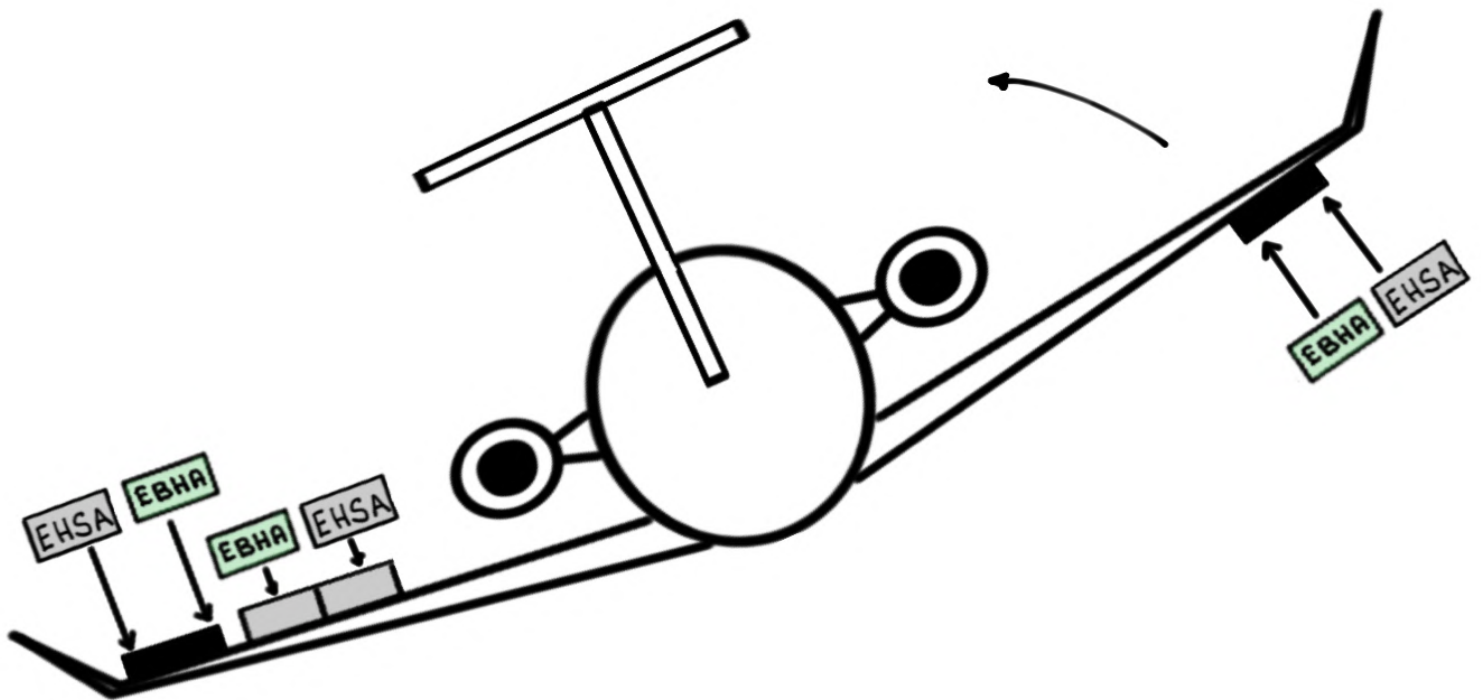
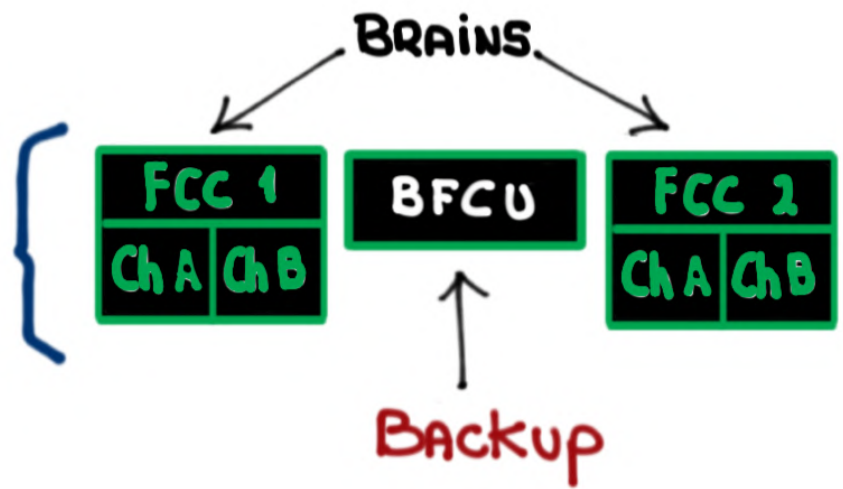


# G600 Flight Control System



For study purposes only

ELECTRICALLY - CONTROLLED

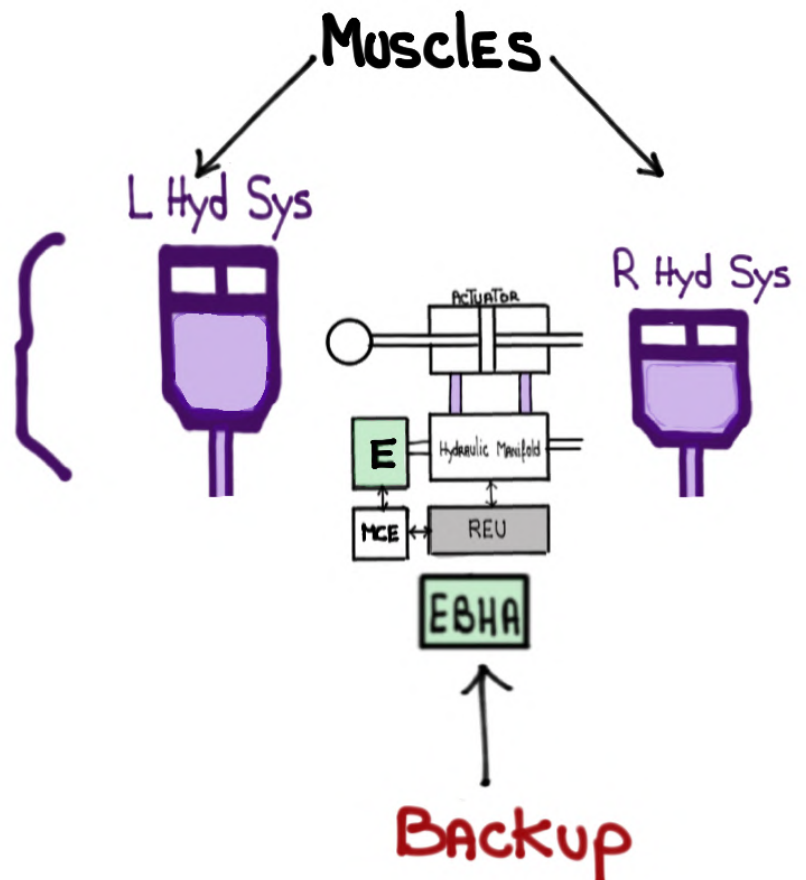


THREE (3) AXIS

Fly-by-wire

FLIGHT CONTROL SYSTEM  
(FCS)

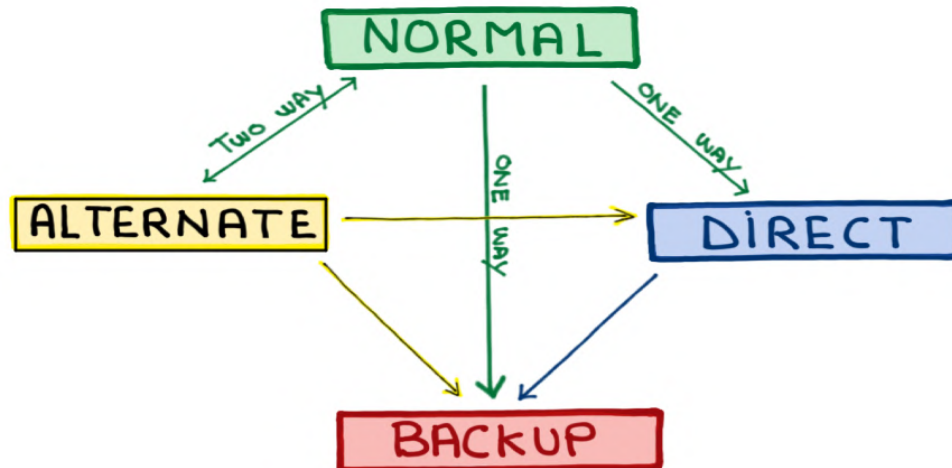
HYDRAULICALLY - ACTUATED



# ELECTRICALLY - CONTROLLED

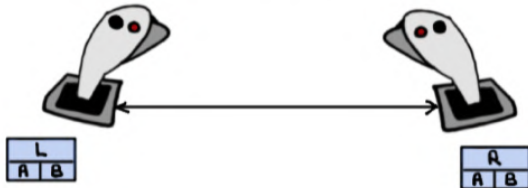
## SOFTWARE:

- FLIGHT CONTROL LAWS



## HARDWARE:

- ACTIVE CONTROL Sidesticks



- FLIGHT CONTROL COMPUTERS



- Backup Flight Control Unit



- REMOTE ELECTRONIC UNITS

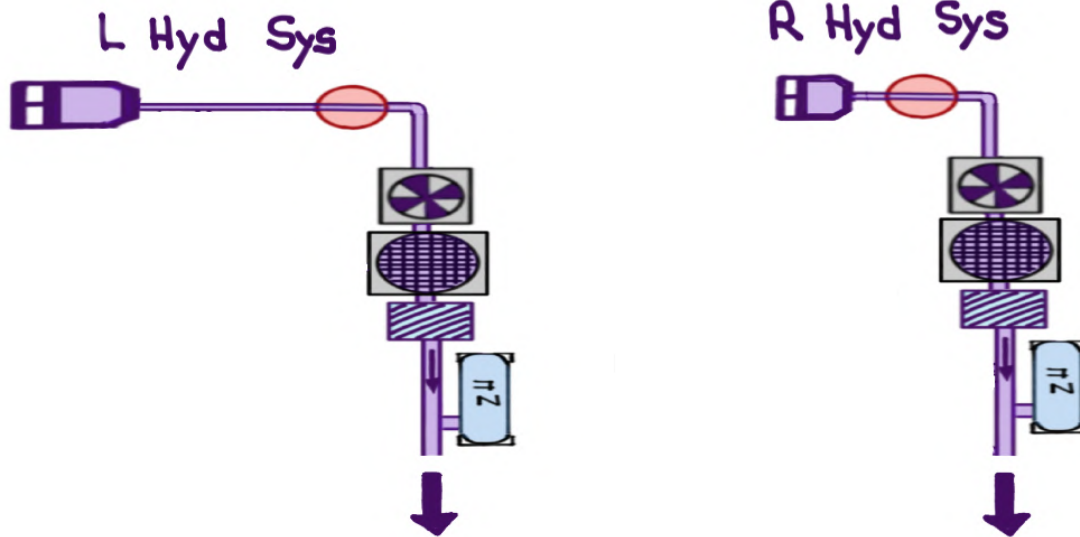


- FLIGHT CONTROL BATTERIES



# Hydraulically - ACTUATED

- Hydraulic SOURCES

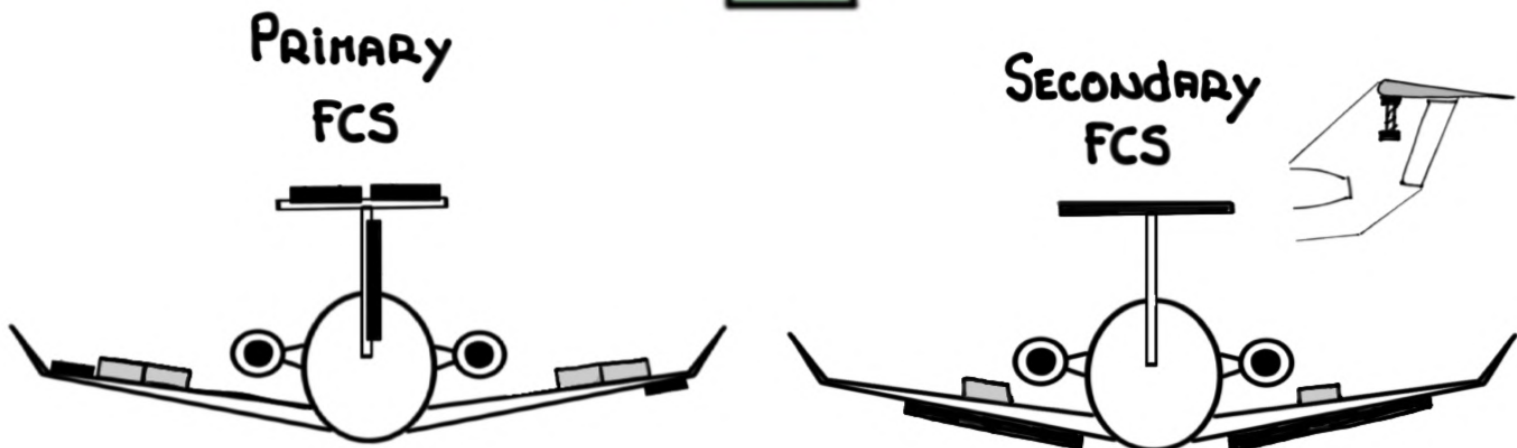


- ELECTRO-HYDRAULIC SERVO ACTUATOR

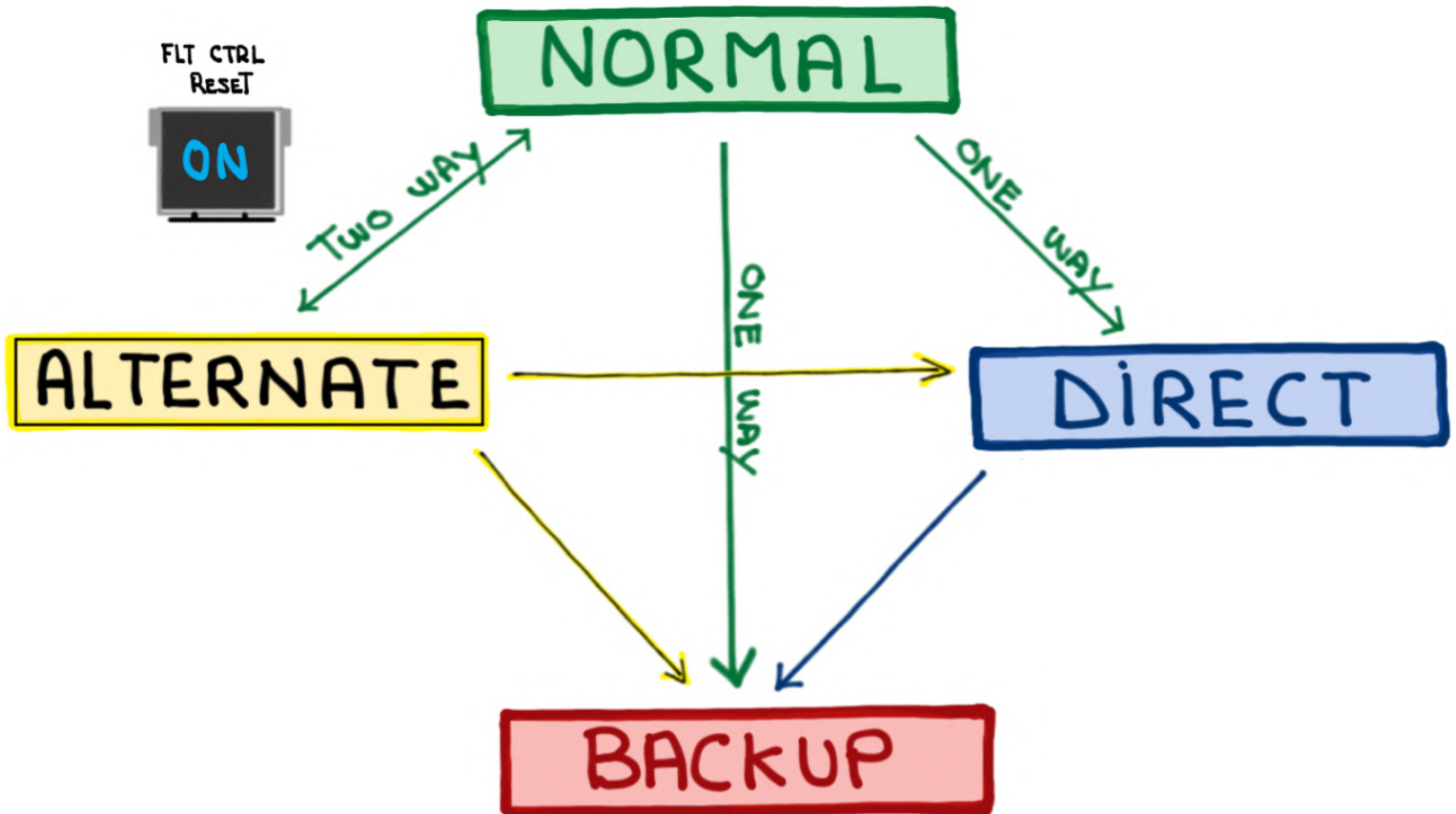
(9) EHSA

- ELECTRICAL BACKUP HYDRAULIC ACTUATOR

(7) EBHA



# FLIGHT CONTROL LAW MODES



**NORMAL**

FCC 1	
ChA	ChB

FCC 2	
ChA	ChB

MINIMUM REQUIREMENTS:

① ONE (1) IRU + ONE (1) AHRS

OR

Two (2) IRUs

② Two (2) ADS



# ALTERNATE

FCC 1
ChA ChB

FCC 2
ChA ChB

FCS ALTERNATE MODE (0)

① < Two (2) ADS

② < Two (2) IRUs

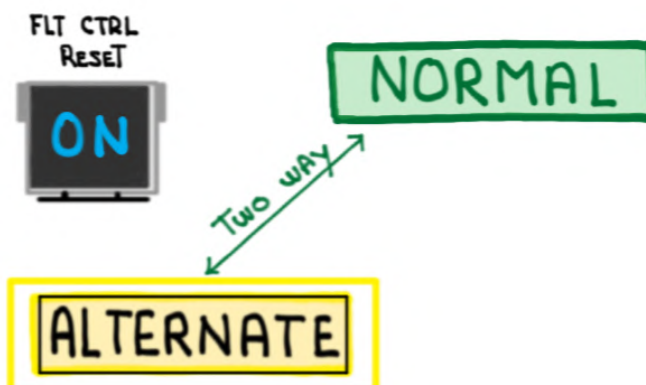
OR

< ONE (1) IRU + ONE (1) AHRS

③ Loss of COMMUNICATION BETWEEN FCCs AND HSTS

- HARDWARE malfunction

- Probability of occurrence: < 1 per 10 million flight hours

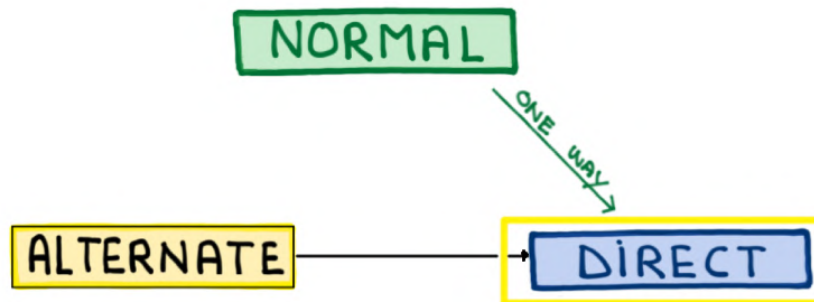


- FLT CTRL RESET switch may allow return to **NORMAL** if the reason for degrade is resolved

# DIRECT

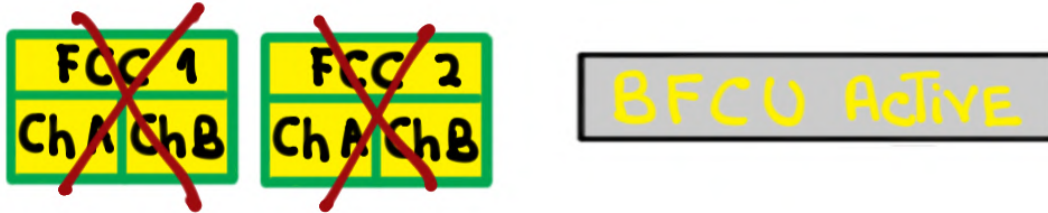


- All FCC channels ARE invalid
- COMMAND **C** AND MONITOR **M** LANES do NOT AGREE

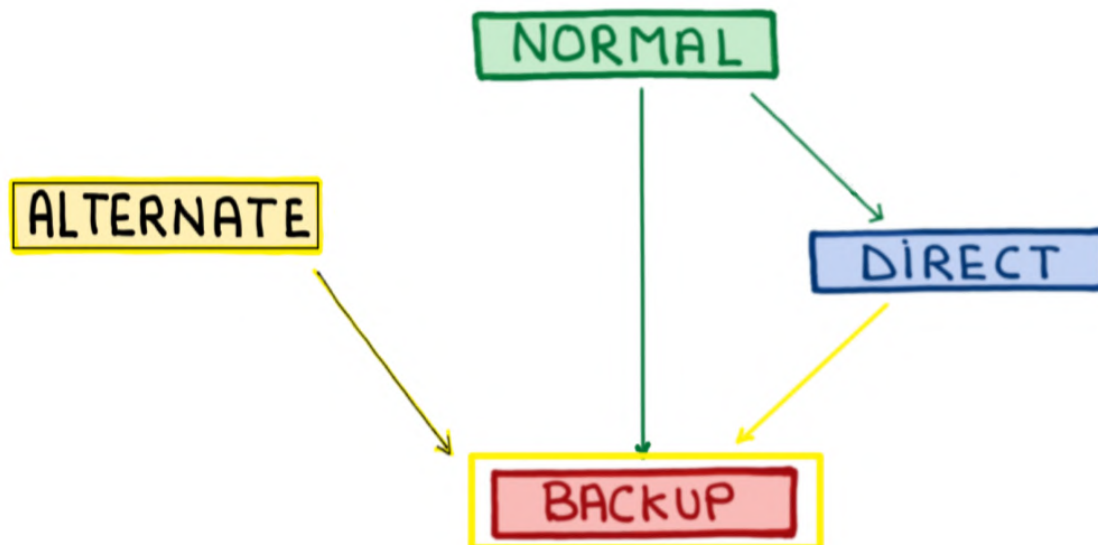


- SOFTWARE malfunction
- RETURN TO **NORMAL** OR **ALTERNATE** NOT possible
- Flying qualities ARE IDENTICAL TO **ALTERNATE** EXCEPT THAT:
  - Sidesticks → DEGRADED ACTIVE MODE
  - PRIMARY pitch trim switches UNAVAILABLE

# BACKUP

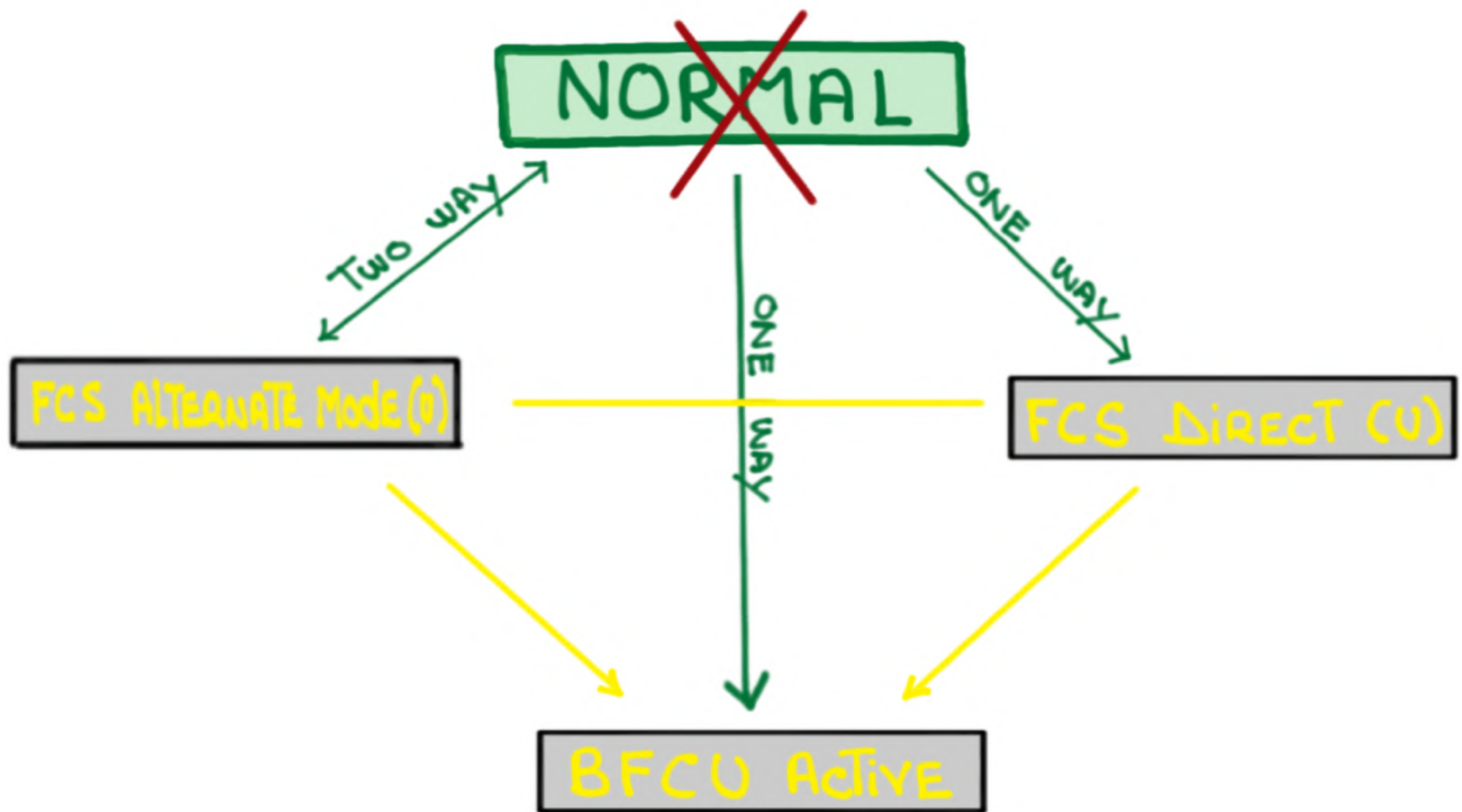


- All FCC channels CANNOT COMPUTE CONTROL LAWS
- **BFCU** AND its own CONTROL LAWS provides GET HOME capability



- **BFCU** COMMUNICATES DIRECTLY WITH **EBHA** ACTUATORS
- PROBABILITY OF OCCURRENCE < 1 IN A billion flight hours





Any FLIGHT CONTROL LAW OTHER THAN **NORMAL** :

- ① Takeoff is prohibited
- ② MAXIMUM speed: **285** KCAS/**M0.90**
- ③ FLIGHT INTO KNOWN icing conditions prohibited. If in icing conditions EXIT icing conditions
- ④ MAXIMUM landing crosswind: **10** knots
- ⑤  $V_{REF} + \mathbf{10}$  minimum

FCS ALTERNATE Mode (v)

FCS DIRECT (v)

BFCU ACTIVE

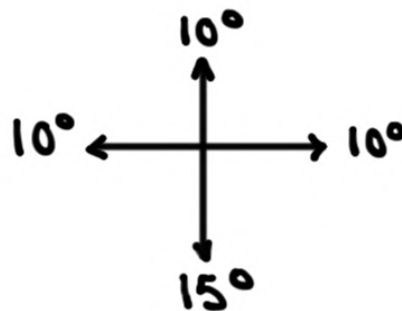
# Active CONTROL Sidesticks (ACS)

- Each ACS CONTAINS A COMPUTER with Two (2) channels ONE ACTIVE AND THE OTHER ON standby



- Sidesticks ARE linked To EACH OTHER. Input on ONE sidestick RESULTS in THE SAME MOTION ON THE OTHER

- RANGE of MOTION:



- THREE (3) OPERATIONAL MODES:

① ACTIVE

② DEGRADED ACTIVE

③ PASSIVE - INTERNAL FAILURE

## ① Active Mode:

- FEEDBACK ENHANCES SITUATIONAL AWARENESS
- CONTROL SURFACE loading provides ELECTRONIC-FEEL
- INPUTS SEEN ON BOTH ACSs

## ② DEGRADED ACTIVE:

Sidestick DEGRADED ActV

- Submode of Active
- STILL CONSIDERED ACTIVE BECAUSE LINKING OF THE ACSs REMAINS OPERATIVE
- DEGRADED ELECTRONIC FEEL

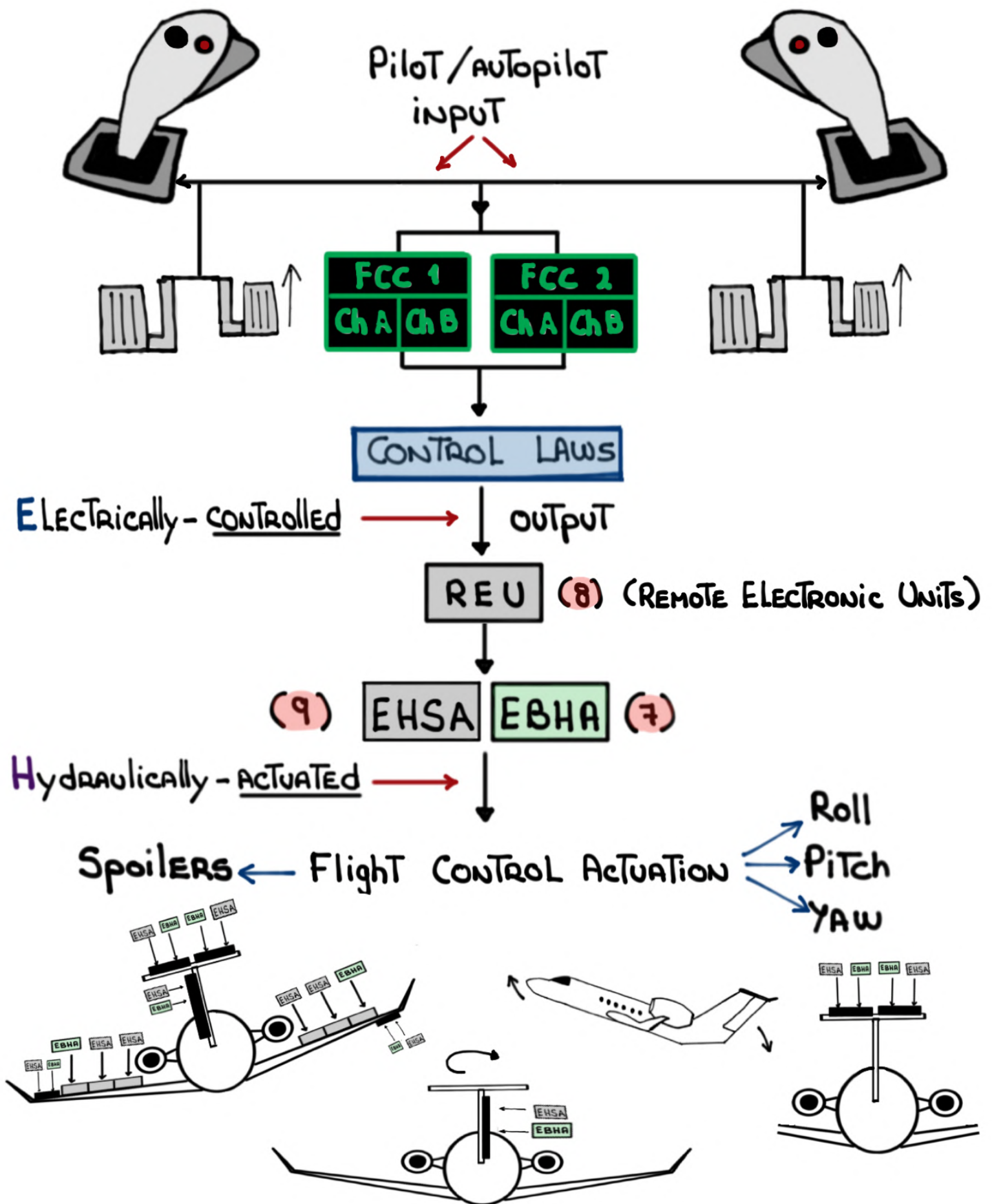
## ③ PASSIVE - INTERNAL FAILURE:

- INTERNAL FAILURE
- LOSS OF CROSS-LINKING



L Sidestick PASSIVE (U)

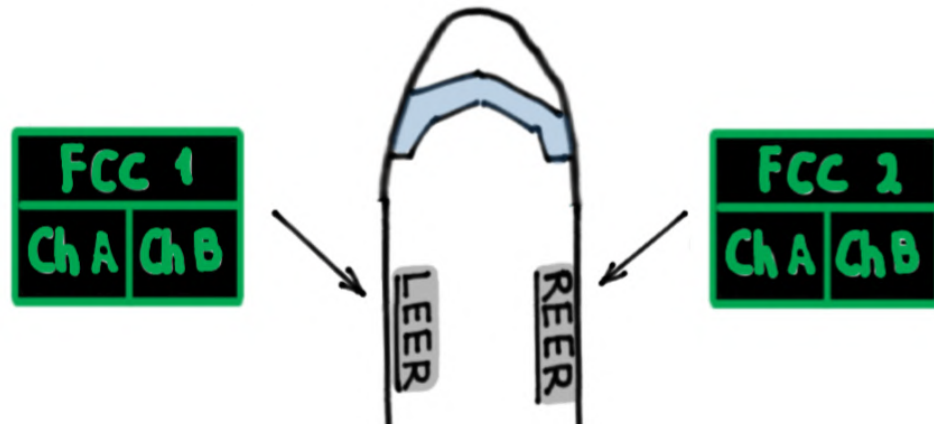






# FLIGHT CONTROL COMPUTERS (FCCs)

- BRAINS of THE FCS
- LOCATED IN THE LEER AND REER

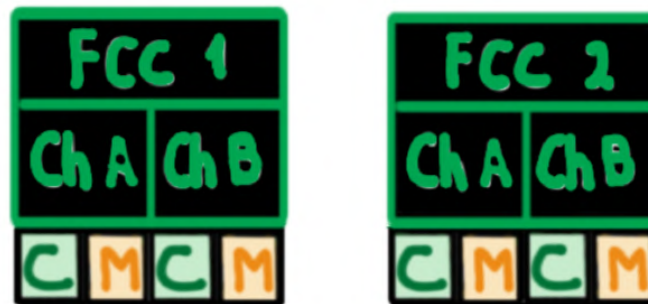


- CONVERT input from THE CREW/AUTOPILOT TO AN ELECTRICAL OUTPUT
- PROVIDE A COMMAND TO THE HYDRAULIC ACTUATORS which MOVE THE flight CONTROL SURFACES TO THE REQUESTED position
- Each FCC HAS TWO (2) CHANNELS for A TOTAL of four (4) CHANNELS
- This configuration provides four (4) REDUNDANT, DISSIMILAR, AND INDEPENDENT channels of OPERATION



- A single FCC channel CAN OPERATE The flight controls

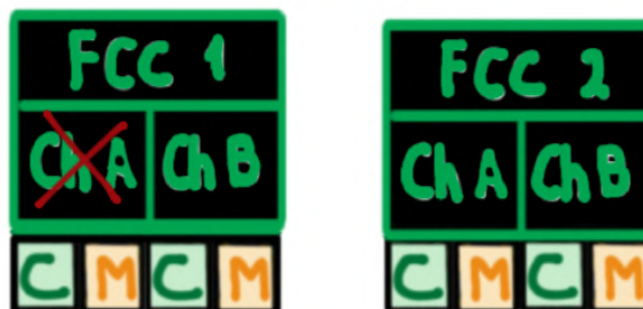
- Each FCC channel has Two (2) LANES:

- ① A COMMAND  lane, AND
- ② A MONITOR  lane

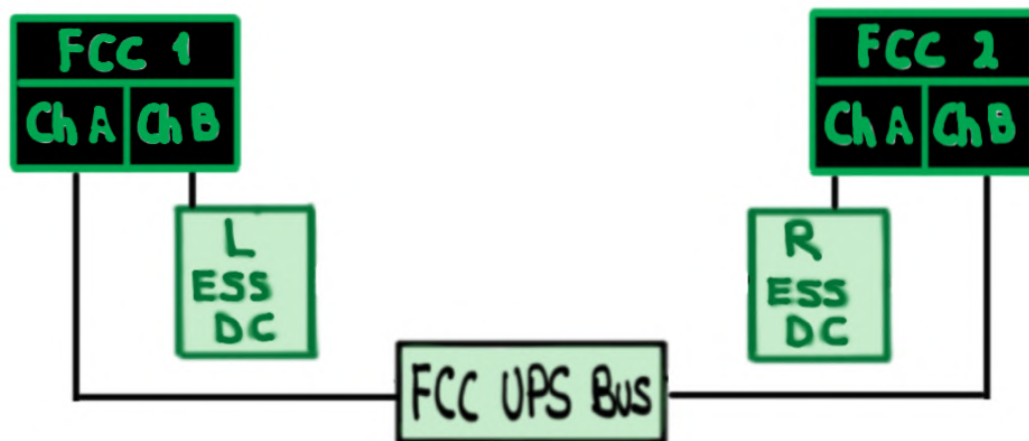


- Their purpose is to provide SYSTEM INTEGRITY by computing input using different SOFTWARE AND HAVING TO COME UP WITH THE SAME OUTPUT

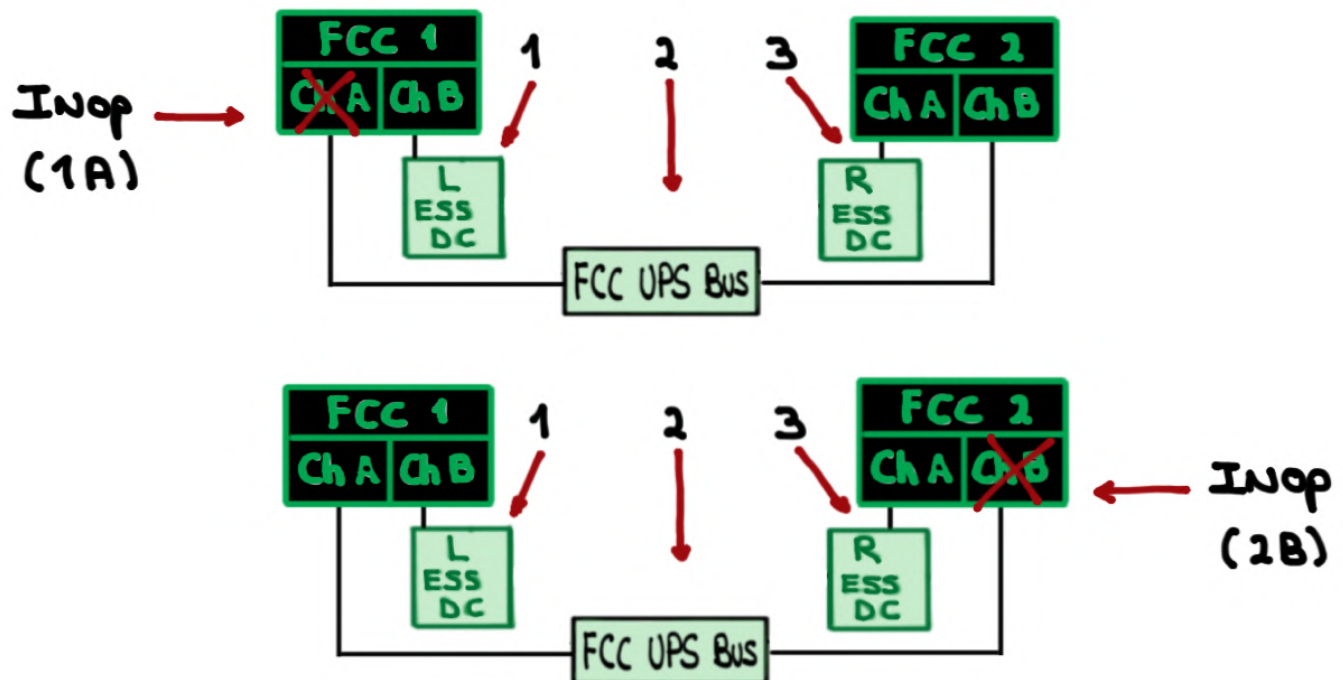
- Any significant difference between a  AND a  lane CAUSES THAT channel TO fail



## - POWER SOURCES:



- THREE (3) SEPARATE POWER SOURCES REQUIRED.
- Dispatch with ONE (1) FCC channel inoperative is possible under the MMEL provided the remaining THREE (3) channels are powered by THREE (3) SEPARATE POWER SOURCES



## - FLIGHT CONTROL RESET switch

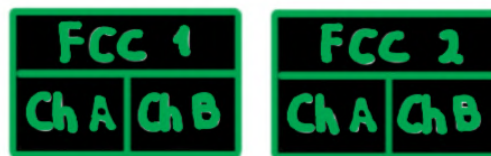
FLT CTRL  
RESET



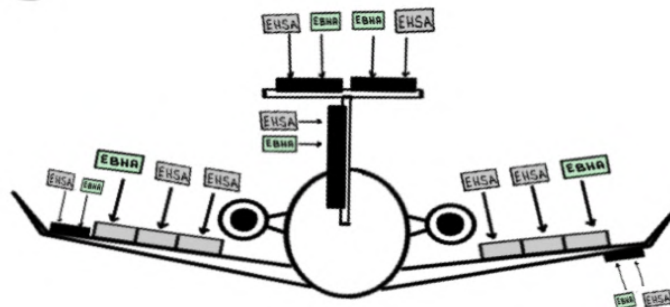
- LOCATED ON CENTER PEDESTAL

- WHEN PRESSED:

- RESETS A AND B CHANNELS IN BOTH FCCs



- RESETS ALL SIXTEEN (16) FLIGHT CONTROL SURFACE ACTUATORS



- USED WHEN DIRECTED BY A CHECKLIST
- DOES NOT WORK IN:

FCS DIRECT (U)

BFCU ACTIVE

FLT CTRL  
RESET





FCC 1		FCC 2	
ChA	ChB	ChA	ChB

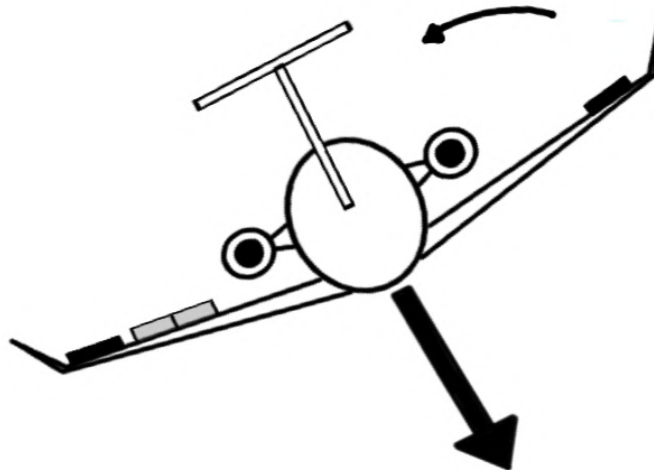
CONTAIN SOFTWARE CALLED CONTROL LAWS OR CLAWS. ITS PURPOSE IS:

- MAKE THE AIRCRAFT fly like A GULFSTREAM
- DAMPEN UNDESIRABLE AIRCRAFT MOTIONS SUCH AS DUTCH ROLL
- IMPLEMENT SEVERAL PROTECTIVE FEATURES:

### ① MANEUVER LOAD ALLEVIATION:

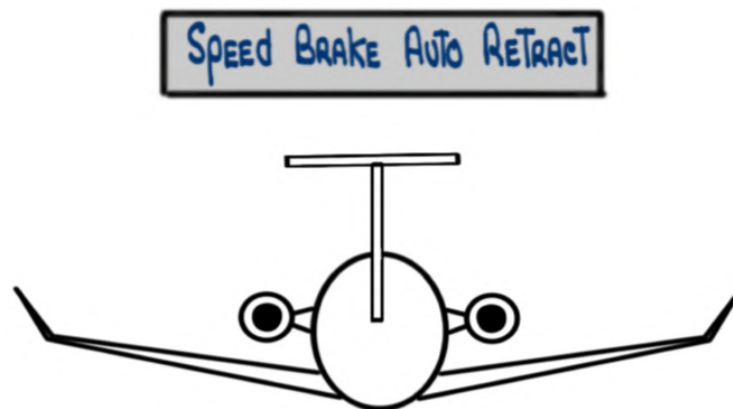
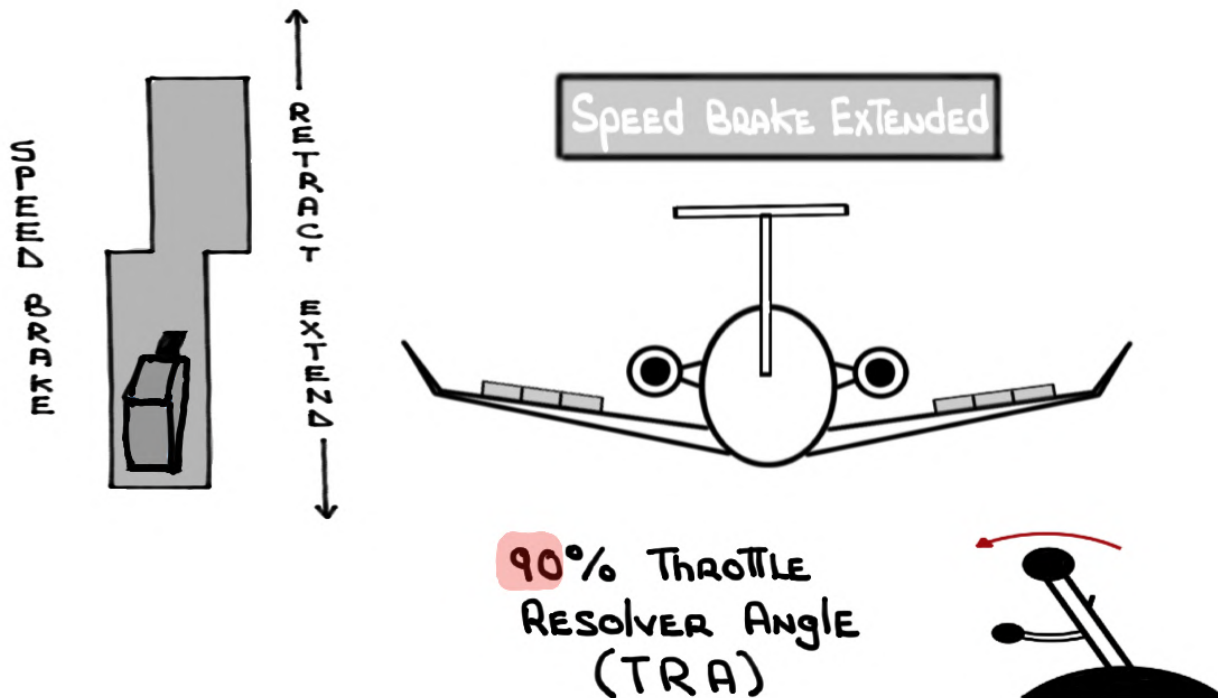
Ailerons SYMMETRICALLY DEFLECT UPWARDS TO REDUCE loads when the pilot commands  $> 1.5$  Gs

REACHES MAXIMUM  $3^\circ$  deflection  $\geq 2.5$  Gs



## ② SPEEDBRAKE - AUTO RETRACT:

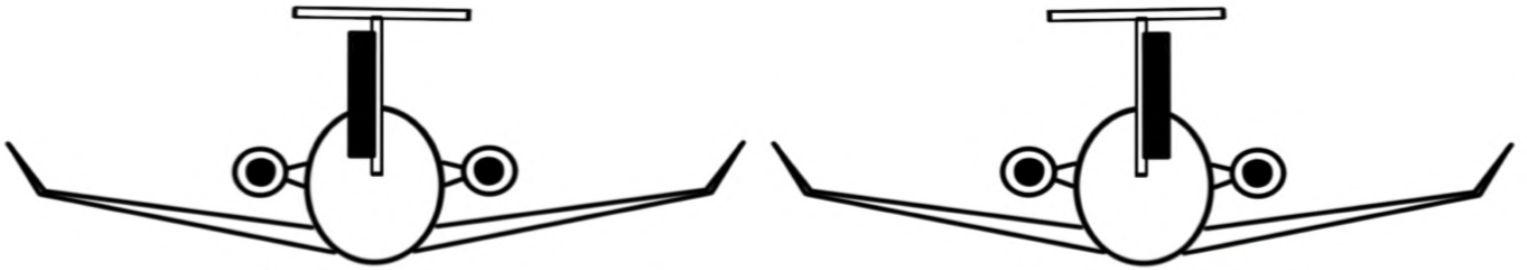
STUCK OR JAMMED SPEED BRAKE HANDLE



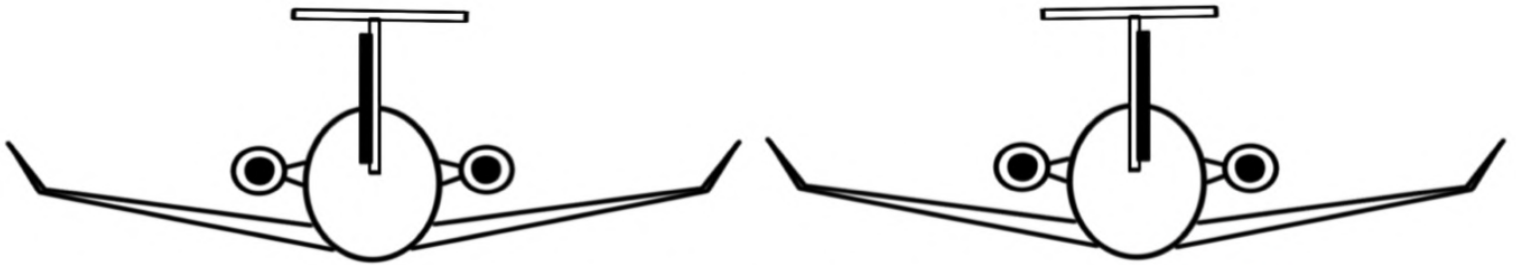
SPEED BRAKES RETRACT BUT SPEED BRAKE HANDLE DOES NOT

### ③ DYNAMIC RUDDER LIMITING:

HELPS PREVENT A PILOT FROM OVERSTRESSING  
THE RUDDER



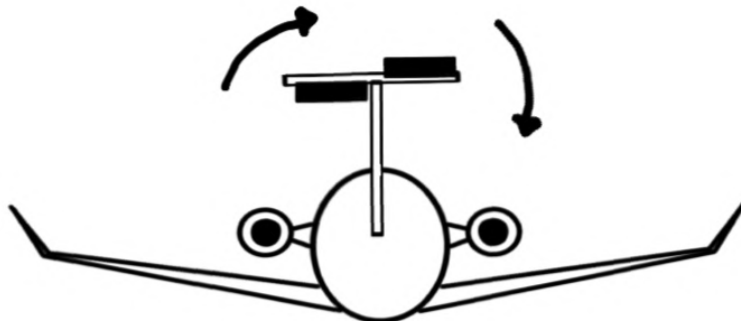
Low speed: High deflection ( $25^\circ$ )



High speed: Low deflection ( $3.6^\circ$ )

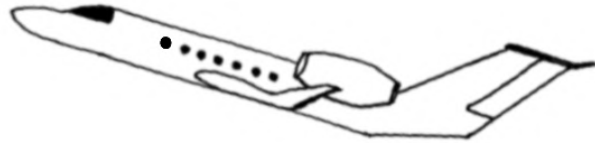
### ④ ELEVATOR Split Load Limiting:

PROTECTS AGAINST LARGE TORQUE ASSOCIATED WITH  
A SPLIT ELEVATOR



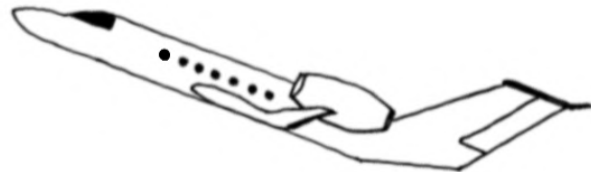
## ⑤ AOA Limiting:

- **0.75** AOA - Pitch Limit Indicator (PLI) Appears



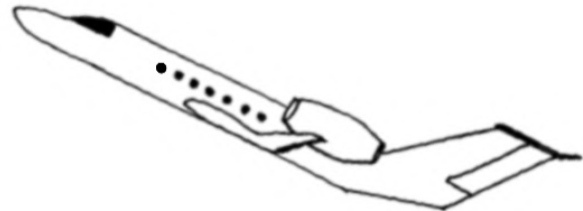
- **0.88 - 0.93** AOA Limiting (based on closure rate)

FCC AOA Limiting



- **0.97** AOA - Stick shaker activates

STALL PROTECTION ACTIVE



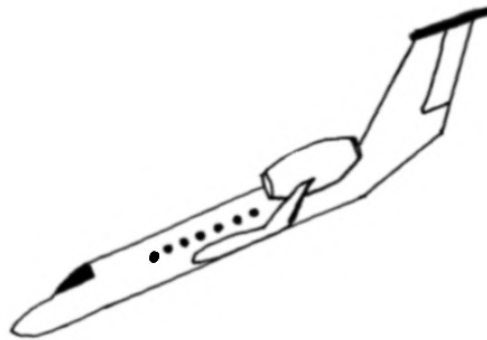
\* EVEN A SUSTAINED full aft sidestick deflection  
will NOT CAUSE THE AIRCRAFT TO STALL



## ⑥ High Speed Protection:

- Available when:
  - Autopilot is OFF
  - $V_{MO}/M_{MO} + 5$  (depending on acceleration rate)
- Pitch control restricted by the FCS
- Helps prevent an overspeed condition by decreasing pitch nose down authority 75%

High Speed PROTECT Active



- Protection inhibited with Autopilot ON or at a high bank angle (protection fades out > 60° bank)
- Does NOT prevent exceeding  $V_{MO}/M_{MO}$

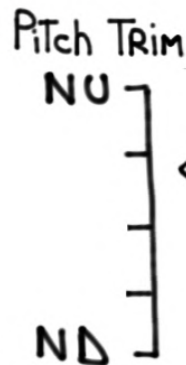
# NORMAL sub-modes:

## Inflight - AP ON



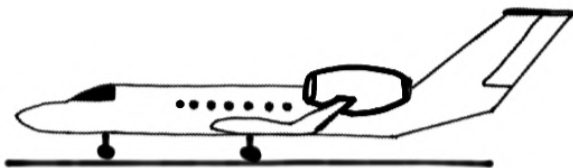
- White Triangle only
- No digits

## Inflight - AP OFF



- Active AT 10' AGL
- Displays TRIMMED KCAS
- Scale: 60 KCAS INCREMENTS

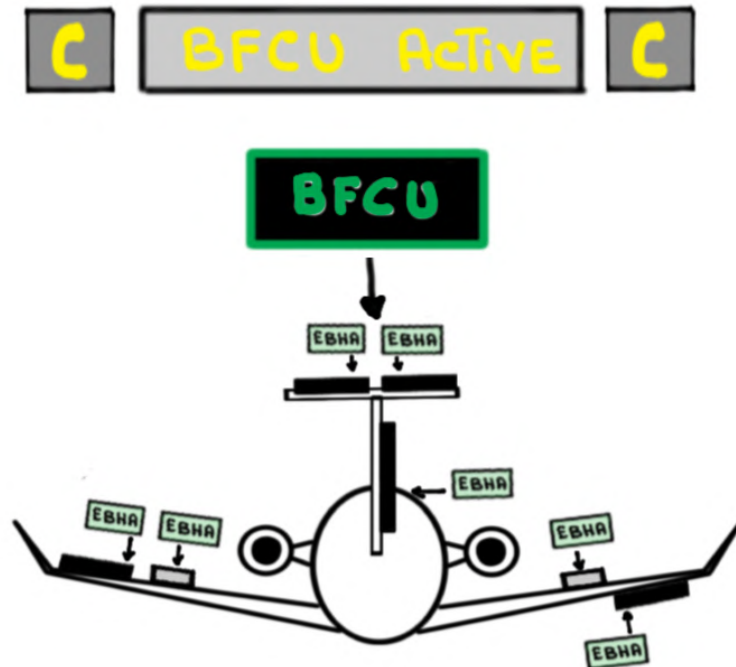
## ON GROUND



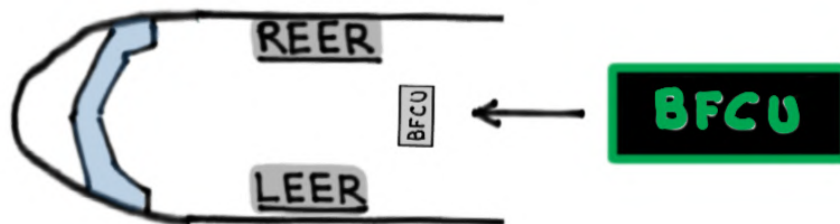
- GREEN BAND
- Stab position in DEGREES NOSE Up / DOWN
- COMMANDS HORIZONTAL STABILIZER
- < 10' AGL

# Backup FLIGHT CONTROL UNIT (BFCU)

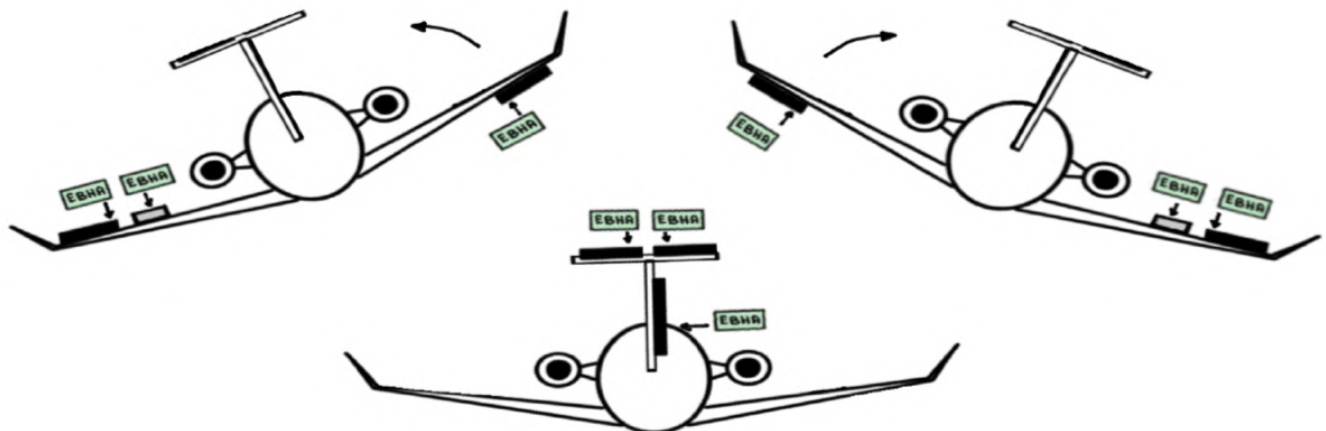
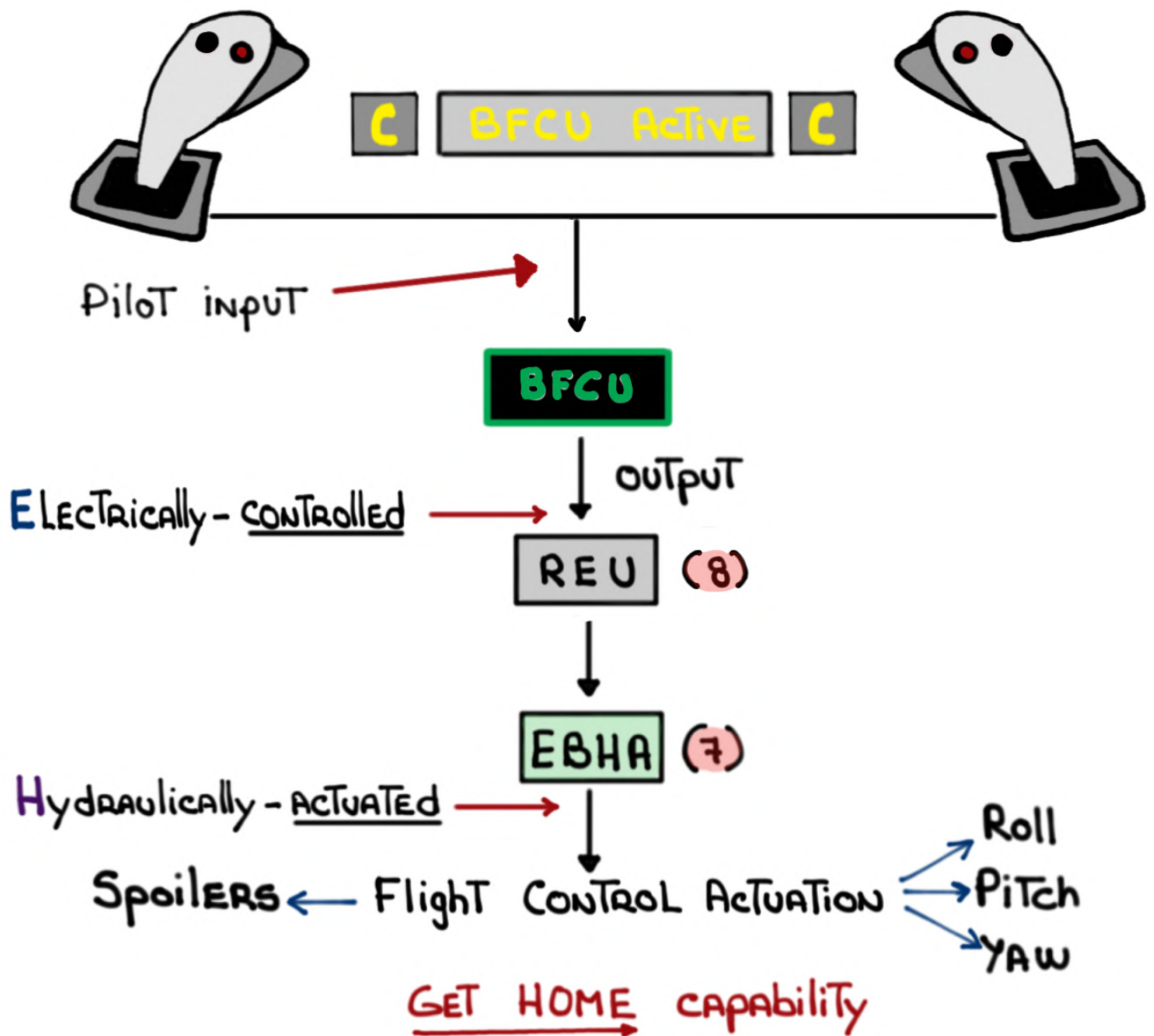
- DESIGNED To provide A GET HOME capability if both FCCs should fail



- The **BFCU** is located UNDER THE floor AND CAN BE DEFERRED AS PER THE MEL



- ONCE ACTIVE IT CANNOT BE RESET in flight
- Inop < 47 knots
- POWERED by FCC UPS BUS

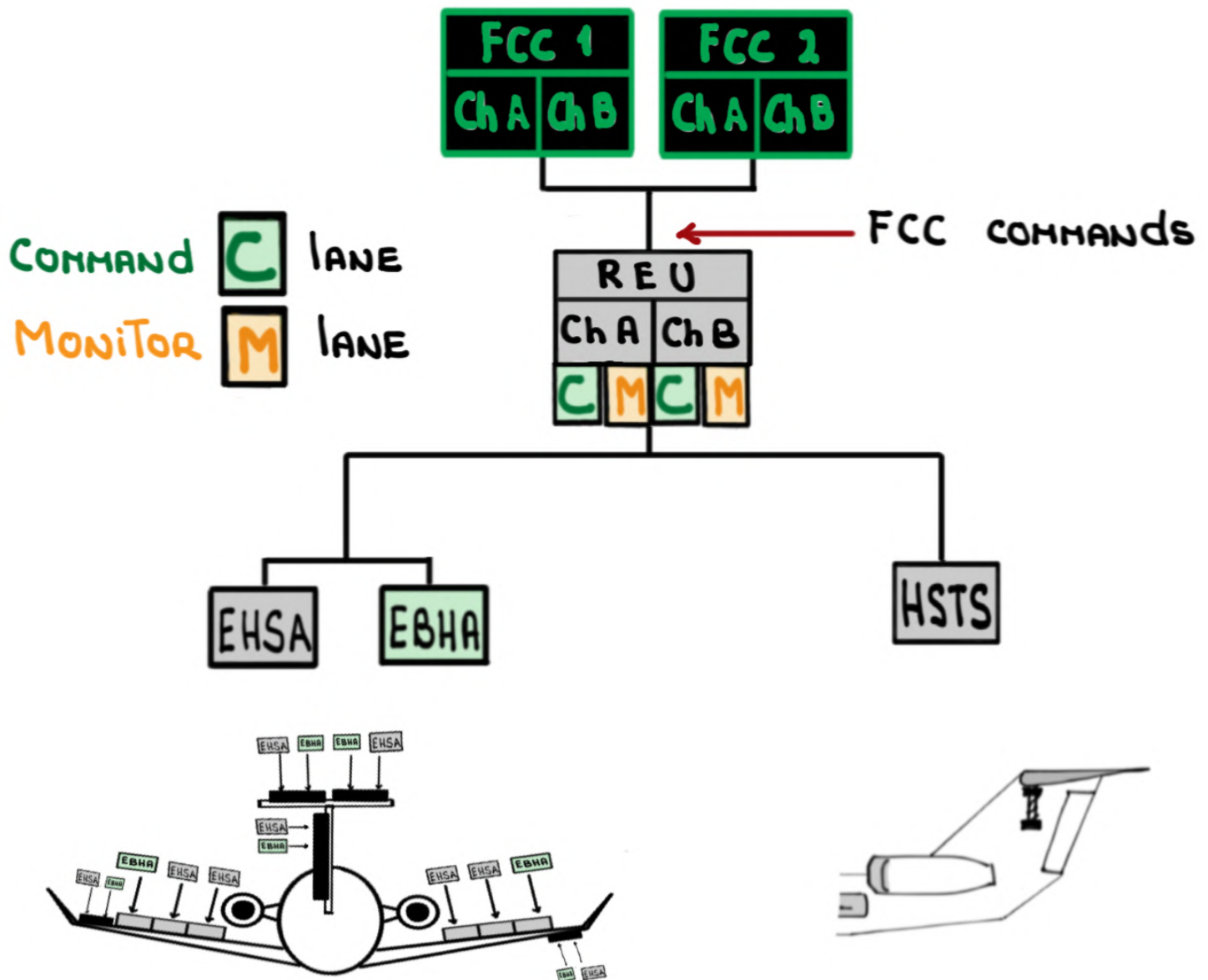




# REMOTE ELECTRONIC UNITS (REU)

- THERE ARE EIGHT (8) REUs

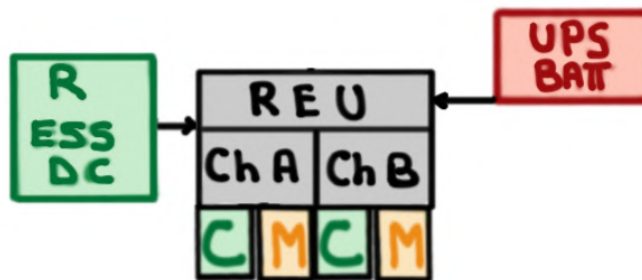
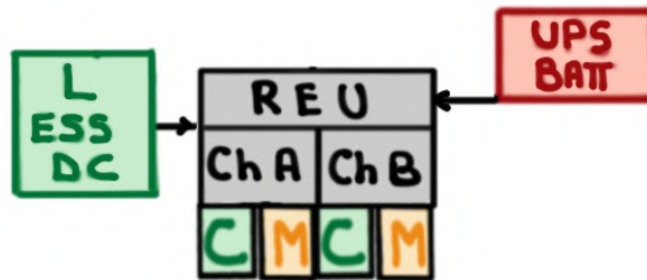
- THE REUs CONTROL THE HYDRAULIC ACTUATORS **EHSA** **EBHA**  
AND HORIZONTAL STABILIZER TRIM SYSTEM **HSTS**  
BASED ON FCC COMMANDS



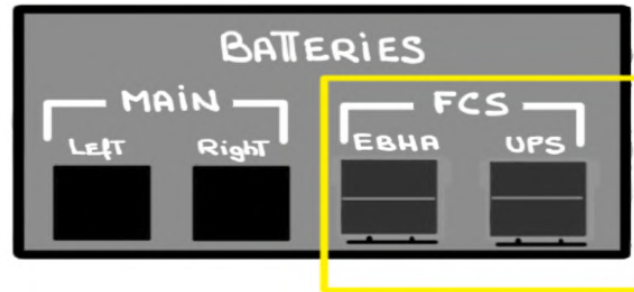
- The REUs ARE located in multiple locations:

- Wings (4)
  - Tail (3)
  - MAIN GEAR well (1)
- > Eight (8)

- Each REU has Two (2) DC power sources:



# FLIGHT CONTROL BATTERIES



THERE ARE TWO (2) Flight Control System (FCS) BATTERIES:

① ELECTRICAL BACKUP HYDRAULIC ACTUATOR (EBHA) BATTERY

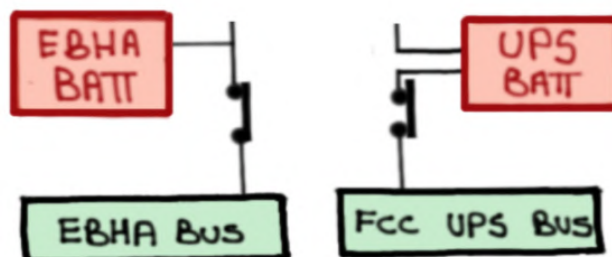


② UNINTERRUPTIBLE POWER SUPPLY (UPS) BATTERY







THE FCS BATTERIES CAN POWER THE FLIGHT CONTROLS FOR THIRTY (30) MINUTES

- ILLUMINATED   if no  power is being produced AND THEY POWER THEIR OWN BUSES (DISCHARGING)

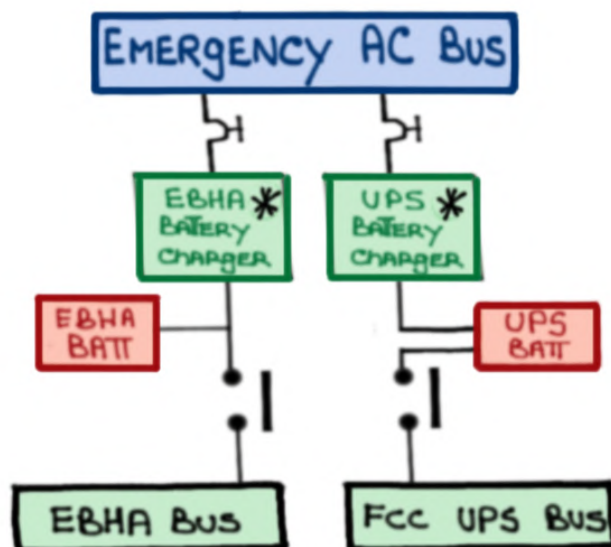


## - SYSTEM POWER ON SELF TEST (SPOST)

-  SELECTED ON first , Then  
 SELECTED ON 

- FORTY five (45) SECOND TEST
- NO ELECTRICAL INTERRUPTIONS DURING SPOST OR A COMPLETE POWER DOWN IS REQUIRED

## - FCS BATTERIES - CHARGER/TRANSFORMER RECTIFIER

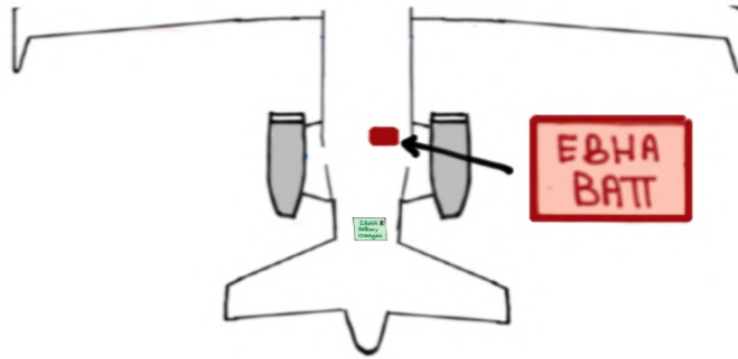


\* DUAL function:  
CHARGER AND TR

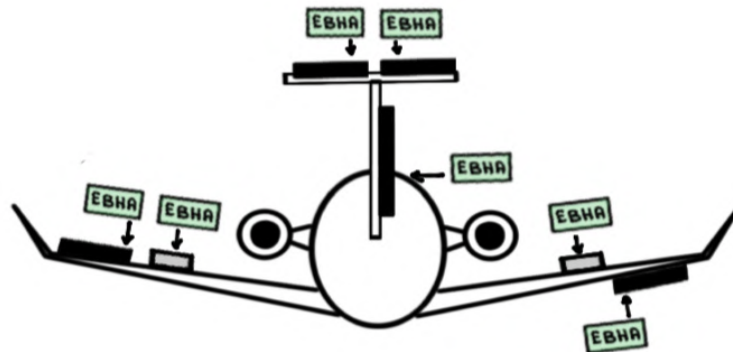


- **EBHA BATT** ELECTRICAL Backup Hydraulic Actuator

- Nicad, **25** Volts, **53** amp/hour
- LOCATED IN THE TAIL COMPARTMENT



- POWERS SEVEN (7) **EBHA** ACTUATORS



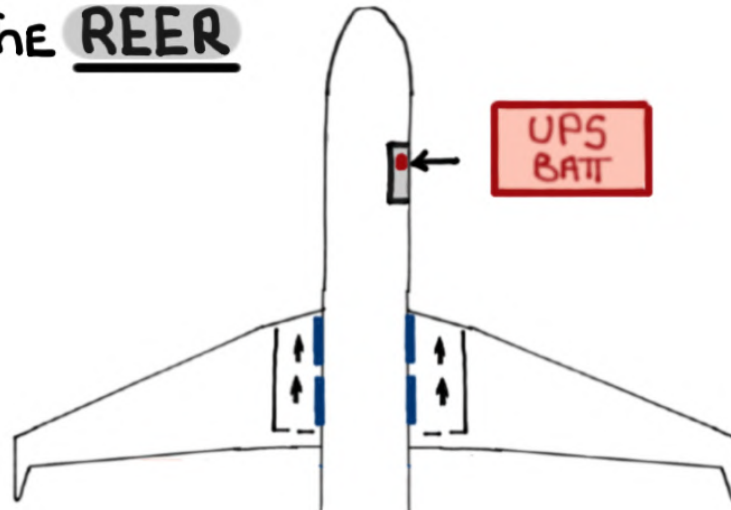
- CAN BE CHARGED by **RAT GEN**  via The **EMERGENCY AC BUS**

- MUST BE REMOVED FROM AIRCRAFT IN COLD SOAKED CONDITIONS ( $\leq -20^{\circ}\text{C}$ ) AND STORED IN A LOCATION WARMER  $> -20^{\circ}\text{C}$

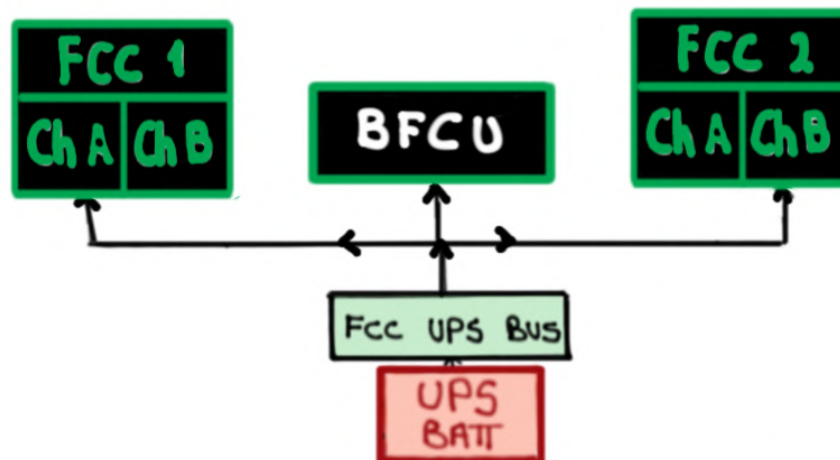
- **UPS BATT** Uninterruptible Power Supply (UPS)

- LEAD Acid, **24** Volts, **10.5** Amp/hour

- LOCATED in The REER



- POWERS FLIGHT CONTROL COMPUTERS channels 1A AND 2B

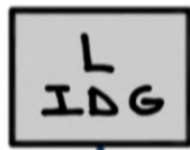


- SECONDARY power SOURCE TO **REU**

- CAN BE CHARGED by **RAT GEN**  VIA THE **EMERGENCY AC BUS**

1

L GEN



R GEN

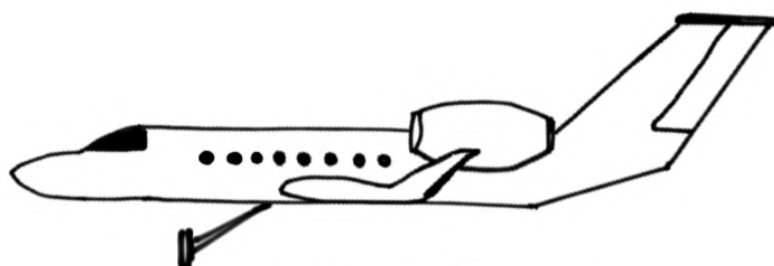


2

APU GEN



3



(> 200 kts)

RAT GEN



4

MAIN BATTERIES



Left

Right

EBHA



UPS



5

EBHA



UPS



1

# Flight Control Law Mode

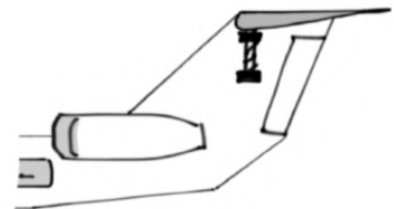
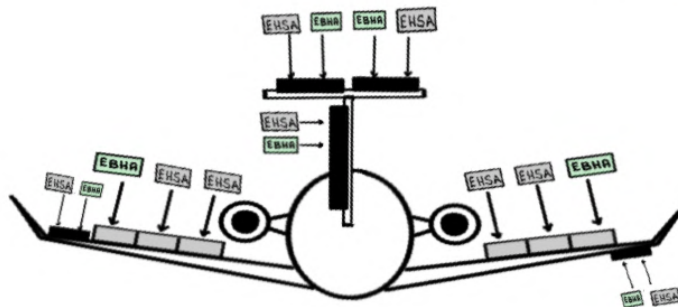
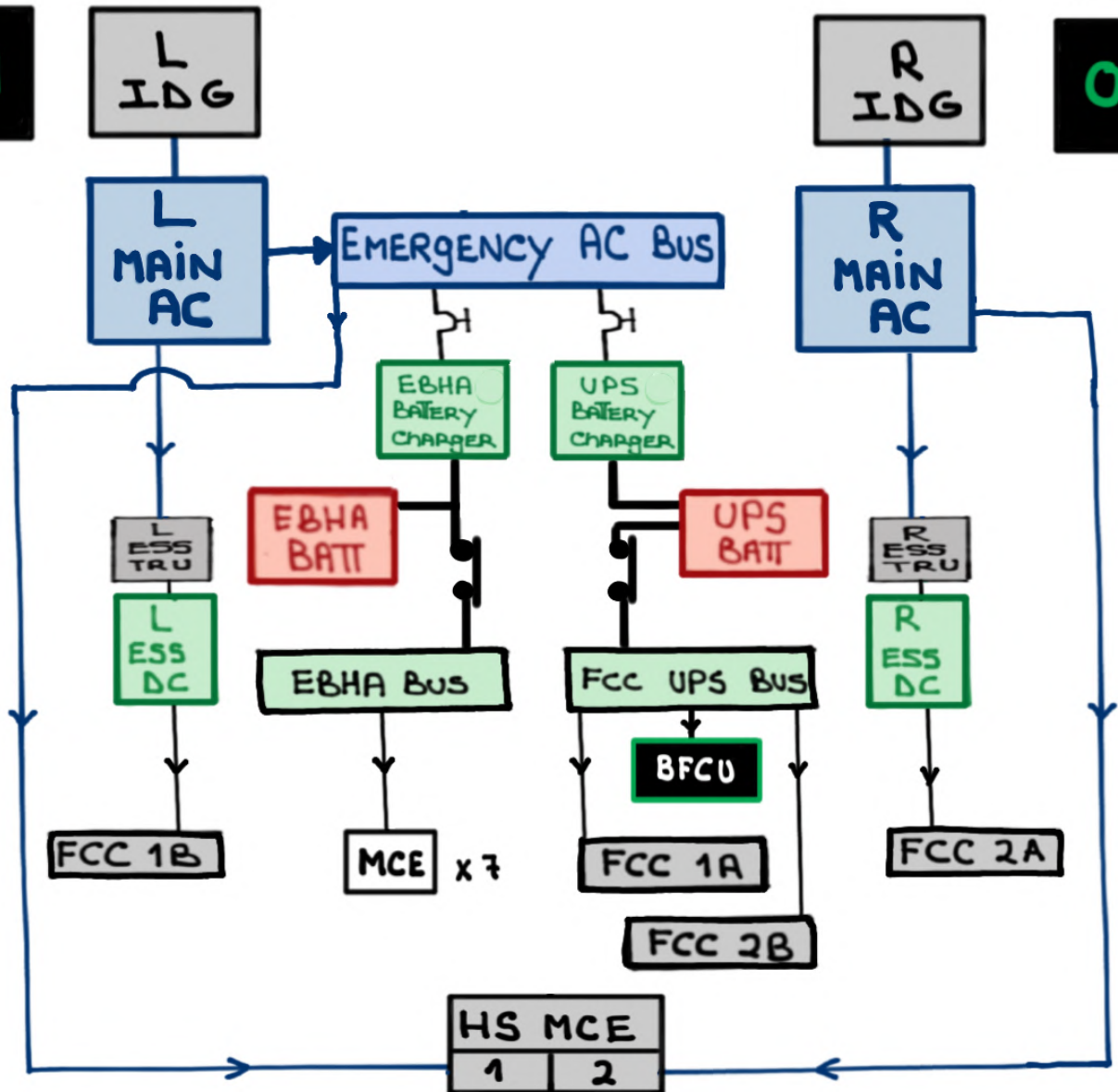
NORMAL

L GEN

ON

R GEN

ON

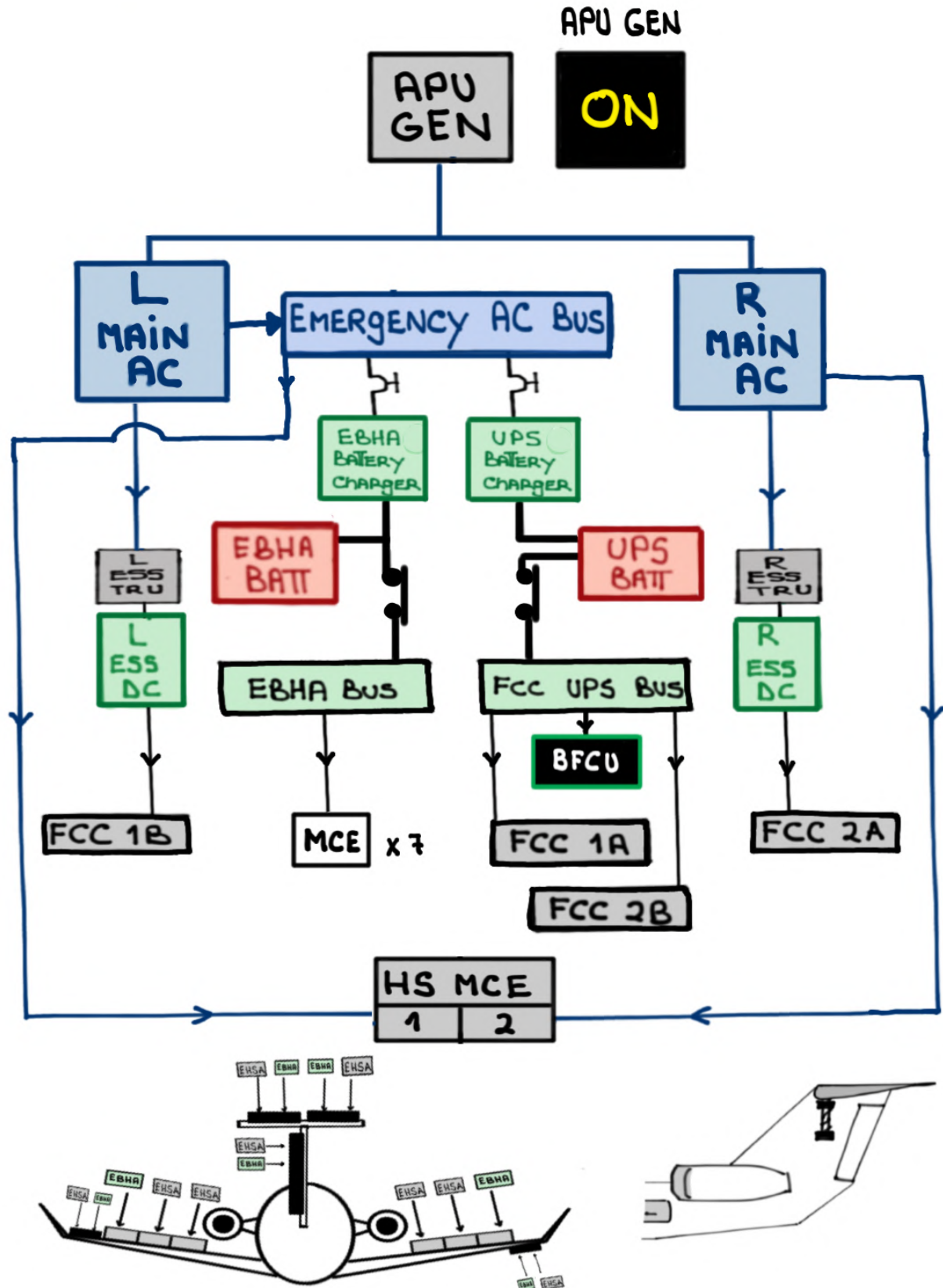




2

# Flight Control Law Mode

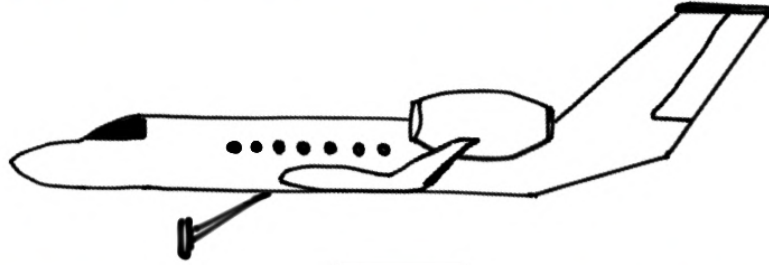
NORMAL



3

## FLIGHT CONTROL LAW Mode

NORMAL

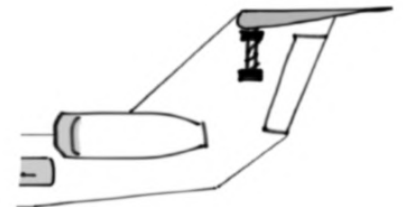
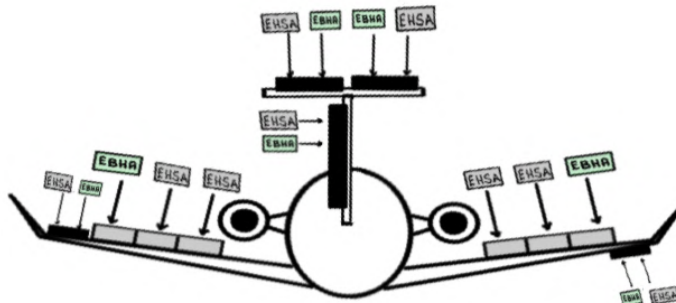
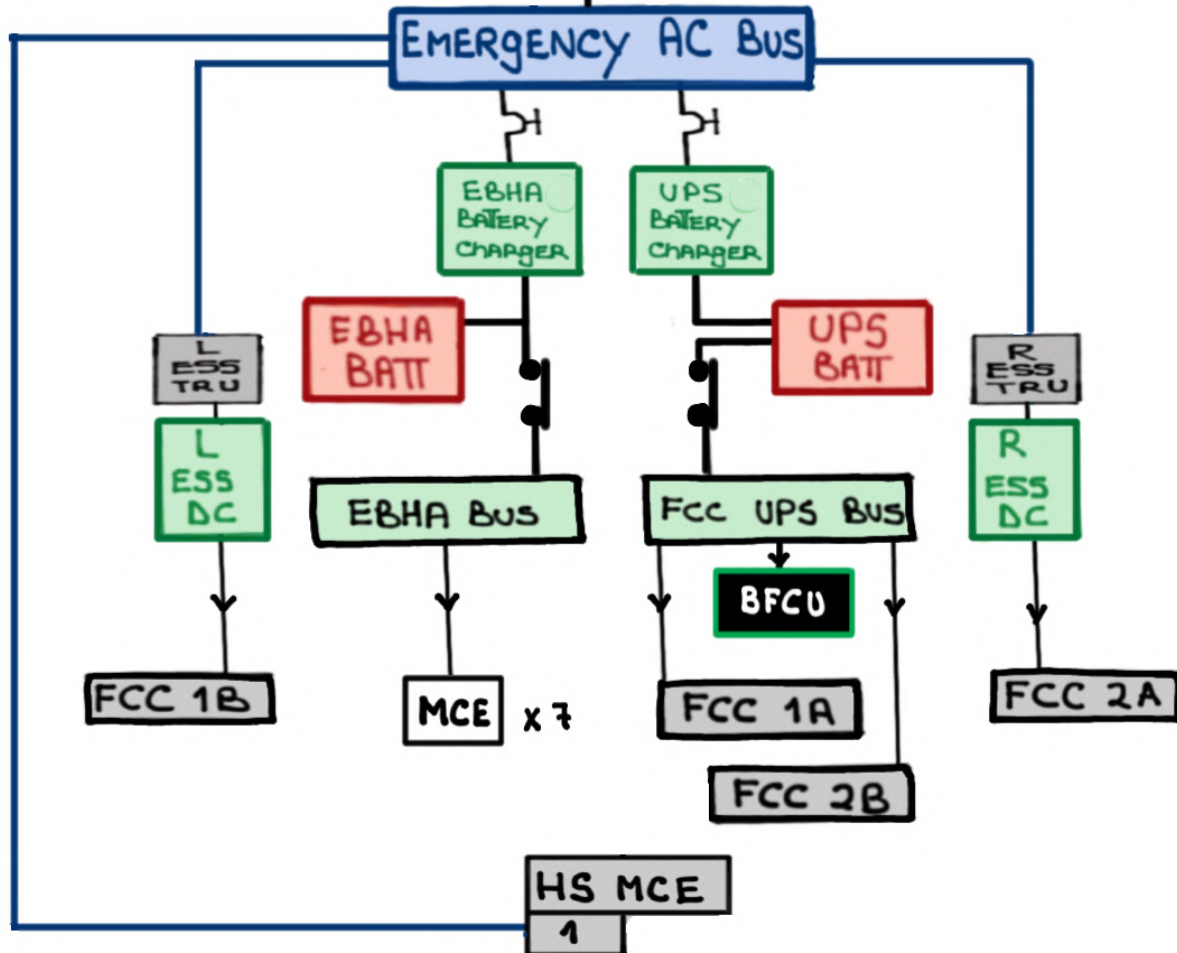


RAT GENERATOR ON

RAT  
GEN

(&gt; 200 kts)

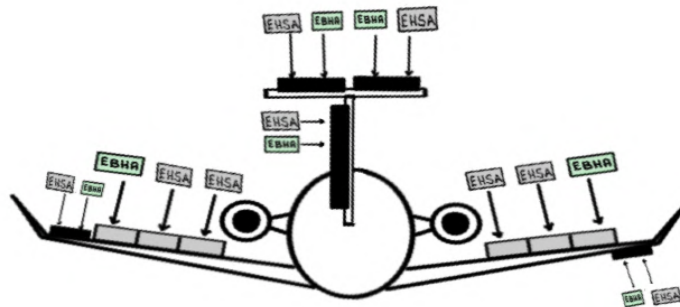
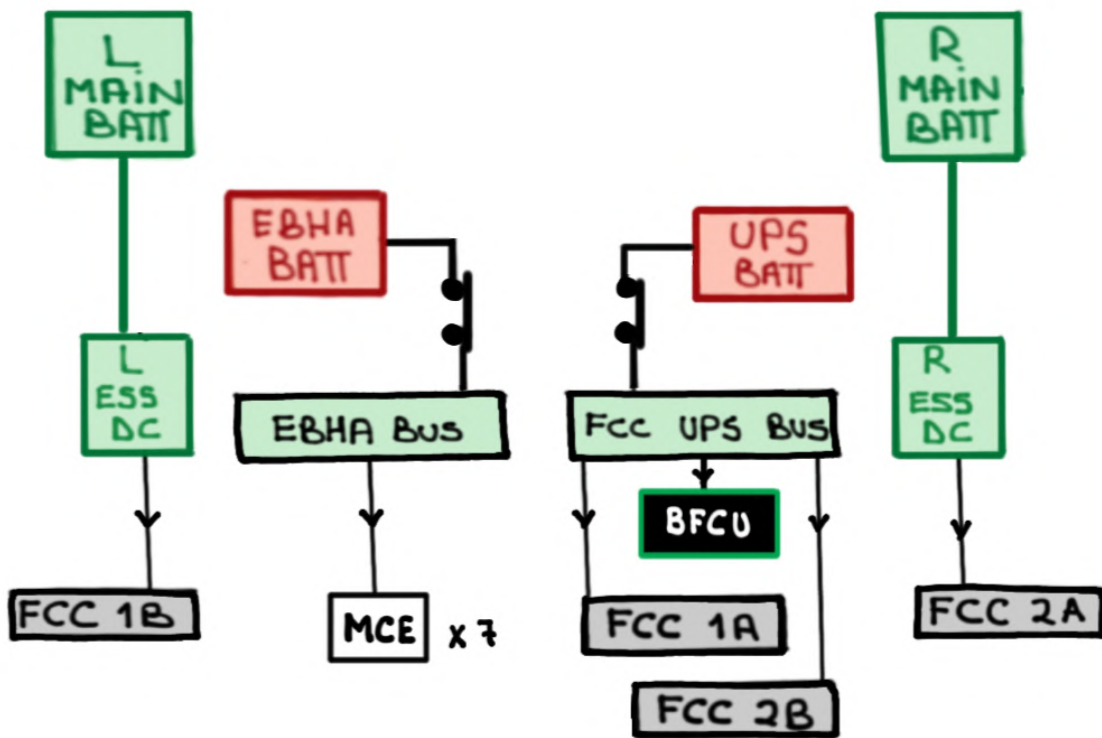
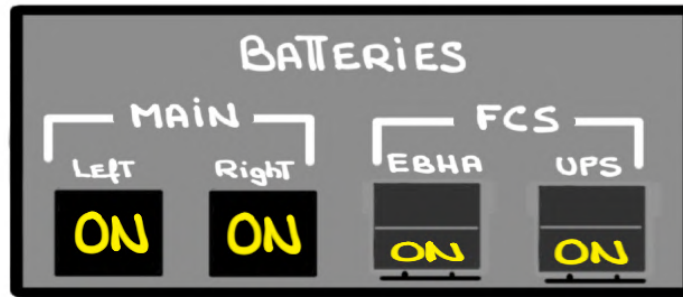
RAT GEN



4

# FLIGHT CONTROL LAW Mode

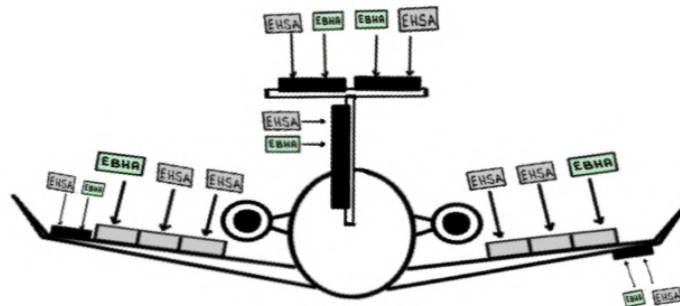
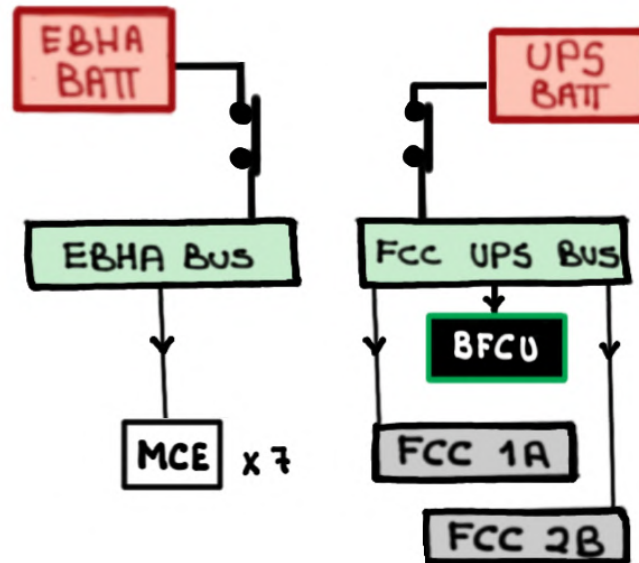
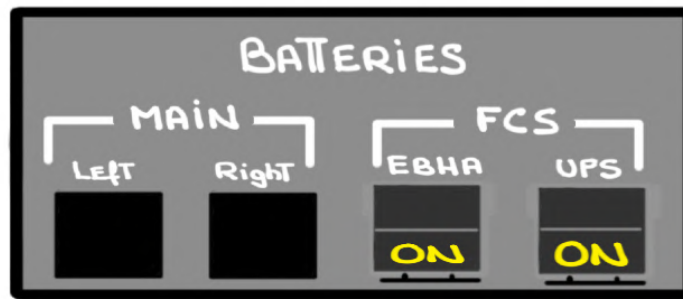
NORMAL



5

# FLIGHT CONTROL LAW MODE

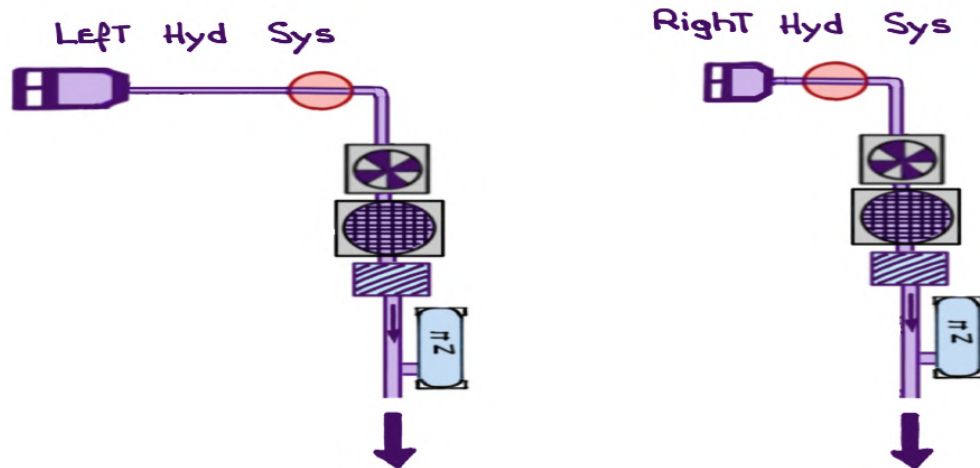
NORMAL





# Hydraulic Actuators

- Hydraulic fluid and pressure is provided by:



- THERE ARE SIXTEEN (16) Hydraulic Actuators

- Two (2) Actuators for EACH primary flight control surface:

- Ailerons (4)
  - Elevators (4)
  - Rudder (2)
- > TEN (10)

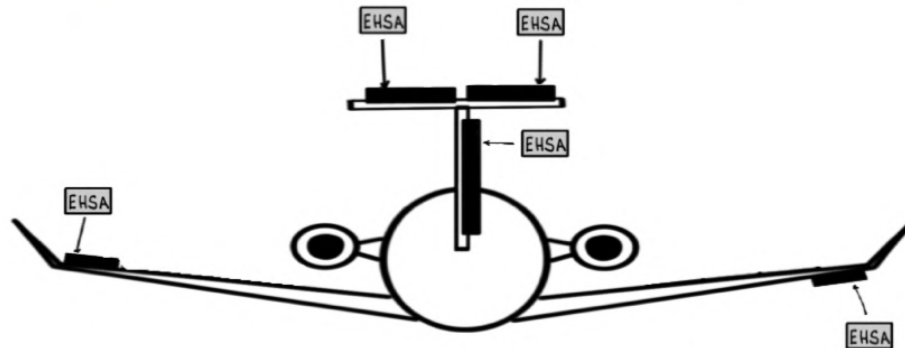
- THERE IS ONE (1) ACTUATOR for EACH spoiler panel

- Inboard (2)
  - Midboard (2)
  - Outboard (2)
- > Six (6)

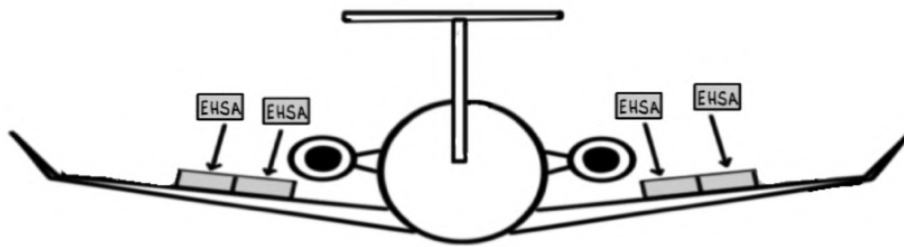
- THERE ARE TWO (2) TYPES OF ACTUATORS:

- ELECTRO-HYDRAULIC SERVO ACTUATOR EHSA

- ONE (1) FOR EACH PRIMARY FLIGHT SURFACE



- ONE (1) FOR EACH INBOARD AND MIDBOARD SPOILER



- USES LEFT AND RIGHT HYDRAULIC SYSTEMS

- COMMANDED BY AN REU → EHSA

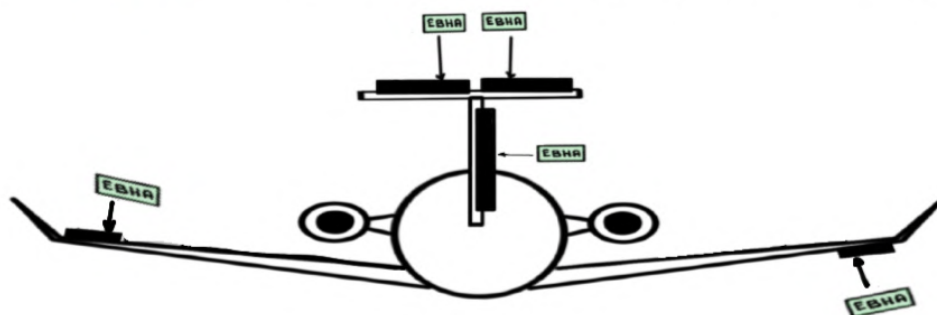
- TWO (2) MODES:

- ① HYDRAULICALLY ACTIVE: NORMAL STATE OF OPERATION

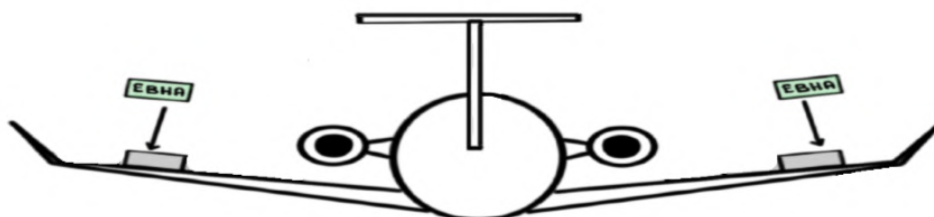
- ② DAMPED BYPASS MODE: PASSIVELY FOLLOWS THE WORKING ACTUATOR

- ELECTRICAL BACKUP HYDRAULIC ACTUATOR **EBHA**

- ONE (1) FOR EACH PRIMARY FLIGHT SURFACE



- ONE (1) FOR EACH OUTBOARD SPOILER PANEL

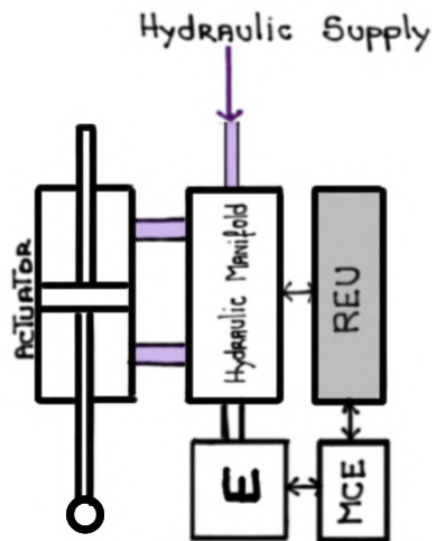


- NORMALLY USES LEFT AND RIGHT HYDRAULIC SYSTEMS
- NORMALLY COMMANDED BY AN **REU** → **EBHA**
- IF NORMAL HYDRAULIC PRESSURE IS NOT AVAILABLE IT REVERTS TO ELECTRIC BACKUP (EB) MODE
- THREE (3) MODES:
  - ① HYDRAULICALLY ACTIVE: NORMAL STATE OF OPERATION
  - ② DAMPED BYPASS MODE: PASSIVELY FOLLOWS THE WORKING ACTUATOR
  - ③ EB MODE

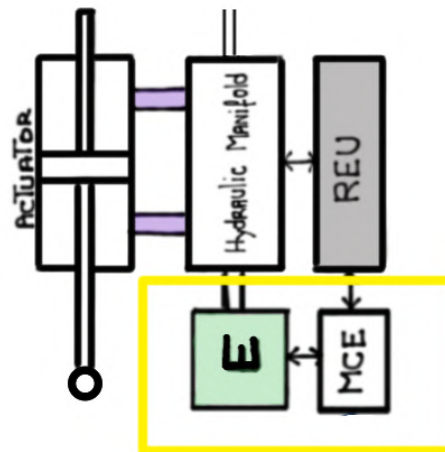
## EB MODE:

- ELECTRIC POWER TO DRIVE A PUMP AT THE ACTUATOR
- PRESSURIZES TRAPPED hydraulic fluid
- ACTS AS A THIRD HYDRAULIC SYSTEM
- A MOTOR CONTROL ELECTRONICS (MCE) IS USED TO CONTROL THE EBHA MOTOR-PUMP WHEN THE ACTUATOR IS IN THE ELECTRIC BACKUP **E** STATE DUE TO HYDRAULIC OR REU FAILURES

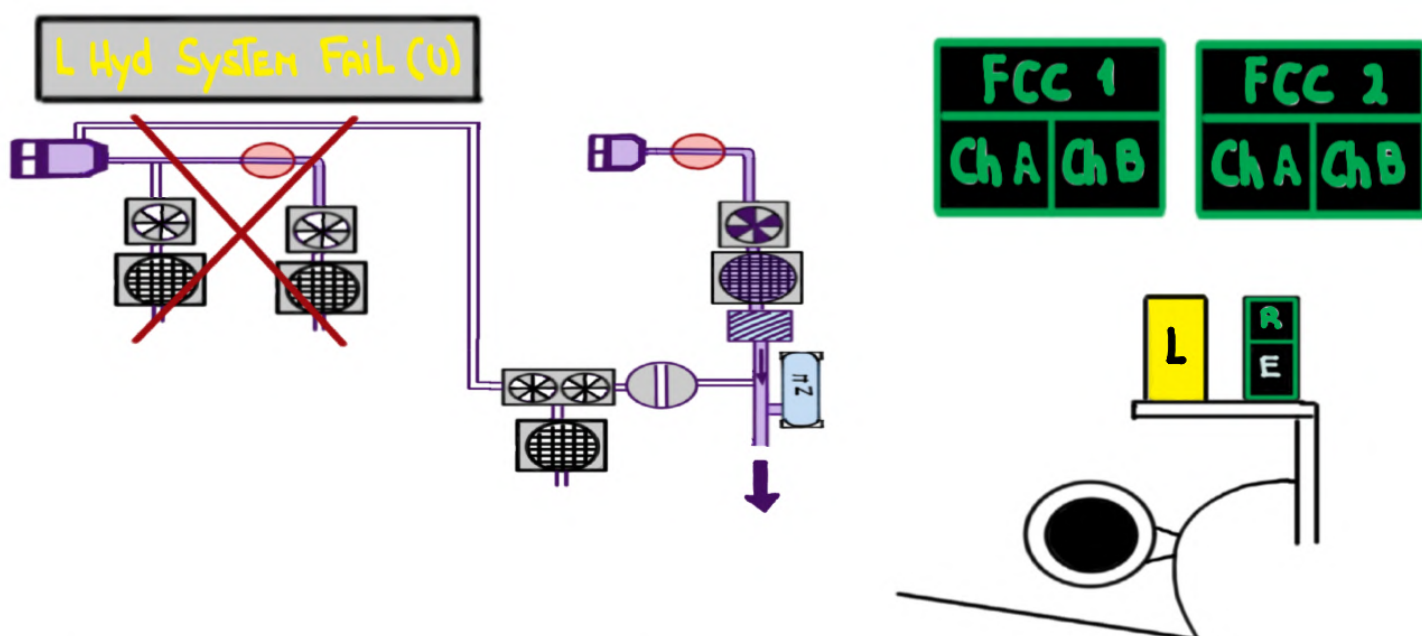
### HYDRAULICALLY ACTIVE



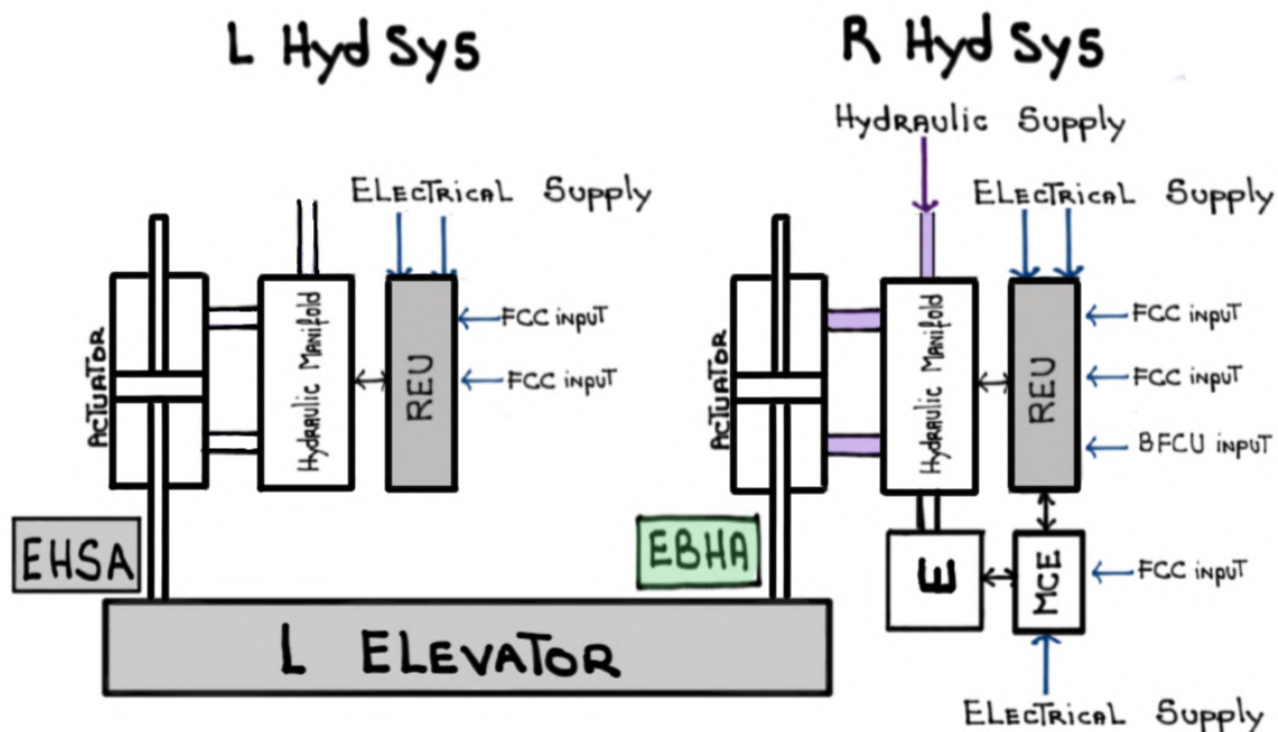
### ELECTRIC BACKUP **E** MODE

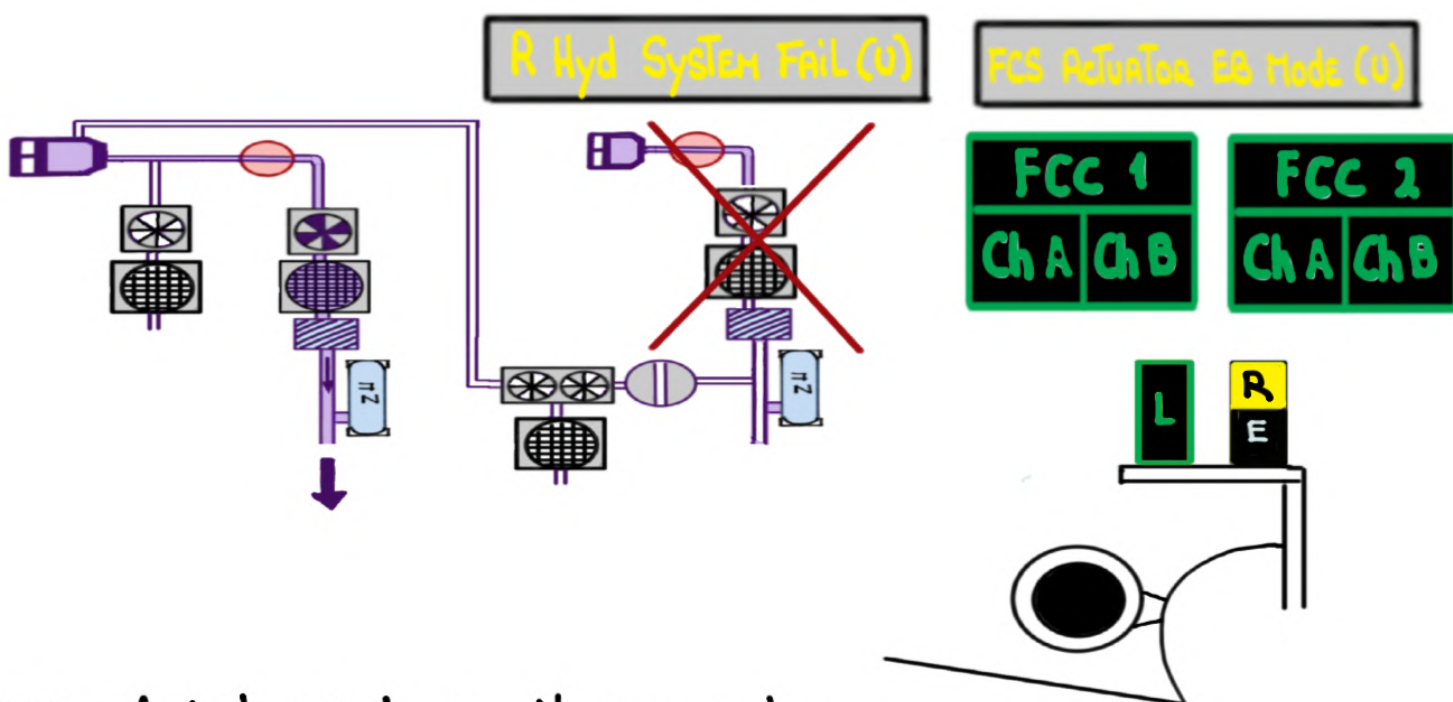




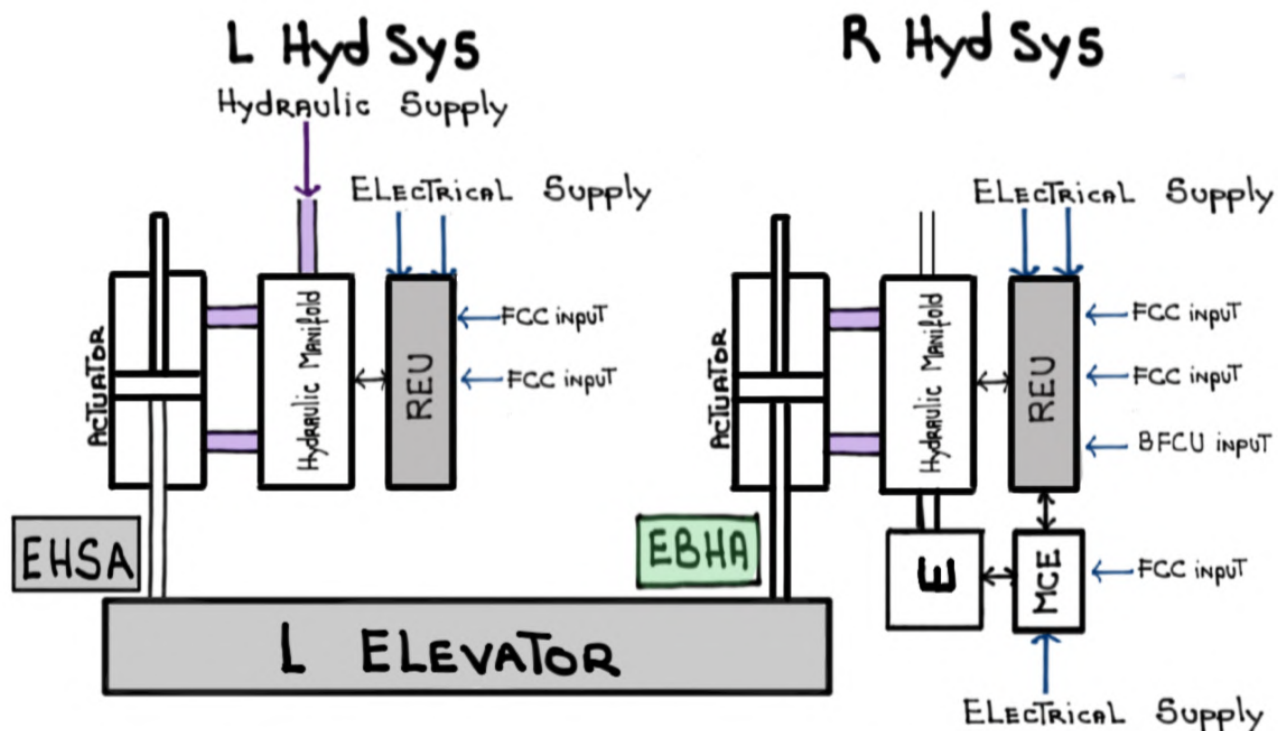


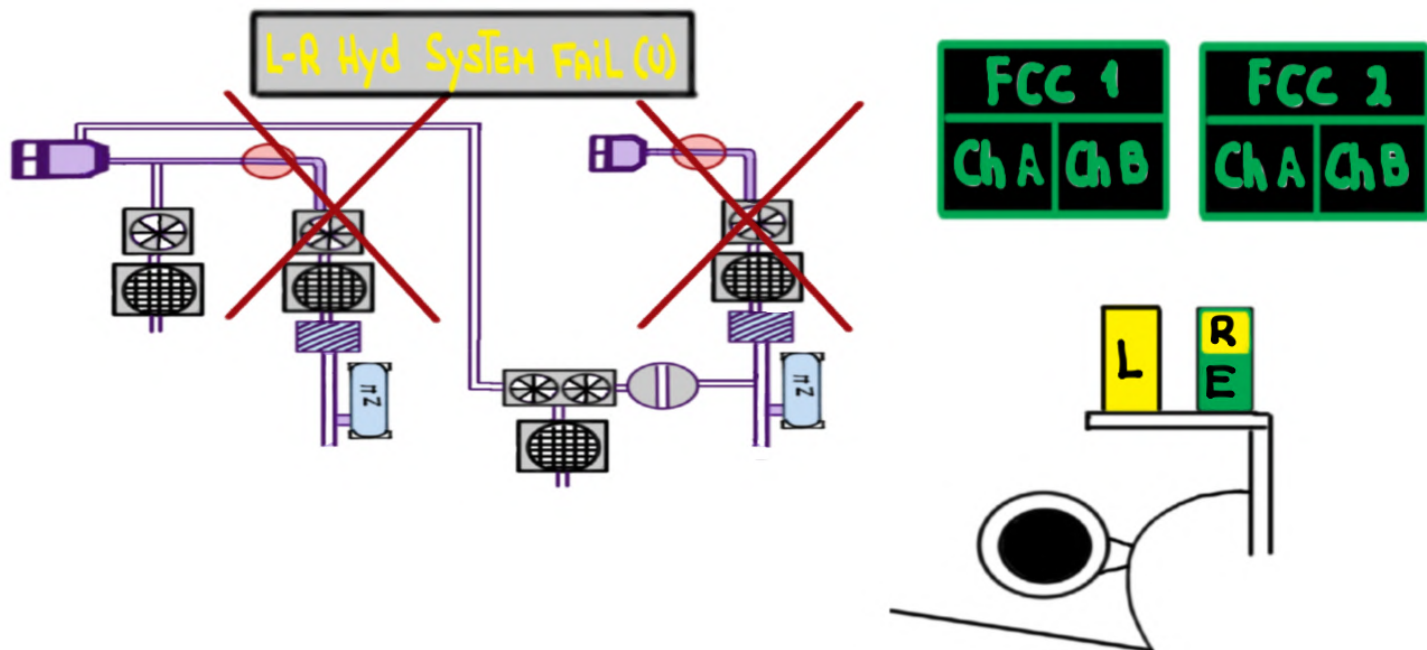
- Loss of midboard spoilers only
- All ACTUATORS powered by The LEFT Hydraulic System operate in damped bypass mode
- MAXIMUM SPEED: 285 KCAS/M0.90



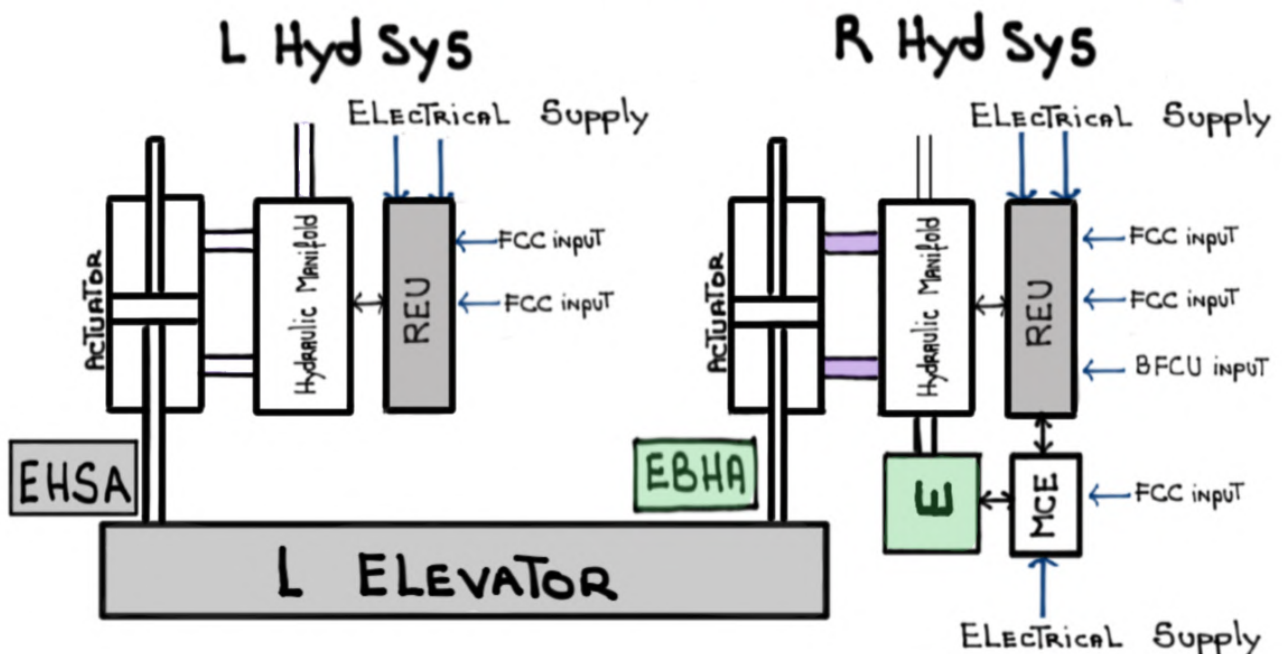


- Loss of inboard spoilers only
- Outboard spoiler actuators operating in EB **E** mode
- All other actuators powered by The Right Hydraulic System operate in damped bypass mode
- MAXIMUM SPEED: 285 KCAS/M0.90





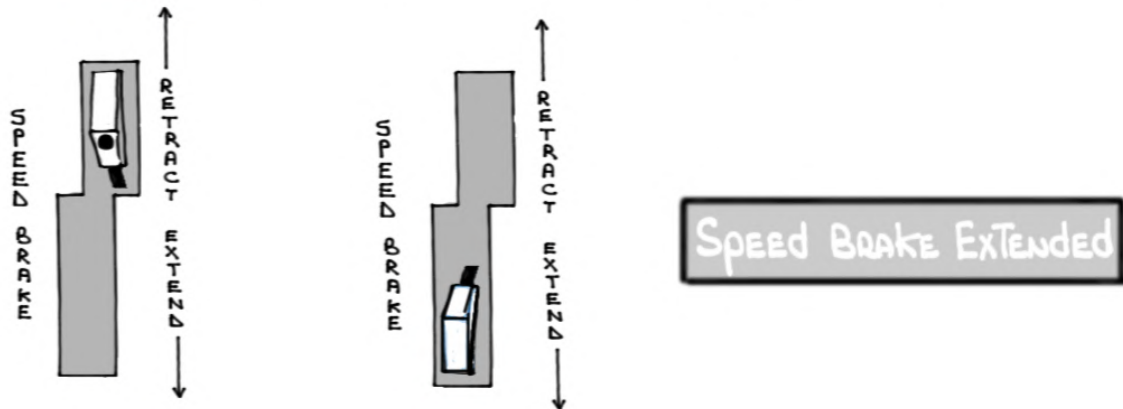
- Loss of midboard and inboard spoilers
- All **EBHA** actuators operate in EB **E** mode
- All other actuators operate in damped bypass mode
- Each flight control surfaces powered by a single actuator
- MAXIMUM SPEED: **285 KCAS/M0.90**



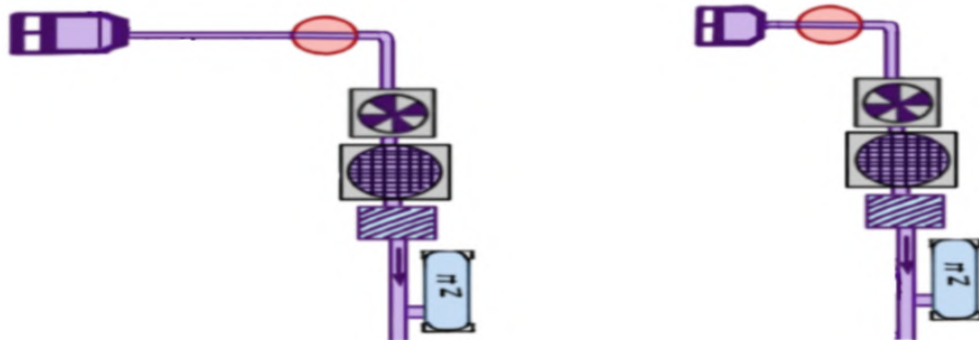


# Spoilers

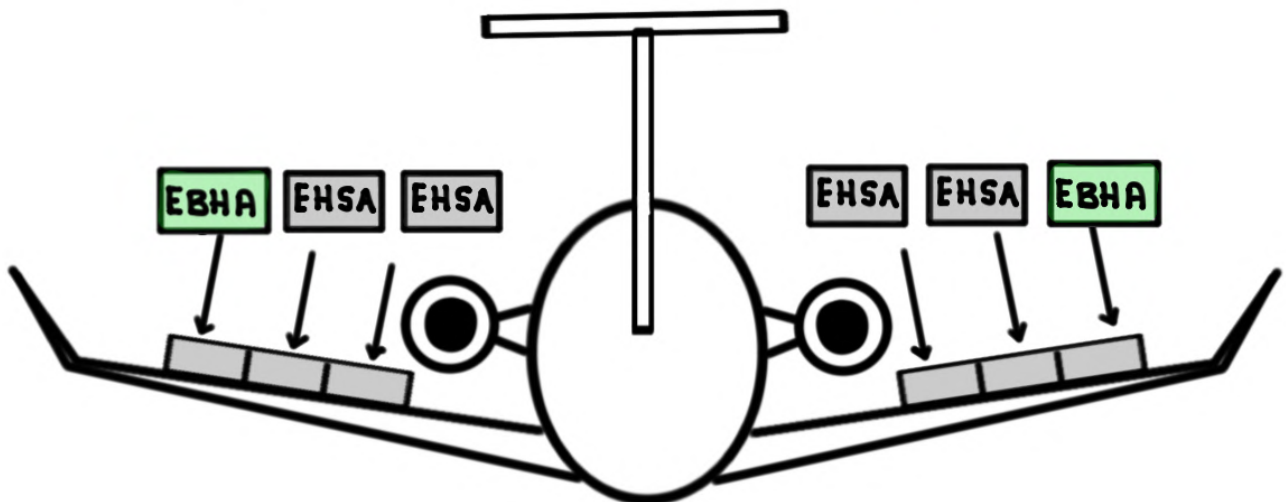
- **ELECTRICALLY** - CONTROLLED VIA SPEED BRAKE HANDLE:



- **HYDRAULICALLY** - POWERED by:

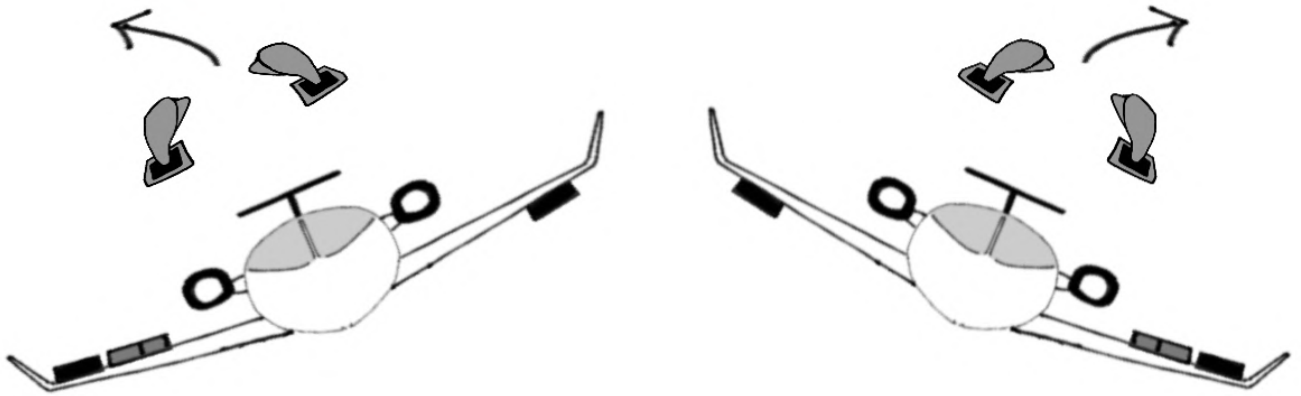


Six (6) spoiler panels - ONE (1) ACTUATOR EACH



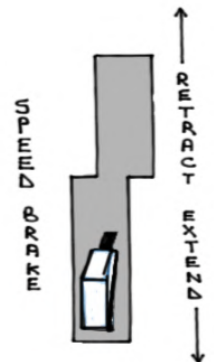
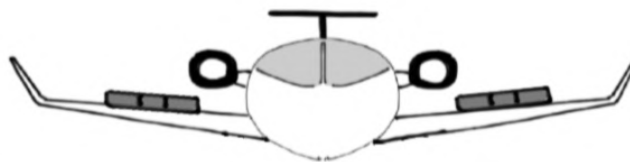


① Roll Augmentation – midboard and outboard panels  
up To  $55^\circ$



② Speed Brakes **in-flight**  
up To  $30^\circ$

Speed Brake Extended



③ Ground Spoilers **ON ground**

Flaps  $< 10^\circ$  :  $30^\circ$

Flaps  $\geq 10^\circ$  :  $55^\circ$



Do NOT EXTEND SPOILERS *in flight* with GEAR DOWN OR flaps 39°

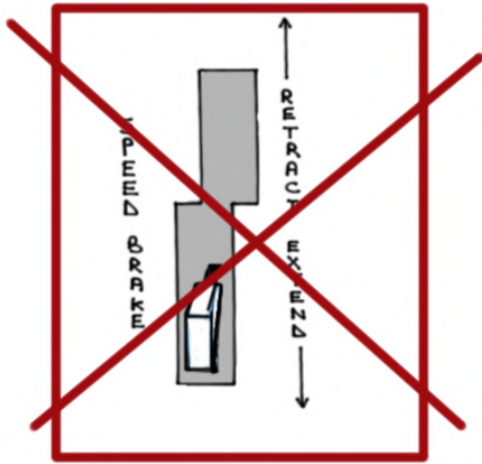
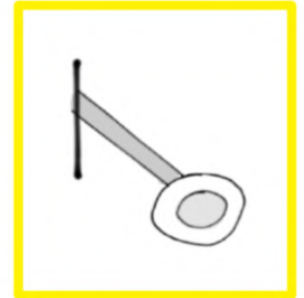
W

Landing Config

W



Prohibited



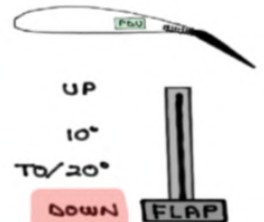
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Landing Config

W

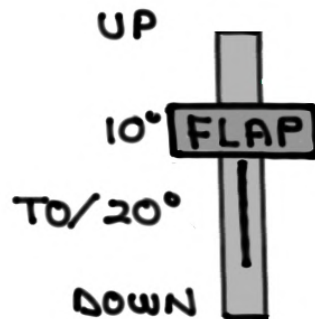


Flap 39

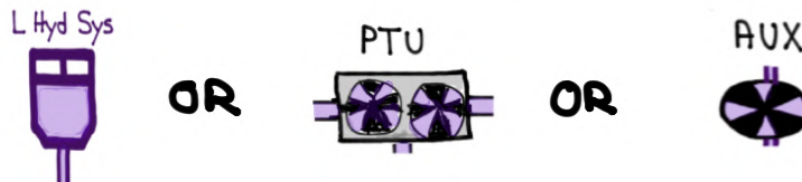


# FLAPS

- **ELECTRICALLY** - controlled by flap handle:



- **HYDRAULICALLY** - powered by:



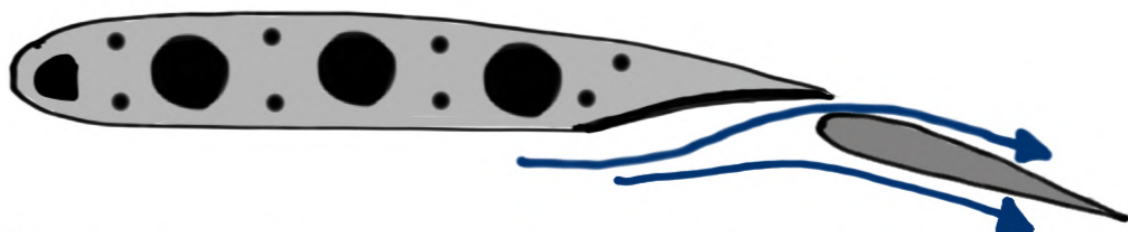
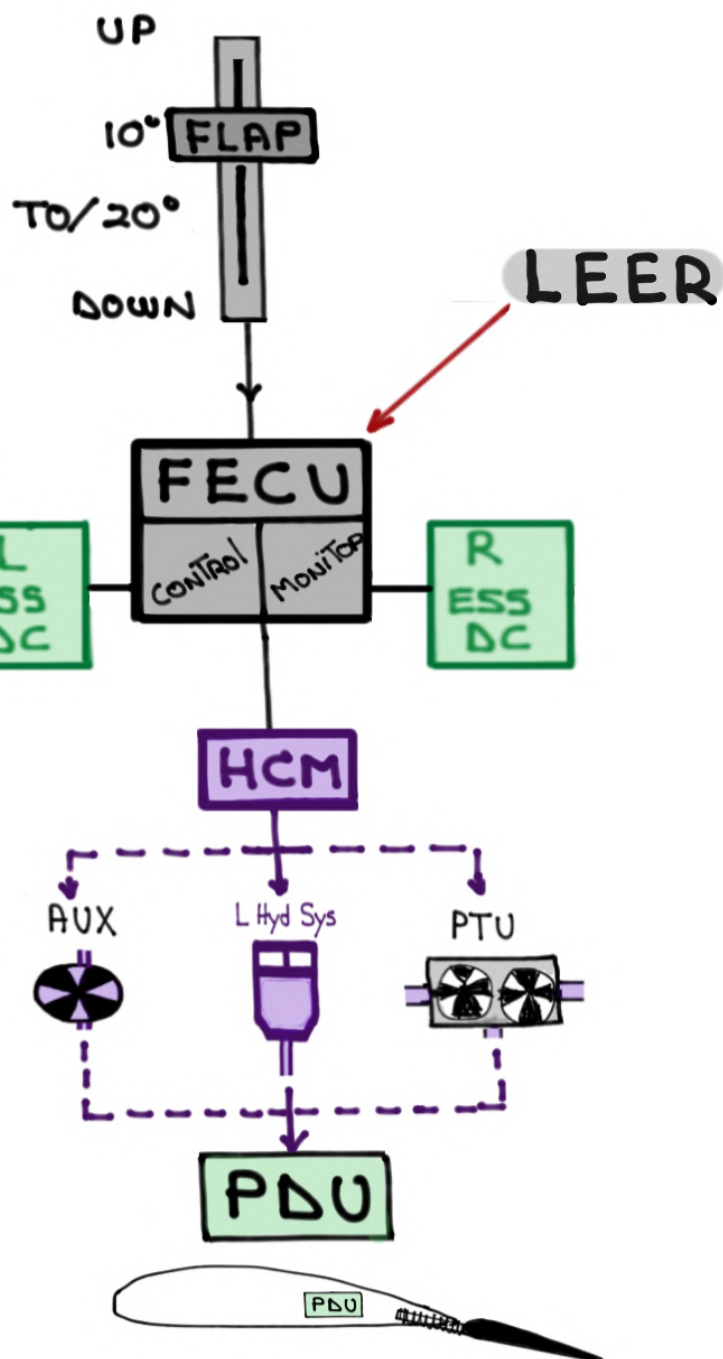
- **MECHANICALLY** - ACTUATED by:

- Flap ELECTRONIC CONTROL UNIT **FECU**  
IT COMMANDS flap MOVEMENT by ELECTRICALLY controlling:
- Hydraulic CONTROL Module **HCM**  
THE HCM CONTROLS HYDRAULIC power TO:
- POWER DRIVE UNIT **PDU**  
THE PDU DRIVES THE MECHANICAL ACTUATOR

ELECTRICALLY - CONTROLLED

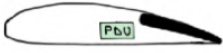
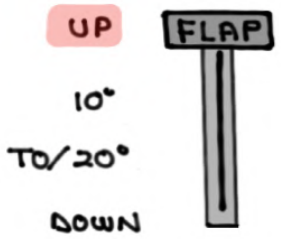
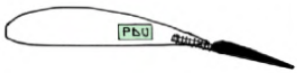
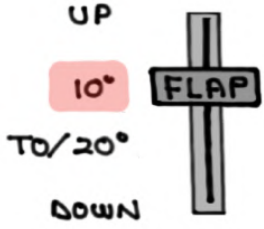

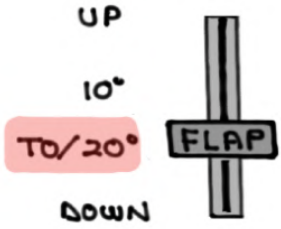
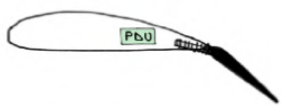
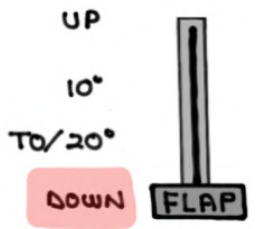
HYDRAULICALLY - POWERED

MECHANICALLY - ACTUATED

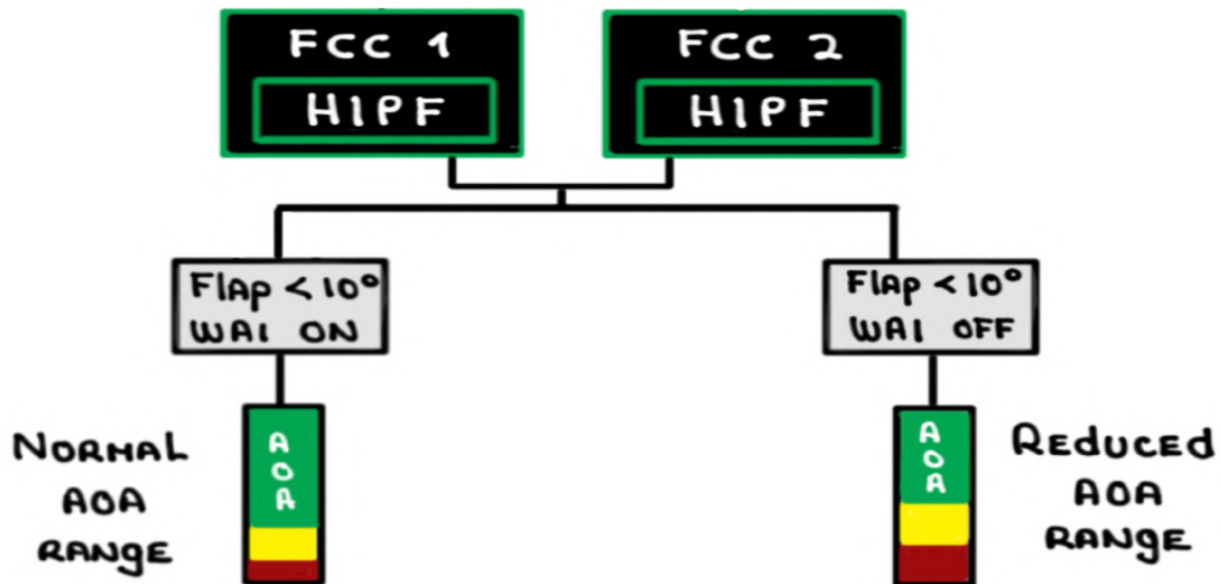


FOWLER-TYPE SINGLE FLAP SURFACE  
(GREATEST AMOUNT OF LIFT FOR LEAST AMOUNT OF DRAG)



Flap 0	Flap 10	Flap 20	Flap 39
 	 	 	 
MAXIMUM EXTENSION/EXTENDED SPEED			
VFE 250 KCAS	VFE 220 KCAS	VFE 180 KCAS	
MAXIMUM G-loads			
-1 To +2.5g	0 To +2g	0 To +2g	0 To +2g 0 To +1.5g (> MLW)
MAXIMUM OPERATING ALTITUDE			
≤ 25,000'	≤ 25,000'	≤ 20,000'	

# High Incidence Protection Function



- FCC STALL PROTECTION SOFTWARE
- If landing with  $< 10^\circ$  of flaps (zero flaps) it ASSUMES THE wing is CONTAMINATED AND ARTIFICIALLY INCREASES THE Flaps  $0^\circ$   $V_{REF}$
- IT ALSO LIMITS THE AVAILABLE AOA SO THAT EVEN WITH full aft CONTROL STICK THE MINIMUM STEADY SPEED IS NOT LESS THAN THE REFERENCE STALL SPEED ( $V_{SR}$ )

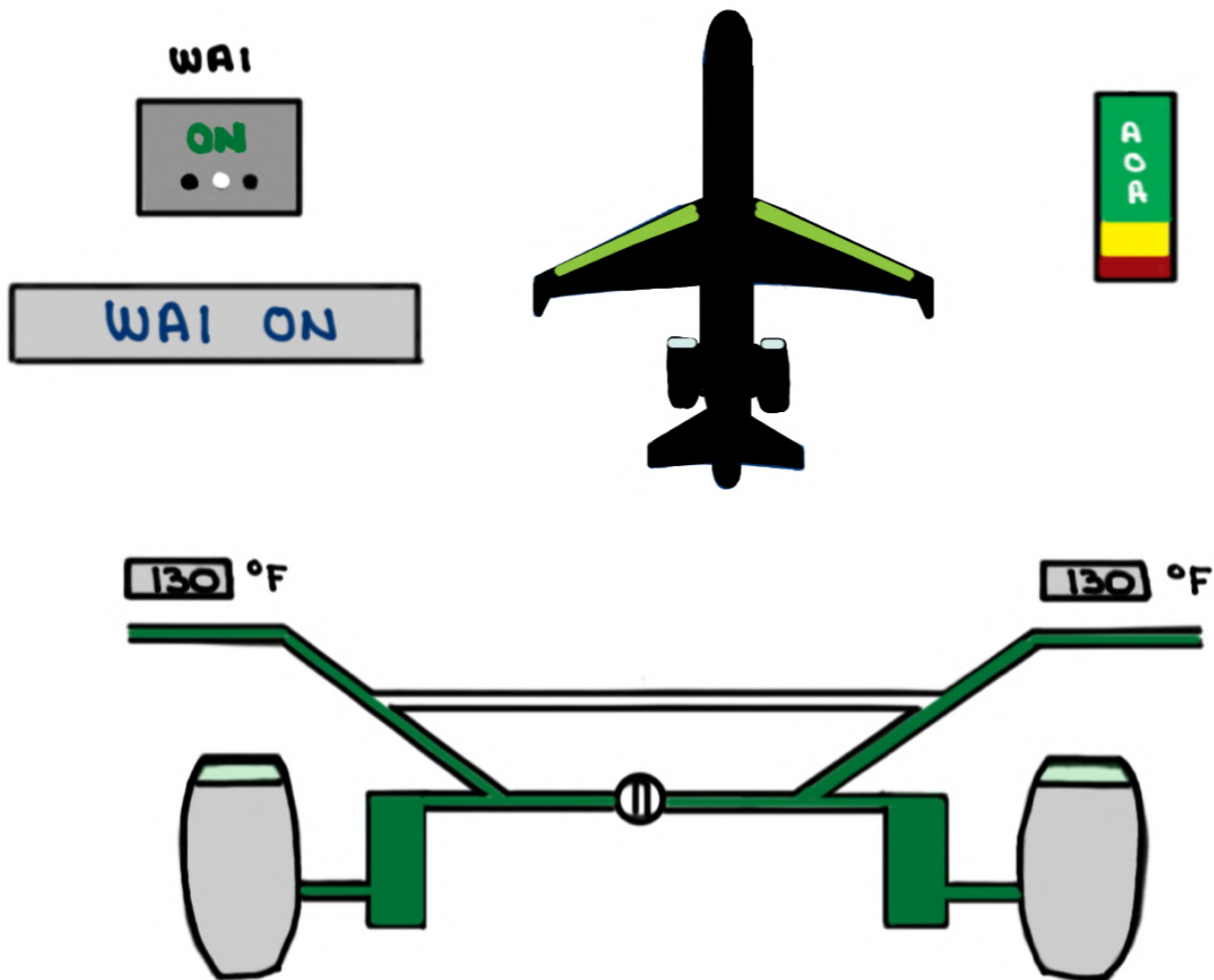
## Flaps Failed (U)



- Reduced usable AOA
  - PLI appears at a lower AOA
  - Stick Shaker activates at a lower AOA
  - Yellow and Red Speed Awareness Tapes appear at higher speeds
- Higher Approach and VREF speeds
- Slower engine response due to lower engine idle speed
- Longer landing distance required
- Hotter brake temperatures



SELECTING Wing ANTI-ICE ON RESETS THE FCS  
LAW logic FOR AOA PROTECTION back TO NORMAL



Wing TEMPERATURE MUST BE  $> 100^{\circ}\text{F}$  AND AIRCRAFT  
ALTITUDE  $> 1,500'$  AGL FOR THE CONTROL LAW logic  
TO CHANGE



# HORIZONTAL STABILIZER TRIM SYSTEM (HSTS)

- Fully TRIMMABLE HORIZONTAL STABILIZER CONTROL SURFACE
- Pitch TRIM is CONTROLLED by THE TRIM SWITCH ON EITHER ACTIVE CONTROL SIDESTICK OR PITCH TRIM SWITCH ON THE PEDESTAL
- INPUT FROM THESE SWITCHES IS TRANSMITTED TO:



- OUTPUT FROM THE FCCs IS TRANSMITTED TO THE 

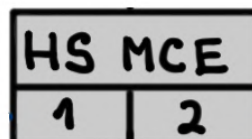
REU
-----
- STABILIZER SURFACE IS MOVED BY THE dual electric motor HORIZONTAL STABILIZER TRIM ACTUATOR (HSTA)



- THE 

HSTA	
A	B

 IS ELECTRICALLY-CONTROLLED FROM THE dual channel HORIZONTAL STABILIZER MCE



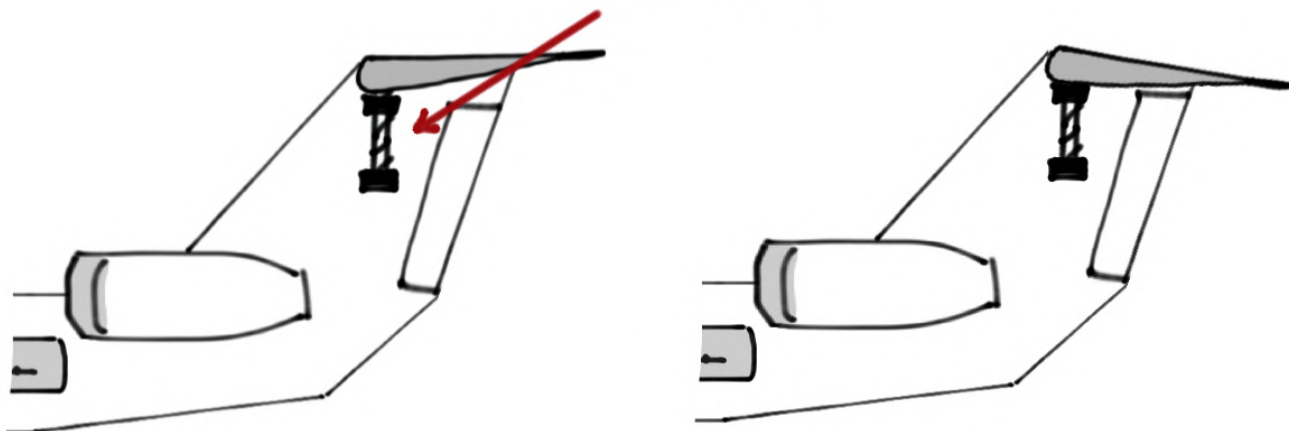
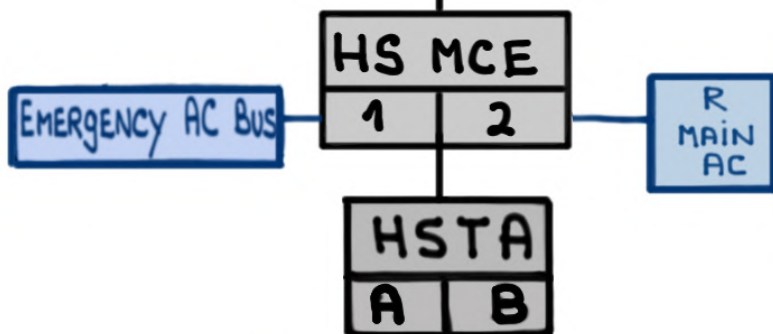
PRIMARY Pitch  
Trim switch

PRIMARY Pitch  
Trim switch

Pitch Trim  
NOSE DOWN

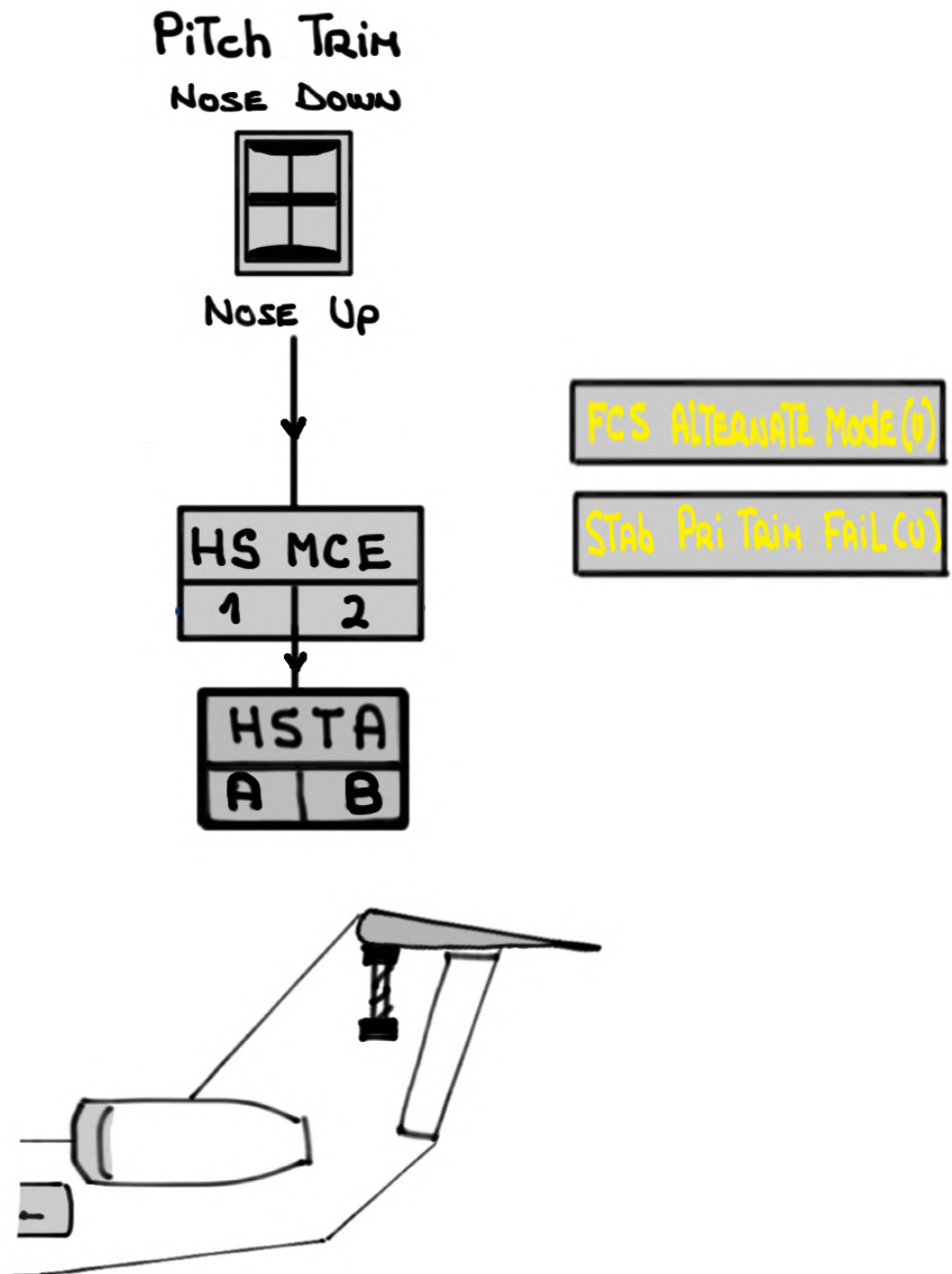


NOSE UP



IN THE EVENT of loss of communication from the FCCs the sidestick pitch trim switches won't be available.

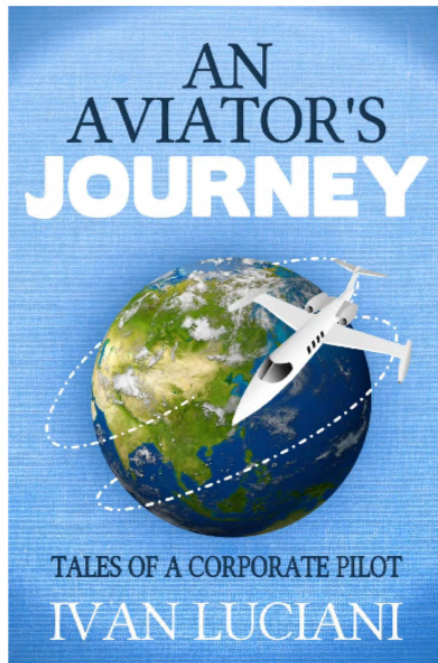
The pedestal switch bypasses the FCCs and signals the HS MCE. The stab moves at a constant rate



**REMINDER:** these system notes are intended for study purposes only. Always refer to official Gulfstream manuals and other approved references when operating your aircraft.

NOTE: these system notes are updated from time to time and what is posted on Code450.com will always be the most recent version.

Questions, comments or errors...please do send me an email:  
[ivan@code7700.com](mailto:ivan@code7700.com)



Thank you!