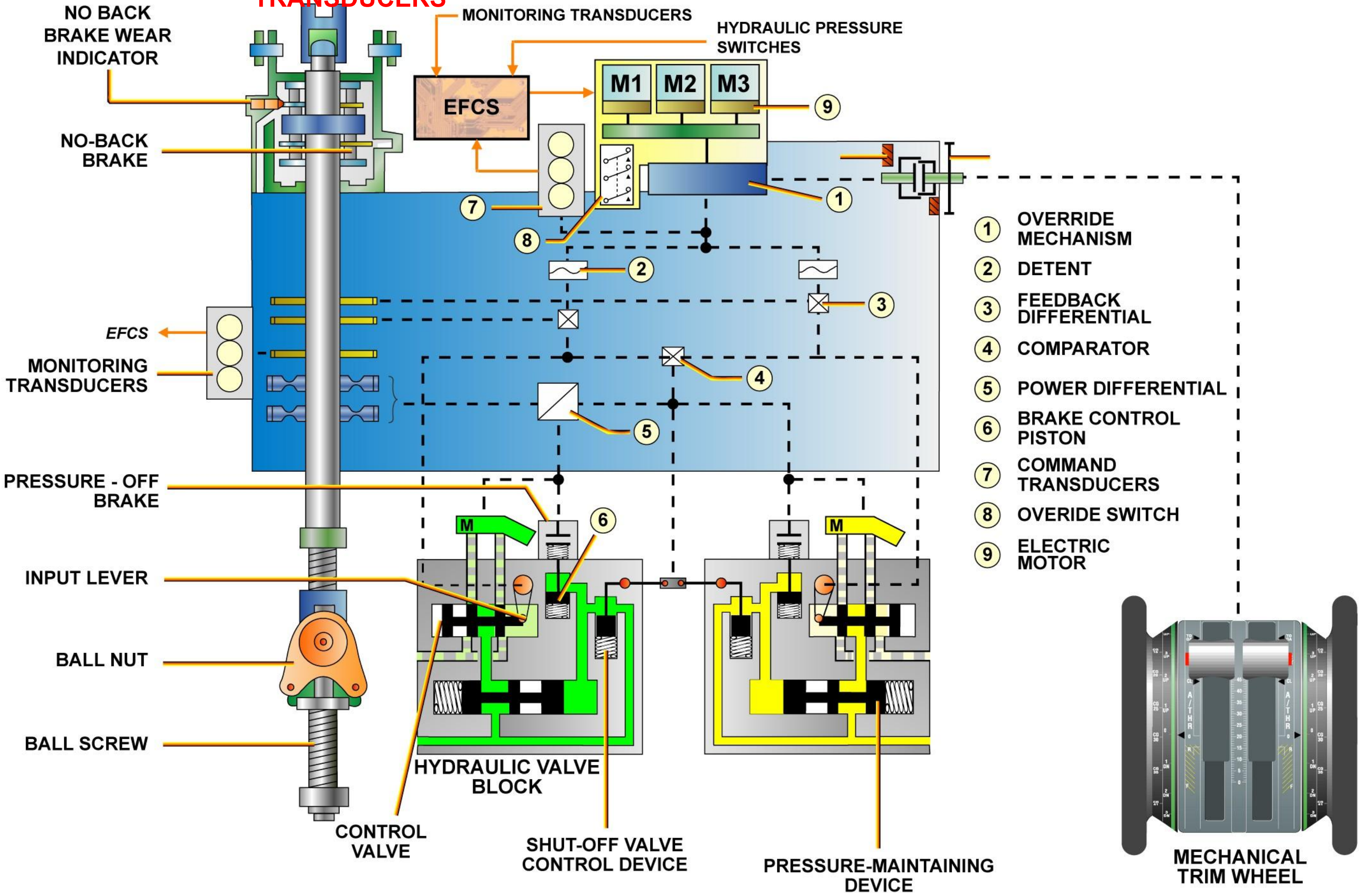
PRESSURE OF BRAKES

The Pressure-Off Brakes (POBs) are applied in case of hydraulic pressure loss.

POSITION TRANSDUCERS

The THS actuator has two inductive position transducer packages. They are the command position transducer and the monitor position transducer. Position transducers are installed to feed back the actual position of the override mechanism output and the ball screw position to the Electrical Flight Control System (EFCS) computer.

THS DESCRIPTION - HYDRAULIC MOTORS - POSITION TRANSDUCERS



THS ACTUATOR OPERATION

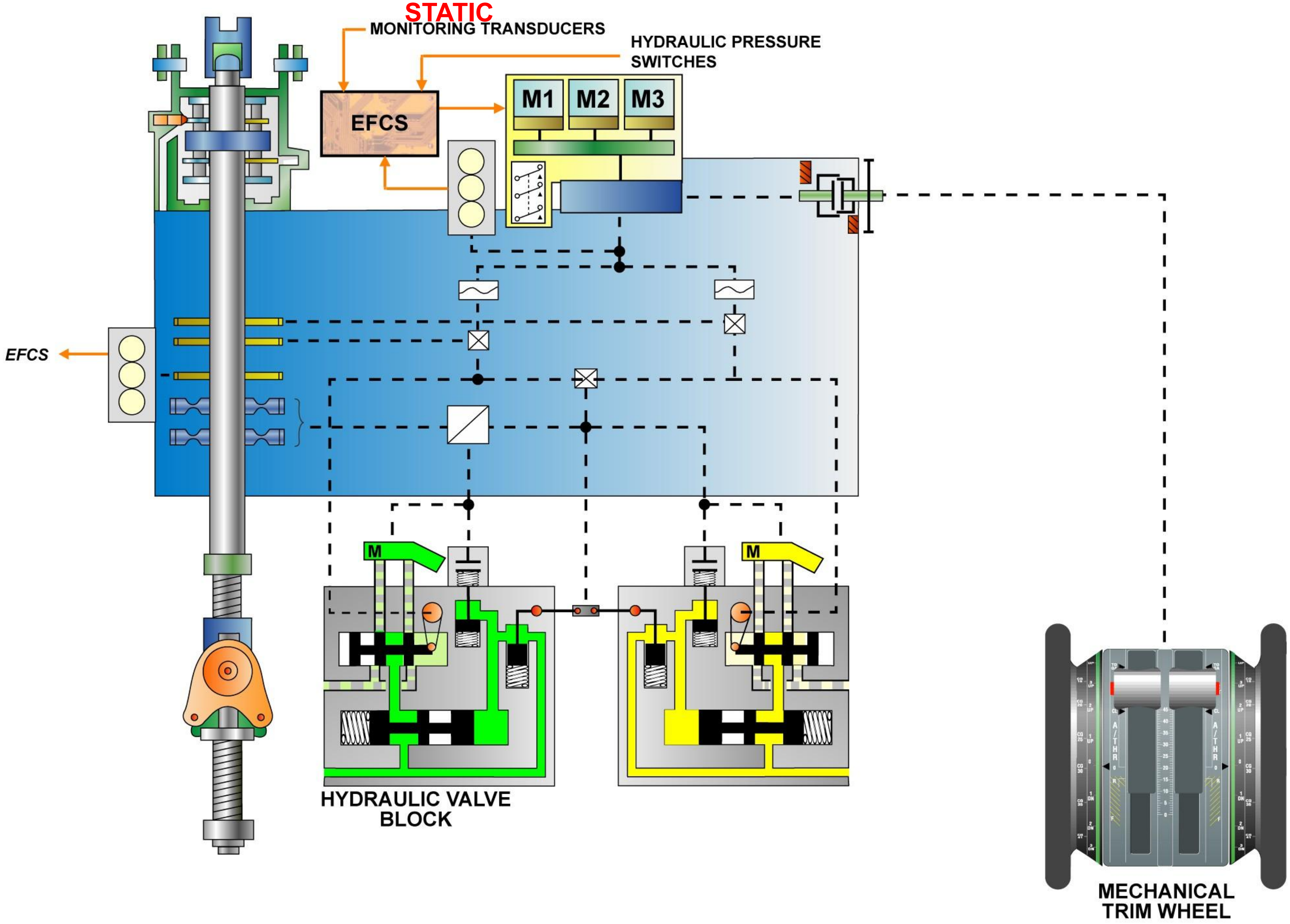
THS OPERATION

THS STATIC

In the Static mode:

- there is no input (no electrical power at all three electrical motors and no mechanical command),
- the control valves are in neutral position,
- the chambers at each end of the control valves are connected to return.

THS OPERATION - THS STATIC



THS ACTUATOR OPERATION

THS OPERATION (continued)

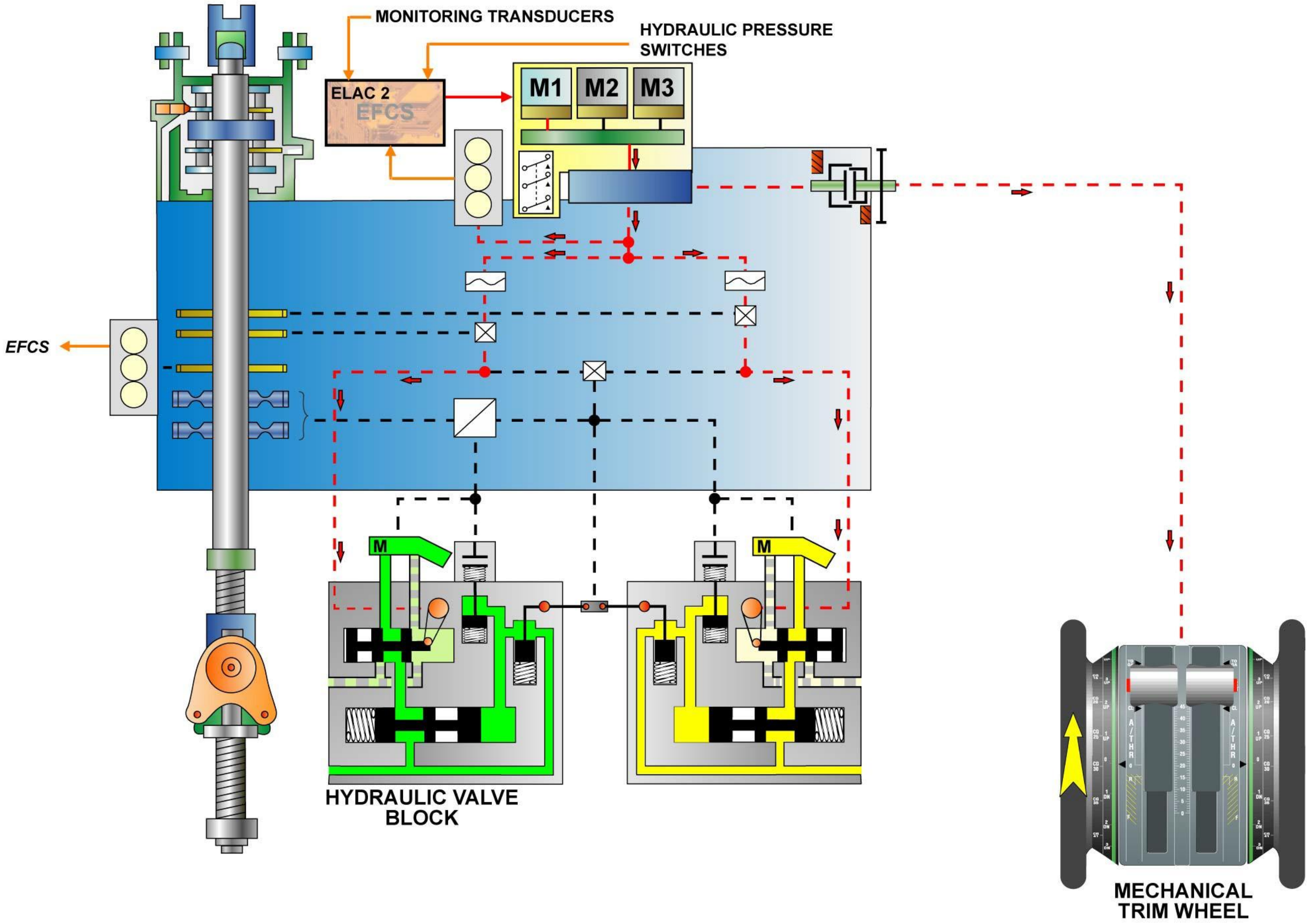
NORMAL OPERATION

ELAC2 (in normal control) sends a drive command to the servomotor No1.The electrical motor No1 causes the input levers and control valves to move and at the same time a mechanical feedback signal is sent from the override mechanism to the cockpit causing the trim wheels to move.

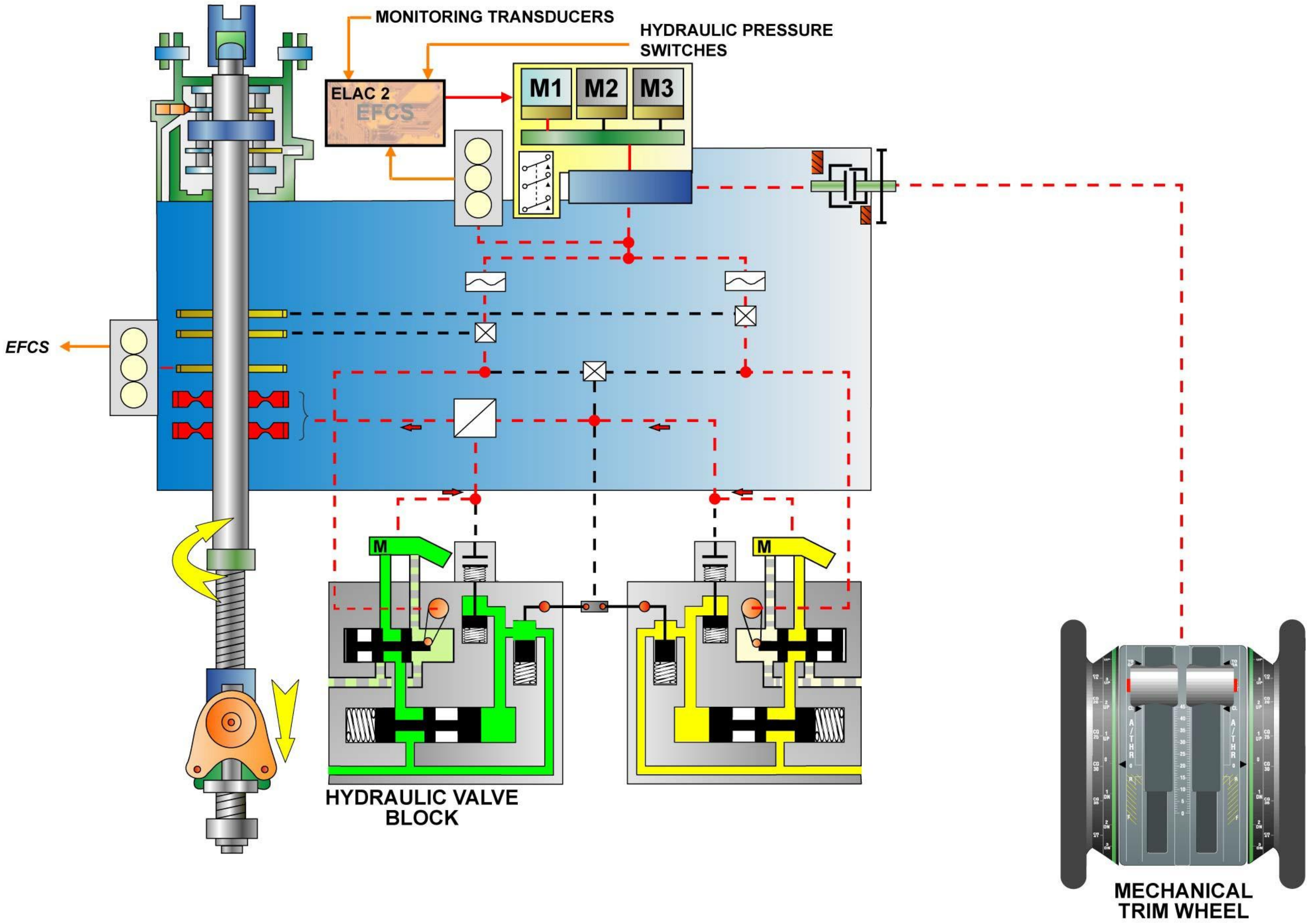
The hydraulic fluid is supplied to both hydraulic motors through the control valve opening. Both hydraulic motors operate at the same time and move the ball screw through the power differential.

The rotation of the screw jack gives a feedback signal to the feedback differential, causing the control valves moving back to neutral, consequently the whole system stop.

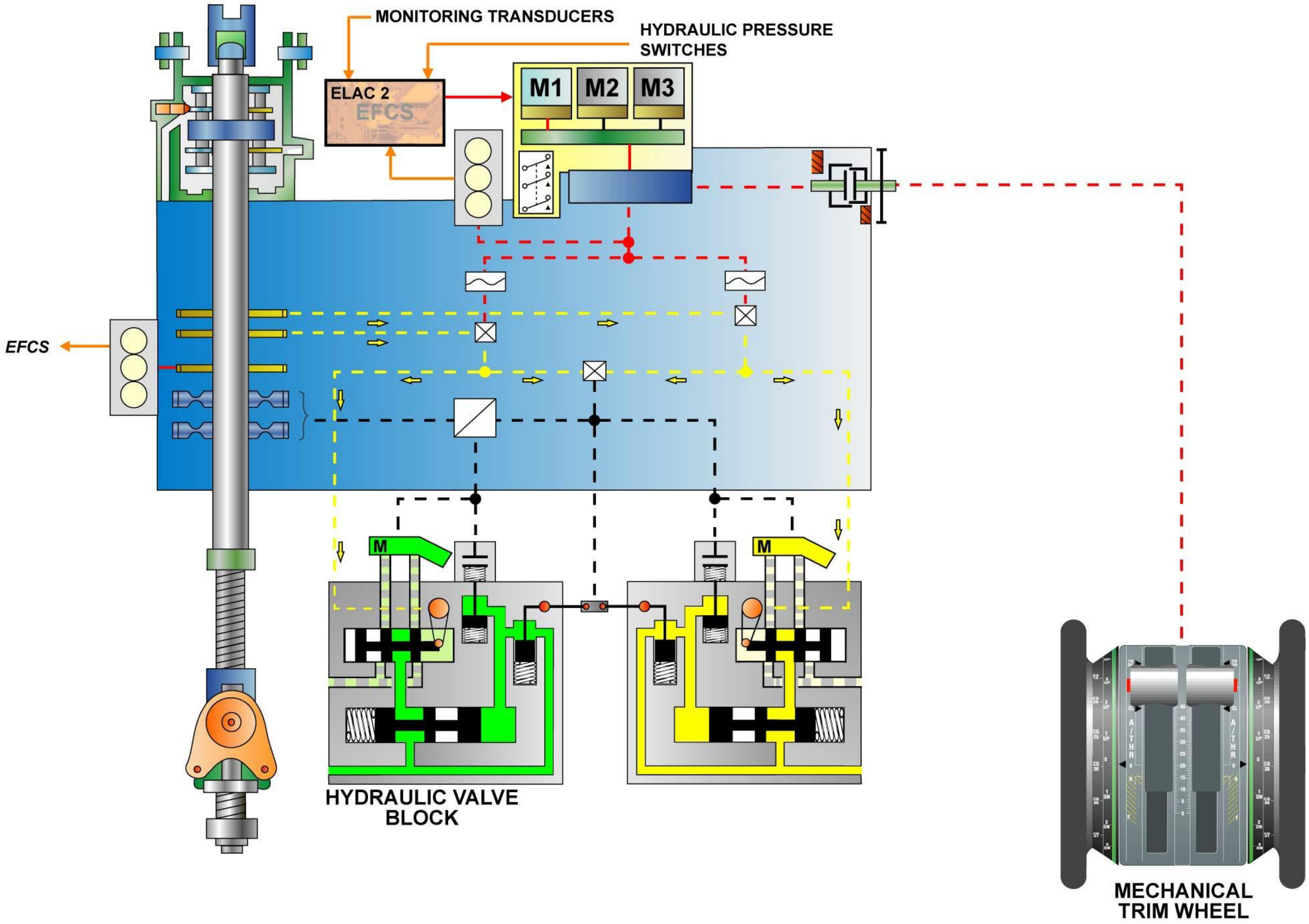
THS OPERATION - NORMAL OPERATION



THS OPERATION - NORMAL OPERATION



THS OPERATION - NORMAL OPERATION



THS ACTUATOR OPERATION

THS OPERATION (continued)

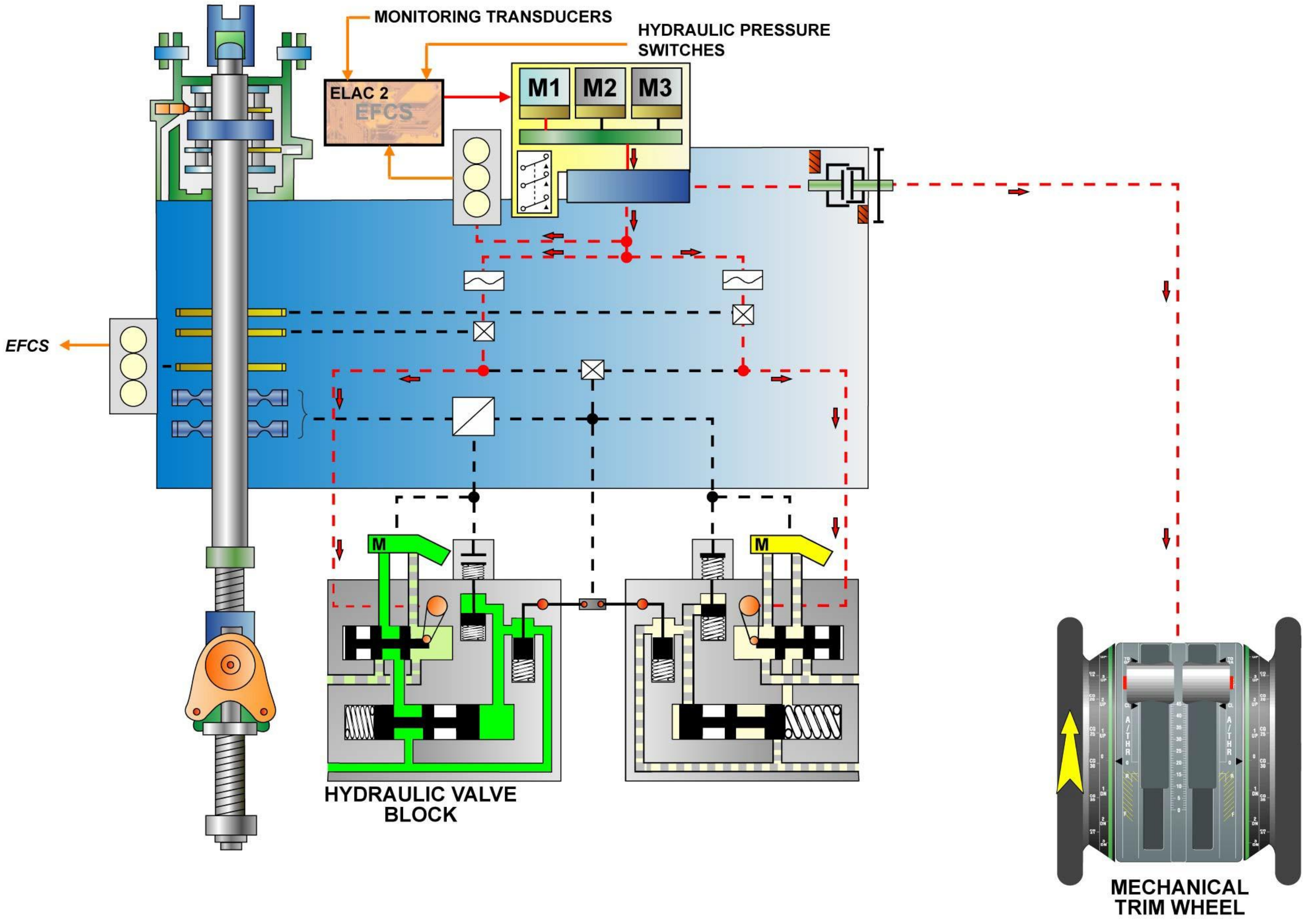
OPERATION WITH ONE HYDRAULIC SYSTEM IN LOW PRESSURE

Since the yellow hydraulic system is in low pressure, only the green hydraulic motor runs to move the ball screw at half speed via the power differential.

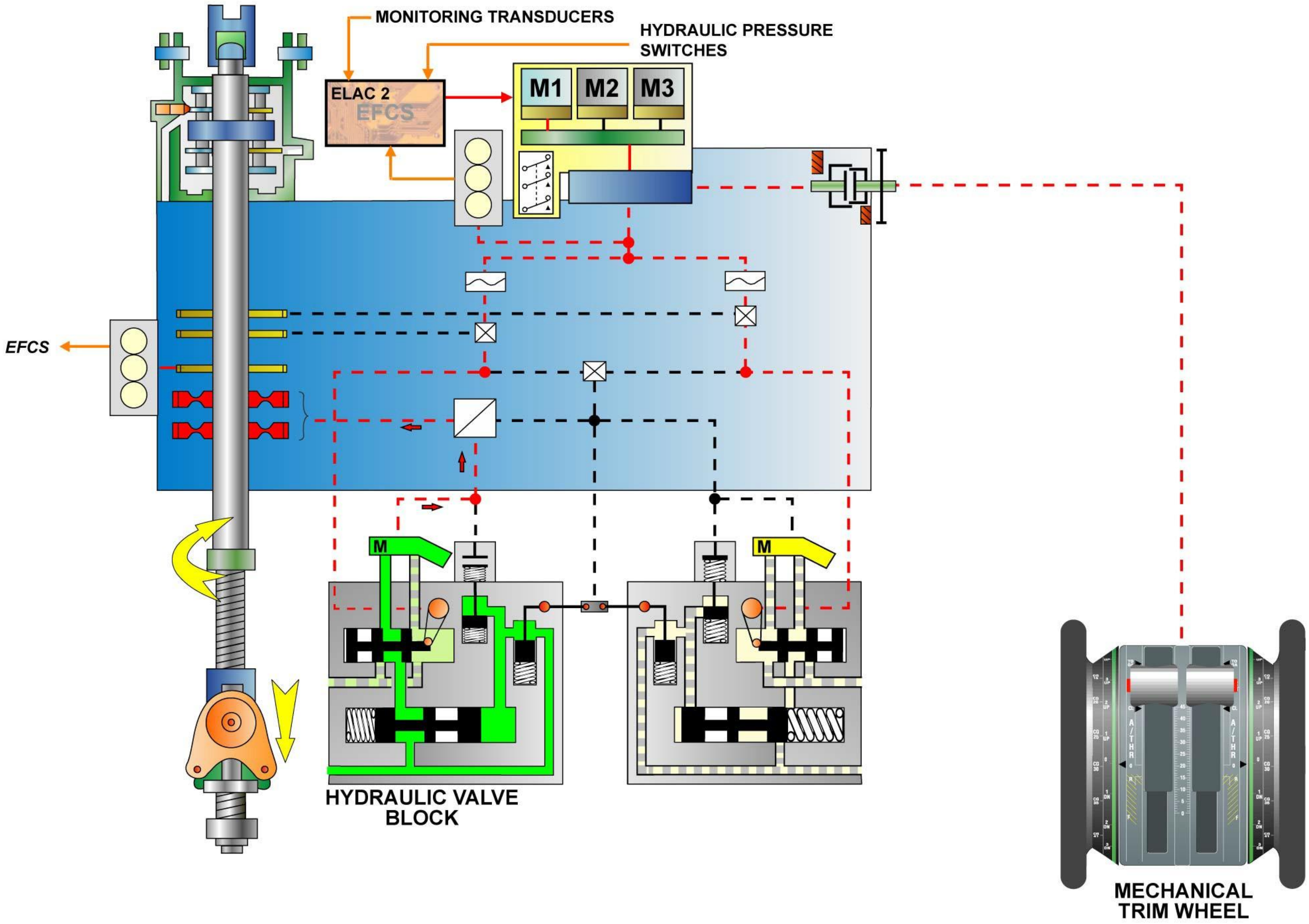
The hydraulic fluid is supplied to the green hydraulic motor only. The green hydraulic motor operates and moves the ball screw through the power differential at half speed.

The rotation of the screw jack gives a feedback signal to the feedback differential, causing the control valves moving back to neutral, consequently the whole system stop.

THS OPERATION - OPERATION WITH ONE HYDRAULIC SYSTEM IN LOW PRESSURE

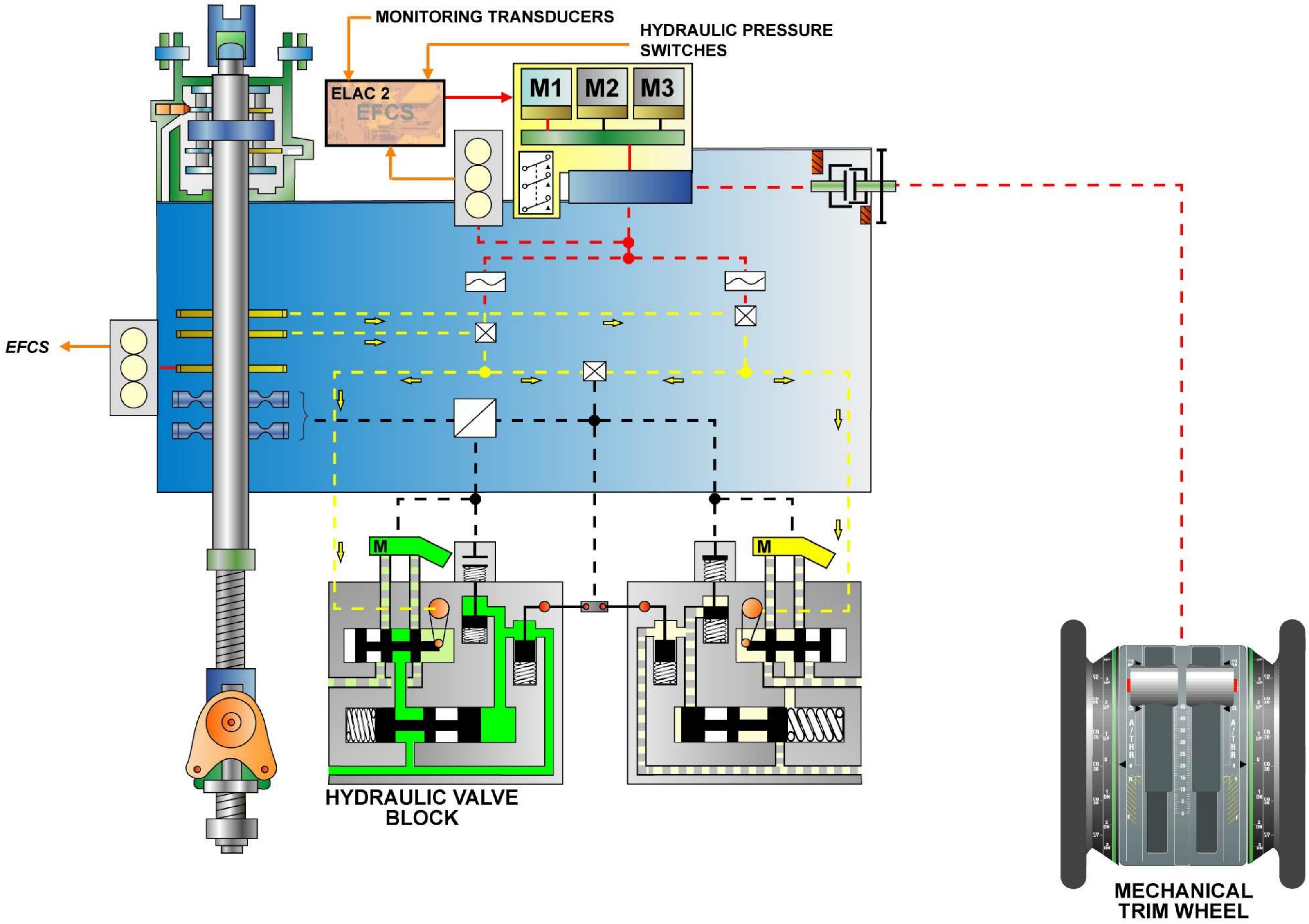


THS OPERATION - OPERATION WITH ONE HYDRAULIC SYSTEM IN LOW PRESSURE



FOR TRAINING PURPOSES ONLY

THS OPERATION - OPERATION WITH ONE HYDRAULIC SYSTEM IN LOW PRESSURE



FOR TRAINING PURPOSES ONLY

THS ACTUATOR OPERATION

THS OPERATION (continued)

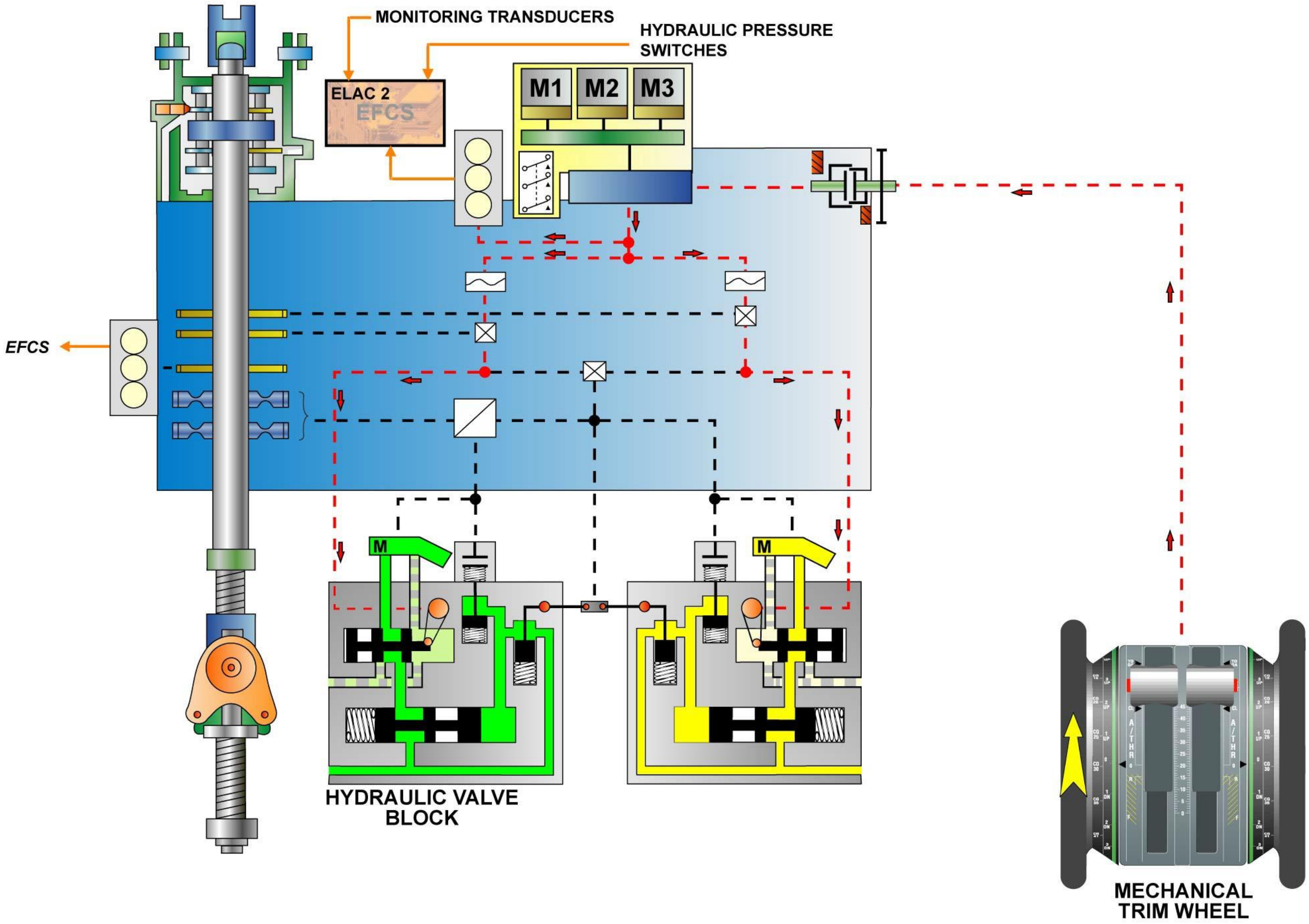
THS MECHANICAL INPUT

A mechanical input link is connected to an override mechanism. This allows the pilot to override the ELAC and SEC signals through the application of a sufficient force to the control wheels in the cockpit. An override mechanism reverts to the electrical control after release of the mechanical control.

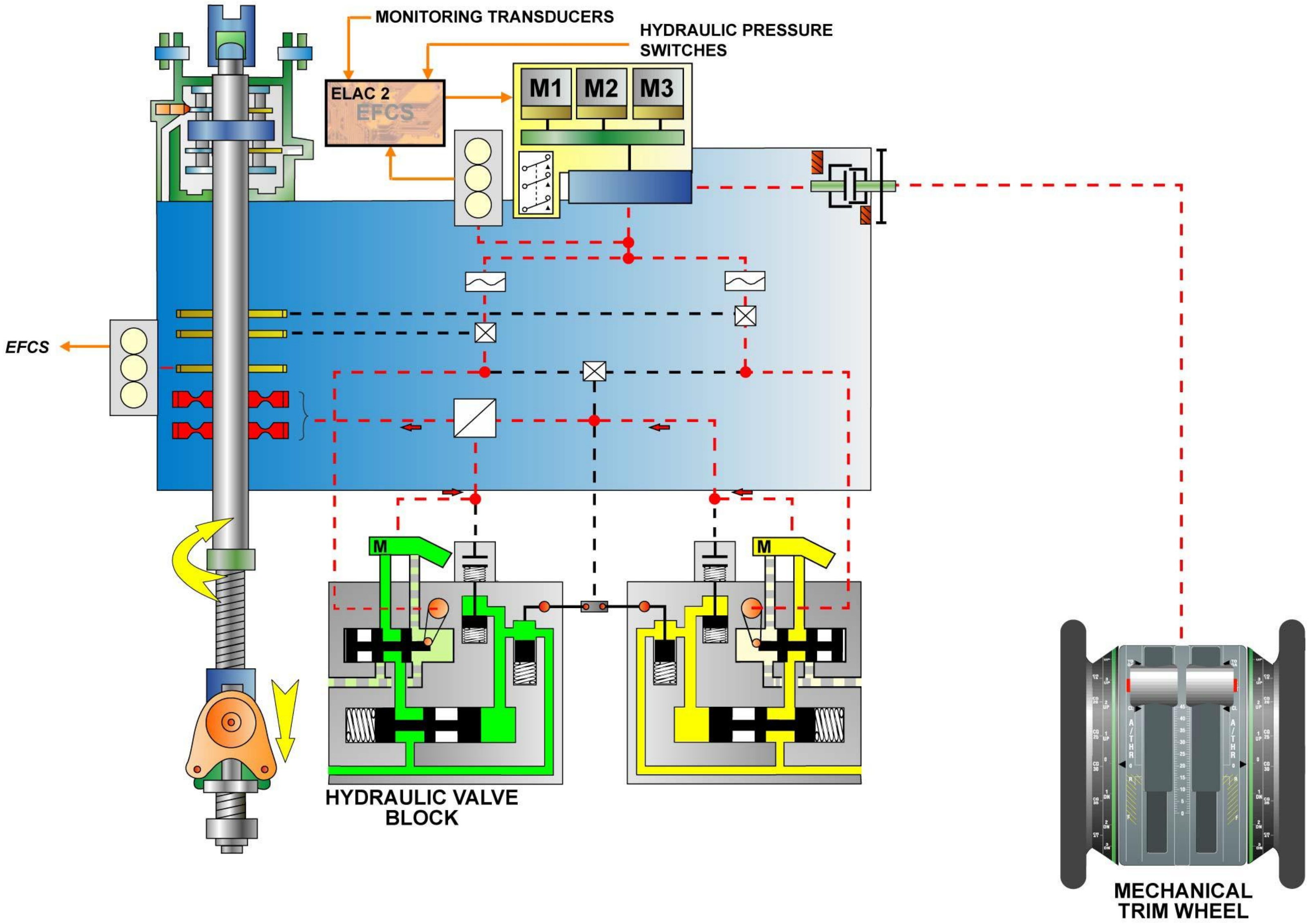
The hydraulic fluid is supplied to both hydraulic motors through the control valve opening. Both hydraulic motors operate at the same time and move the ball screw through the power differential.

The rotation of the screw jack gives a feedback signal to the feedback differential, causing the control valves moving back to neutral, consequently the whole system stop.

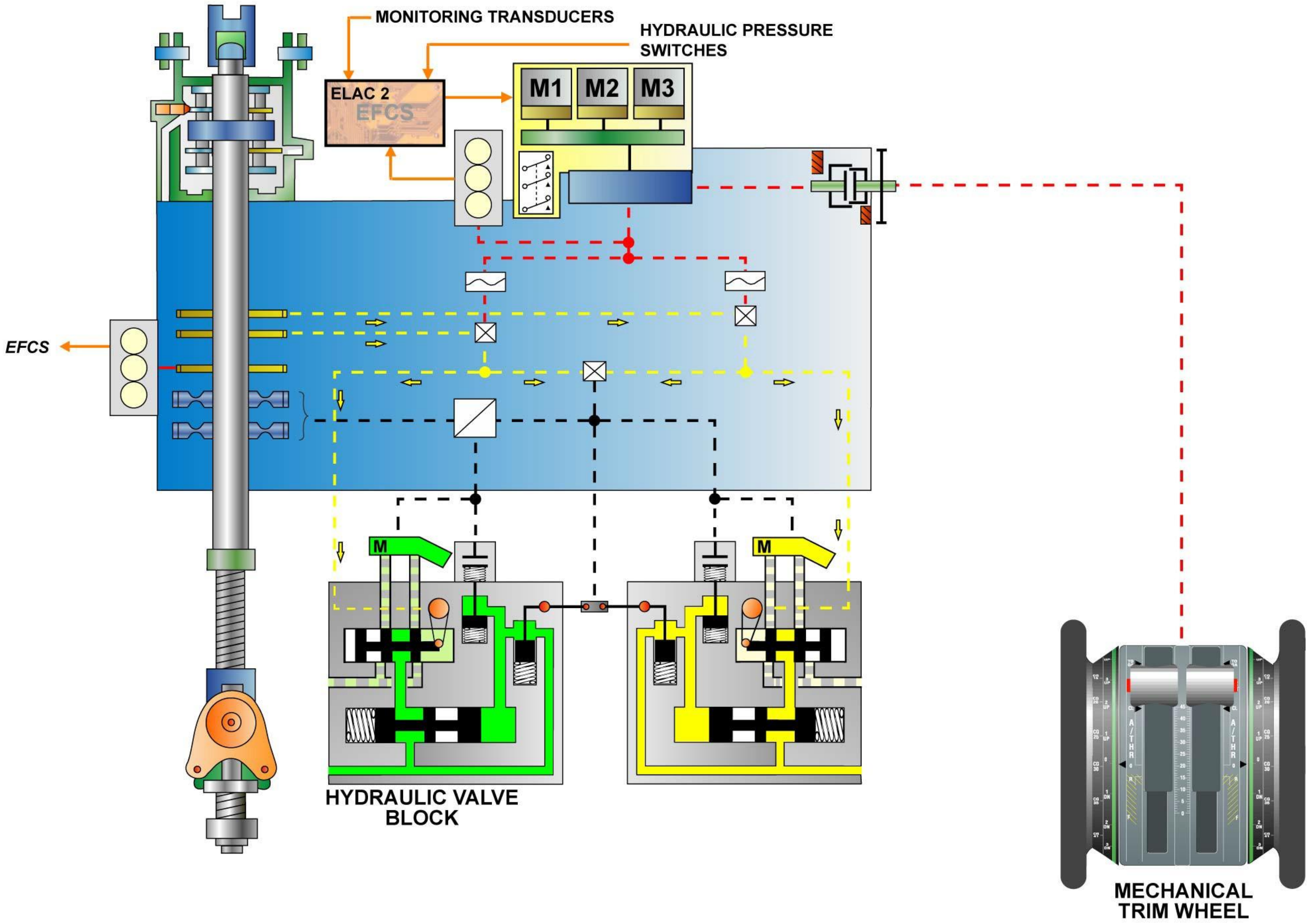
THS OPERATION - THS MECHANICAL INPUT



THS OPERATION - THS MECHANICAL INPUT



THS OPERATION - THS MECHANICAL INPUT



THS ACTUATOR OPERATION

THS OPERATION (continued)

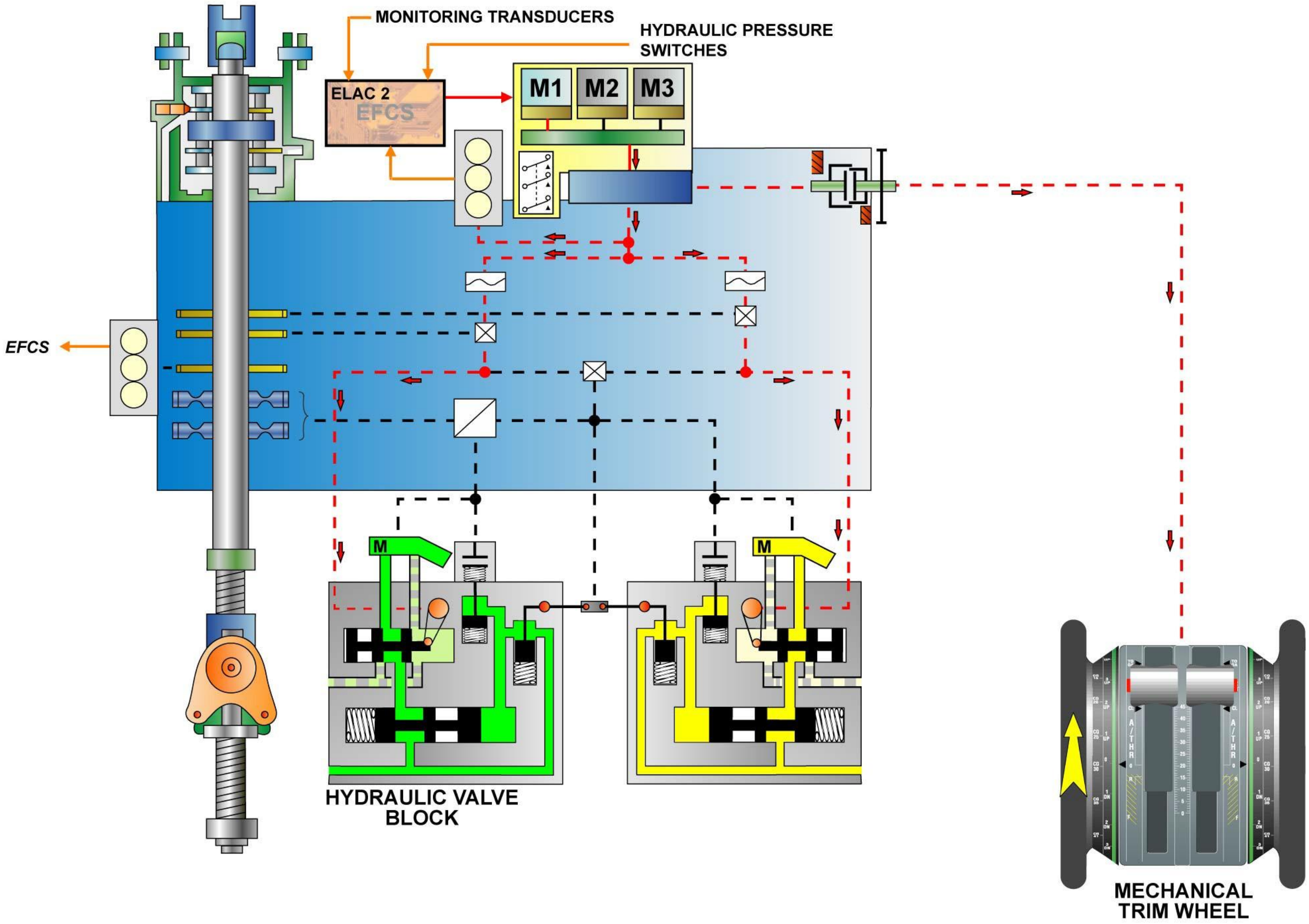
JAMMING MODE

ELAC2 (in normal control) sends a drive command to the servomotor No1.The electrical motor No1 causes the input levers and control valves to move and at the same time a mechanical feedback signal is sent from the override mechanism to the cockpit causing the trim wheels to move.

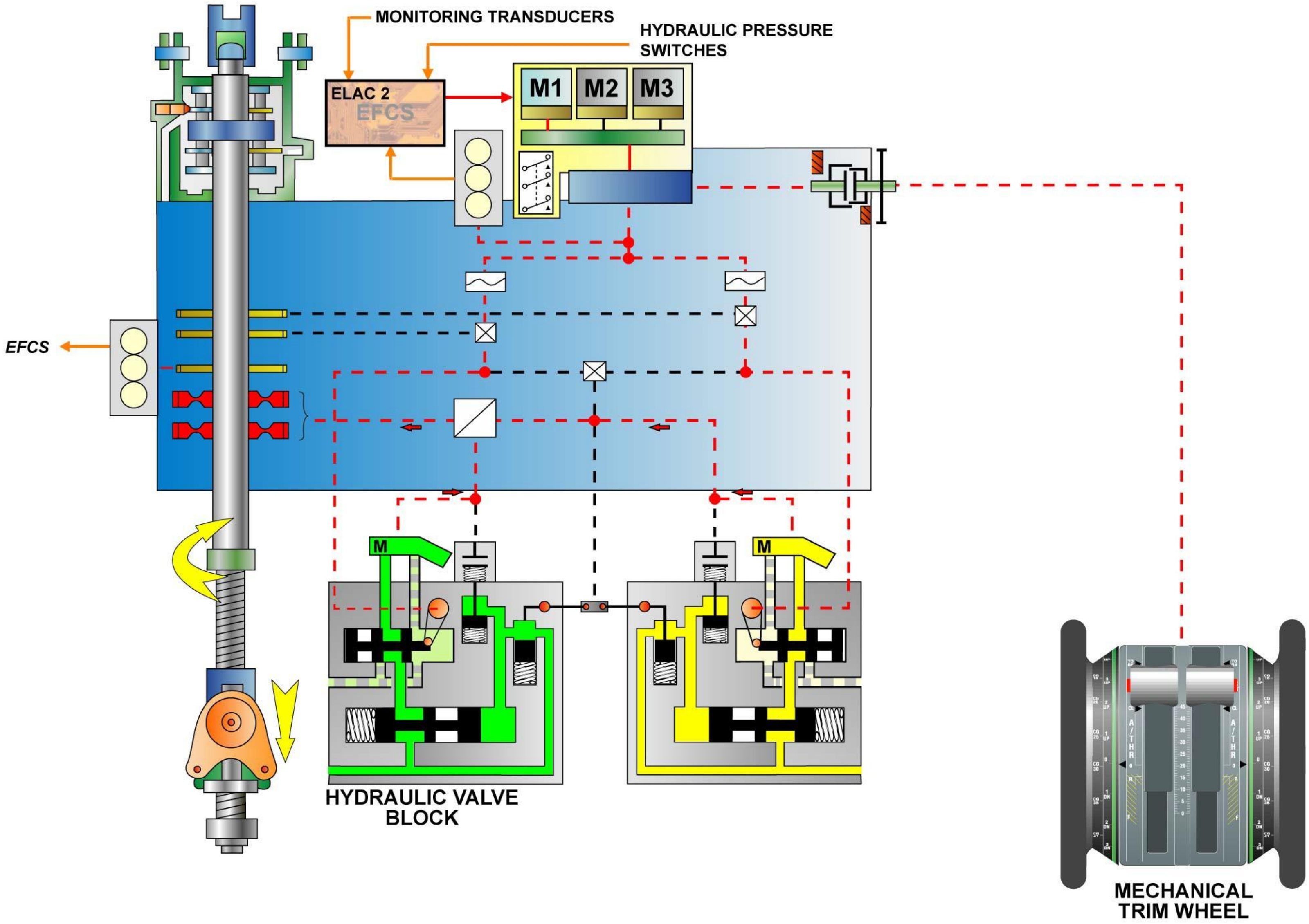
The hydraulic fluid is supplied to both hydraulic motors through the control valve opening. Both hydraulic motors operate at the same time and move the ball screw through the power differential.

If one control valve or its driving mechanism is jammed the hydraulic supply of both hydraulic motors is cut by the Shut-Off Valve (SOV) control device in each valve block, the comparator piston operates both SOVs. Both POBs are applied and the THS is immobilized and locked.

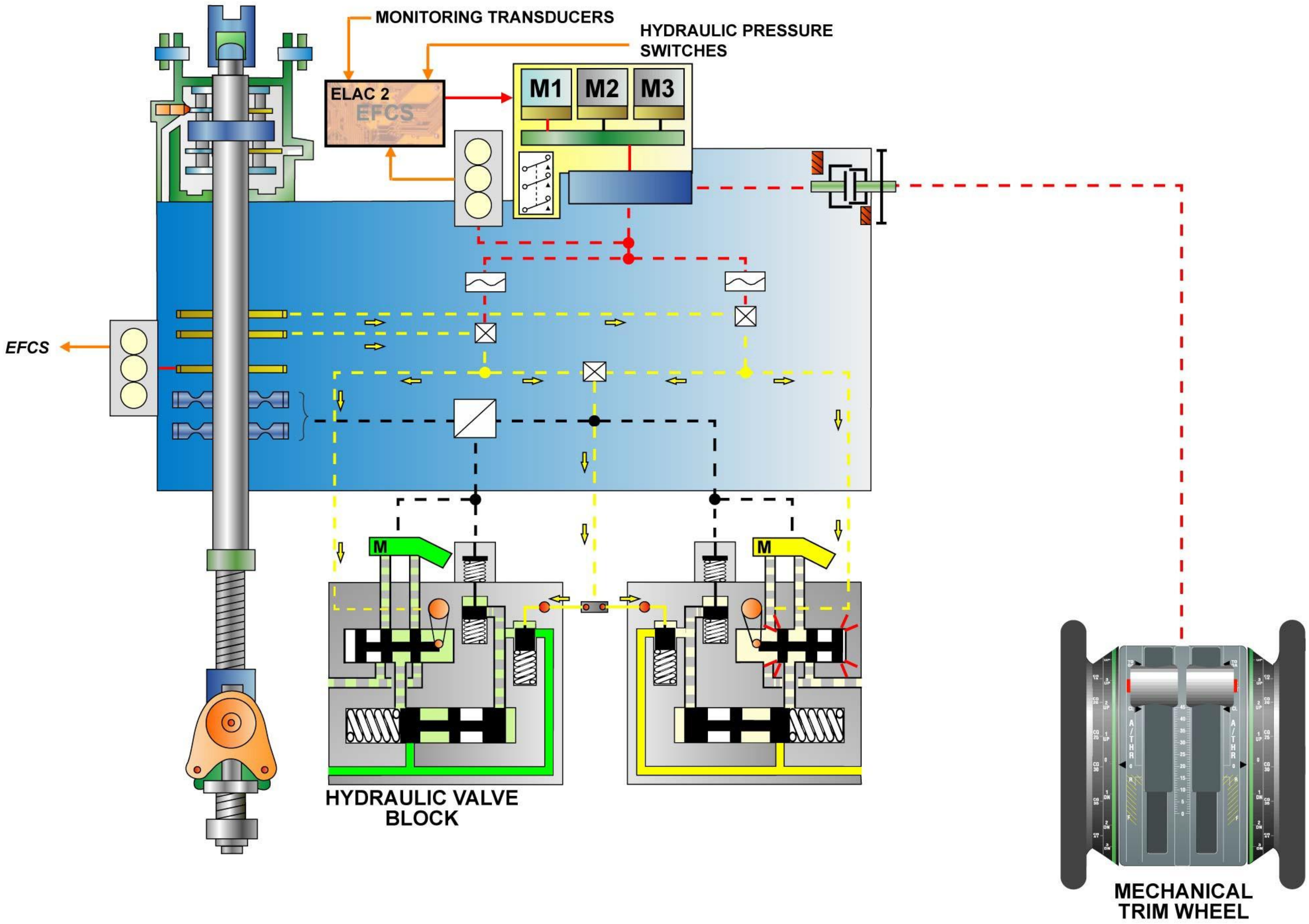
THS OPERATION - JAMMING MODE



THS OPERATION - JAMMING MODE



THS OPERATION - JAMMING MODE



FOR TRAINING PURPOSES ONLY

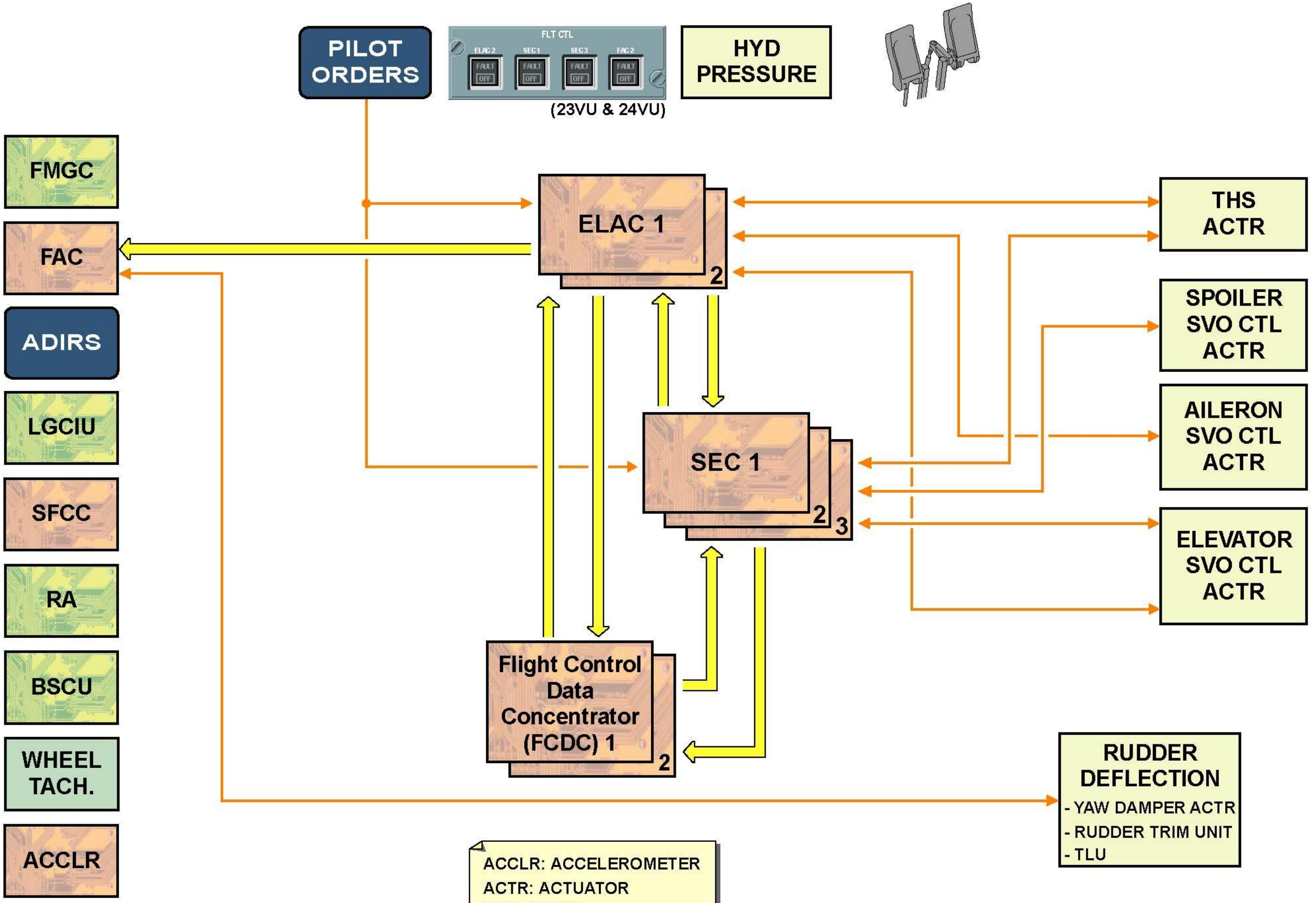
EFCS

EFCS CONTROL INTERFACE

PILOT ORDERS

The pilot orders like side stick, speed brake, ground spoiler or throttle position signals, are transmitted to the ELevator Aileron Computers (ELACs) and Spoiler Elevator Computers (SECs). According to these inputs and their control laws, the computers calculate the elevator, aileron, spoiler, THS and rudder deflection.

PILOT ORDERS



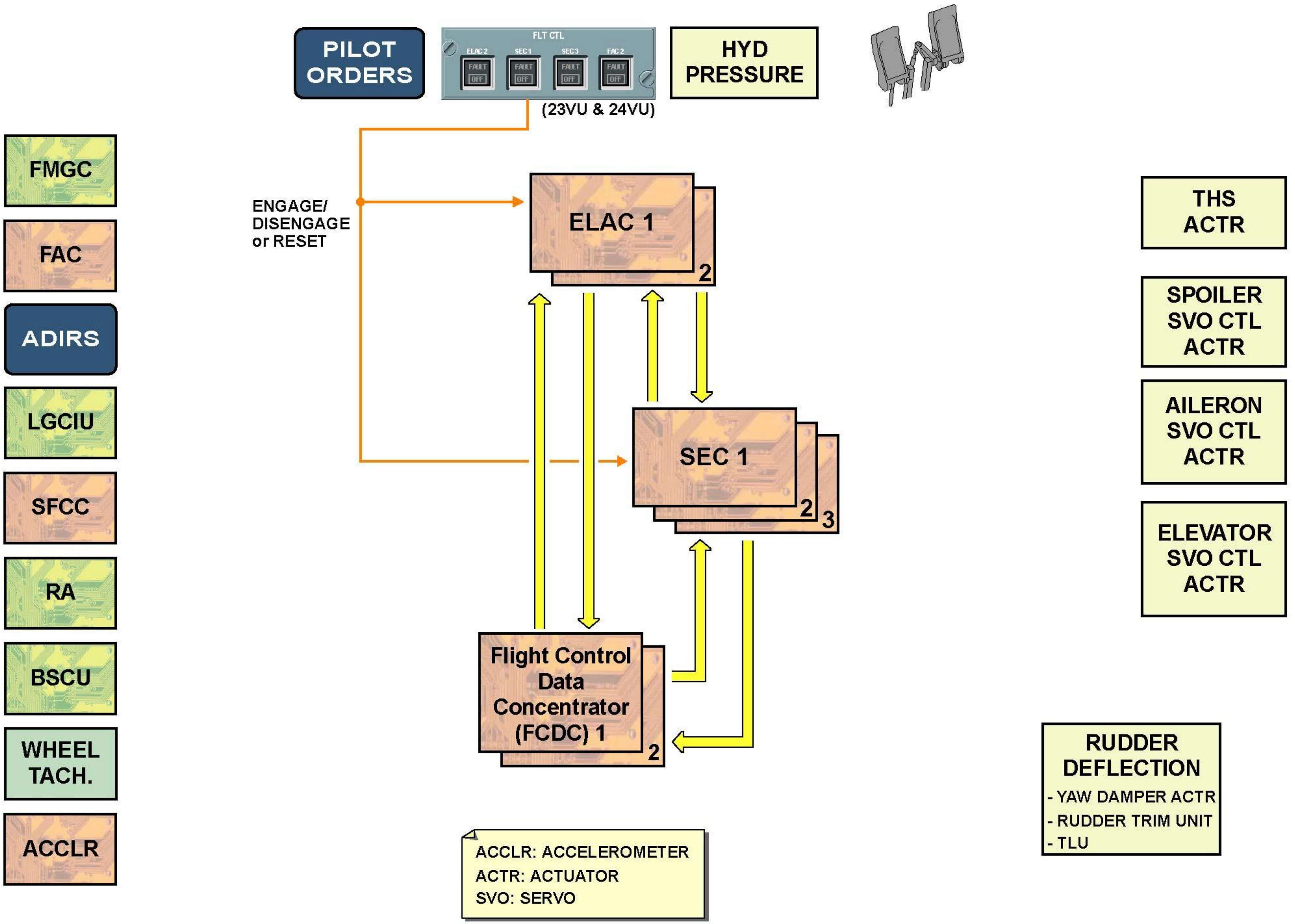
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

FLIGHT CONTROL PANELS

P/Bs located on the FLighT ConTroL panels are used to engage/disengage or reset their respective computer software.

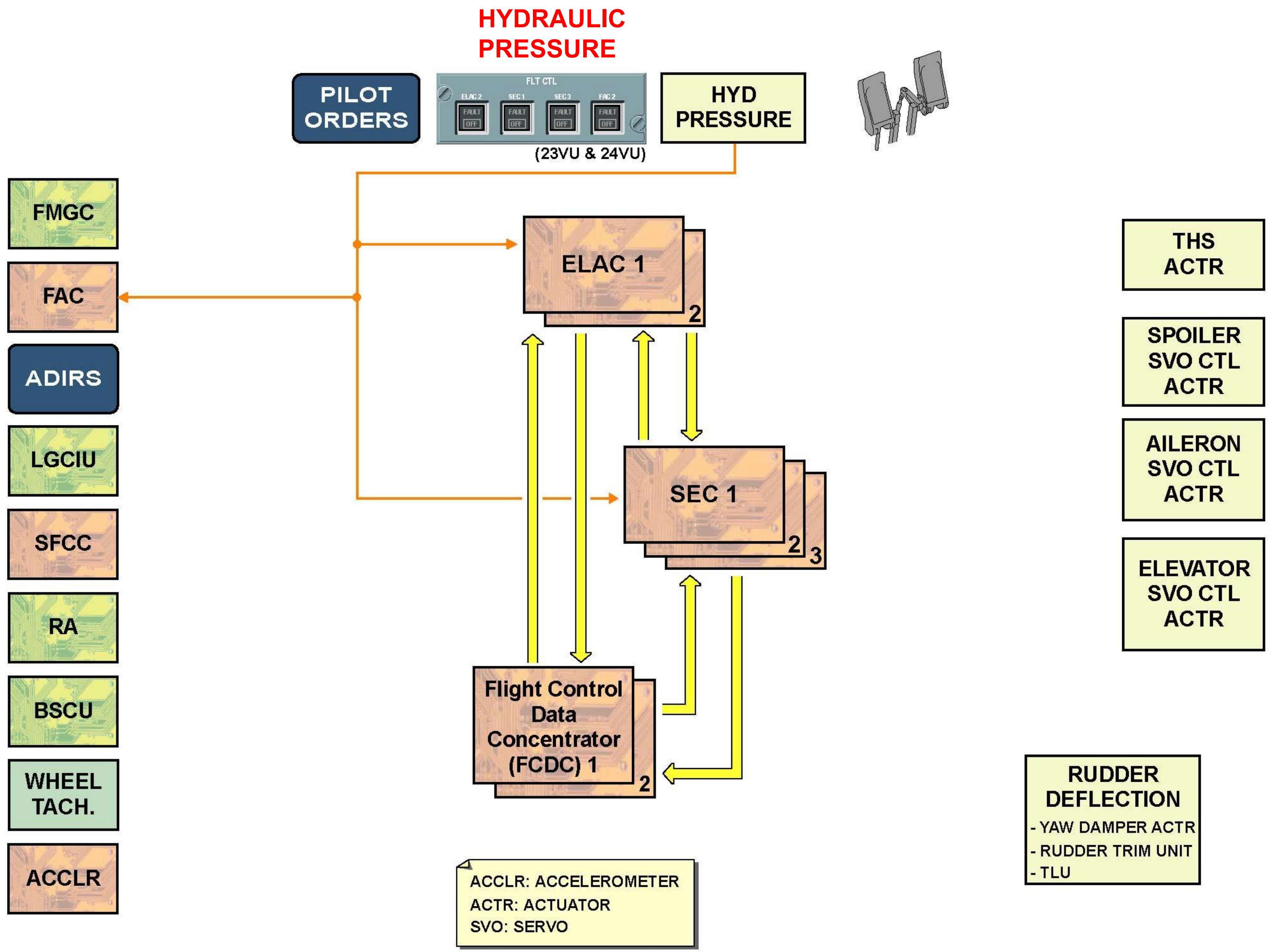
FLIGHT CONTROL PANELS



EFCS CONTROL INTERFACE

HYDRAULIC PRESSURE

The hydraulic pressure status is sent to the ELACs and SECs for activation or deactivation of the related servo controls and laws.
The hydraulic pressure is also sent to the Flight Augmentation Computers (FACs), at least for yellow and green for the yaw damper actuator.

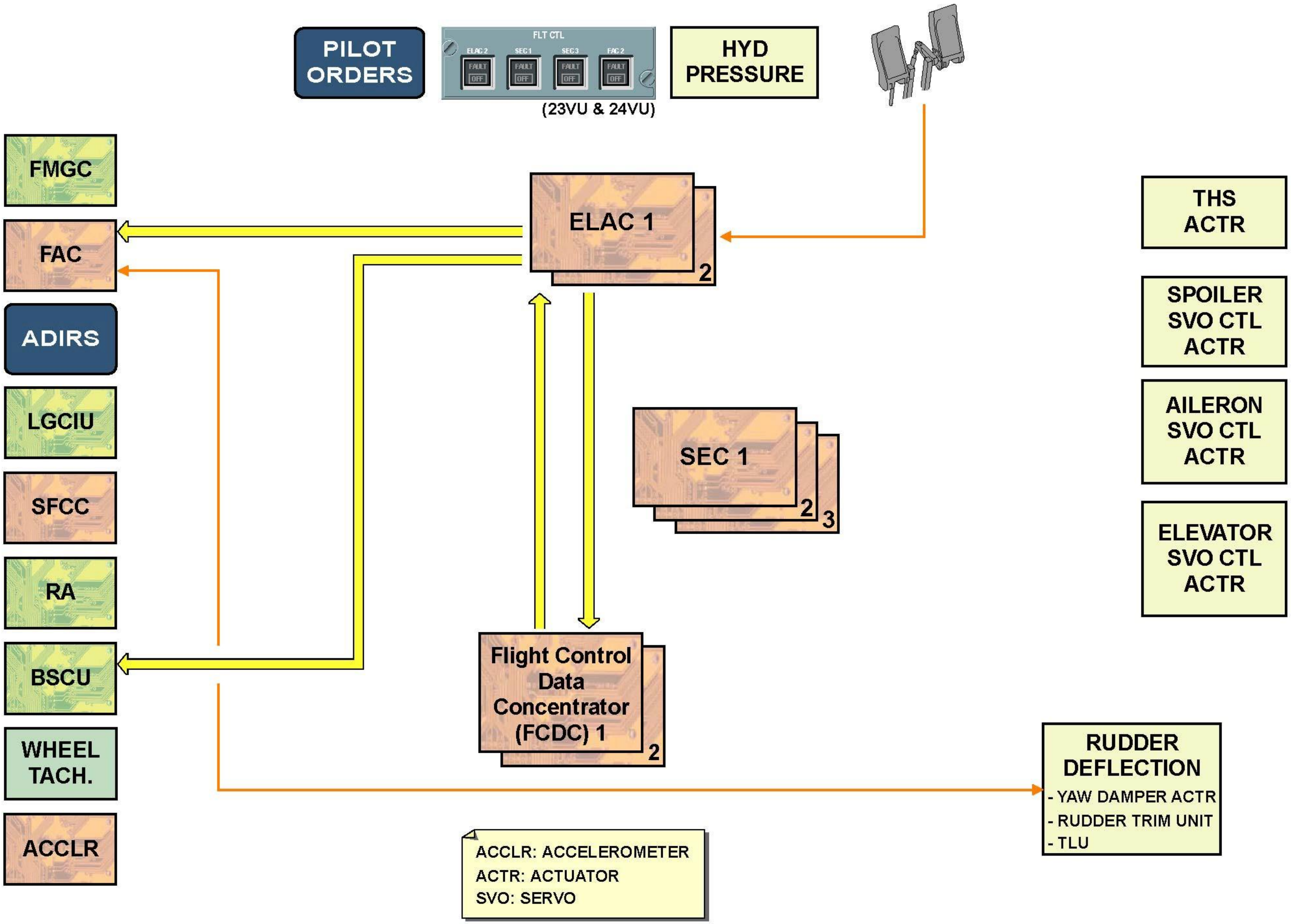

HYDRAULIC PRESSURE
PILOT ORDERS
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

RUDDER PEDAL POSITION

The signal from the rudder pedal transducers is used for nose wheel steering via ELACs / Braking Steering Control Unit (BSCU) and to tell ELACs / FACs that the pilot is now in control for turn coordination, while yaw damping signals are maintained.

RUDDER PEDAL POSITION

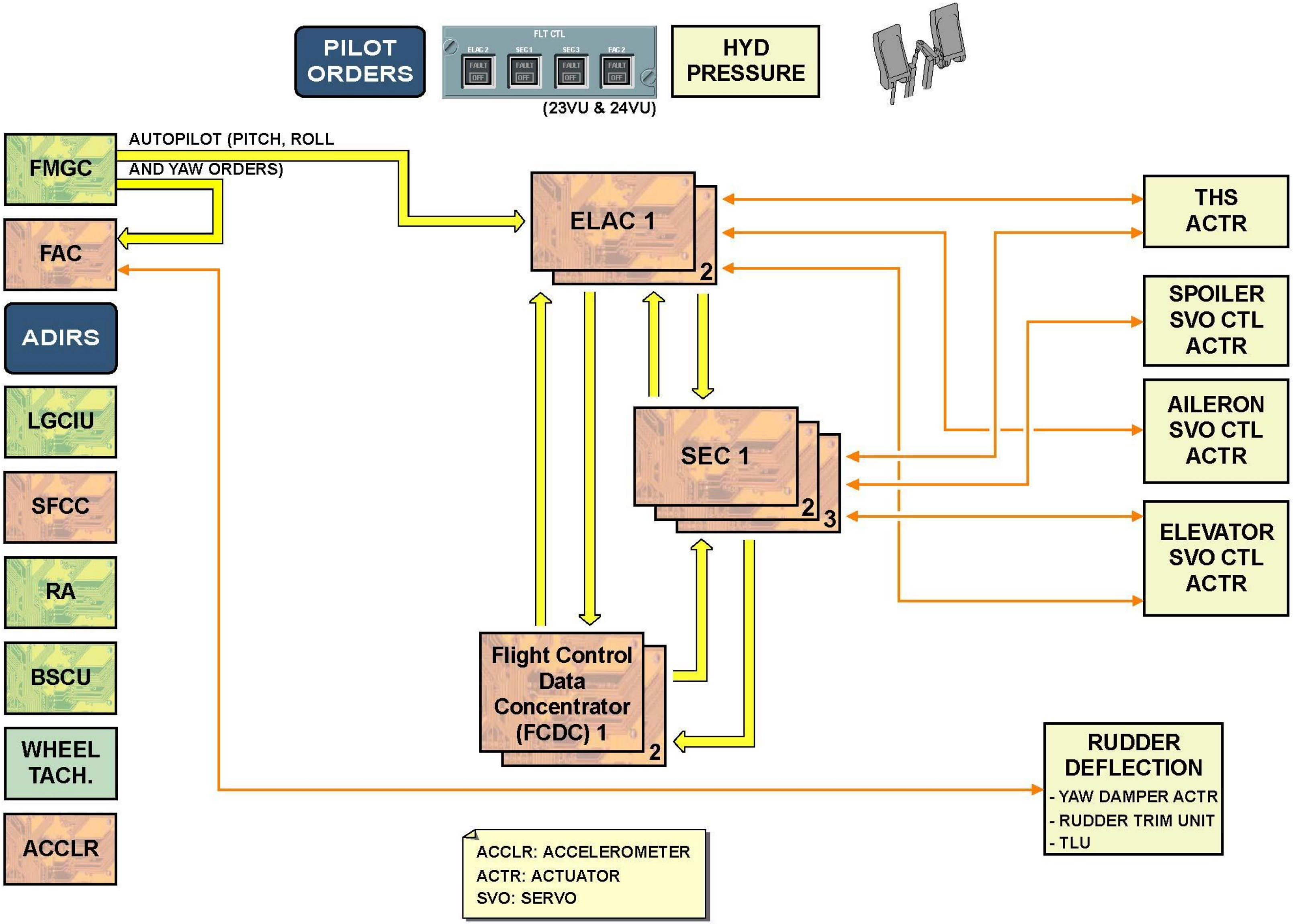


EFCS CONTROL INTERFACE

FMGC

If the autopilot is active, pitch, roll and yaw orders computed by the Flight Management and Guidance Computer (FMGC) are sent to the ELACs and FACs, which control and monitor the surface deflections.

FMGC

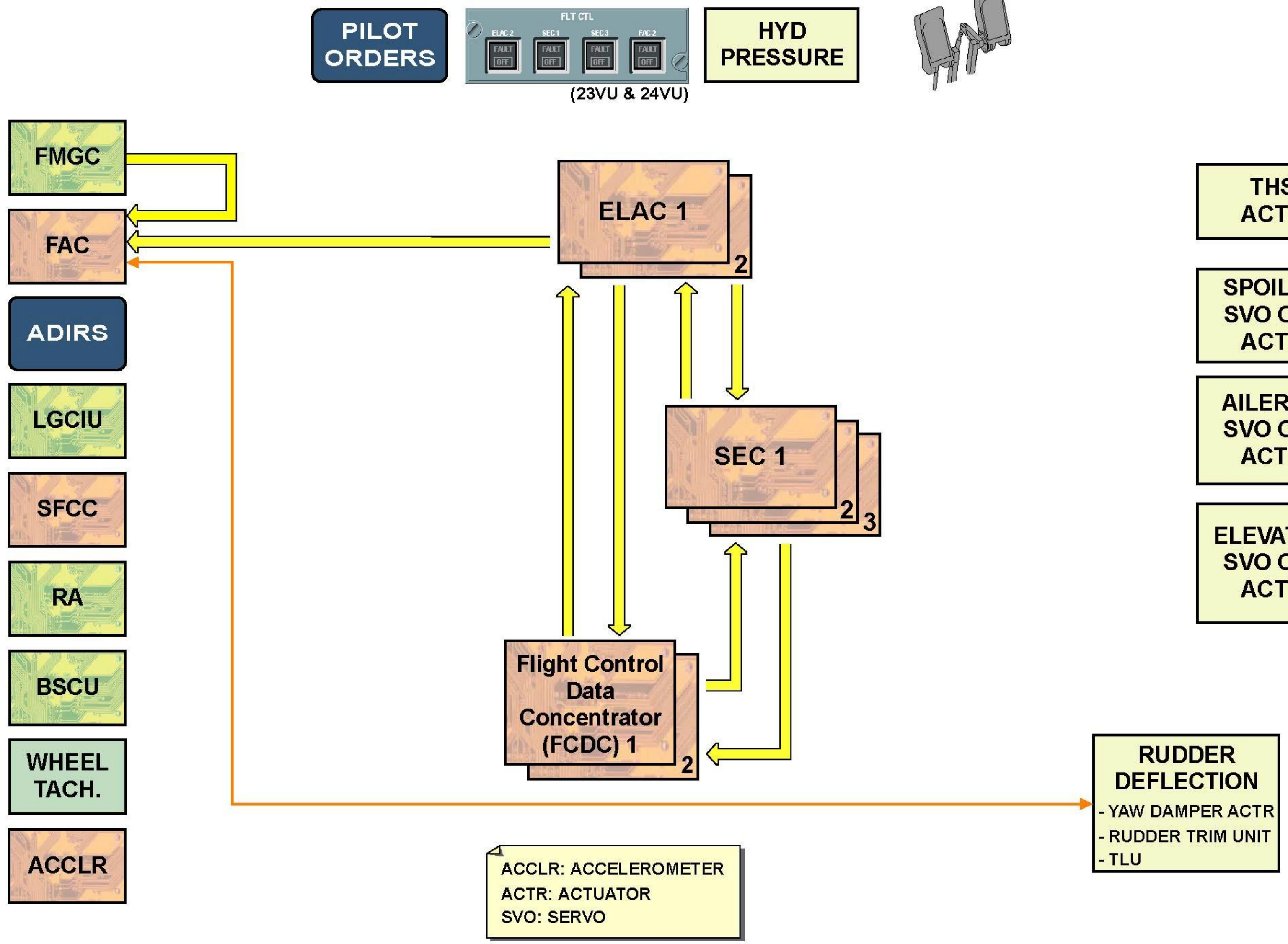

PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
FAULT
OFF
(23VU & 24VU)
HYD PRESSURE
FMGC
AUTOPILOT (PITCH, ROLL AND YAW ORDERS)
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

FAC

The FACs receive rudder deflection information computed either by the ELACs or FMGCs for dutch roll damping, engine failure compensation and turn coordination.

FAC

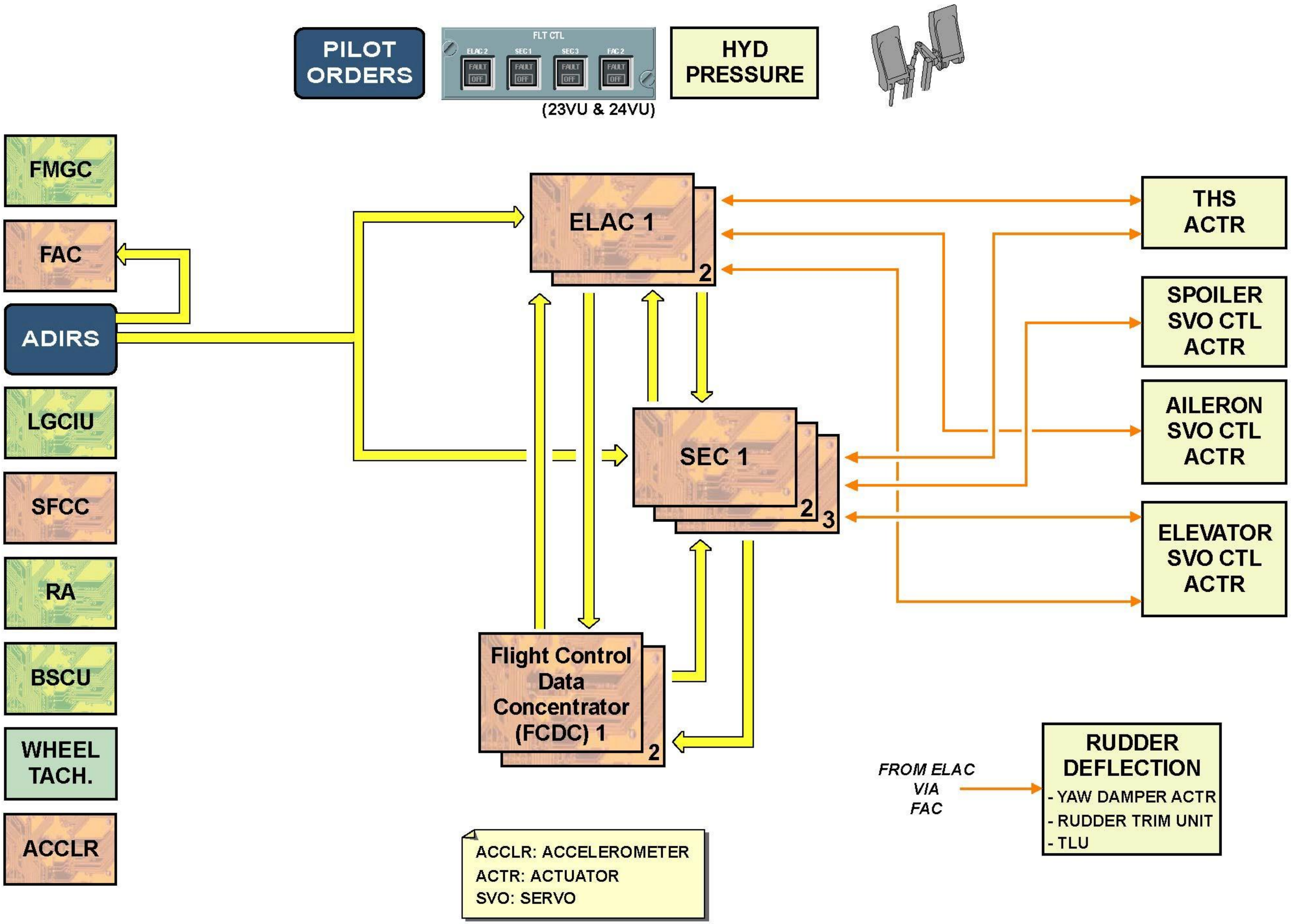

PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

ADIRS

The Air Data/Inertial Reference System (ADIRS) transmits air data and inertial reference data to the ELACs and SECs, and also to the FACs (see ATA 22 course) for flight envelope protection computation.

ADIRS



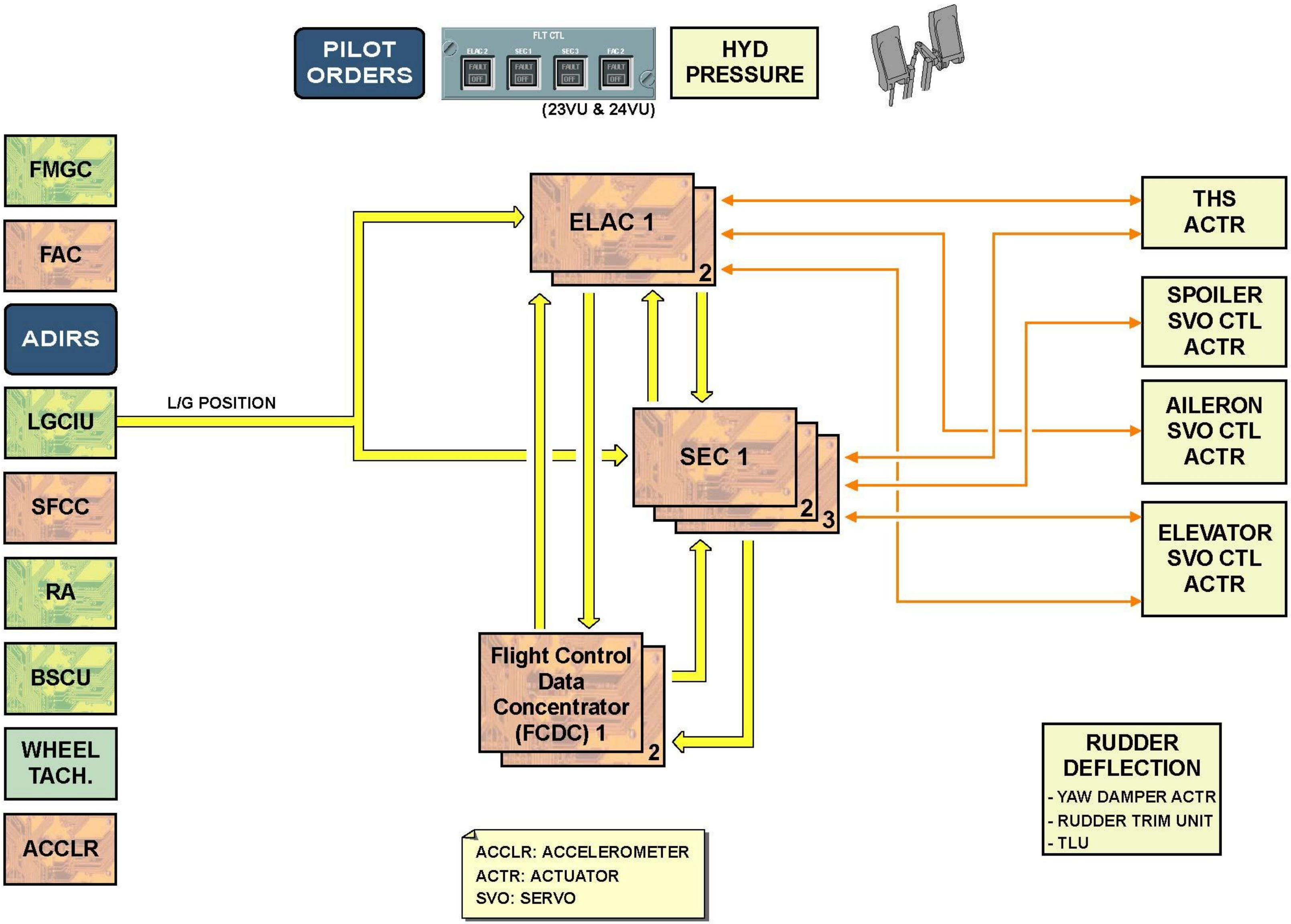
FOR TRAINING PURPOSES ONLY

EFCS CONTROL INTERFACE

LGCIU

The Landing Gear Control and Interface Units (LGCIUs) transmit L/G position information to the ELACs and SECs.

LGCIU

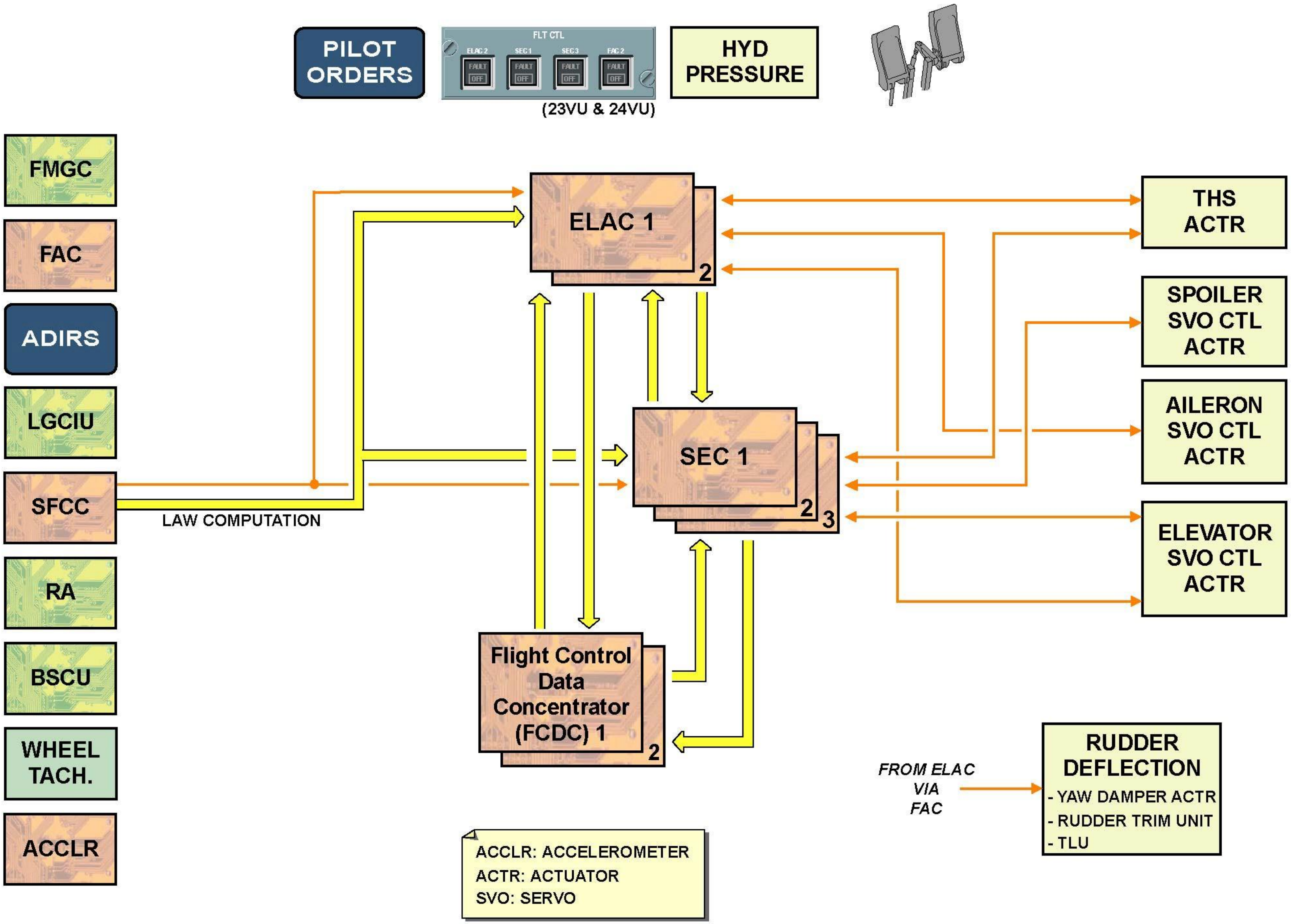

PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
FAULT
OFF
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
L/G POSITION
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

SFCC

The Slat Flap Control Computers (SFCCs) transmit slat flap surface position to the ELACs and SECs for law computation.

SFCC

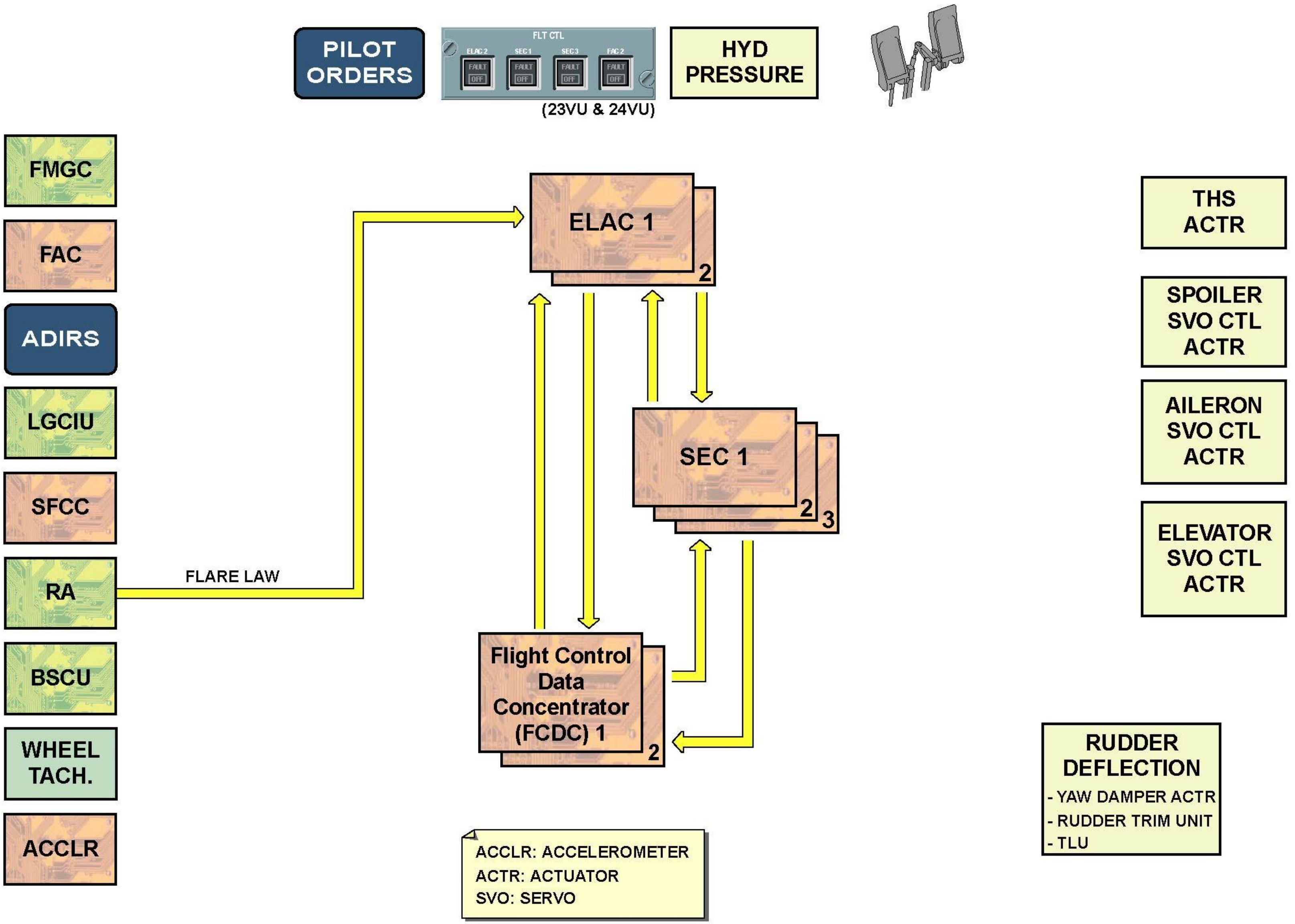

PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
LAW COMPUTATION
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
FROM ELAC VIA FAC
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

RA

The Radio Altimeter (RA) transmits the altitude information to the ELACs for flare law activation.

RA

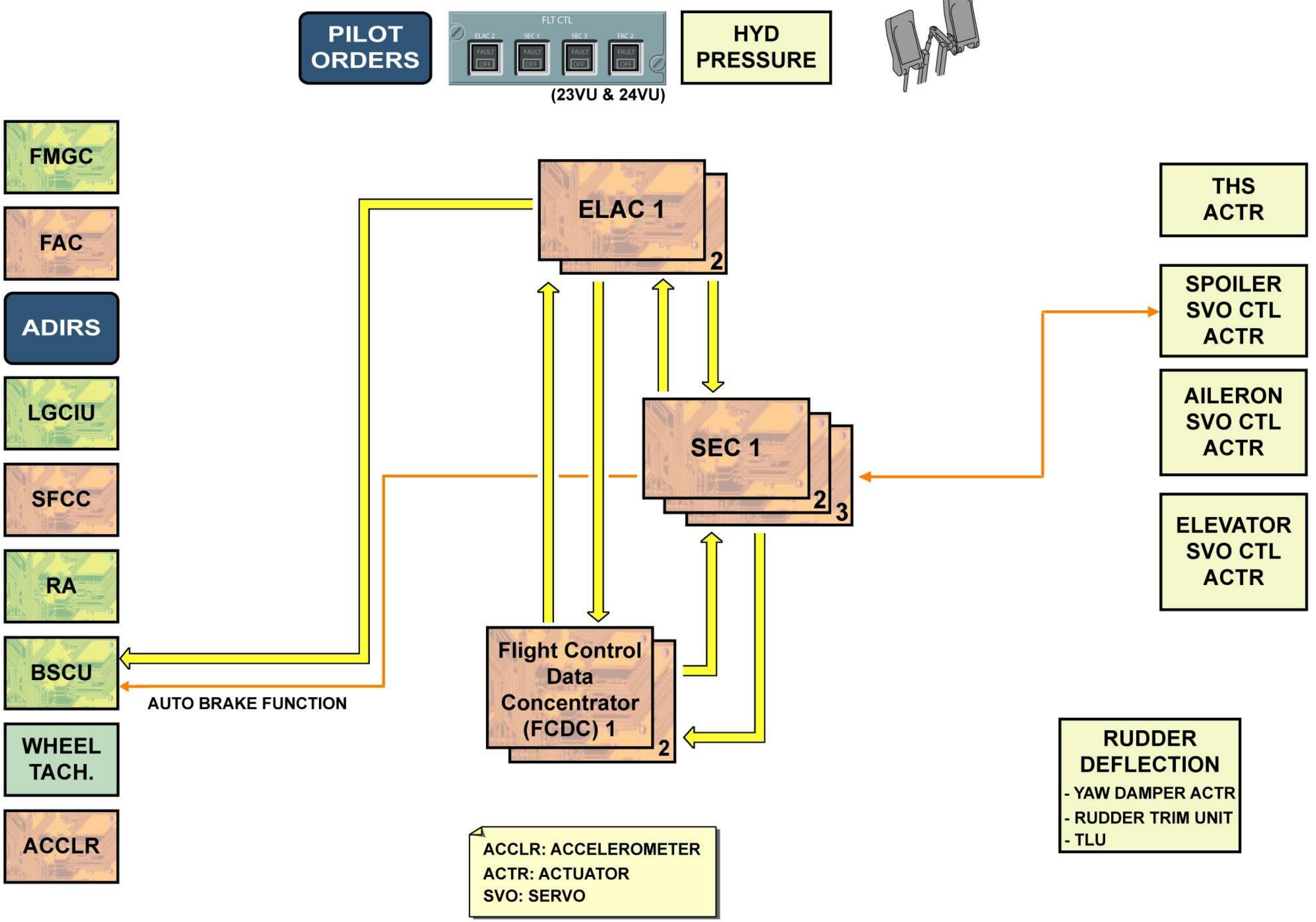

PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
FAULT
OFF
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
FLARE LAW
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

BSCU

The BSCU receives information from the ELACs for the nose wheel steering system and from the SECs for the auto brake function.

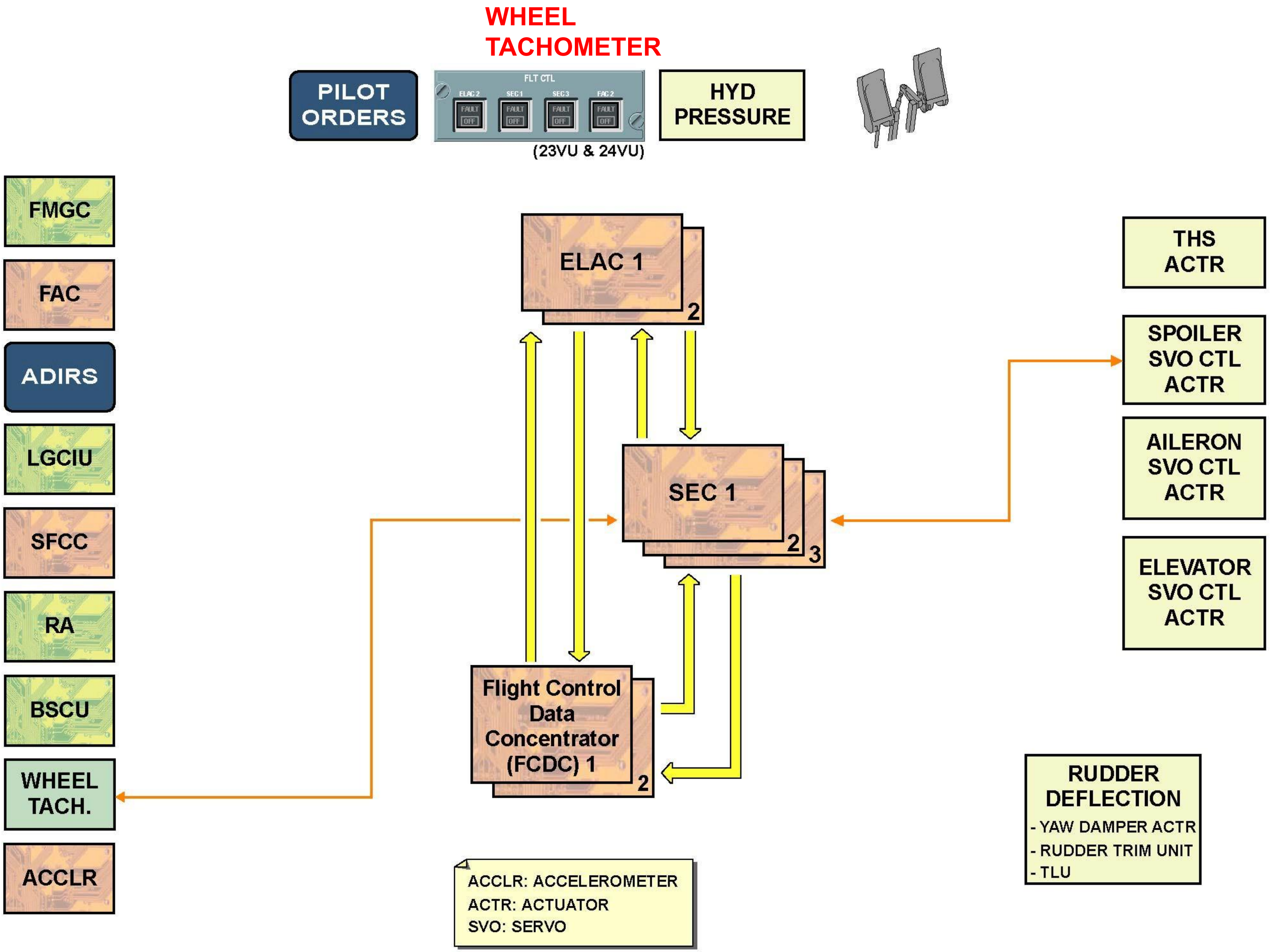
BSCU


PILOT ORDERS
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
AUTO BRAKE FUNCTION
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

WHEEL TACHOMETER

Each MLG wheel speed is transmitted by wheel tachometers to the SECs for ground spoiler, only in case of Rejected Take-Off.

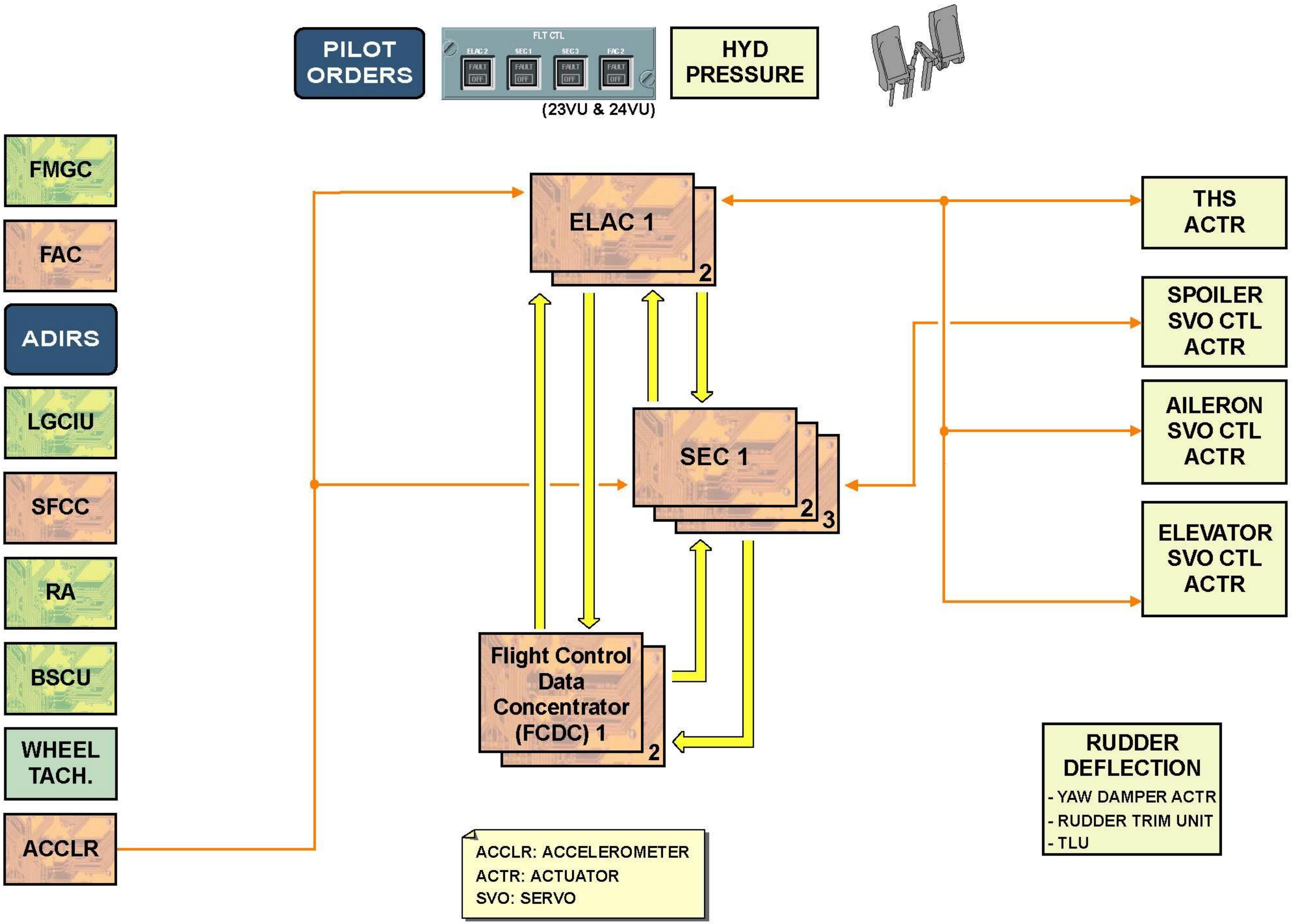

WHEEL
TACHOMETER
PILOT ORDERS
FLT CTL
ELAC 2
SEC 1
SEC 3
FAC 2
FAULT
OFF
(23VU & 24VU)
HYD PRESSURE
FMGC
FAC
ADIRS
LGCIU
SFCC
RA
BSCU
WHEEL TACH.
ACCLR
ELAC 1
2
SEC 1
2
3
Flight Control Data Concentrator (FCDC) 1
2
THS ACTR
SPOILER SVO CTL ACTR
AILERON SVO CTL ACTR
ELEVATOR SVO CTL ACTR
RUDDER DEFLECTION
- YAW DAMPER ACTR
- RUDDER TRIM UNIT
- TLU
ACCLR: ACCELEROMETER
ACTR: ACTUATOR
SVO: SERVO

EFCS CONTROL INTERFACE

ACCELEROMETER

The vertical accelerometers, installed in the FWD cargo compartment, transmit the vertical acceleration of the A/C to the ELACs and SECs. The vertical accelerometers are also used for the computation of the pitch trim function and load factor function.

ACCELEROMETER



EFCS MONITOR INTERFACE

FWC/ECAM

The flight control system failures are sent to the Flight Warning Computers (FWCs) by the Flight Control Data Concentrators (FCDCs). The FWCs elaborate the failure messages on the EWD display. The FWCs receive flight control data from the FCDCs for indication on the ECAM displays.

CFDIU/MCDU

Data are exchanged between the FCDCs and the Centralized Fault Display System (CFDS), which enables two communication modes, normal mode and interactive mode.

Normal mode:

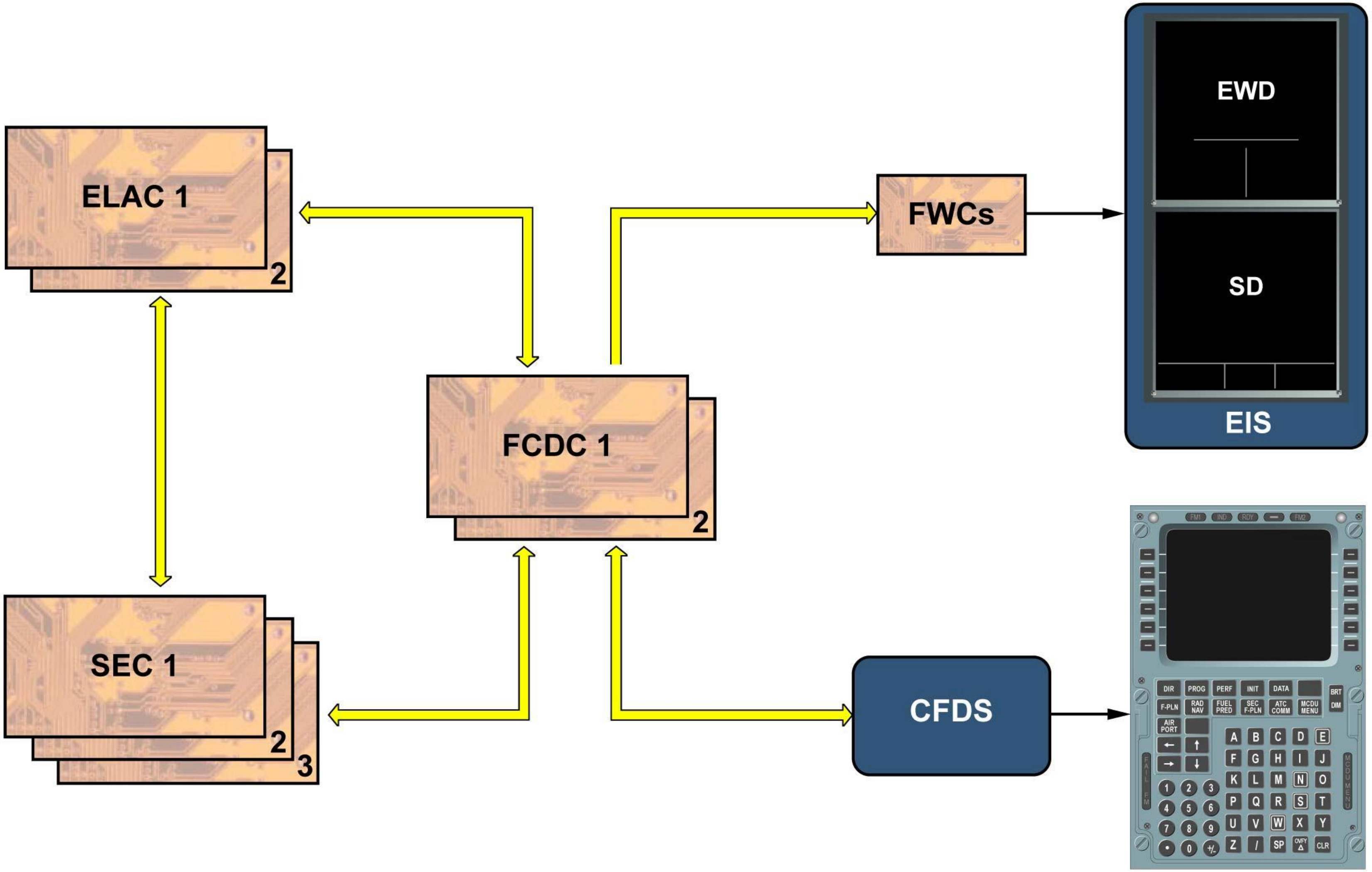
- the FCDCs send the flight control system failures to the CFDS,
- the CFDS adds general data such as time, date, ATA chapter, flight phase, leg, to the failure message on the MCDU display.

Interactive mode: the CFDS sends to the FCDCs:

- the request for consultation of the BITE inside each computer,
- the maintenance test request.

The CFDS receives faulty Line Replaceable Unit (LRU) data from the FCDCs which are displayed on the MCDU for trouble-shooting and test purposes.

FWC/ECAM & CFDIU/MCDU



SLATS AND FLAPS

SLATS/FLAPS CONTROL D/O

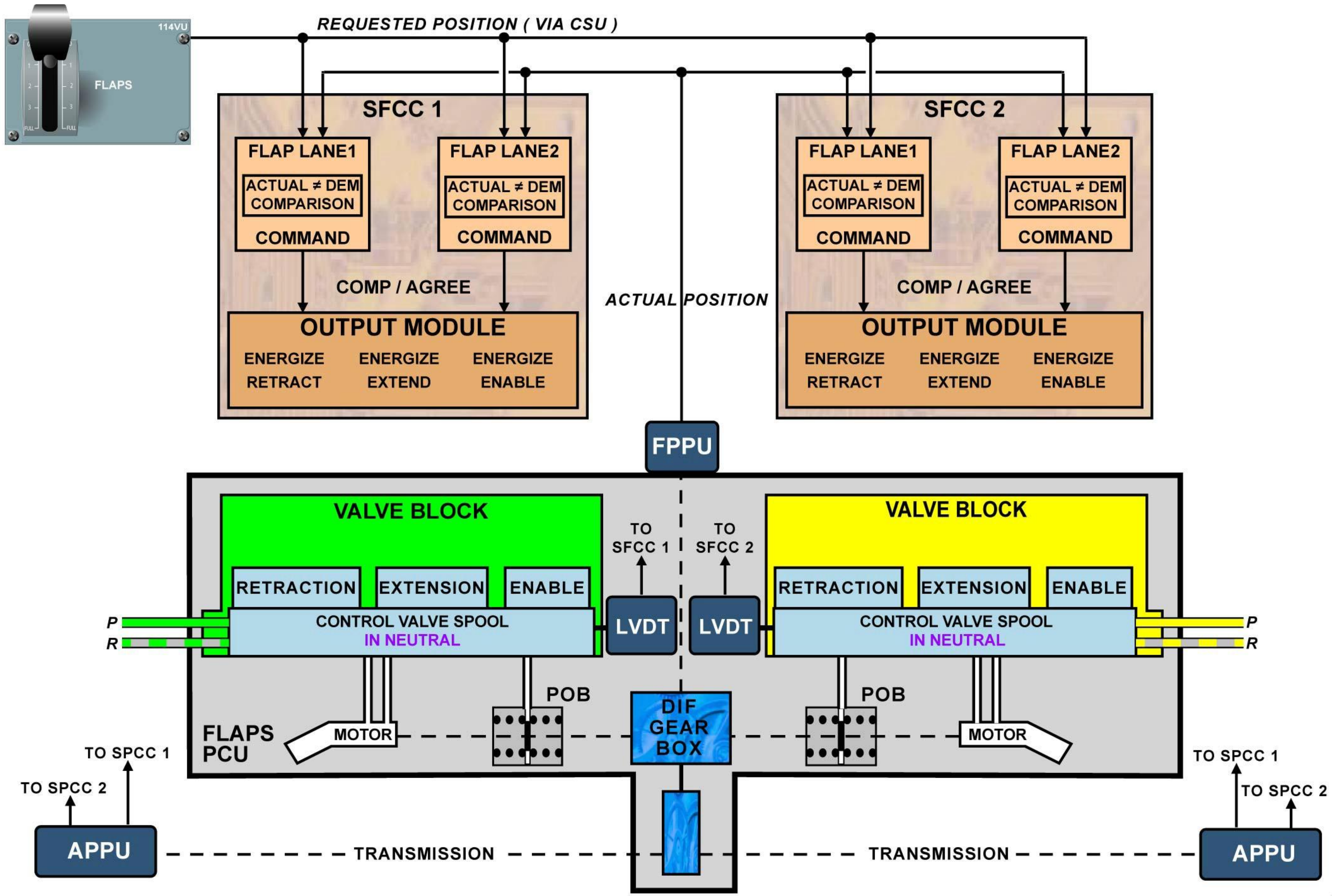
PCU/SFCC DESCRIPTION

This presentation shows the detailed operation of the Power Control Unit (PCU) and the Slat Flap Control Computer (SFCC), through a normal extension sequence. As slat and flap system control is identical, only the flap system is shown.

Each SFCC flap channel includes 2 lanes and an output module that controls its related valve block. Each valve block includes three solenoid valves. Two of them, called directional valves, command the control valve spool for retraction or extension, while the enable solenoid valve controls the Pressure-Off Brake (POB).

The output module has several functions:
• collect and analyze the data from lanes 1 and 2,
• output data to the related valve blocks.

PCU/SFCC DESCRIPTION



SLATS/FLAPS CONTROL D/O

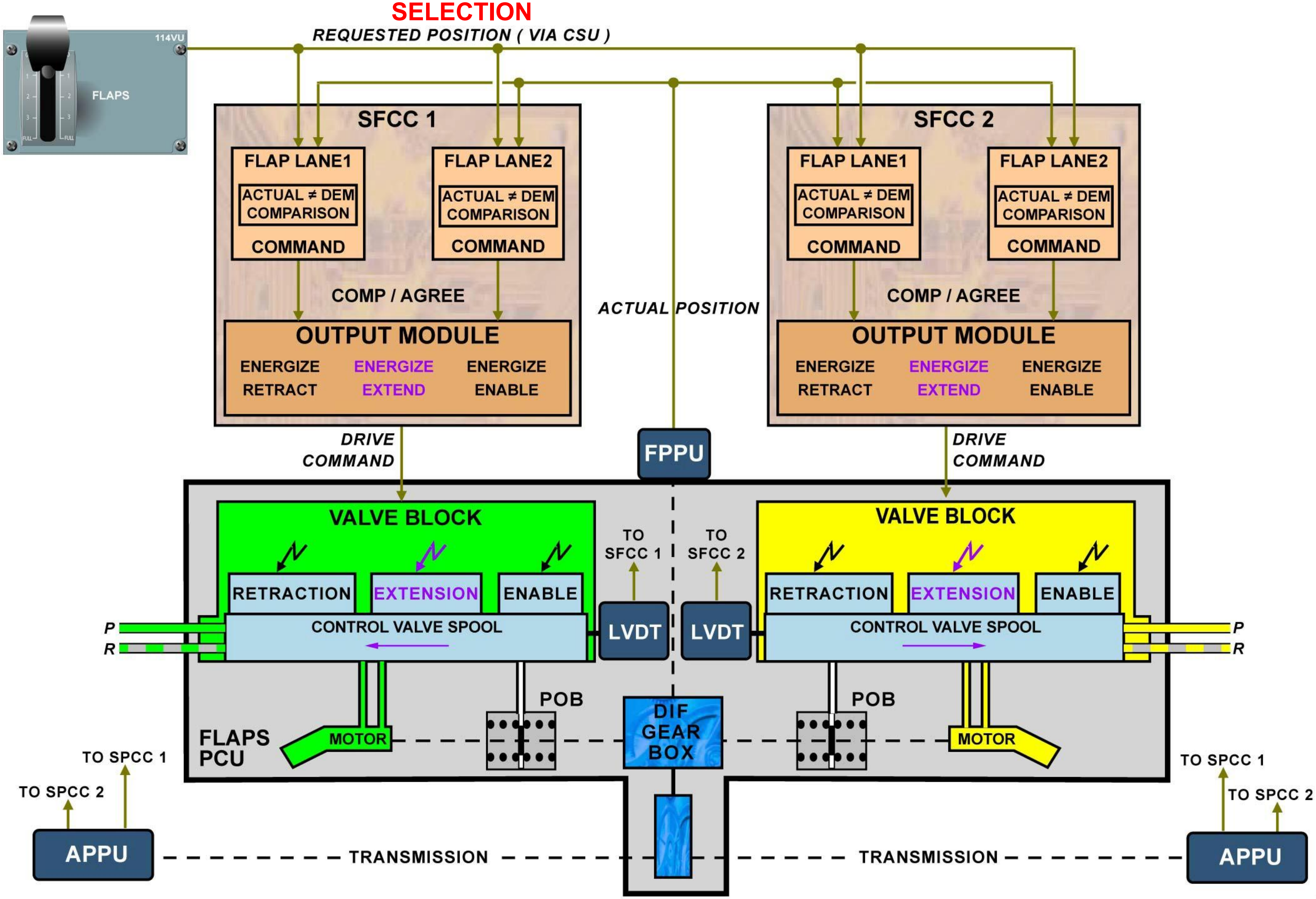
SOLENOID VALVE

EXTENSION SELECTION

Moving the slat flap lever rotates the Command Sensor Unit (CSU), which issues a new position demand signal to each SFCC. This signal is processed in flap lanes 1 and 2. The position demand and the actual position from the Feedback Position Pick-off Unit (FPPU) are compared in the SFCC flap lanes. If the requested and actual positions are different, each lane generates command signals that are compared by the output module. If the command signals are in agreement, the output module generates drive commands for PCU valve block activation. Each SFCC channel controls its related solenoid valves.

As the extend solenoid is energized, the control valve spool moves from neutral towards the fully deflected position. The direction of valve spool movement controls the direction of rotation of the motor. The degree of valve spool movement controls the rotation speed of the motor. The position of the control valve spool is monitored by a Linear Variable Differential Transducer (LVDT) mounted on one end of the valve block.

SOLENOID VALVE - EXTENSION SELECTION



FOR TRAINING PURPOSES ONLY

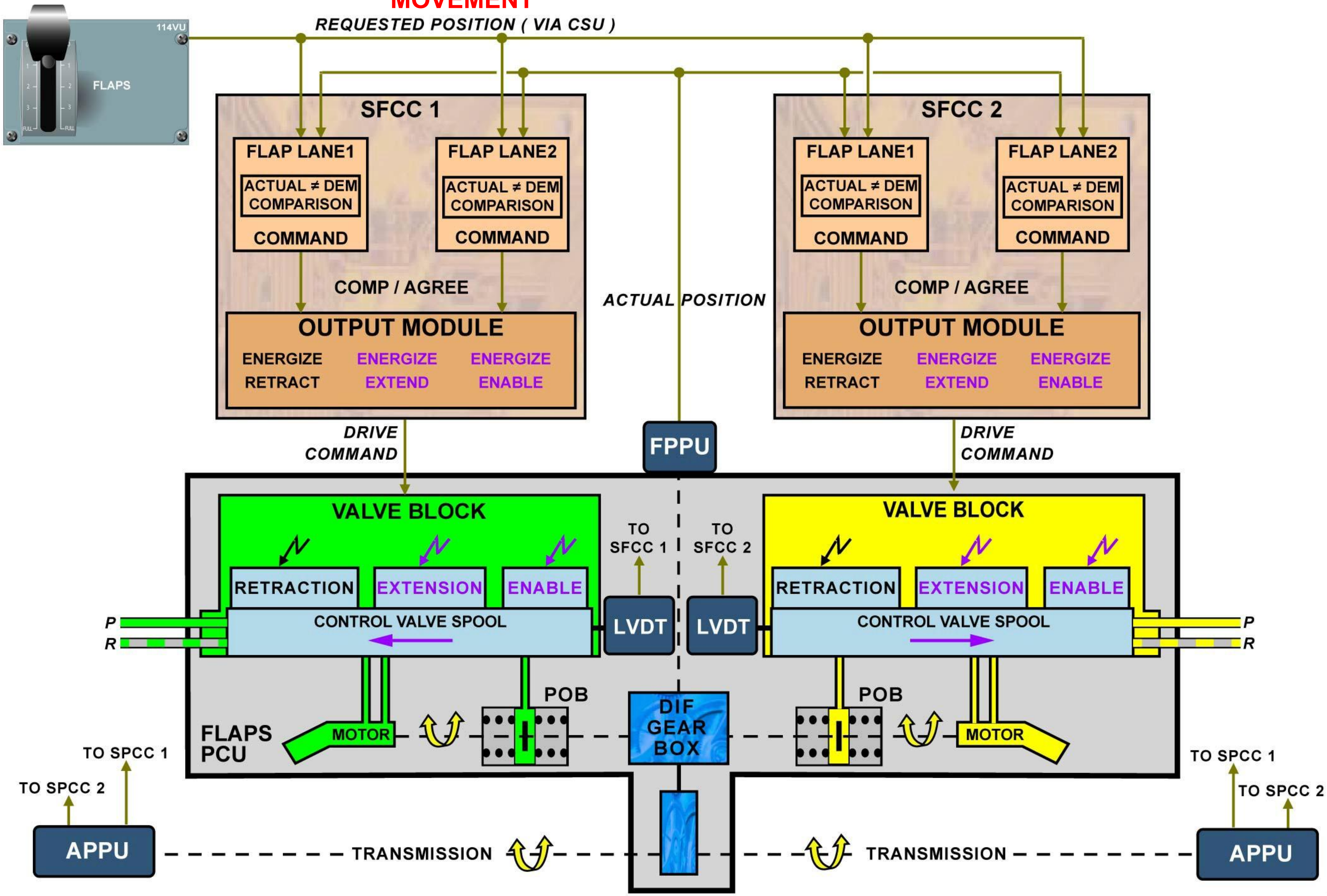
SLATS/FLAPS CONTROL D/O

SOLENOID VALVE (continued)

HIGH SPEED MOVEMENT

The enable solenoid valve is energized to release the POB, and the flaps begin to extend. With the control valve spool fully deflected, the maximum available fluid flow is directed to the motors, which run at full speed for flap extension.

SOLENOID VALVE - HIGH SPEED MOVEMENT



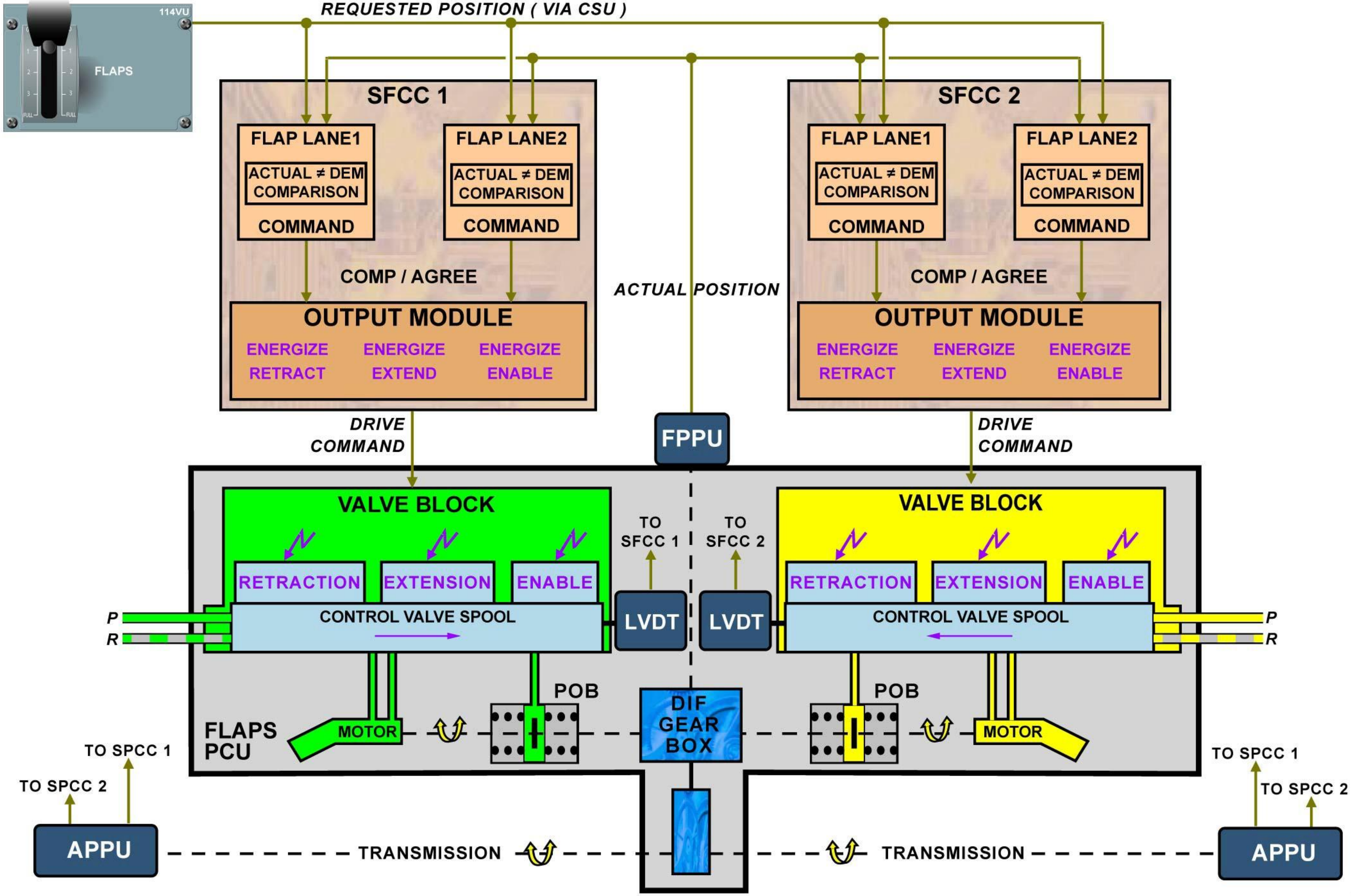
SLATS/FLAPS CONTROL D/O

SOLENOID VALVE (continued)

LOW SPEED MOVEMENT

As the flap approaches the requested position, detected by FPPU, the SFCC energizes the retract solenoid. This causes the spool control valve to move back slowly to the neutral position. The control valve spool movement reduces the fluid flow, which reduces the motor speed.

SOLENOID VALVE - LOW SPEED MOVEMENT



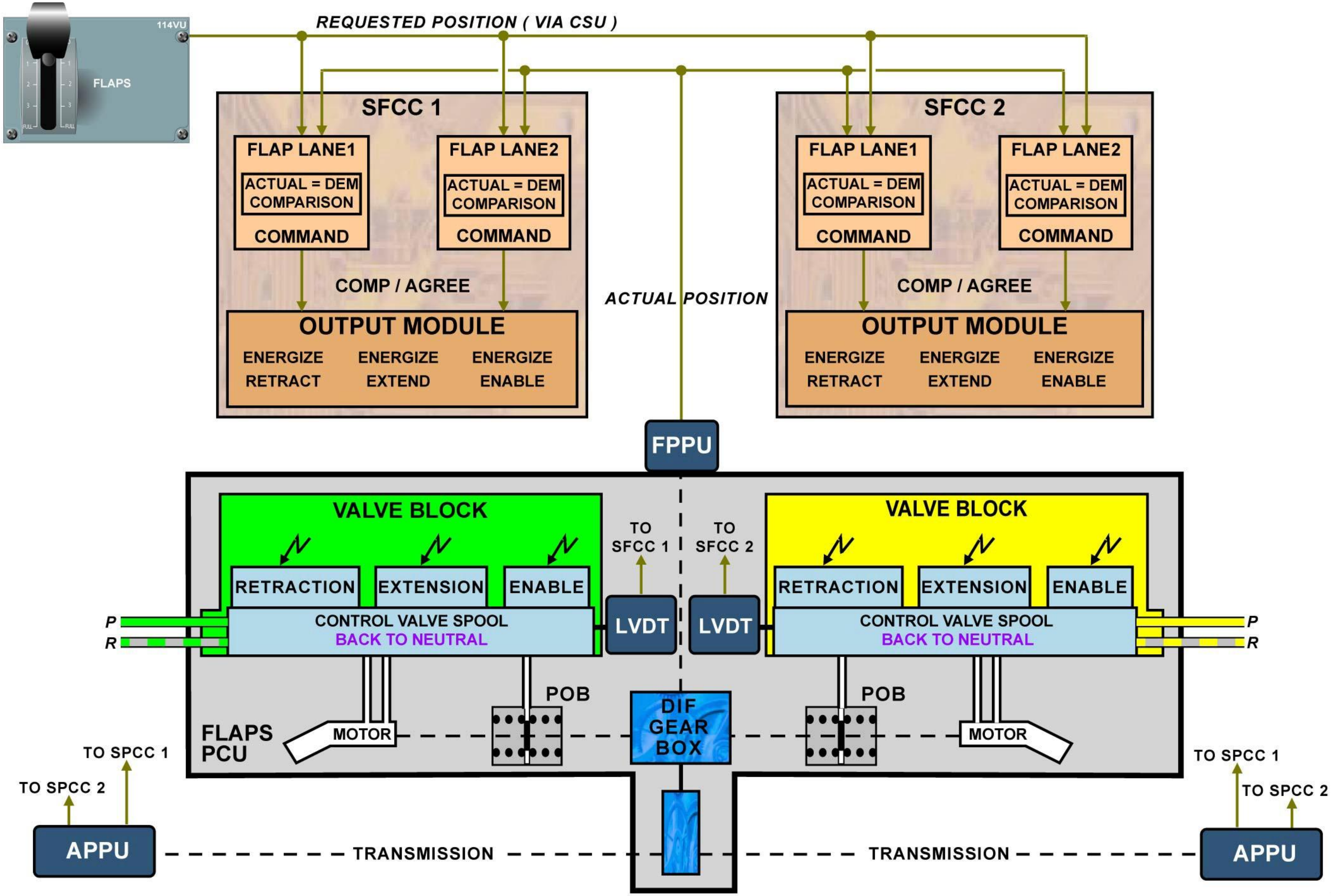
FOR TRAINING PURPOSES ONLY

SLATS/FLAPS CONTROL D/O

POB

When the flaps reach the requested position, all solenoid valves are de-energized and the POB is applied. The motor stops and the POB is applied to lock the flaps until a new position is requested.

POB


REQUESTED POSITION (VIA CSU)
114VU
FLAPS
SFCC 1
FLAP LANE1
ACTUAL = DEM
COMPARISON
COMMAND
FLAP LANE2
ACTUAL = DEM
COMPARISON
COMMAND
COMP / AGREE
OUTPUT MODULE
ENERGIZE RETRACT
ENERGIZE EXTEND
ENERGIZE ENABLE
SFCC 2
FLAP LANE1
ACTUAL = DEM
COMPARISON
COMMAND
FLAP LANE2
ACTUAL = DEM
COMPARISON
COMMAND
COMP / AGREE
OUTPUT MODULE
ENERGIZE RETRACT
ENERGIZE EXTEND
ENERGIZE ENABLE
ACTUAL POSITION
FPPU
VALVE BLOCK
RETRACTION
EXTENSION
ENABLE
CONTROL VALVE SPOOL
BACK TO NEUTRAL
TO SFCC 1
TO SFCC 2
LVDT
LVDT
VALVE BLOCK
RETRACTION
EXTENSION
ENABLE
CONTROL VALVE SPOOL
BACK TO NEUTRAL
P
R
P
R
POB
POB
FLAPS PCU
MOTOR
DIF GEAR BOX
MOTOR
TO SPCC 1
TO SPCC 2
TO SPCC 1
TO SPCC 2
APPU
TRANSMISSION
TRANSMISSION
APPU

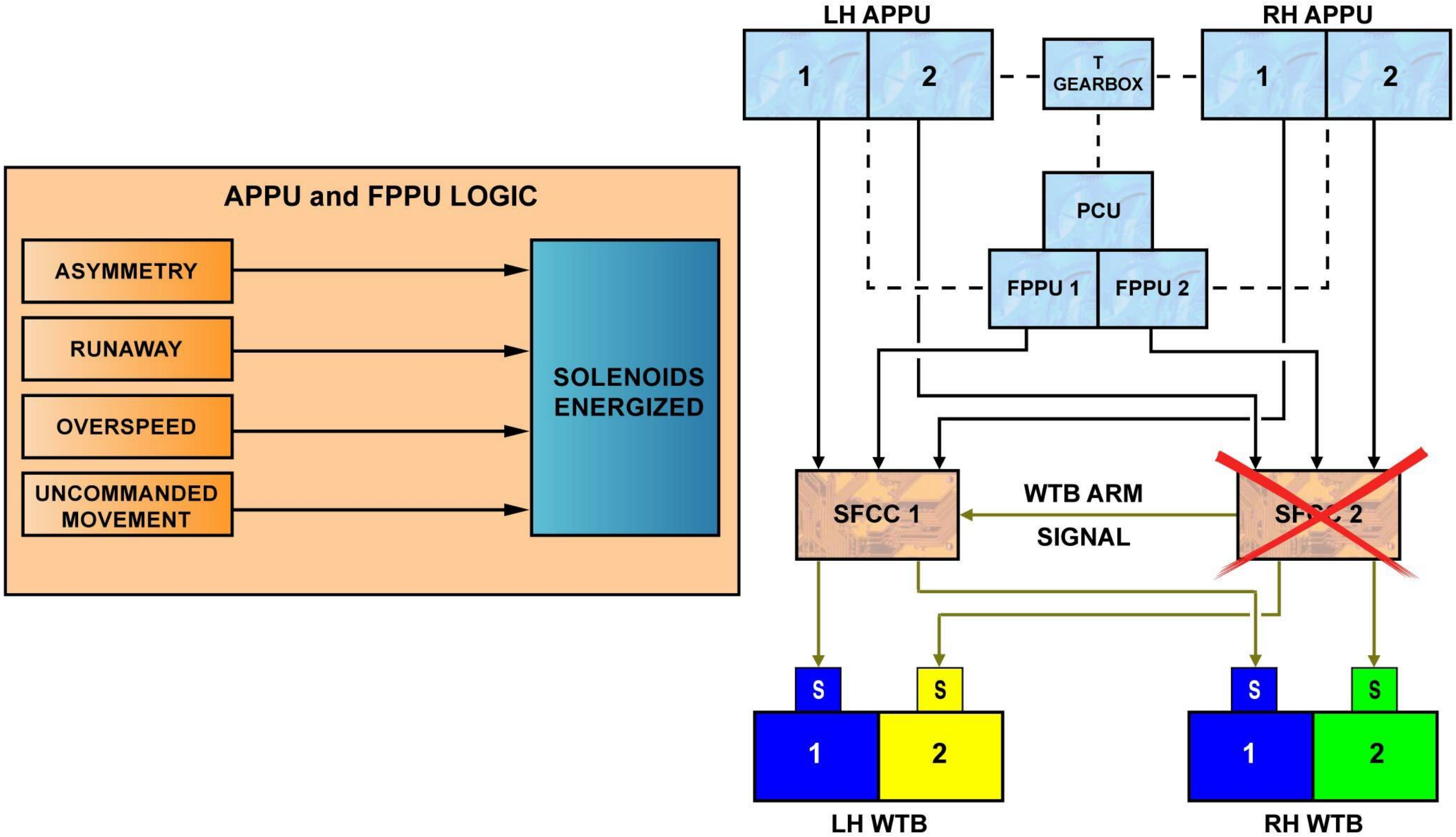
SLATS/FLAPS ABNORMAL LOCKING OPERATION

GENERAL

Here is a brief reminder of the Wing Tip Brake (WTB) application logic. Asymmetry, runaway, overspeed and uncommanded movement are detected by cross comparison of Asymmetry Position Pick-Off Unit (APPU) and Feedback Position Pick-off Unit (FPPU) signals. If any of these failures are detected by a Slat Flap Control Computer (SFCC) and confirmed by the second one, the WTBs are applied.

NOTE: That if an SFCC does not operate, the other SFCC receives a WTB-arm signal automatically. Thus, if the second SFCC subsequently detects a failure, a solenoid valve on each WTB is energized.

GENERAL


APPU and FPPU LOGIC
ASYMMETRY
RUNAWAY
OVERSPEED
UNCOMMANDED MOVEMENT
SOLENOIDS ENERGIZED
LH APPU
1
2
T GEARBOX
RH APPU
1
2
PCU
FPPU 1
FPPU 2
SFCC 1
WTB ARM
SIGNAL
SFCC 2
S
S
S
S
1
2
1
2
LH WTB
RH WTB

SLATS/FLAPS ABNORMAL LOCKING OPERATION

ASYMMETRY

Asymmetry is defined as a positional difference between the LH and RH APPUs. Asymmetry is usually due to a broken shaft between both APPUs. The asymmetry threshold is above 5° synchro positional difference between both APPUs.

RUNAWAY

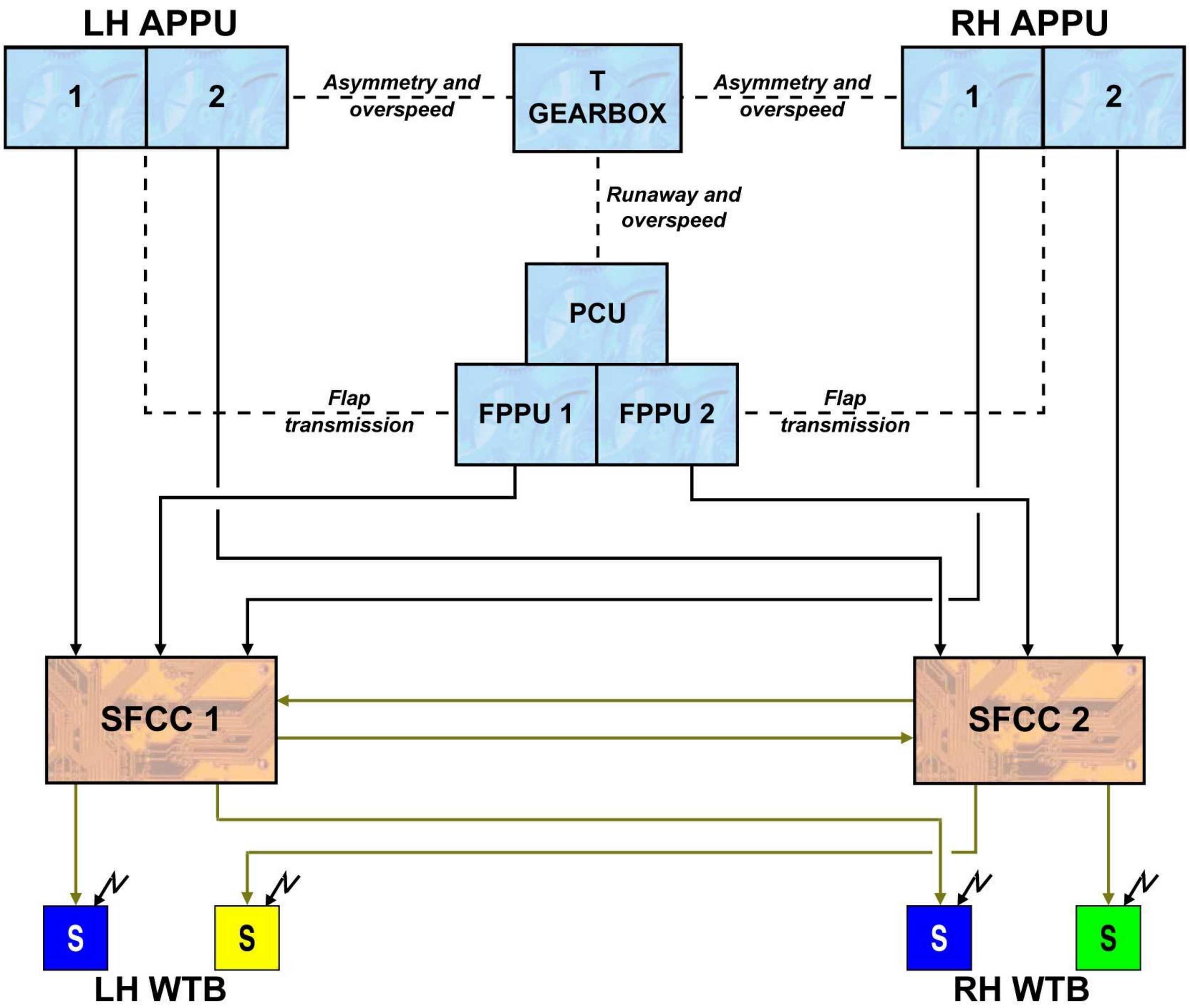
The SFCCs identify a runaway by comparing the LH and RH APPU positions with the FPPU position. The reason for a runaway on slat transmission could be a broken shaft between the slat PCU and the T-gearbox. To avoid that air loads move the slats in a runaway condition, the WTBs will be applied.

As LH and RH flap transmissions are directly connected to the Flap PCU only a gearbox failure can cause a runaway. To avoid that air loads move the flaps in a runaway condition, the WTBs will be applied.

OVERSPEED

An overspeed is detected when the rotation speed of the transmission measured by any Position Pickoff Unit (PPU) is too high.

ASYMMETRY - RUNAWAY & OVERSPEED

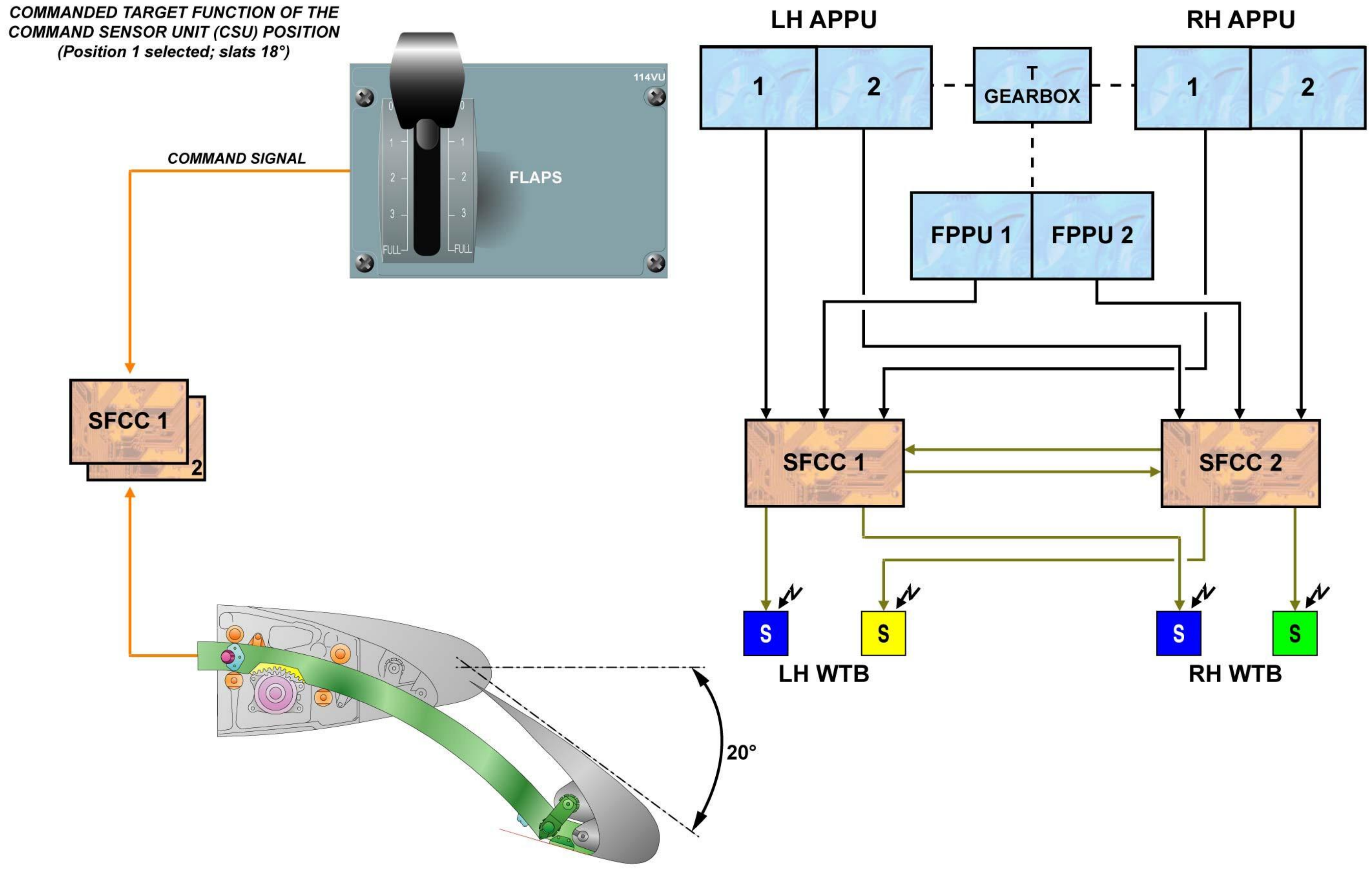


SLATS/FLAPS ABNORMAL LOCKING OPERATION

UNCOMMANDED MOVEMENT

Uncommanded movement is defined as a movement away from the selected position by a value that exceeds the threshold.

UNCOMMANDED MOVEMENT



SLATS VALUE EXCEEDED 20°, WTB APPLIED

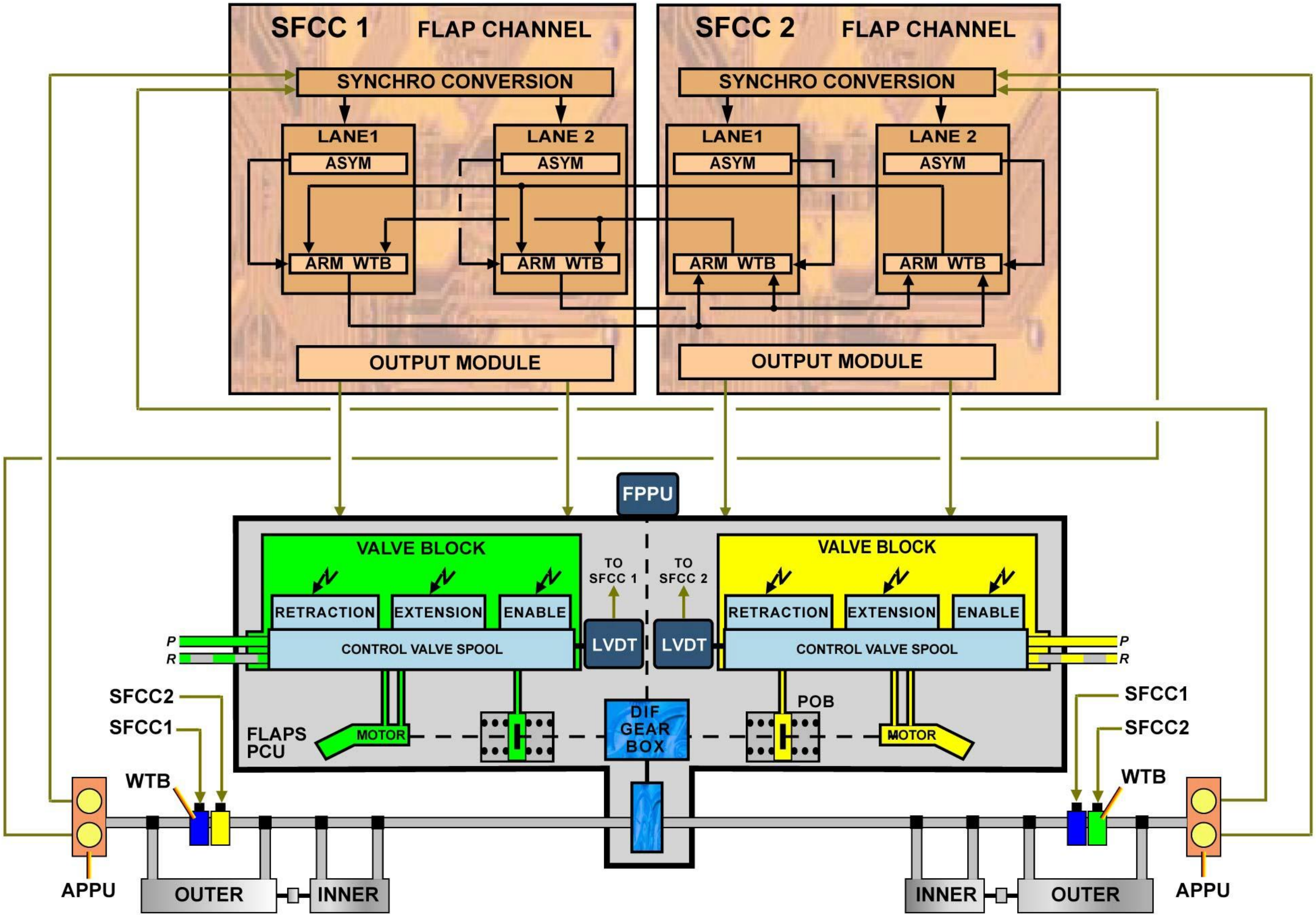
SLATS/FLAPS ABNORMAL LOCKING OPERATION

FAILURE MONITORING

If PCUs are in operation, extended solenoid and enable solenoid are energized and the flaps extend. PPU information is used for system monitoring. If one SFCC detects an asymmetry, its associated valve block is de-energized. A "WTB arm" signal is sent to the other SFCC flap channel to check whether asymmetry is confirmed, or not.

If the other SFCC confirms the asymmetry, the WTB solenoid is energized, PCUs are de-energized and the flap drive system is stopped. A reset of the WTBs can be done on ground only via the Centralized Fault Display System (CFDS). If asymmetry is only detected by one computer, the associated flap drive system is considered faulty.

FAILURE MONITORING



FOR TRAINING PURPOSES ONLY

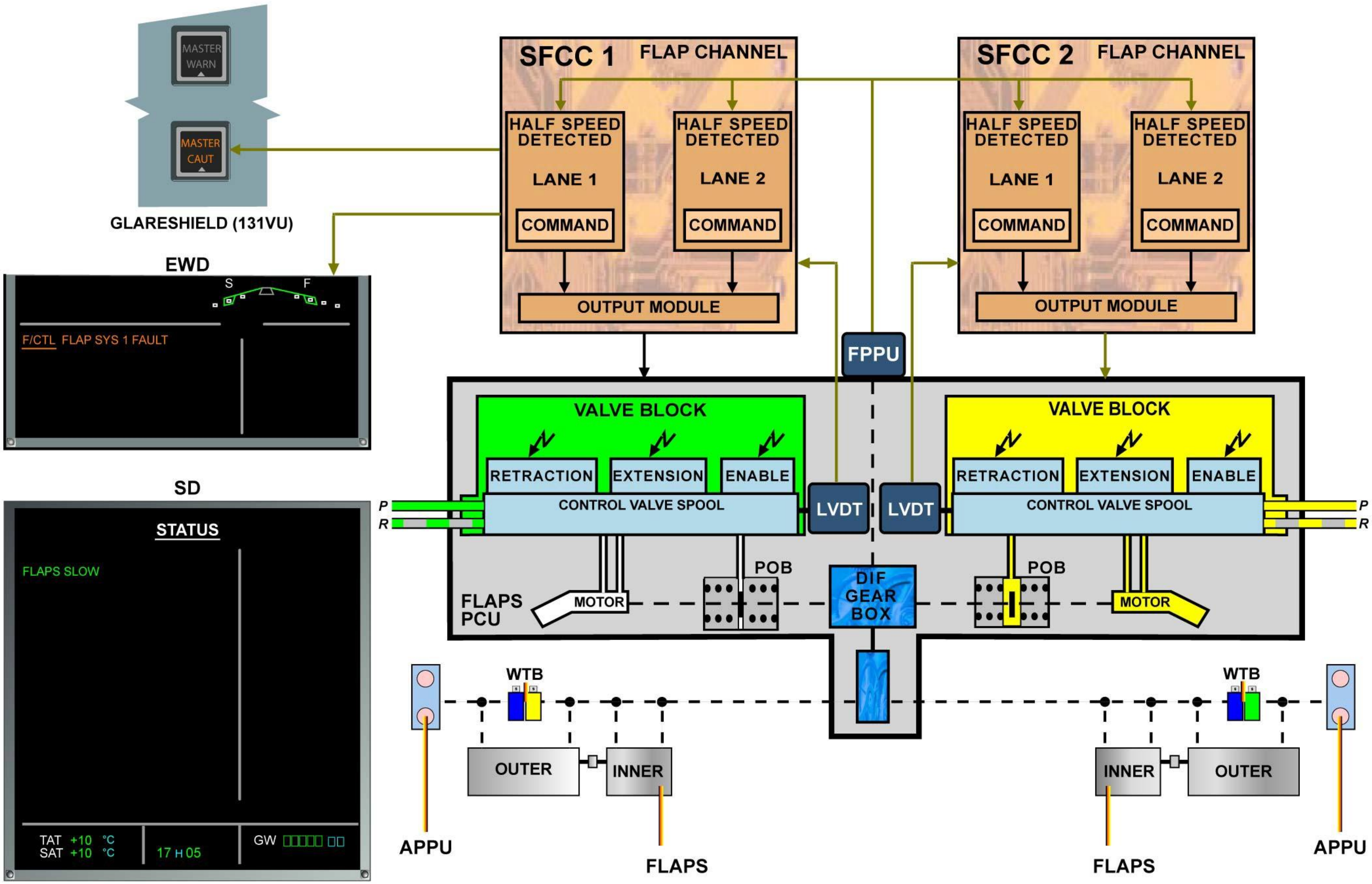
SLATS/FLAPS ABNORMAL HALF SPEED OPERATION

PRESENTATION

We will study examples on abnormal operations which cause the system to operate at half speed. As slat and flap operations are identical, only flaps operation will be shown. When half speed is detected, a level 1 caution is generated and a fault message is displayed on the EWD.
The STS page appears after the pilot confirms the Flap fault by pressing the CLEAR button on the ECAM control panel or calls the STS by pressing STS button on the ECP. A green message SLAT/FLAP SLOW is displayed on the SD.

NOTE: The STS message " SLAT/FLAP SLOW" will only appear if both Engines are running. On ground with engines off, no Slat/ Flaps STS message will appear.

PRESENTATION

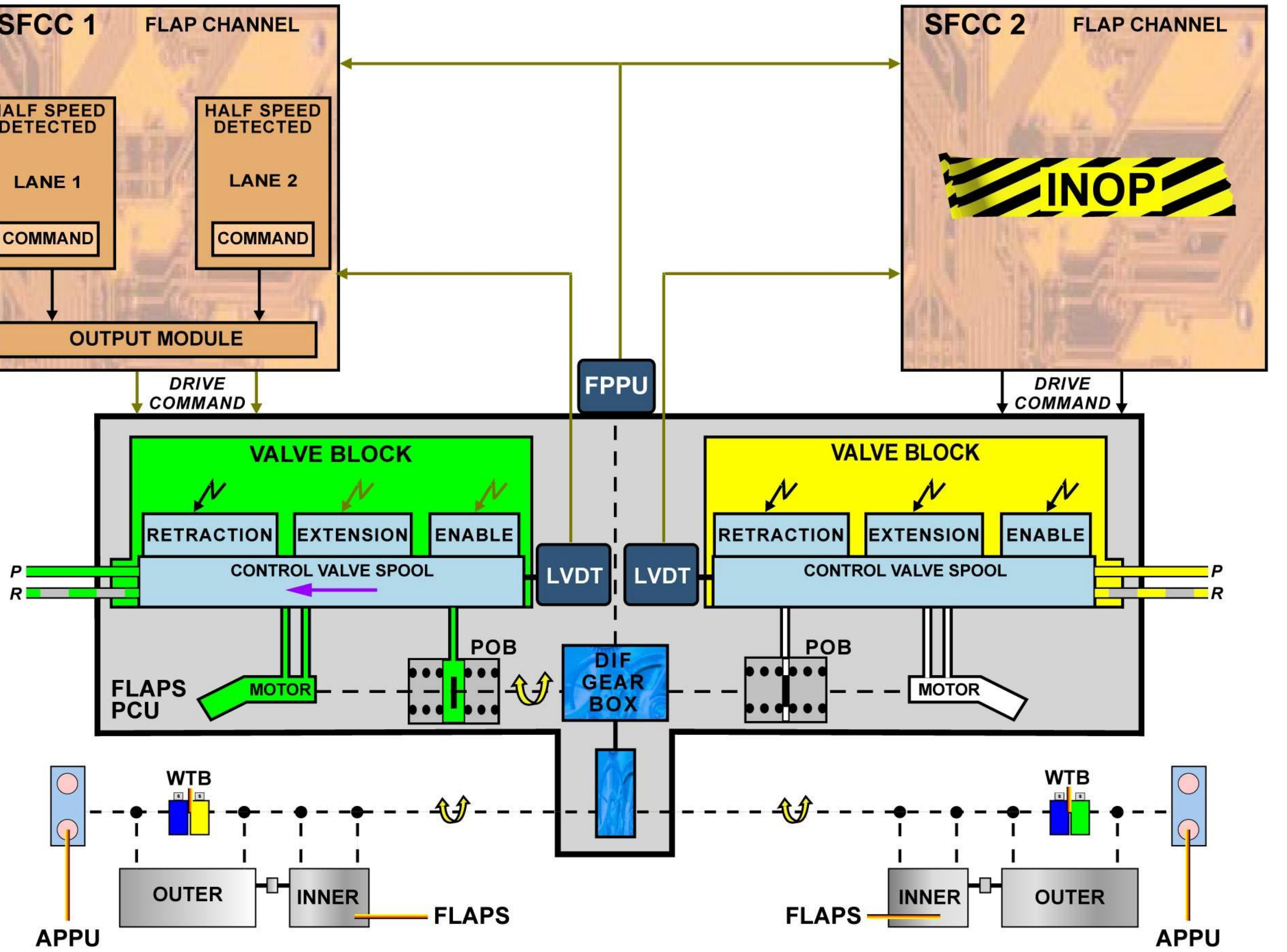


SLATS/FLAPS ABNORMAL HALF SPEED OPERATION

SFCC FAILURE

In this example Slat Flap Control Computer (SFCC) 2 flap channel is inoperative and SFCC 1 operates normally. Each flap channel lane of SFCC 1 generates command signals. The drive commands, generated in SFCC1 Output module, control the related solenoid valve in the flap PCU. Only the related green hydraulic motor is operative. As the yellow valve block is not energized, the Pressure-Off Brake (POB) holds the output shaft of the yellow hydraulic motor. Due to the differential gearbox, the system moves with full torque at half speed.

SFCC FAILURE



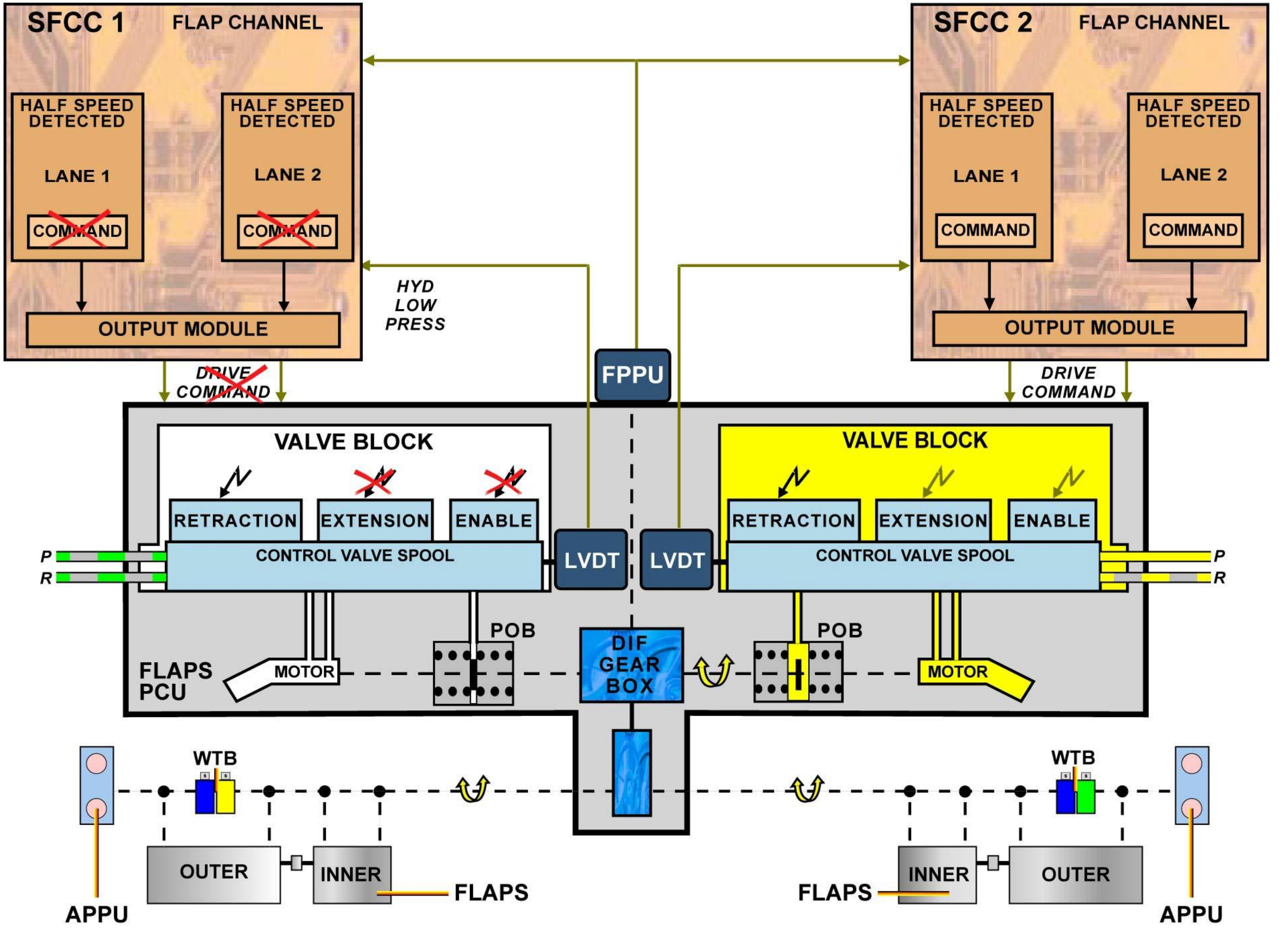
FOR TRAINING PURPOSES ONLY

SLATS/FLAPS ABNORMAL HALF SPEED OPERATION

HYDRAULIC FAILURE

Each SFCC channel monitors the hydraulic pressure for its associated PCU motor. Signals from the Linear Variable Differential Transducer (LVDT) are used to compare the position of the control valve with the drive command orders. In this example, a green hydraulic low pressure is detected by SFCC1. As soon as the hydraulic pressure drop is detected, the PCU valve block solenoids are de-energized. The POB holds the output shaft of the green hydraulic motor. Only the yellow valve block is energized, so only the yellow hydraulic motor is operative. Due to the differential gearbox, the system moves with full torque at half speed. As the green hydraulic system also supplies one slat PCU motor, the slat system is affected as well.

HYDRAULIC FAILURE



FOR TRAINING PURPOSES ONLY

SLATS MECHANICAL DRIVE D/O

GENERAL

Torque shafts and gearboxes transmit power from the Power Control Unit (PCU) to the actuators which drive the slat operating mechanism.

PCU

The PCU incorporates two hydraulic motors, each controlled by an electrically signaled valve block. The slat PCU drives the slat transmission system via a single output shaft.

TORQUE SHAFTS

The rotation of the torque shafts drives all gearboxes and rotary actuator input shafts simultaneously and at the same speed. Steady bearings, attached to the structure, support the torque shafts where small angular changes of alignment occur.

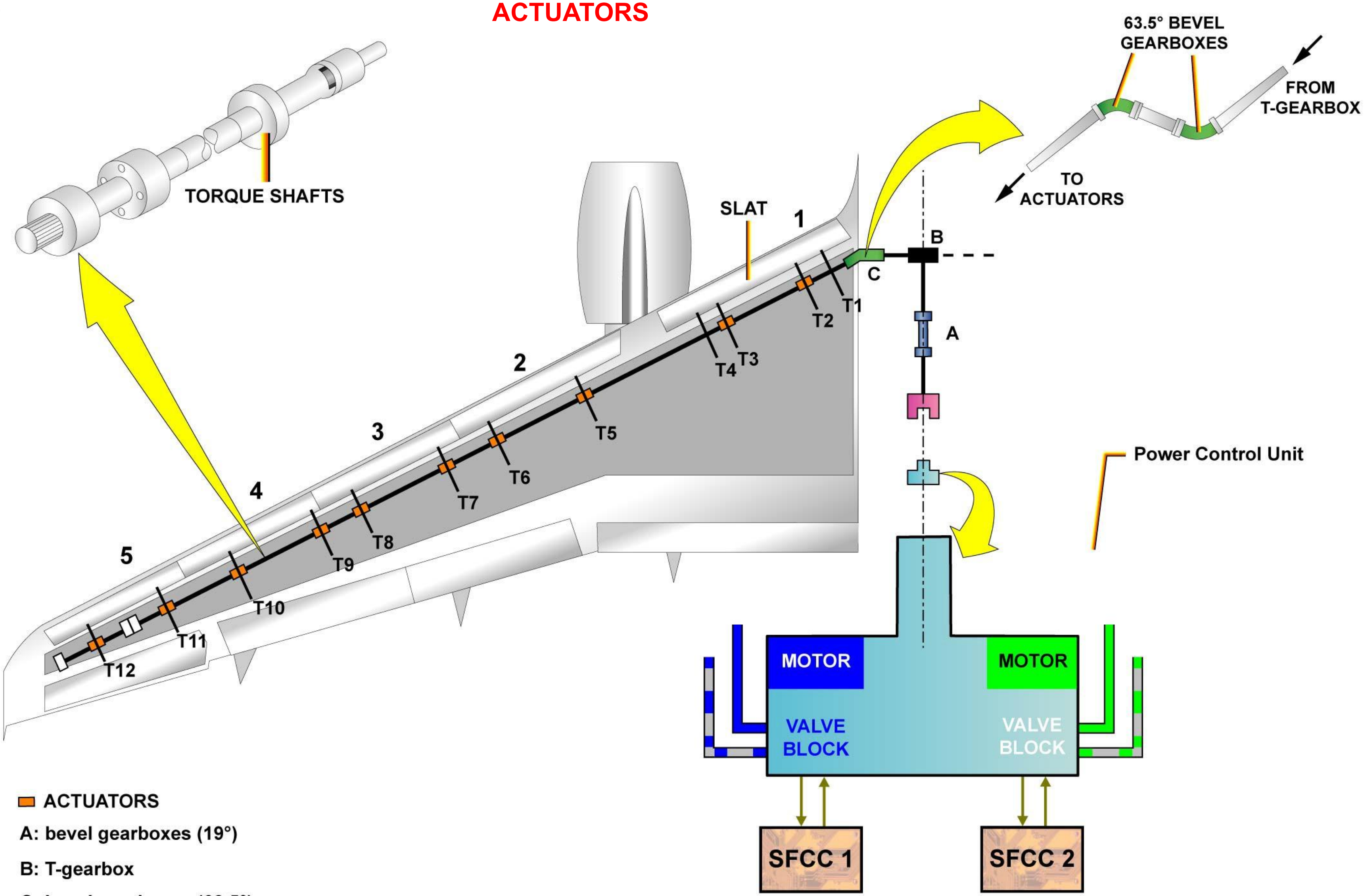
GEARBOXES

Six gearboxes are used in the slat transmission system where changes in torque shaft alignment occur:
• one 19-degree bevel gearbox changes alignment under the wing center box,
• one T-gearbox changes alignment through 90 degrees in each wing,
• two 63.5-degree bevel gearboxes take drive from below each wing level into the wing leading edge.

ACTUATORS

The actuators produce the torque and speed reduction necessary to drive the slats at the required rate. Each actuator drives its associated slat track through a pinion driven by the actuator output shaft.

GENERAL - PCU - ACTUATORS



ACTUATORS
A: bevel gearboxes (19°)
B: T-gearbox
C: bevel gearboxes (63.5°)

SLATS MECHANICAL DRIVE D/O

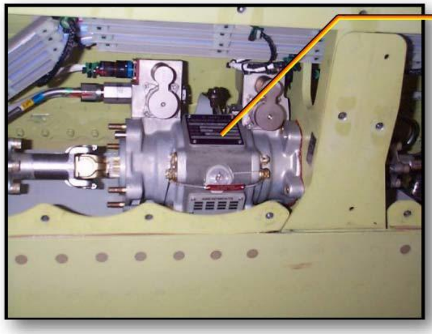
TRACKS
The slats are attached to the forward ends of the tracks which run in guide rollers. Slat 1 is supported by four tracks, but only T2 and T3 are driven. T1 and T4 prevent slat loss in case of attachment failure. Slats outboard of the pylon are supported by two driven tracks.

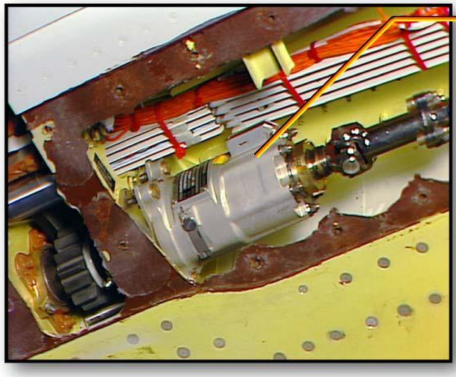
TORQUE LIMITERS
Each actuator incorporates a bi-directional torque limiter which protects the structure from overload.

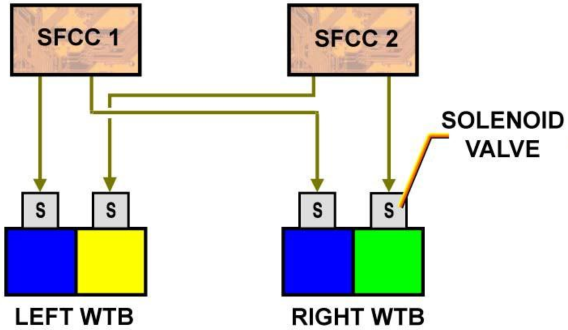
WTB
The Wing Tip Brakes (WTBs) stop and hold the transmission if the Slat Flap Control Computers (SFCCs) detect abnormal operation such as asymmetry and runaway. Once applied, the WTBs can only be reset on the ground by maintenance action via the Centralized Fault Display System (CFDS).

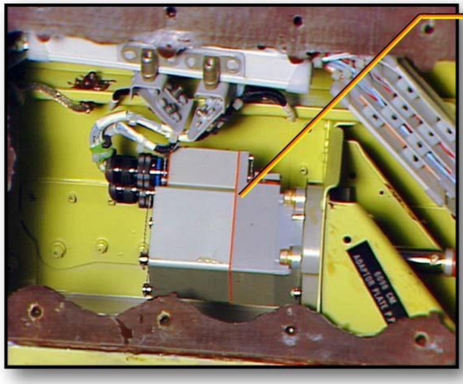
APPU
The Asymmetry Position Pick Off Units (APPUs) enable the SFCC to monitor the system for asymmetry and runaway conditions. One APPU is mounted outboard of track 12 in each wing. It gives the slat actual position to the SFCC.

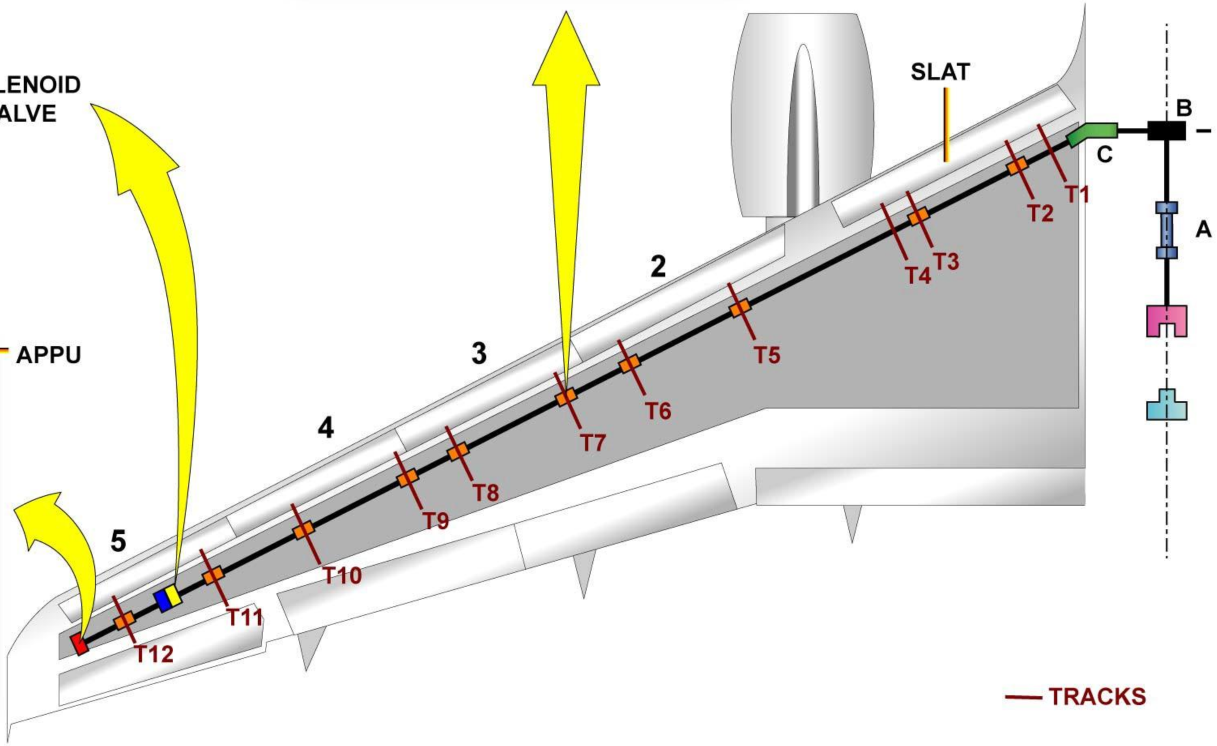
TRACKS - TORQUE LIMITERS - APPU











FLAPS MECHANICAL DRIVE D/O

PCU
The Power Control Unit (PCU) incorporates two hydraulic motors, each one controlled by an electrically-signaled valve block. The flap PCU drives the flap transmission output shafts.

TORQUE SHAFTS
The rotation of the torque shafts drives all gearboxes and rotary actuator input shafts simultaneously, at the same speed. Steady bearings, attached to the structure, support the torque shafts where small angular changes are present.

GEARBOXES
Three types of one-to-one ratio gearboxes are used in the flap transmission where large changes in torque shaft alignment are present. A right angle gearbox changes alignment through 90 degrees for input to track 1 offset gearbox. A line gearbox transmits the drive along the rear face of the rear false spar. A 19-degree bevel gearbox aligns the drive with the rear spar.

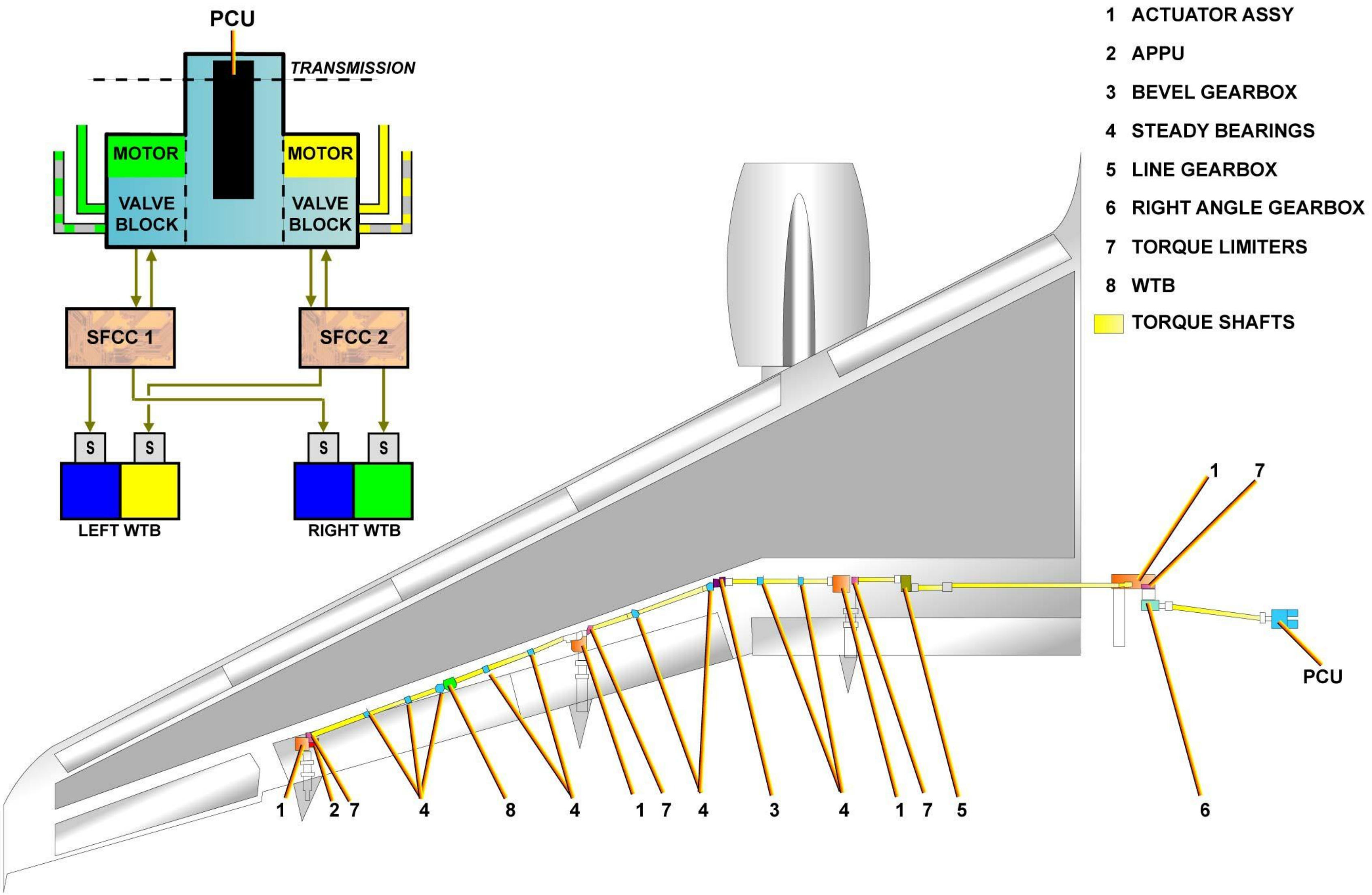
ACTUATORS
One actuator operates the flap mechanism at each track. It supplies the torque and speed reduction necessary to drive the flap at the required rate. Each actuator is driven by an offset gearbox that transmits power from the torque shaft to the plug-in rotary actuator.

TORQUE LIMITERS
Each actuator incorporates a bi-directional torque limiter which protects the structure from overload.

WTB
The Wing Tip Brakes (WTBs) stop and hold the transmission if the Slat Flap Control Computers (SFCCs) detect abnormal operation such as asymmetry, runaway, overspeed or uncommanded movement. Once applied, the WTBs can only be reset on the ground, by maintenance action via the Centralized Fault Display System (CFDS).

APPU
The Asymmetry Position Pick Off Units (APPUs) enable the SFCC to monitor the system for asymmetry and runaway conditions. The APPUs are mounted on the flap actuator assemblies No. 4. They give the flap actual position to the SFCC.

PCU - TORQUE SHAFTS - APPU



FLAPS MECHANICAL DRIVE D/O (A321)

PCU
The Power Control Unit (PCU) incorporates two hydraulic motors, each one controlled by an electrically signaled valve block. The flap PCU drives the flap transmission output shafts.

TORQUE SHAFTS
The rotation of the torque shafts drives all gearboxes and rotary actuator input shafts simultaneously, at the same speed. Steady bearings, attached to the structure, support the torque shafts where small angular changes are present.

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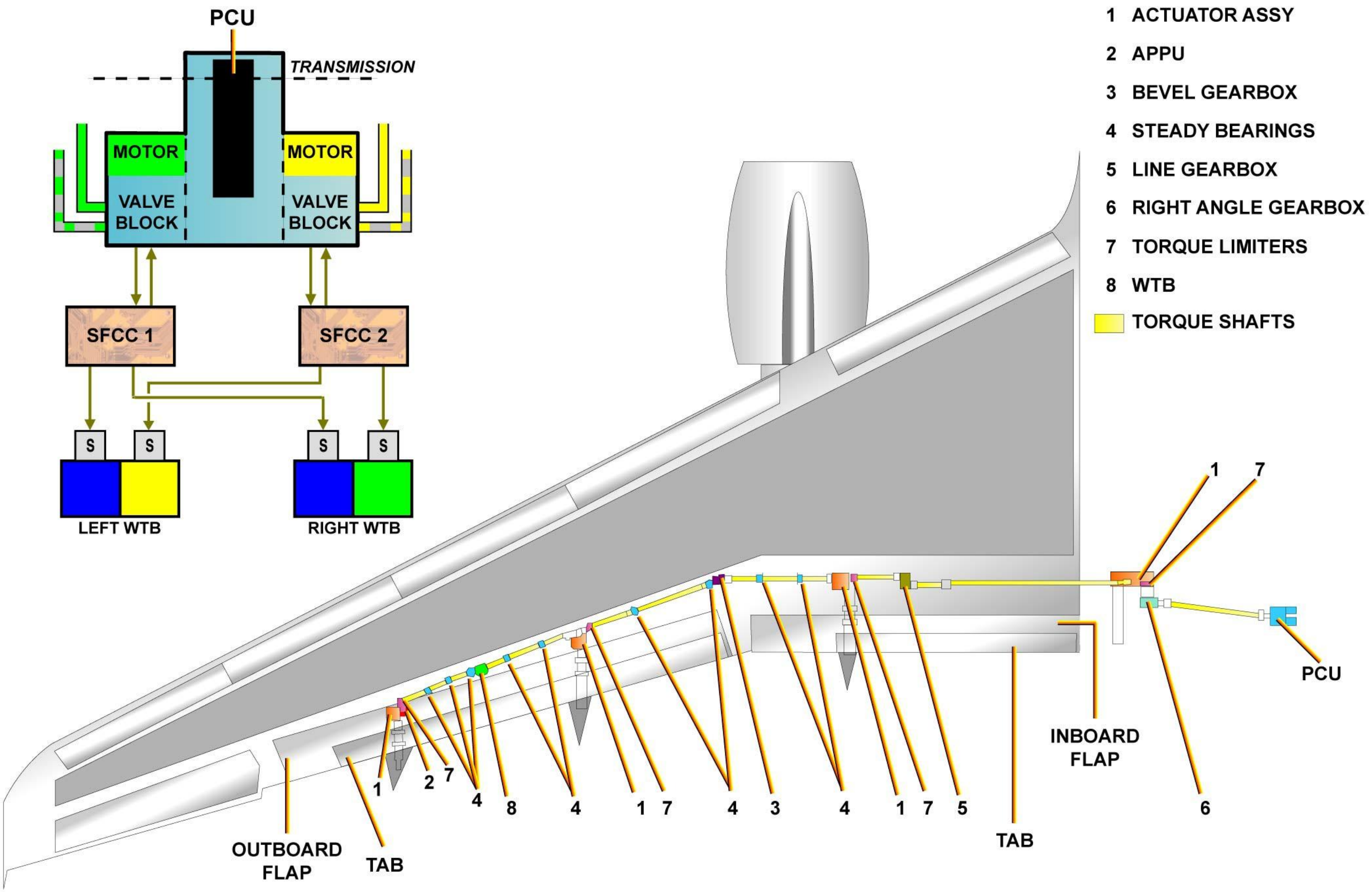
PCU - TORQUE SHAFTS - APPU

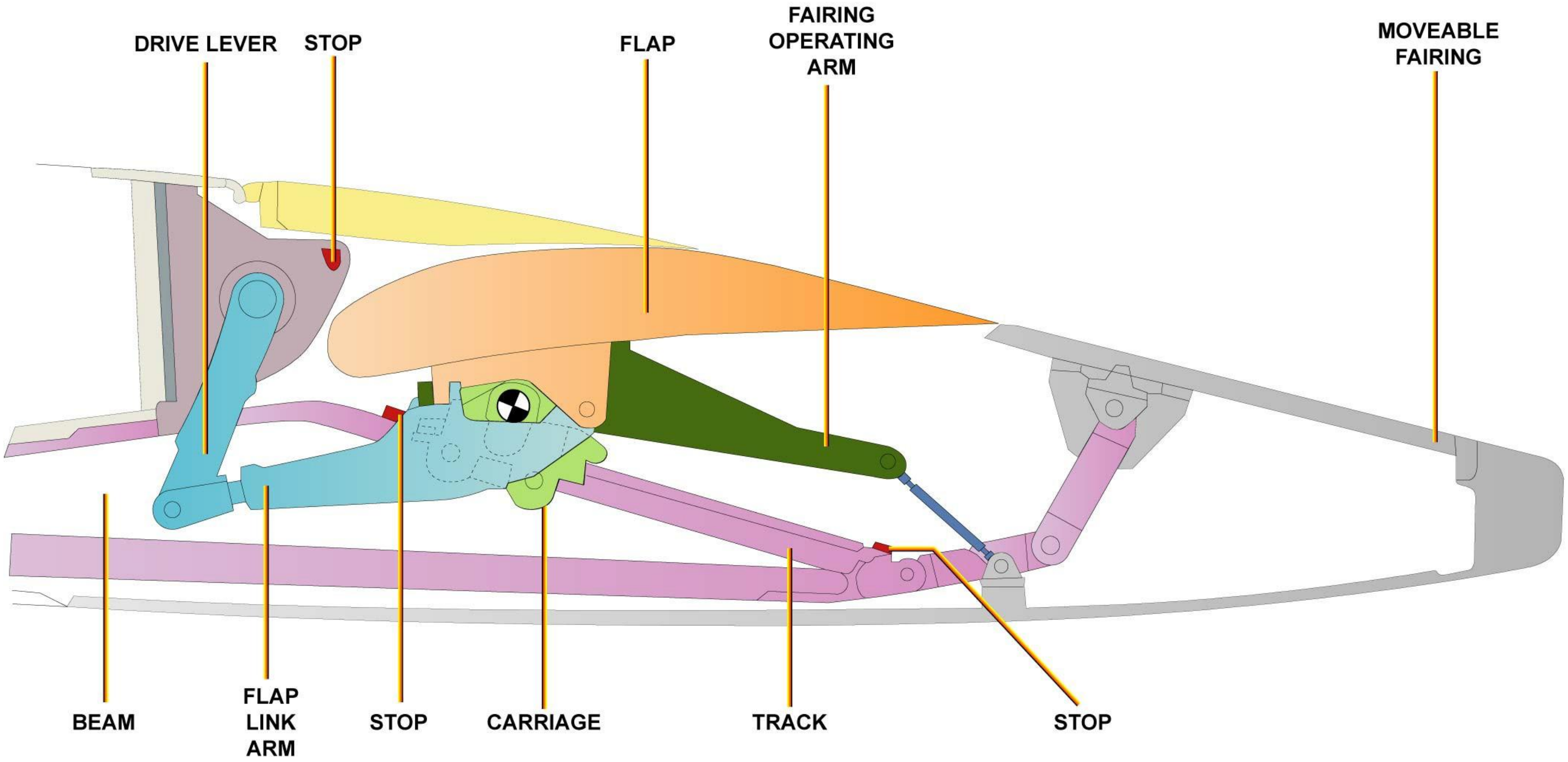


FLAPS DRIVE STATIONS D/O

GENERAL

Each flap is supported by carriages that run on tracks extending from the wing rear spar. Each carriage has a containment device to hold it on the track if a failure occurs. The carriages, tracks and beams at tracks 2, 3 and 4 are of similar construction. Track 1 is attached to the fuselage.

GENERAL



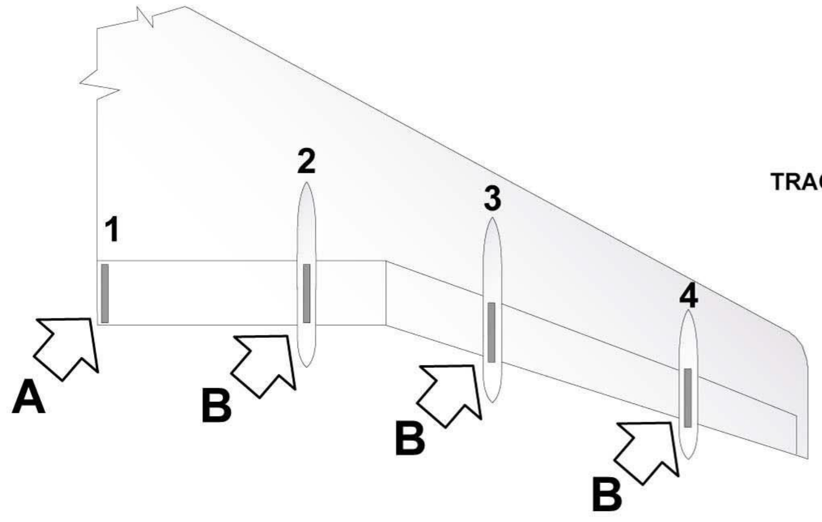
DRIVE LEVER
STOP
FLAP
FAIRING OPERATING ARM
MOVEABLE FAIRING
BEAM
FLAP LINK ARM
STOP
CARRIAGE
TRACK
STOP

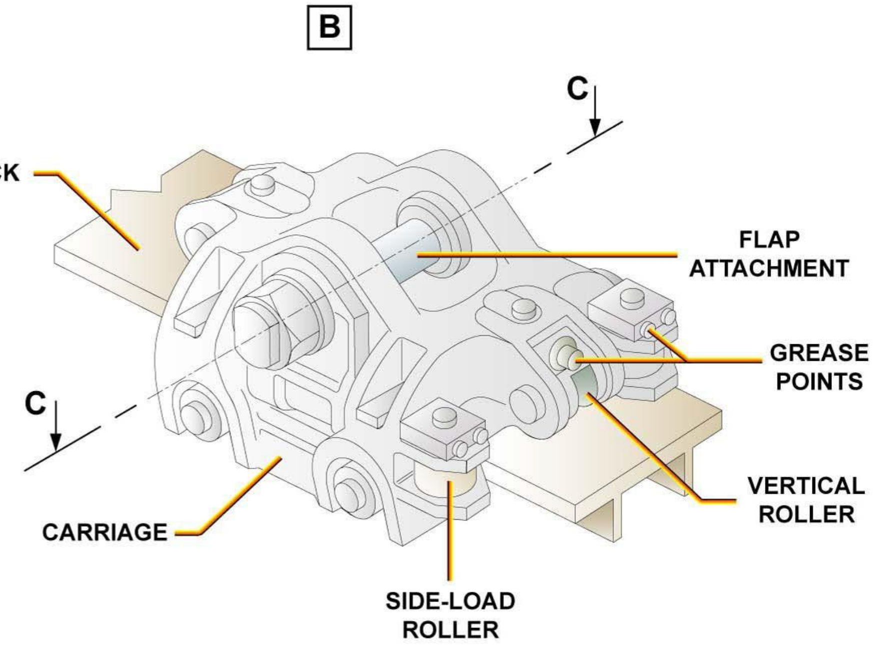
FLAPS DRIVE STATIONS D/O

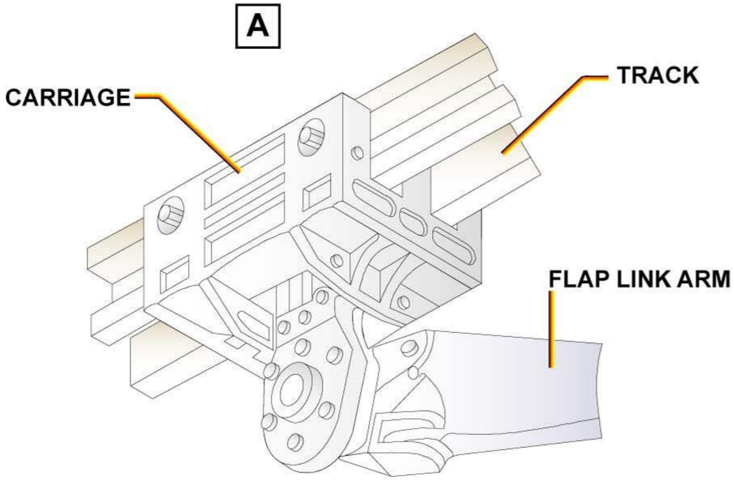
FLAP DRIVES

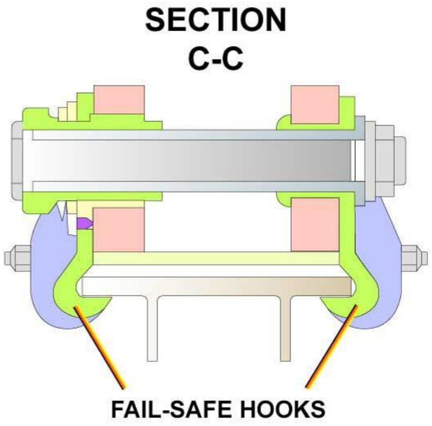
Carriage 1 is held below the track and travels on four vertical-load and two side-load rollers. The rollers contain bearings that are grease-lubricated through grease points on the carriage. Carriages 2, 3 and 4 are retained on their tracks by six vertical and four side-load rollers. The rollers are lubricated through grease points at the front and rear of the carriage. A fail-safe hook retains the flap on the track in the event of a structural failure of the carriage.

FLAP DRIVES









FOR TRAINING PURPOSES ONLY

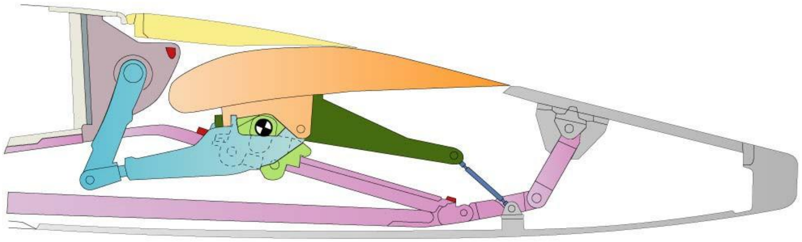
FLAPS DRIVE STATIONS D/O

FLAP AND TRACK FAIRINGS

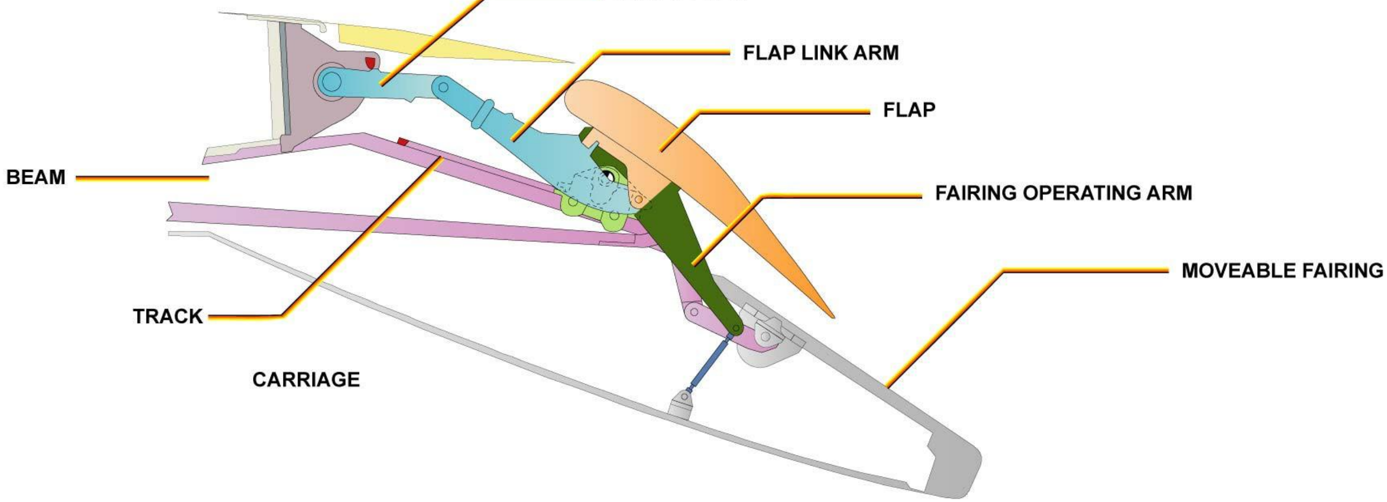
A flap link arm is attached to the flap bottom surface immediately outboard of each track position. The forward end of each link arm is bolted to the drive lever on its associated actuator. At tracks 2, 3 and 4 a track fairing operating arm is attached to the flap bottom surface. The operating arm is connected to a linkage that operates the moveable track fairing during flap extension and retraction. The link arms transmit the drive from the rotary actuators directly to the flap surface.

FLAP AND TRACK FAIRINGS

RETRACTED



EXTENDED

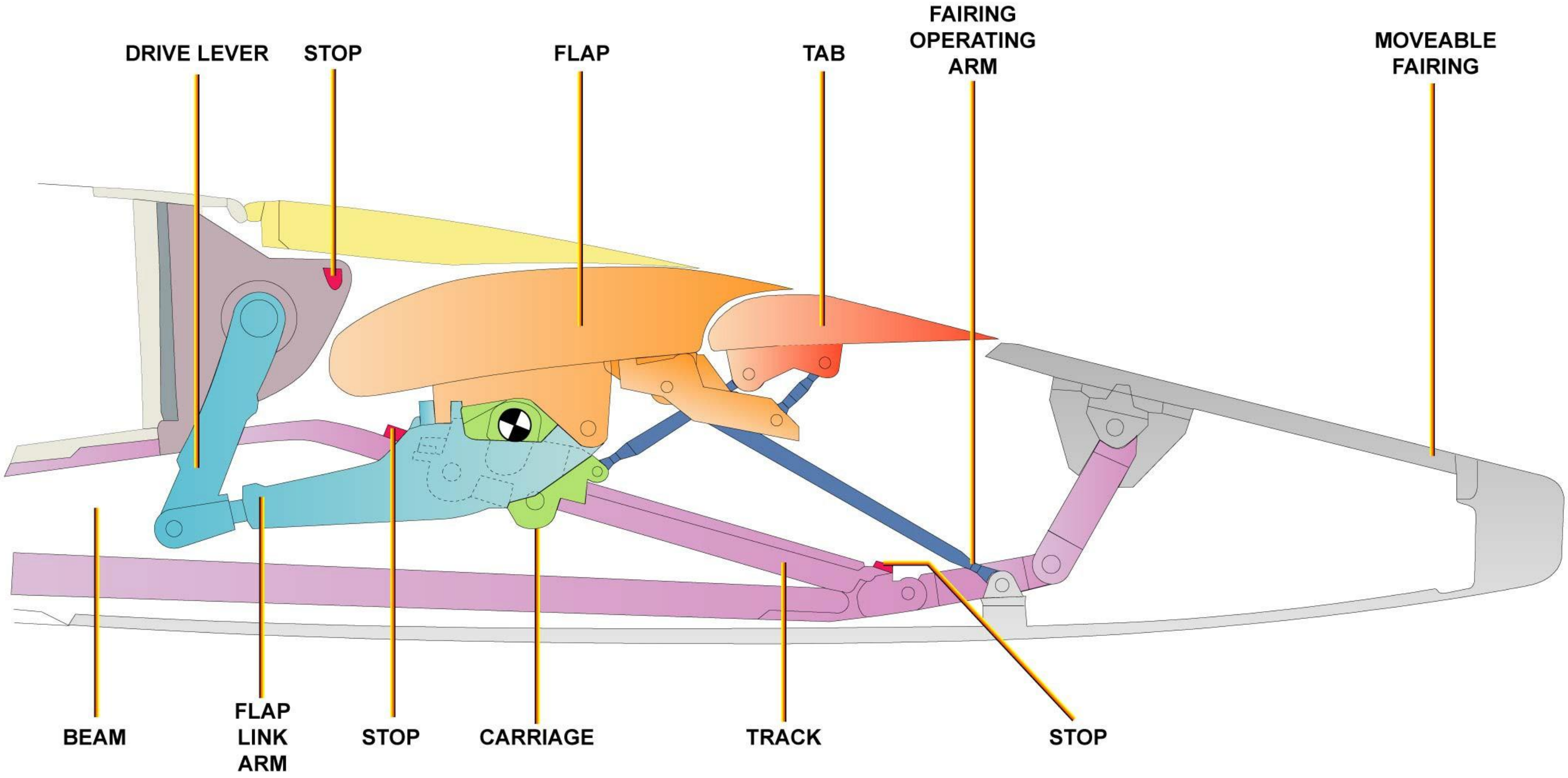


FLAPS DRIVE STATIONS D/O (A321)

GENERAL

Each flap is supported by carriages that run on tracks extending from the wing rear spar. Each carriage has a containment device to hold it on the track if a failure occurs. The carriages, tracks and beams at tracks 2, 3 and 4 are of similar construction. Track 1 is attached to the fuselage. A hinge mechanism connects the leading edge of the tab surface to the primary surface of the flap.

GENERAL

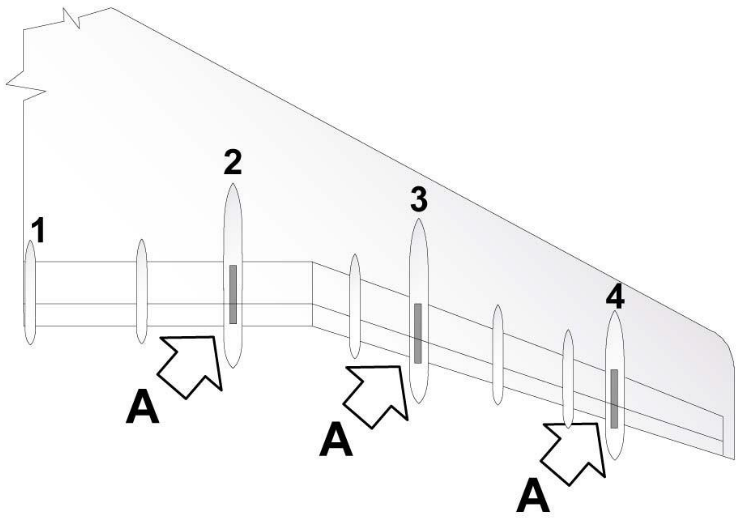

DRIVE LEVER
STOP
FLAP
TAB
FAIRING OPERATING ARM
MOVEABLE FAIRING
BEAM
FLAP LINK ARM
STOP
CARRIAGE
TRACK
STOP

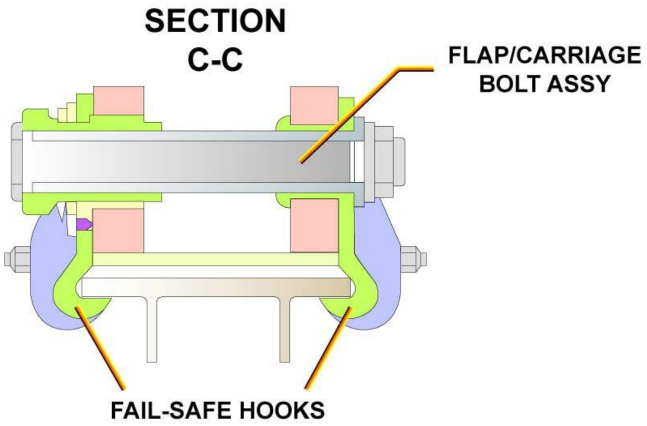
FLAPS DRIVE STATIONS D/O (A321)

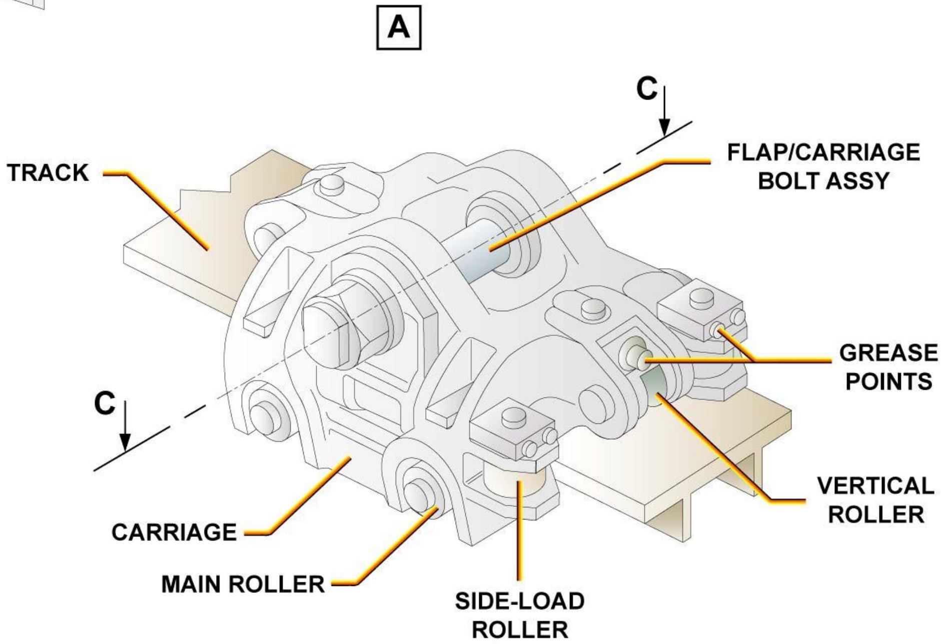
FLAP DRIVES

Six vertical-load and four side-load rollers hold each carriage on its track at tracks 2, 3 and 4. Only four vertical-load and two side-load rollers hold the carriage on track 1. A fail-safe hook keeps the flap on the track if there is a structural failure of the carriage. Bolts attach the carriage to the flaps. Bolts have eccentrics for flaps rigging.

FLAP DRIVES


1
2
3
4
A
A
A


SECTION
C-C
FLAP/CARRIAGE
BOLT ASSY
FAIL-SAFE HOOKS

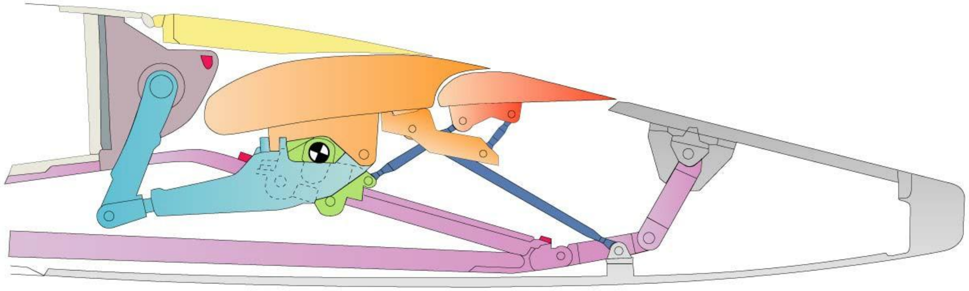

A
C
C
TRACK
FLAP/CARRIAGE
BOLT ASSY
GREASE
POINTS
VERTICAL
ROLLER
CARRIAGE
MAIN ROLLER
SIDE-LOAD
ROLLER

FLAPS DRIVE STATIONS D/O (A321)

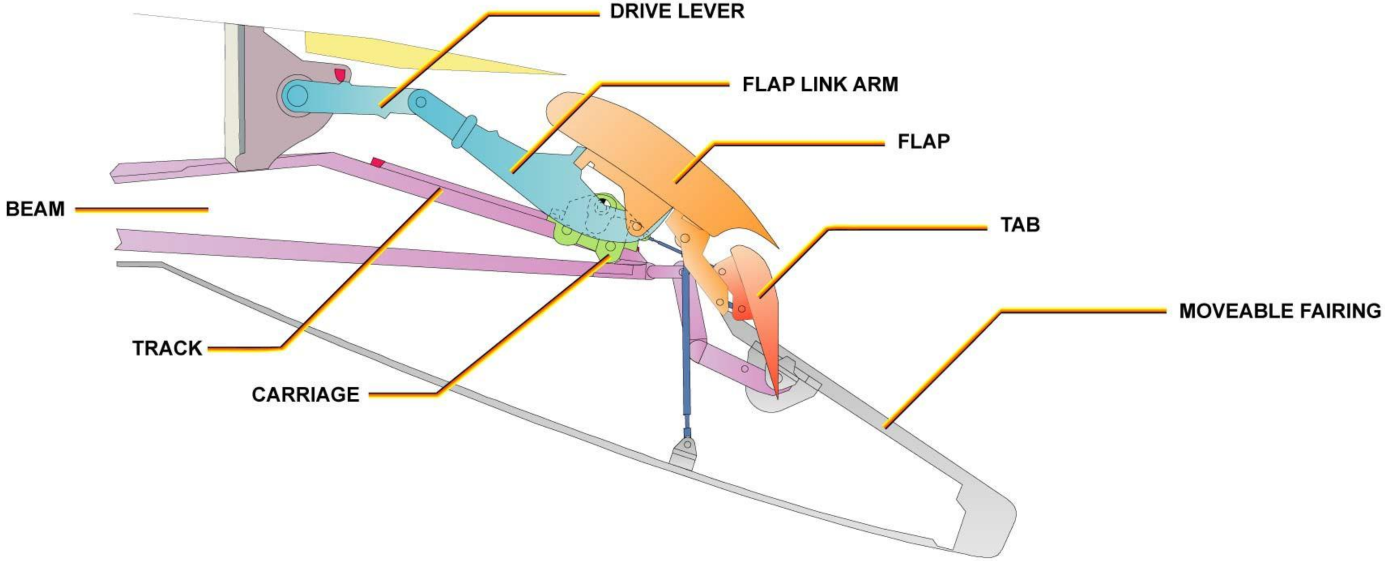
FLAP AND TRACK FAIRINGS

A flap link arm is attached to the flap bottom surface immediately outboard of each track position. The link arms transmit the movement from the rotary actuators to the flap surface. Attached to the flap bottom, at tracks 2, 3 and 4, a track operates the moveable track fairing during flap movement.

RETRACTED



EXTENDED



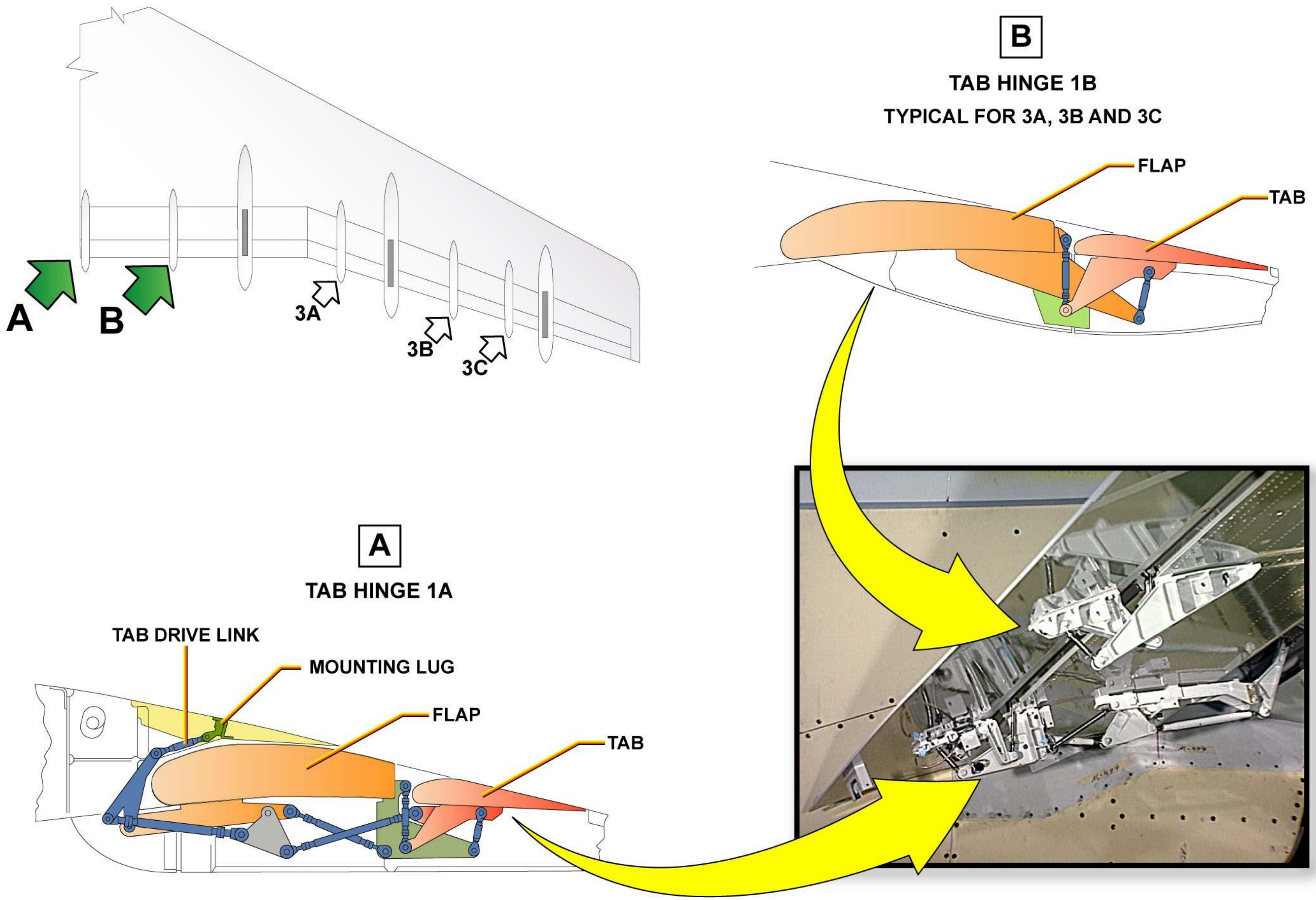
FLAPS DRIVE STATIONS D/O (A321)

TYPICAL TABS

The inner tab is attached to the rear spar of the flap at track 2 and hinges 1A and 1B. The outer tab is attached to the rear spar of the flap at tracks 3 and 4 and at hinges 3A, 3B and 3C.

When the flaps move, the tabs are operated by a linkage connected from:
• the shroud box assembly to hinge 1A tab attachment bracket,
• the roller carriages of tracks 2, 3 and 4 to the tab attachment brackets.

TYPICAL TABS



FLAPS DRIVE STATIONS D/O (A321)

A321 FIELD TRIP

A321 FIELD TRIP

FLAPS ATTACHMENT FAILURE DET DESCRIPTION

SENSORS

Two flap disconnect sensors are fitted on the interconnecting strut between inner and outer flaps on each wing. The flap disconnect sensors, which are proximity sensors, detect any flap disconnection.

LGCIU

Each Landing Gear Control and Interface Unit (LGCIU) receives signals from two sensors and transmits this data to its related Slat Flap Control Computer (SFCC). The LGCIUs are used to process signals from proximity sensors.

SFCC

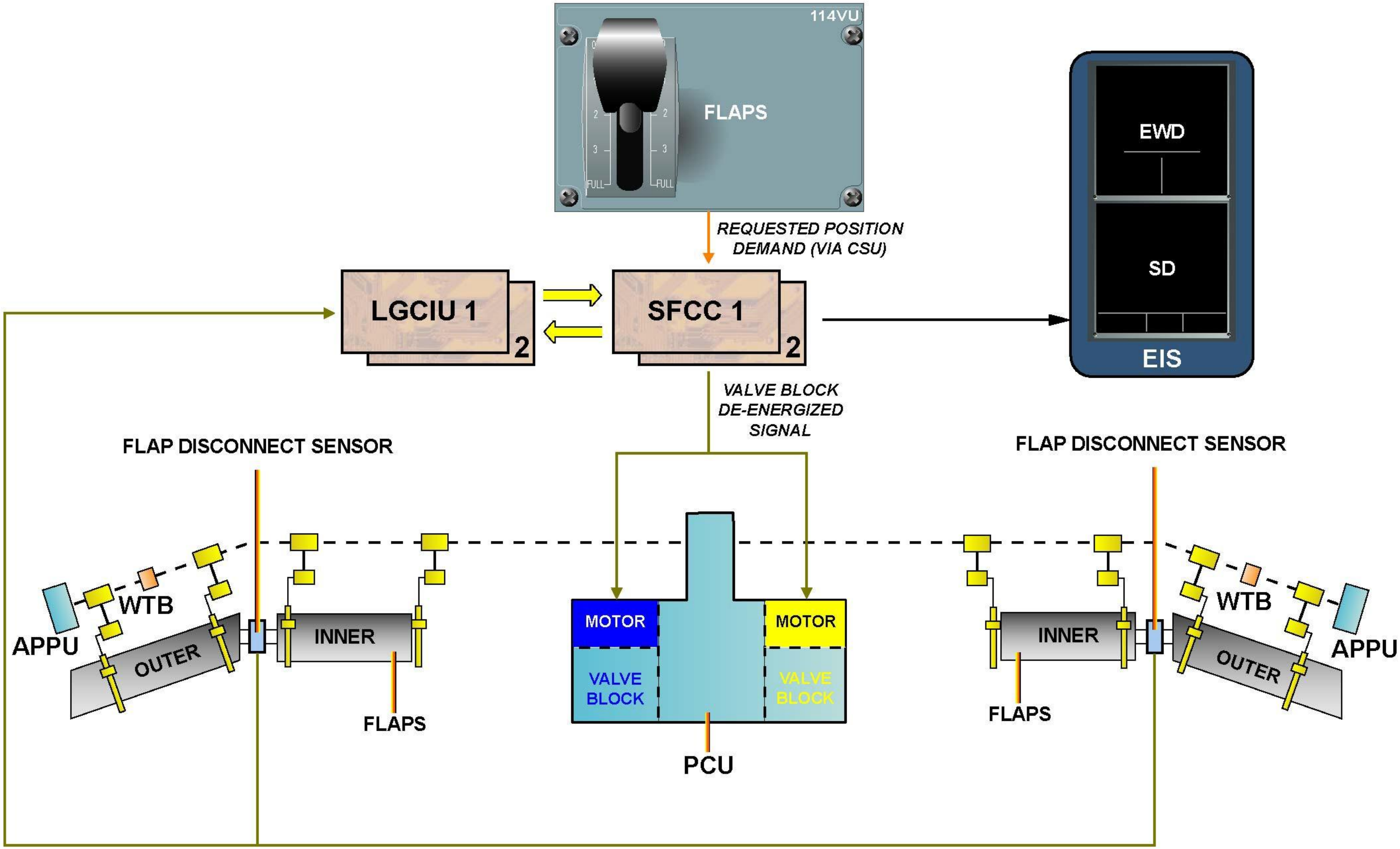
The SFCCs monitor the flap-attachment failure detection sensors to find connection failure.
If the SFCCs receive a flap disconnect signal:

- the valve block solenoids on the Power Control Unit (PCU) are de-energized,
- the Pressure-Off Brakes (POBs) lock the two hydraulic motors,
- the SFCCs give a class 1 level 2 caution and the ECAM display unit shows a failure message.

System reset is only possible on the ground.
The ECAM display unit shows a failure message if:

- the SFCC gets different data from the two sensors on the same wing or,
- one sensor gives incorrect data.

SENSORS - LGCIU & SFCC



APPU: Asymmetry Position Pick Off Unit
CSU: Command Sensor Unit

SFCC CONTROL INTERFACES

CSU
The Command Sensor Unit (CSU) sends two discrete signals to each channel for a new slat/flap position request.

LH AND RH APPU
The Asymmetry Position Pick Off Units (APPUs) send synchro signals to each channel for asymmetry detection and system monitoring.

FPPU
The position of the Power Control Unit (PCU) output shaft is measured by the Feedback Position Pick-off Unit (FPPU) and sent to the computers for system control and monitoring.

LH AND RH WTB
Discrete outputs from the computers are sent to the Wing Tip Brakes (WTBs) for solenoid valve control.

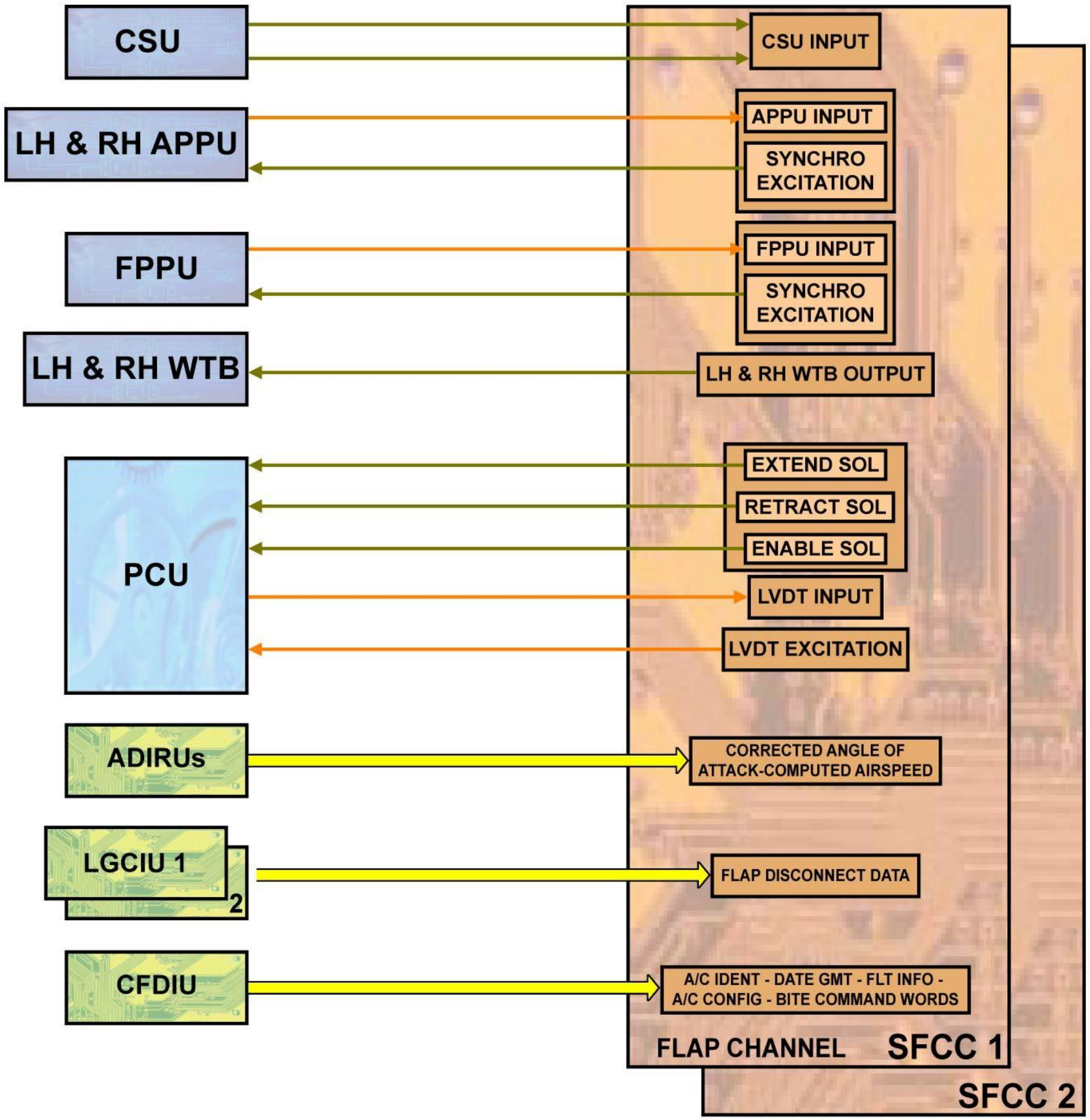
PCU
Discrete outputs from the computers are transmitted to the PCU for solenoid valve control. Analog signals are sent by the Linear Variable Differential Transducers (LVDTs) to monitor the control spool valves of the PCU.

ADIRU
Air Data/Inertial Reference Units 1 and 2 (ADIRUs 1 and 2) send corrected angle of attack and computed air speed data for ALPHA LOCK computation.

LGCIU
Landing Gear Control and Interface Units (LGCIUs) send flap disconnect data for control of flap attachment failure detection.

CFDIU
The Centralized Fault Display Interface Unit (CFDIU) sends data about failure environment and command words for BITE tests.

CSU - CFDIU


CSU
LH & RH APPU
FPPU
LH & RH WTB
PCU
ADIRUs
LGCIU 1
2
CFDIU
CSU INPUT
APPU INPUT
SYNCHRO EXCITATION
FPPU INPUT
SYNCHRO EXCITATION
LH & RH WTB OUTPUT
EXTEND SOL
RETRACT SOL
ENABLE SOL
LVDT INPUT
LVDT EXCITATION
CORRECTED ANGLE OF ATTACK-COMPUTED AIRSPEED
FLAP DISCONNECT DATA
A/C IDENT - DATE GMT - FLT INFO - A/C CONFIG - BITE COMMAND WORDS
FLAP CHANNEL
SFCC 1
SFCC 2

SFCC MONITOR INTERFACES

FWC

The Instrumentation Position Pick-off Units (IPPUs) supply slat/flap position data to the Flight Warning Computer (FWC), for warning activation.

SDAC

The System Data Acquisition Concentrators (SDACs) receive ARINC data in order to generate the appropriate ECAM displays. Information received from the Slat Flap Control Computers (SFCCs) can be displayed after the flight on operator request. Level 2 cautions, resulting from flap system faults, are processed in the SDACs and then displayed on the ECAM upper display. Slat channel interface is identical.

ELAC AND SEC

Position data received from the SFCCs are used for electrical flight control law selection.

FAC

Position data sent to the Flight Augmentation Computers (FACs) are used for flight envelope protection computation.

GPWC

The Ground Proximity Warning Computer (GPWC) receives the flap position data for approach and landing via the control panel 21VU. There is no slat information sent by the SFCC slat channel.

CFDIU

The Centralized Fault Display Interface Unit (CFDIU) receives failure data from the SFCCs and command words for the BITE test. Information received from the SFCCs can be displayed after the flight on operator request. Test plugs can be used for trouble-shooting when the Centralized Fault Display System (CFDS) is inoperative or not installed. Slat channel interface is identical.

ADIRU

Flap position data are used by the Air Data/Inertial Reference Units (ADIRUs) for Angle-Of-Attack (AOA) and static source correction. Flaps higher than 9° and 34° data are used for AOA correction. Flaps higher than 19° data are used for the static source correction. There is no slat channel interface to the ADIRUs.

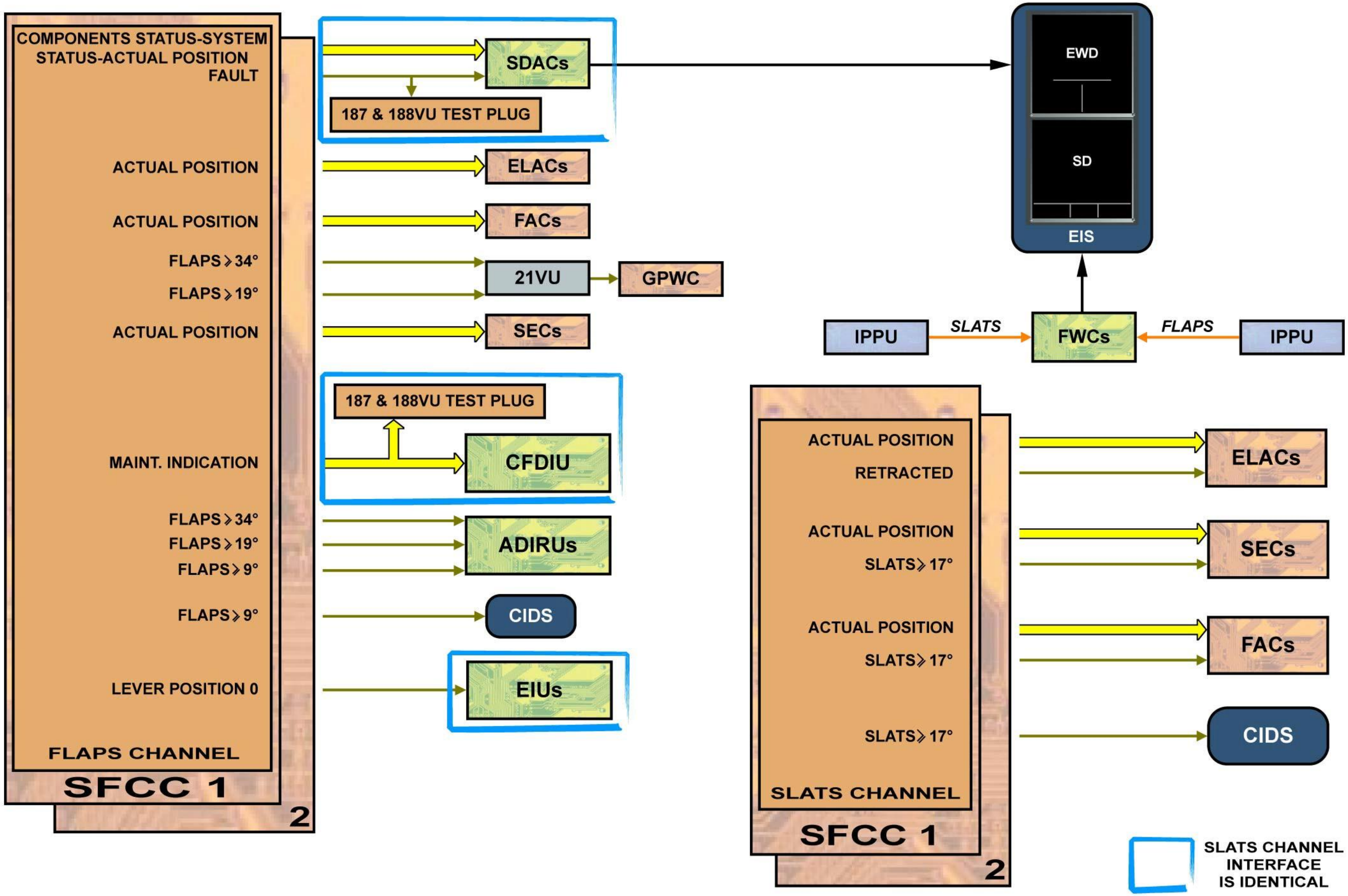
CIDS

The Cabin Intercommunication Data System (CIDS) receives slat flap position discretes for automatic lighting of cabin passenger signs.

EIU

The Engine Interface Unit (EIU) receives a slat flap lever retracted position discrete for minimum idle. Slat channel interface is identical.

FWC - EIU



FOR TRAINING PURPOSES ONLY

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

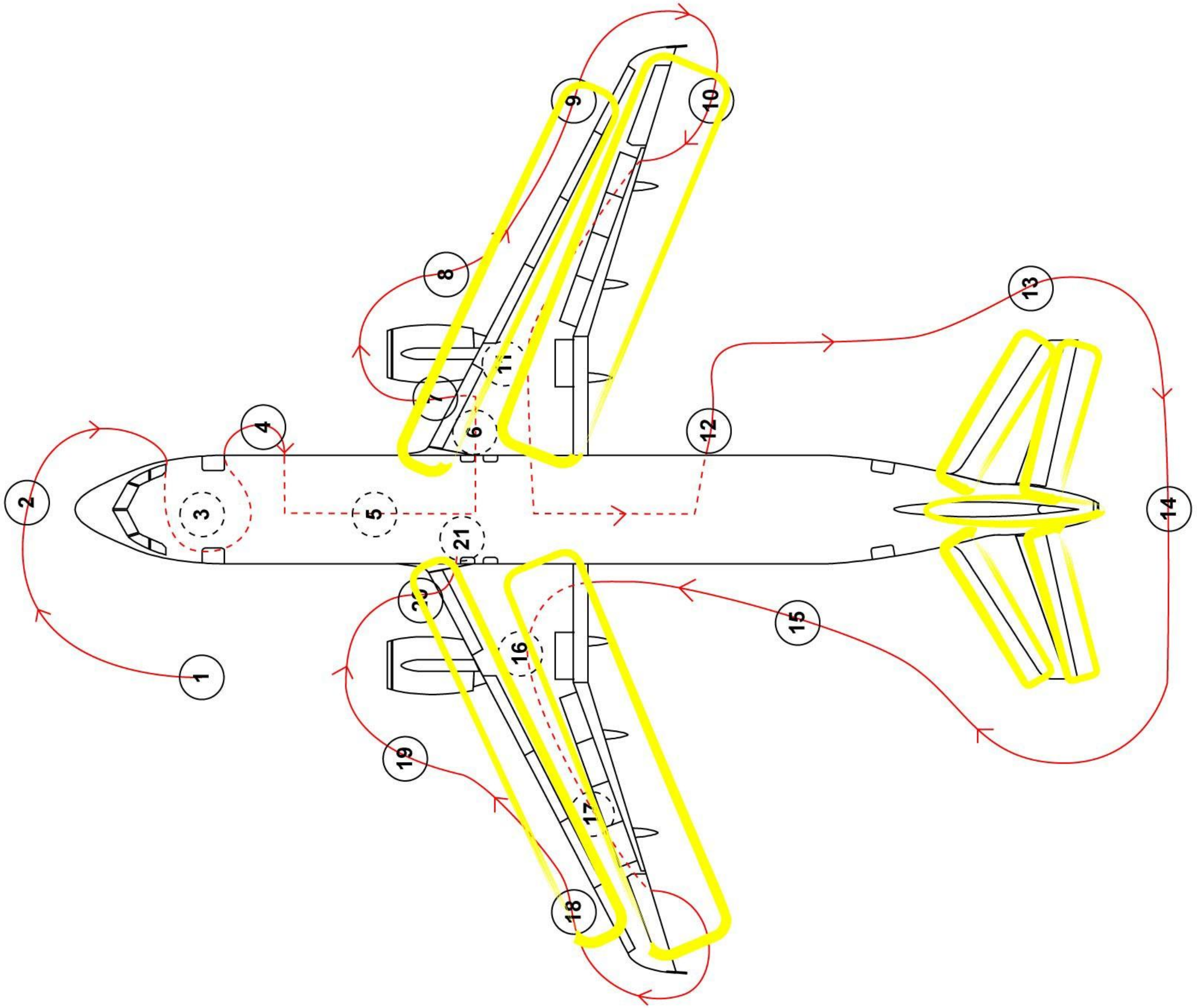
DAILY CHECK

During the daily check, the external walk around will include the visual check for evidence of damage and fluid leakage of the:

- Left and right wing leading edge slats,
- Left and right wing trailing edge flaps and flap track fairings,
- Left and right ailerons,
- Left and right THS surfaces,
- Left and right elevators,
- Rudder.

NOTE: The visual check of the Flight Control Surfaces is made from the ground with Flaps/Slats in the retracted position.

DAILY CHECK



FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MEL/DEACTIVATION

AILERONS

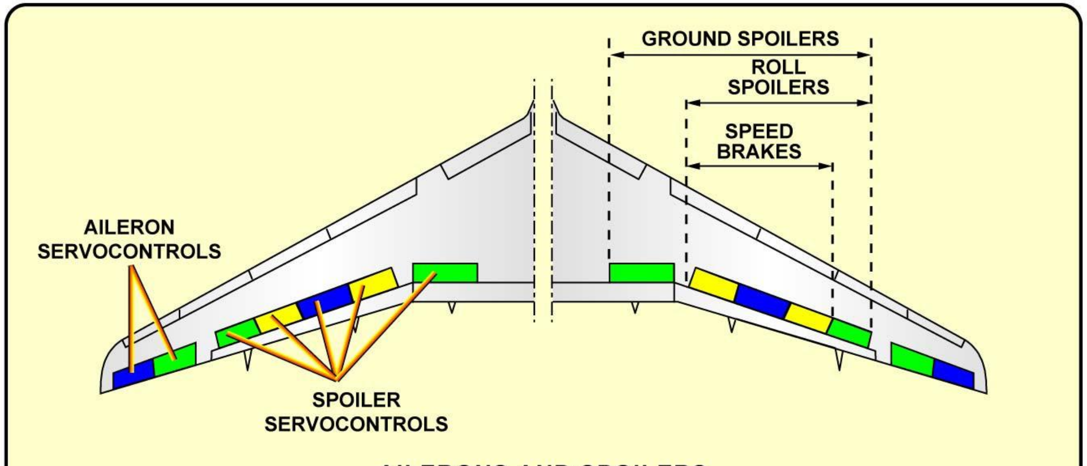
As aileron servocontrol is a MMEL item, the deactivation is done by disconnecting the related electrical connector. The detailed procedure is given in the AMM.

SPOILERS

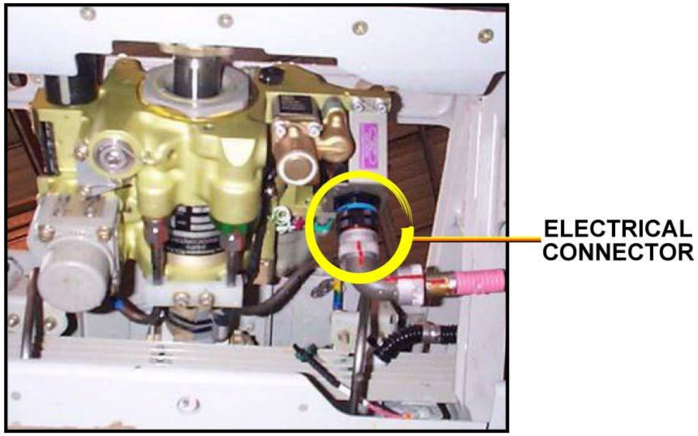
The spoiler servocontrol is a MMEL item. To deactivate the spoiler servocontrol, disconnect the electrical connector from the receptacle of the servocontrol.
The detailed procedure is given in the AMM.

MEL/DEACTIVATION - AILERONS & SPOILERS

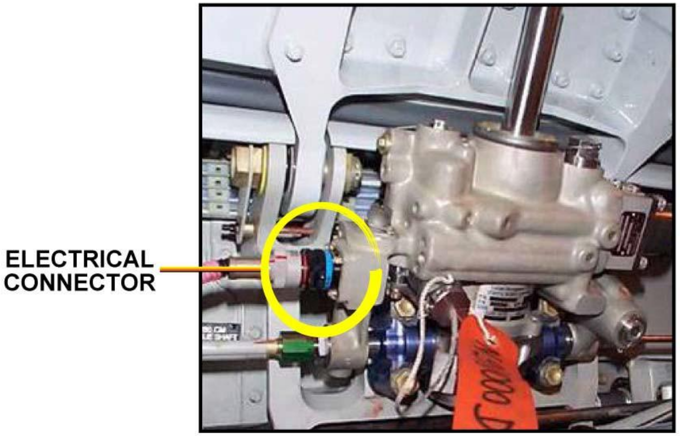
- Deactivation of aileron servocontrol
- Deactivation of spoiler servocontrol



AILERONS AND SPOILERS



AILERON SERVOCONTROL



SPOILER SERVOCONTROL

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

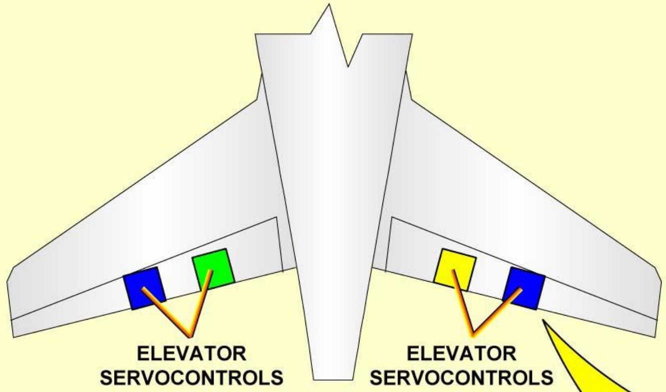
MEL/DEACTIVATION (continued)

ELEVATORS

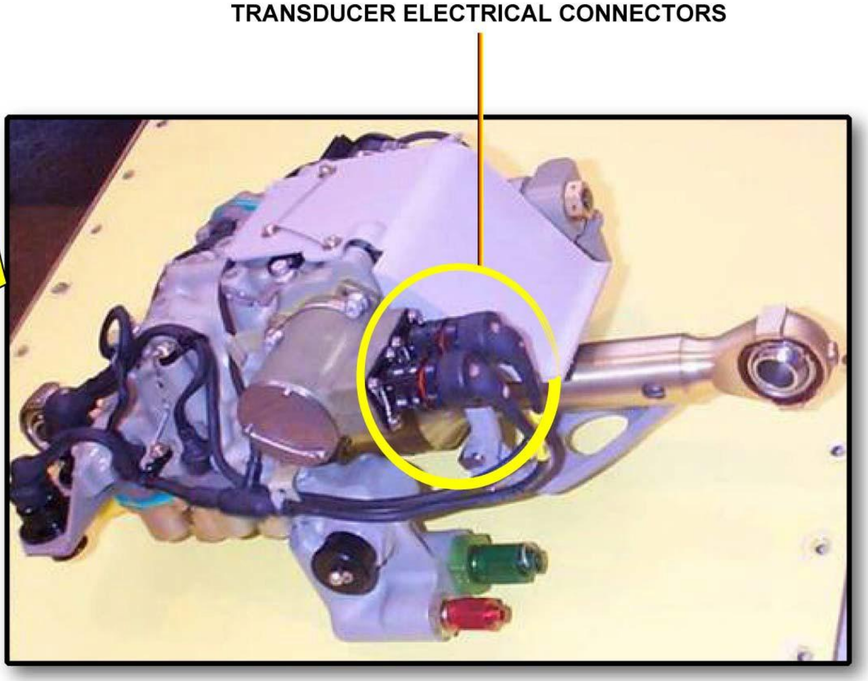
The elevator servocontrol position transducer (XDCR) is a MMEL item.
If an ECAM warning "ELEVator SERVO FAULT "appears with a Centralized Fault Display System (CFDS) message "USE STandBY XDCR", the two plugs of the elevator servocontrol position XDCRs must be swapped. Detailed procedures are given in the AMM.

MEL/DEACTIVATION - ELEVATORS

- Swap of elevator servocontrol position transducers



ELEVATORS



ELEVATOR SERVO CONTROL

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MEL/DEACTIVATION (continued)

ELAC

There are two ELACs (ELAC 1 and 2).
Both ELACS are MEL items. Inoperative ELAC 2 is a NO GO item. Except for Extended Range (ER) operations, ELAC 1 or any ELAC 1 function may be inoperative if all the MMEL restrictions are applied. Maintenance procedures related to ELAC 1 deactivation are detailed in the AMM.

SEC

There are three SECs.
Only one SEC out of three can be inoperative and deactivated if all MMEL restrictions are applied.
Maintenance procedures related to one SEC deactivation are detailed in the AMM.

FAC

There are two FACs (FAC 1 and FAC 2) are installed on the A/C. An inoperative FAC 1 is a NO GO item.
FAC 2 may be inoperative and deactivated if all MMEL restrictions are applied.
Maintenance procedures related to FAC 2 deactivation are detailed in the AMM.

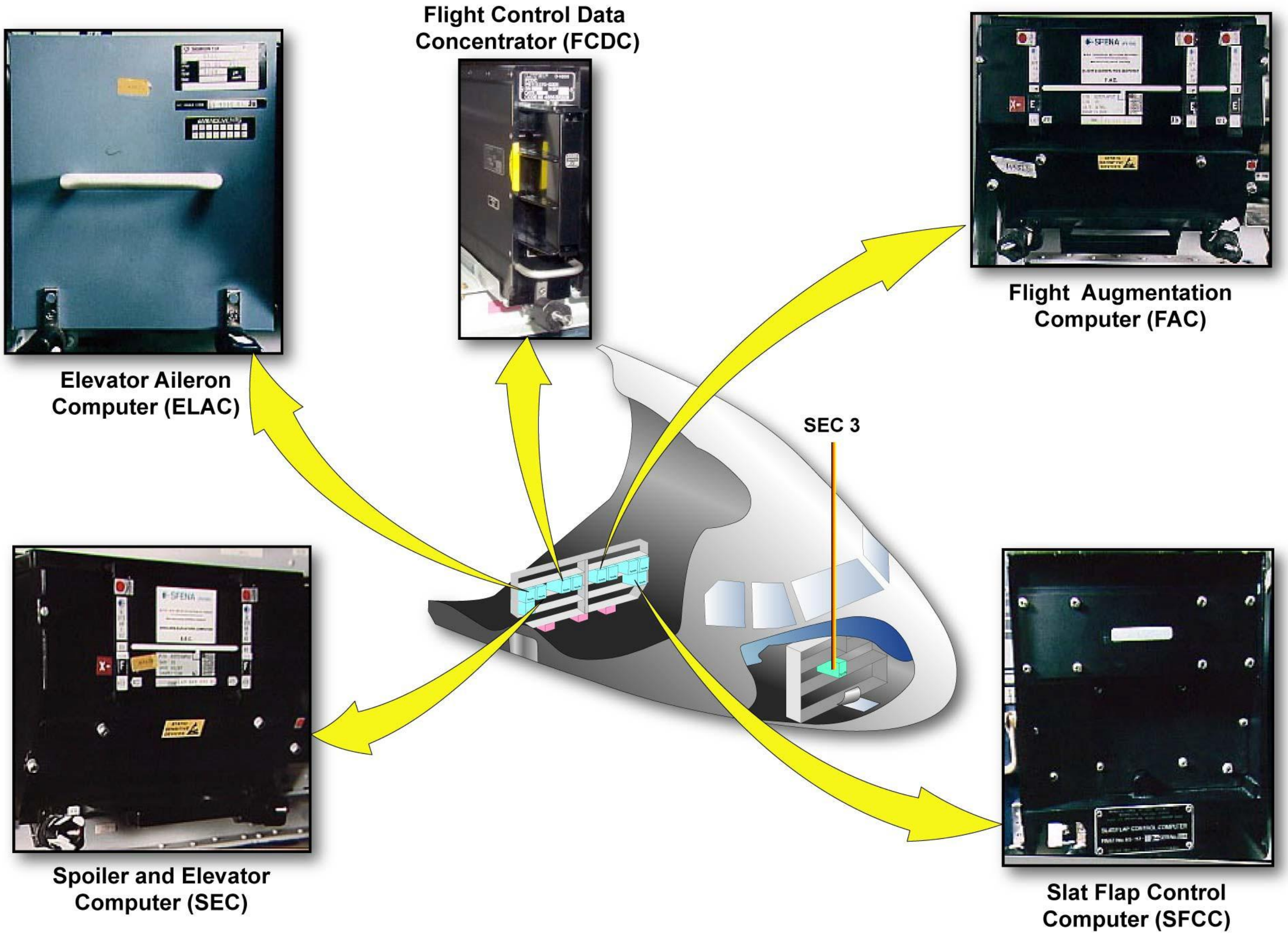
FCDC

There are two FCDCs installed on the A/C. An inoperative FCDC 1 is a NO GO item.
FCDC 2 may be inoperative and deactivated following a flight crew procedure.

SFCC

SFCC1 and SFCC2 monitor and control the flaps.
An inoperative SFCC 1 is a NO GO item.
Only SFCC 2 flap and slat channel may be inoperative if all restrictions given in the MMEL are applied.

MEL/DEACTIVATION - ELAC - SFCC



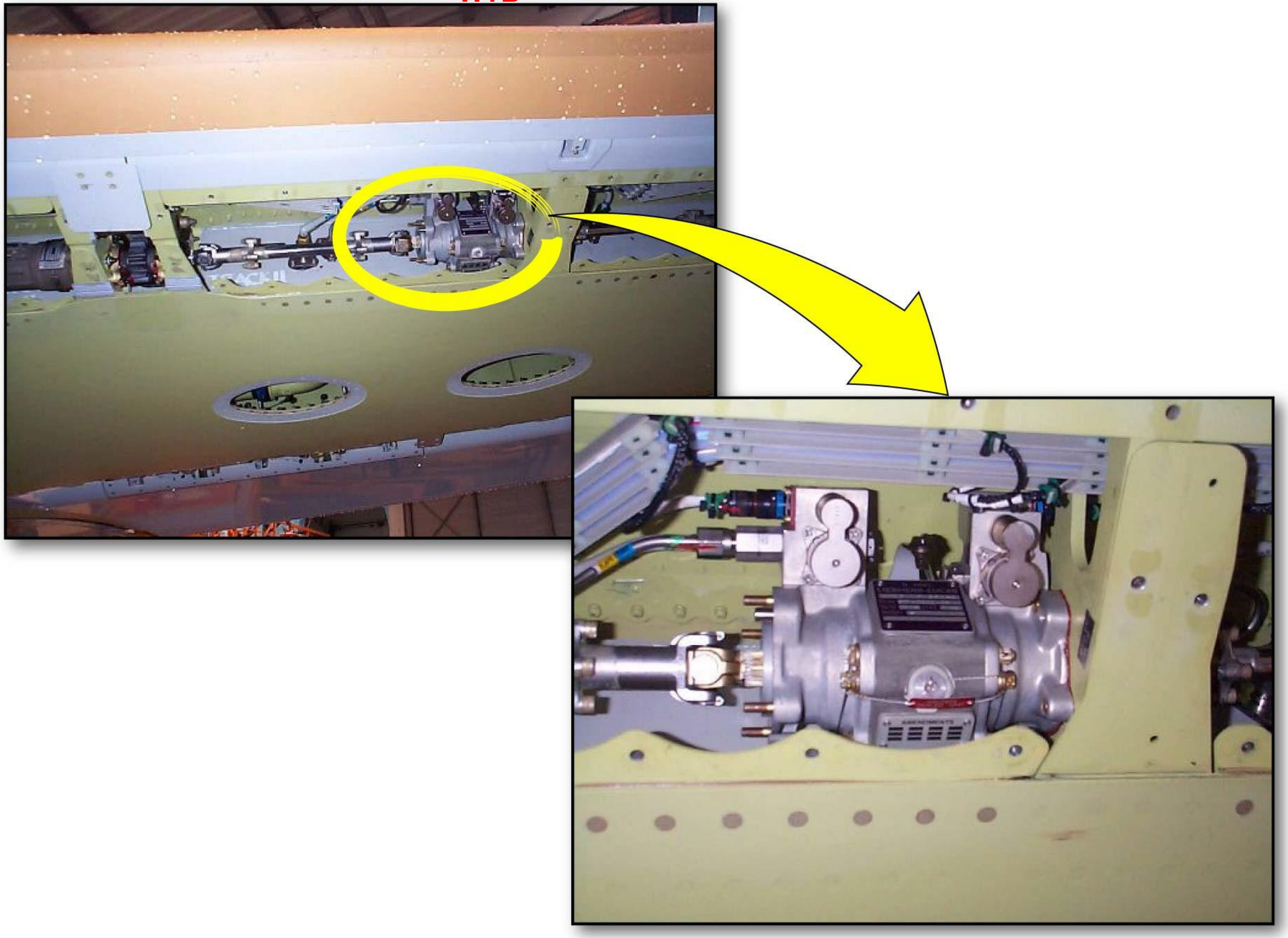
FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MEL/DEACTIVATION (continued)

WTB

On SLAT or FLAP WTBs, one or two solenoids related to SFCC 2 may be inoperative if operation of SFCC 1 WTB is confirmed by a test before each flight.
The related procedure for deactivation of the WTB solenoid is detailed in the AMM.

MEL/DEACTIVATION - WTB



WING TIP BRAKE (WTB)

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MAINTENANCE TIPS

IMPROVE FLIGHT CONTROL SYSTEM TROUBLE SHOOTING AND MINIMIZE NO FAULT FOUND RATE (ELAC/SEC)

Put the trouble shooting on fault message into focus and not only on the ECAM warning. Indeed, message gives precise information on the possible root causes. TSM task related to the fault message has to be followed.

Follow step by step the TSM related to the failure messages:

• Taking into account previous action done (i.e. LRU removal), if issue is still there on A/C, do the following step proposed by the TSM.

Send Trouble Shooting data with removed LRU to ease repair in shop:

• Repair shop can do dedicated tests or actions (e.g. relay replacement) if the PFR, test result and / or trouble shooting data, if available, are given.

Intermittent faults must follow a trouble shooting as per TSM:

Intermittent fault = repetitive fault experienced in flight and not confirmed on ground.

• After three occurrences of the same phenomenon (even if the ground test is still OK), the other steps of the TSM procedure must be followed.

• While doing the wiring inspection, it is advised to check the wires to help reproducing the issue on ground.

MAINTENANCE TIPS

IMPROVE FLIGHT CONTROL SYSTEM TROUBLE SHOOTING AND MINIMIZE NO FAULT FOUND RATE (ELAC/SEC) (continued)

Do the follow-up of A/C & remove the LRU, to confirm the failure origin and identify potential rogue units:
This lets:
- either explain No Fault Found (NFF), if the issue is still shown on A/C,
- or to confirm the failure origin (Fault Found (FF) in accordance with removal cause),
- or to identify potential rogue Units, if the issue is no more on A/C despite NFF LRU.

Removed LRU can be put in quarantine pending the end of Trouble Shooting:
This applies for intermittent trouble shooting issues and:
- give updated and complete information to the repair shop,
- avoid installation of a unit with intermittent failure on a new A/C,
- get easier LRU follow-up.

Use Thales Chronic unit policy (send units suspected as chronics to Thales):
As per Thales policy, chronic unit policy (deep investigations) applies to computers:
- removed 3 times within 18 months,
- whatever the reason of removal,
- FF or NFF.

MAINTENANCE TIPS - IMPROVE FLIGHT CONTROL SYSTEM TROUBLE SHOOTING AND MINIMIZE NO FAULT FOUND RATE (ELAC/SEC)

IMPROVE FLIGHT CONTROL SYSTEM TROUBLE SHOOTING AND MINIMISE NO FAULT FOUND RATE (ELAC/SEC)

FOLLOW STEP BY STEP THE TSM RELATED TO THE FAILURE MESSAGES
SEND TROUBLE SHOOTING DATA WITH REMOVED LRU TO EASE REPAIR IN SHOP
INTERMITTENT FAULTS MUST FOLLOW TROUBLE SHOOTING AS PER TSM
PERFORM A/C & REMOVED LRU FOLLOW-UP TO CONFIRM THE FAILURE ORIGIN AND IDENTIFY POTENTIAL ROGUE UNITS
REMOVED LRU CAN BE PUT IN QUARANTINE PENDING THE END OF TROUBLE SHOOTING
USE THALES CHRONIC UNIT POLICY (SEND UNITS SUSPECTED AS CHRONICS TO THALES)

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MAINTENANCE TIPS (continued)

ELEVATOR SERVOCONTROL SWAPPING TOOL (BUNDLE)

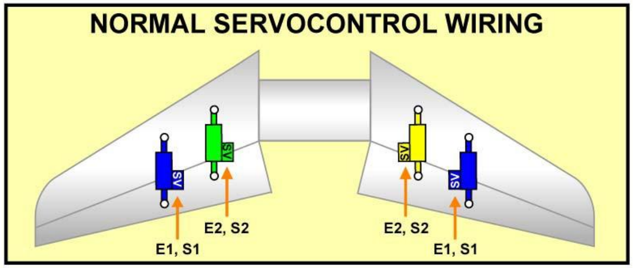
When applicable, use the elevator servocontrol swapping tool (bundle). This tool lets either confirm a servocontrol failure or direct on other possible causes, which are wiring or computer issue.
It can be used in case of an "ELEVATOR SERVO FAULT" or "ELAC PITCH FAULT" warning message experienced.
In this procedure, the operator can interchange the wiring between two servocontrols (the one supposed unserviceable and one known as serviceable).

Let there be "X" as ELAC & SEC computers (E1, S1 or E2, S2) and related servocontrol.
Without the swapping tool (normal wiring), computers "A" control the elevator Servocontrol "A" and computers "B" control the elevator Servocontrol "B".
When the swapping tool is used, computers "A" control the elevator Servocontrol "B" and computers "B" control the elevator Servocontrol "A".

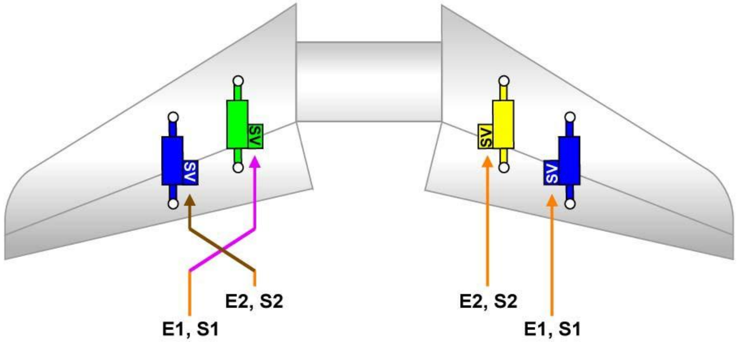
Two wiring mode can be used to connect the servocontrols:
• Adjacent servocontrol wiring.
• Opposite servocontrol wiring.

NOTE: As solenoid valve short-circuit could cause damage a serviceable computer, swapping is not applicable for servocontrol solenoid valves issues: see caution note in TSM tasks.

MAINTENANCE TIPS - ELEVATOR SERVOCONTROL SWAPPING TOOL (BUNDLE)

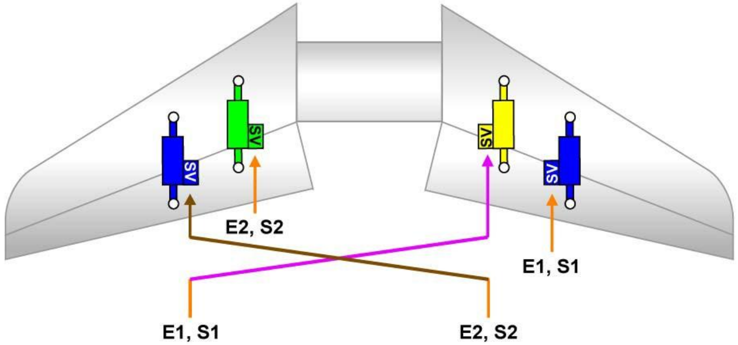


ADJACENT SERVOCONTROL WIRING



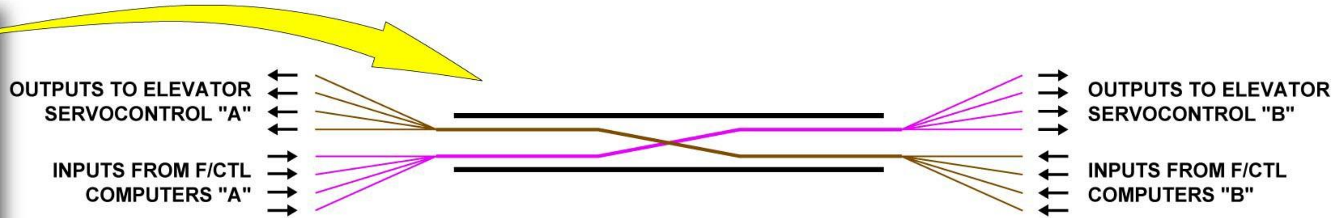
L/H side shown as example.
Also applicable on R/H side.

OPPOSITE SERVOCONTROL WIRING



Swapping on blue and yellow hydraulic system shown as example. However, several configurations are possible.

SWAPPING TOOL



Note : The swapping tool is plugged as an extension between the A/C wires and the servocontrol.

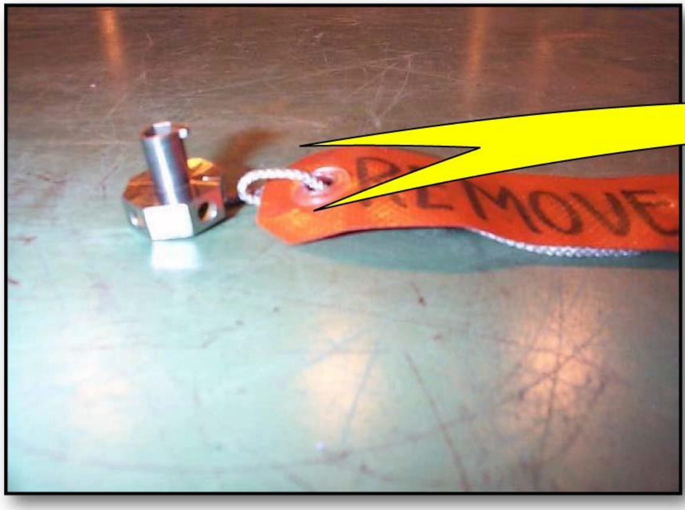
FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MAINTENANCE TIPS (continued)

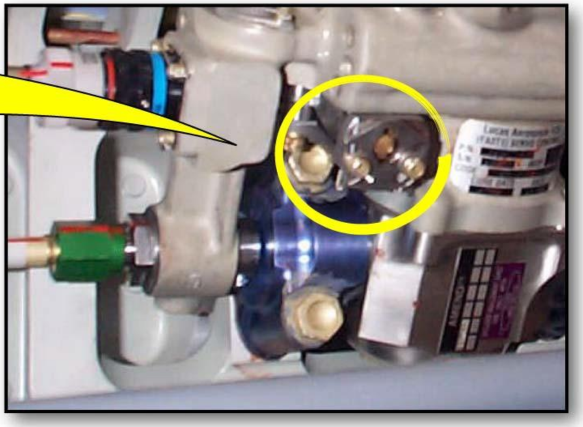
EXTENSION

To be unlocked, the servo control actuator must be depressurized. After the Flaps full extension the Slats/Flaps Locking Tool must be installed on the flap/slat control lever.
Deactivate the spoilers electrical control by pulling the related Circuits Breakers.
The maintenance unlocking device tool can be engaged by using a key with a red flame.
This tool cannot be removed when the servo control is in maintenance mode.

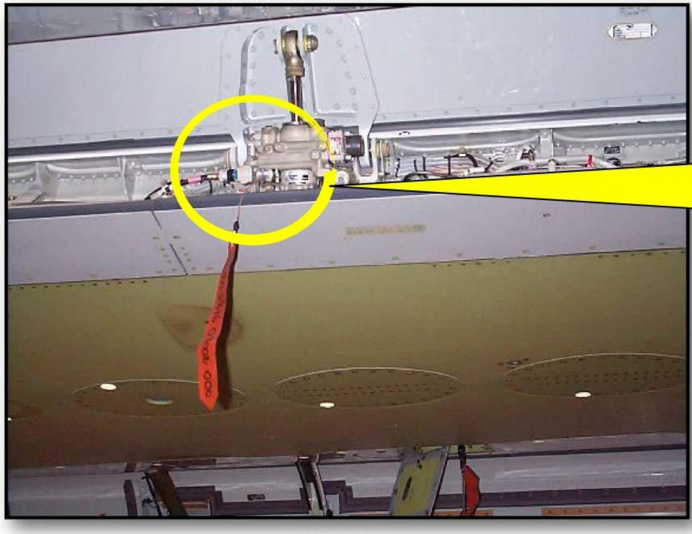
MAINTENANCE TIPS - EXTENSION



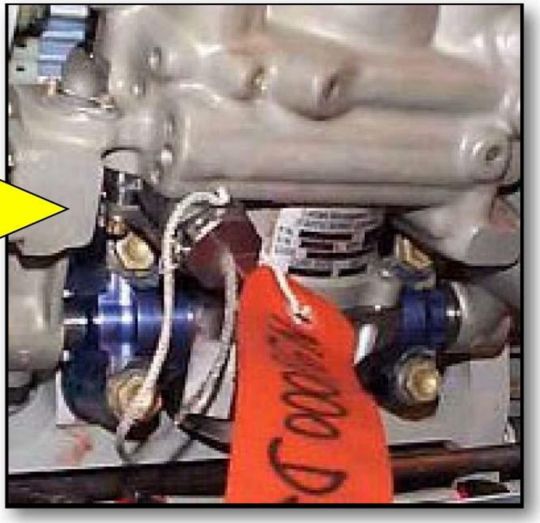
SPOILER MAINTENANCE KEY



SPOILER SERVOCONTROL



SPOILER



KEY INSTALLED

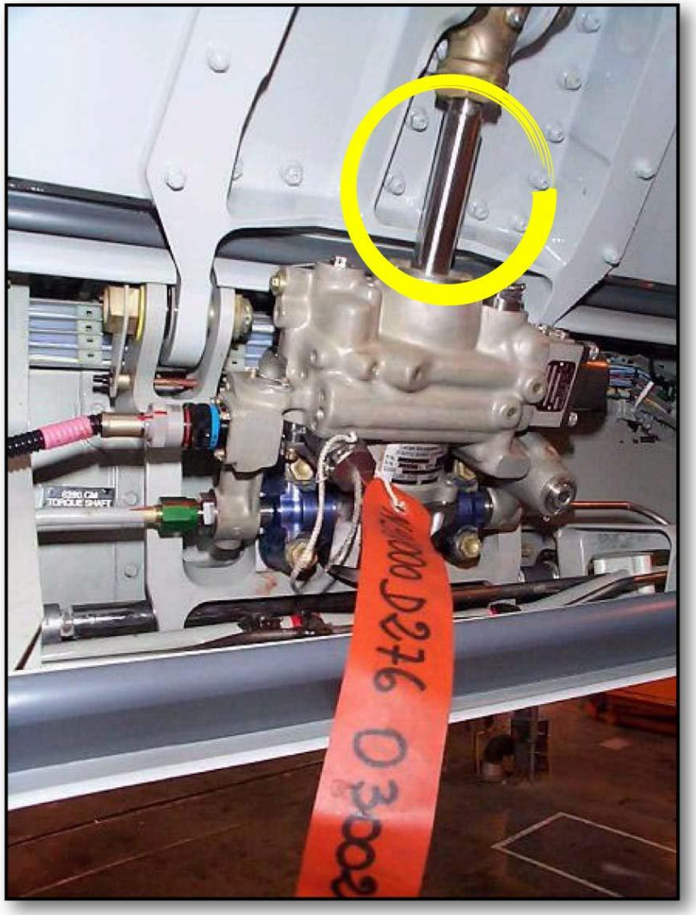
FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MAINTENANCE TIPS (continued)

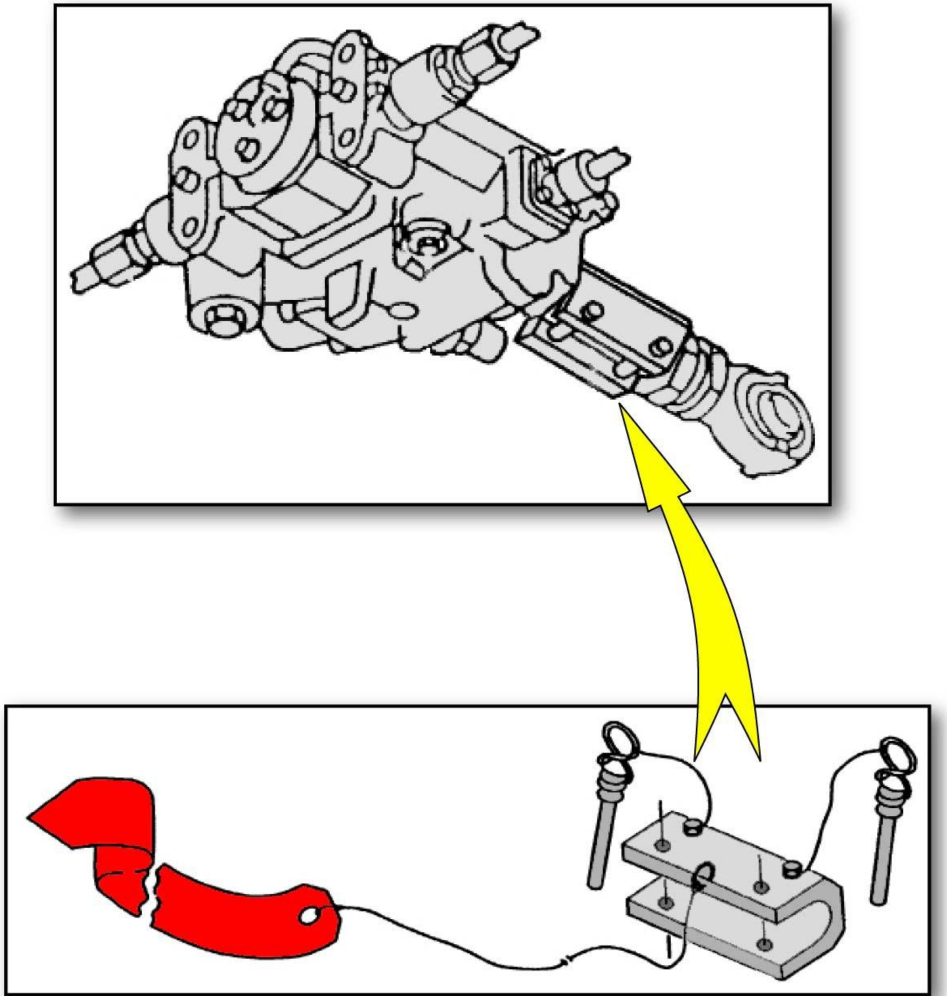
SAFETY COLLAR INSTALLATION

Once the maintenance-unlocking device is engaged the spoiler surface can be raised manually for inspection functions.
After the spoiler is fully raised by hand, install the Safety Collar on the servocontrol rod.

MAINTENANCE TIPS - SAFETY COLLAR INSTALLATION



SPOILER SERVO CONTROL



SAFTY COLLAR

FOR TRAINING PURPOSES ONLY

FLIGHT CONTROLS SYSTEM LINE MAINTENANCE

MAINTENANCE TIPS (continued)

RETRACTION

To retract the spoiler, the Safety Collar must be removed from the servocontrol rod.
When the maintenance unlocking device tool is turned and disengaged, the spoiler servocontrol is back to active mode.
Reactivate the spoilers electrical control by reengaging the related Circuits Breakers.
Do the operational test of the spoiler hydraulic actuation.
Return the aircraft to the initial configuration (retract Flaps/Slats).

MAINTENANCE TIPS - RETRACTION