AIRBUS

A318/A319/A320/A321 Flight deck and systems briefing for pilots

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Issue 4- February 2007

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A318/A319/A320/A321 General

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A319

A318/A319/A320/A321 General

A320

A321

A318/A319/A320/A321 General

Dimensions

	A318-100	A319-100	A320-100	A320-200	A321-100
Span	34.10m 111ft 10in	34.10m 111ft 10in	33.91m 111ft 3in	34.10m 111ft 10in	34.10m 111ft 10in
Length	31.45m 103ft 2in	33.84m 111ft	37.57m 123ft 3in	37.57m 123ft 3in	44.51m 146ft
Height	12.56m 41ft 2in	11.76m 38ft 7in	11.76m 38ft 7in	11.76m 38ft 7in	11.81m 38ft 9in
Fuselage Diameter	3.95m 12ft 11in	3.95m 12ft 11in	3.95m 12ft 11in	3.95m 12ft 11in	3.95m 12ft 11in
Track	7.59m 24ft 11in	7.59m 24ft 11in	7.59m 24ft 11in	7.59m 24ft 11in	7.59m 24ft 11in
Max. pax	129	145	180	180	220
Max. FL	390	390	390	390	390

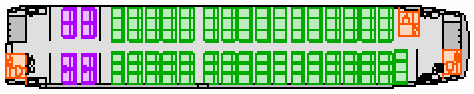
A318/A319/A320/A321 General

Typical Cabin Layout

A318

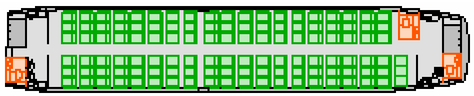
Two-class

107 seats



Single-class

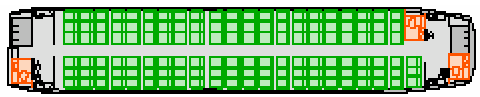
117 seats



Single-class

High density

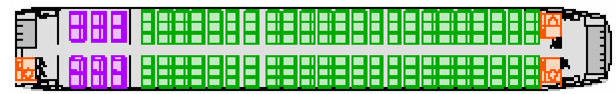
129 seats



A320

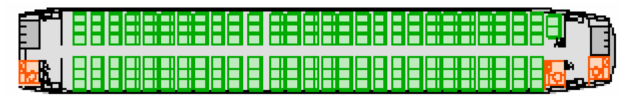
Two-class

150 seats



Single-class

164 seats

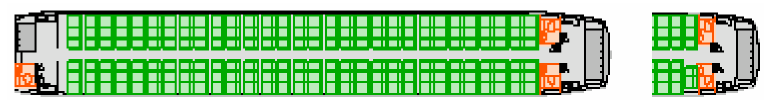


Single-class

High density

180 seats (JAA)

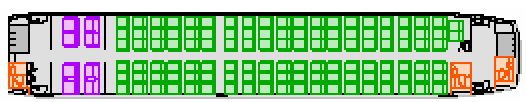
179 seats (FAA)



A319

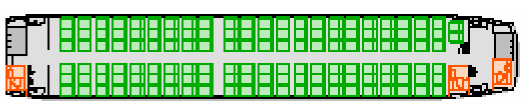
Two-class

124 seats



Single-class

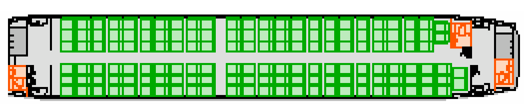
134 seats



Single-class

High density

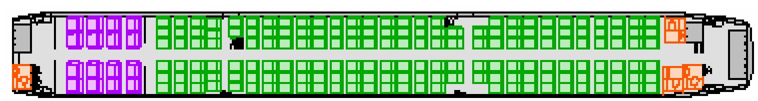
145 seats



A321

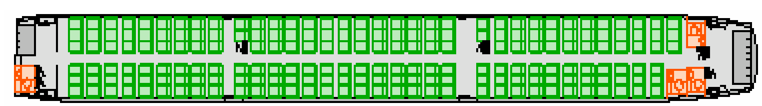
Two-class

185 seats



Single-class

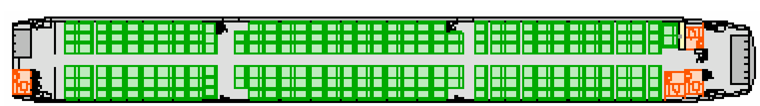
199 seats



Single-class

High density

220 seats



Design Weights – A318/A319/A320

Model	Engine		Maximum weights (kg)			Operation limits	
	Manuf.	Type	MTOW	MLW	MZFW	Mmo	Vmo
A318-111	CFM	CFM 56-5-B8	59 000 (options: from 61 500 up to 68 000)	56 000 (option: 57 500)	53 000 (option: 54 500)	0.82	350kt
A318-112	CFM	CFM 56-5-B9					
A318-121	PW	PW 6122					
A318-122	PW	PW 6124					
A319-111	CFM	CFM56-5-B5	64 000 (options: from 68 000 up to 78 000)	61 000 (options: 62 500 or 74 000)	57 000 (options: 58 500 or 70 500)		
A319-112	CFM	CFM56-5-B6					
A319-113	CFM	CFM56-5-A4					
A319-114	CFM	CFM56-5-A5					
A319-115	CFM	CFM56-5-B7					
A319-131	IAE	V2522-A5					
A319-132	IAE	V2524-A5					
A319-133	IAE	V2527-M-A5					
A319 Corporate Jet	CFM IAE	CFM56-5-B6/5-B7 V2524-A5/V2527-M-A5	75 500	62 500	58 500		
A320-111	CFM	CFM56-5-A1	68 000	63 000	59 000		
A320-211	CFM	CFM56-5A1/5-A3	73 500 (options: from 68 000 up to 77 000)	64 500 (option: 66 000)	61 000 (option: 60 500 or 62 500)		
A320-212	CFM	CFM56-5-A3					
A320-214 A320-231	CFM IAE	CFM56-5-B4 V2500-A1					
A320-232	IAE	V2527-A5					
A320-233	IAE	V2527E-A5					

Design Weights – A321

Model	Engine		Maximum weights (kg)			Operation limits	
	Manuf.	Type	MTOW	MLW	MZFW	Mmo	Vmo
A321-111	CFM	CFM56-5B1	83 000 (options: 78000 or 85 000)	73 500 (option: 74 500 or 75 000)	69 500 (option: 70 500 or 71 000)	0.82	350kt
A321-112	CFM	CFM56-5B2					
A321-131	IAE	V2530-A5					
A321-211	CFM	CFM56-5B3	89 000 (options: from 78 000 up to 93 000)	75 500 (option: 73 500 or 77 800)	71 500 (option: 69 500 or 73 800)		
A321-212	CFM	CFM56-5B1					
A321-213	CFM	CFM56-5-B2					
A321-231	IAE	V2533-A5					
A321-232	IAE	V2530-A5					

Aircraft Design Specifications

- **Design Speeds**

V_{MO} = 350 kt CAS
M_{MO} = 0.82
M_B = 0.76
V_D = 381 kt CAS
M_D = 0.89
V_{LO} (landing gear) extension = 250 kt
V_{LO} retraction = 220 kt
V_{LE} (Landing gear extended) = 280 kt

- **Slat and flap design speeds**

Lever position	Function	Config. No.	Placard speed V_{FE} kt (CAS)	
			A318/A319 A320	A321
0	Climb/cruise/holding	0	-	-
1	Holding	1	230	230
1	Take-off	1 + F	215	215
2	Take-off/approach	2	200	215
3	Take-off/approach Landing	3	185	195
Full	Landing	Full	177	190

- **Structural life (design aims)**

The objectives for primary structure fatigue life are as follows, based on average flight time of 1.25 hours:

- Structural endurance under normal operational conditions, allowing for repairs but not for the replacement of major structural components or the introduction of an uneconomic overall structural inspection . . . . . .48 000 flights
- Endurance of structurally significant items before the development of cracks detectable by detailed or special detailed inspections . . . . 24 000 flights
- Threshold for initial inspection . . . . 20 000 flights

- **Landing gear**

The design aim is 60 000 landings.
Endurance corresponding to safe life operation in accordance with FAR and JAR requirements.

- **Cabin pressure**

Max nominal operational differential pressure	556 mb ±7 mb	8.06 psi ± 0.1 psi
Safety valve setting pressure	593 mb ± 7 mb	8.60 psi ± 0.1 psi
Max relief valve overpressure	621 mb	9 psi
Max negative differential pressure	- 70 mb	-1.00 psi

A318/A319/A320/A321 General

Aircraft Design Specifications

- **Fuel capacity (litres)**

A318/A319/A320
Total wing fuel = 15609
Center tank fuel = 8250
Total aircraft fuel = 23859

A321
Total wing fuel = 15500
Center tank fuel = 8200
Total aircraft fuel = 23700

- **Pavement strength**

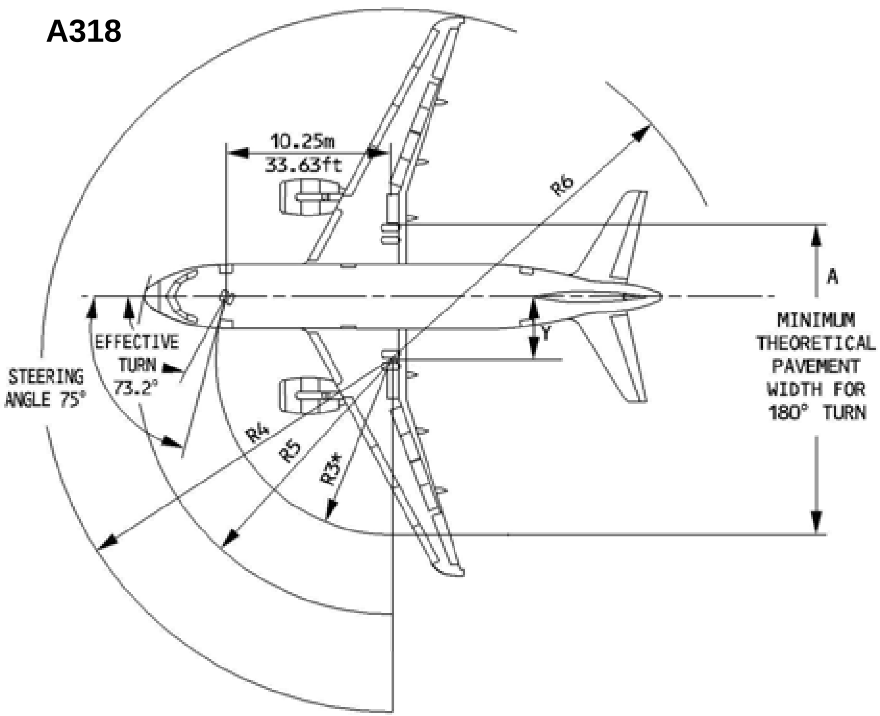
Max ramp weight and max aft CG

	ACN							
	Flexible pavement				Rigid pavement			
	Cat A	Cat B	Cat C	Cat D	Cat A	Cat B	Cat C	Cat D
A318	28	29	32	37	30	32	34	36
A319	32	33	36	42	35	37	39	41
A320	39	40	44	50	44	46	48	50
A321-100	45	48	53	59	51	54	57	59
A321-200	49	52	58	63	56	59	62	64

Ground Maneuvre Capability

Minimum turning radius

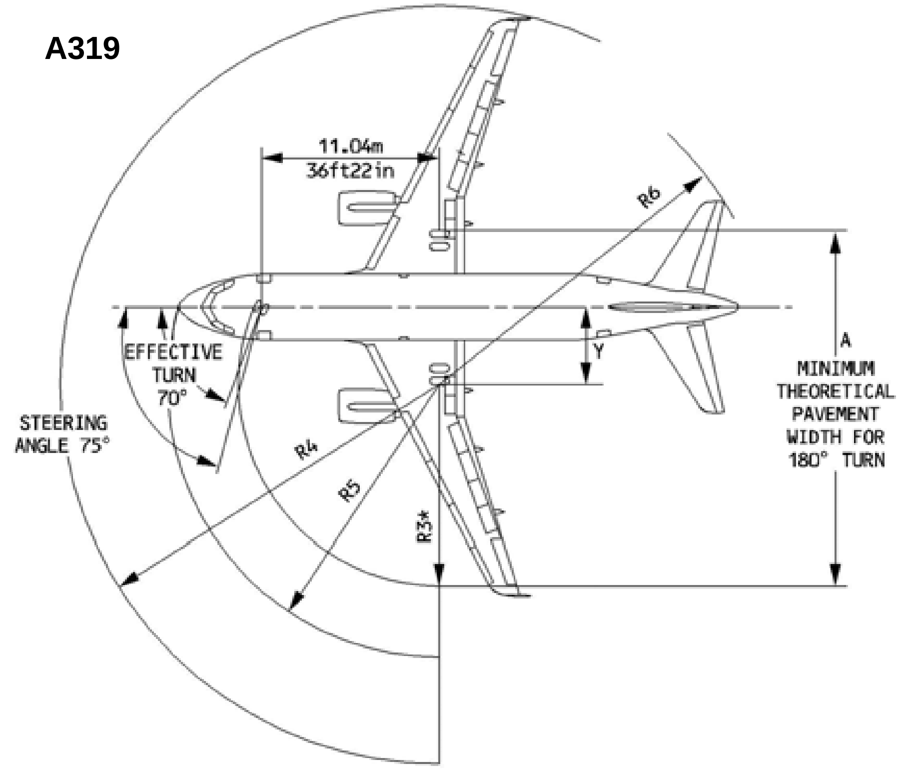
A318



	Y	A	R3	R4	R5	R6
FT	10.17	61.35	36.42	67.59	51.18	58.73
M	3.10	18.70	11.10	20.60	15.60	17.90

* NOSE GEAR RADIUS (R3) MEASURED FROM OUTSIDE FACE OF TIRE

A319

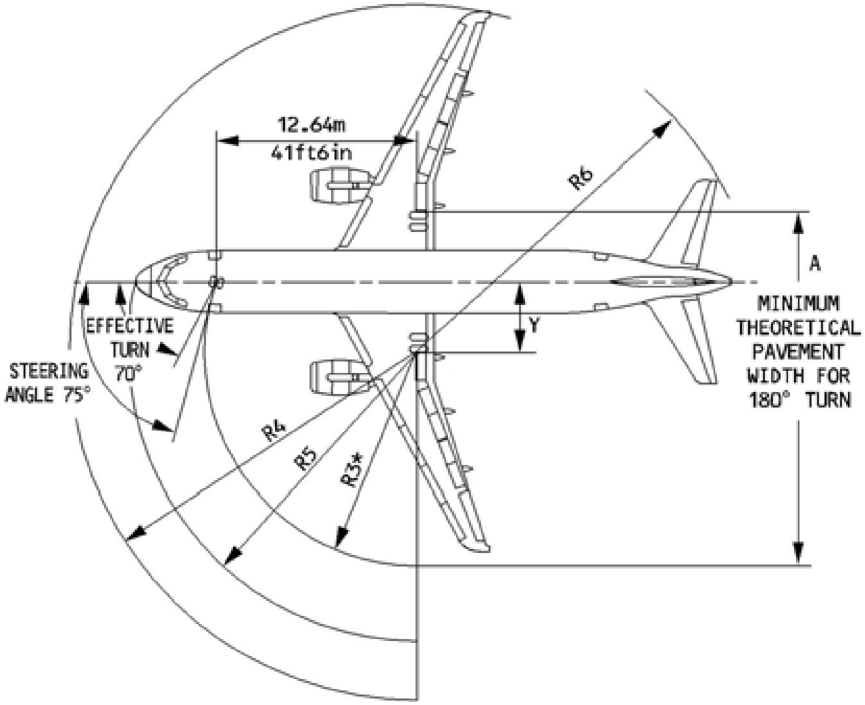


	Y	A	R3	R4	R5	R6
FT	13ft2in	67ft9in	39ft9in	70ft10in	54ft6in	64ft10in
M	4.01	20.64	12.11	21.58	16.6	19.77

* NOSE GEAR RADIUS (R3) MEASURED FROM OUTSIDE FACE OF TIRE

Ground Maneuvre Capability

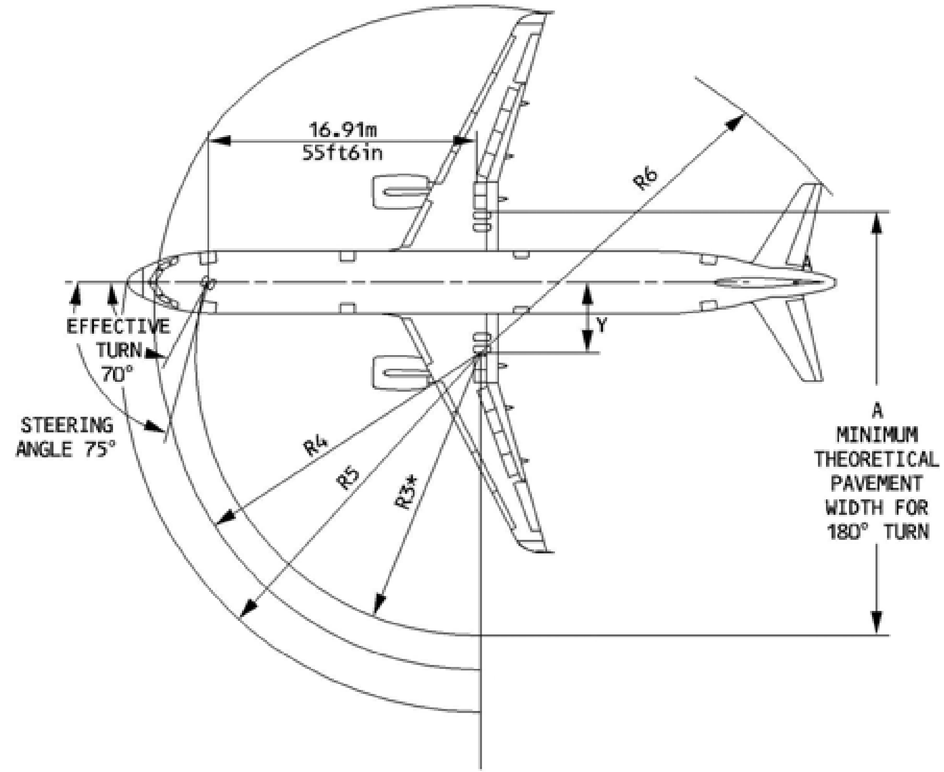
A320



	Y	A	R3	R4	R5	R6
FT	15ft1in	75ft2in	45ft4in	72ft2in	60ft	71ft11in
M	4.60	22.90	13.81	21.99	18.30	21.91

* NOSE GEAR RADIUS (R3) MEASURED FROM OUTSIDE FACE OF TIRE

A321



	Y	A	R3	R4	R5	R6
FT	16ft9in	90ft7in	59ft1in	74ft6in	74ft2in	80ft5in
M	5.1	27.6	18	22.7	22.6	24.5

* NOSE GEAR RADIUS (R3) MEASURED FROM OUTSIDE FACE OF TIRE

Ground Maneuvre Capability

Towing

The A318/A319/A320/A321 can be towed or pushed up to a nosewheel angle of 95° from the aircraft center line at all weights up to maximum ramp weight (MRW) without disconnecting the steering.

Taxiing

Minimum turning radii (with tire slip) and minimum pavement width for 180° turn are as illustrated on the precedent pages

A318/A319/A320/A321 Introduction

The A318/A319/A320/A321 are narrow body, twin-engined, short / medium-range aircraft, the A318 being a shortened version of the A319, the A319 being the shortened version of the A320, and the A321 being the stretched version of the A320.

They both offer an increased fuselage cross-section leading to an increased revenue potential through:

- Greater passenger comfort with wider seats and aisle
- Greater overhead baggage volume
- Greater cargo capacity
- Wide-body compatible container capability
- Quicker turnrounds.

Advanced technology applied to aerodynamics, structure, systems and powerplant offer reduced costs through:

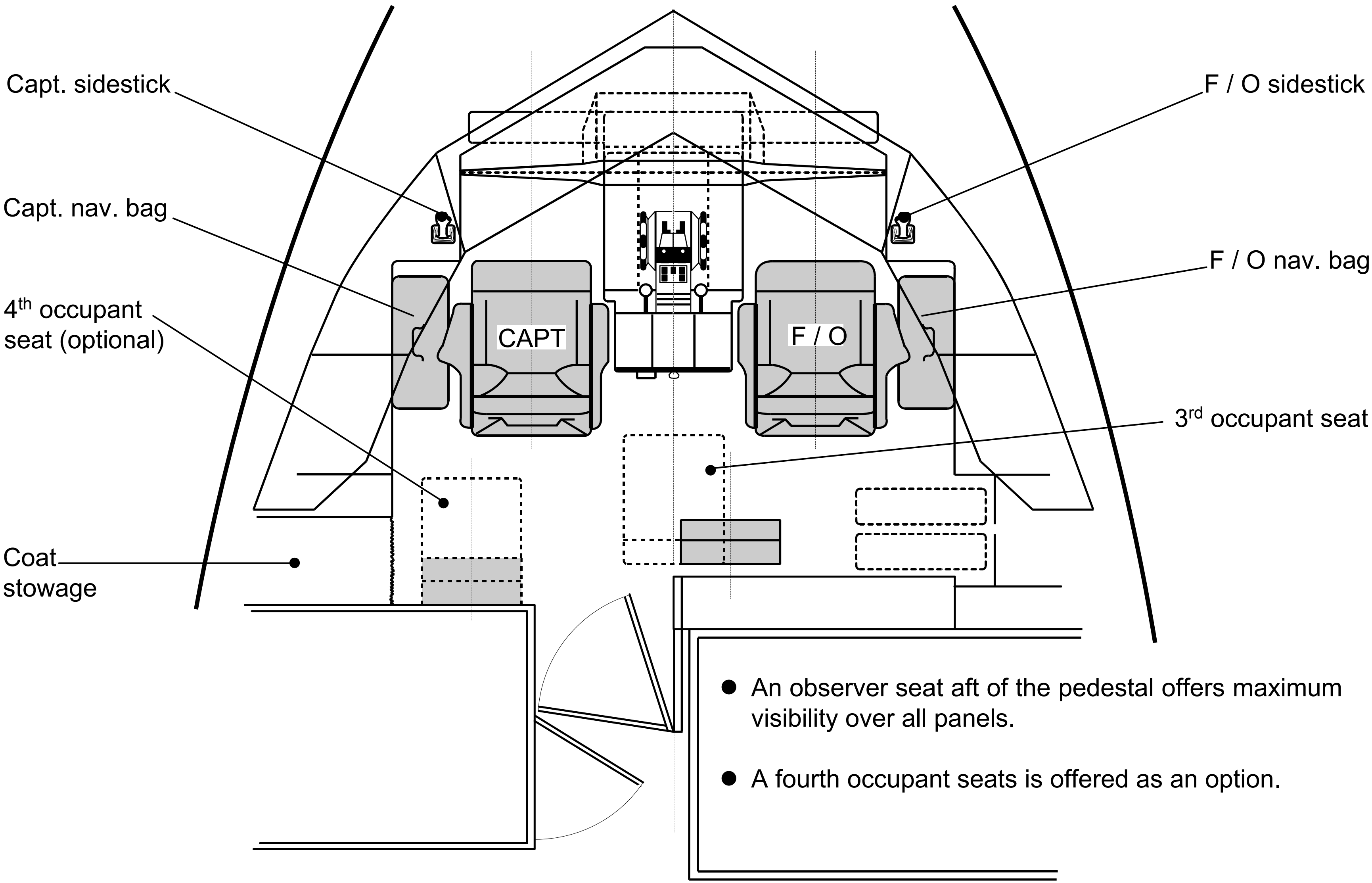
- Unmatched fuel efficiency
- More accurate flight path control
- Reduced maintenance costs
- Increased reliability
- Reduced trouble-shooting time.

Introduced for airline service in March 1988, the A320 represents the largest single advance in civil aircraft technology since the introduction of the jet engine and results in a major stride forward in airline profitability.

A computer-managed system gives complete protection against excursions outside the normal flight envelope and greatly improves the man / machine interface.

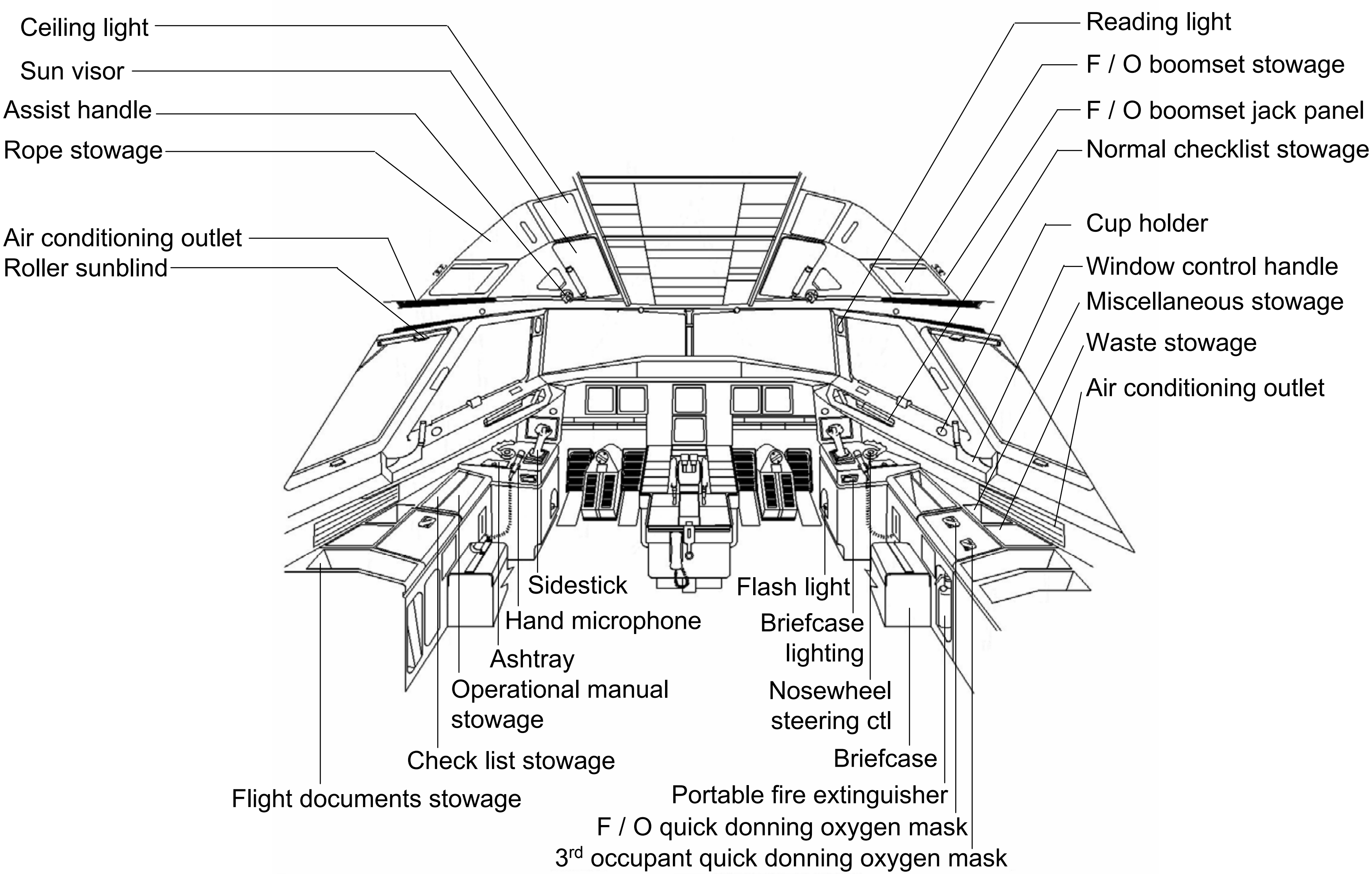
2. Flight Deck Layout

A318/A319/A320/A321 Flight Deck – Plan View



- An observer seat aft of the pedestal offers maximum visibility over all panels.
- A fourth occupant seats is offered as an option.

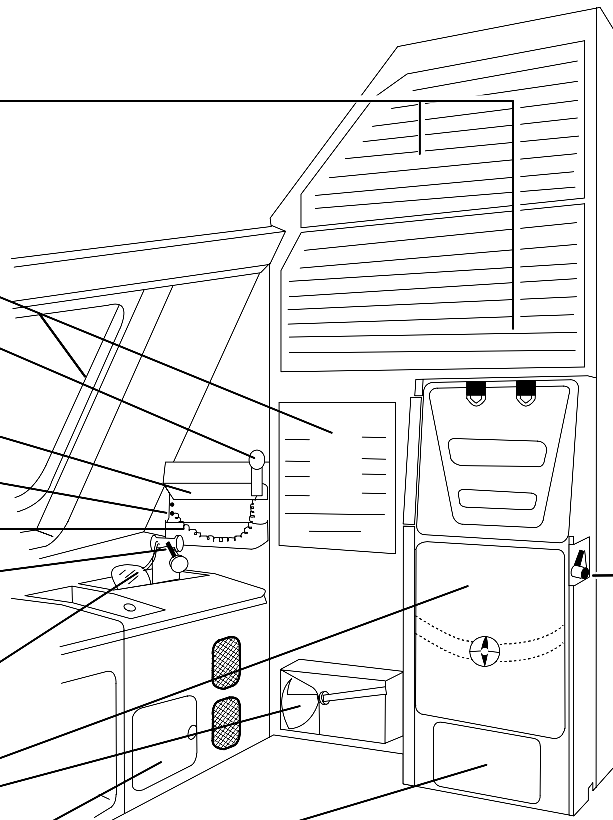
Forward View



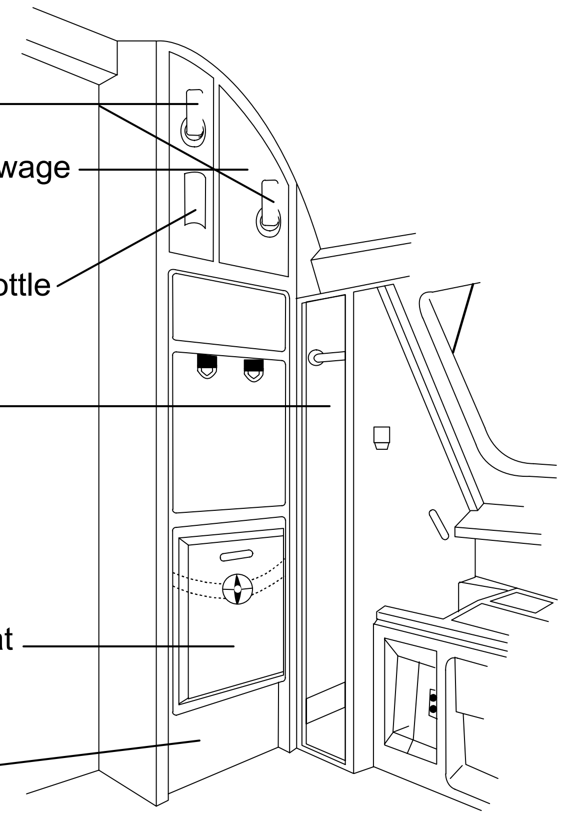
A318/A319/A320/A321 Flight Deck Layout – General Arrangement

Rear View

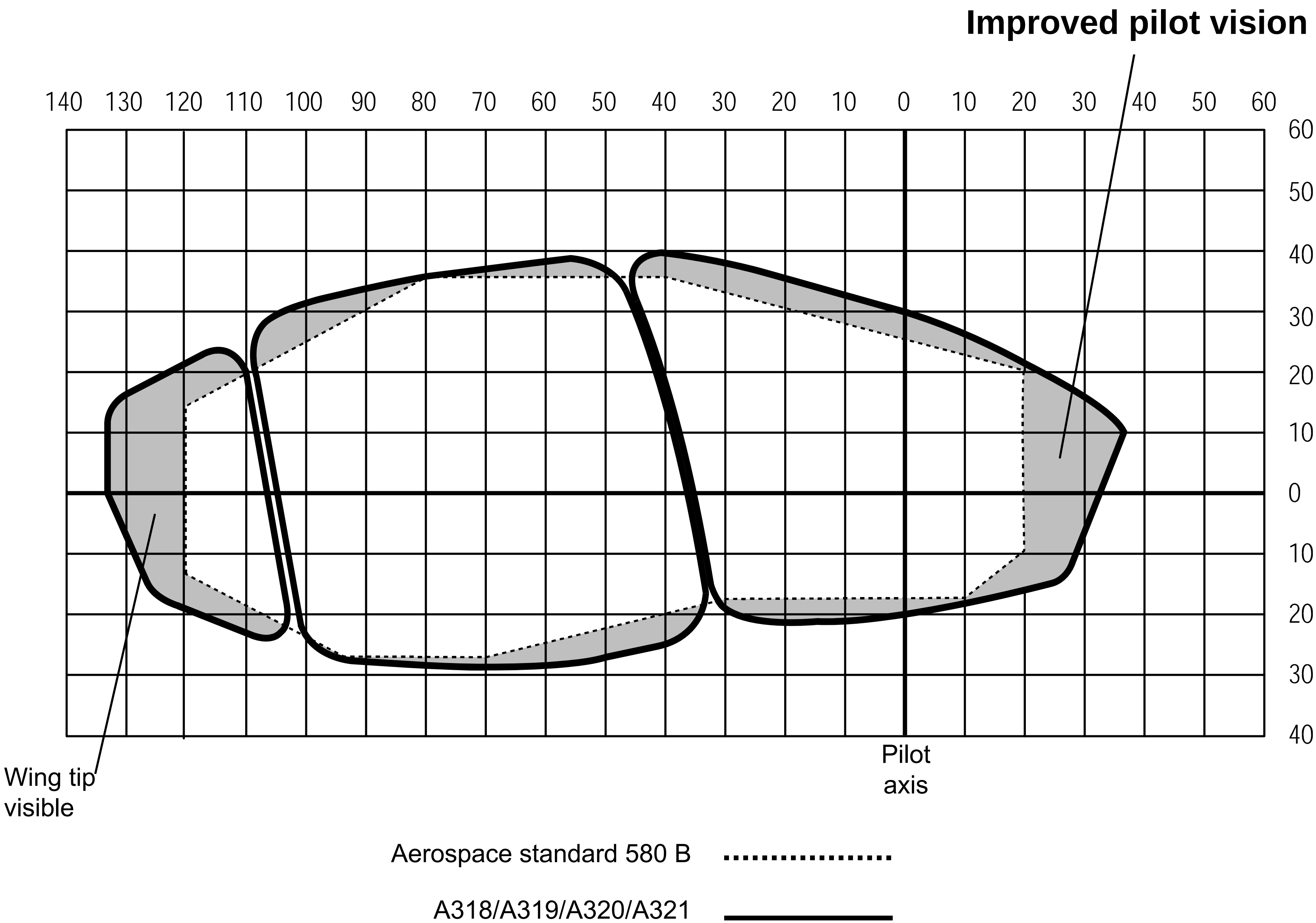
Right corner



Left corner



A318/A319/A320/A321 Flight Deck – Pilot's Field of View



Visibility

- Windows are designed to meet or exceed the Aerospace standard 580 B.

  Geometry :

  - Windshield panels : Flat glass
  - Lateral windows : Curved acrylic.

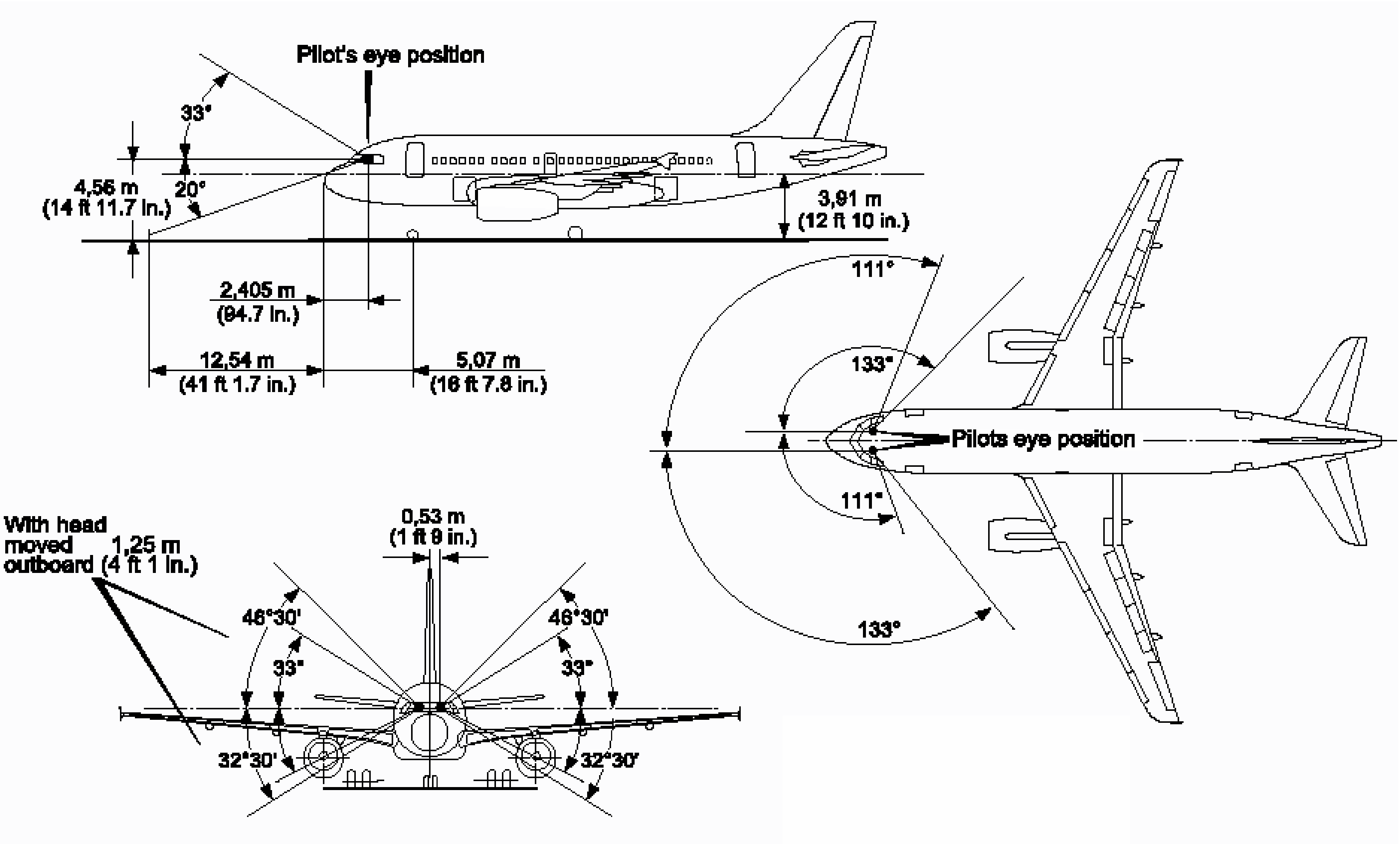
- Clear surface of each window :

Windshield panel	0.52m^2 each
Lateral sliding window	0.36m^2 each
Lateral rear window	0.30m^2 each
Flight deck total	2.36m^2

- This geometry improves external aircraft monitoring, thereby increasing safety standards:

  - Downward visibility in the pilot axis is 20°
  - Wing tips visible from respective pilot stations.

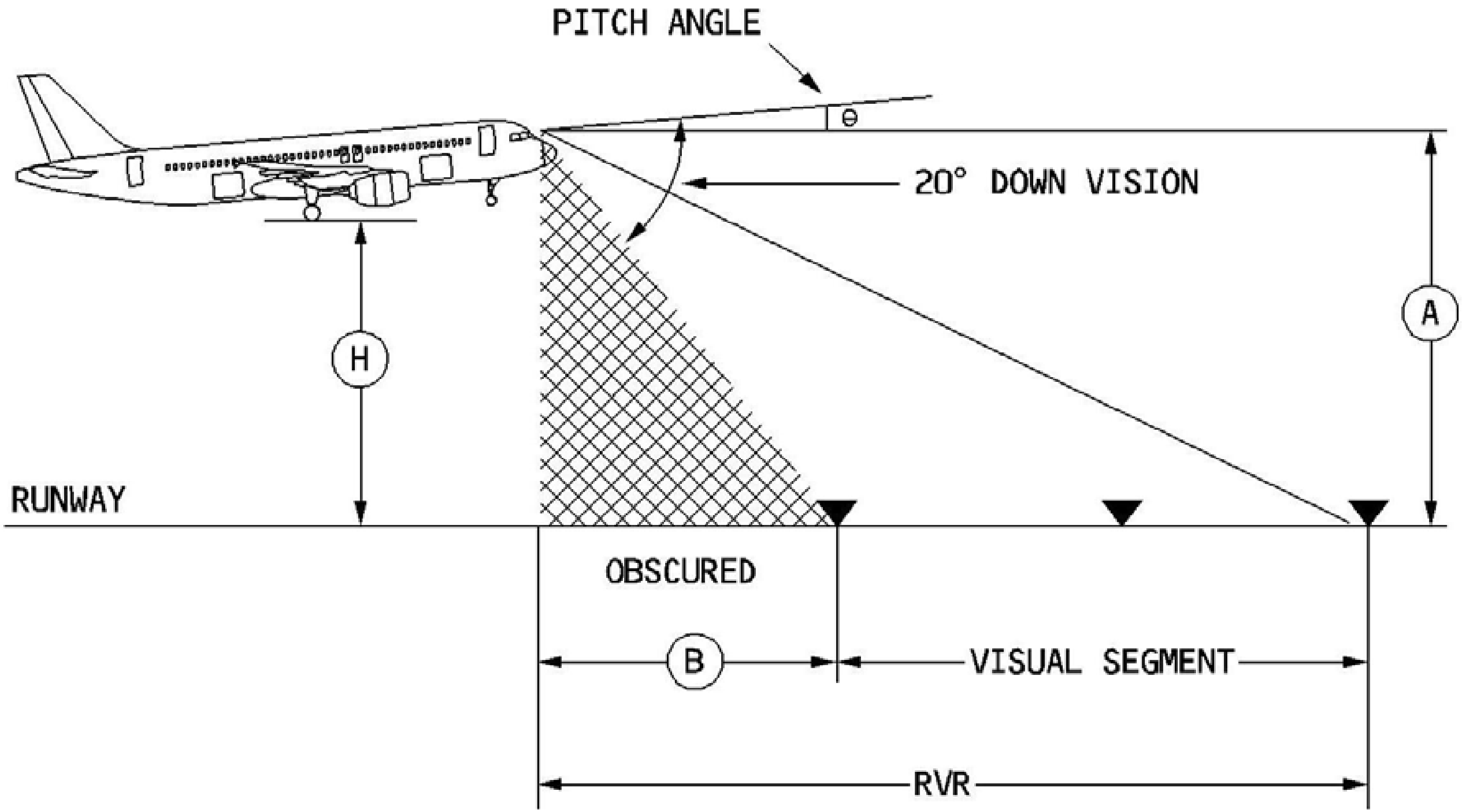
A318/A319/A320/A321 Flight Deck – Pilot's Field of View



* All values are available for the entire A320 family

A318/A319/A320/A321 Flight Deck – Pilot's Field of View

Landing Configuration



Landing Configuration

A318	CAT III		CAT II
H	15 ft (θ = 4.6°)	50 ft (θ = 3.7°)	100 ft (θ = 3.7°)
VISUAL SEGMENT	60 m (197 ft)		120 m (394 ft)
A	33 ft	68 ft	118 ft
OBSCURED B	37 m (121 ft)	71 m (232 ft)	123 m (403 ft)
MINIMUM RVR	97 m (318 ft)	131 m (429 ft)	183 m (797 ft)

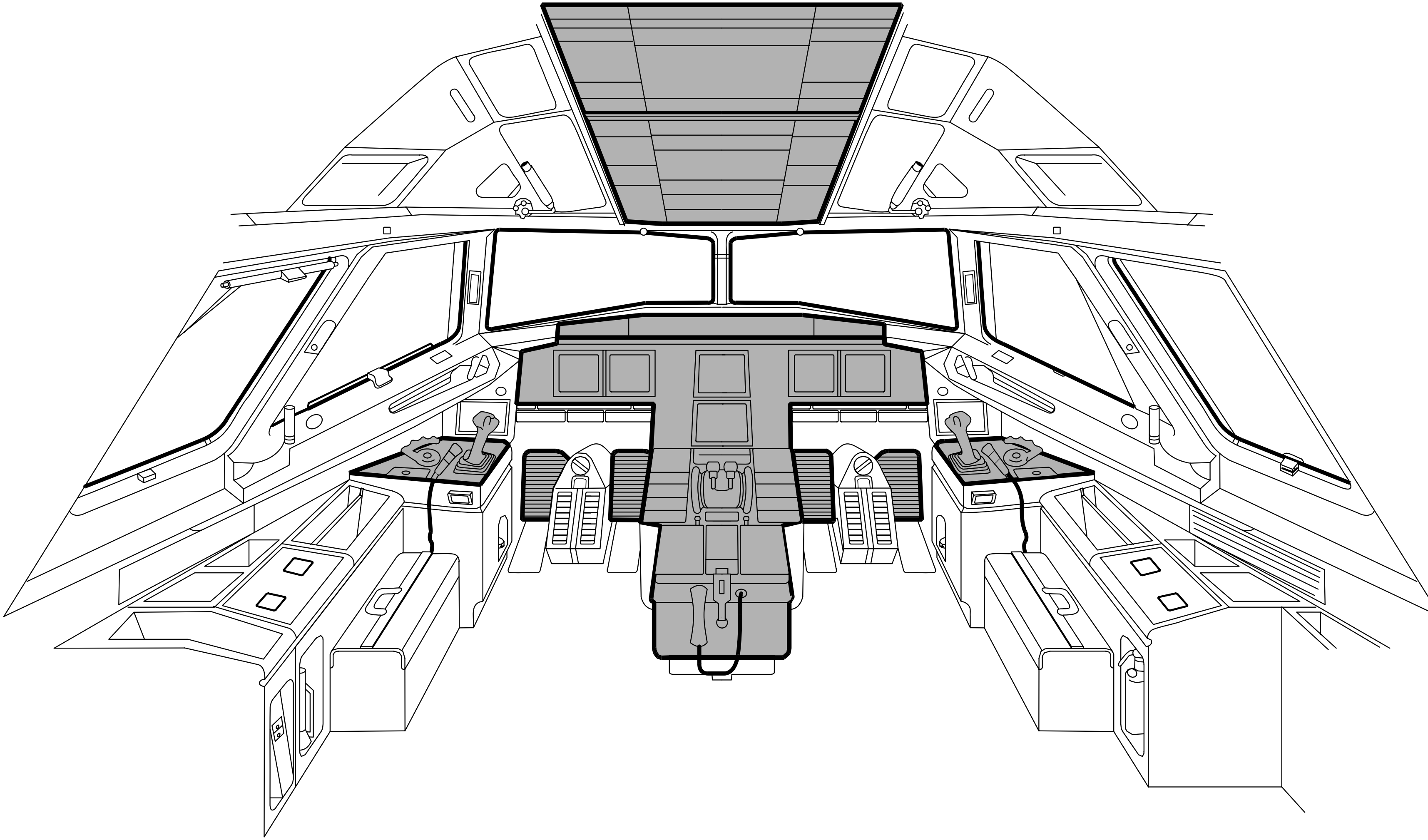
A319	CAT III		CAT II
H	15 ft (θ = 4.9°)	50 ft (θ = 5.3°)	100 ft (θ = 5.3°)
VISUAL SEGMENT	60 m (197 ft)		120 m (394 ft)
A	35 ft	71 ft	121 ft
OBSCURED B	40 m (131 ft)	82 m (269 ft)	140 m (460 ft)
MINIMUM RVR	100 m (328 ft)	142 m (466 ft)	260 m (854 ft)

A320	CAT III		CAT II
H	15 ft (θ = 5.4°)	50 ft (θ = 4.7°)	100 ft (θ = 4.7°)
VISUAL SEGMENT	60 m (197 ft)		120 m (394 ft)
A	36 ft	71 ft	121 ft
OBSCURED B	43 m (140 ft)	79 m (259 ft)	134 m (442 ft)
MINIMUM RVR	103 m (337 ft)	139 m (456 ft)	254 m (836 ft)

A321	CAT III		CAT II
H	15 ft (θ = 4.5°)	50 ft (θ = 4.1)	100 ft (θ = 4.1°)
VISUAL SEGMENT	60 m (197 ft)		120 m (394 ft)
A	36 ft	71 ft	121 ft
OBSCURED B	40 m (132 ft)	76 m (249 ft)	130 m (425 ft)
MINIMUM RVR	100 m (329 ft)	136 m (446 ft)	250 m (819 ft)

A318/A319/A320/A321 Flight Deck – Main Features

Control and indication panels in bold outline



A318/A319/A320/A321 Flight Deck – Main Features

- The main features :

  - Sidestick controllers which leave the main instrument panel unobstructed

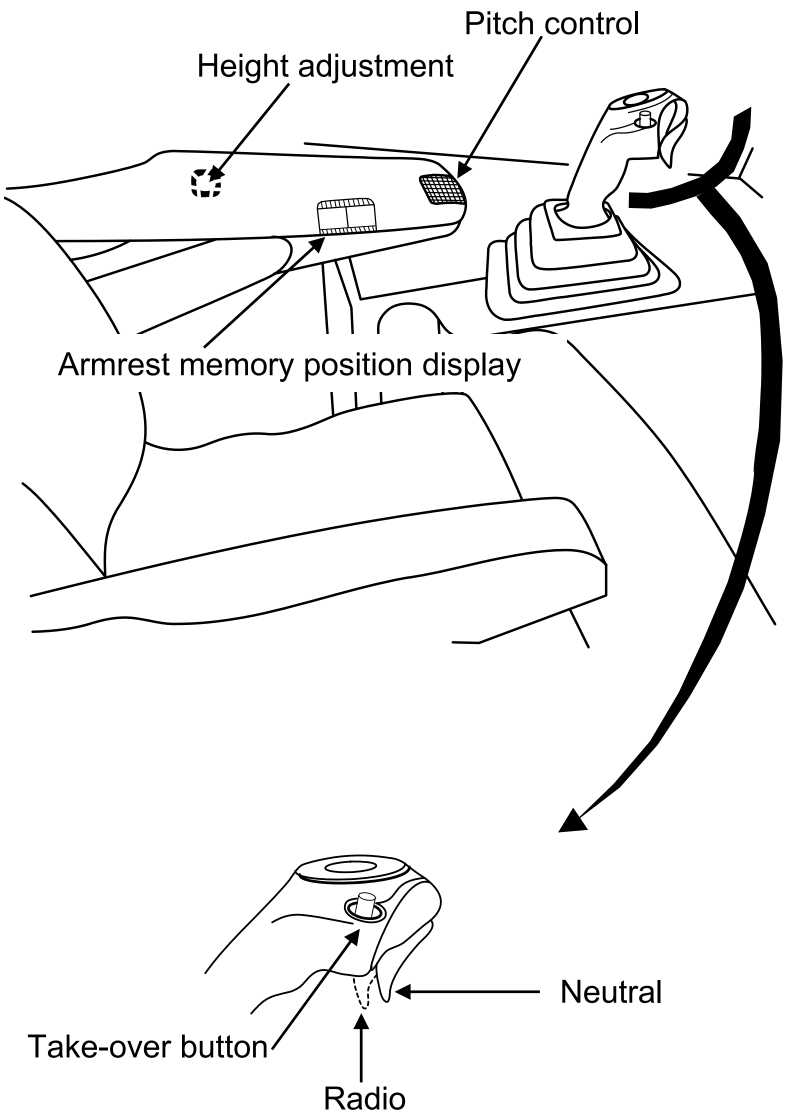
  - Six display units **(DU)** interchangeable, switchable and integrated into the same system architecture (EFIS / ECAM)

- The other features evolve directly from the concepts introduced with the A300 / A310 family:

  - Ergonomic layout of panels, synoptically arranged according to frequency of use (normal, abnormal, emergency) within easy reach and visibility for both crewmembers
  - Philosophy of panels (e.g., “lights out” philosophy for overhead panel)
  - Principles of presentation on information (“need to know” concept)
  - Monitoring of systems through an Electronic Centralized Aircraft Monitor (ECAM)
  - Coherent system of colour coding for EFIS, ECAM and panel lights.

A318/A319/A320/A321 Flight Deck – Sidestick Arrangement

- Sidesticks are installed on the CAPT and F / O forward lateral consoles.
- An **adjustable armrest** to facilitate free wrist movement is fitted on each seat.
- The sidestick works against a spring force proportional to the angular displacement.
- Sidestick includes :
  - Radio communication trigger
  - A take-over button for autopilot disconnection and priority take-over.

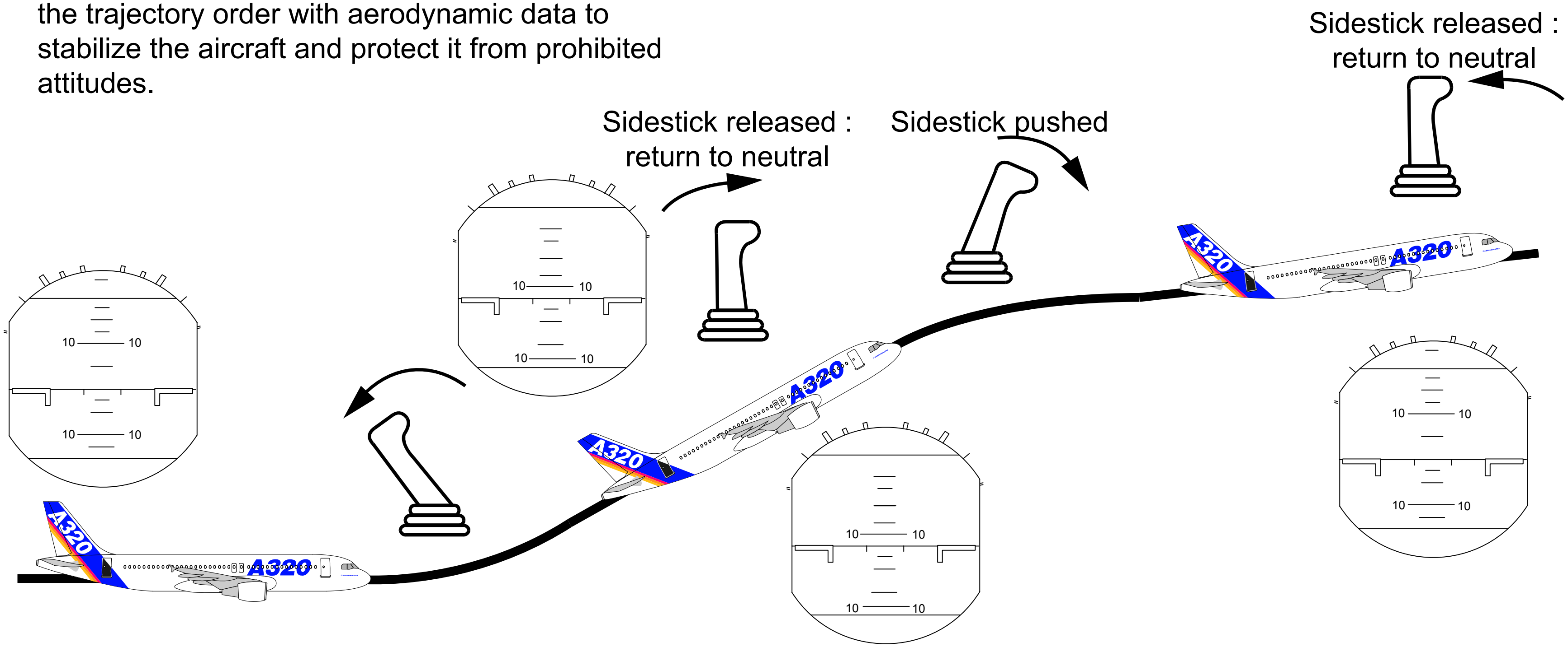


A318/A319/A320/A321 Flight Deck – Sidestick Operation

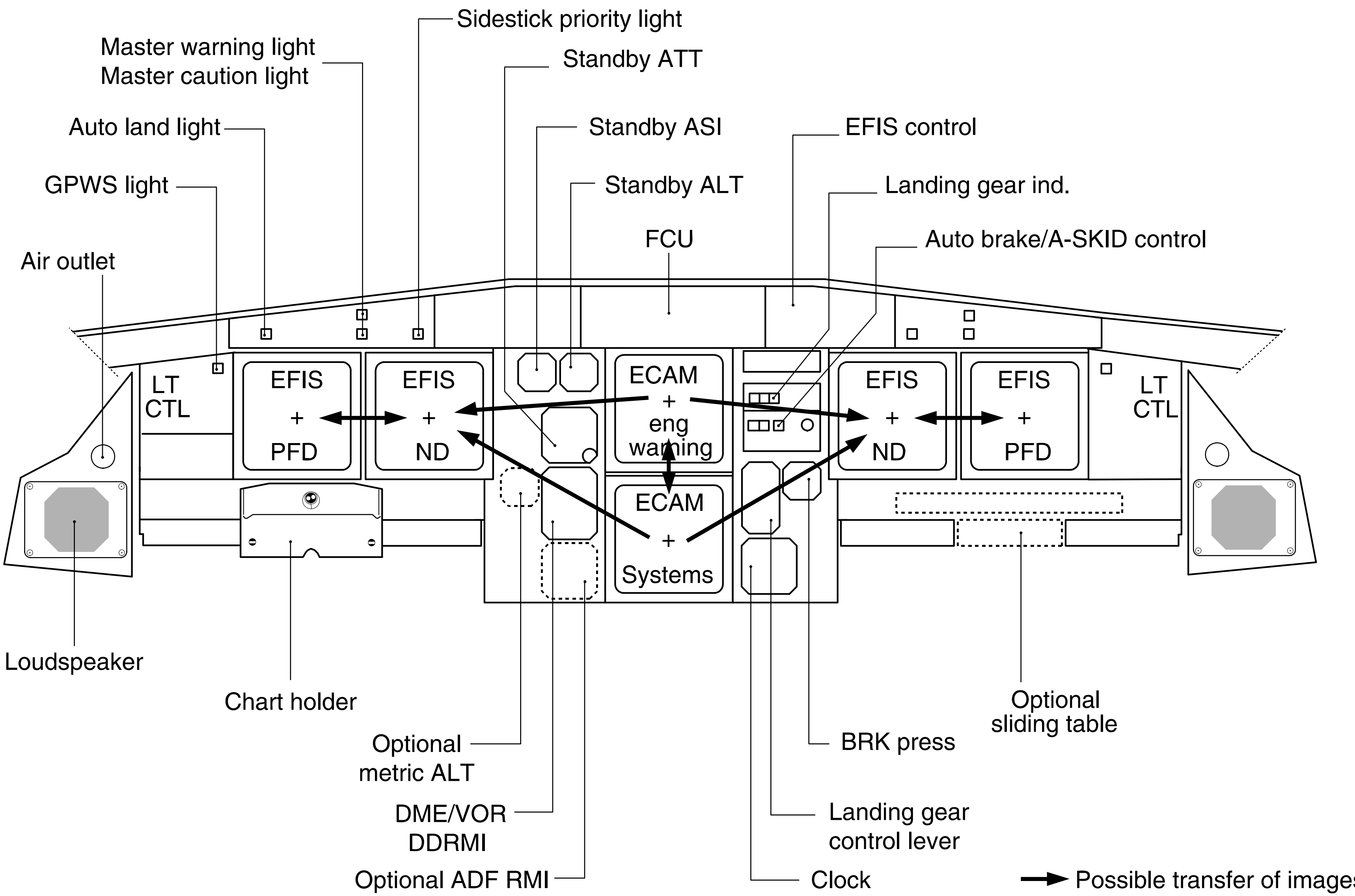
- Moving the sidestick results in “setting the aircraft trajectory” with a certain level of “g” for the requested manoeuvre depending on the amount of sidestick movement.

- Movement is very precise since back lash and friction are negligible.

- Control of the flight path is performed by the Electronic Flight Control System **(EFCS)** which links the trajectory order with aerodynamic data to stabilize the aircraft and protect it from prohibited attitudes.



A318/A319/A320/A321 Flight Deck – Main Instruments Panels



- The CAPT and F / O panels are mirror image of each other ; both incorporate two side-by-side Display Units **(DU's)** :

  - A Primary Flight Display **(PFD)**
  - A Navigation Display **(ND)**.

- This arrangement facilitates:

  - A better visibility on all DUs in normal configuration and in case of reconfiguration (PFD ND or ECAM ND)
  - The possibility to install a sliding table (option) and a footrest in front of each pilot.

- **Primary Flight Display** includes the complete Basic T with:

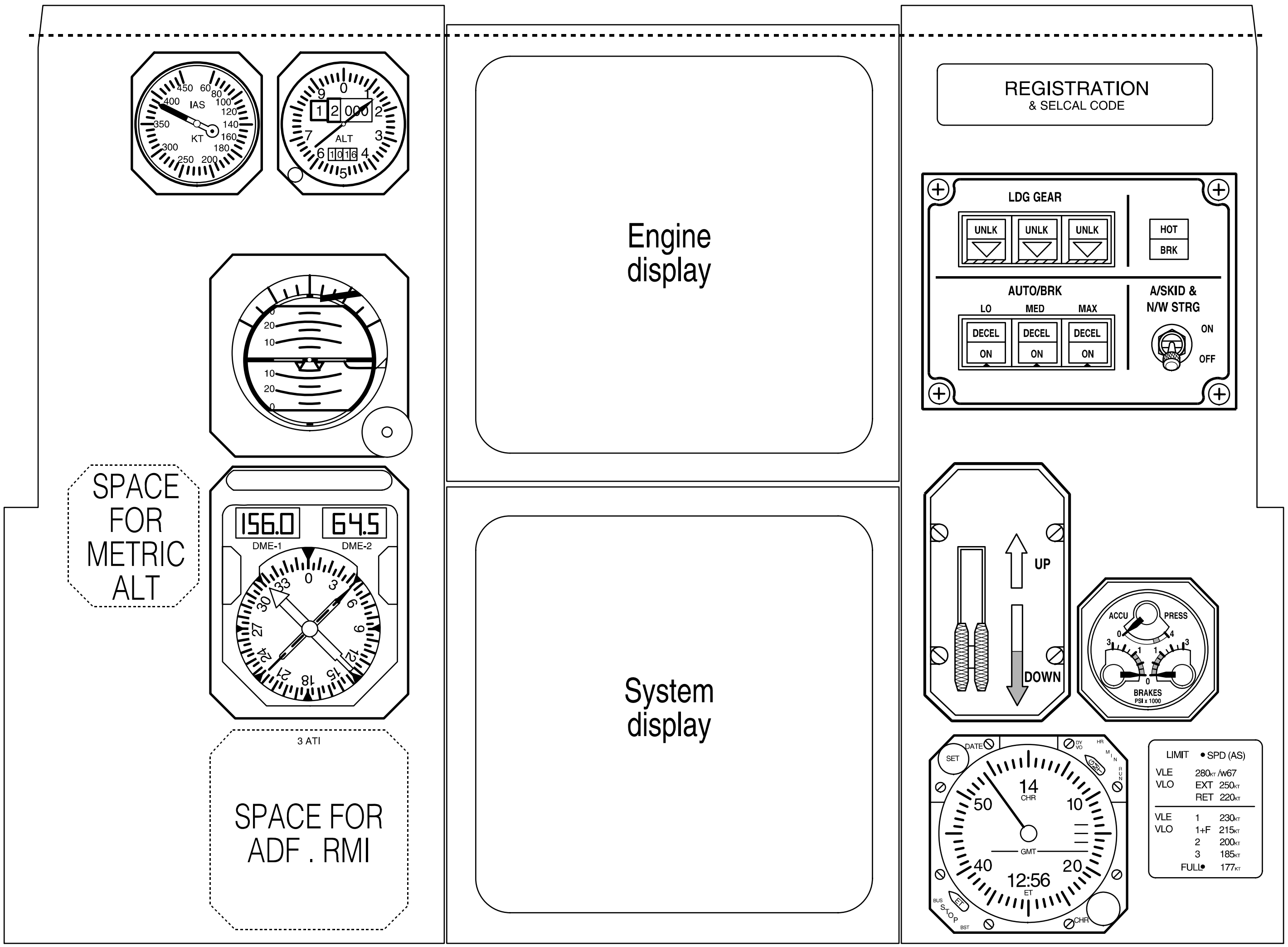
  - Attitude
  - Airspeed / Mach (with all upper ad lower limits)
  - Altitude / vertical speed
  - Heading
  - AFS status
  - ILS deviation / maker
  - Radio altitude

- **Navigation Display** offers three modes:

  - **ROSE** mode (ILS, VOR or NAV): heading up, aircraft symbol in screen center, with radar available,
  - **ARC** mode: heading up, horizon limited to a 90° forward sector, with radar available,
  - **PLAN** mode: north up, display centered on selected waypoint.

Note : In ROSE-NAV, ARC, and PLAN modes, MAP data from FMS is presented.

A318/A319/A320/A321 Flight Deck – Centre Panel



The centre panel groups:

- Two DUs, one above the other, same size and interchangeable with the CAPT and F / O DUs :

- **Engine Display** (DU 1), showing:

  - The main engine parameters : N1, EGT; N2 (CFM) or EPR, EGT, N1, N2 (IAE)
  - Thrust limit and command
  - Total fuel
  - The flaps and slats position
  - Memo and warning.

- **System Display** (DU 2) showing:

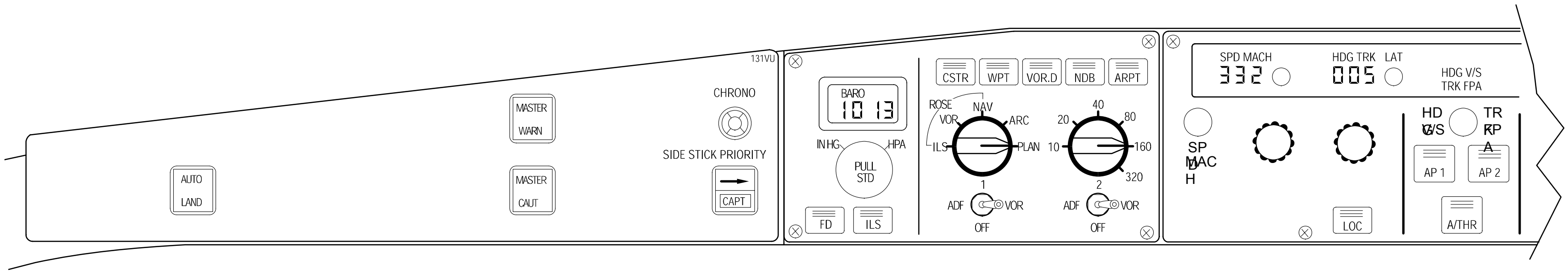
  - Presentation of system synoptic diagrams
  - Status of the aircraft (list of all operationally significant items)

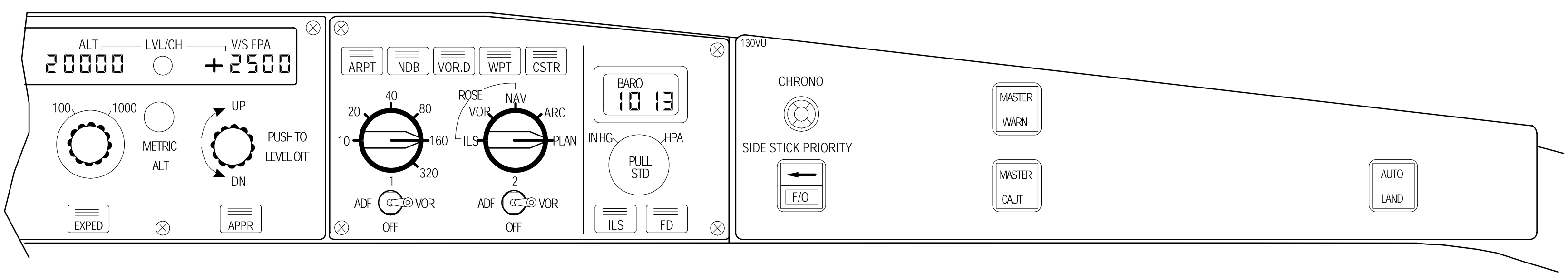
- Standby instruments

- Landing gear control and indications (including brakes)

- Clock

A318/A319/A320/A321 Flight Deck – Glareshield





A318/A319/A320/A321 Flight Deck – Glareshield

- The Flight Control Unit **(FCU)** provides short-term interface between the FMGC and crew for:

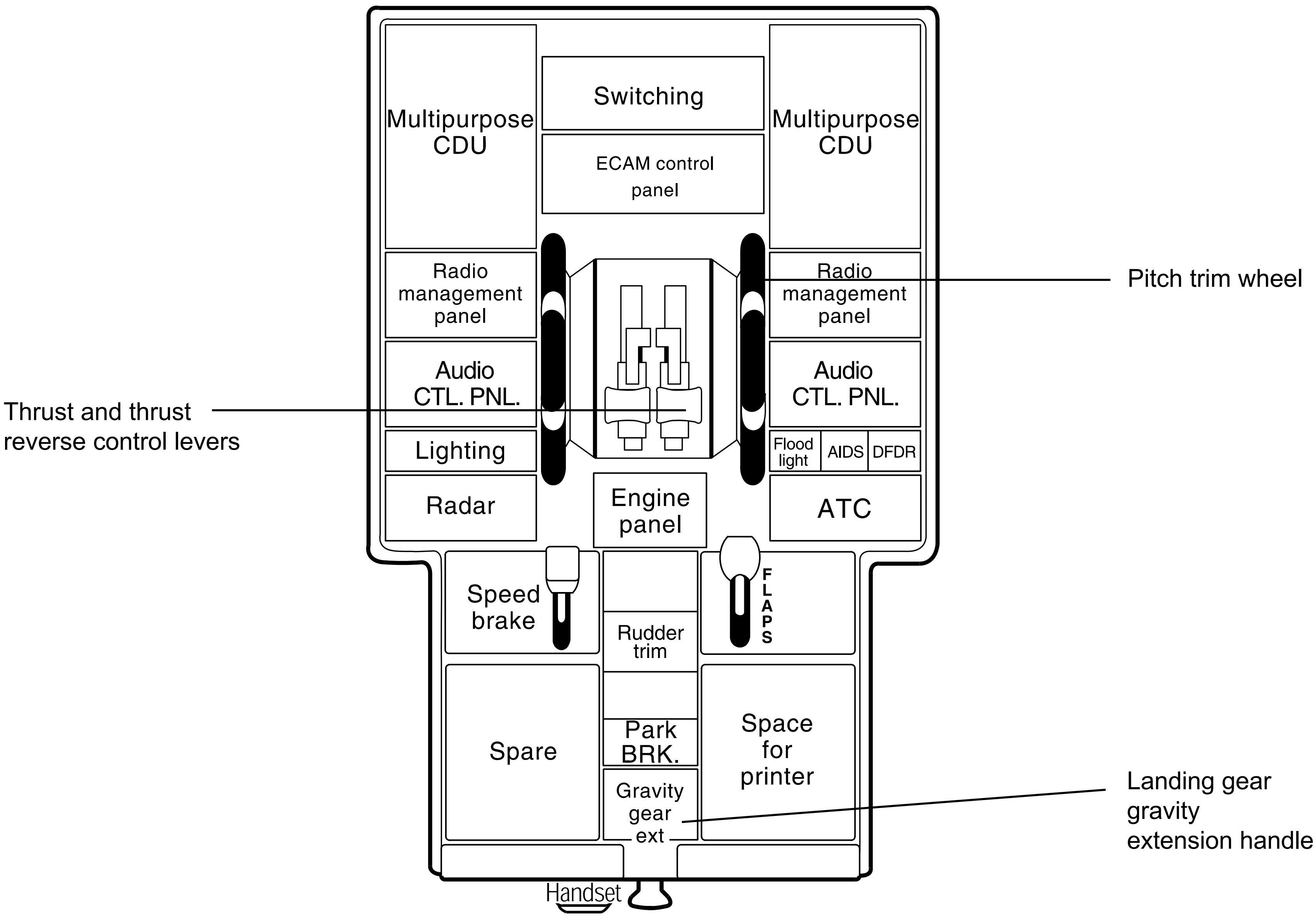
  - Engagement of A / P, FD, ATHR
  - Selection of required guidance modes
  - Manual selection of flight parameters SPD, MACH, ALT, VSPD, HDG or track.

- The EFIS control panels for:

  - Selection of desired ND modes (ROSE-ILS, -VOR, ARC, PLAN) and ranges,
  - Selection of baro setting.

- The master warning, master caution, autoland and sidestick priority lights.

A318/A319/A320/A321 Flight Deck – Pedestal

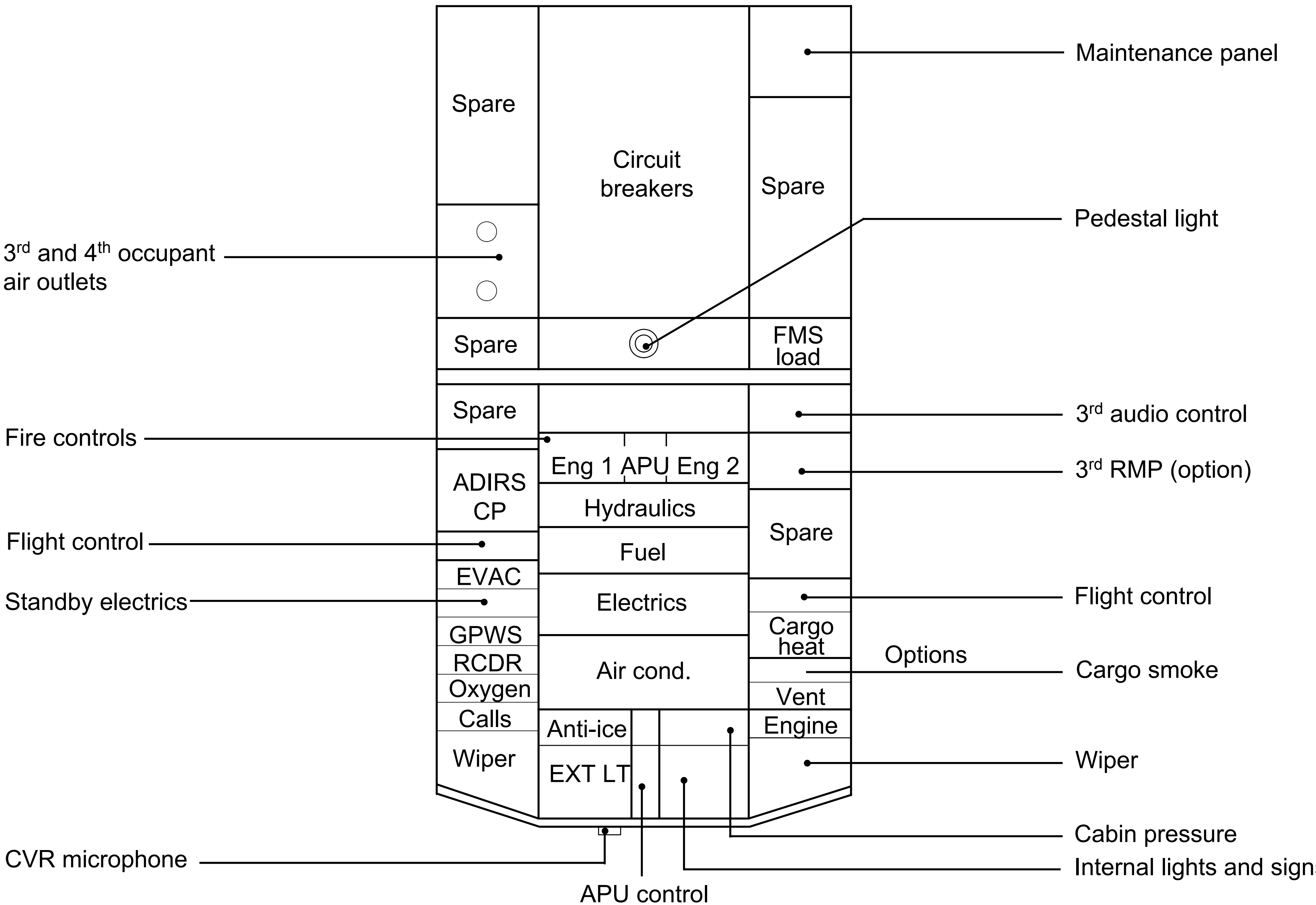


A318/A319/A320/A321 Flight Deck – Pedestal

In addition to the thrust levers and the engine control functions, the main features on the pedestal are:

- The Multipurpose Control and Display Units **(MCDU)** for flight management functions and various other functions such as data link, maintenance etc…
- The Radio Management Panel **(RMP)** for tuning of: all radio communications and the radio navigation as a back-up to the normal operation through the Flight Management and Guidance Computers **(FMGC)**.
- The electrical rudder trim.
- A handle at the rear of the pedestal enables the gravity landing gear function, to be operated easily and rapidly.

A318/A319/A320/A321 Flight Deck – Overhead Panel



Overhead Panel

- The overhead panel is “single slope” and one inch higher than on previous Airbus aircraft.

- All controls on the overhead panel can be reached by either pilot.

- Two main zones are separated by protective padding :

  - **Forward zone:**

    - For most frequently used functions at the front of the panel
    - For system controls : arranged in three main rows :
      - Center row for engine related systems arranged in a logical way
      - Lateral rows for other systems

  - **Aft zone,** not used in flight, mainly:

    - For circuit breakers corresponding to essential systems necessitating segregation
    - For a small maintenance panel corresponding to some systems not linked to the Centralized Fault and Display System **(CFDS)**.

- **The push-button philosophy** is identical to that already applied on existing Airbus aircraft.

3. Electrical System

A318/A319/A320/A321 Electrical System Architecture

The electrical power generation comprises:

- Two **engine-driven AC generators**, nominal power 90kVA
- One auxiliary power unit **(APU) AC generator** nominal power 90kVA
- One **emergency generator** nominal power 5kVA, hydraulically driven by the Ram Air Turbine **(RAT)**, automatically deployed in case of main generators loss
- One **ground connector**, power 90kVA.
- DC network supplied via three identical Transformer / Rectifier Units **(TRU)** :

  - Two of them are normally used (TR1 and TR2)
  - The third ESS TR is used:
    - In emergency configuration (loss of main AC generators)
    - In case of TR 1 or TR 2 failure

- Two **batteries**, nominal capacity 23Ah each

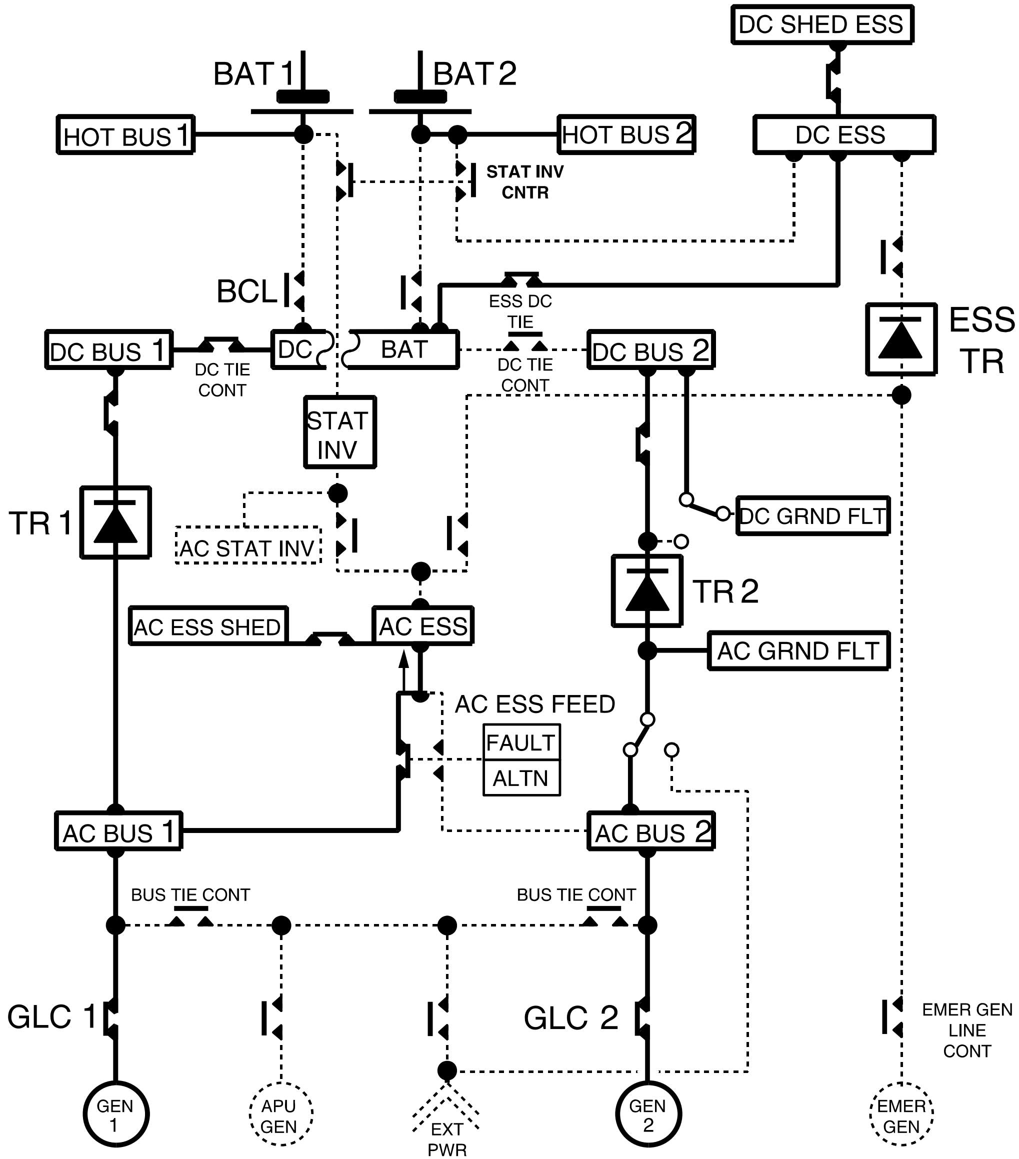
  - On ground : to provide an autonomous source mainly for APU starting
  - In emergency electricity configuration : to feed some equipment:
    - During RAT deployment
    - When the emergency generator is not available
    - When the RAT is no longer efficient:

      → After landing gear extension for A320 with the old electrical configuration

      → On the ground for A318/A319/A321 or A320 with the new electrical configuration

- One **static inverter** to provide a source of AC power from the batteries.

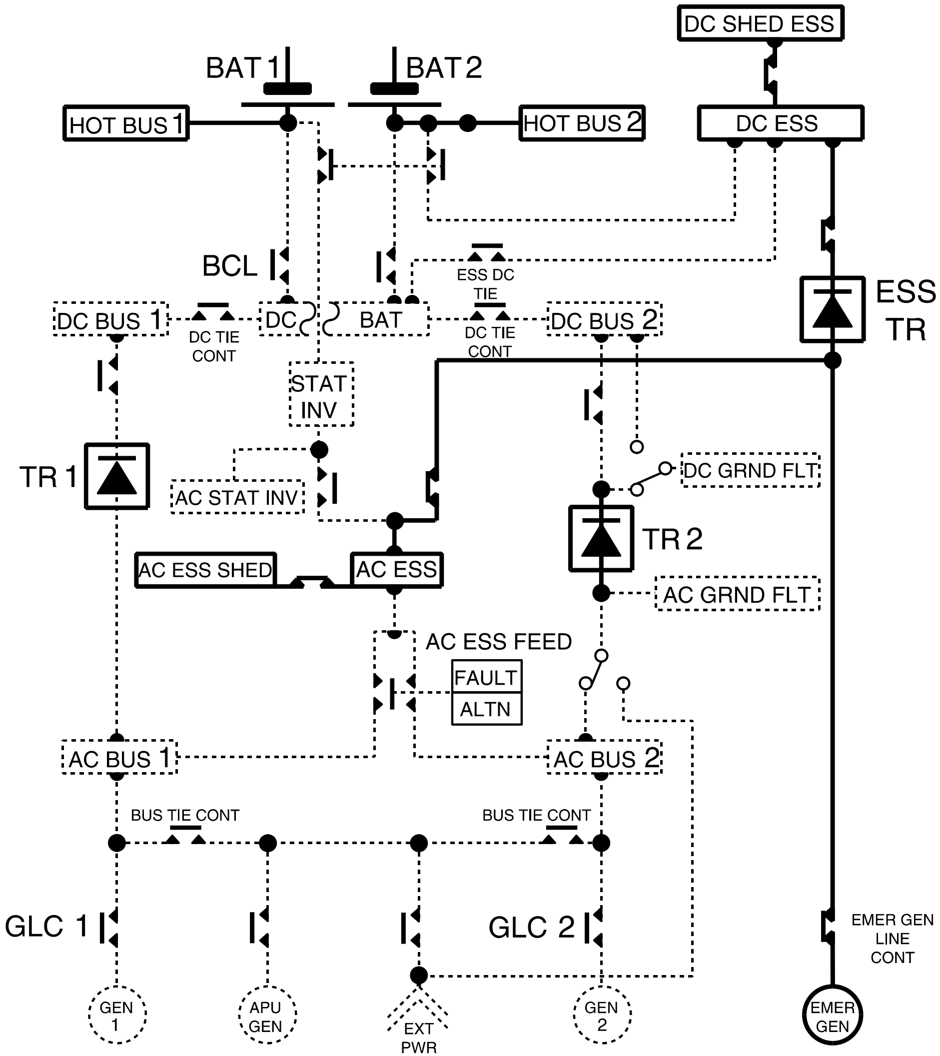
A318/A319/A320/A321 Normal Electrical Flight Configuration



A318/A319/A320/A321 Normal Electrical Flight Configuration

- In normal configuration, both normal AC systems are split.
- Each engine-driven generator supplies its associated AC BUS via its Generator Line Contactor (GLC).
- AC ESS BUS is normally supplied from AC BUS 1 via a contactor. This contactor allow to supply AC ESS BUS with AC BUS 2, through the AC ESS FEED pushbutton.
- DC BAT BUS (part of the DC distribution network) and the DC ESS BUS are normally powered by the TR 1.
- Two batteries are connected to the DC BAT BUS via the Battery Charge Limiter (BCL).
- Each battery has its own HOT BUS bar (engine / APU firesquib, ADIRS, CIDS, ELAC 1, SEC 1, slide warnings, parking brake etc).

Loss of main electrical generators – EMER GEN running



- In case of failure of one main generator, the failed generator is automatically replaced by:

  - The APU generator if available
  - The other main generator with automatic partial galley load shedding.

- In case of total loss of all main generators, the RAT is automatically extended and drives the emergency generator via a hydraulic motor.

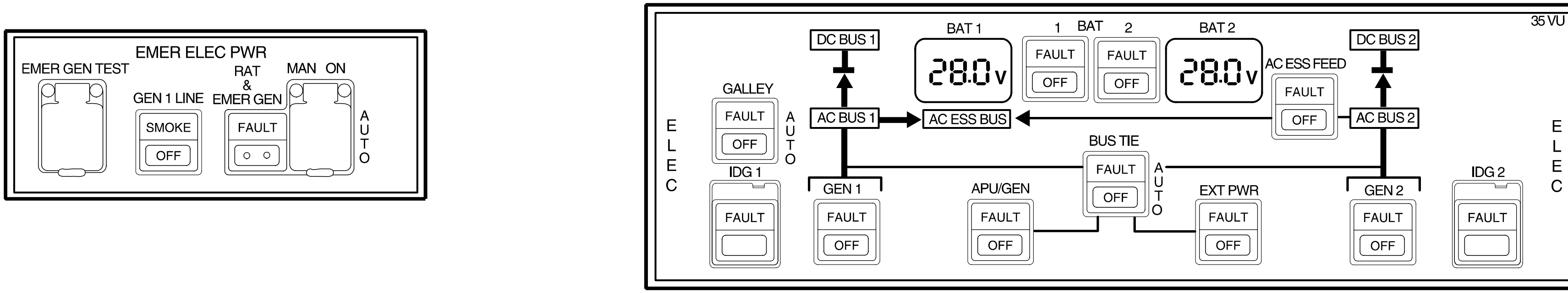
  The EMER GEN supplies the AC ESS BUS and the DC ESS BUS via the ESS TR.

  Only the Upper ECAM DU remains powered by the AC ESS BUS. It addresses the procedure to follow.

  Alternate law becomes operative.

A318/A319/A320/A321 Electrical – Control and Display

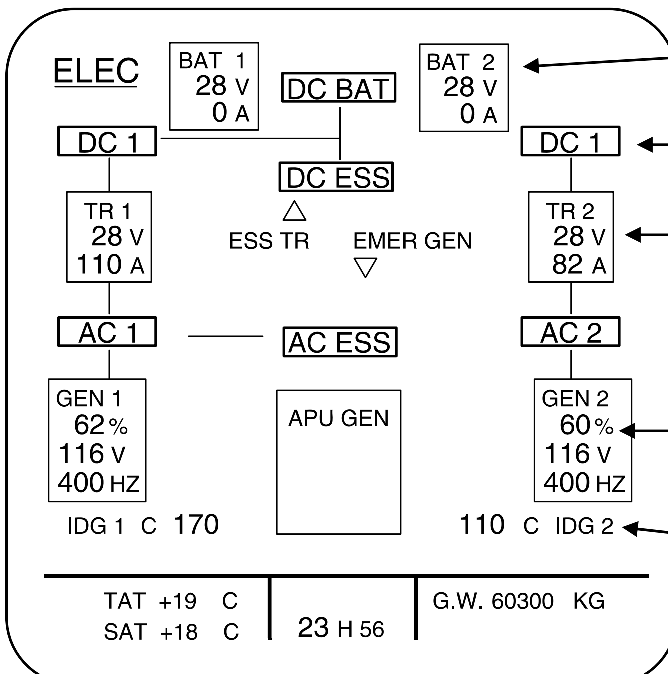
Control Panel



System Display :

ELEC system page

Normal configuration



Batteries indication

Buses indication

Transformer / Rectifier

Generator indication

Integrate Drive Generator indications

A318/A319/A320/A321 Cockpit Circuit - Breakers

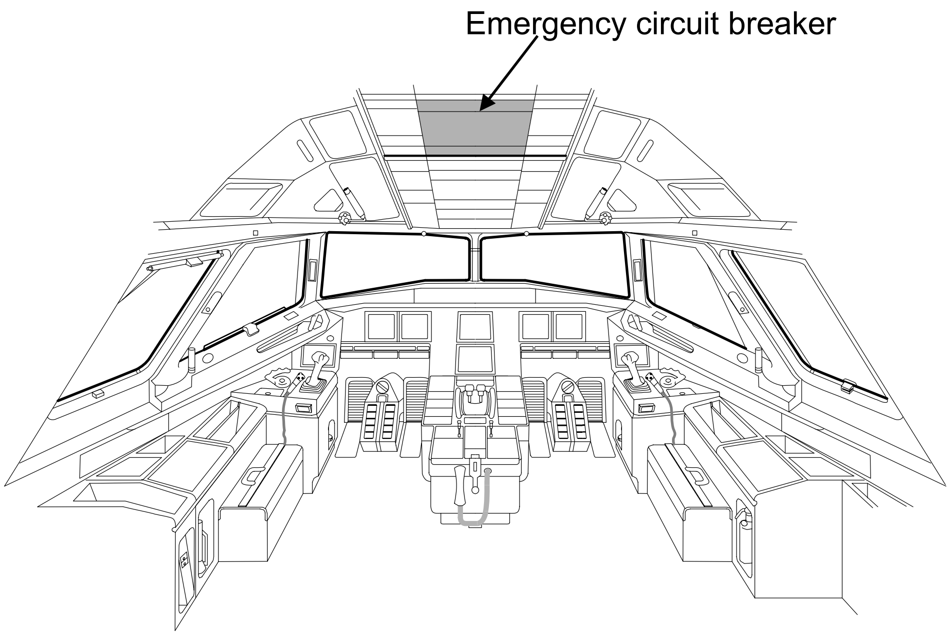
- Circuit breakers (C / Bs) are constantly monitored and the tripping of a C / B will be clearly indicated:

either through
- Activation of a system warning
- A failure test
- An abnormal instrument configuration

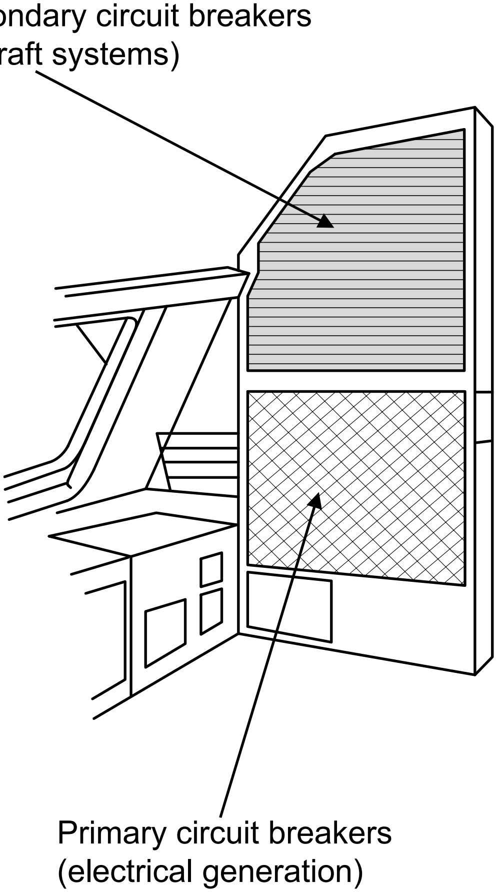
or, for C / Bs monitored by the ECAM system:

- Six zones have been defined
- Each time a C / B trips, the corresponding zone is identified

Overhead panel

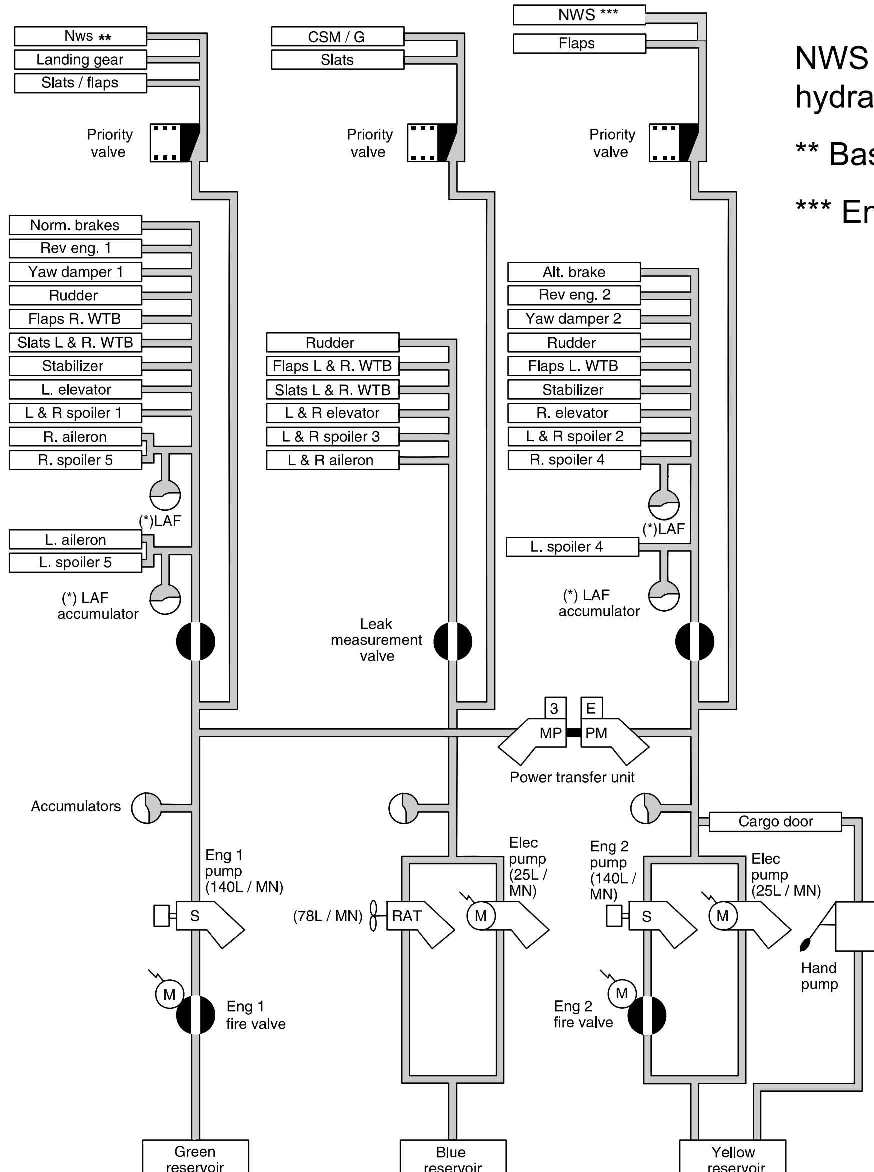


Rear right panel



4. Hydraulic System

A318/A319/A320/A321 Hydraulic System Architecture



NWS is supplied by green or yellow hydraulic system, depending on :

** Basic Nose Wheel Steering system,or

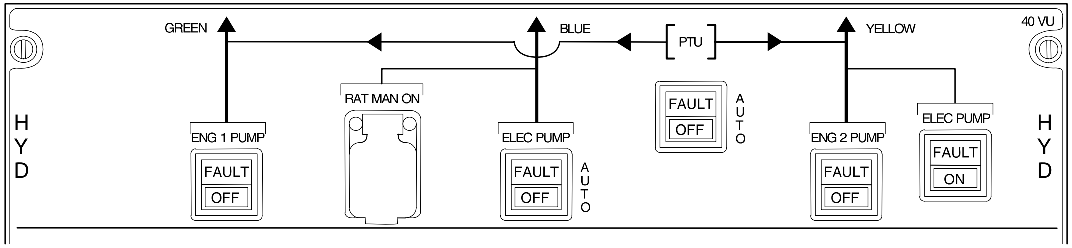
*** Enhanced Nose Wheel Steering system

(*) only for A320 equipped with Load Alleviation Function (LAF – refer to chapter 5).

A318/A319/A320/A321 Hydraulic System - General

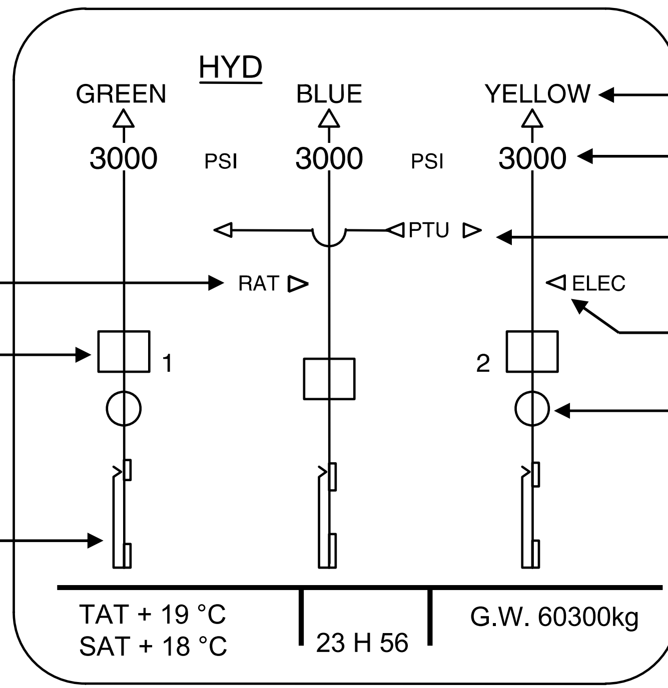
- The aircraft has three fully independent systems: **Green, Yellow**, **Blue**.
- Normal operation functioning description:
  - Green and Yellow system are pressurized by an engine-driven pump (one pump for each system)
  - Blue system is pressurized by an electric pump
- Abnormal operation description:
  - **If** engine No. 1 is inoperative or Green pump has failed : The Green system is pressurized by the reversible Power Transfer Unit **(PTU)**
  - **If** engine No. 2 is inoperative or Yellow pump has failed : The Yellow system is pressurized by the reversible PTU
  - In case of dual engine failure or total electrical power loss:
    The Ram Air Turbine **(RAT)** will pressurize the Blue system.
- On ground:
  - Blue and Yellow systems can be pressurized by electric pumps.
    A handpump (operated from the ground on the yellow system) facilitates manoeuvring of the cargo doors.
  - Green/Yellow system can be pressurized by the PTU.

Control panel



System display :

HYD system page



System label

System pressure

Power Transfer Unit

RAT

Yellow electrical pump

Engine pump

Fire valve position

Reservoir quantity indication

5. Flight Controls

A318/A319/A320/A321 EFCS Advantages

The Electrical Flight Control System (EFCS) provides:

- Safety improvements (stall / windshear / overstress / overspeed protection)

- Economical aspects

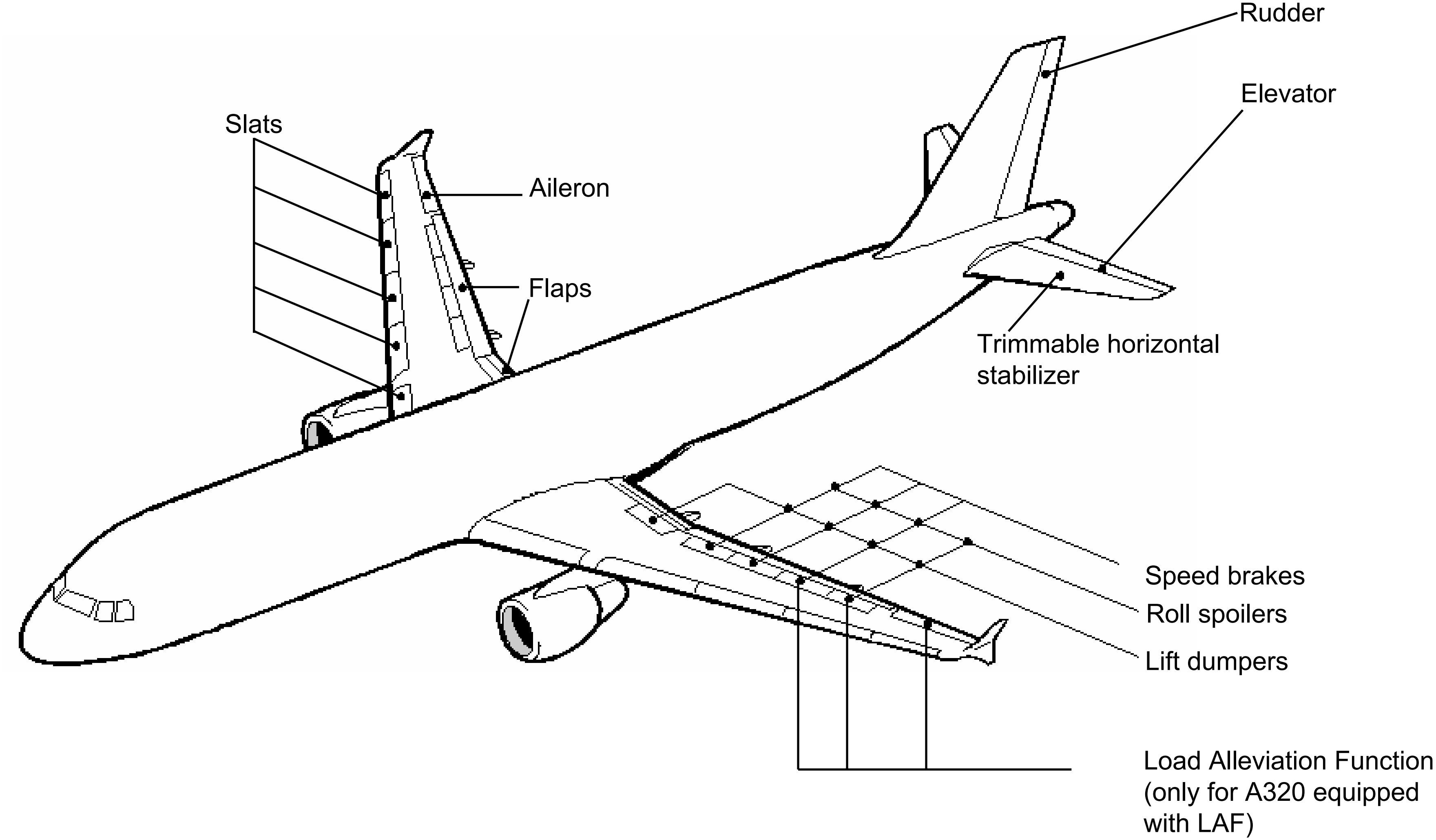
  - Weight saving = Δ W > 200kg considering the impact on AFS
    A319/A320/A321 plus same weight gain on wing structure due to integration of load alleviation function function (A320 only).

  - Maintenance costs decreased
  - Training costs decreased
  - Production costs decreased

- Improvements in handling and comfort

  - Flight handling improvement
  - New cockpit concept

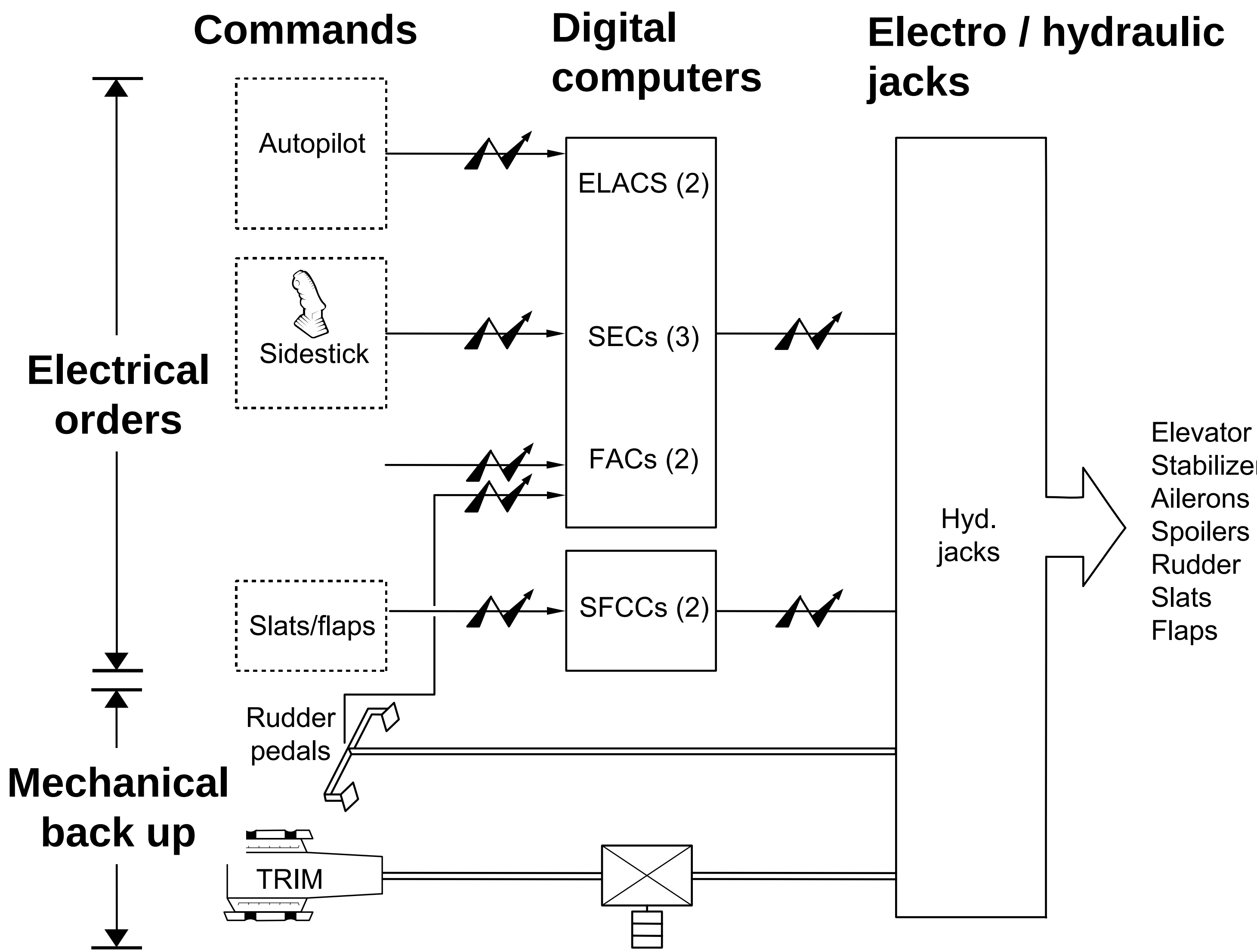
A318/A319/A320/A321 Flight Controls Surfaces



A318/A319/A320/A321 Flight Controls Surfaces

- Control is achieved through conventional surfaces
- All the surfaces are hydraulically actuated
- Roll and pitch control is electrical:
  - Elevator
  - Ailerons
  - Roll spoilers
  - Trimmable horizontal stabilizers
  - Slats and flaps (single flap surfaces for A320, A319 and A318, double slotted surfaces for A321)
  - Speedbrakes / ground spoilers.
- Yaw control is mechanical:
  - rudder (yaw damping, turn coordination and trim are electrically ensured)
- Mechanical back up:
  - trimmable horizontal stabilizer
  - rudder

A318/A319/A320/A321 EFCS Command Principle



A318/A319/A320/A321 EFCS Computer

Flight control is achieved by three types of computer:

- Two **ELAC**s (Elevator Aileron Computer) to ensure commands of :

  - Elevators and trimmable horizontal stabilizer for normal pitch control
  - Aileron control

- Three **SEC**s (Spoiler Elevator Computer)

  - Three computers achieve spoiler control
  - Two of them are devoted to standby elevator and stabilizer control

- Two **FAC**s (Flight Augmentation Computer)

  Two computers which achieve:
    - Electrical rudder control (yaw damping, turn coordination of rudder and trim, and Rudder Travel Limitation)
    - Flight envelope function: characteristic speeds computation for display on the PFD, and α floor function

  In addition

  - Two **SFCC**s (Slats Flaps Control Computer)
  - Two **FCDC**s (Flight Control Data Concentrator) acquire data from ELACs and SECs and send them to ECAM and CFDS.

Classic and Fly-by-Wire (FBW) Controls Compared

Classic Flight Controls

- Directly proportional relationship between pilot stick input and control surface position.
- Aircraft response depending on aircraft dynamics and flight envelope area coverage.
- Airworthiness and aircraft performance requirements leading to increasingly complex system:
  - Variable artificial feel to modulate pilot forces with flight conditions (efforts / g),
  - Hydraulically powered servocontrols, served autopilots, control wheel steering,
  - Stall protection devices (stick shaker, stick pusher),
  - Stability augmentation systems (Mach trim, speed trim, angle-of-attack trim, roll and yaw damping).

Fly-by-Wire Controls

- No directly proportional relationship between pilot stick input and control surface position.
- Computers' response to stick input modulating servocontrolled jacks to satisfy:
  - Normal, alternate or direct laws (pitch, roll and yaw axes),
  - Optimized flight control characteristics (easy Handling, good stability),
  - Improved safety :overspeed, stall, windshear, manoeuvre and attitude protections.

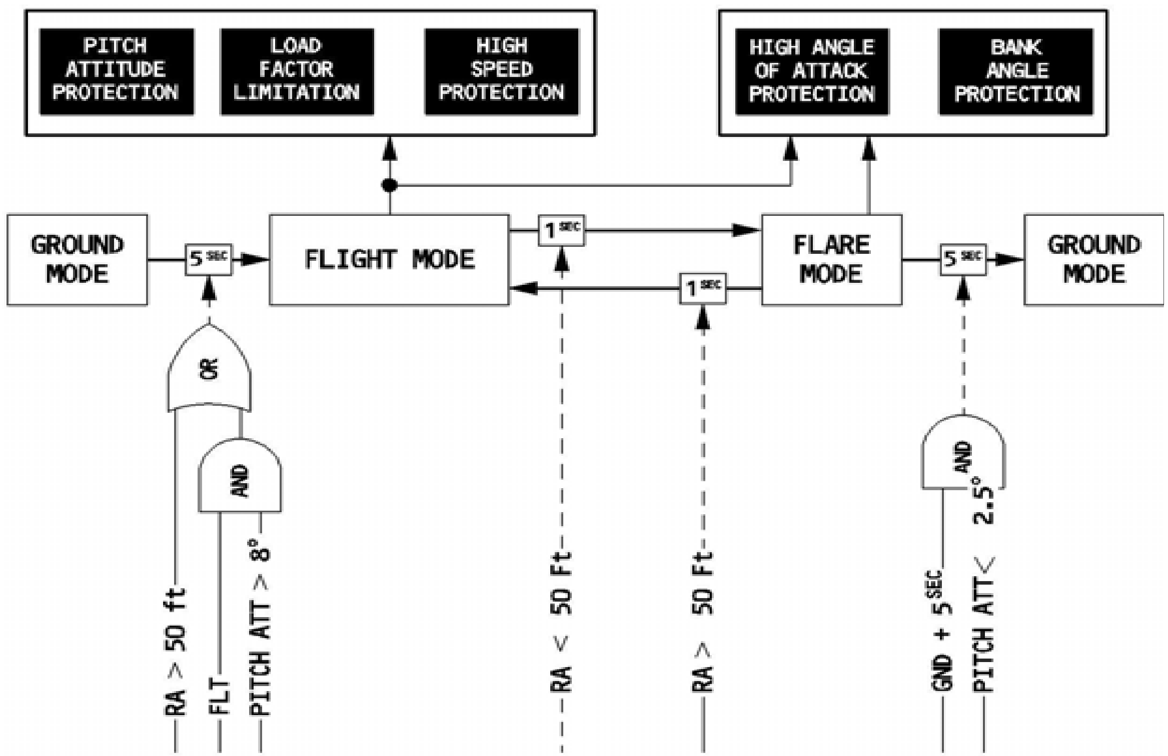
Control Law Introduction

- **Flight through computers**
  Depending upon the EFCS status, the control law is :
  - **Normal Law** (normal conditions even after single failure of sensors, electrical system, hydraulic system or flight control computer)

  According to number and nature of subsequent failures, it automatically reverts to:
  - **Alternate Law**, or
  - **Direct Law**.

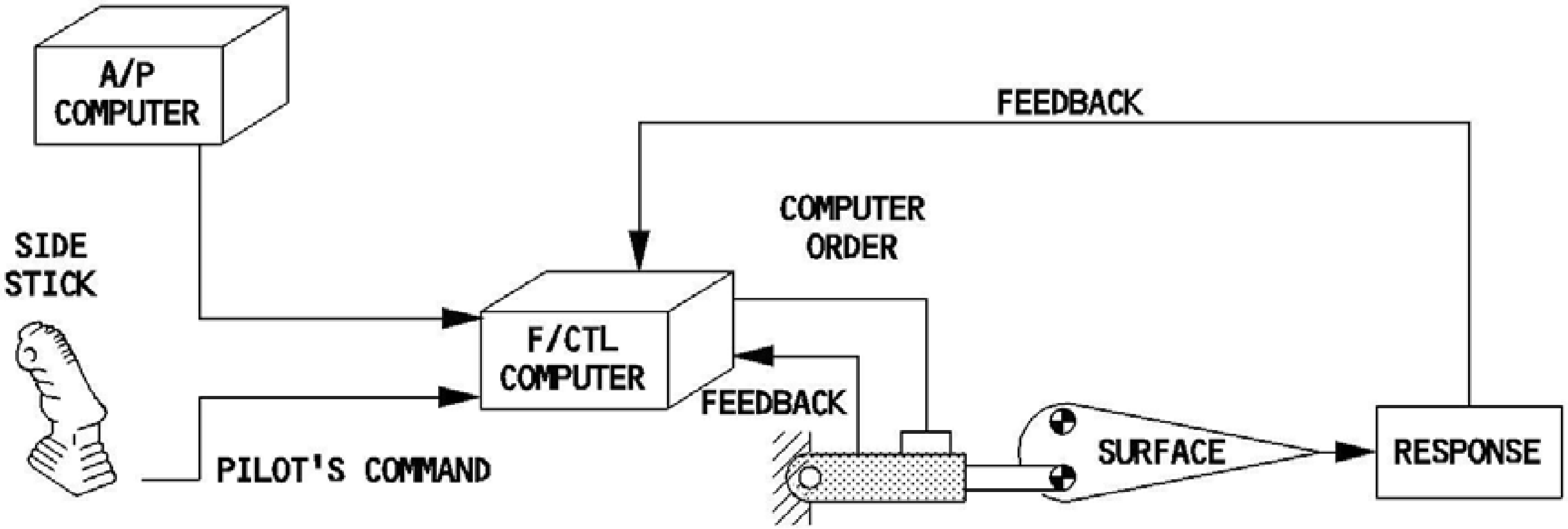
- **Mechanical back-up**
  During a complete loss of electrical power the aircraft is controlled by:
  - Longitudinal control through trim wheel
  - Lateral control from pedals

Overall Normal LAW schematic



Normal Law – Flight Mode

Basic principle



• **Highlights**

- No direct relationship between sidestick and control surface deflection.
- The sidestick serves to provide command objectives
- Computers command surface deflections to achieve Normal Law objectives (if compatible with protections)

A318/A319/A320/A321 Normal Law Description

Generalities

- **Flight mode**

• **Pitch axis:**

Sidestick deflection corresponds to a vertical load factor demand.

The Normal Law elaborates elevator and THS orders

• **lateral axis:**

Sidestick deflection corresponds to a roll rate demand which is converted into a bank angle demand.

The Normal Law signal roll and yaw surfaces to achieve bank angle demand and maintain it.

Pedal deflection corresponds to a sideslip/bank angle demand.

- **Ground mode, take-off mode**

Normal Law is the same for these phases, it establishes the same direct relationship between pilot's inputs and surface deflection which is speed dependent.

- **Landing mode**

• **Pitch axis:**

The objective derived from a stick input is adapted from a load factor demand to a pitch attitude demand.

• **Lateral axis:**

As per flight mode.

A318/A319/A320/A321 Normal Law – Pitch Axis

- Manoeuvre demand law as basic flight mode
  - Neutral speed stability with full flight envelope protection
- Vertical load factor control proportional to stick deflection :
  - Independent of speed, weight, center of gravity
  - Stick displacement : □N_z = n N_z = n + 1g
  - Stick neutral : □N_z = O N_z = 1g
- Flight path stability instead of speed stability
  - Control inputs are made to alter the flight path, not to hold it.
- Medium-term flight path stability:
  - Maintenance of parallel trajectory 1g in pitch even after atmosphere disturbance.
- Automatic pitch trim eliminating need to correct for speed or configuration changes:
  - Electric autotrim function holding elevator position for constant flight path,
  - Control surface autotrim function returning elevators to the THS trail.
- Automatic elevator for bank angle compensation up to 33°.

A318/A319/A320/A321 Normal Law – Pitch Axis

- Adaptation of basic control law objectives to:

  - Ground phase: **ground mode**

    Direct relationship between stick and elevator available before lift-off and after touch-down

  - Take-off phase: **take-off mode**

    For smooth transition, blend of ground phase law and N_z command law over 5 seconds after lift off.

  - Landing phase: **flare mode**

    At 50ft the attitude is memorized as reference pitch attitude.

    At 30ft this value is progressively reduced to 2° nose down to induce gentle positive pilot action for a conventional flare.

A318/A319/A320/A321 Normal Law – Roll and Yaw Axes

- Roll rate demand (15° / Sec max.) as basic flight mode :
- Coordinated roll and yaw surfaces deflections:
  - To achieve and maintain bank angle up to 33°, stick released
- Bank angle protection above 33°:
  - Positive spiral stability restored up to 67° inside normal flight envelope
  - Limit of 67° bank angle
- Lateral control laws providing handling quality features such as:
  - Bank angle resistance to disturbance, stick free,
  - Precise piloting
  - Good turn coordination,
  - Dutch roll damping,
  - Sideslip minimization.
- Sidestick free with pedal deflection results in stabilized sideslip and bank angle facilitating "de-crabbing" in crosswind landings.
- Engine failure or aircraft asymmetry compensation consisting of:
  - If no pilot action:
    - Stabilized sideslip and bank angle followed by,
    - Automatic rudder trimming to compensate asymmetric thrust
    - Slowly diverging heading.
  - Recommended action:
    - Zero sideslip target with pedals (take-off, go-around),
    - Heading stabilization with stick input,
    - Steady flight stick free / no pedal forces (rudder trim).
- Adaptation of basic control law objectives to:
  - Ground phase: **ground mode**
    - Direct relationship between stick and roll control surfaces
    - Rudder: mechanical control from pedals + yaw damper function
- Transition from **ground to in-flight law** (and vice versa)
  Switching over in 5 second after lift-off or touch-down.

A318/A319/A320/A321 Control Laws – Reconfiguration Logics

Normal law

Double self-detected ADR or IRS failure
or double (2nd not self-detected) ADR failure
or triple ADR failure
or double ELAC failure
or triple SEC failure
or double FAC failure
or double SFCC slat channel failure
or slats locked in clear and flaps >conf 1
or yaw damper failure

or double hydraulic failure (B+G) or Y+G)
or double aileron failure
or loss of all spoilers
or THS jammed
or emergency power supply or on BAT only
or sidestick fault
or one elevator loss

Alternate law

Double (2nd not
self-detected
IRS failure

Triple IRS failure
or double radio-altimeter
failure (when landing gear
extended)

Direct law

Crew action (identification of failed IRS), ELAC 1+2 reset

Alternate Law

- Flight mode as basic control laws:

  - Pitch axis: as normal law, stick deflection to change N_z,
  - Roll/yaw axes: a direct stick-to-roll surface relationship which is speed, configuration, surface availability dependent.
  - Automatic pitch trim.

- Loss of flight envelope protections except:

  - Manoeuvre protection against excessive load factor
  - Low speed stability
  - Conventional aural stall and overspeed warning

- Reversion of basic control law:

  - Alternate law not being adapted to landing phase - automatic reversion to direct law after landing gear extension.

- Automatic reconfigurations after loss of basic control law in either axis.

A318/A319/A320/A321 Direct Law and Mechanical Back-Up

Direct Law

- Flight mode:

  - Pitch/roll axes: direct stick to elevator or roll control surface relationship.
  - Yaw axis: control with the rudder pedals.
  - The yaw damping and turn coordination functions are lost.
  - Center of gravity, configuration and surface availability dependent.

- Manual trimming through trim wheel:

  - Amber message on PFD ("USE MAN PITCH TRIM")

- Loss of all flight envelope protections:

  - Conventional aural stall and overspeed warning.

- Automatic reconfiguration after loss of basic control law in either axis.

Mechanical Back-Up

- Highly improbable operational necessity.

- To sustain the aircraft during a temporary complete loss of electrical power.

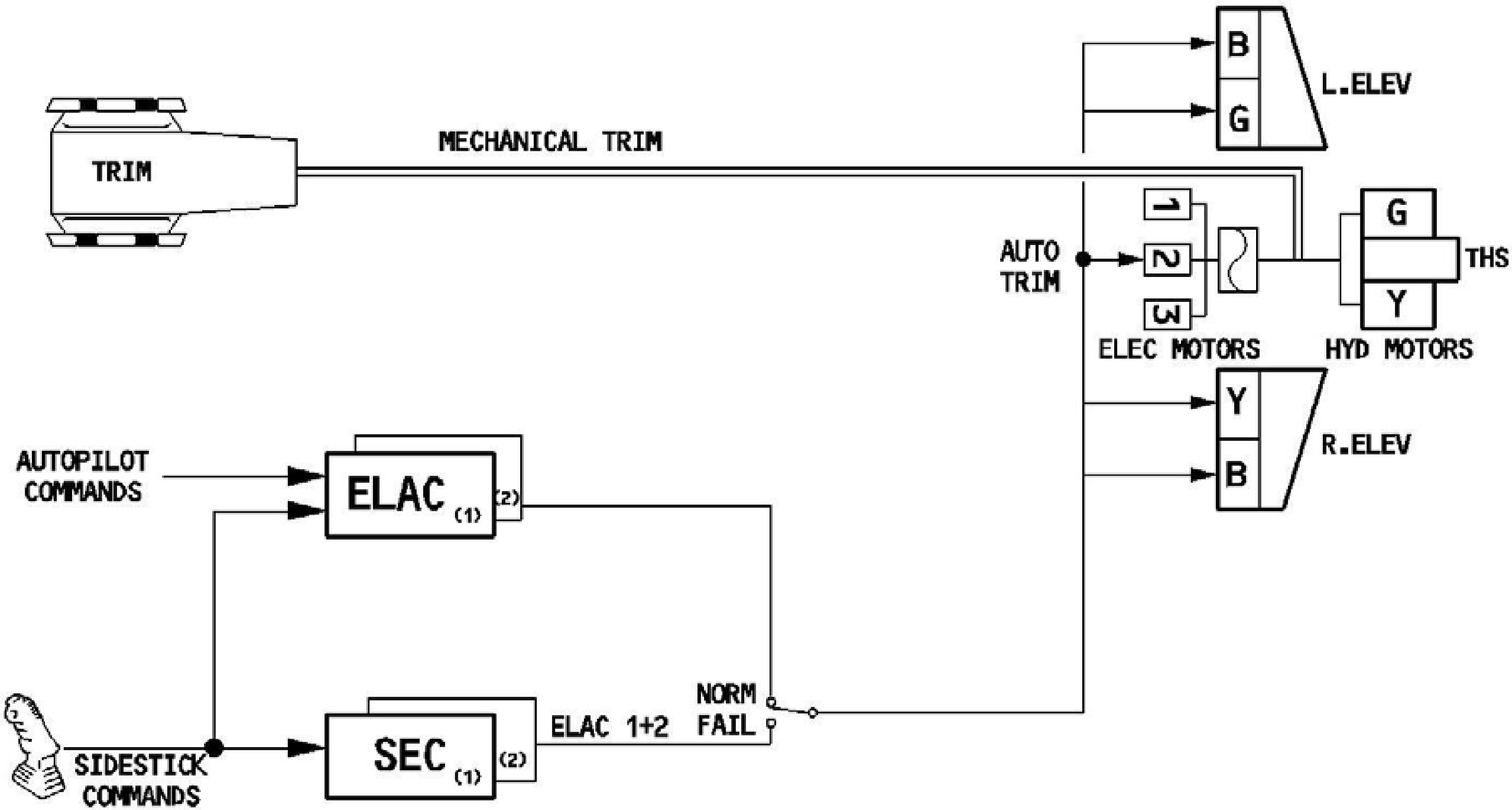
- Longitudinal control of the aircraft through trim wheel. Elevators kept at zero deflection..

- Lateral control from pedals.

- Manual trimming through trim wheel:

  - Red message on PFD ("MAN PITCH TRIM ONLY")

A318/A319/A320/A321 - Pitch Control



A318/A319/A320/A321 - Pitch Control

- Pitch control is provided by two elevators and the THS:

  - Elevator deflections 30° nose up - 17° nose down

  - THS deflections 13.5° nose up - 4° nose down.

- Each elevator is actuated by two independent hydraulic servo controls. The two elevators are driven by Green and Yellow hydraulic jacks.

  In normal operation one servo control is active, the other is damped. (i.e. jack follows the surface movement)

  In case of failure on the active servo-jack, the damped one becomes active and the failed jack is automatically switched to the damping mode.

  If both jacks are not being controlled electrically or hydraulically, they are automatically switched to the damping mode.

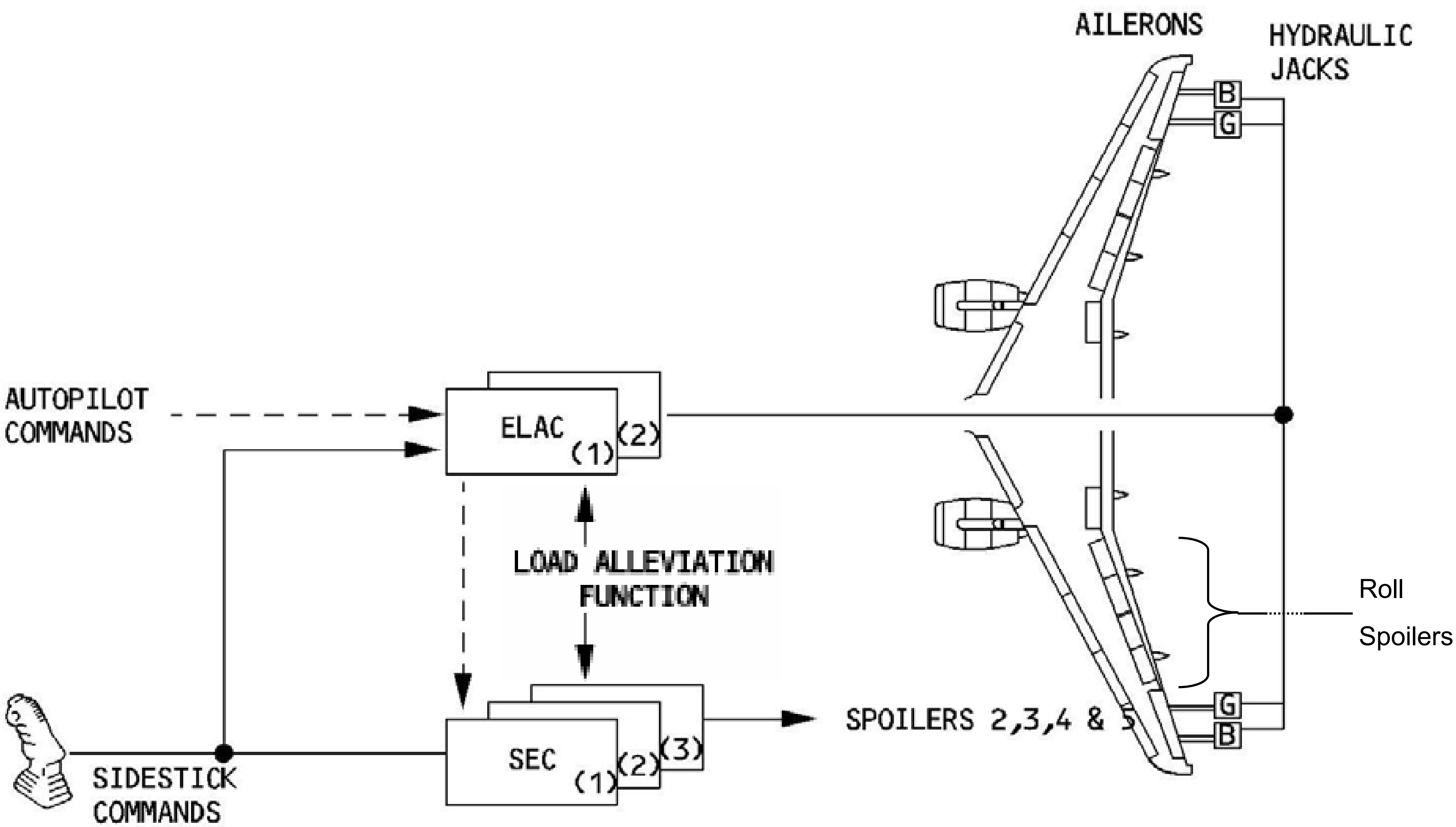
- The THS is actuated by a fail-safe ball screw-jack driven by two independently supplied hydraulic motors. These motors are controlled either:

  - By one of the three electrical motors

  - Or by mechanical trim wheel

  The control wheels are used in case of major failure (Direct Law or mechanical back-up) and have priority over any other command.

A318/A319/A320/A321 - Roll Control



A318/A319/A320/A321 - Roll Control

- Roll control is provided by one aileron and four spoilers (spoiler 2 to 5) per wing:
  - Aileron deflection is ±25°
  - Spoiler max deflection is 35° (7° for spoiler 3 on A321)

- Each aileron is powered by two independent hydraulic servo controls.

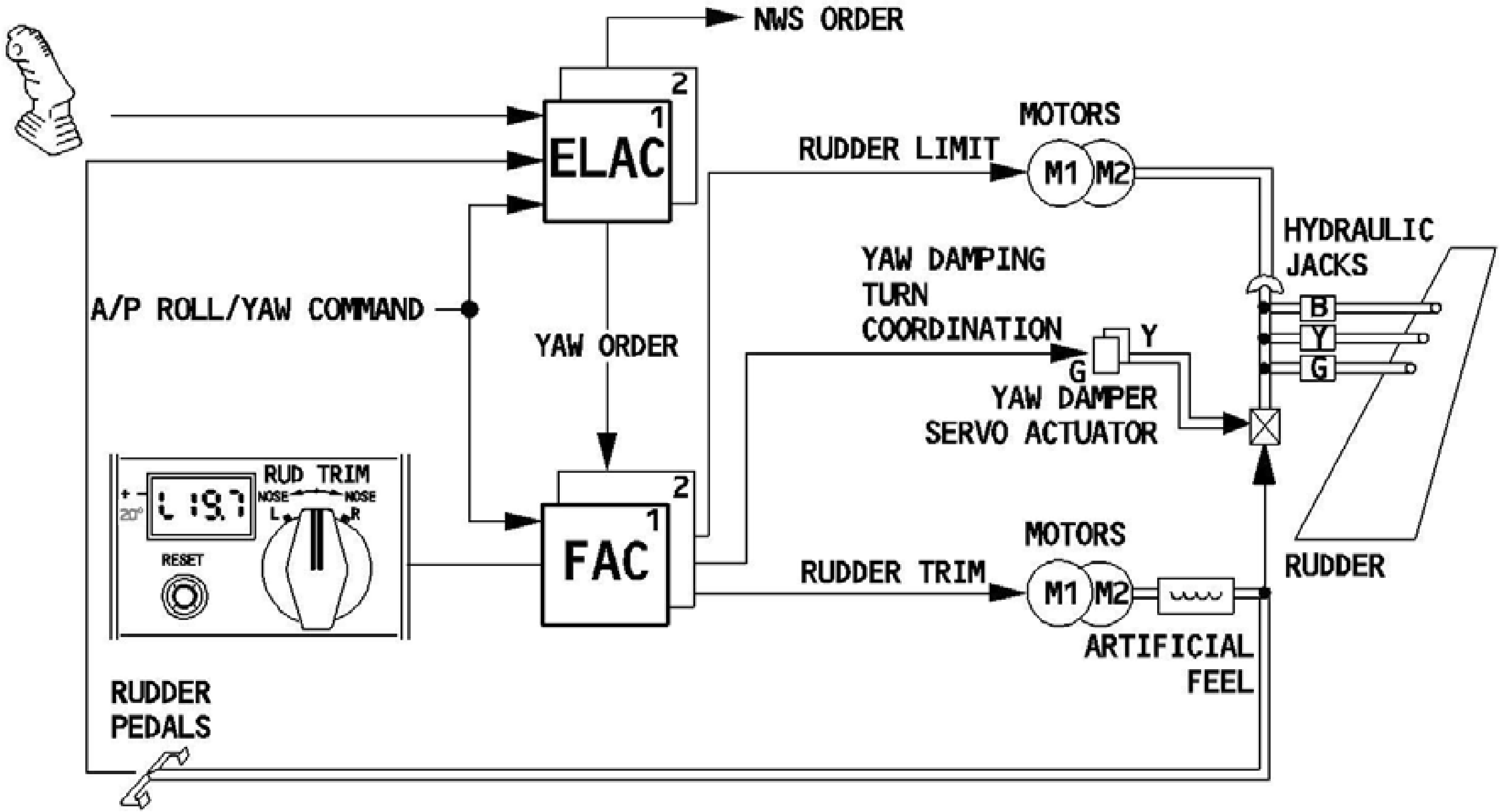
  In normal operation one servo control is active through ELAC, the other is damped.

  The system automatically selects damping mode, if both ELACs fail or in the event of blue and green hydraulic low pressure.

- Each spoiler is driven by a single servo control.
  Each servo-jack receives hydraulic power from either the green, yellow, or blue hydraulic system, controlled by the SEC1, 2 or 3.

  When a spoiler surface on one wing fails, the symmetric one on the other wing is inhibited.

A318/A319/A320/A321 - Yaw Control



A318/A319/A320/A321 - Yaw Control

- Yaw control is provided by one rudder surface
  - Rudder maximum deflection is:
    - 20° on A320/A321
    - 25° on A318/A319

- The rudder is actuated by three independent hydraulic servo controls, mechanically signaled from the pedals and the yaw dampers actuators.

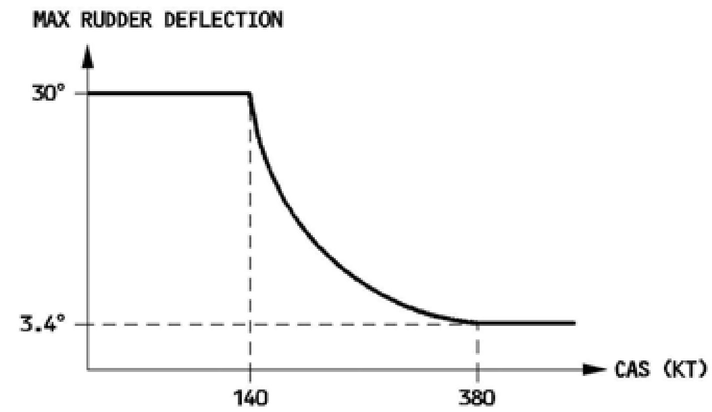
  The deflection of the rudder and the pedals is limited as a function of speed. The FACs control electric motors coupled with a variable stop mechanism.

  In manual flight, in normal conditions, rudder position is controlled by the FACs.
  Autoflight orders are processed by the FACs directly.

  Rudder trim is through electric motors driving the artificial feel spring. They are controlled through the FACs.
  Manual trim orders are received from a switch located on the center pedestal.

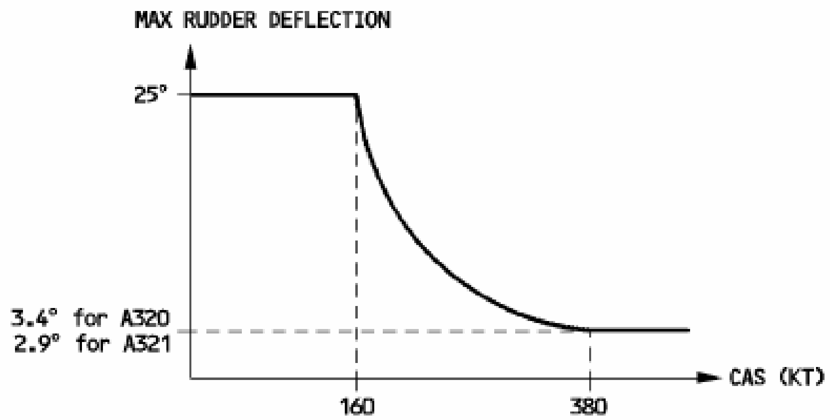
- On A318, Rudder Travel Limiter is also function of altitude. (Optimization of rudder deflection)

- **For A318 and A319:**



*On A318 : depending on the altitude, the Max rudder deflection may decrease slightly (by less than 1 degree).

- **For A320 and A321:**



Performance comparison of sidestick/FBW and conventional controls

- A300 flying testbed equipped with dual sidestick/FBW system (left side) and control column conventional flight control system (right side).

- Two pilots twice flew each of the following three flight conditions in well-specified and demanding experimental circuits :

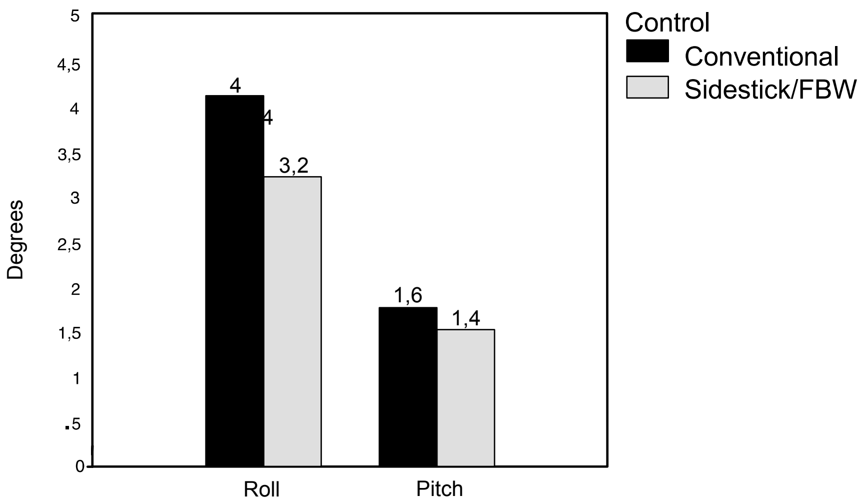
  - Flight Director (FD) : FD and autothrottle system on,
  - ILS (raw data) : FD and autothrottle system off,
  - NDB (non-precision) : FD, autothrottle and ILS off.

- The following measurements of recorded flight parameters were calculated when appropriate and compared for flying with the sidestick and conventional controls :

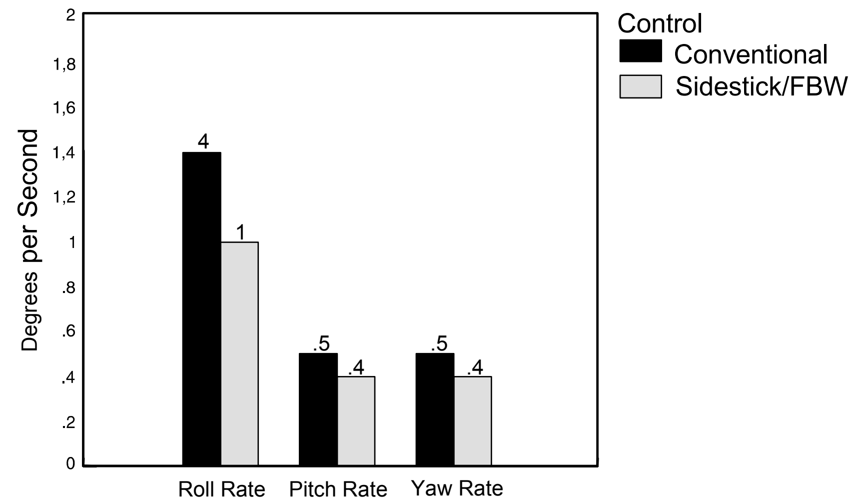
  - Mean : average of 1 second values,
  - Standard deviation : amount of variation around the mean,
  - Rate zero : number of sign changes per minute,
  - Reversal rate : number of direction reversals per minute.

Performance comparison of sidestick/FBW and conventional controls

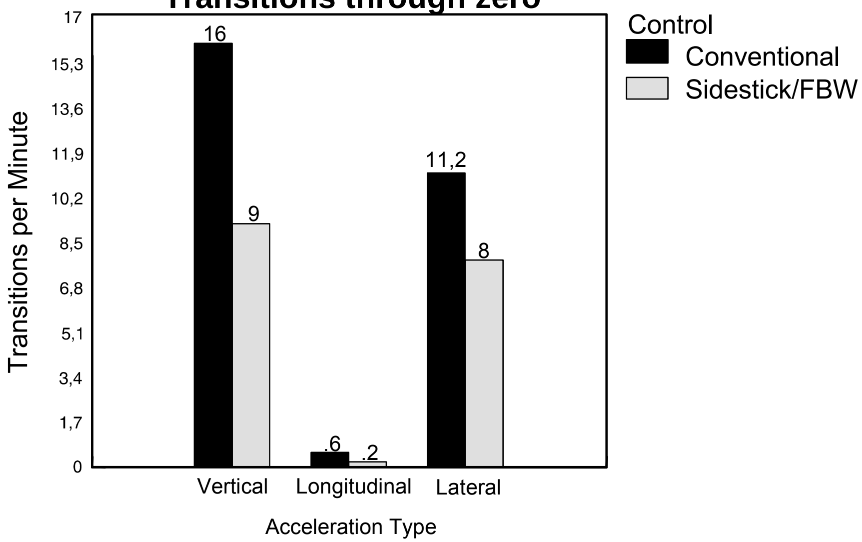
Roll and pitch angles Standard deviation



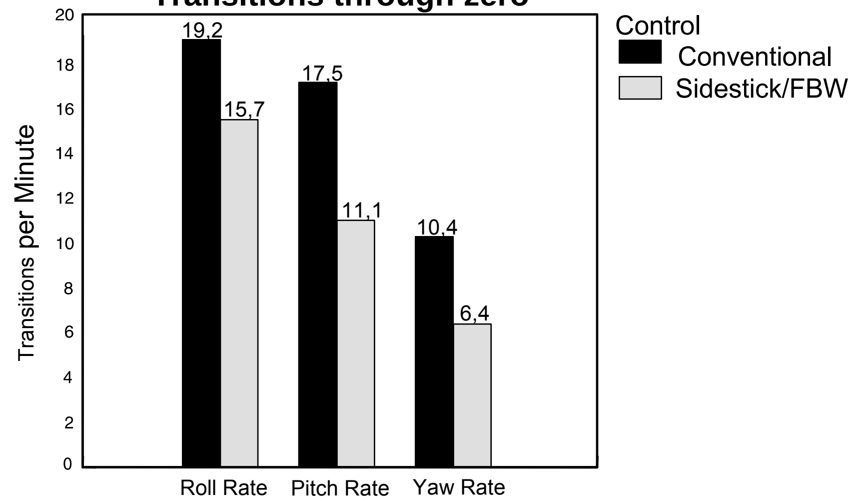
Roll, pitch and yaw rates Standard deviation



Acceleration Transitions through zero



Roll, pitch and yaw rates Transitions through zero



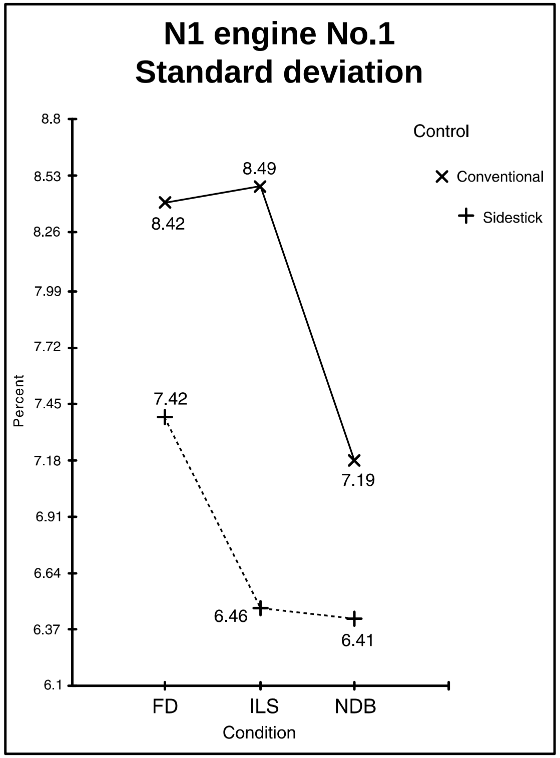
Performance Comparison : Major Results and Conclusions

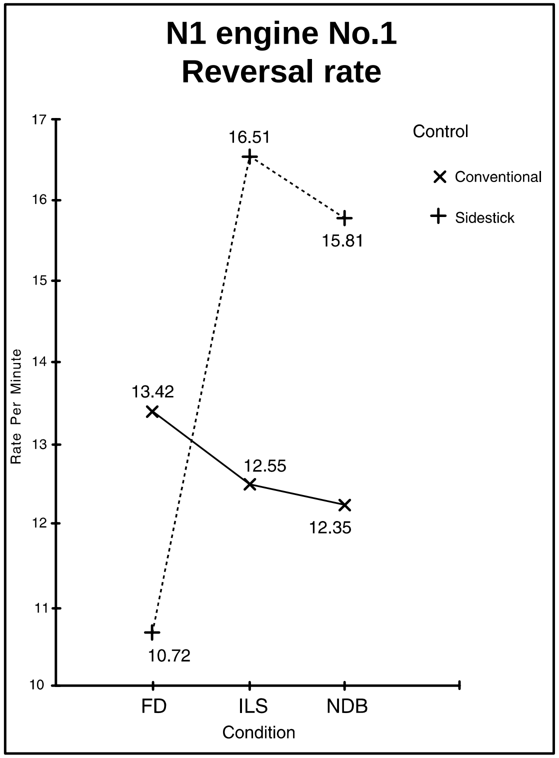
- All measurements of smoothness and stability favoured the sidestick by a large margin:

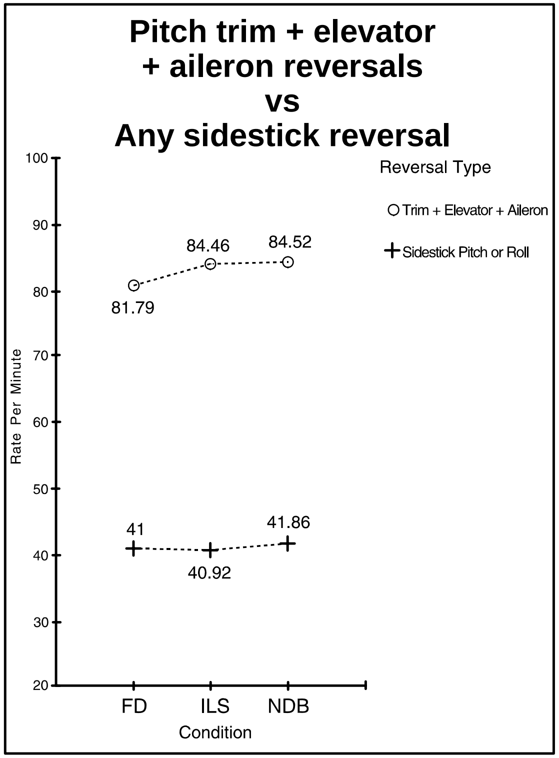
  - For roll and pitch angles and rates, standard deviations and rate through zero were reduced by 20% or more when flying with the sidestick,

  - Accelerations in all three axes showed a large reduction in standard deviation and rate through zero when flying with the sidestick

Performance comparison of sidestick/FWB and conventional controls







Performance Comparison : Major Results and Conclusions

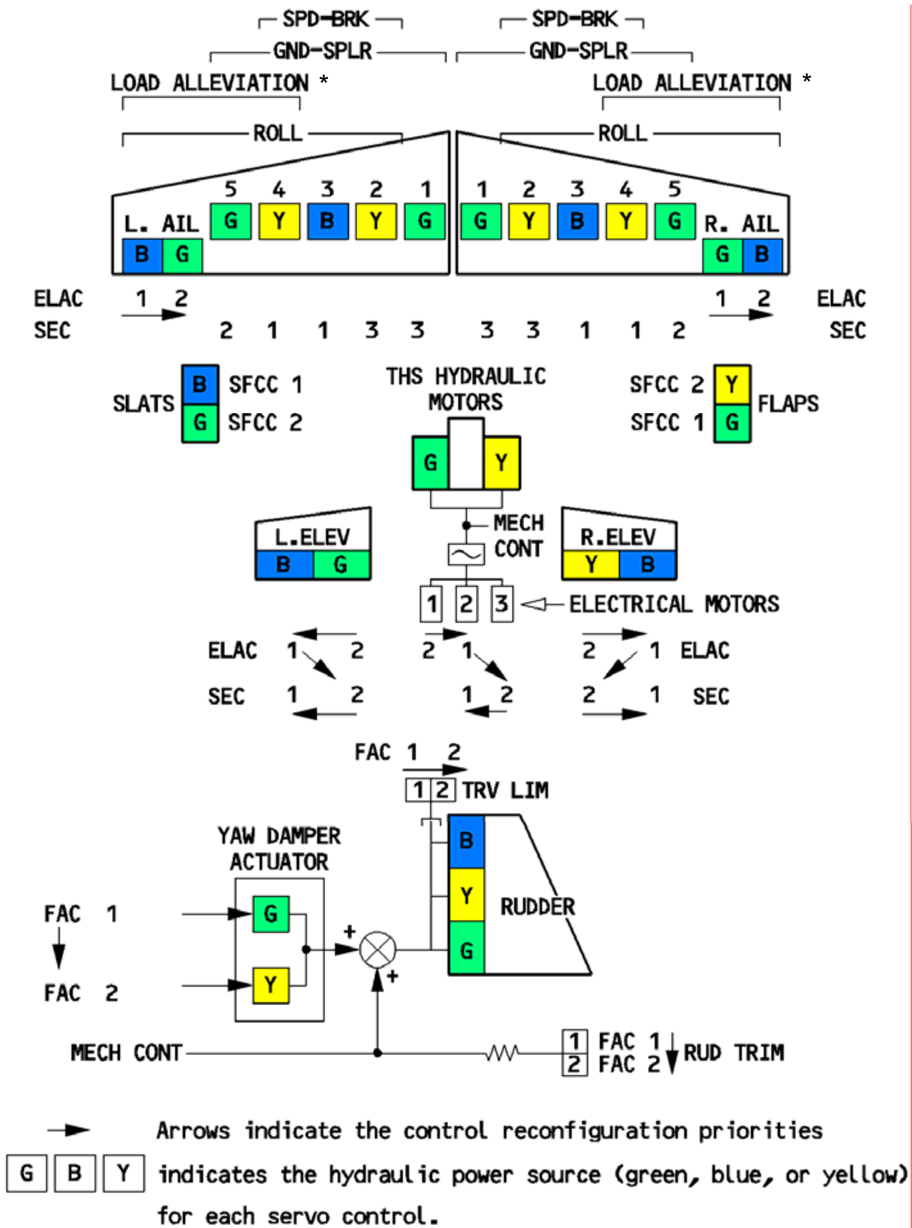
- All parameters related to fuel burn showed significantly better values with sidestick:

  - The sidestick/EFCS combination should improve fuel economy through unnecessary control surface movements and increased rear C.G. limits.

- Pilot control inputs were reduced by 50% or more and the system still achieved much better overall performance:

  - Lower pilot workload should allow more time for dealing with emergencies and managing flight efficiency.

A318/A319/A320/A321 EFCS Architecture



* Load Alleviation Function (only for A320 equipped with LAF)

A318/A319/A320/A321 EFCS Redundancy Aspects

Use of dissimilar redundancy

- Two types of computer
  - Two ELACs to achieve aileron control and normal pitch control
  - Three SECs to achieve spoiler control and standby pitch control

- Different type of hardware computer

- Each ELAC and SEC is divided into two units:
  - One Control Unit (COM)
  - One Monitoring unit (MON)

- Four different softwares: ELAC COM + MON
  SEC COM + MON.

- Physical separation of hardware for COM and MON units.

  In addition, **mechanical back-up** (through rudder and stabilizer control) will ensure adequate control in case of temporary loss of all electrical power sources including batteries.

Self tests

- Each computer is able to detect its own failures:

  - Processor test (check sum, watchdog…)
  - Electrical supply monitoring
  - Input and output test
  - Wrap around of output to input.

- Inputs are monitored:

  - By comparison of signals of the same type but sent by different sources
  - By checking the signal coherence.

Other protections

- Specific routes are dedicated to:
  control signals
  monitoring signals

- Signals are linked:
  ELAC 1 and SEC 1 computers on one side
  ELAC 2, SEC 2 and SEC 3 computers on the other side.

- ELAC and SEC computers are qualified in convenience with DO 160 for electrical susceptibility test, the most severe category (Z) being applied.

  - Wires are installed in metal shields in the exposed areas.
  - For each signal, wires are twisted.
  - No signal grounding in the exposed areas.
  - Computer inputs and outputs connected to exposed wires are protected against the most severe spikes.

- This protection, combined with the precautions taken in the software, ensure good protection against lightning strikes and electromagnetic disturbances.

Overspeed Protection

- **Design aims**
  To protect the aircraft against speed overshoot above Vmo/Mmo.

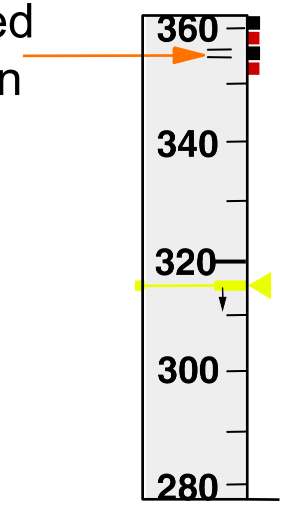
- **Principle**
  - Positive load factor demand automatically applied when Vmo + 6kt or Mmo + 0.01 is reached.
  - Speed limited to around Vmo + 16kt and Mmo + 0.04 when full nose-down stick is maintained (pilot nose-down authority is reduced)

- **Vmo/Mmo warning** :
  - Continuous repetitive chime
  - Master warning light
  - Overspeed red message on ECAM
  - Red and black strip along the PFD scale
  - Automatic AP disconnection

- Bank angle limitation to 45°

- On A318, the pitch trim is no longer frozen when aircraft is in High Speed protection mode. (available on A320 with ELAC post.L83).
THS is limited between the value it had at the entry in the High Speed protection and 11° nose UP

Overspeed protection symbol



Note : OVERSPEED ECAM Warning is provided at Vmo +4kt or Mmo+0.006

PFD speed scale

- **AOA protection – principle**

  - When α becomes greater than α prot, the system switches elevator control from normal mode to a protection mode, in which the angle-of-attack is proportional to sidestick deflection. Autotrim stops, resulting in a nose-down tendency.

  - If α reaches α floor, the auto-thrust system will apply go-around thrust.

  - The α max cannot be exceeded even if the stick is pulled fully back.

  - At α max + 4° an audio stall warning (cricket + synthetic voice: “STALL STALL”) is provided.

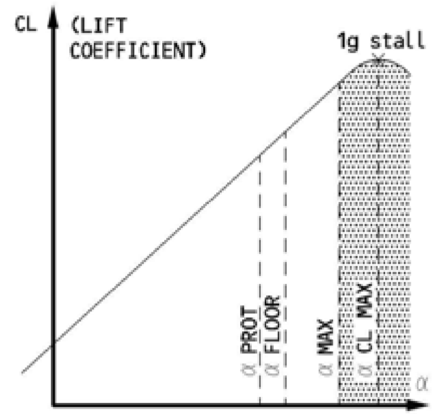
- **Consequences**

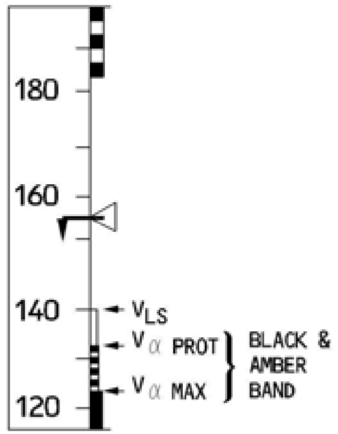
  - α prot is maintained if sidestick is left neutral

  - α max is maintained if sidestick is deflected fully aft

  - Return to normal law is obtained when sidestick is pushed forward.

- Amber strip on PFD indicates 1.13 Vs at take-off, or 1.23 Vs in other phases of flight.





- **Manoeuvre Protection**

  The objective is to limit the load factor so as to allow the pilot to apply full sidestick deflection when high manoeuvrability is required.

  Load factor limits : + 2.5 g to –1 g in clean configuration
  + 2 g to 0 g flaps extended.

- **Attitude Protection**

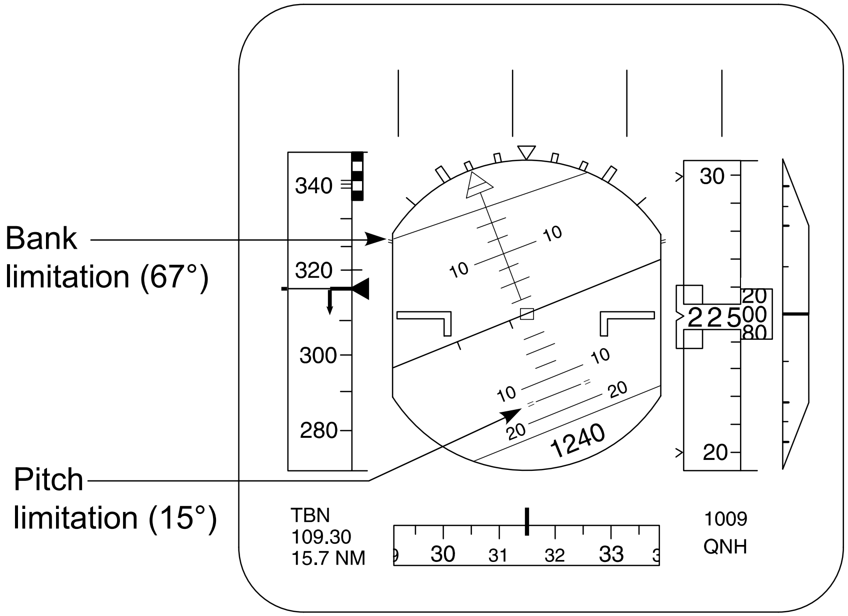
  The objective is to complement AOA and high speed protection in extreme conditions and in windshear.

  Bank is limited to : 33° stick released
  67° stick fully deflected.

  Pitch is limited to : 30° nose up
  15° nose down.

  If these limits are approached, the aircraft pitch and roll rate decrease and stop at the limit.

Primary Flight Display



- **Windshear protection**

  Windshear protection is ensured by:

  - SRS more
  - Speed trend indication
  - Wind (speed and direction indication)
  - Flight path vector
  - High angle of attack protection
  - Windshear warning (optional).

- **Low energy protection (basic on A318, A319 and A321)**

  - An audio warning “SPEED, SPEED, SPEED” is triggered to indicate to the crew that a thrust increase is necessary to recover a positive flight path angle through pitch control.

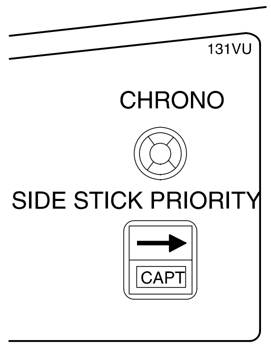
- **Load Alleviation Function (LAF) (only for A320)**

  - The load alleviation function is used in conditions of turbulence in order to relieve wing structure loads

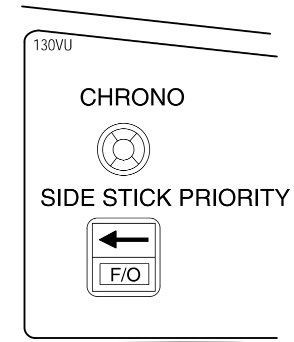
  - The LAF becomes active when the difference between aircraft load factor and pilot demanded load factor exceeds 0.3 g, in which case the ailerons and the spoilers 4 and 5 are deflected symmetrically upwards

  - The LAF is no longer necessary for A321, A319 and A318 which benefit from a reinforced structure.

Red
Green



Priority lights in front of CAPT and F / O



Red
Green

- Both sidesticks are coupled electronically to deal with:

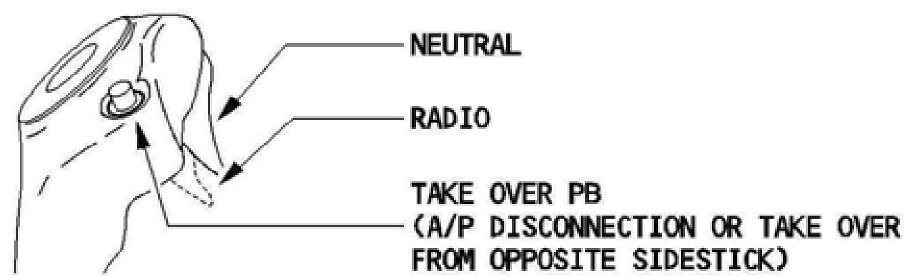
  - Simultaneous inputs
  - Conflicts.

- Full control is obtained by pressing and keeping pressed the take-over button, thereby deactivating the other pilot's stick.

- After pressing the take-over button for more than 40 seconds, it can be released without loosing priority.

- When both pilots press their take-over buttons, the last pilot to press will get the priority.

- onside priority can be maintained throughout by keeping the button pressed continuously for 40s.



A318/A319/A320/A321 EFCS Sidestick Priority Display Logic

Captain's side		First Officer's side	
Sidestick	Annunciation	Annunciation	Sidestick
Take-over button depressed	CAPT Green	Red	Sidestick deflected
Take-over button depressed	"Light off"	Red	Sidestick in neutral
Sidestick deflected	Red	Green F / O	Take-over button pressed
Sidestick in neutral	Red	"Light off"	Take-over button depressed

Red arrow in front of the pilot = loss of authority

Green light in front of the pilot = authority when opposite sidestick deflected

"PRIORITY RIGHT/LEFT" audio voice message when priority is taken.

A318/A319/A320/A321 EFCS Speed Brakes and Ground Spoilers

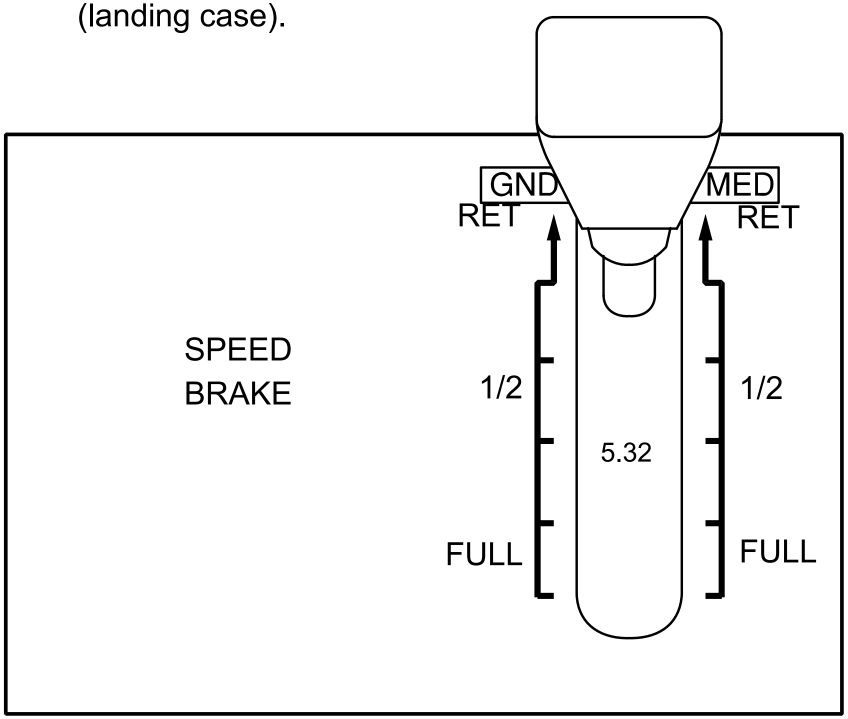
- **Speed Brakes**
  - Achieves by three surfaces (spoiler 2, 3, 4)
  - When the sum of a roll order and a simultaneous speed brake order on either surface is greater than the maximum deflection achievable, the symmetrical surface is retracted until the difference between both corresponding surfaces is equal to the roll order.

- If engine power is above idle, the "SPEED BRAKE STILL OUT" ECAM caution message is displayed.

- Speedbrakes are automatically retracted when :
  - Selection of flaps configuration FULL for A320 and A319 (or 3 or FULL for A321)
  - AOA protection is active
  - SEC1 and SEC 3 both have faults
  - An elevator (L or R) has a fault (in this case,only spoilers 3 and 4 are inhibited).
  - At least one thrust levers is above MCT position
  - Alpha Floor activation

- On A318, there is no longer automatic speedbrake retraction when configuration FULL is selected (to allow steep approach)
  However, the "SPEED BRAKE STILL OUT" ECAM caution will be triggered at landing for reminder

- **Ground Spoilers**
  - Achieves by spoilers 1 to 5
  - Preselection achieved:
    - With control handle in the armed position and both idle thrust selected, or
    - With one idle thrust selected and one reverse thrust selected, or
    - With speedbrakes still extended, CONF 3 or FULL selected, and both idle thrust selected (A318 only)
  - Maximal extension (50°) of all surfaces then automatically achieved when wheels speed >72kt (aborted take-off case), or the aircraft has touched down (landing case).

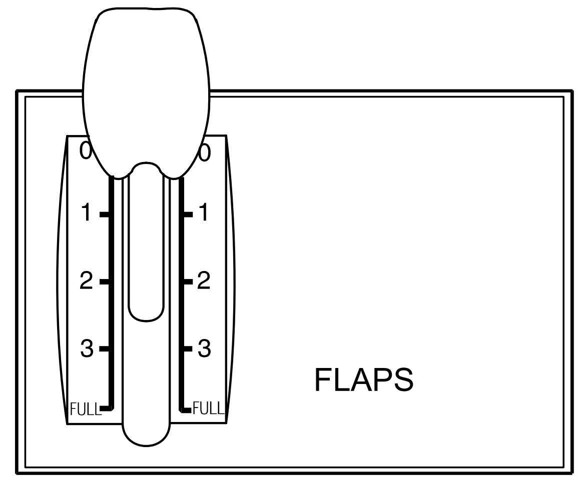


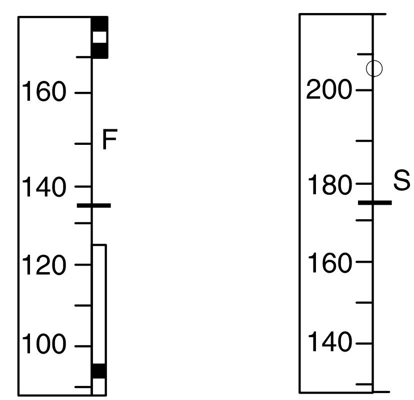
- Each wing has two flap surfaces and five slat surfaces
- The flaps lever selects simultaneous operation of the slats and flaps.
- The five positions of the lever correspond to the following surfaces positions and flight phases:

Position	Slats	Flats	Flight phases			ECAM
0	0°	0°		Hold	Cruise	
1	18°	0°			Approach	1
		10°	Take off			1+F
2	22°	15°(14°)		Approach		2
3	22°	20° (21°)			Landing	3
FULL	27°	35°* (25°)	Landing			FULL

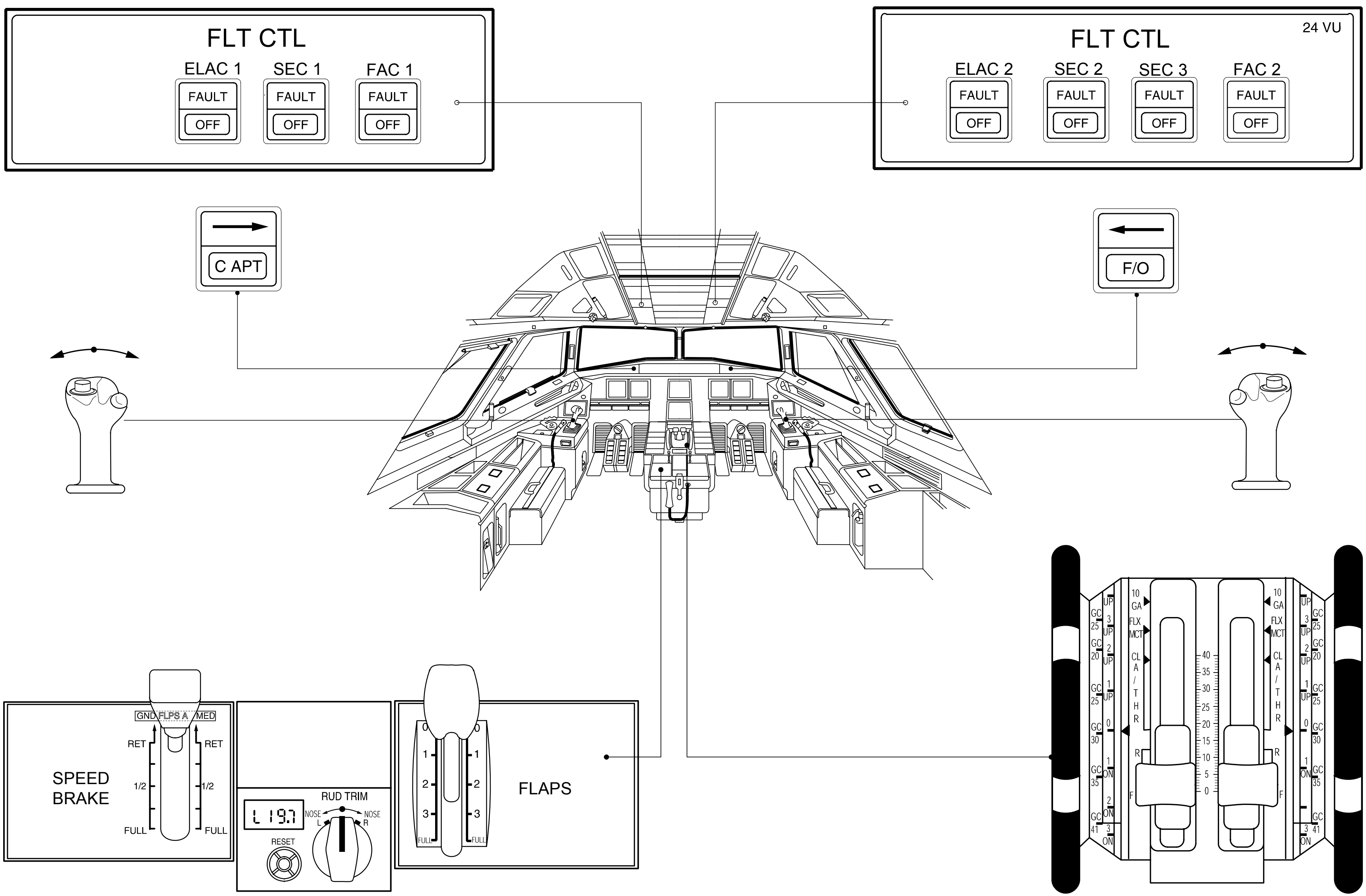
* : 40° for A320 with IAE engine or A319 and A318
() : setting for A321

- Computed by FACs, retraction speeds are presented on PFDs for:
  - Minimum flaps retraction or F -speed,
  - Minimum slats retraction or S -speed.



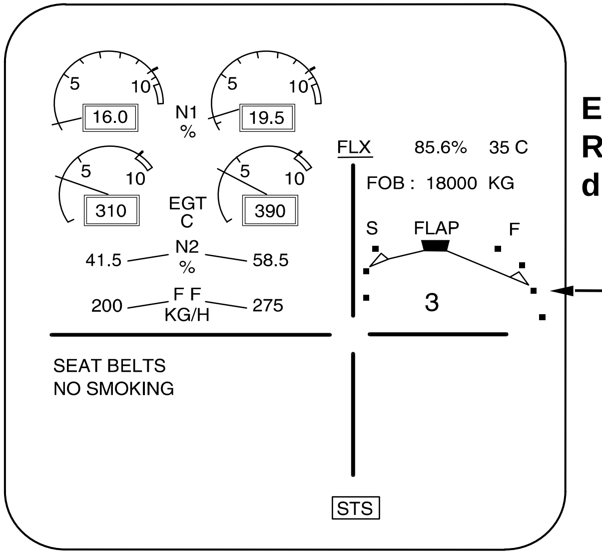


A318/A319/A320/A321 EFCS Controls



A318/A319/A320/A321 EFCS Indications

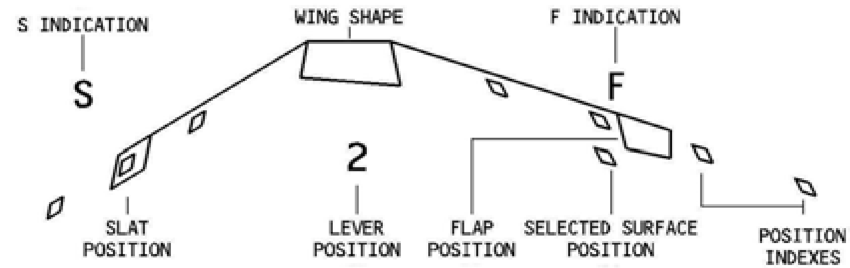
ECAM upper display



Slats/flaps indication

EIS 1 = Cathode Ray Tubes (CRT) displays

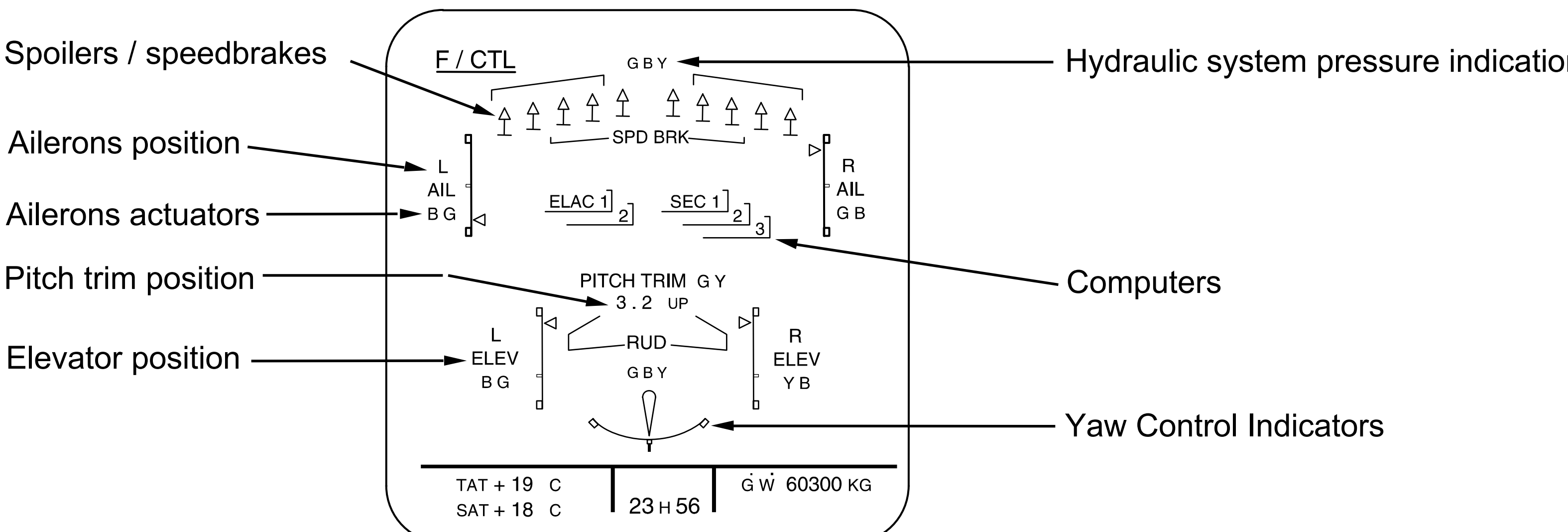
EIS 2 = Liquid Crystal Displays (LCD)



Slat/Flaps indication modified on the upper ECAM

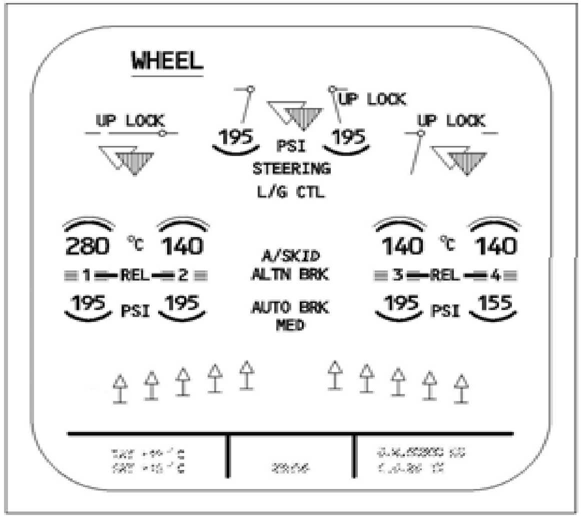
ECAM lower display

F / CTL page (ex: EIS1)

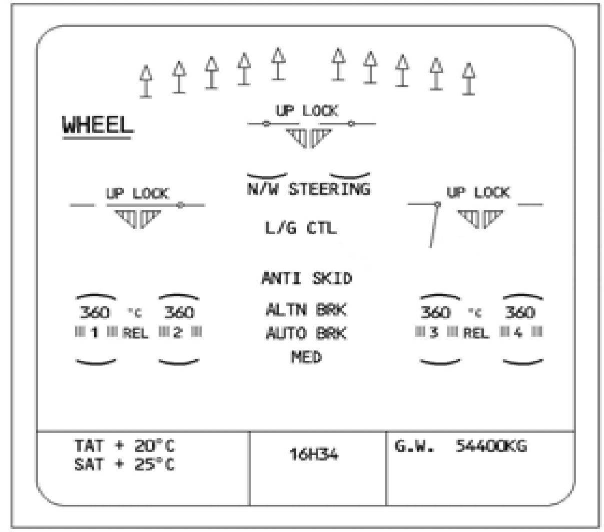


A318/A319/A320/A321 EFCS Indications

● WHEEL Page

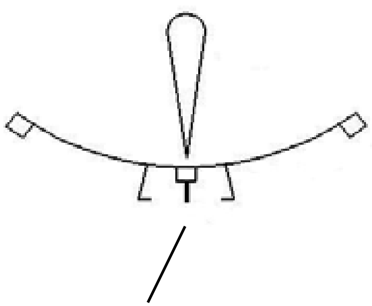


Electronic Instrument System (EIS) 1 = CRT displays



Electronic Instrument System (EIS) 2 = LCD

● A318 EFCS indications changes



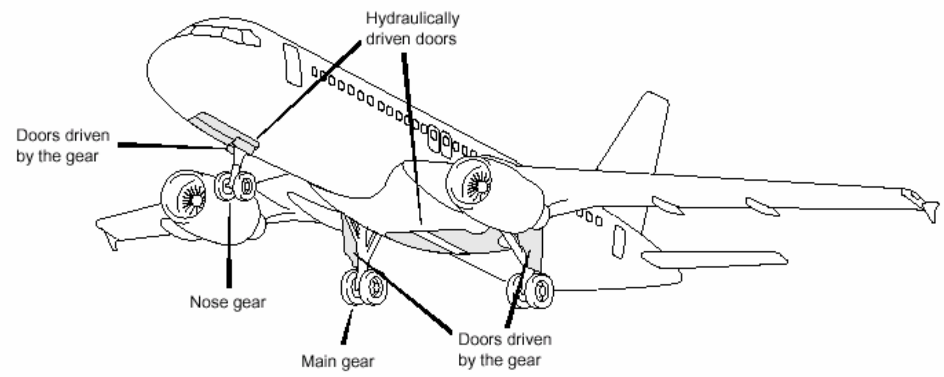
Rudder travel limiter position moves with the speed and altitude changes

6. Landing Gear

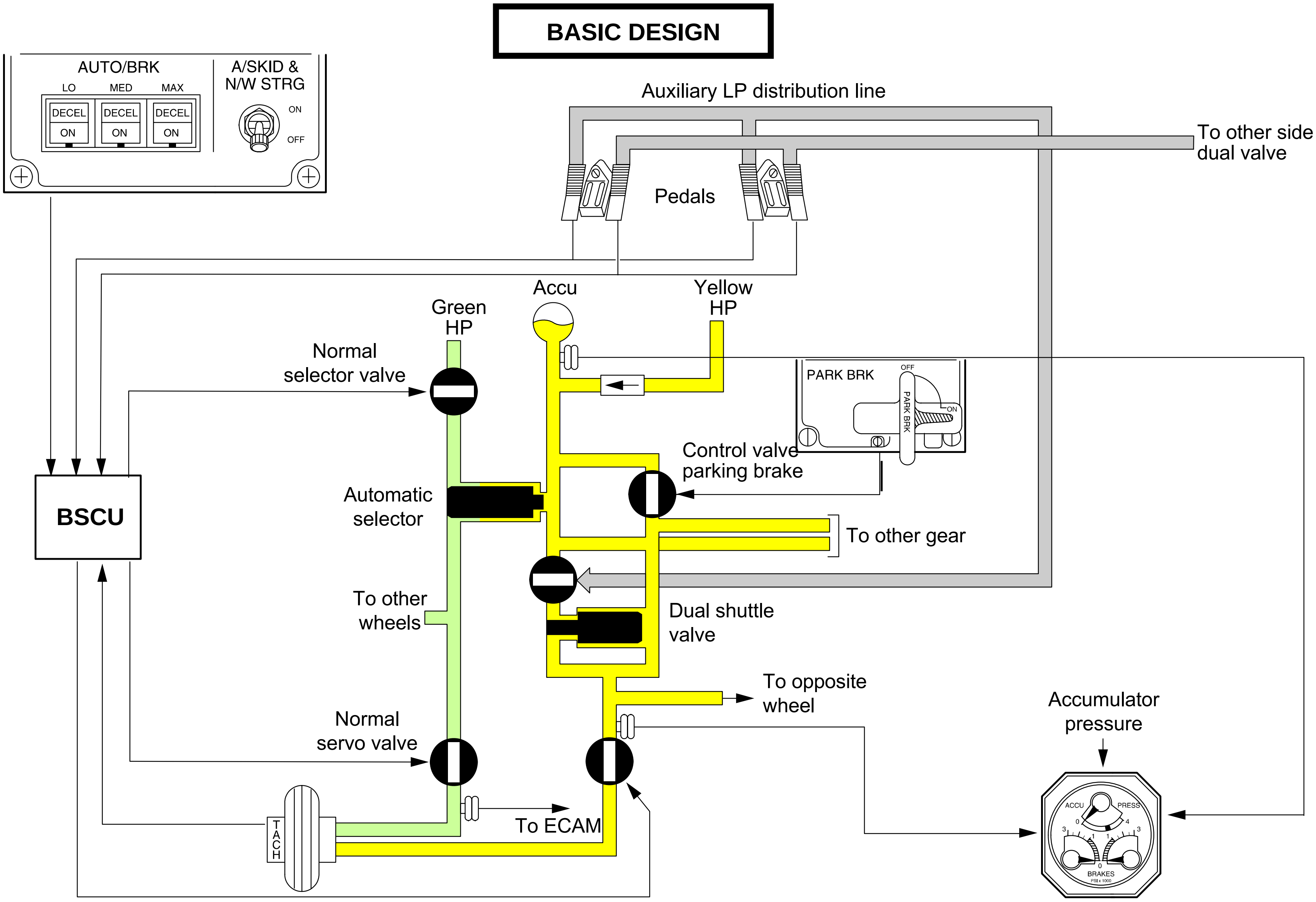
A318/A319/A320/A321 Landing Gear

Main Features

- Conventional diabolo or bogie (option) landing gear and direct-action shock absorbers.
- Main gear retracts laterally and nose gear forward into the fuselage.
- Electrically controlled by two Landing Gear Control/Interface Units **(LGCIU)**.
- Hydraulically actuated with alternative free-fall/spring downlock mode
- Alternating use of both LGCIUs for each retraction/extension cycle.
- LGCIUs also control the operation of the door and they supply information about the landing gear to ECAM for display
- When a LGCIU detects a fault in its own system, it automatically transfers control of the landing gear to the other LGCIU.
  Resetting the landing gear control lever results in transition to the other LGCIU
- Elimination of microswitches by use of trouble-free proximity detectors for position sensing.
- In case of loss of hydraulic systems or electrical power, a hand crank on the center pedestal allows to extend the landing gear by gravity.
- The landing gear is designed to achieve a life of 60000 landings. Endurance corresponding to safe-life operation in accordance with FAR and JAR requirements (no damage- tolerant concept).



A319/A320/A321 Landing Gear – Basic Braking System



- The Braking and Steering Control Unit **(BSCU)** is a fully digital dual-channel computer controlling the following functions:

  - Normal braking system control
  - Anti-skid control (normal and alternate)
  - Auto brake function with LO, MED, MAX
  - Nosewheel steering command processing
  - Monitoring of all these functions

- Carbon disk brakes are standard.

- Normal system (Green hydraulic system supply):

  - Electrically signaled through anti-skid valves
  - individual wheel anti-skid control
  - Autobrake function
  - Automatic switchover to alternate system in event of Green hydraulic supply failure.

- Alternate braking system with anti-skid (Yellow hydraulic system supply):

  - Hydraulically controlled through dual valve
  - Individual wheel anti-skid control
  - No autobrake function.

- Alternate braking system without anti-skid (Yellow hydraulic system supply or Yellow brake power accumulator):
  - Hydraulically controlled by pedals through dual valve
  - Brake pressure has to be limited by the pilot referring to the gauges
  - No autobrake function.
  - No anti-skid system

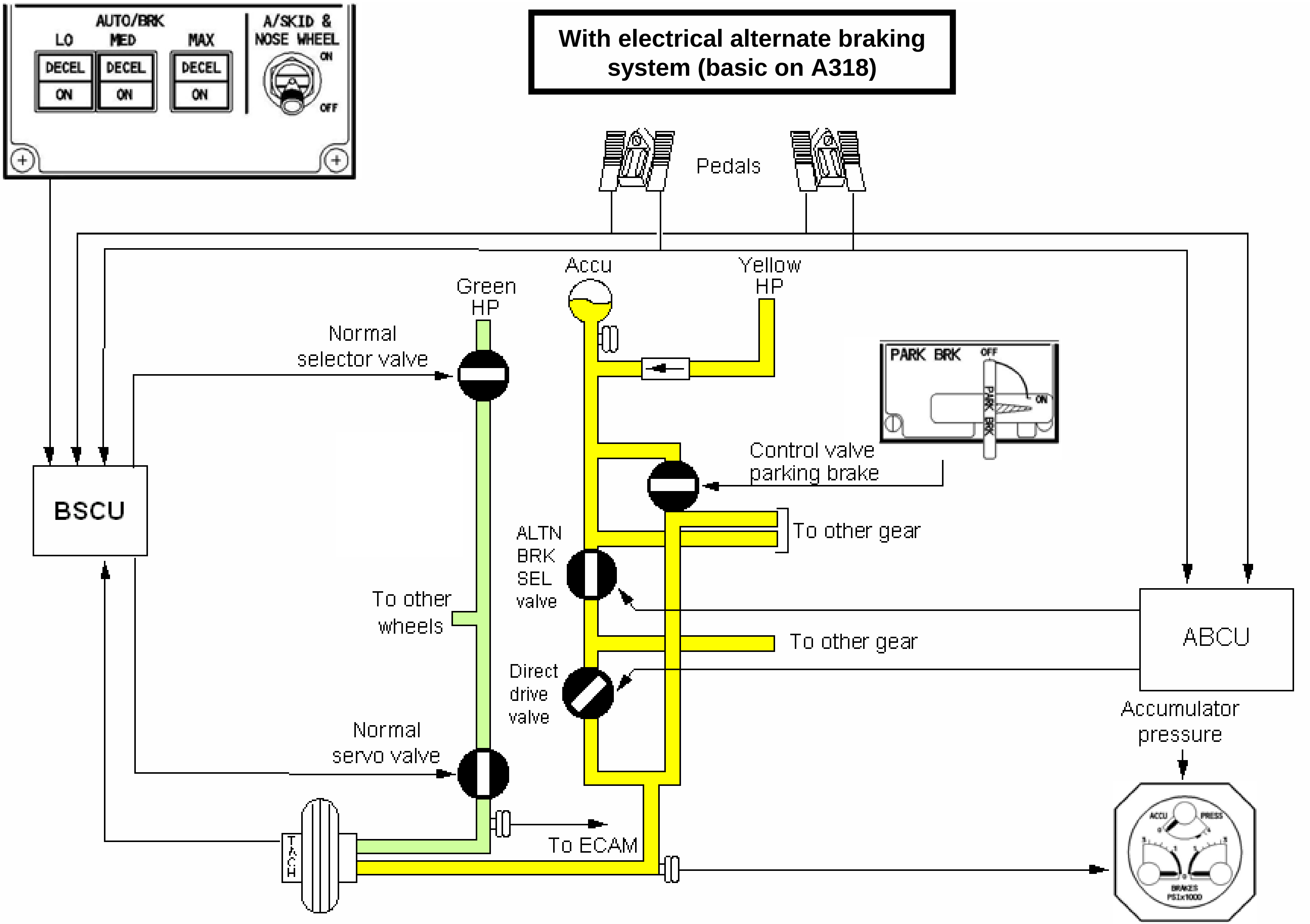
- Emergency braking system (Yellow hydraulic system supply or Yellow brake power accumulator):

  - Hydraulically controlled by pedals with brake pressure indication on gauges
  - No anti-skid control

- Parking brake (Yellow hydraulic system supply or Yellow brake power accumulator):

  - Electrically signaled
  - Hydraulically controlled with brake pressure indication on gauges.

A318/A319/A320/A321 Landing Gear - Enhanced Braking System



A318/A319/A320/A321 Landing Gear - Enhanced Braking System

- Braking philosophy is the same as for the basic braking system but alternate braking is fully electrical.

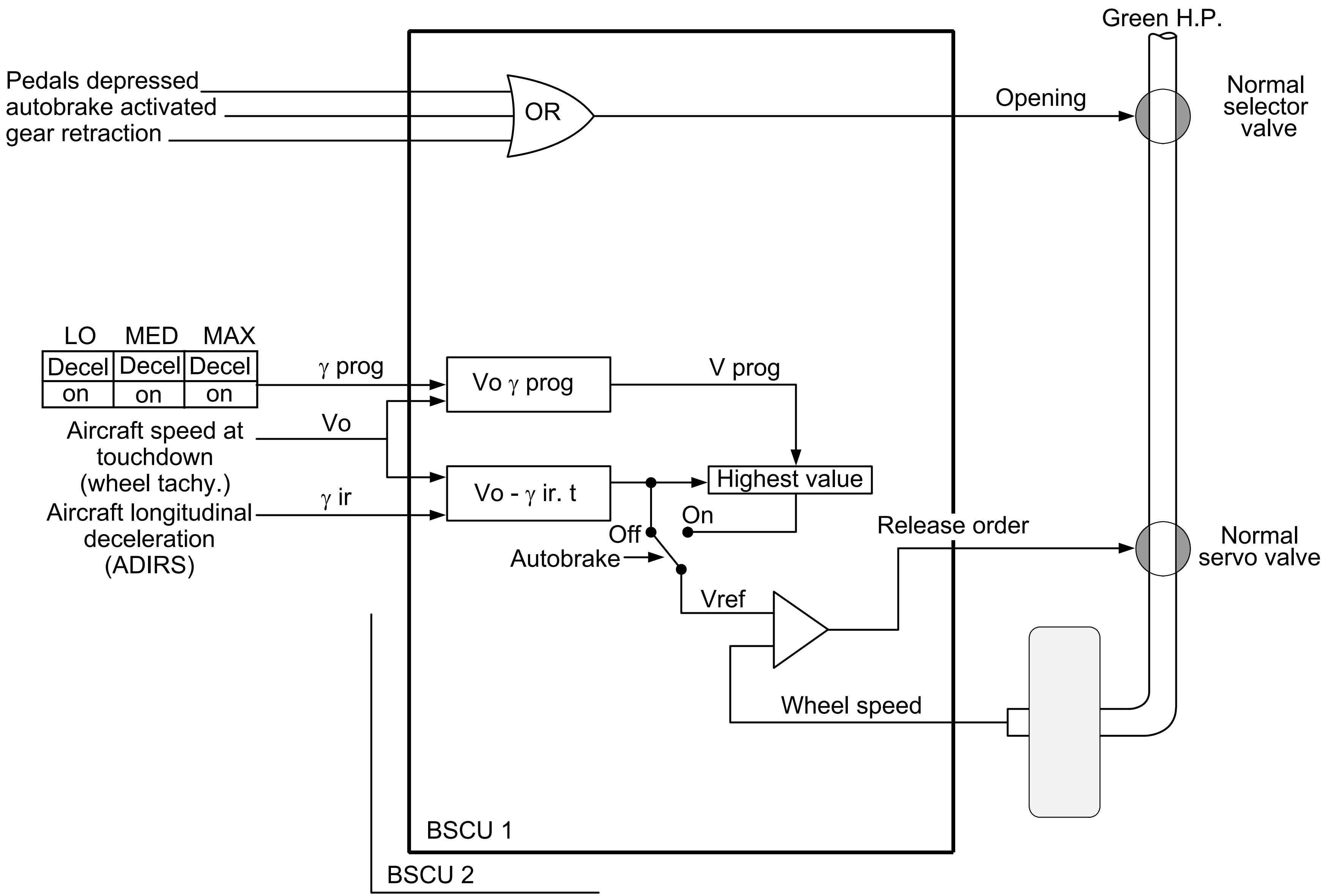
- Alternate braking system with anti-skid (Yellow hydraulic system supply):
  - Electrical orders are made by brake pedals, and are provided to the Alternate Brake Control Unit (ABCU).
  - ABCU energizes the alternate brake selector valve to pressurize the yellow hydraulic circuit
  - ABCU electrically controls the Alternate Servo Valve to obtain the correct pressure for the related brakes.

- Alternate braking system without antiskid:
  - Electrical control provided by the ABCU independently from the BSCU.
  - Brake pressure is automatically limited to 1000 PSI by ABCU, in order to protect wheels against blocking and tire burst.

- Parking brake (Yellow hydraulic system supply or Yellow brake power accumulator):
  - Similar to basic braking design

- Alternate Brake Control Unit (ABCU):
  - Automatically tests all hydraulic components of the alternate braking system at landing gear extension
  - Provides an ECAM warning, when the alternate braking system is failed

A318/A319/A320/A321 Landing Gear – Anti-Skid Principle



Anti-Skid System

- The anti-skid system produces maximum braking efficiency by maintaining the wheels just short of an impending skid.

- From touchdown, aircraft speed is computed based on touchdown speed (wheels) and integrated deceleration (ADIRS). This reference speed is compared with each wheel speed to generate a release order for closing the normal servo valve in case of skid exceeding 13%.

- Brake pedals order results in opening this servovalve also modulated by anti-ski closing signals.

Autobrake system

- This system allows:
  - To reduce the braking distance in case of an aborted takeoff
  - To establish and maintain a selected deceleration rate during landing, thereby improving passenger comfort and reducing crew workload.

- From touchdown a specific speed is computed based on touchdown speed (wheels) and programmed deceleration (low, medium, max). This programmed speed is compared with each wheel speed to generate a release order for closing the normal servovalve to meet selected deceleration.

- If reference speed exceeds programmed speed (contaminated or iced runways) the former will take over for the anti-skid to modulate the normal servo valve.

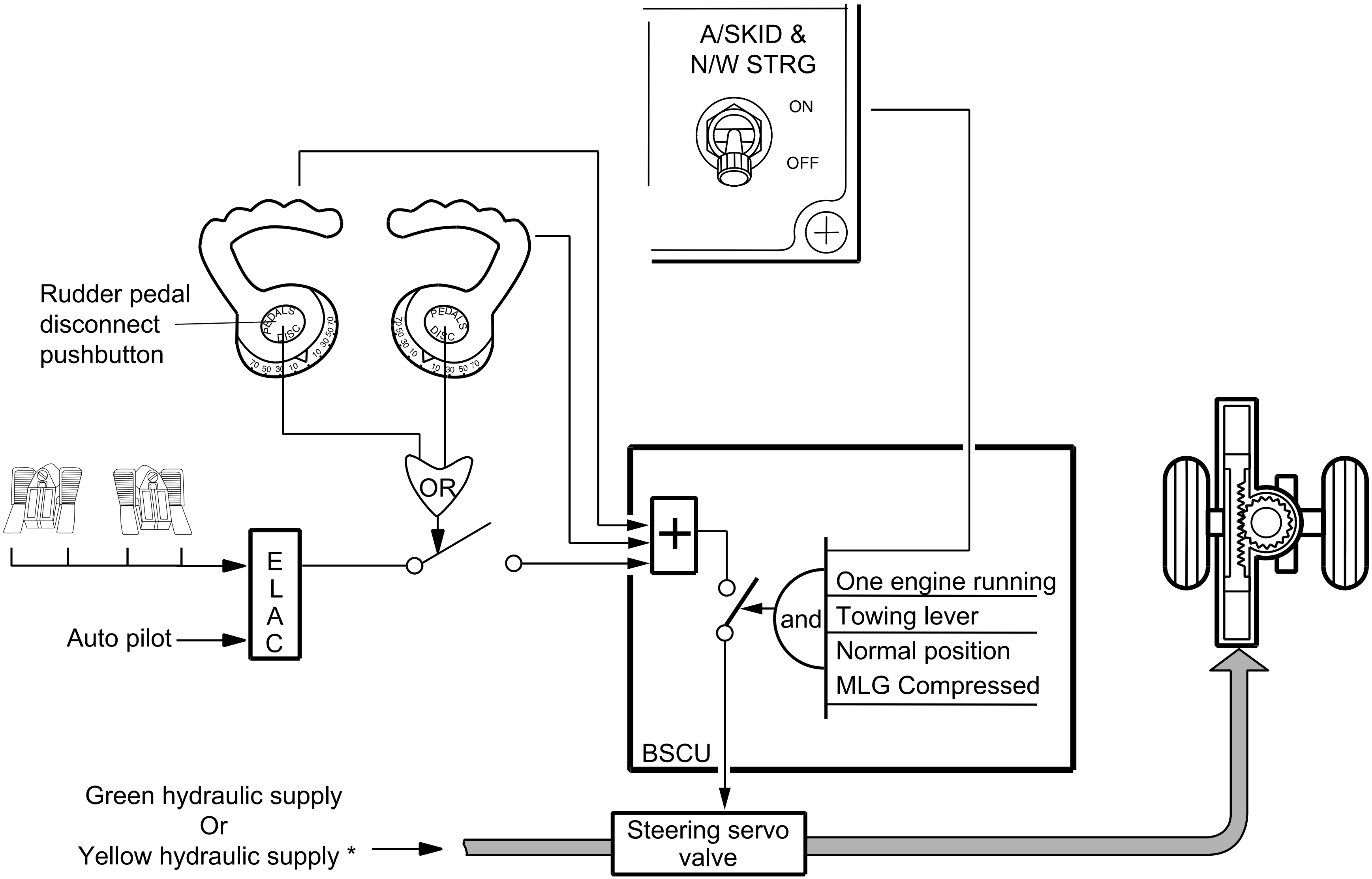
Enhanced autobrake system (basic on A318)

- Enhanced autobrake function
  - Enhanced accuracy in achieving the selected deceleration rate
  - Perfect level of comfort maintained
  - Enhanced pressure monitoring for all brakes (more consistent temperatures in all brakes)

- MED deceleration is only controlled when the Nose gear is on ground.

- Arming/engagement logics:
  A/B MAX mode cannot be selected in flight and cannot be engaged on ground below 40 kts.

A318/A319/A320/A321 Landing Gear - Nose Wheel Steering Principle



* *With enhanced Nose Wheel Steering system*

A318/A319/A320/A321 Landing Gear - Nose Wheel Steering Principle

Description

- The hydraulic system supplies pressure to the cylinder. Electric signals from the Brake and Steering Control Unit (BSCU) control it.
- The BSCU transforms orders into nose wheel steering angle.

- Angles are limited : - Normal operating angle ± 75°
  - Aircraft towing, steering angle ± 95°
  - Rudder pedals ± 6°

- After take-off, an internal cam mechanism inside the shock-absorber returns the wheels to center position and the hydraulic supply is cut off at gear retraction.

Nose Wheel Steering changes due to the enhanced Nose Wheel Steering system (basically fitted on A318):

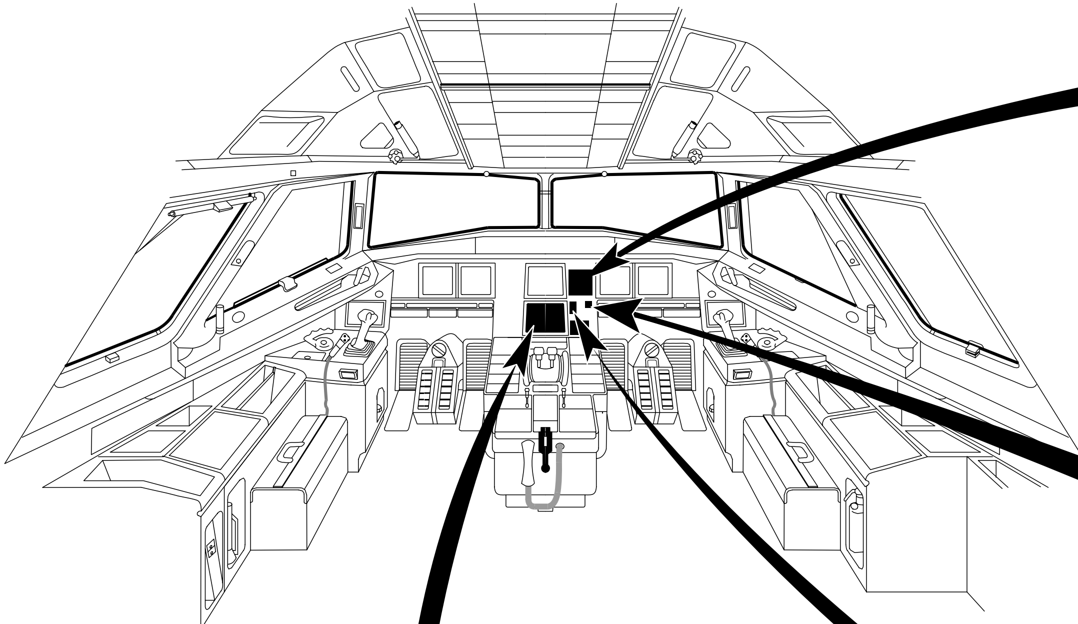
- Objectives:
  - Avoid simultaneous loss of Normal braking and nose wheel steering functions on a single hydraulic failure.
  - Avoid loss of nose wheel steering function due to ADIRU or LGCIU failure.
  - Make the nose wheel steering function available after a landing gear free fall extension.

- Modifications:
  - The hydraulic power supply has changed. The Yellow hydraulic system has replaced the Green hydraulic system.

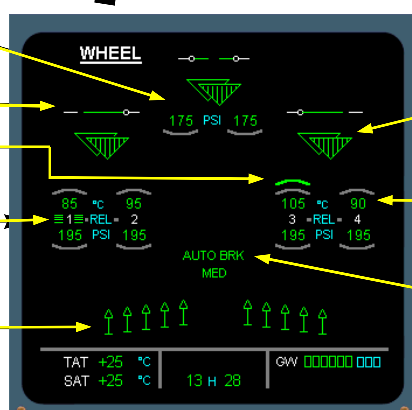
  - The BSCU software has been modified due to changes of hydraulic power supply, associated logics and monitoring have evolved.

  - Modified warnings associated to nose wheel steering on Yellow hydraulic system.

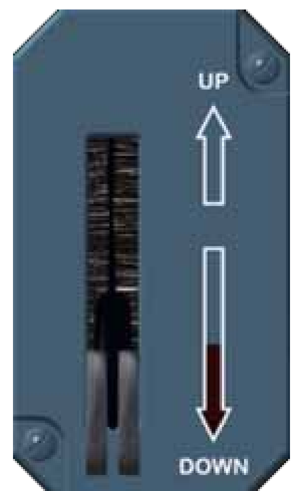
A318/A319/A320/A321 Landing Gear - Display



Autobrake panel and gear position indicator (System 1)



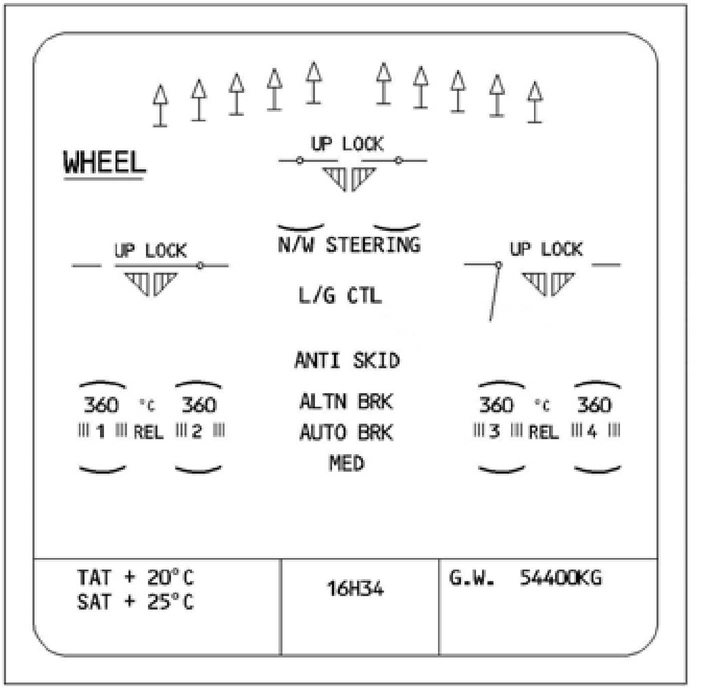
Wheel system page



Brake pressure indication (alternate system)

The enhanced Brake and Steering Control System and the new Electronic Instrument System with LCD technology (EIS 2) instead of cathode ray tube (EIS1), involve new Brake Warnings and Indications. Both enhanced systems are basic on A318.

- Alternate braking is now fully monitored.
Warnings are more explicit and there is no need for alternate braking before taxiing.



New Brake Warnings

- BRAKES NORM BRK FAULT
  Loss of the NORMAL brake mode
- BRAKES ALTN BRK FAULT
  Complete loss of the ALTERNATE brake mode
- BRAKES NORM + ALTN BRK FAULT
  Loss of all means of braking from pedals (park brake available)
- BRAKES BRK Y ACCU LO PR
- BRAKES / NWS MINOR FAULT
- BRAKES ALTN L(R) RELEASED
  Loss of alternate braking on one main landing gear.
  → If normal braking is also lost, the new "ASYMMETRIC BRAKING" paper procedure must be applied
- BRAKES RELEASED

A318/A319/A320/A321 Landing Gear - Display

Example of Landing gear system page with LCD ECAM (EIS 2)

Both BSCU channels available

Both green and yellow hydraulics not available

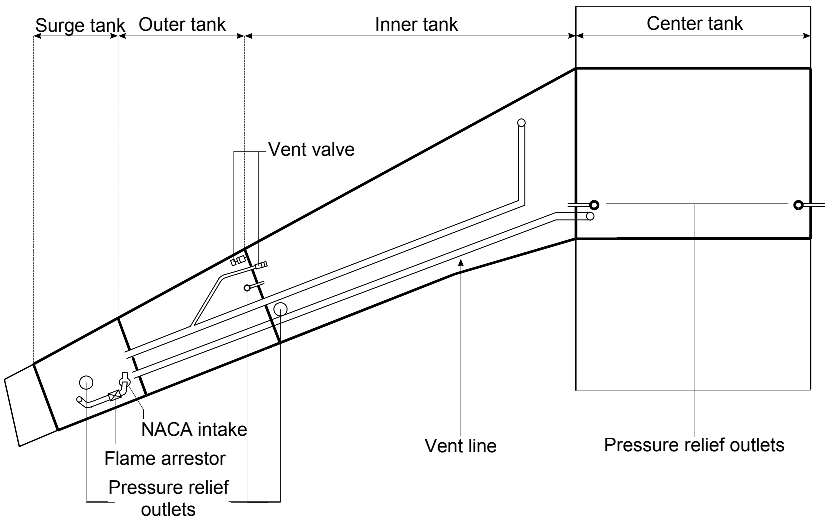
The ALT braking is available thanks to the accumulator power supply

Both BSCU channels not available

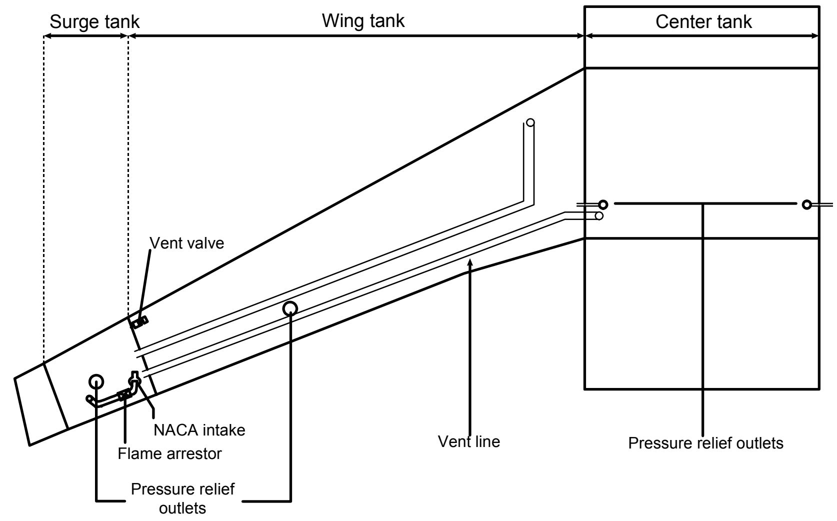
Both green and yellow hydraulics available

7. Fuel System

A318/A319/A320



A321



A318/A319/A320/A321 Fuel System – Basic Layout

- **Total Fuel Capacity**

A318 / A319 / A320	
Two outer tanks	1 760 liters (1 408kg)
Two inner tanks	13 849 liters (11 079kg)
One center tank	8 250 liters (6 600kg)

A321	
Two wing tank	15 500 liters (12 400kg)
One center tank	8 200 liters (6 560kg)

(Weight calculated with a density of 0.8)

An additional center tank (optional) increases the total fuel capacity by: 2 992 liters (2 393kg) for A318/A319/A320; 2 900 liters (2 320kg) for A321.

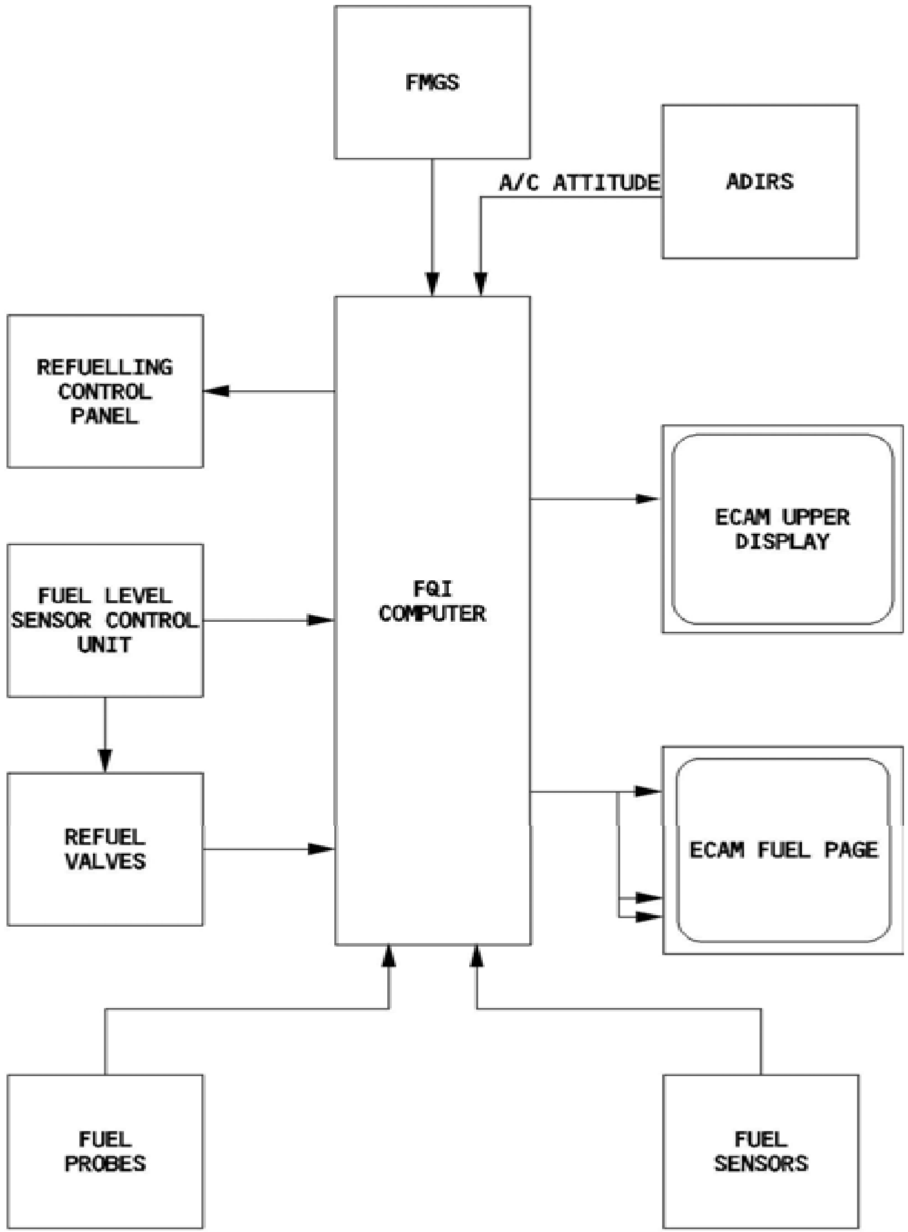
On the A319 Corporate Jet, up to 6 additional center tanks can be added to increase the total fuel capacity by up to 16 781 liters.

An additional volume of 2% is available for expansion without spillage into the vent surge tank.

- **Ventilation**

  - Each tank is separately ventilated via surge tanks at each wing tip.
  - The center tank is ventilated via the LH surge tank.
  - The surge tanks are opened to atmosphere via flame arrestors and NACA inlets.
  - Vent valves ensure correct operation of the vent system.
  - Pressure relief outlets protect the tanks from over- or under- pressure.

A318/A319/A320/A321 Fuel System – Control and Monitoring



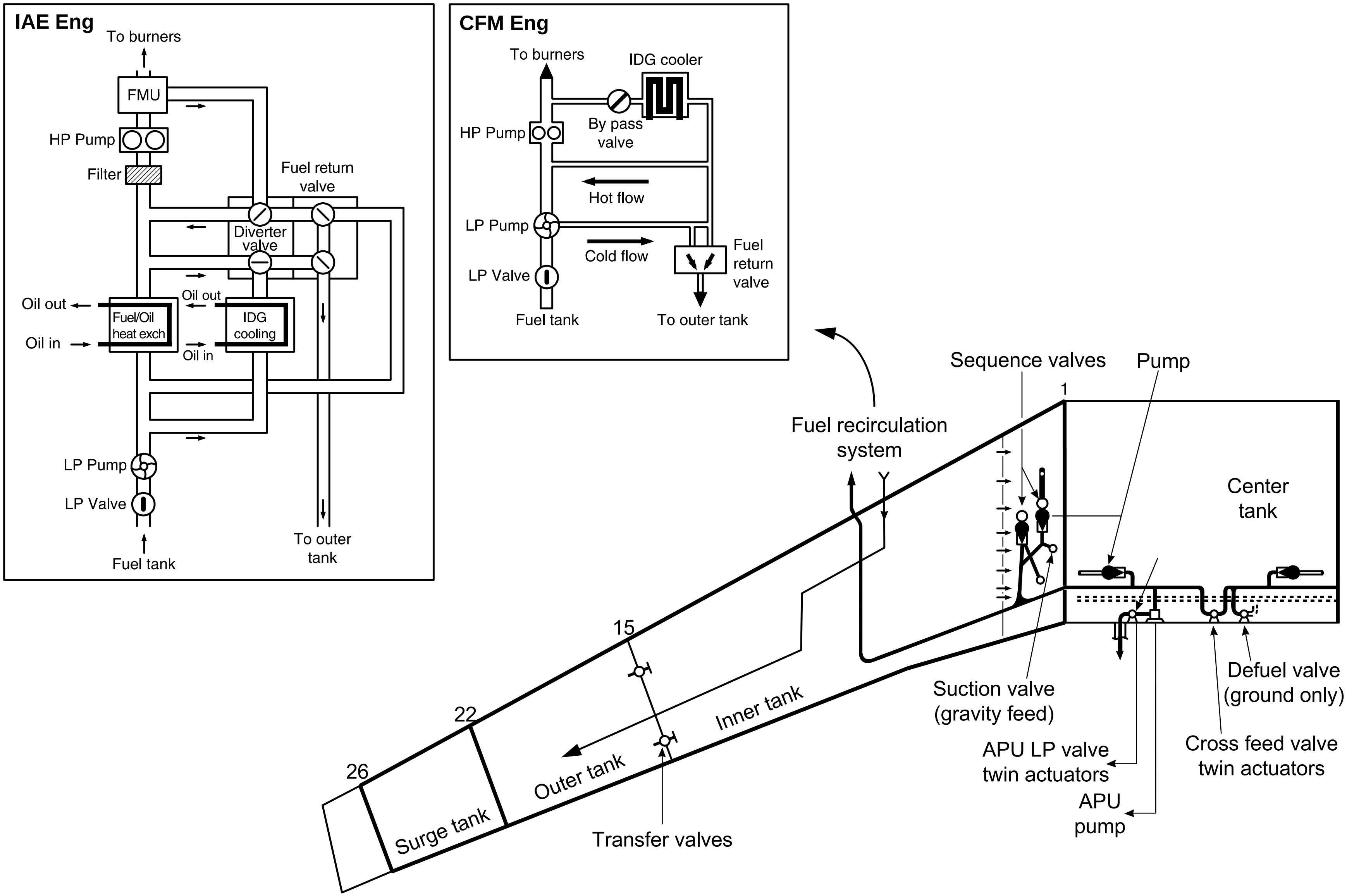
A318/A319/A320/A321 Fuel System – Control and Monitoring

- The Fuel System is automatically controlled by the Fuel Quantity Indication Computer (FQIC).

- This computer assures functioning of the Fuel Quantity Indication System (FQIS) and the two Fuel Level Sensor Control Units (FLSCU).

- FQIS and FLSCU provide:
  - Fuel quantity measurement and indication
  - Fuel transfer control
  - Level sensing
  - Fuel temperature indication
  - Refuel/defuel control
  - Signals to FADEC for IDG cooling control

A318/A319/A320 Fuel System – Engine Feed



A318/A319/A320 Fuel System – Engine Feed

A318/A319/A320 Definition

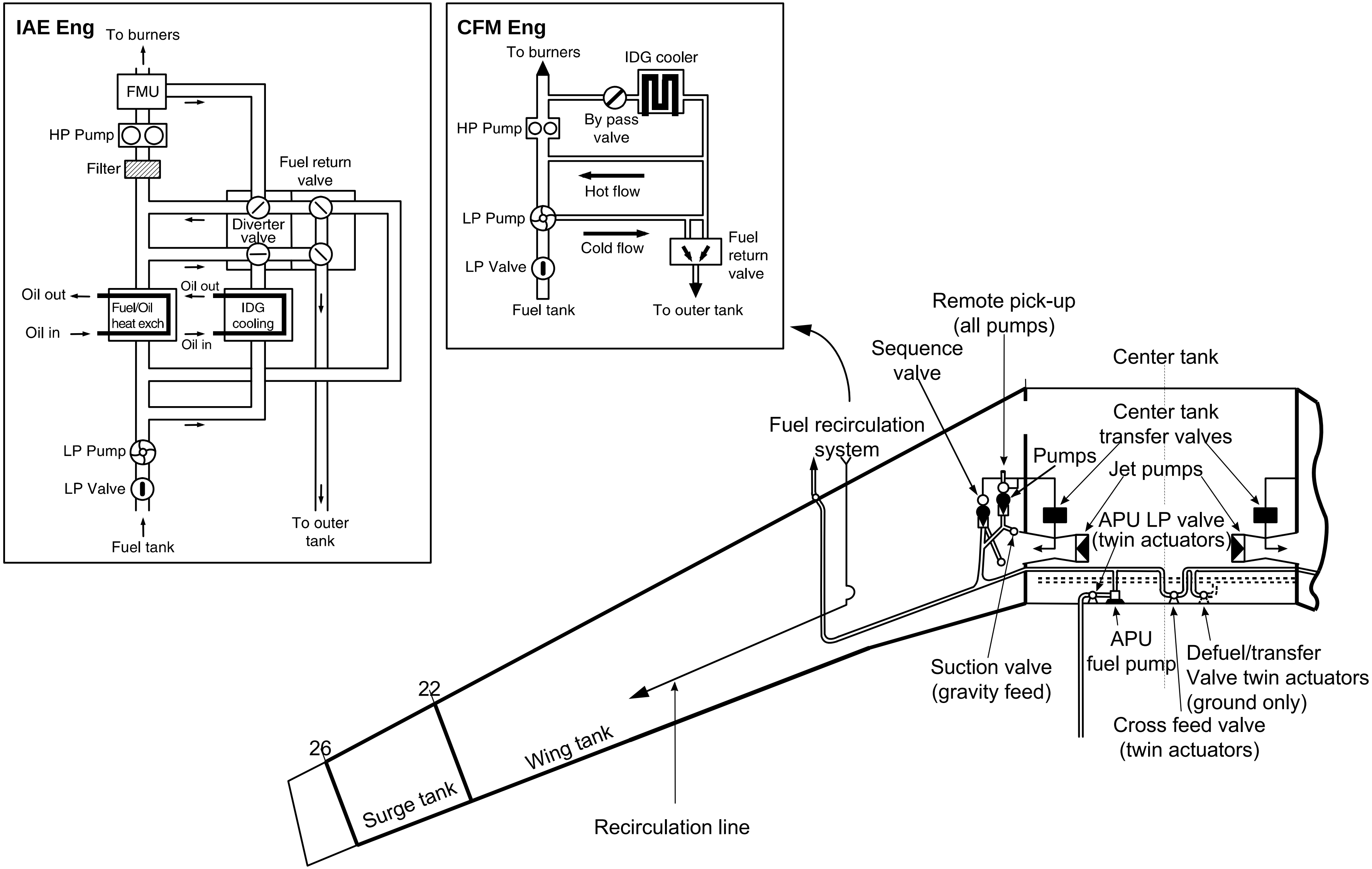
- Fuel is delivered to the engines by means of booster pumps.

  - Each tank is equipped with two identical booster pumps.
  - Center tank feeds first, except during take-off and fuel recirculation when center tank pumps are switched off automatically.
  - Wing tank pumps operate permanently at a lower pressure than center tank pumps.
  - Thus, when center tank pumps stop, engine feed comes automatically from wing tank pumps.

- Two electrical transfer valves are installed on each wing.
  They automatically open when the inner tank fuel reaches a low level (about 750kg) for fuel to drain from the outer to the inner tanks.

- Fuel is recirculated automatically and transparently to the crew:
  It ensures the IDG cooling (CFM and IAE eng.) and the engine oil cooling (IAE only) through a set of valves controlled by the FADEC.

A321 Fuel System – Engine Feed



A321 Fuel System – Engine Feed

A321 Definition

The A321 fuel system has been simplified compared to the A318/A319/A320:

- Single wing tank in place of two cells wing tank, suppression of the outer/inner tanks transfer valves.

- Center tank transfer to wing tank in place of center tank feed to engines:

  When the transfer valves are open, fuel tapped from the wing pumps flows into the center tank jet pumps. It creates a depressurization which sucks the center tank fuel into the wing tanks

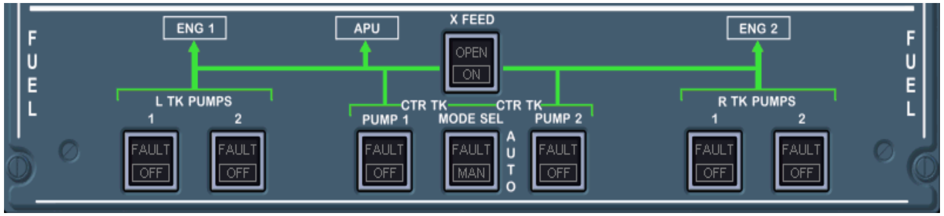
  - A transfer valve automatically closes when the related wing tank is overfilled or when the center tank is empty.

  The fuel recirculation principle is identical to A318/A319/A320, the recirculated fuel being returned into the wing tank.

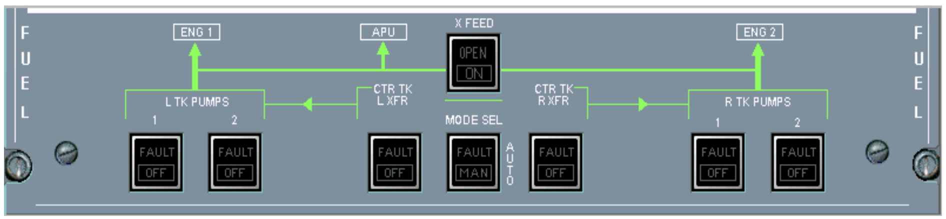
A318/A319/A320/A321 Fuel System – Control and Display

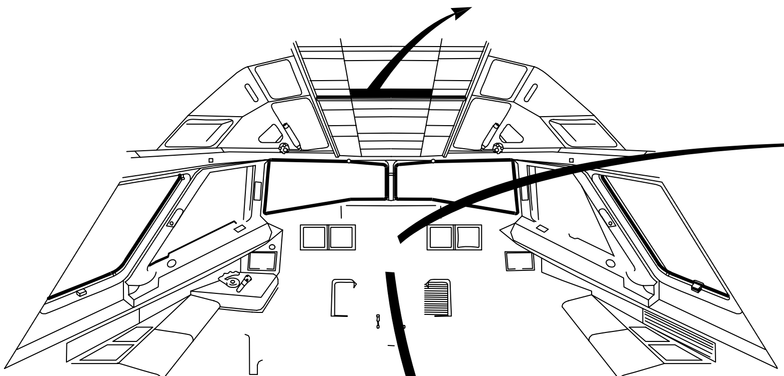
OVERHEAD PANEL

A318/A319/A320

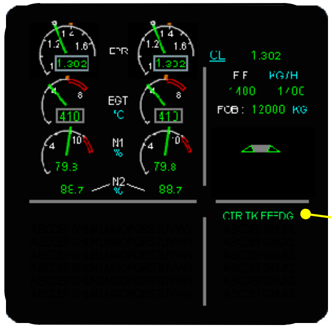


A321



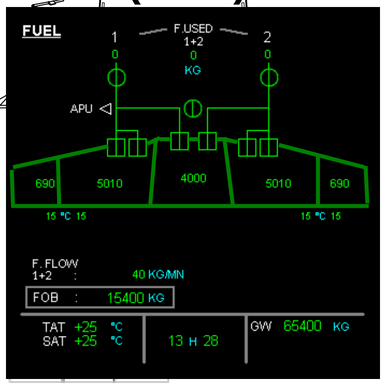


UPPER ECAM (EIS1)



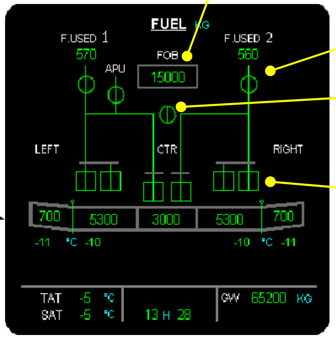
Memo indications: systems temporarily used

A318/A319/A320 (EIS2)



LOWER ECAM (EIS1)

A318/A319/A320



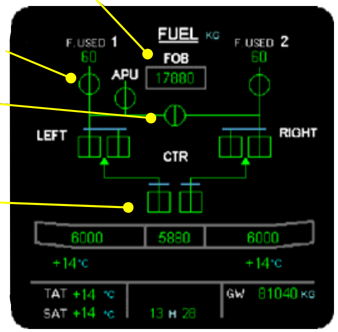
Fuel on board

Low pressure valve

Cross-feed valve

Pumps indication

A321



A318/A319/A320/A321 Fuel System – Control and Indications

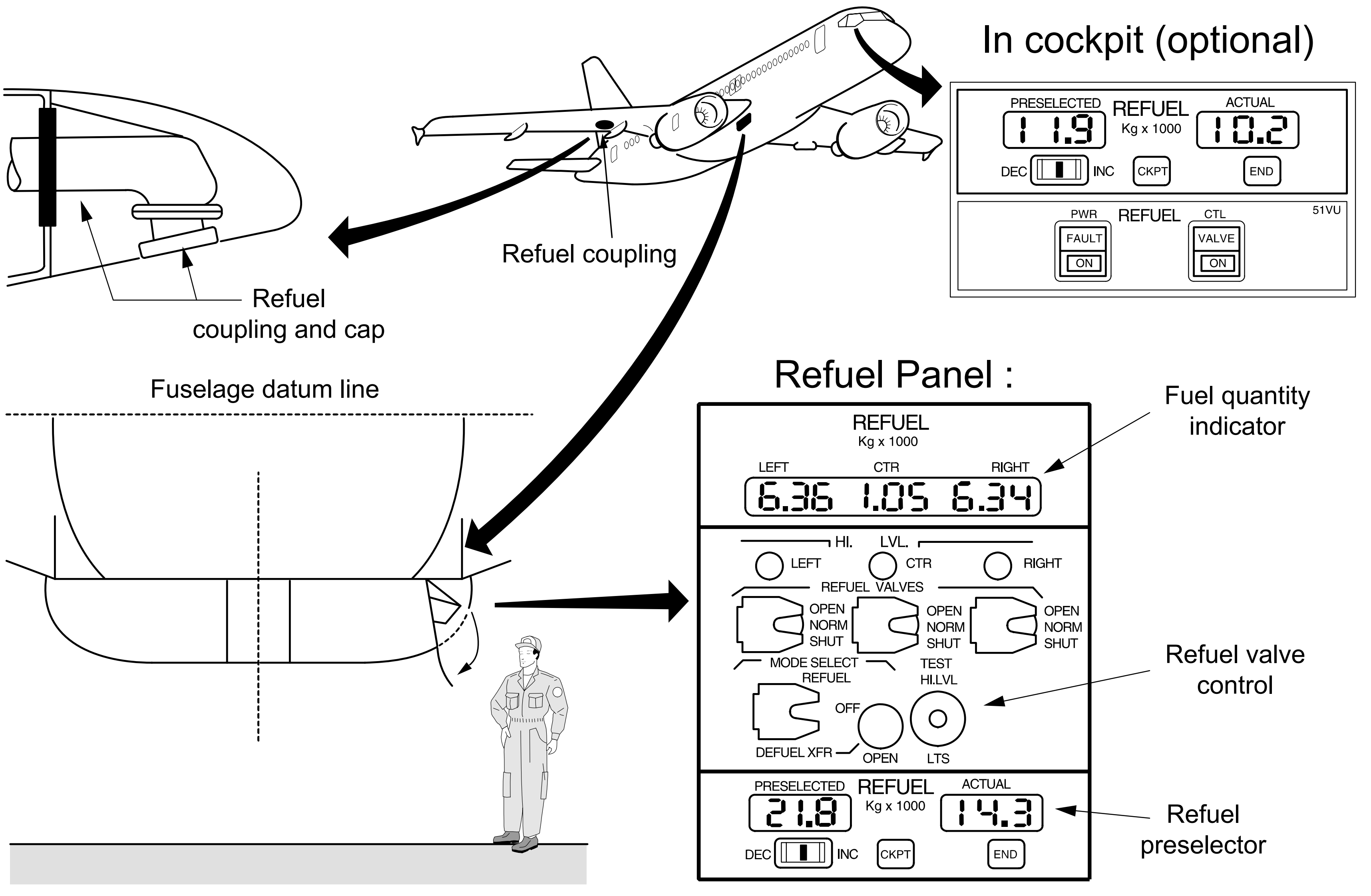
- No crew action is required for normal operation.

- Indications:

  - Fuel data (quantity, temperature) are available from a Fuel Quantity Indication **(FQI)** system
  - Fuel quantity is permanently displayed on upper ECAM DU
  - Fuel system synoptic on lower ECAM DU is displayed according to ECAM logic
  - Low level warning is totally independent from FQI.

- Abnormal operations:

  - Fuel feed sequence may be operated manually
  - One or both engines may be fed from any tank via cross-feed valve
  - Gravity feed is possible from wing tanks.

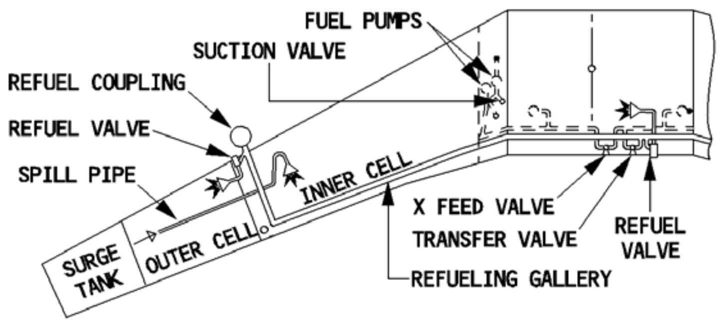


In cockpit (optional)
PRESELECTED
REFUEL
Kg x 1000
ACTUAL
11.9
10.2
DEC
INC
CKPT
END
PWR
REFUEL
CTL
51VU
FAULT
ON
VALVE
ON
Refuel coupling
Refuel
coupling and cap
Fuselage datum line
Refuel Panel :
REFUEL
Kg x 1000
LEFT
CTR
RIGHT
6.36
1.05
6.34
HI. LVL.
LEFT
CTR
RIGHT
REFUEL VALVES
OPEN
NORM
SHUT
MODE SELECT
REFUEL
OFF
DEFUEL XFR
OPEN
TEST
HI.LVL
LTS
PRESELECTED
REFUEL
Kg x 1000
ACTUAL
21.8
14.3
DEC
INC
CKPT
END
Fuel quantity
indicator
Refuel valve
control
Refuel
preselector

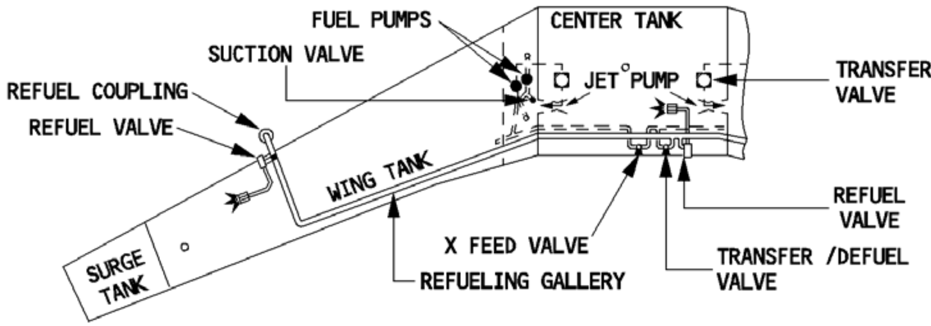
- Refuel/defuel control is performed from external panels located in the fuselage fairing under the RH wing within easy reach from the ground.
- One refuel/defuel coupling is located under the RH wing.
- Identical coupling on LH wing is available as an option.
- Refuelling is auto sequenced:

  It starts with the outer tanks (A318/A319/A320) or the wing tanks (A321).
  If the selected fuel quantity exceeds the wing tank capacity, the center tank is refuelled simultaneously.
- Refuelling time at nominal pressure is approximately 25 minutes for all tanks.
- Gravity refuelling can be achieved by overwing refuelling points.

A318/A319/A320



A321



8. Engine Controls

A318/A319/A320/A321 Engine Controls - FADEC

- Thrust control is operated through Full Authority Digital Engine Control **(FADEC)** computers which:

  - Command the engines to provide the best suited power to each flight phase
  - Automatically provide all the associated protection required:
    -Either in manual (thrust lever)
    -Or in automatic (autothrust) with a fixed thrust lever.

- Engine performance and safety better than with current hydromechanical control system.

  Simplification of engine/aircraft communication architecture.

  Reduction of crew workload by means of automatic functions (starting, power management).

  Ease of on-wing maintenance.

- The system design is fault-tolerant being fully duplicated, with “graceful degradation” for minor failures (i.e. sensor failures may lose functions but not the total system).

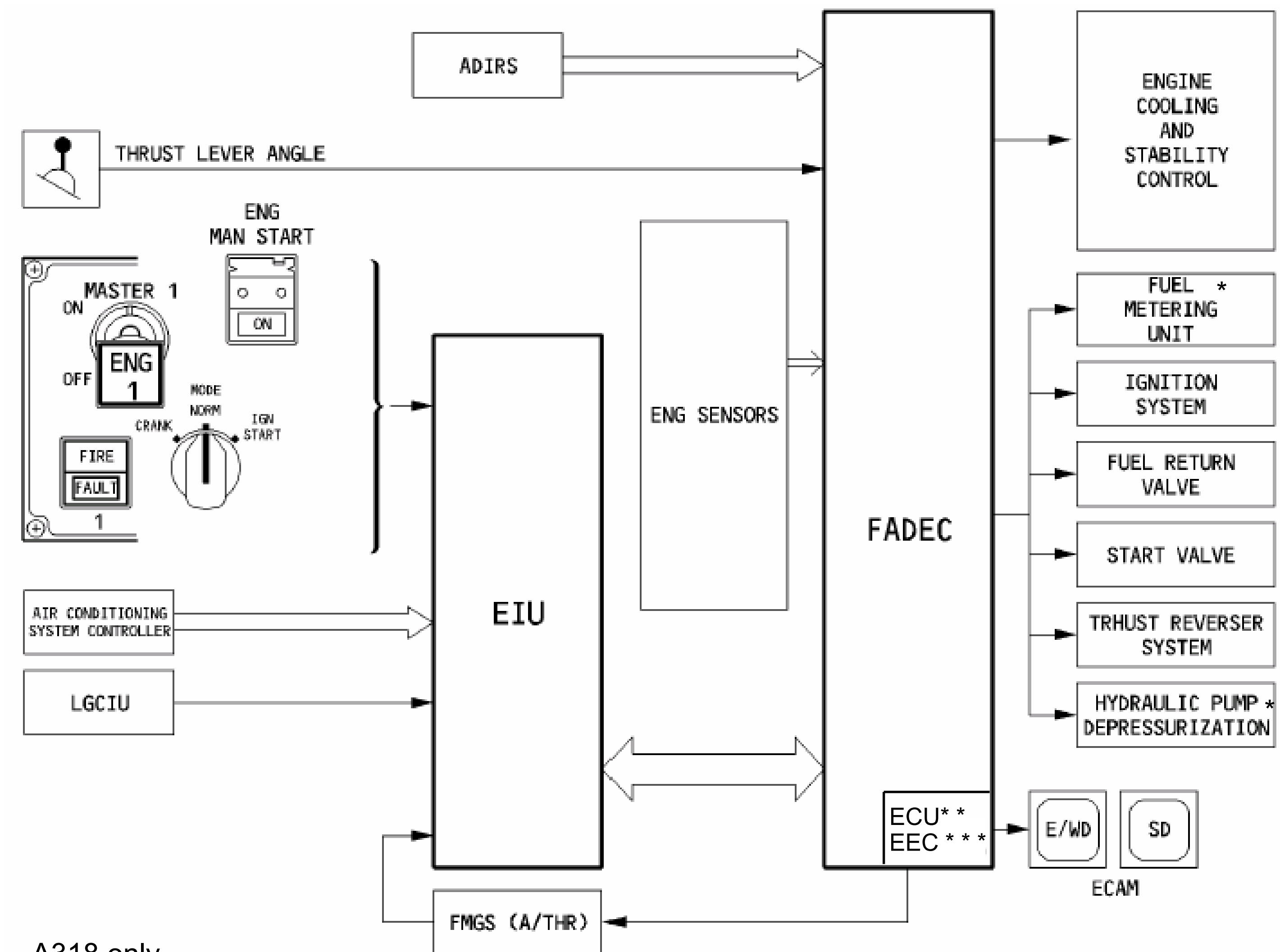
  The engine shut-down rate resulting from FADEC failures will be at least as good as today’s latest hydromechanical systems with supervisory override.

- FADEC is an electronic system which incorporates a fully redundant Engine Control Unit **(ECU)** for aircraft equipped with CFM engine or Electronic Engine Control **(EEC)** for aircraft equipped with IAE/PW engine and an Engine Interface Unit **(EIU)**.

  Each engine is equipped with a FADEC which provide the following operational functions:

  - Gas generator control
  - Engine limit protection
  - Engine automatic starting
  - Engine manual starting
  - Power management
  - Engine data for cockpit indication
  - Engine condition parameters
  - Thrust reverser control and feed back.
  - Fuel recirculation control
  - Detection, isolation and recording of failures
  - FADEC cooling

A318/A319/A320/A321 Engine Controls – FADEC Architecture



* A318 only
* * CFM Eng
* * * IAE/PW Eng

A318/A319/A320/A321 Engine Controls – FADEC and EIU

FADEC

● One FADEC is located on each engine with dual redundant channels (active and standby). Each channel have separate 28V DC aircraft power sources to ensure engine starting on ground and in flight.

● In addition dedicated FADEC alternator assures self power above 15% N2 for CFM56 (15% N2 for IAE V2500, 10 % N2 for PW 6000).

● **Characteristics**

- Dual redundancy for electrical input devices (ADIRS 1+2, TLAs, engine parameters).

- Dual redundancy for electrical part of control actuator.

- Simple system for hydromechanical parts of the control.

- Fault tolerance and fail operational capability.

- High level of protection against electromagnetic disturbance.

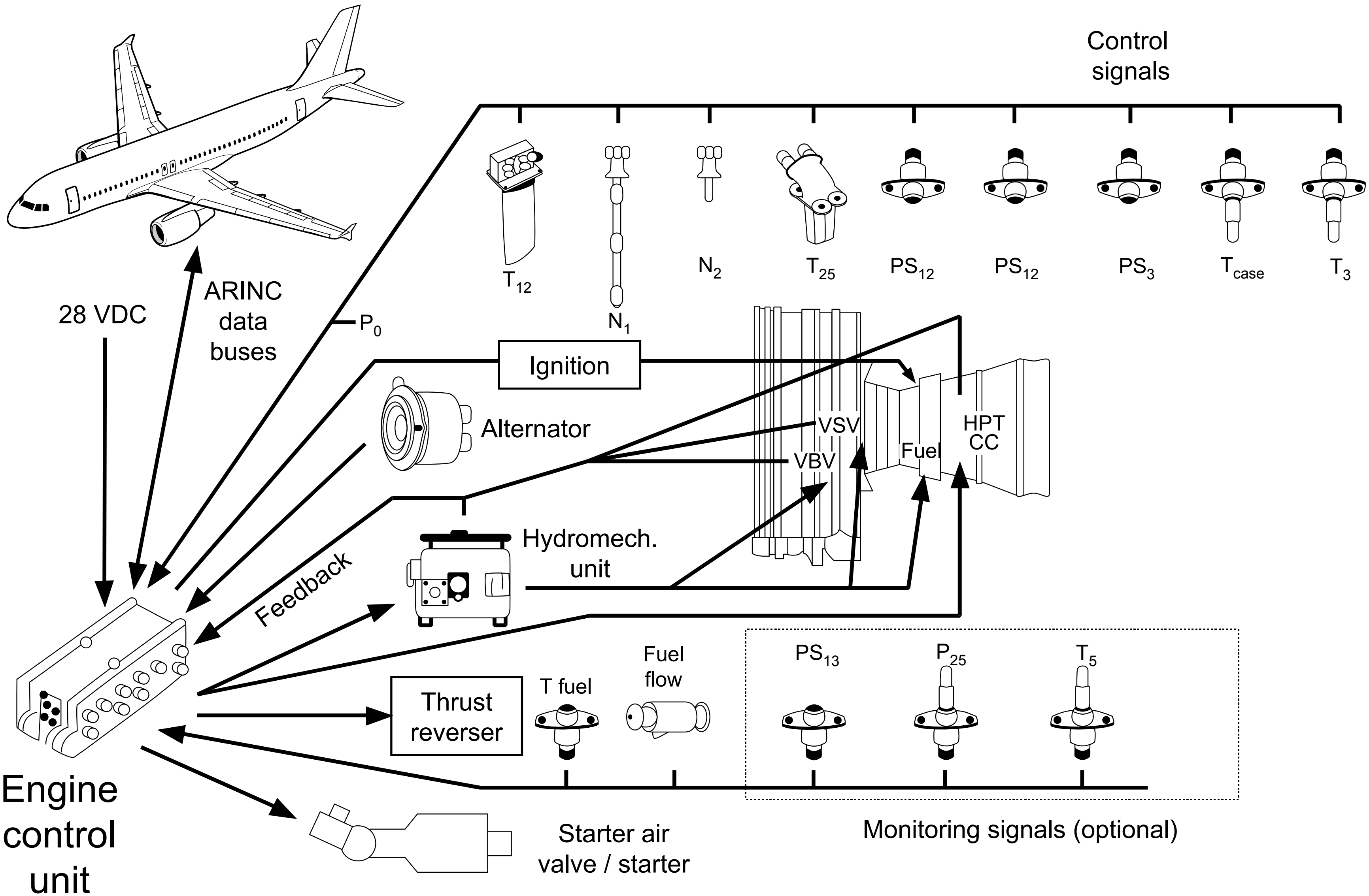
EIU

● The interface between the FADEC system and the other aircraft systems is mainly performed by the EIU through digital data buses.

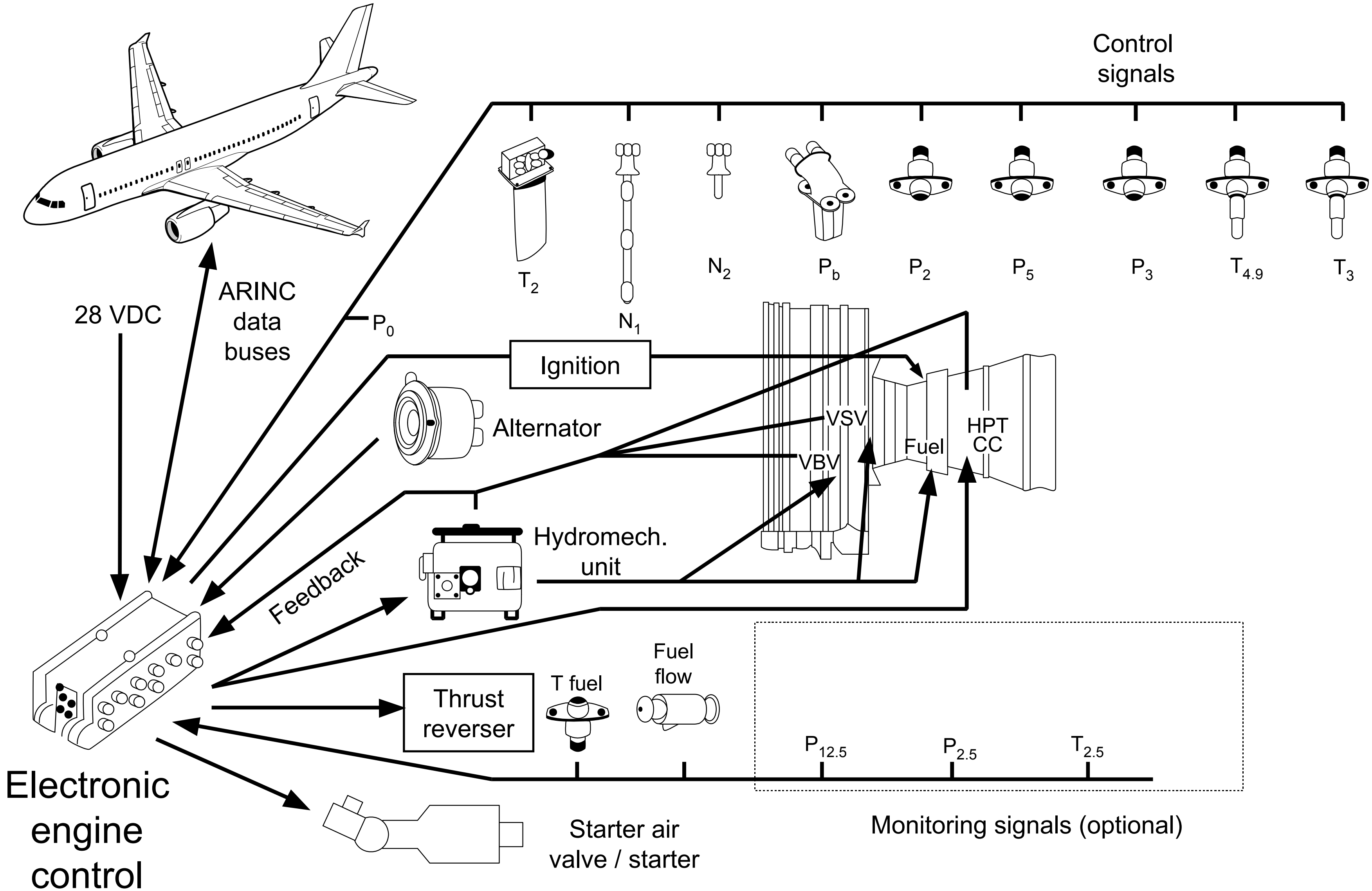
● One EIU per engine is located in the avionics bay.

● Care is taken to preserve systems segregation for safety and integrity.

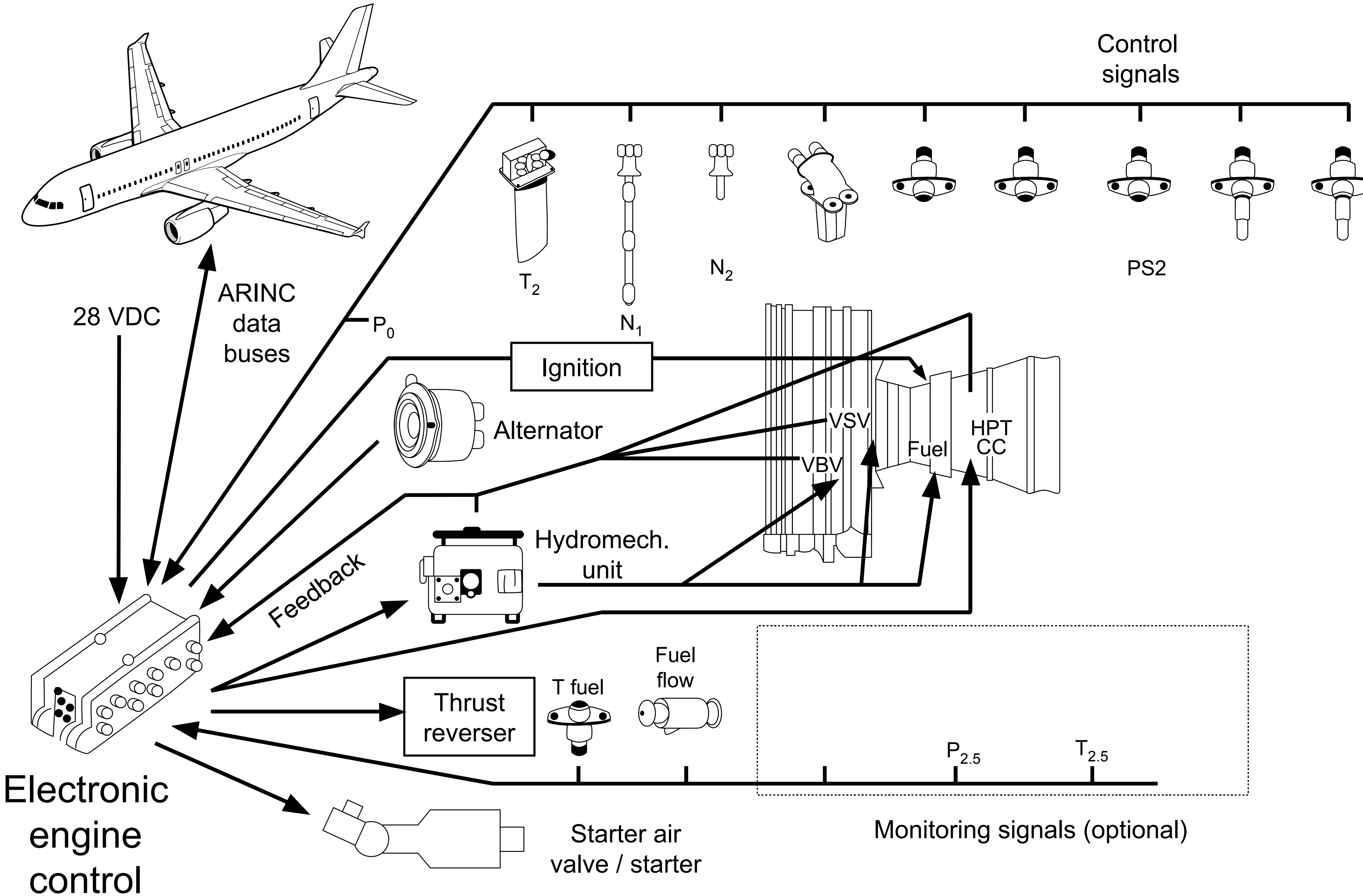
A318/A319/A320/A321 Engine Controls – CFM56



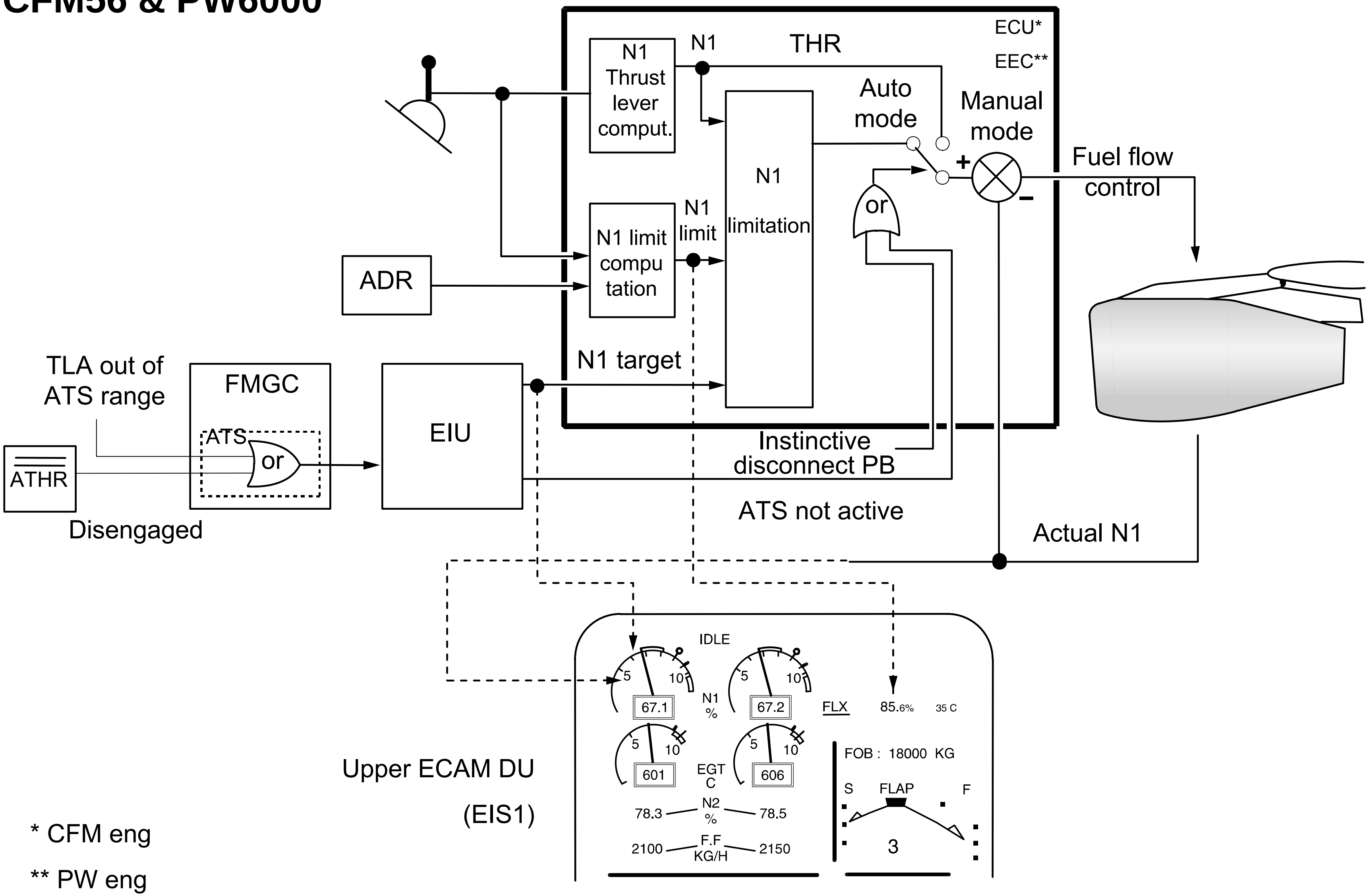
A319/A320/A321 Engine Controls – V2500



A318 Engine Controls – PW 6000



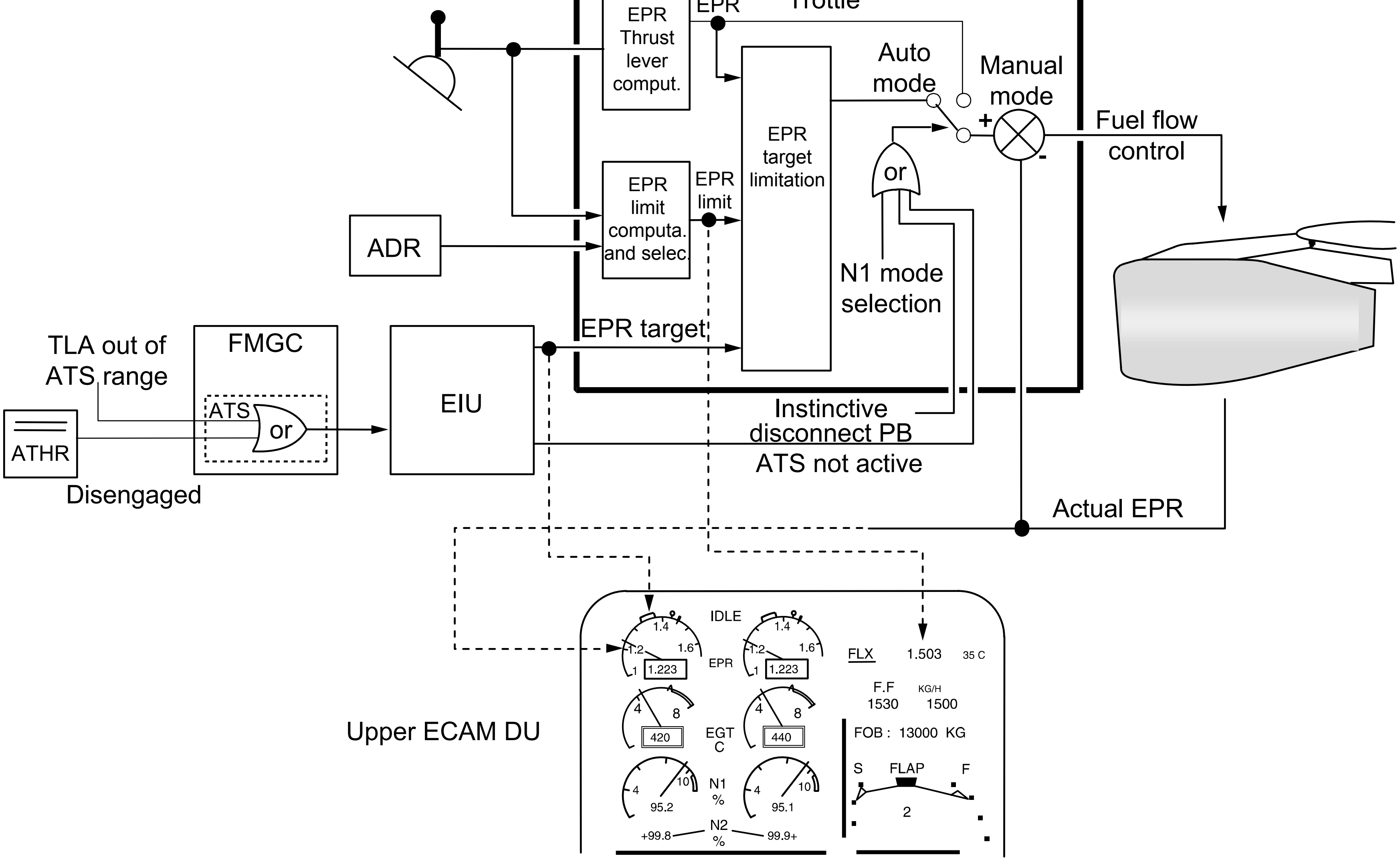
CFM56 & PW6000



* CFM eng

** PW eng

IAE V2500


EEC
EPR Thrust lever comput.
EPR
Trottle
Auto mode
Manual mode
EPR target limitation
+
-
Fuel flow control
or
EPR limit computa. and selec.
EPR limit
ADR
N1 mode selection
EPR target
TLA out of ATS range
FMGC
ATS
or
EIU
ATHR
Disengaged
Instinctive disconnect PB
ATS not active
Actual EPR
Upper ECAM DU
IDLE
EPR
1.223
1.223
EGT C
420
440
N1 %
95.2
95.1
N2 %
+99.8
99.9+
FLX
1.503
35 C
F.F KG/H
1530
1500
FOB : 13000 KG
S
FLAP
F
2

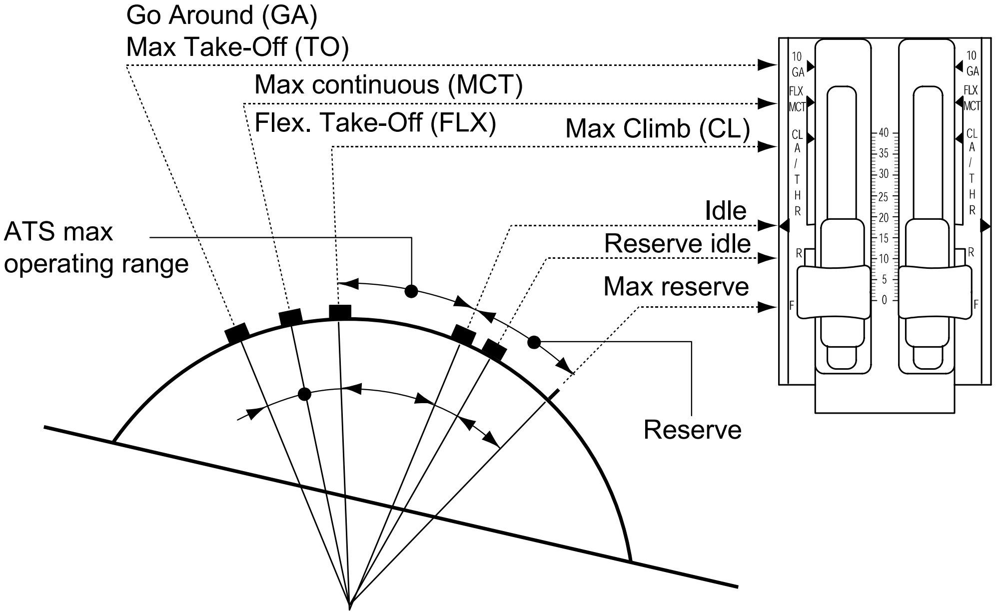
Limited thrust parameters (N1 for CFM56 and PW6000, EPR for V2500) are computed by FADEC.

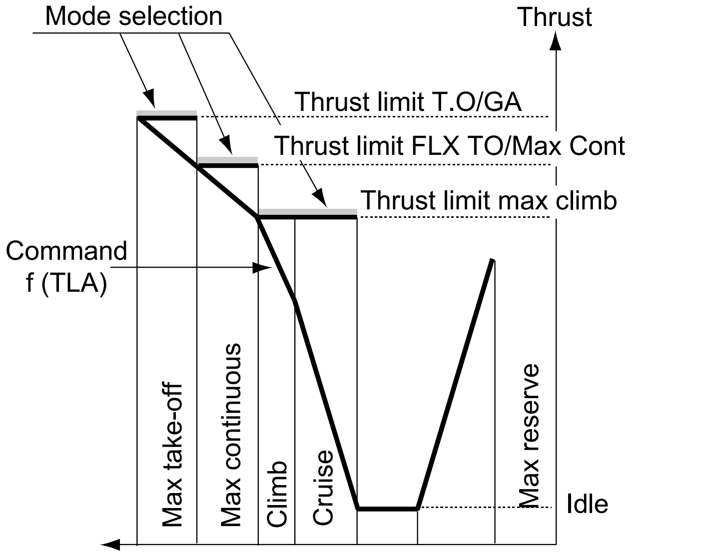
Selection of thrust limit mode is obtained directly by thrust lever position :
Six positions defined by detents or stops.

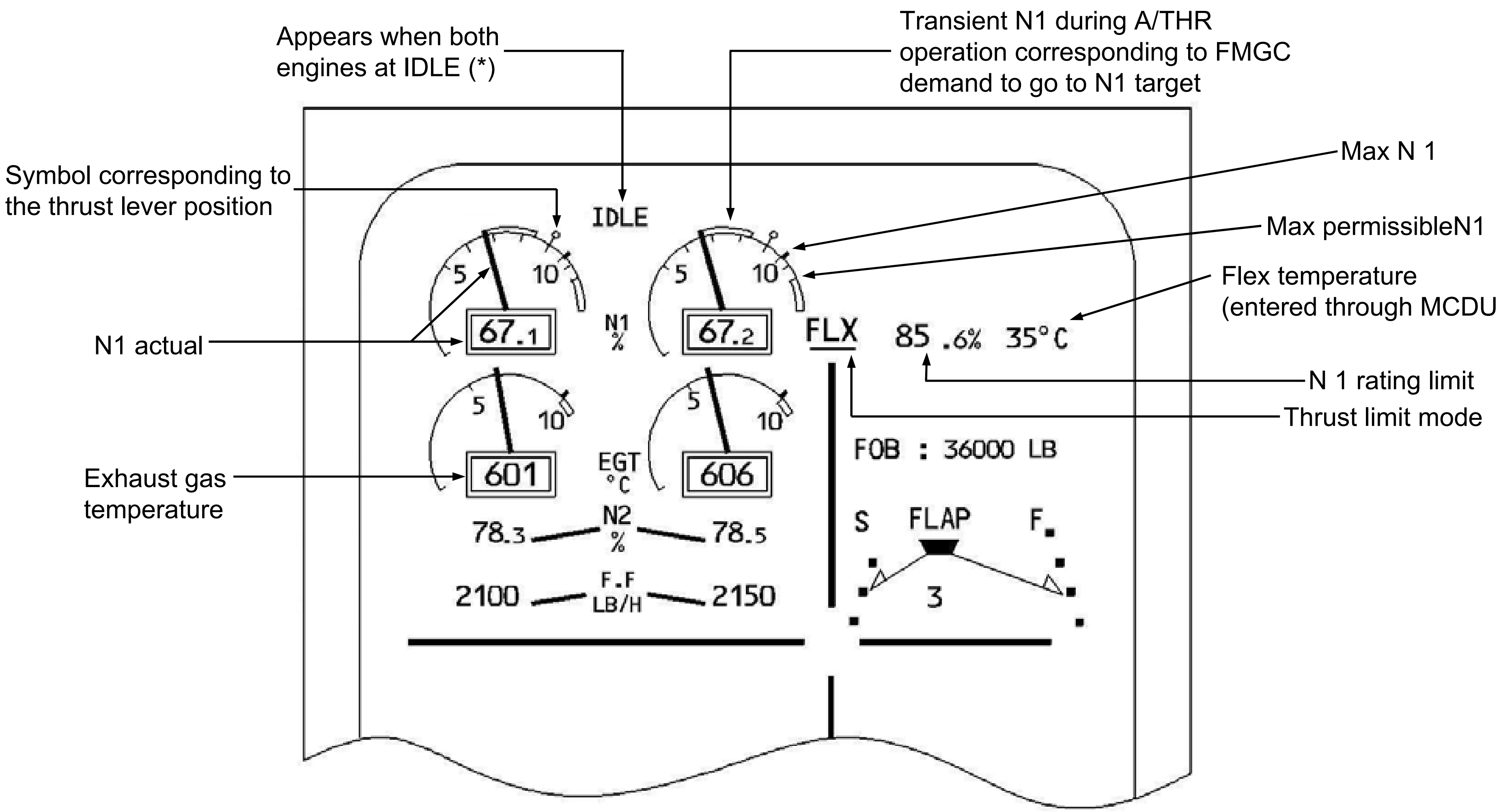
The thrust lever can only be moved manually (no servomotor): lever position not necessarily representing engine thrust delivered

According to the thrust lever position, the FADEC computes:

- Thrust rating limit
- N1 (EPR) when in manual mode
- N1 (EPR) which can be achieved in automatic mode (ATS)



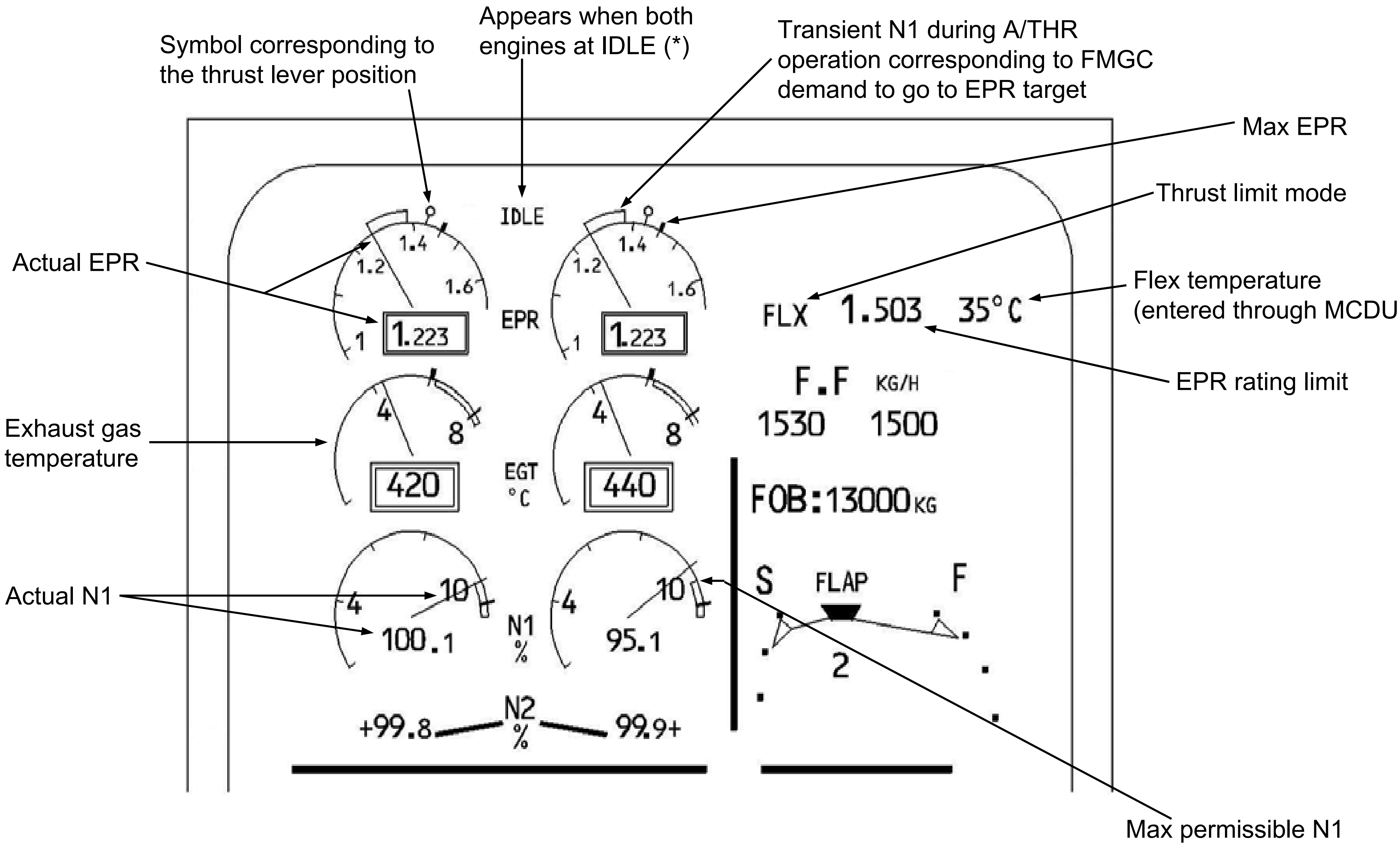




EIS 1 = Cathode Ray Tubes displays

* Basic on A319/A321

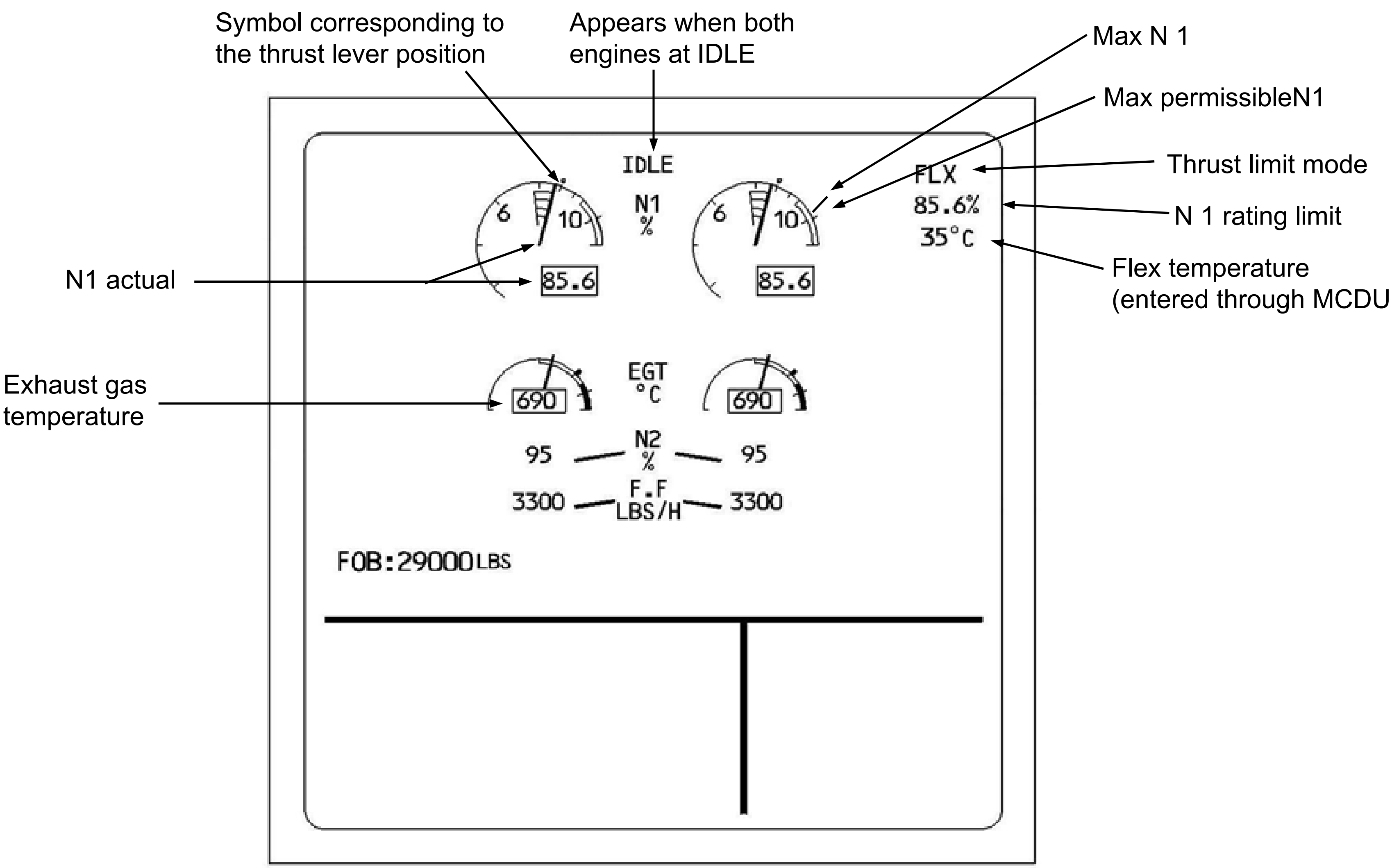
A319/A320/A321 Engine Controls Indications (IAE 2500) on ECAM Upper DU



EIS 1 = CRT displays

* Basic on A319/A321

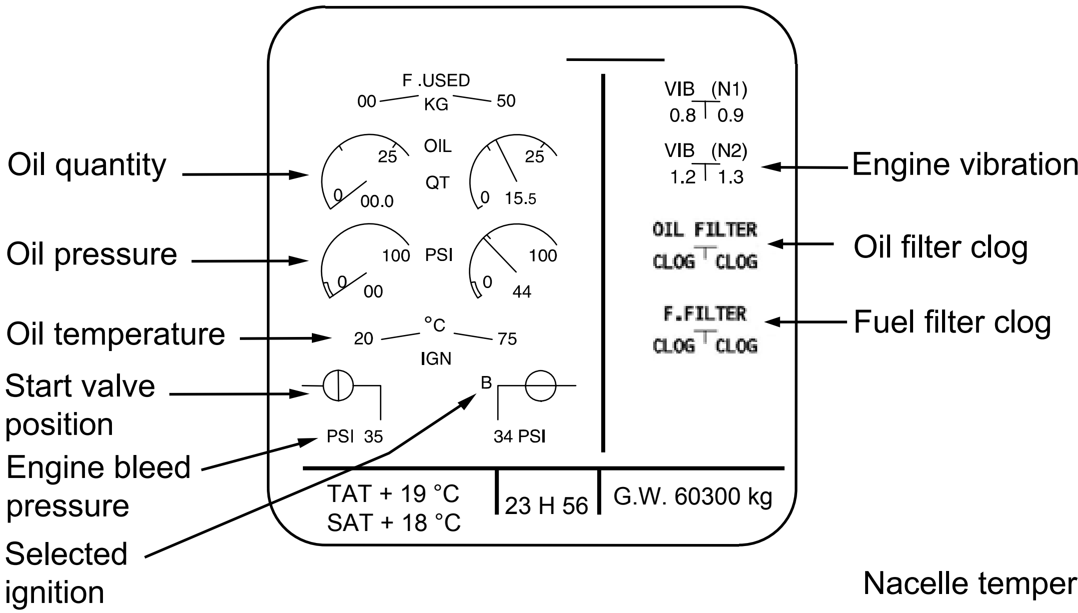
A318 Engine Controls Indications (CFM56 & PW6000) on ECAM Upper DU



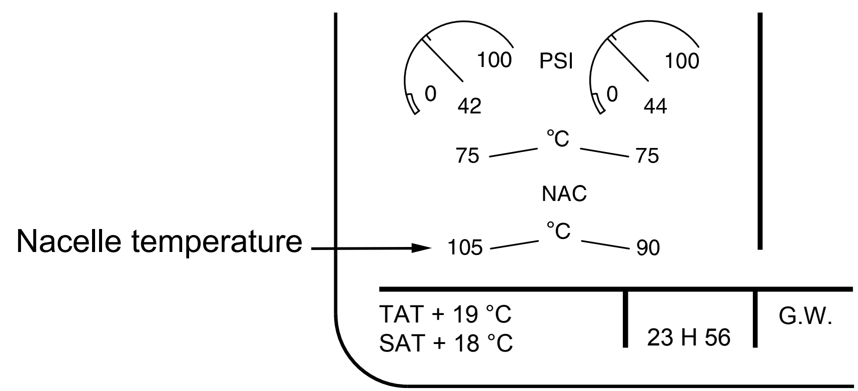
EIS 2 = Liquid Crystal Displays

A319/A320/A321 EIS Independent : after “clear” action

Start configuration



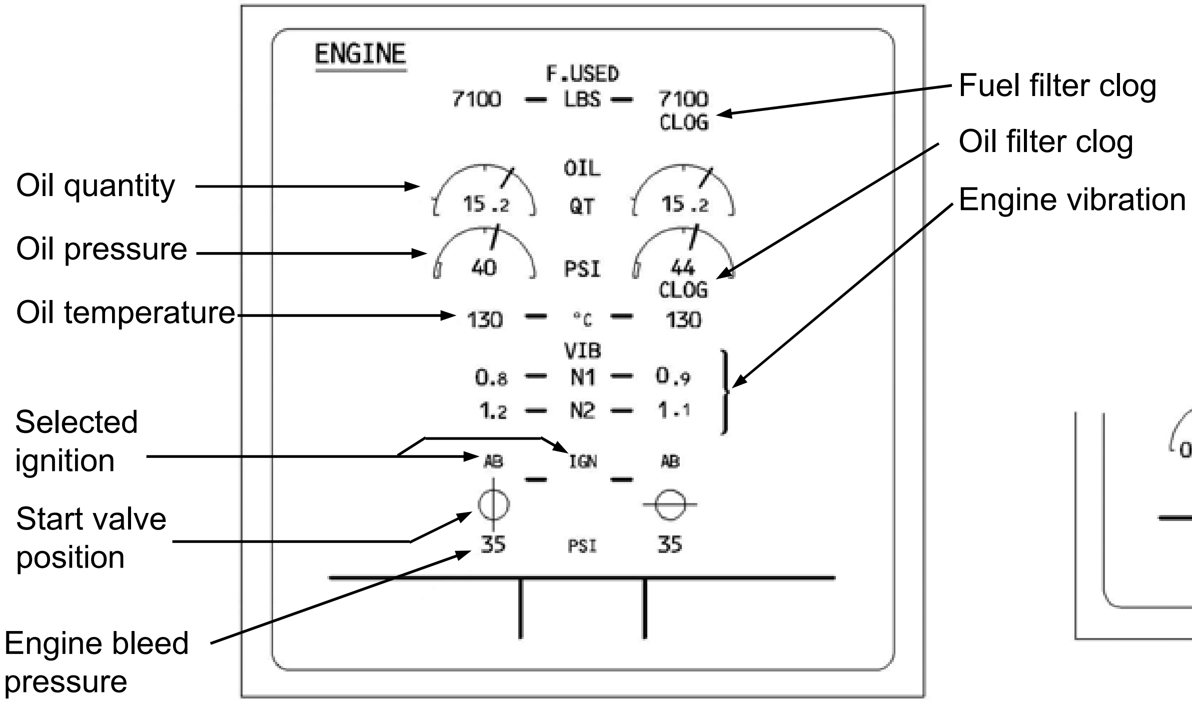
After start configuration



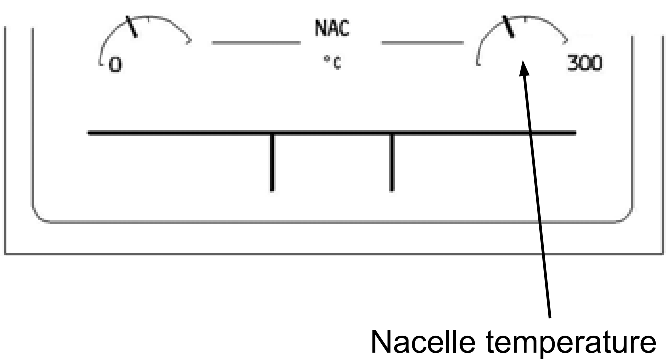
EIS 1 = CRT displays

A318/A319/A320/A321 EIS 2 independent : after “clear” action

Start configuration



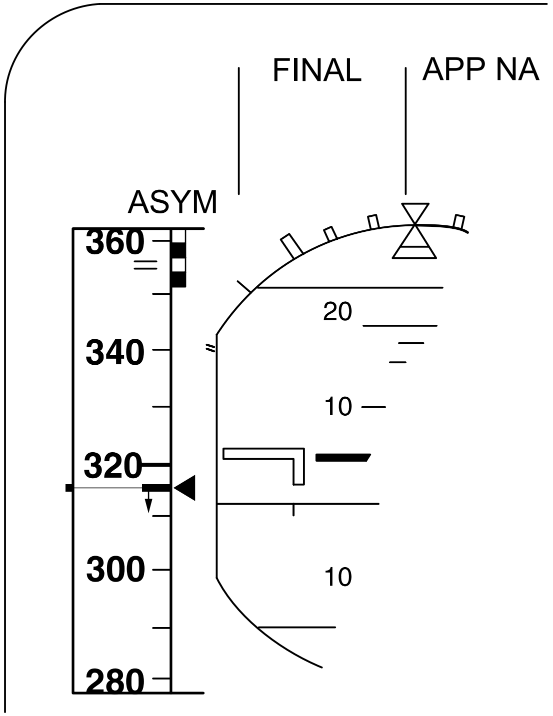
After start configuration



EIS 2 = LCD

The following indications may appear on the PFD Flight Mode Annunciator (FMA), in upper left corner:

ASYM	:	Only one thrust lever is set to CLB or MCT position,
CLB	:	Flashing when aircraft above thrust reduction altitude and thrust levers not in CLB notch,
MCT	:	Flashing in case of engine failure if the non-affected thrust lever is not set at MCT,
A-FLOOR	:	α -floor condition encountered,
TOGA LK	:	When leaving α -floor condition and thrust still at TOGA



Description

- Reverser deployment is selected by positioning thrust lever into reverse area and by acting on independent locking levers.

- Thrust lever position below rev. idle modulates reverse power.

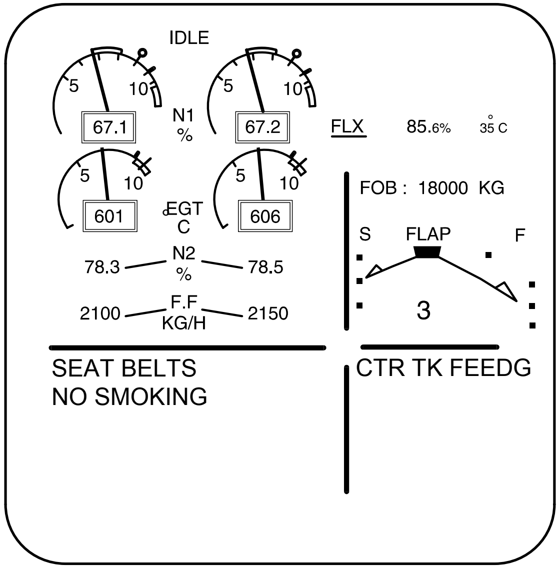
- Automatic engine idle is set in case of reverser malfunction.

- Automatic max. reverse power limitation versus ambient conditions with full rearward thrust lever position.

- Reverser status is displayed on ECAM upper DU.

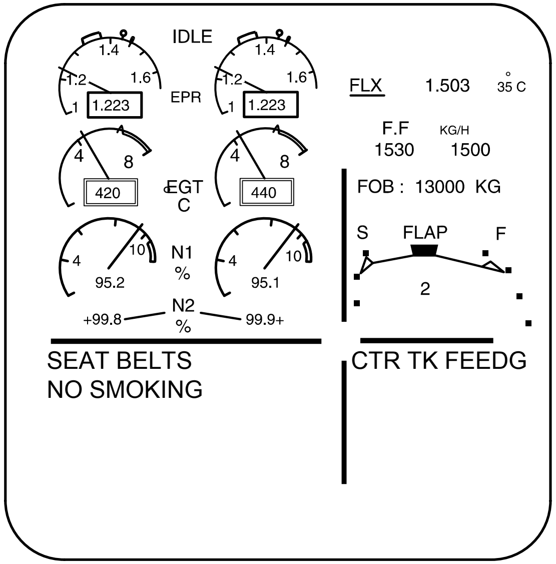
EIS 1

CFM

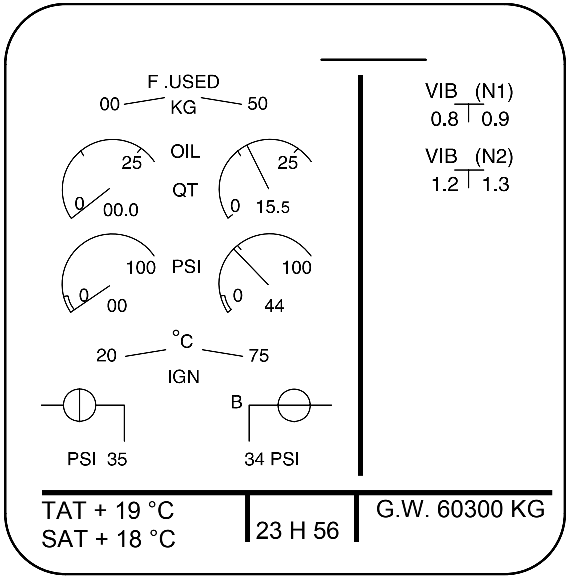


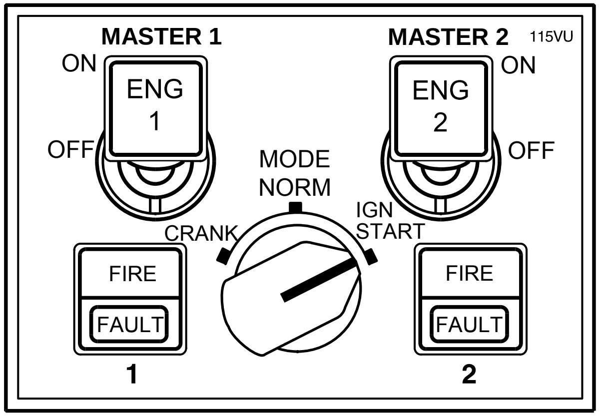
Upper
ECAM DU

IAE



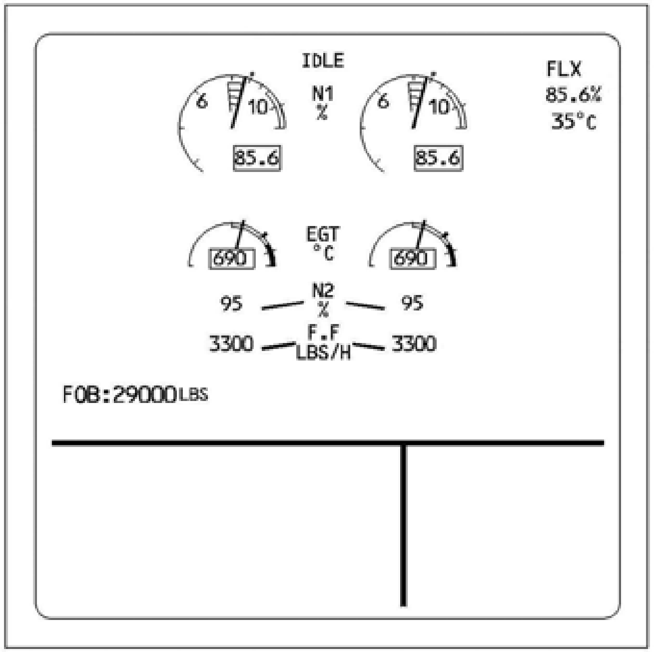
Lower ECAM DU



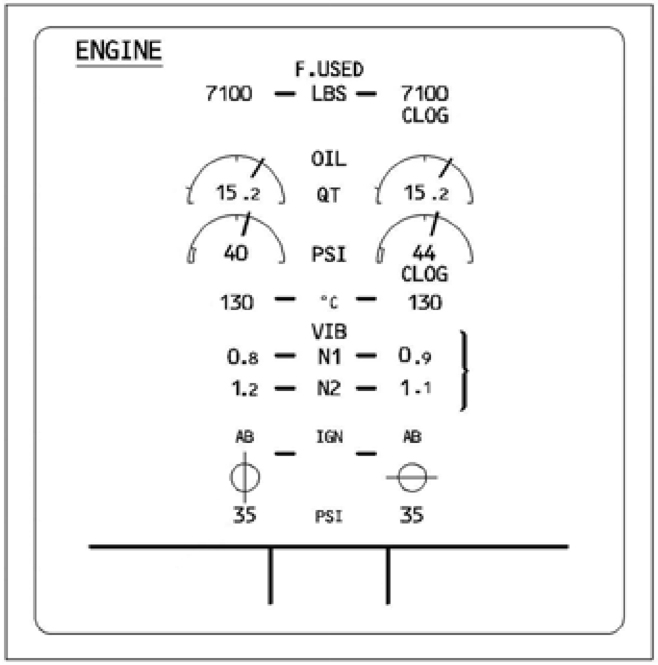


EIS 2

Upper ECAM DU



Lower ECAM DU



CFM

&

PW

A318/A319/A320/A321 Engine Controls - Start Procedure

- Engine mode selection .... IGN/START

  ECAM ENG page is automatically displayed on lower ECAM.
  - Pack valves close (CFM and PW engines)

- MASTER switch .... ON
  - Start valve opens
  - APU RPM increases
  - N2 increases
  - Oil pressure increases
  - Pack valves close (IAE engines)

  Depending on N2 values reached :
  - Ignition starts
  - HP fuel valve opens

  When sufficient N2 value is reached :

  - Start valve closes, ignition stops, APU RPM returns to normal, pack valve reopens.

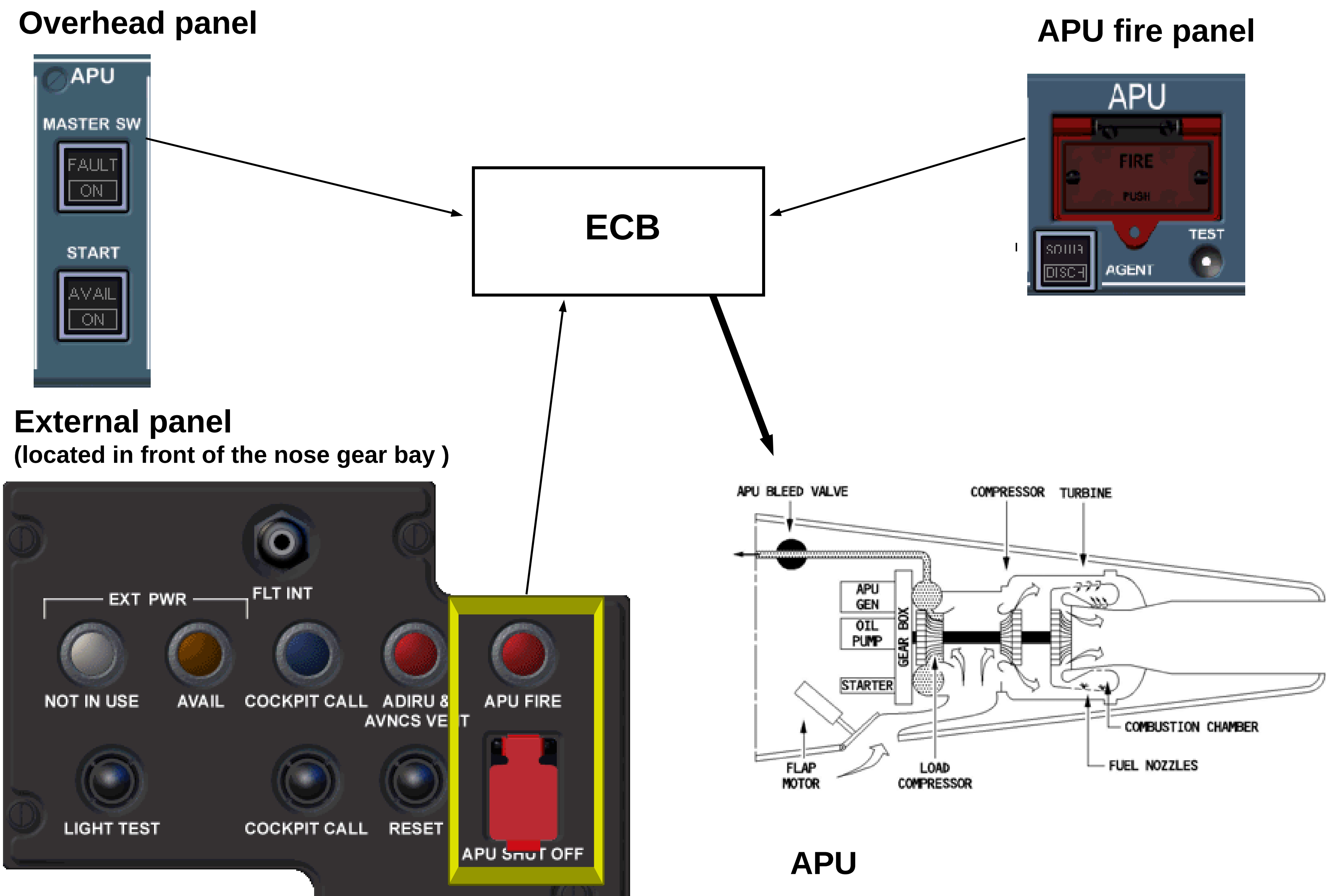
- Main and secondary parameters .... CHECK NORMAL

For abnormal conditions on ground :

FADEC automatically controls :
- Start abort in case of hot start, hung start or no light up.
- Automatic engine crank after :
  - First start abort for IAE
  - Any additional start attempts for CFM and PW.

9. Auxiliary Power Unit

A318/A319/A320/A321 APU – Controls and Display



- On ground, the APU makes the aircraft independent of pneumatics and electrical sources by:
  - Providing bleed air for engine start and air conditioning systems
  - Providing electrical power to supply the electrical system

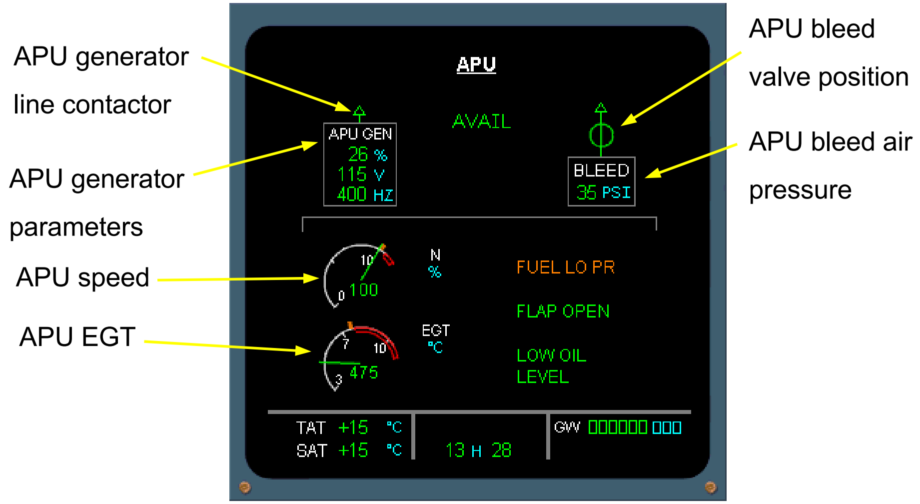
- In flight, provision of back-up power for electrical and air conditioning systems,

- The APU may be started using either the aircraft batteries, external power or normal aircraft supply. APU starting is permitted throughout the APU start envelope.

- The APU is automatically controlled by the Electronic Control Box **(ECB)** which is mainly acting as FADEC for monitoring start and shut-down sequences, bleed air and speed/temperature regulation.

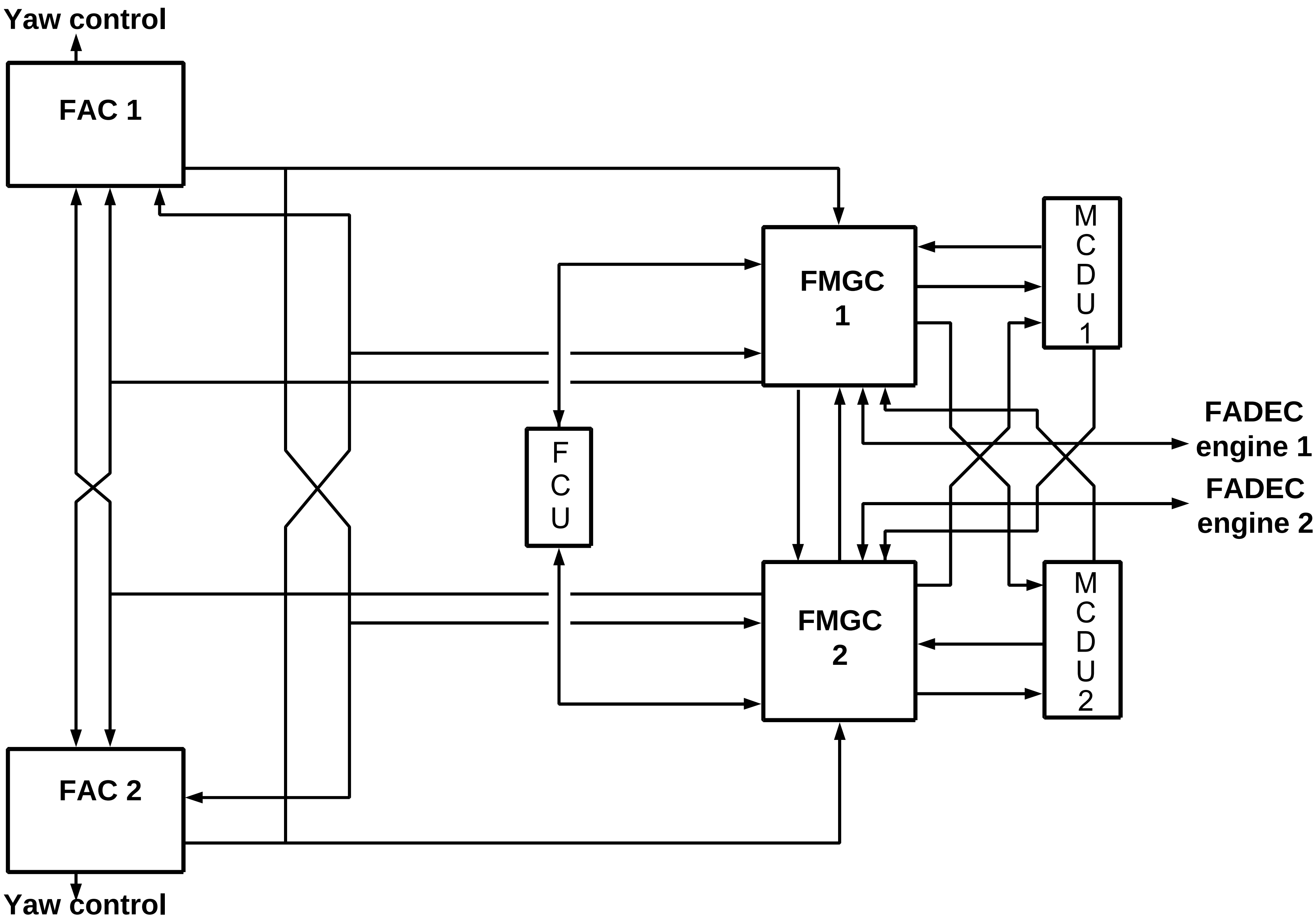
- Control and displays:
  - On the overhead panel for APU normal operation and fire protection
  - On the ECAM for APU parameters display
  - On the external panel, under the nose fuselage, for APU shut down.

ECAM Lower Display:
APU system page



10. Automatic Flight System

A318/A319/A320/A321 FMGS System Architecture



Flight Management Guidance and Envelope system

The flight management and guidance system (FMGS) performs navigation functions and lateral and vertical flight planning functions. It also computes performance parameters and guides the aircraft along a pre-planned route.

- Composed of two Flight Management and Guidance Computers (FMGC), this pilot interactive system provides:

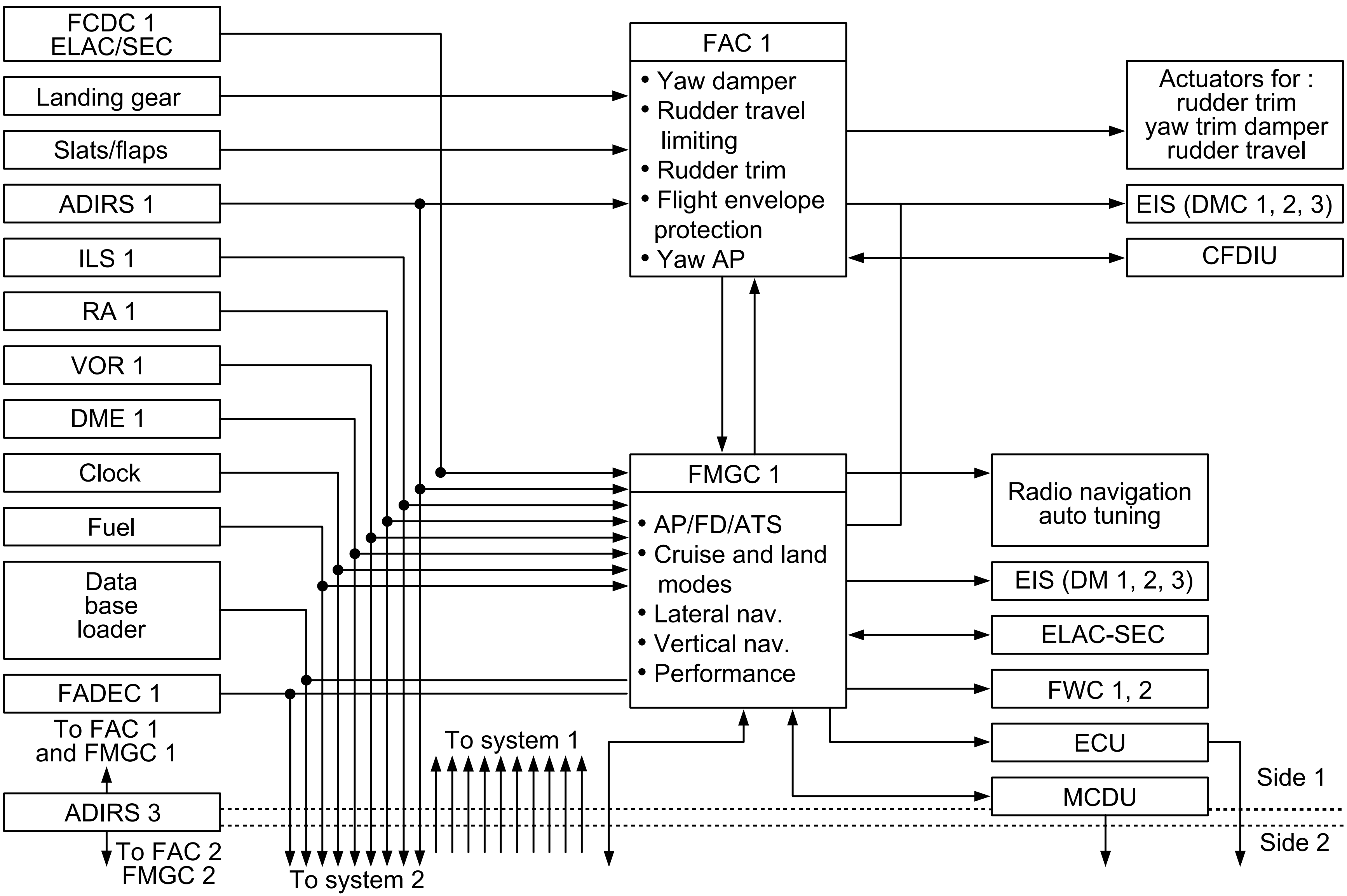
  - Flight Management for navigation, performance optimization, radio navaid tuning and information display management,
  - Flight Guidance for autopilot commands (to EFCS), flight director (FD) display and thrust commands (to FADECs).

- Two **FAC**s (Flight Augmentation Computer) provide:

  - Rudder commands (yaw damping, rudder trim and limiting, turn coordination, automatic engine failure compensation),
  - Flight envelope and speed computation.

- For operational convenience the FMGS offers two types of guidance concept:
  - **Managed**: automatic control of the aircraft with regard to speed, lateral path and vertical plan as computed by the FMGCs.
  - **Selected**: manual control of the aircraft with regard to speed and vertical plan (selected through FCU), lateral path (through FMGC or FCU).

A318/A319/A320/A321 FMGS – System Interface



A318/A319/A320/A321 FMGS – System Redundancy

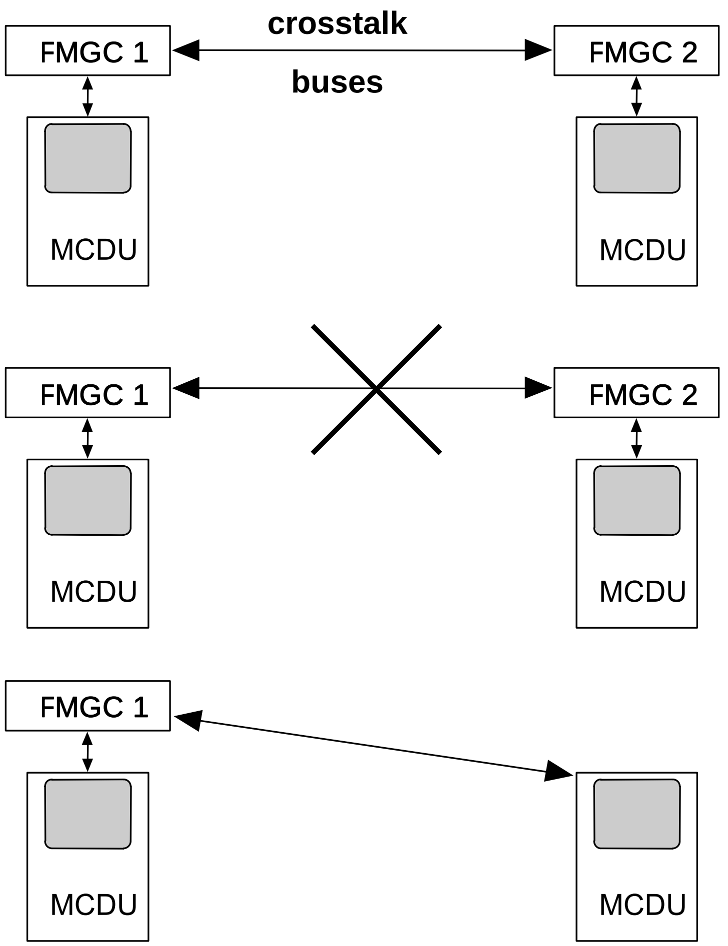
Two FMGCs associated to two MCDUs provide a redundant configuration.

The FMGS has three modes of operation

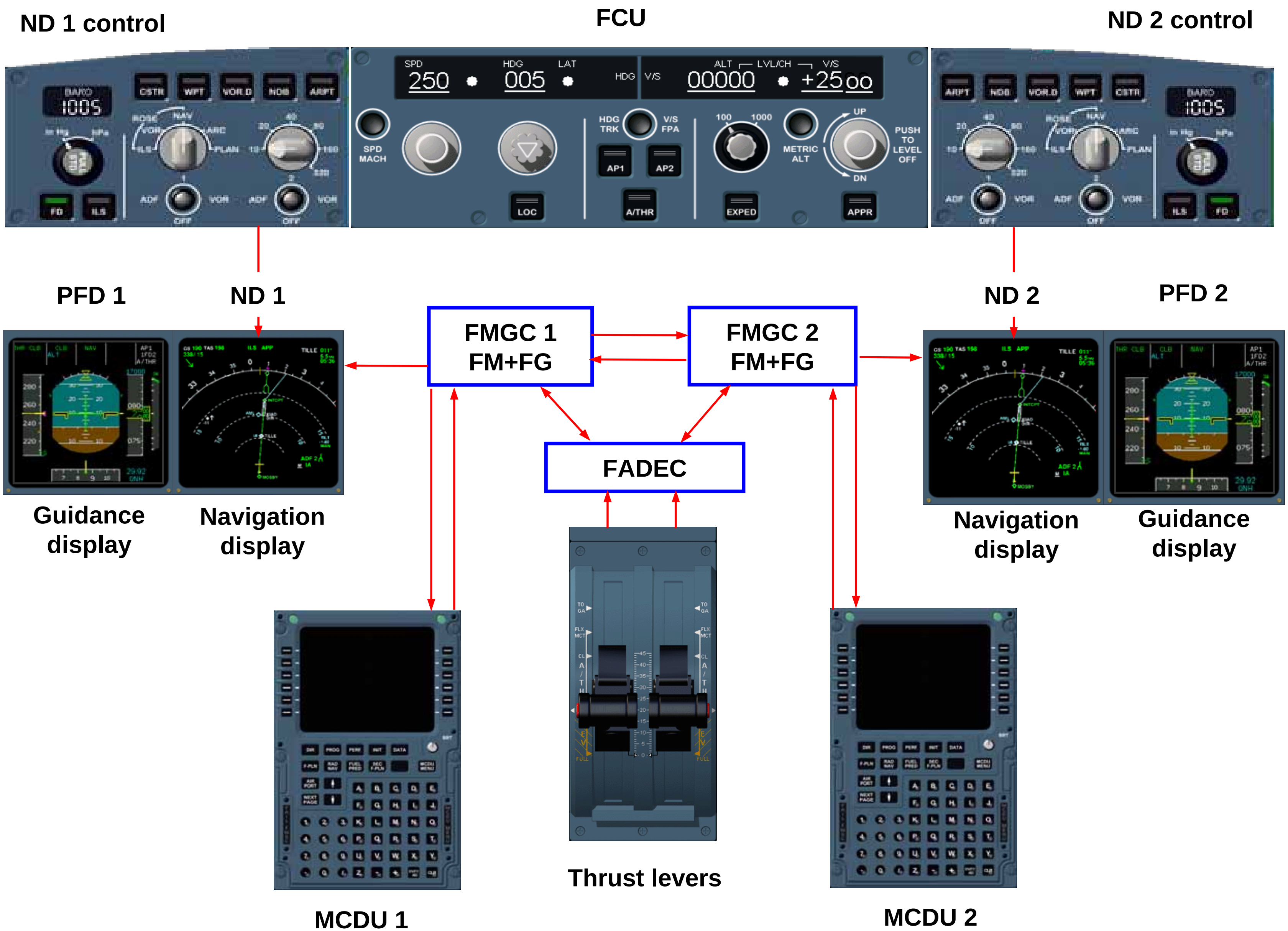
- Normal mode operation: **dual mode**
  - Each FMGC makes its own computation
  - One FMGC is **MASTER** – the other one is **SLAVE**
  - Both MCDUs act independently (entries are automatically recopied on the other MCDU and applied to both FMGCs)

- **Independent mode**
  - Automatically operative if mismatch between FMGCs
  - Independent operation of FMGCs with associated MCDUs. (Data insertion and display related to the side concerned).
  - One FMGC remains master.

- **Single mode**
  - One FMGC fails
  - Either MCDU can be used to enter or display data related to the remaining FMGC.



A318/A319/A320/A321 FMGS Crew Interface



A318/A319/A320/A321 FMGS Crew Interface

- Two MCDUs on the central pedestal provide long-term interface between the crew and FMGCs in terms of:
  - Flight plan definition and display
  - Data insertion (speeds, weights, cruise level, etc)
  - Selection of specific functions (direct to, offset, secondary flight plan).
- One FCU with 2 or 3 independent channels on the central glareshield to provide short-term interface between crew and FMGCs.
- Two thrust levers (one for each engine) linked to the FMGCs and FADECs provide autothrust or manual thrust control selection to the crew.
- Two PFDs and two NDs provide visual interface with flight management and guidance related data such as:

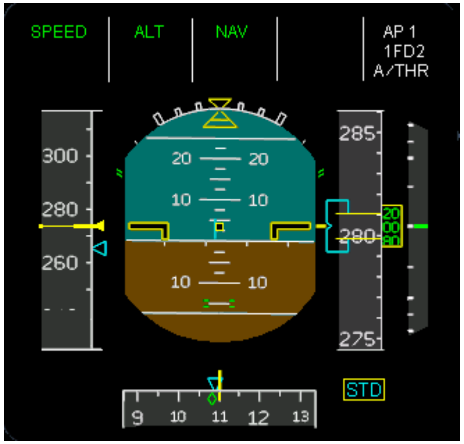
on PFD :

- FMGS guidance targets,
- Armed and active modes
- System engagement status

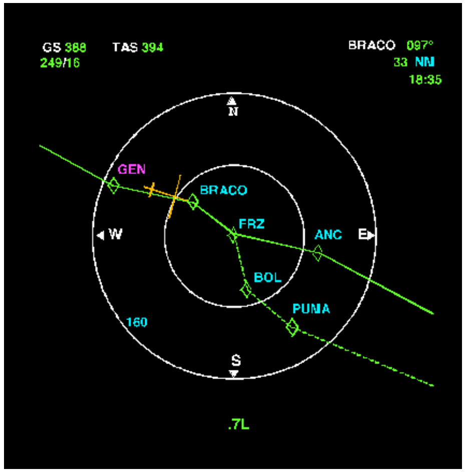
on ND :

- Flight plan presentation,
- Aircraft position and flight path,
- Navigation items (radio navaid, wind).

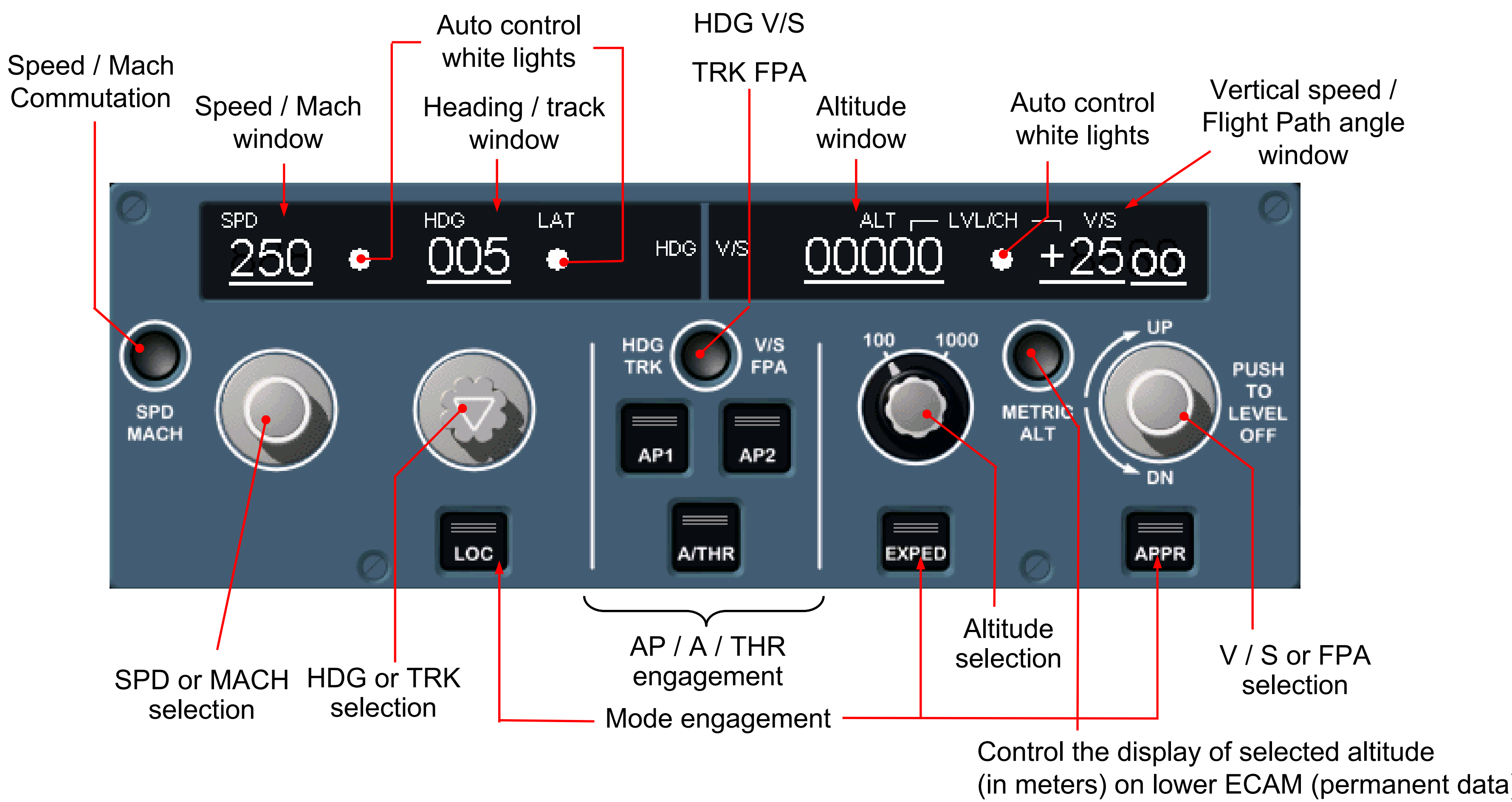
PFD



ND



Flight Control Unit (FCU)



- FCU function
  The pilot can use two types of guidance to control the aircraft in auto flight.
  - Managed guidance : FCU windows display dashes and the white dots next to those windows light up.
  - Selected guidance : The windows display the selected numbers and the white dots do not light up.

- The **FCU** is the main crew interface for short-term guidance with a single rule for the various control knobs:

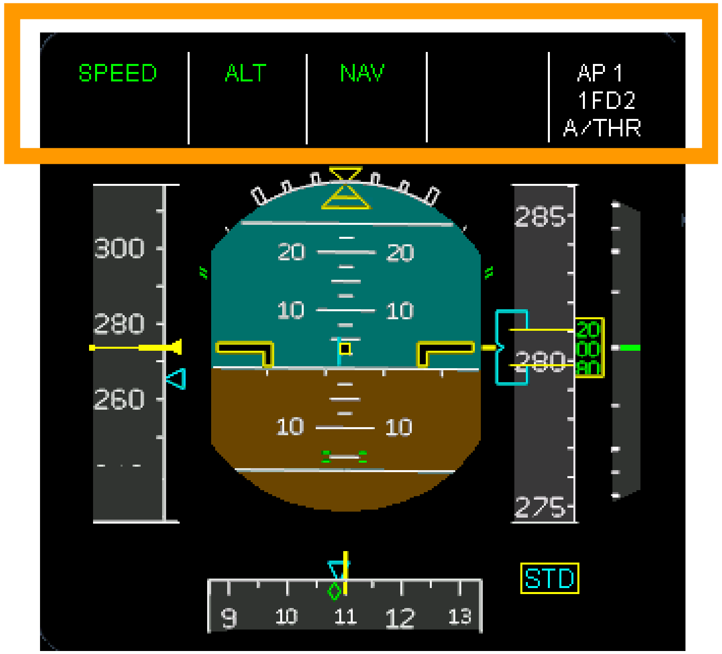
  - Pull + rotate = pilot input (selected guidance)
  - Push = return to FMGS control (managed guidance)

- As an example, a change of altitude can be achieved by a double action on the FCU:

  - Either by selection of a new altitude through the FCU selector and validation of this new altitude pushing this knob (managed guidance).
  - Or byselection of a V/S through the FCU selector and validation of this new V/S by pulling this knob (selected guidance).

- Actions on the FCU are displayed on the FCU as well as on the PFD (Primary Flight Display) in the dedicated **FMA** (Flight Management Annunciator) part.

FMA : Flight Management Annunciator :



A318/A319/A320/A321 FMGS – AP / FD Modes

Guidance Modes

Guidance	Managed	Selected
Lateral	• NAV and APP NAV • APPR • LOC • RWY • RWY TRK • G.A. TRK • ROLL OUT	• HDG -TRK
Vertical	• CLB • DES • SRS (TO / GA) • G / S • FLARE • FINAL	• OP CLB • OP DES • Expedite (towards altitude selected on FCU but managed speed) • ALT • V / S • FPA
Speed	• FMS Computed (ex: optimum) • Expedite	• FCU selected

Guidance Modes

- **Managed Guidance**

Take-off:

- **RWY** : Automatic runway axis follow up through ILS use
- **RWY. TRK** : Follow up of the memorized runway axis
  - **SRS** : Pitch guidance to maintain V2 + 10

Climb/Cruise/Descent:

- **NAV** : Lateral guidance along the defined F.PLN
- **CLB/DES** : Vertical guidance respecting the F.PLN defined constraints
- **APP NAV** : Lateral guidance along a defined non precision approach

Approach and landing:

- **APPR** : ILS approach (ILS beams capture and track) and non precision approach
- **LOC** : LOC use only (capture and track)
- **FLARE** : Automatically performed around 30ft
- **FINAL** : vertical guidance along a defined non precision approach
- **ROLL OUT:** aircraft guidance on the runway following an automatic landing

- **Selected Guidance**

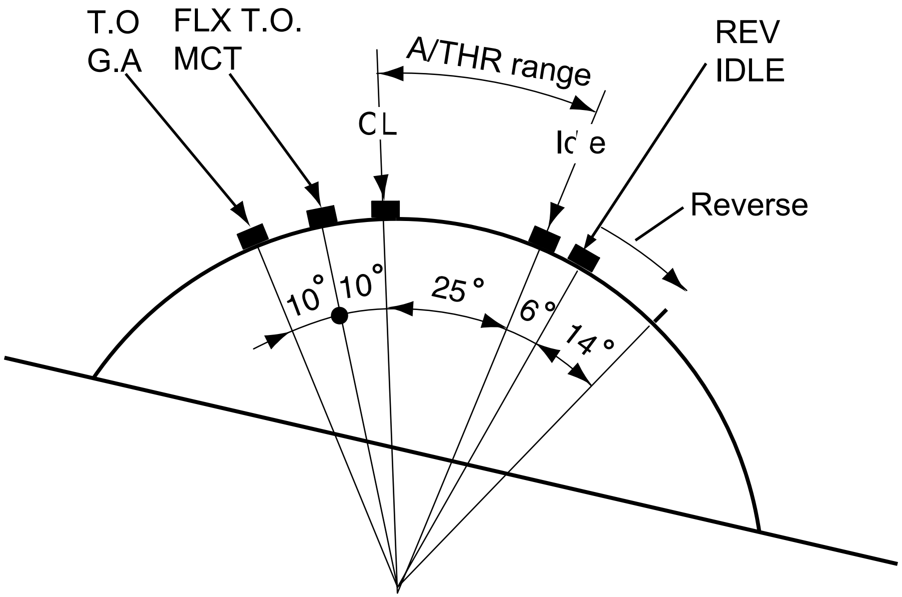
Lateral:

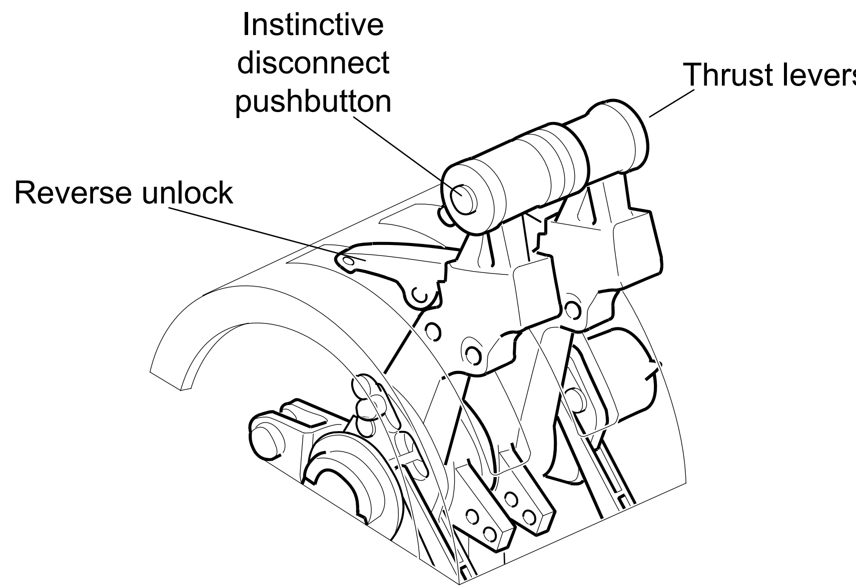
- **HDG/TRK** : Heading or track

Vertical:

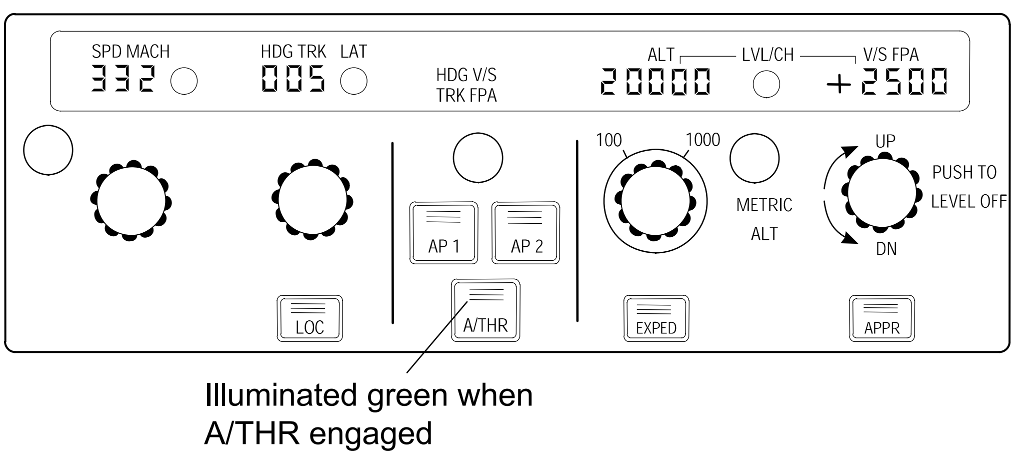
- **OP CLB/OP DES** : Open modes for level changes with a fixed thrust and speed held on elevator. FPLN constraints are then ignored
- **EXPED** : Level change with maximum climb/descent
- **ALT** : Altitude capture and hold
- **V/S-FPA** : Vertical speed or flight path angle track

A318/A319/A320/A321 A/THR – Controls and Display

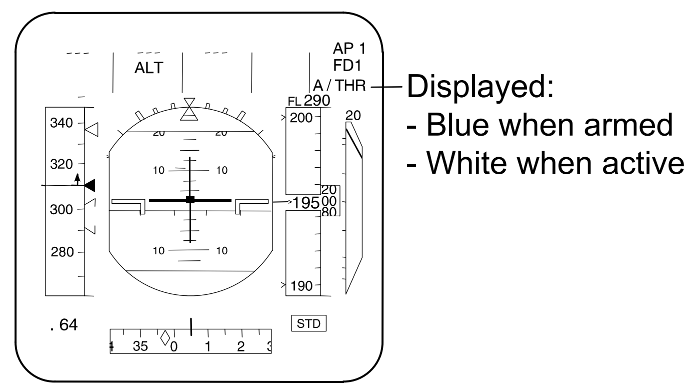




FCU



PFD



A318/A319/A320/A321 FMGS – Autothrust Function

- Autothrust **(A/THR)** is part of FMGC

- No mechanical linkage between levers and engines. Thrust levers position is measured and transmitted to the FADEC in digital form.

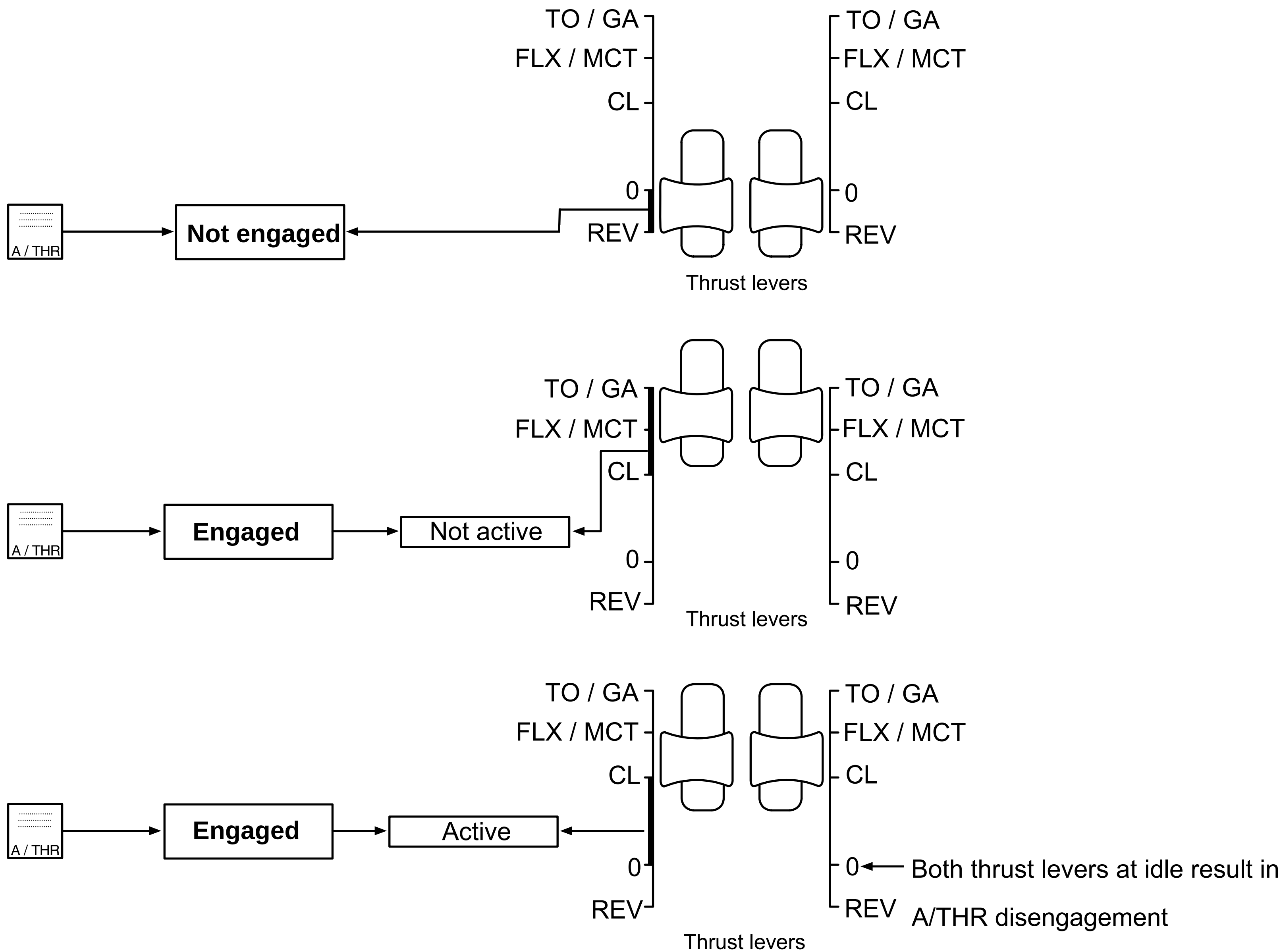
- Autothrust:

  - either ensures thrust control depending upon AP/FD modes (if these are engaged)
  - or manages thrust to hold the current target speed (if no AP/FD engaged)
  - with A/THR engaged, no feedback is sent to the thrust levers. The thrust levers do not move.

- A/THR engagement status and thrust limit mode depend upon thrust lever angle (TLA). Thrust limit selection and computation are made by the FADEC.

- 5 positions are fitted within the levers position range.

A318/A319/A320/A321 FMGS – Autothrust Function



Operational Rules

- A/THR can be armed:

  - Manually by pressing the A/THR pushbutton
  - Automatically, by setting the thrust levers at TO/GA or FLEX position.

- A/THR becomes active if thrust levers are set between CL (included) and IDLE (excluded) gates.
  In this case, commanded thrust is limited by the thrust levers position (except ALPHA-FLOOR activation).

  - A/THR not active (A/THR p/b on FCU extinguished) & thrust levers within A/THR range } Pressing A/THR p/b on FCU activates A/THR

- A/THR can be disengaged by:

  Depressing the instinctive disconnect P/B on the levers or depressing the illuminated A/THR P/B on FCU or setting both thrust levers in IDLE gate.

- If the levers are in CLB gate and A/THR is disengaged then:
  - Thrust is frozen at its current value until thrust levers are moved out of the gate.
    THR LK amber message appear on PFD to warn the pilot that the thrust is locked.

- If the levers are not in CLB gate when A/THR is disengaged then:
  - Thrust is not frozen but is set according to the lever position.

- Engagement of A/THR mode depends on AP/FD engaged mode:

AP/FD mode		A/THR mode
V/S-FPA ALT (ACQ/HOLD)		SPEED/MACH
Expedite		Thrust
Descent/Climb		Thrust/SPEED/MACH
SPD/Mach		Thrust
Approach	final descent	SPEED
	glide	SPEED
	flare	Retard
TO/ GA		A/THR Armed

- In SPEED/MACH mode, the A/THR adjusts the thrust in order to acquire and hold a speed or mach target.
  The speed or Mach target may be:
  - Selected on the FCU by the pilot.
  - Managed by the FMGC.

- In THRUST mode, A/THR commands a specific thrust level in conjunction with the AP/FD pitch mode. This thrust level is limited by thrust lever position.

Autothrust Operation

- Take-off performed :

  - In TO limit mode if the levers are in TO/GA detent
  - In FLEX TO limit mode if the levers are in FLX TO/MCT detent provided a FLX temperature has been entered on MCDU (take-off page). Lowest FLX TO thrust is automatically limited to CL thrust.

  Note : In both cases, this manoeuvre also engages the flight director TO mode.

- Once out of take-off (or go around), the nominal phases in autothrust are always:

  - CL detent in twin engine situation
  - MCT detent in single engine situation

  This is indicated to the crew by a CLB or MCT message on PFD

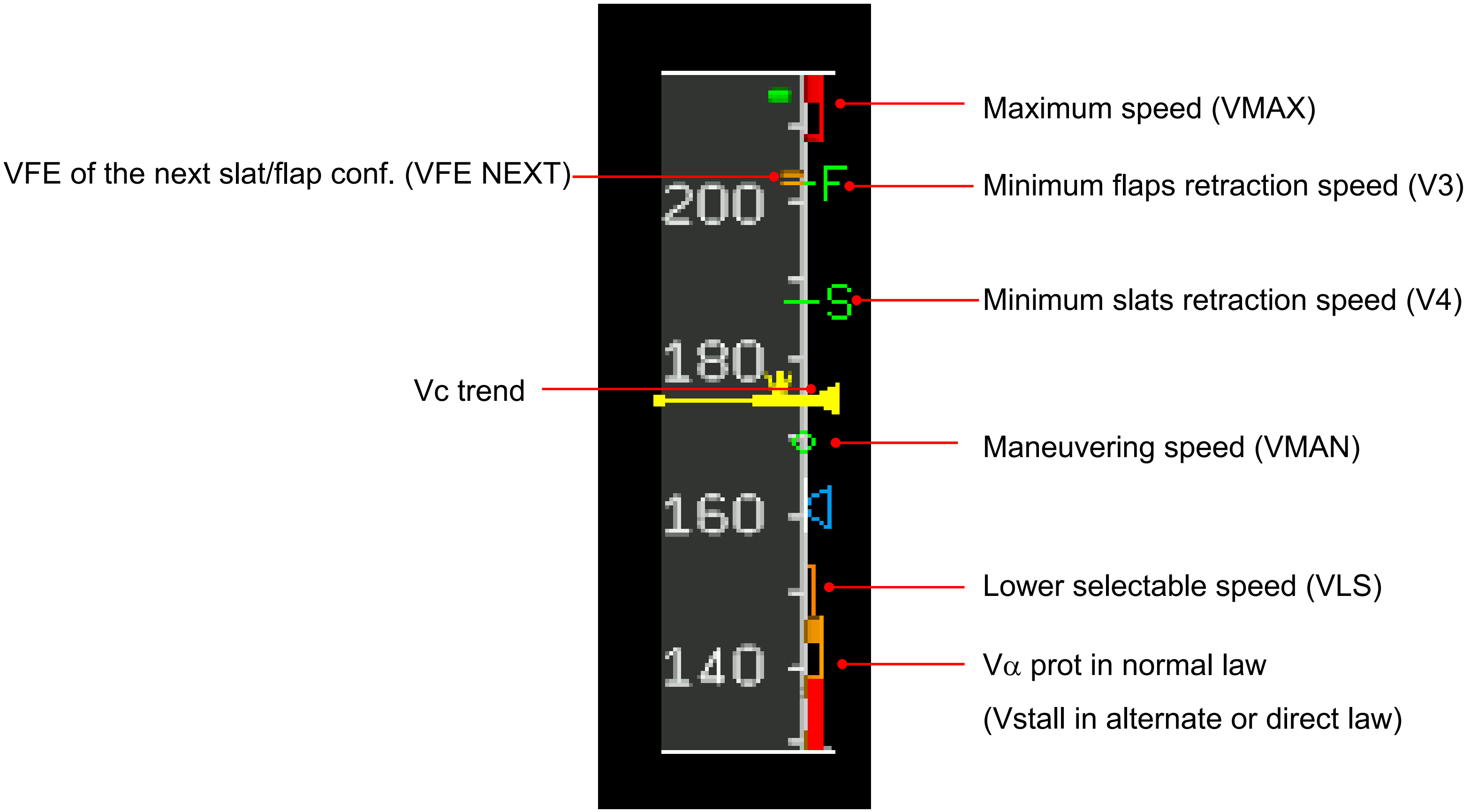
  - One lever in CL gate and the other out of this gate (in twin-engine operation) causes the engines to be regulated differently. ASYM amber message appears on PFD

- In approach, A/THR control depends on type of approach (ILS, non precision) and vertical mode selected on FCU.

- If Alpha floor protection is activated, TO/GA thrust is automatically applied whatever the lever position and A/THR status are.

Flight Envelope Protection

- Envelope protection is achieved by computing maximum and minimum selectable speed, stall warning, low energy threshold, alpha floor signal and reactive windshear detection. The FAC computes also maneuvering speed, flap/slat retraction speeds.



Flight Plan Stringing

Flight plan definition by company route or city pair.

Departure and arrival procedures including associated, speed/altitude/time constraints.

Flight plan revision (offset, DIR TO, holding pattern, alternate flight plan activation,…)

Secondary flight plan creation similar to primary flight plan.

Navigation

Automatic guidance along flight plan from take-off to approach and landing.

Aircraft position determination.

Aircraft position referenced to the flight plan.

Automatic radio navaids selection.

IRS alignment.

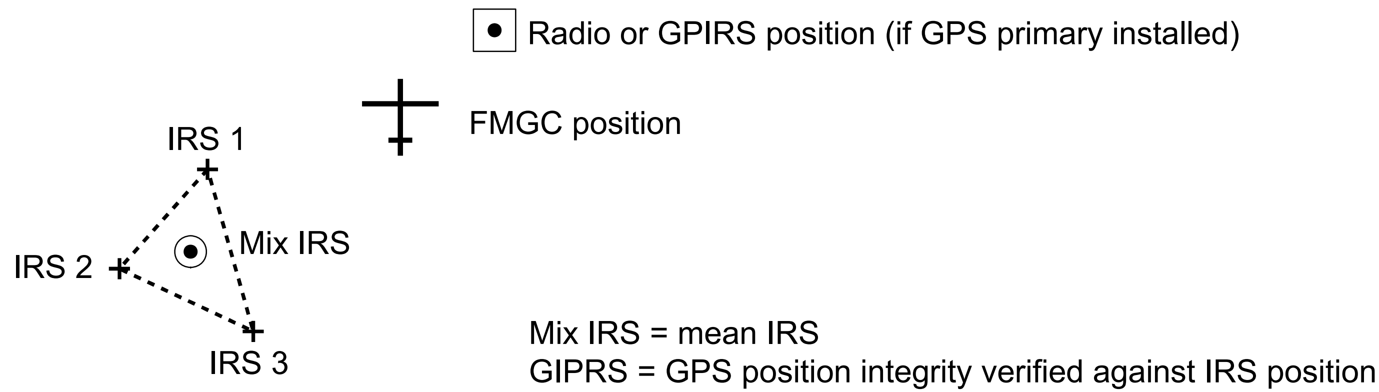
Ground speed and wind computation.

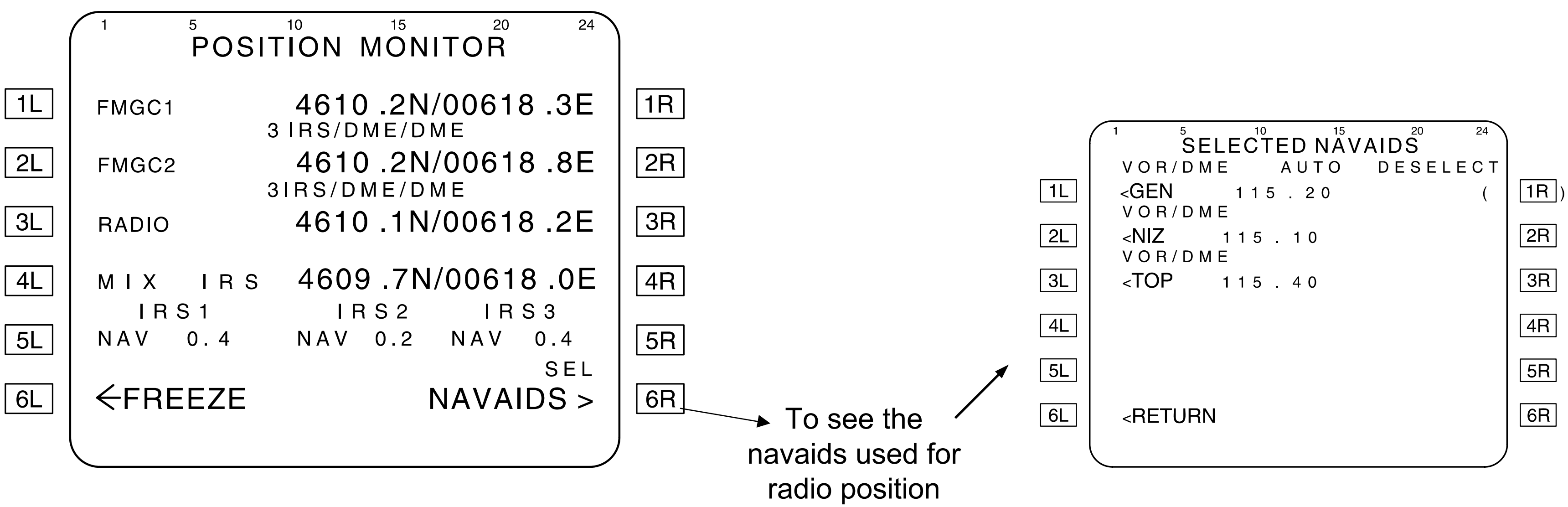
Optimum radio GPS and inertial sensor mixing.

Flight Plan Aspects

- Flight plan optimization, through the performance data base, in terms of:
  - Optimum speeds
  - Optimum altitudes.
- The computations are based on:
  - Flight conditions (cruise level, weights, center of gravity, meteorological data)
  - Cost index
  - Speed entered on the FCU or optimum speeds computed by the FMS.
- Performance predictions:
  - Time, altitude, speed at all waypoints
  - Estimated time of arrival, distance to destination, estimated fuel on board at destination.
- Advisory functions:
  - Fuel planning
  - Optimum altitudes and step climb.
- Full vertical guidance related to flight plan predictions from initial climb to final approach.

Position Computation





- Position computation:

  - Before flight, the three IRSs are aligned are initialized: manually, semi-automatically via database or automatically using the GPS position.
  - At take-off, the position is automatically updated to the runway threshold
  - In flight, position updating is computed using GPS if installed, and radio navaids (DME,VOR, ILS)

  The FMGC position depends upon the IRS's mean position, the GPS and the radio position.

- Navigation mode selection:

  - If the aircraft is equipped with GPS primary, the FMGC uses GPIRS position in priority
  - If the GPIRS position is not available or if the aircraft is not equipped with GPS primary, depending upon availability of navaids and sensors, FMGC automatically tunes the best navaids to compute the most accurate position.

The navigation modes may be:

En route:

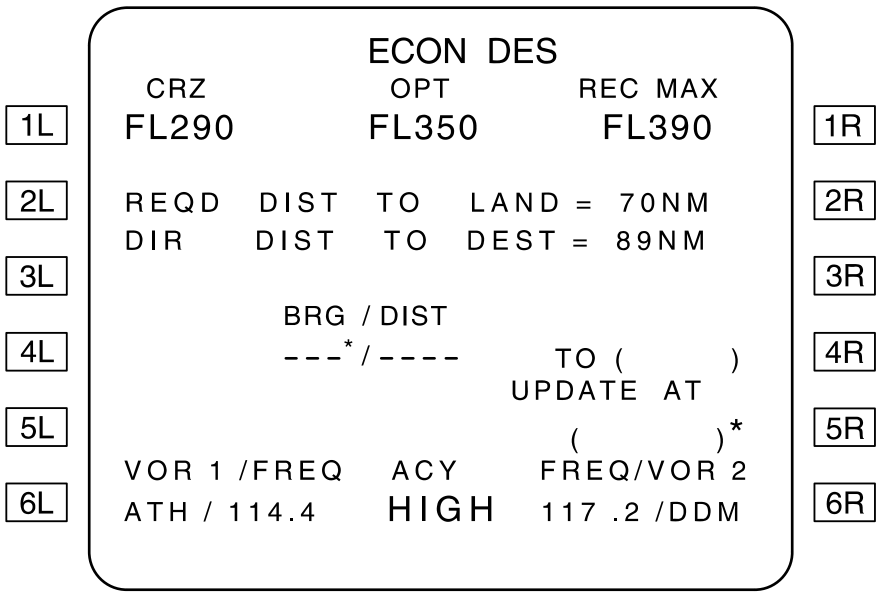
IRS – GPS (if GPS installed)
IRS – DME
IRS – VOR/DME
IRS only

In approach:

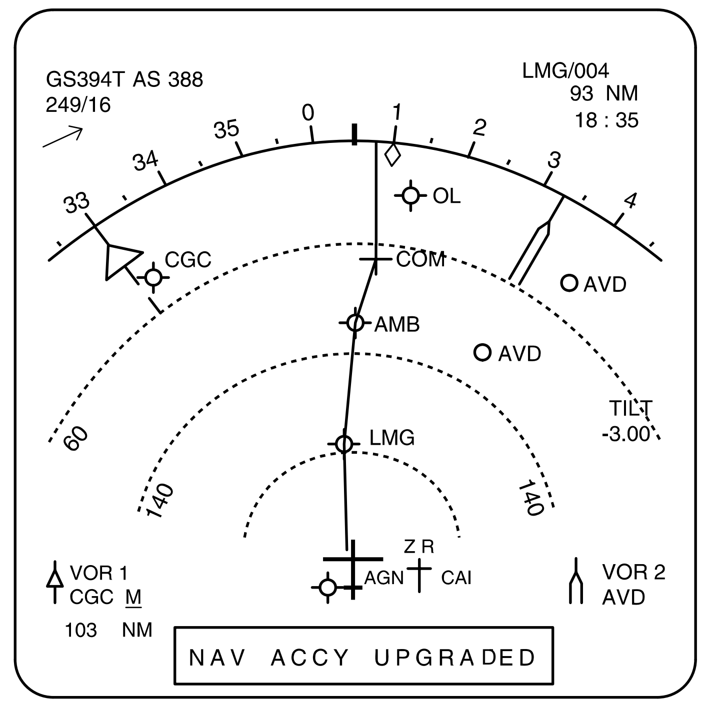
IRS – GPS (if GPS installed)
IRS – DME
IRS – VOR/DME
IRS – ILS/DME

Accuracy Display

MCDU



ND



A318/A319/A320/A321 FMGS - Lateral Navigation

- FMGC provides the crew with lateral position and its associated accuracy criteria which depend upon:

  - FMGC Estimate Position Error **(EPE)**
  - Zone currently flown (en route, terminal, approach)
  - Required navigation precision (RNP).

- If EPE $\leq$ RNP then HIGH is displayed on MCDU and the computed positions may be used without restriction.

- If EPE > AAAR then LOW is displayed on MCDU and the position must be cross-checked with raw data (ADF/VOR needles, DME reading).

- Each time HIGH (or LOW) reverts to LOW (or HIGH) the message NAV ACCY DOWNGRADED (or UPGRADED) is displayed on NDs and MCDUs.

- In GPS primary, the accuracy always comply with the RNP (no navaid cross-checking is necessary).

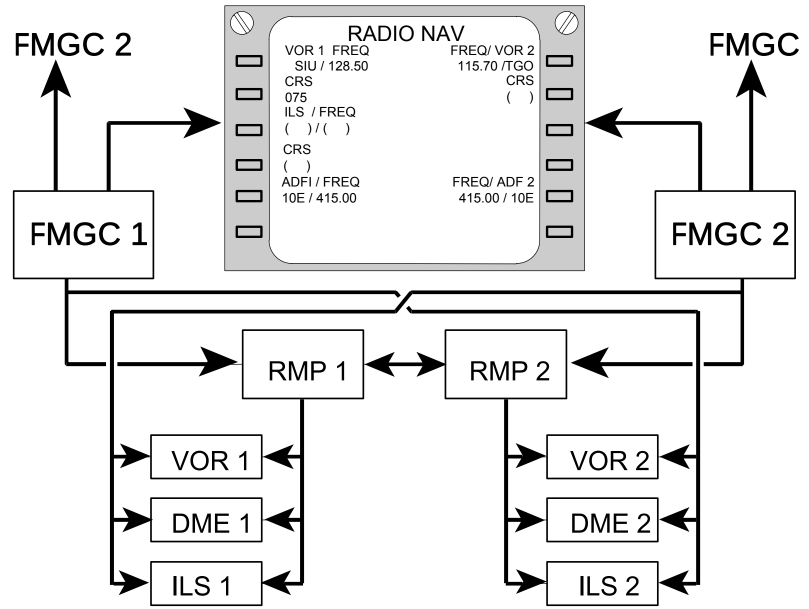
System Architecture

- Radio navaids are tuned for display and position computation.

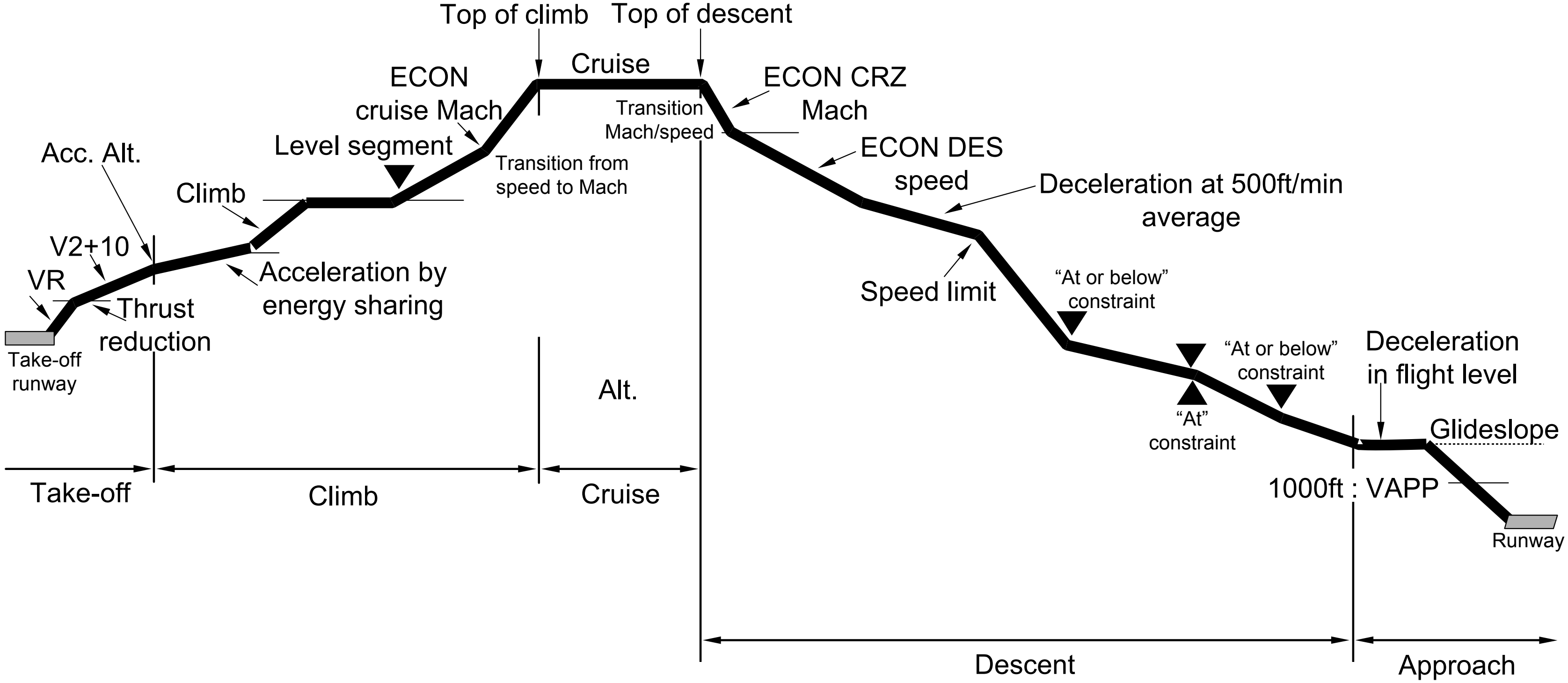
  Tuning for display may be achieved in different ways :
  - Automatic tuning (FMGC software)
  - Manual tuning through the MCDU RAD NAV page
  - Manual tuning through the Radio Management Panel (RMP) in case of failure of both FMGCs or both MCDUs.

- The FMGS automatically tunes the radio navaids for the computation of radio position.

- Manual tuning has priority over autotuning



A318/A319/A320/A321 FMGS – Vertical Profile



- **Take-Off:**

  SRS control law maintains V2 + 10 up to thrust reduction altitude where max climb thrust is applied. V2 + 10 is held up to acceleration altitude (ACC LT).

- **Climb:**

  Energy sharing is applied for acceleration (70% thrust) and for altitude (30% thrust) from ACC ALT up to first climb speed. Max climb thrust is kept – Altitude constraints are taken into account.

- **CRZ:**

  Steps may exist and/or may be inserted.

- **Descent:**

  Top of Descent (T/D) is provided on ND.
  From T/D down to the highest altitude constraint, ECON descent speed is supposed to be held on elevator and IDLE + Δ on thrust.
  Then, if it is necessary to respect the constraint, geometric segments will be followed and the speed is adapted in consequence.

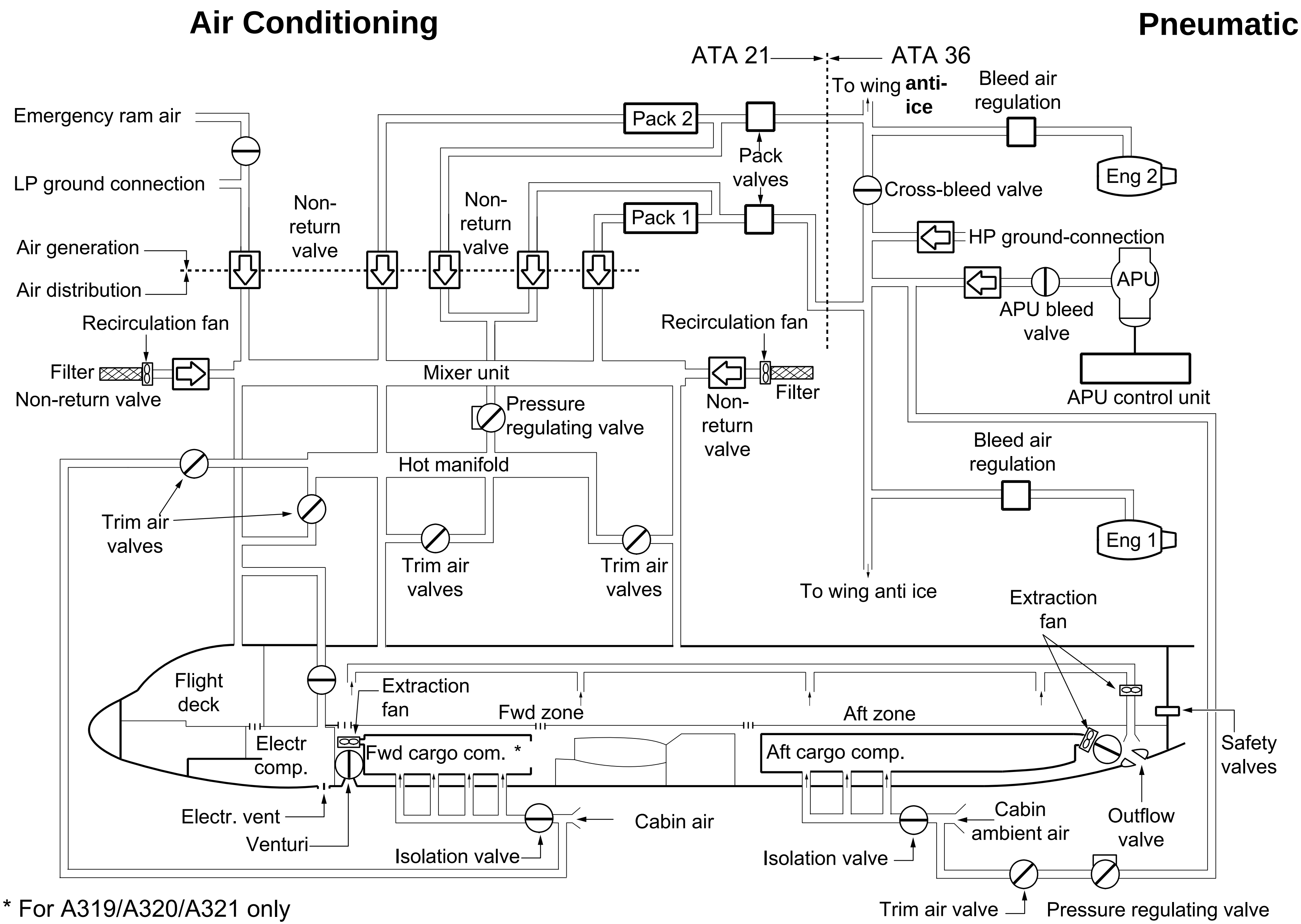
- **Approach:**

  From DECEL point a deceleration allows configuration changes in level flight.

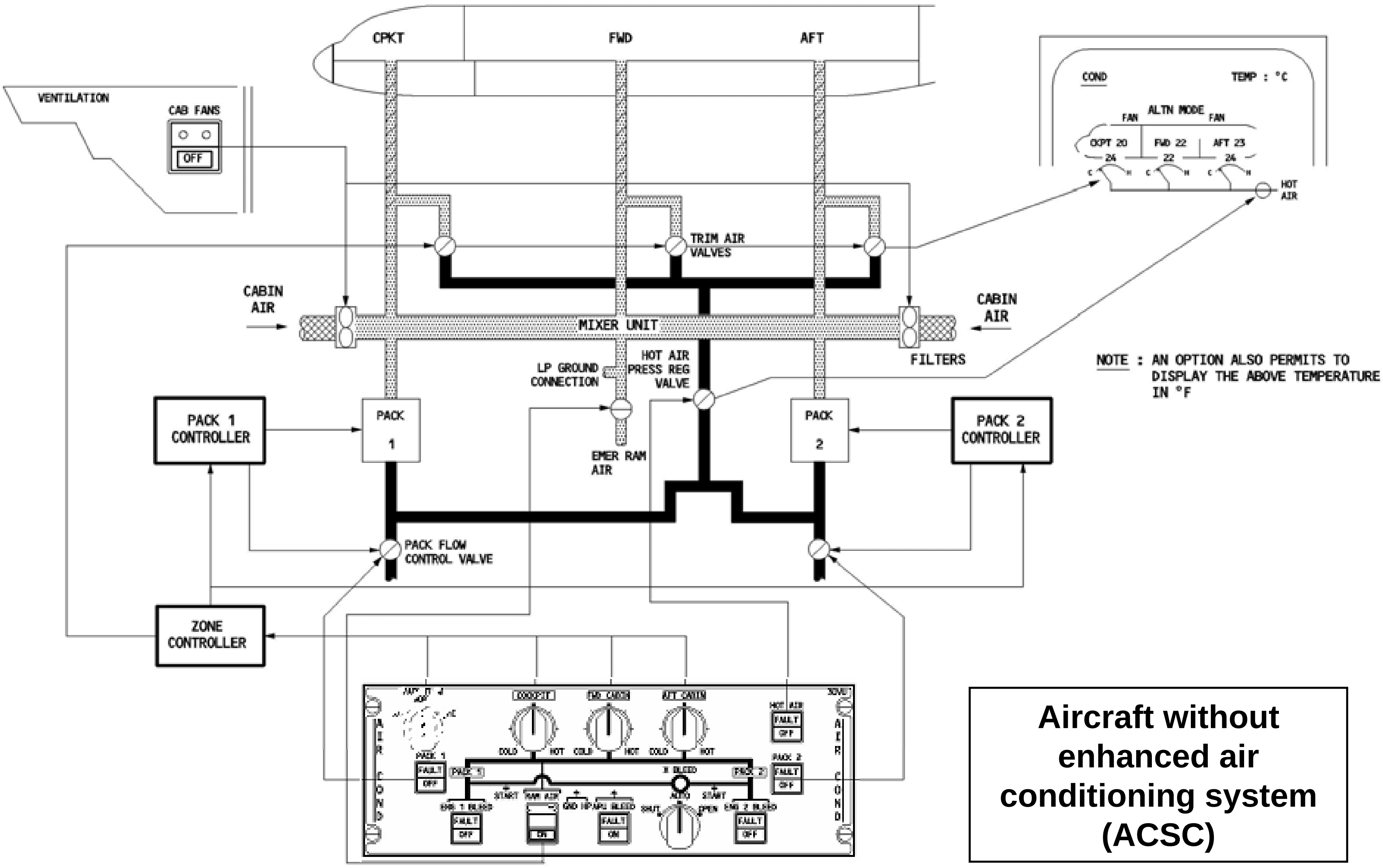
  Approach phase is planned to reach approach speed (VAPP) at 1000ft above ground level.

11. Environmental Control System

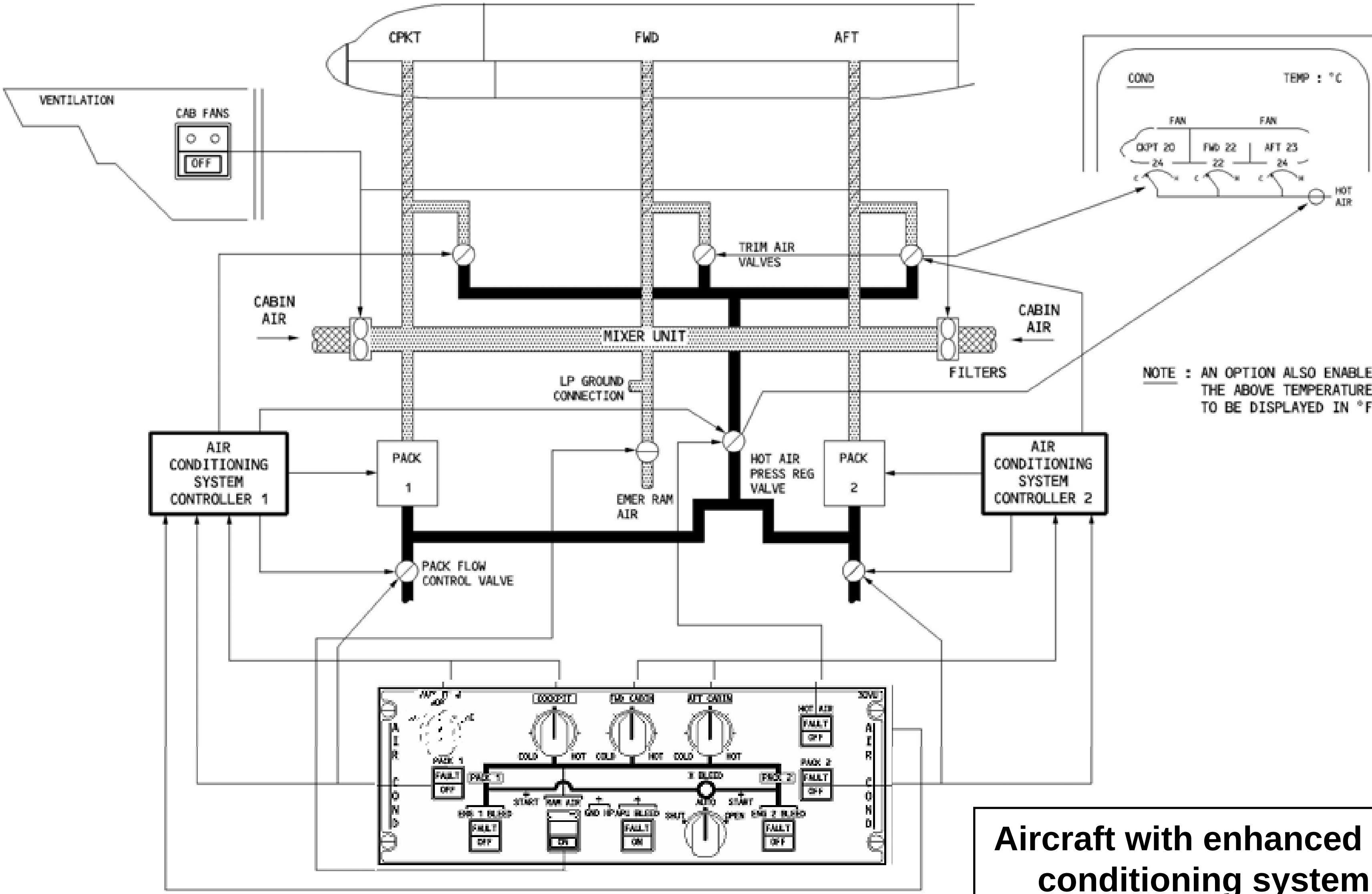
A318/A319/A320/A321 ECS – System Schematic



* For A319/A320/A321 only



Aircraft without enhanced air conditioning system (ACSC)



Aircraft with enhanced air conditioning system (ACSC)

Control System

- **General**
  The air conditioning system provides temperature controlled air to 3 independent zones : Cockpit, FWD cabin and AFT cabin. The air comes from the bleed system via two independent air conditioning cooling packs. It is then mixed with recirculation air to ensure good ventilation. Hot air may be added through three trim air valves to ensure temperature adjustment.

- **Functional description**
  Two pack flow control valves which are constant volumetric flow regulating and system shut-off valves. Pre-selected pack flow is adjustable to different levels.

  Packs ensure the cooling of the air coming from bleed system.

  Pressure regulating valve acts as regulation and shut-off valve for the balancing hot air to be regulated by the Trim Air Valves.

- **Temperature regulation**
  Temperature regulation is controlled via:
  - A zone controller and two pack controllers
  or
  - Two Air Conditioning System Controllers (ACSC) (system basic on A318)

- **Pack Controller**
  Each pack controller regulates the temperature of its associated pack, by modulating the bypass valve, the ram air inlet and outlet flaps.
  The pack controllers also regulate flow by modulating the associated pack flow control valve.

- **Zone Controller**
  - The PACK FLOW selector allows to adjust the pack flow for the number of passengers and for external conditions.
  - The system delivers automatically high flow when:
    - A single-pack operates
    - The APU is supplying bleed air
  - The Zone Controller sends a pressure demand signal to both Engine Interface Units (EIU) in case of low bleed pressure.
  - When the APU bleed valve is open, the zone controller signals the APU 's Electronic Control Box (ECB) to increase the APU flow output when any zone temperature demand cannot be satisfied.

- **ACSC**
  - This new controller merges the previously installed Pack Controllers and Zone Controller.
  - It will ensure exactly the same functions, but with improved reliability and reduced the maintenance costs (2 boxes instead of 3).
  - Both controllers include two redundant channels.

A318/A319/A320/A321 - ECS - Pack Configuration

Pack Description

- **General**
  The bleed air is pre-cooled in the Primary Heat Exchanger, then compressed in the Compressor of the Air Cycle Machine, then cooled again in the Main Heat Exchanger.

- The By-Pass valve regulates the temperature at pack outlet depending on cockpit and cabin requirement.

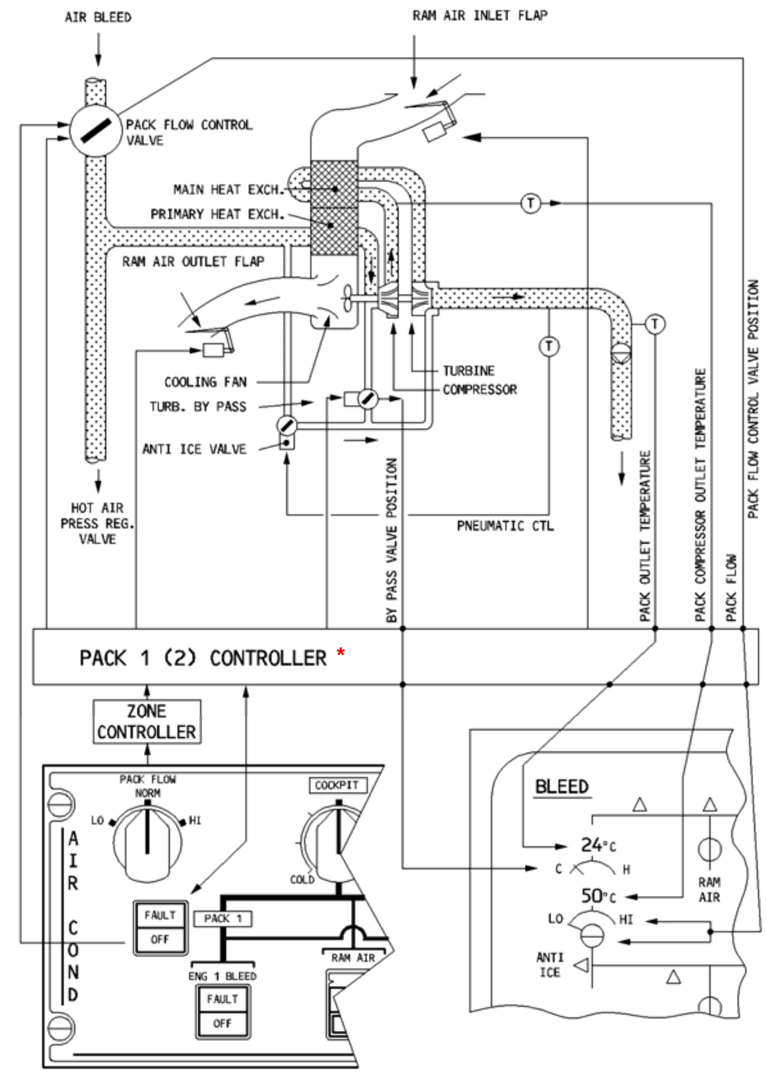
- Anti-Ice Valve avoids ice in exchangers and pipes.
  - Anti-Ice valve allows fully pneumatic temperature backup regulation (with Pneumatic Temperature Sensor) for A319/A320/A321.
  - Anti-Ice valve is automatically controlled by ASCS for A318

- The Ram Air inlet and outlet flaps close during takeoff and landing to avoid ingestion of foreign matter.
  The emergency Ram Air inlet valve ventilates the cabin and the cockpit to remove smoke, in case of packs failure
  Ram Air Inlet and Outlet are driven to 'minimum opening' in order to optimize the aircraft drag factor.

- For the A319/320/321, the backup pneumatic sensors allow regulation and safety functions for backup fully pneumatic pack functioning.

- For the A318, the ACSC can perform limited temperature control by using battery power in case of loss of normal electrical power.

Basic configuration



* ACSC configuration : pack controllers and zone controllers are merged into the Air Conditioning System Controllers

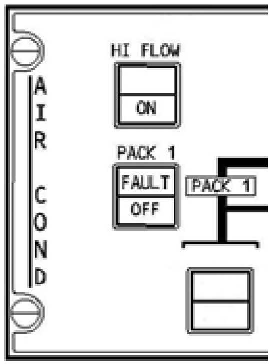
A318/A319/A320/A321 ECS – Temperature and Flow Control

Pack and zone temperature control panel

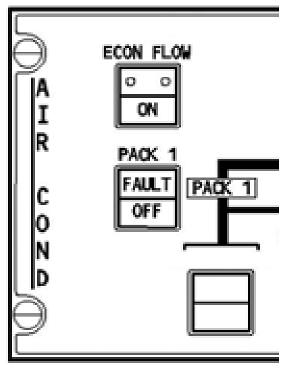
Automatic temperature control selectors

Variable flow selector

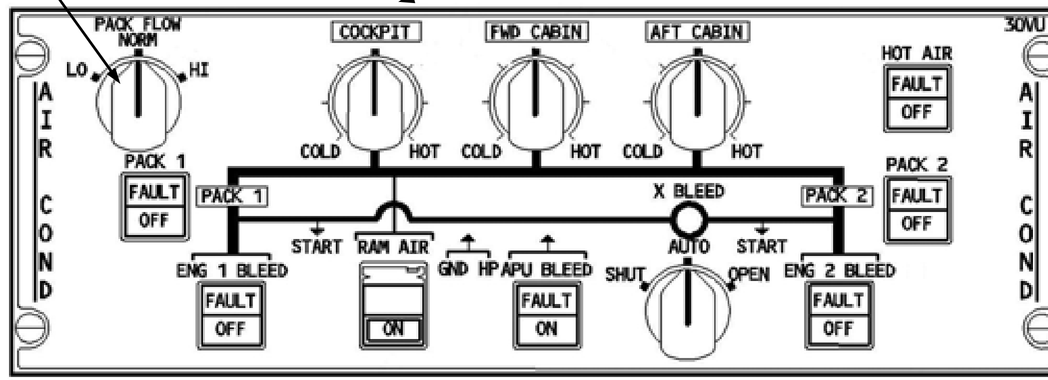
Flight deck



A318

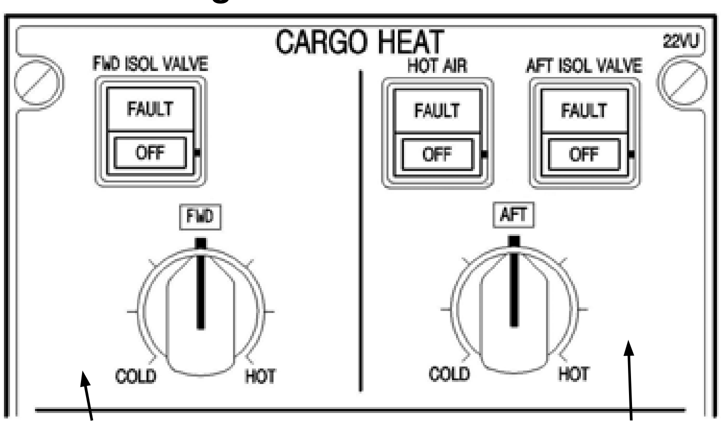


A321



A319/A320

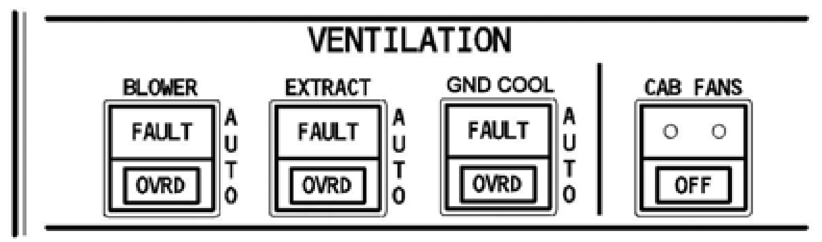
Cargo Control Panel



A319/A320/A321*   A318/A319/A320/A321

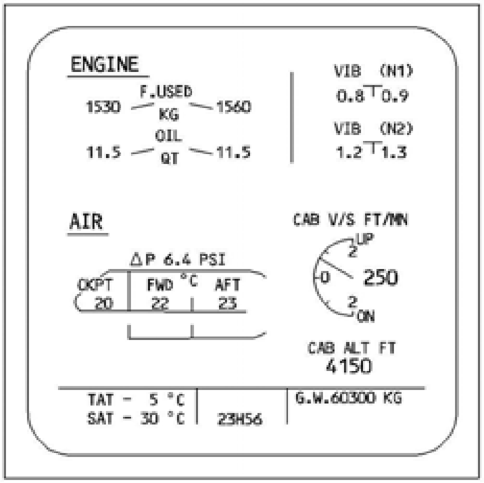
* FWD cargo heating is not available for A318

Avionics vent and fan control panel

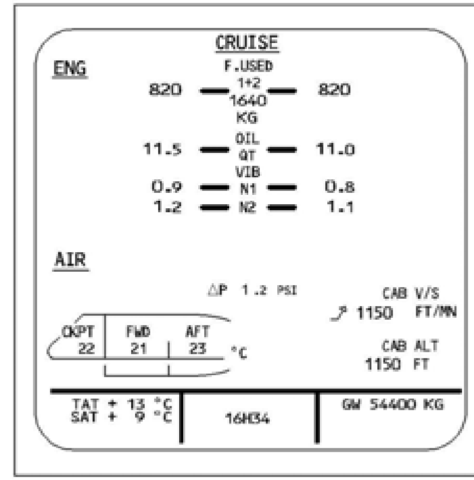


System Display

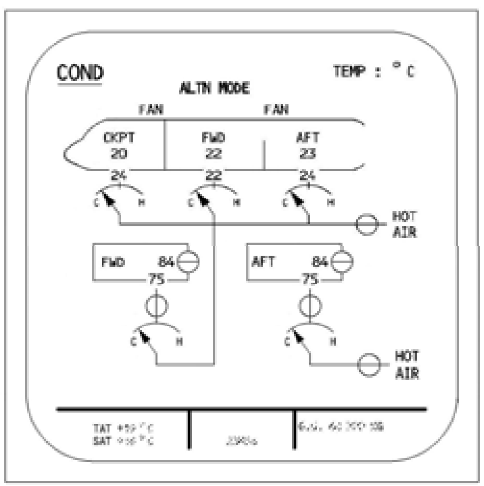
Cruise page (EIS 1)



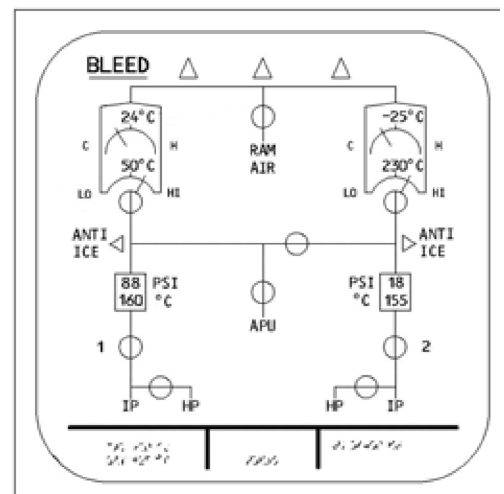
Cruise page (EIS 2)



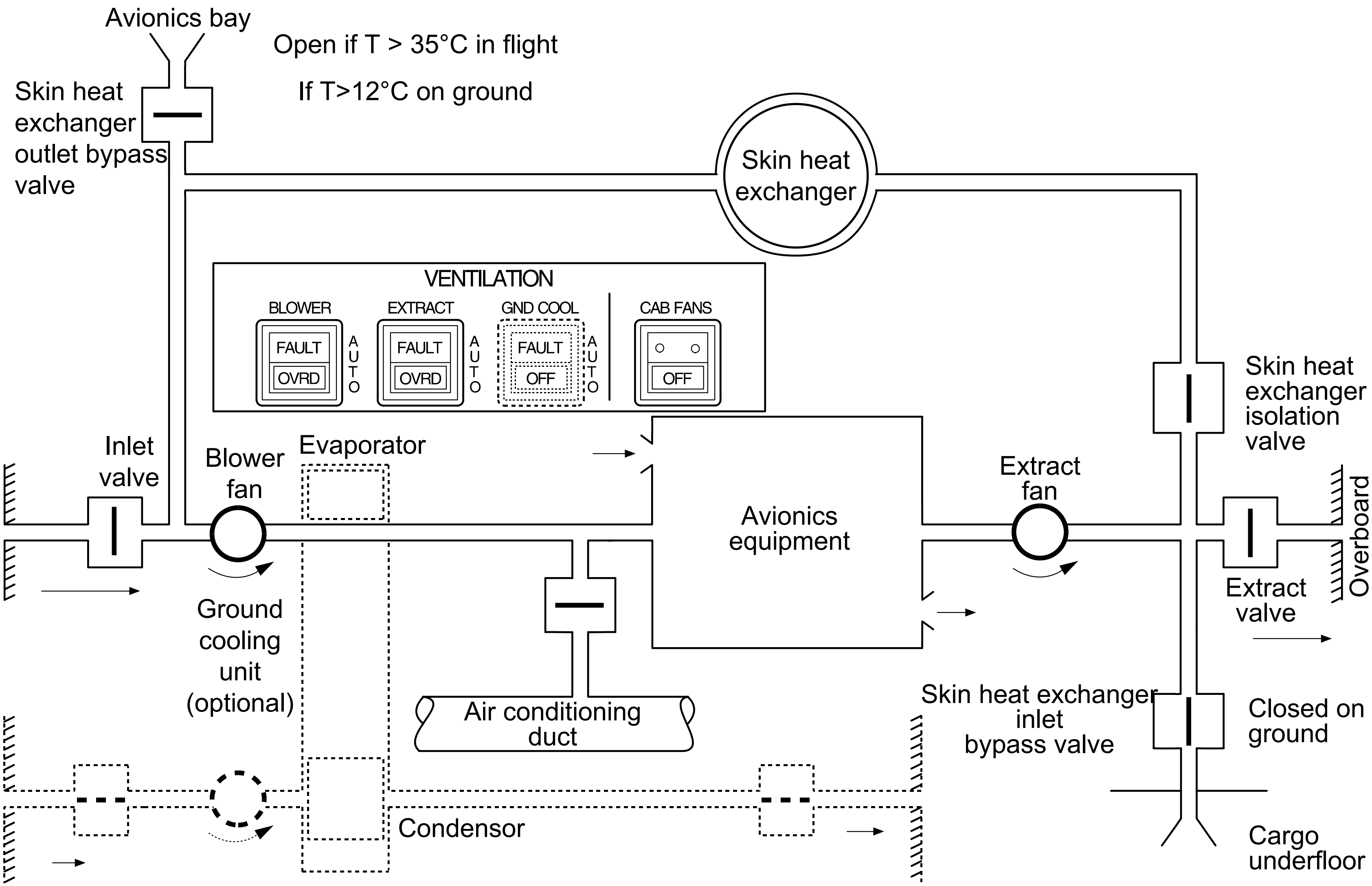
Cond page (EIS 1)



Bleed page (EIS 2)



A318/A319/A320/A321 ECS – Ventilation



Avionics ventilation

Ventilation and cooling are provided to avionics and electronic equipment under digital control **(AEVC: Avionics Equipment Ventilation Controller)** and without crew intervention.

Three main operational configurations are automatically selected (depending on the flight phase):

- In flight, in normal configuration:
  closed-circuit configuration. Air is cooled by means of an aircraft skin heat exchanger and circulated by the blower and extract fans.

- In flight, in abnormal configuration:
  in case of high temperature, air from the avionics bay is admitted and hot air is discharged by the extract valve which is maintained half open.

- On ground
  open-circuit configuration using outside fresh air through opening of inlet and extract valves.
  Or
  closed-circuit configuration at low temperatures

Battery ventilation

Ventilation is achieved by ambient air being drawn around the batteries and then vented directly outboard via a venturi.

Lavatory & galley ventilation

Ventilation is achieved by ambient cabin air extracted by a fan near the outflow valve.

Fwd and Aft compartment ventilation

Available as an option:

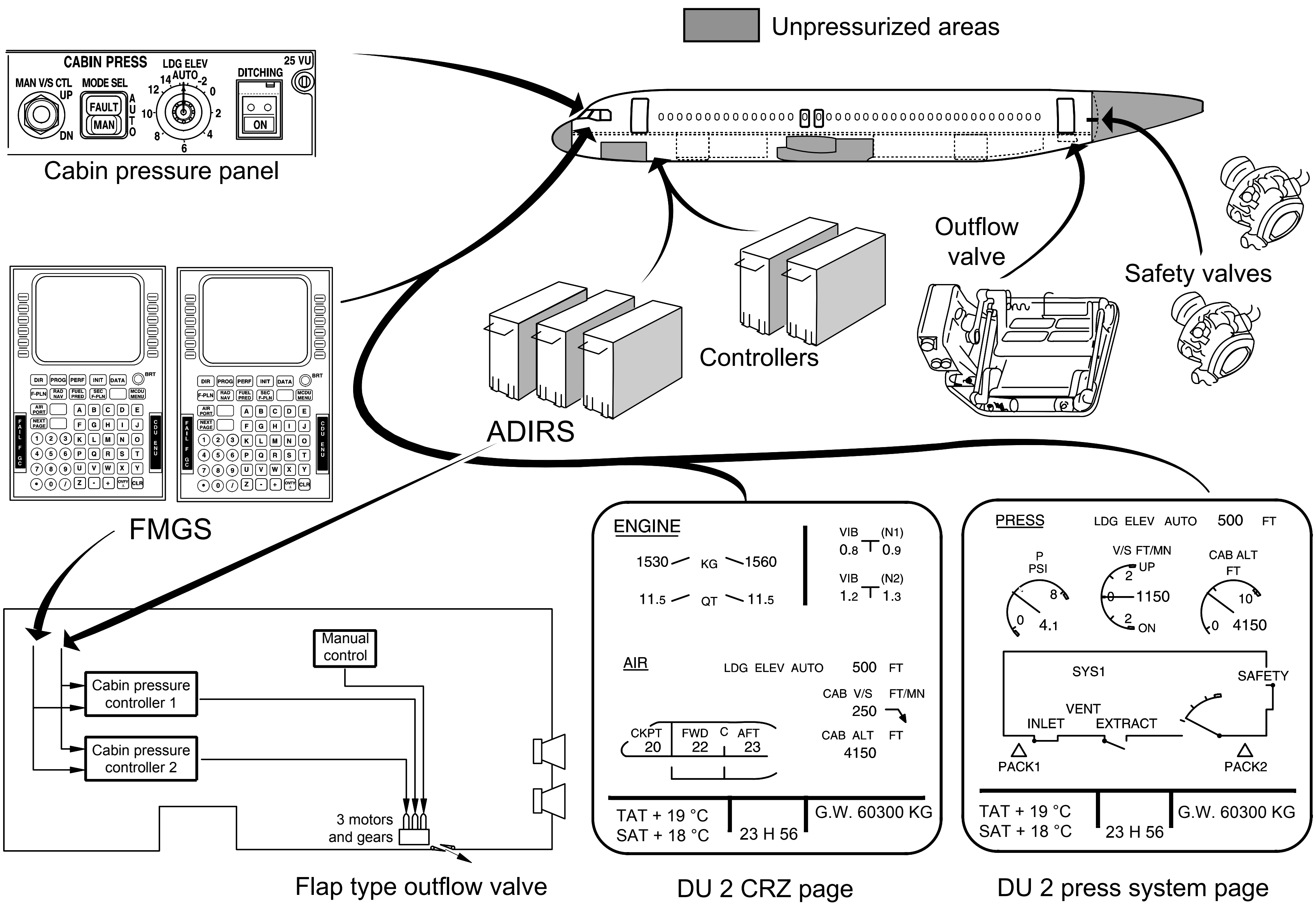
- For the A318 in the aft cargo compartment only
- For the A319/A320/A321 in either or both the forward and the aft cargo compartments

- The heating is provided by hot air from the bleed passing through a pressure regulating and shut-off valve and a trim air valve.

- For the forward cargo hold, the ventilation flow is provided by an extractor fan on ground and by the differential pressure through a venturi as soon as the aircraft altitude is sufficient.

- For the aft cargo hold, the ventilation flow is always provided by an extractor fan, and the airflow is blown near the pressurization system outflow valve.

A318/A319/A320/A321 ECS – Cabin Pressure Control



Description

- The pressurization control system operates fully automatically.
- Dual system (two identical Cabin Pressure Controller) with automatic switchover after failure. Alternative use for each flight. A single outflow valve is operated by one of three independent electric motors. Two of these are associated with automatic controllers.
- In normal operation, cabin altitude and rate of change are automatically controlled from FMGC flight plan data:
  - Cruise FL, landing field elevation, QNH,
  - Time to top of climb, time to landing.
- In case of dual FMGC failure, the crew has to manually select the landing elevation. The cabin altitude varies according to field law.
- In case of failure of both pressurization system auto-controllers, the manual back-up mode is provided through the third outflow valve motor.

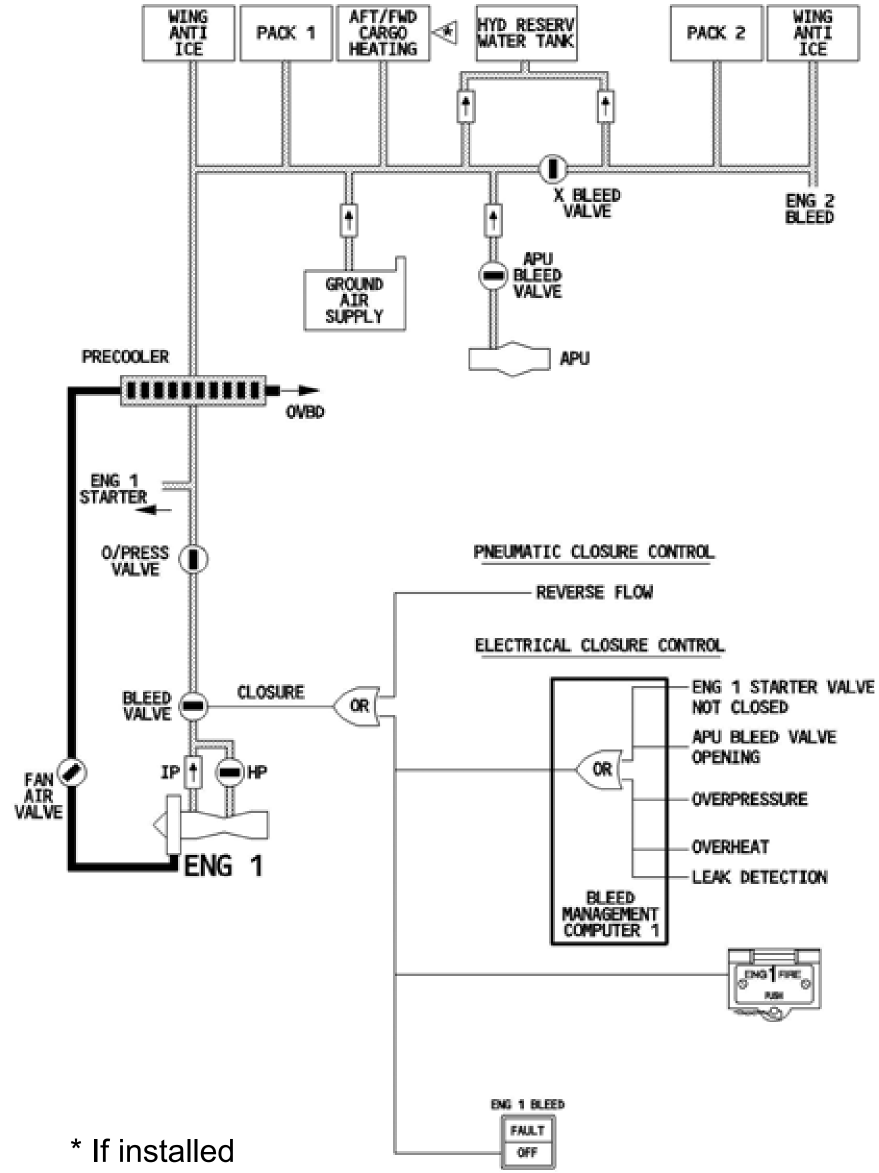
Pneumatic

- High pressure air is supplied for:

- Air conditioning and pressurization
- Engine starting
- Wing anti-icing
- Water pressurization
- Hydraulic reservoir pressurization
- Rain repellent purge system

- System operation is electrically monitored by two Bleed Monitoring Computers **(BMC)**, and is pneumatically controlled.

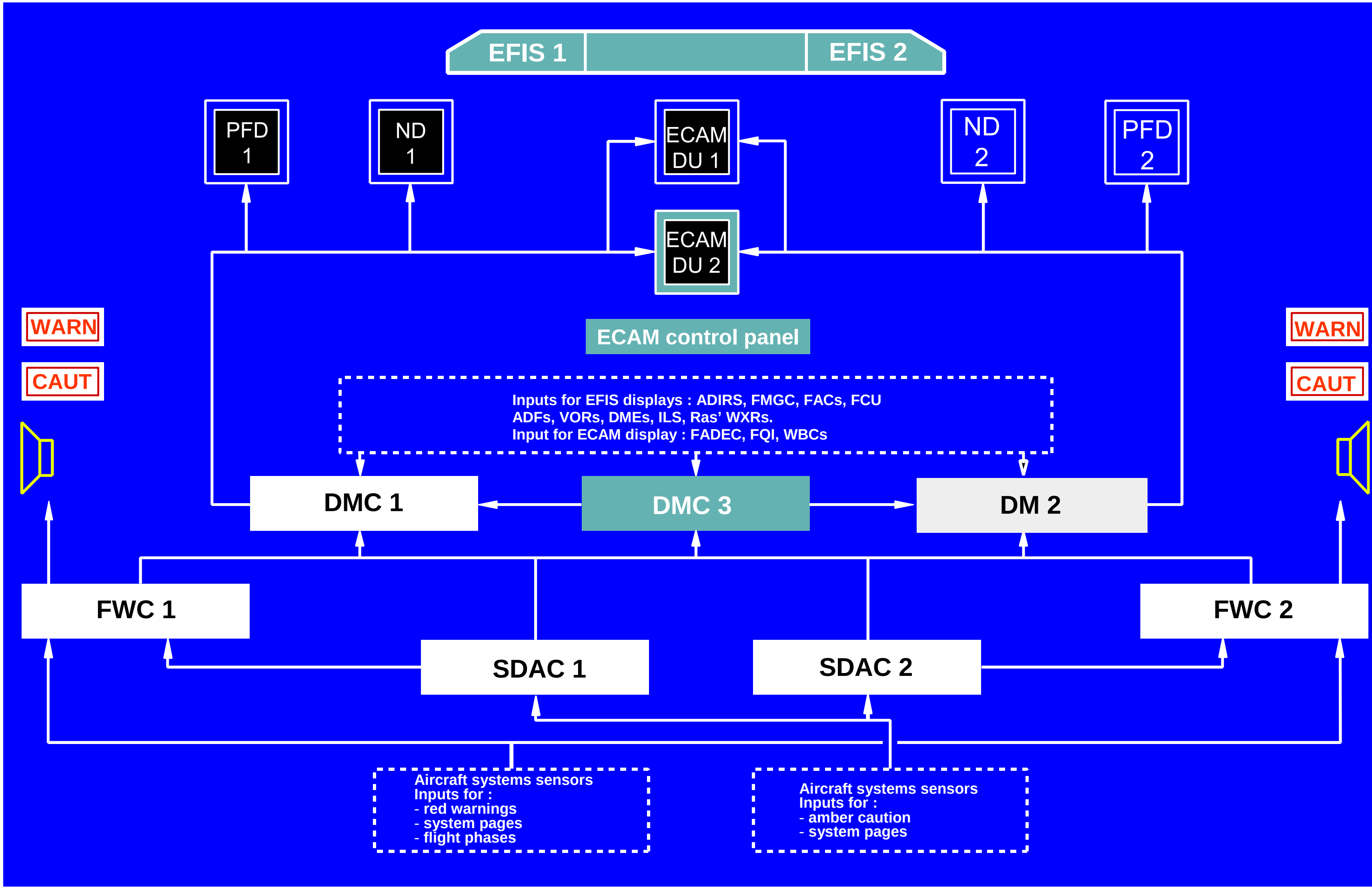
- A leak detection system is provided to detect any overheat in the vicinity of the hot air ducts.



* If installed

12. Electronic Instrument System

A318/A319/A320/A321 EIS – EFIS/ECAM Architecture



A318/A319/A320/A321 EIS - Components

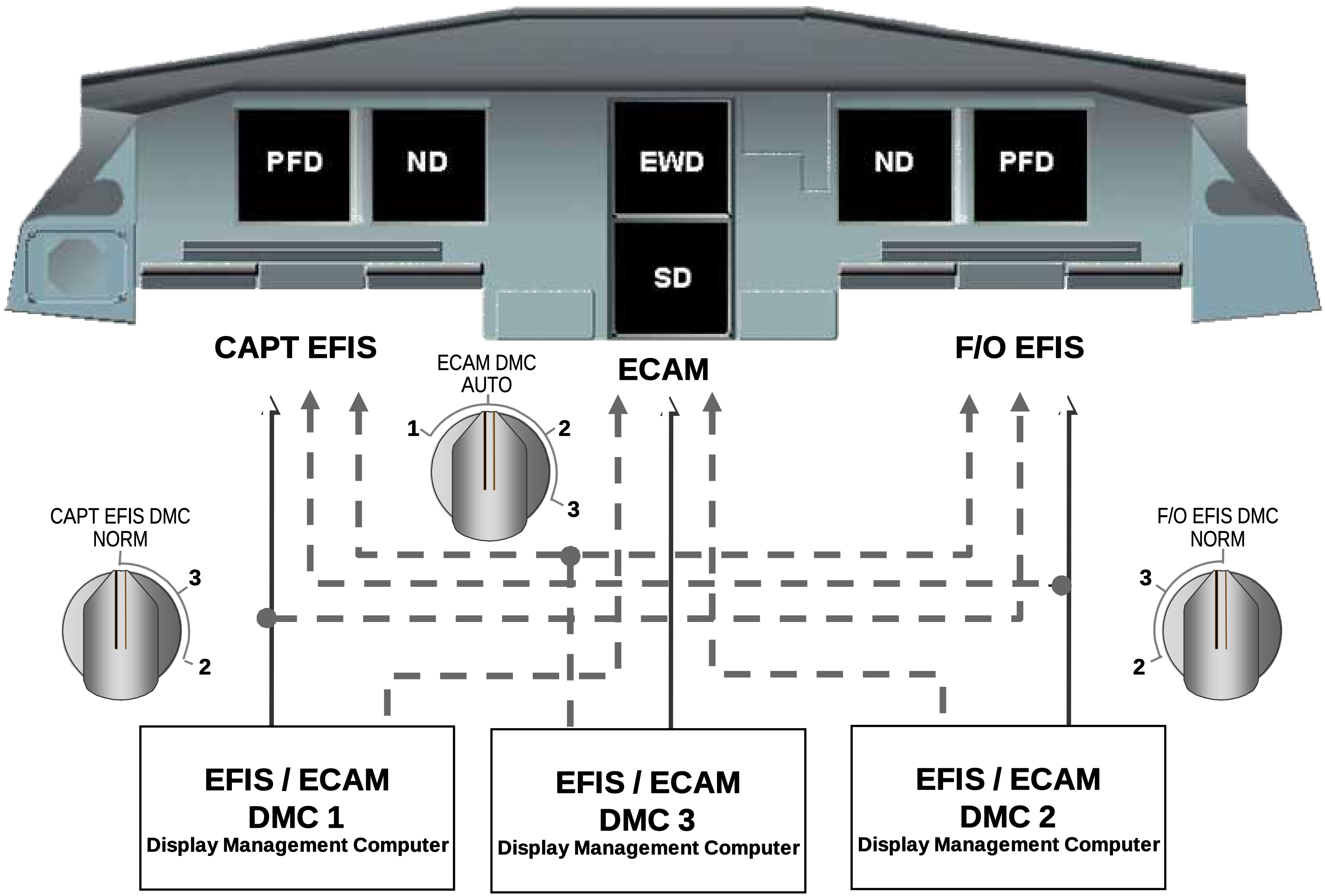
- Six identical Display Units **(DU)**, including integrated graphics generator:
  EFIS:
  - Two primary flight displays (PFD)
  - Two navigation display (ND)

  ECAM:
  - One engine warning display (EWD)
  - One system display (SD)
- Three Display Management Computers **(DMC)**
  - Generating images to be displayed on PFD, ND and ECAM DUs
  - Digital data link to display units
  - No.3 DMC may replace either No.1 or No.2
- Two System Data Acquisition Concentrators **(SDAC)**
  - Acquiring systems data for transmission of caution/warnings to FWCs and systems condition to DMCs
  - Operations not affected with either SDAC failure.
- Two Flight Warning Computers **(FWC)**
  - Generating alert messages, aural alerts and procedural messages for display on ECAM
  - Operations not affected with either FWC failure.
- For aircraft fitted with the EIS1 the Display Units are Cathode Ray Tubes.
  For aircraft fitted with the EIS2 the DUs are Liquid Cristal Displays

  Inherent advantages of the Liquid Crystal Display:
  - Increased screen size of the PFD, ND and ECAM. The usable surface of the screens is now 6”25 x 6”25 (compared to today’s 5”25 x 5”25).

  - Improved Display Unit contrast. LCD offers far better contrast and stability throughout its lifespan.
- Optional equipment
  It is possible to fit an aircraft with an additional DU software. This software allow to display video images in the DUs (example: TACS).

A318/A319/A320/A321 EIS - Architecture



A318/A319/A320/A321 EIS - EFIS Arrangement

- Primary Flight Display:

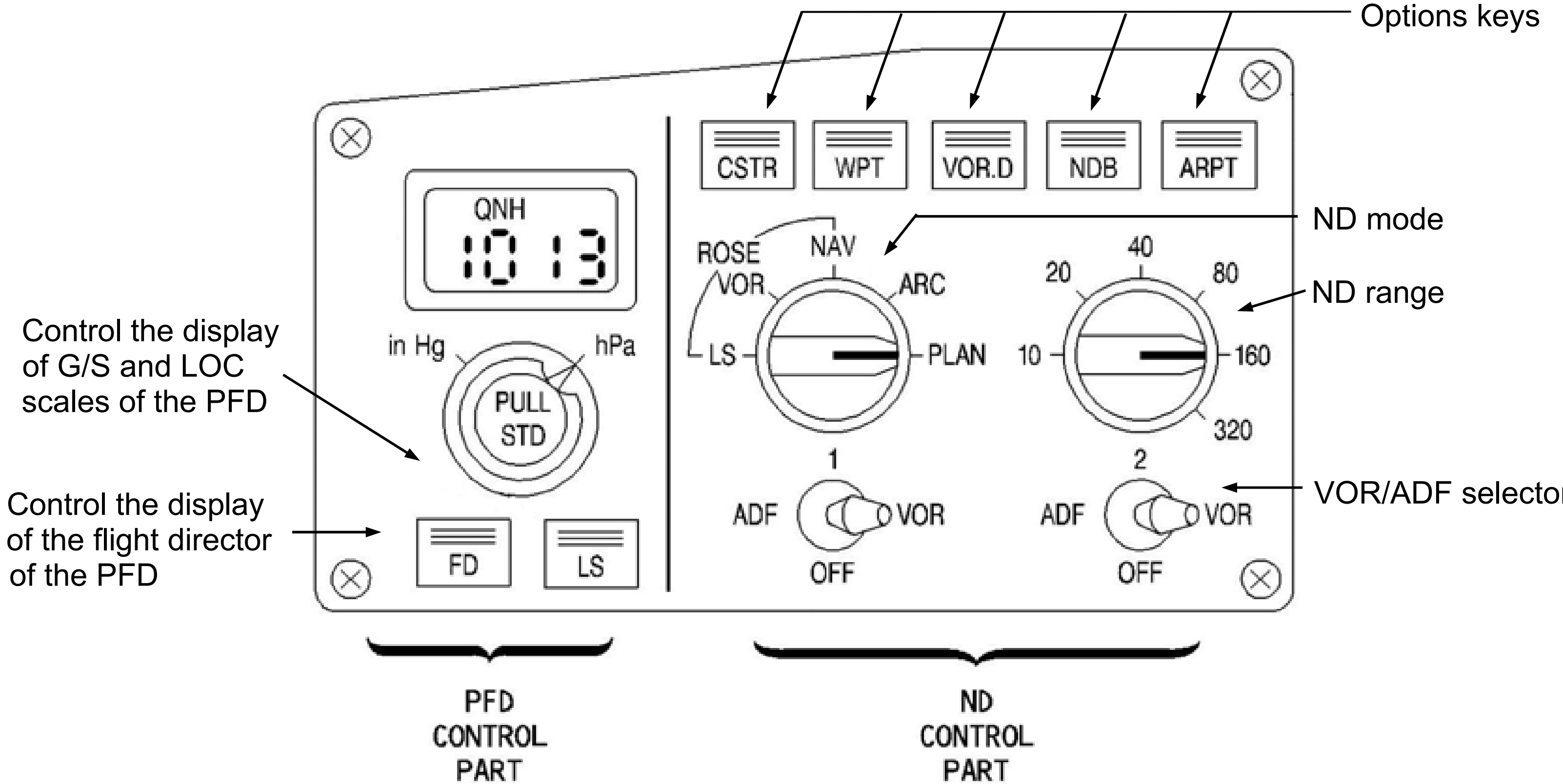
  - Attitude
  - Airspeed
  - Altitude/vertical speed
  - Heading
  - ILS deviation/marker
  - Radio altitude
  - AFS status (FMA)

- Navigation Display, three modes:

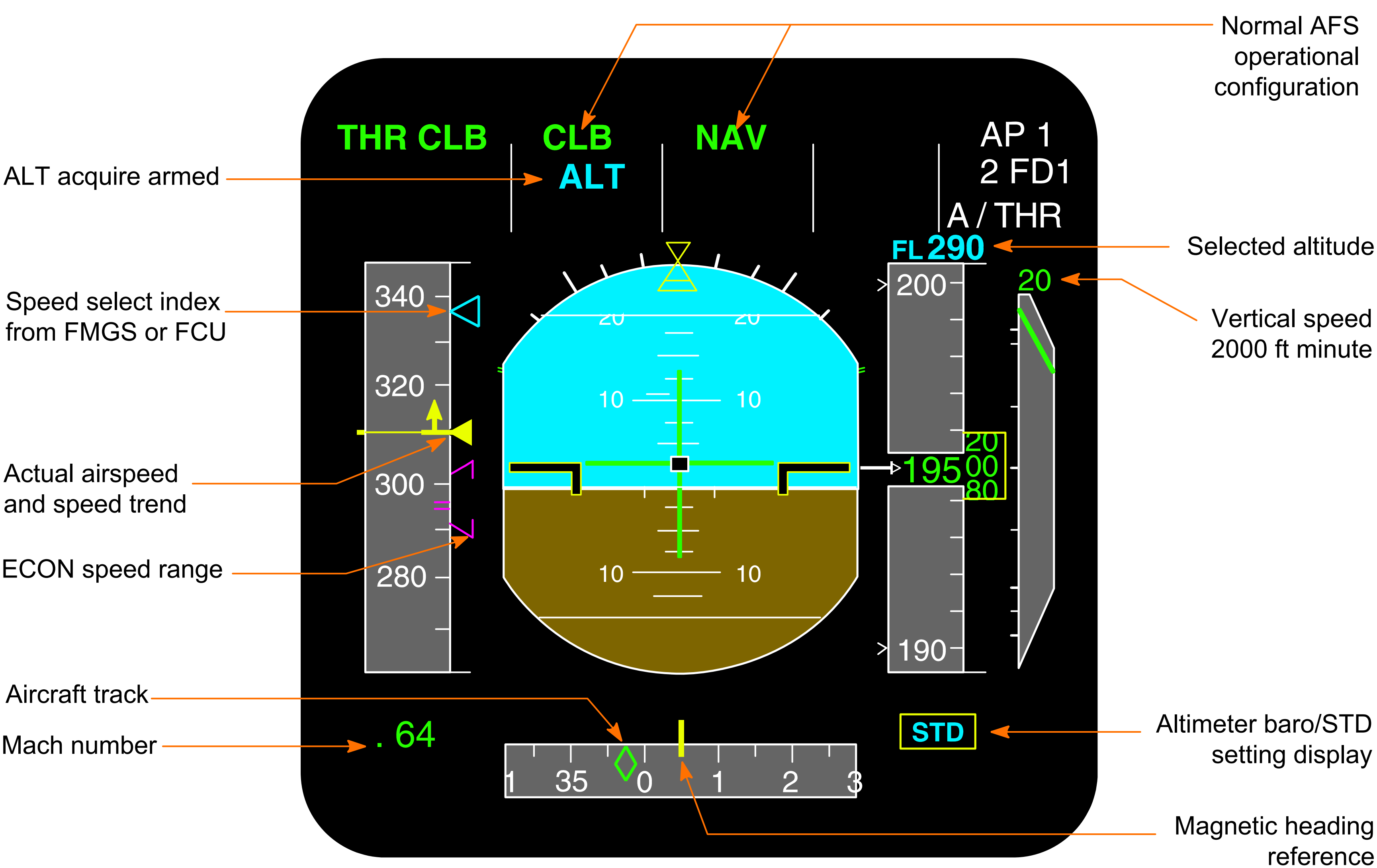
  - **ROSE** mode **(ILS, VOR or NAV)**: aircraft symbol in screen centre, heading up with radar available
  - **ARC** mode: aircraft symbol in lower part of the screen, heading up with radar available
  - **PLAN** mode: display centered on selected waypoint, north up

Note: In ROSE-NAV, ARC and PLAN modes, map data from FMS are presented

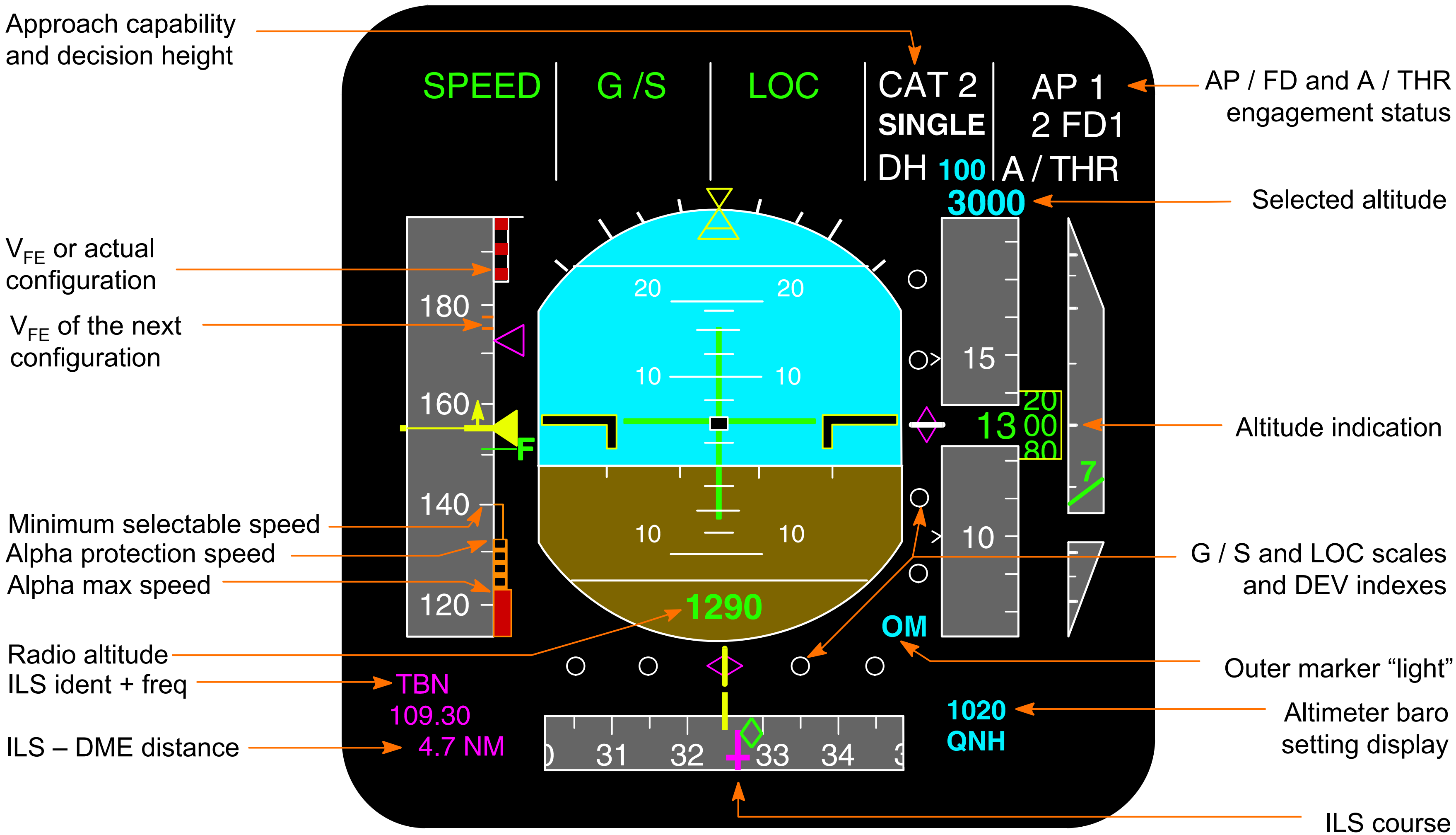
Capt. EFIS control panel



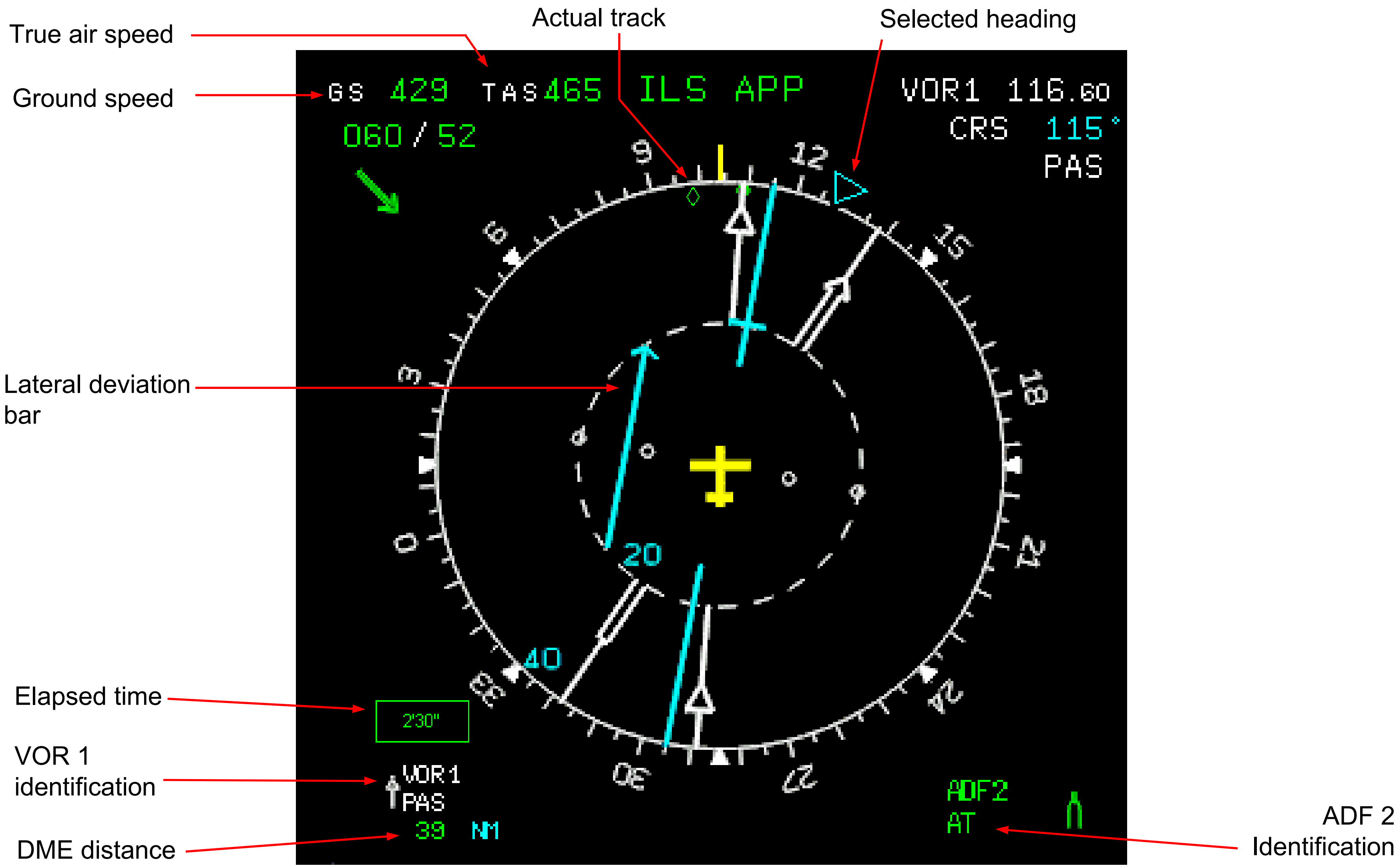
A318/A319/A320/A321 EIS - PFD: Climb – FMS Guidance



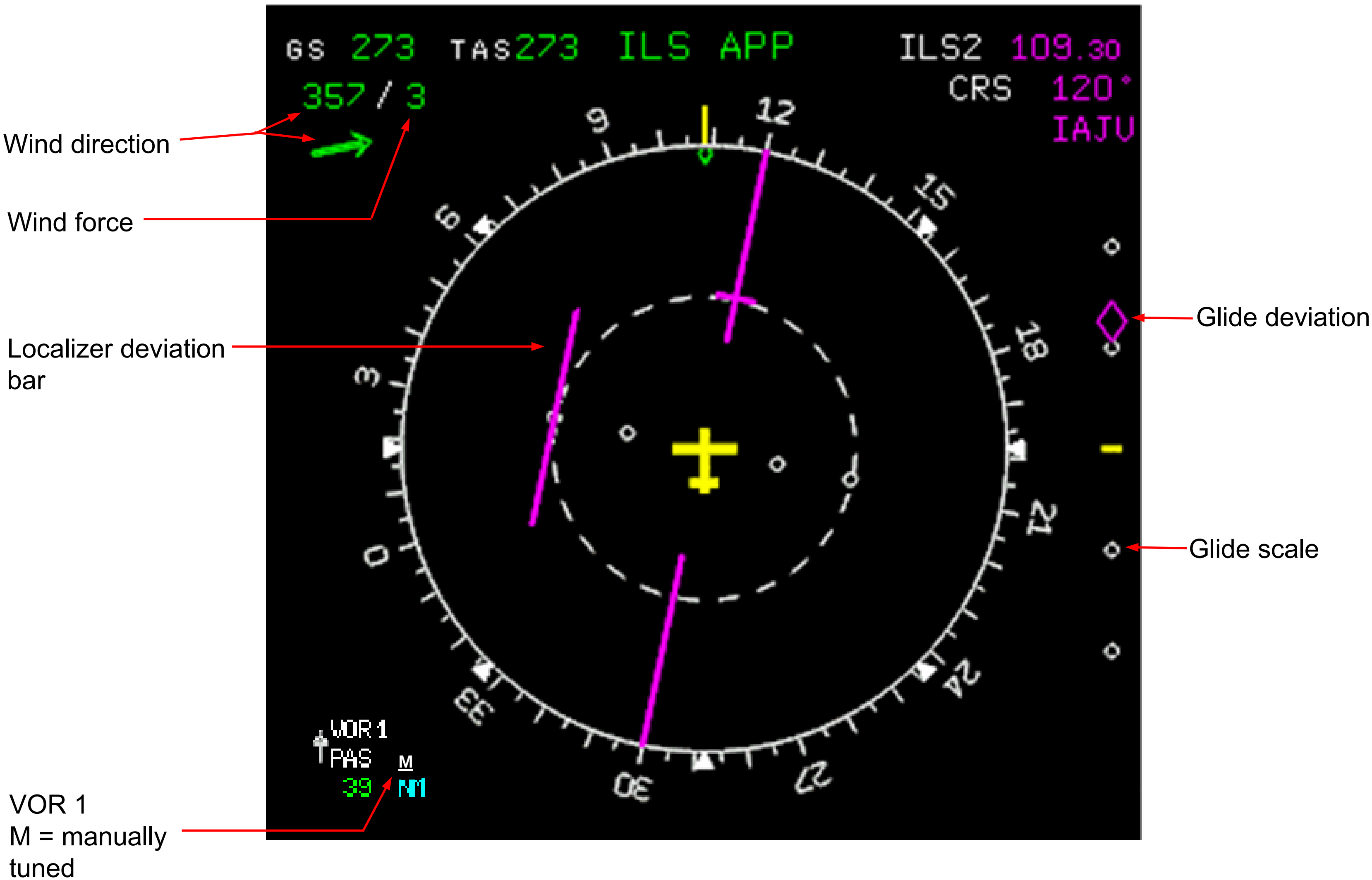
A318/A319/A320/A321 EIS - PFD: Approach Configuration



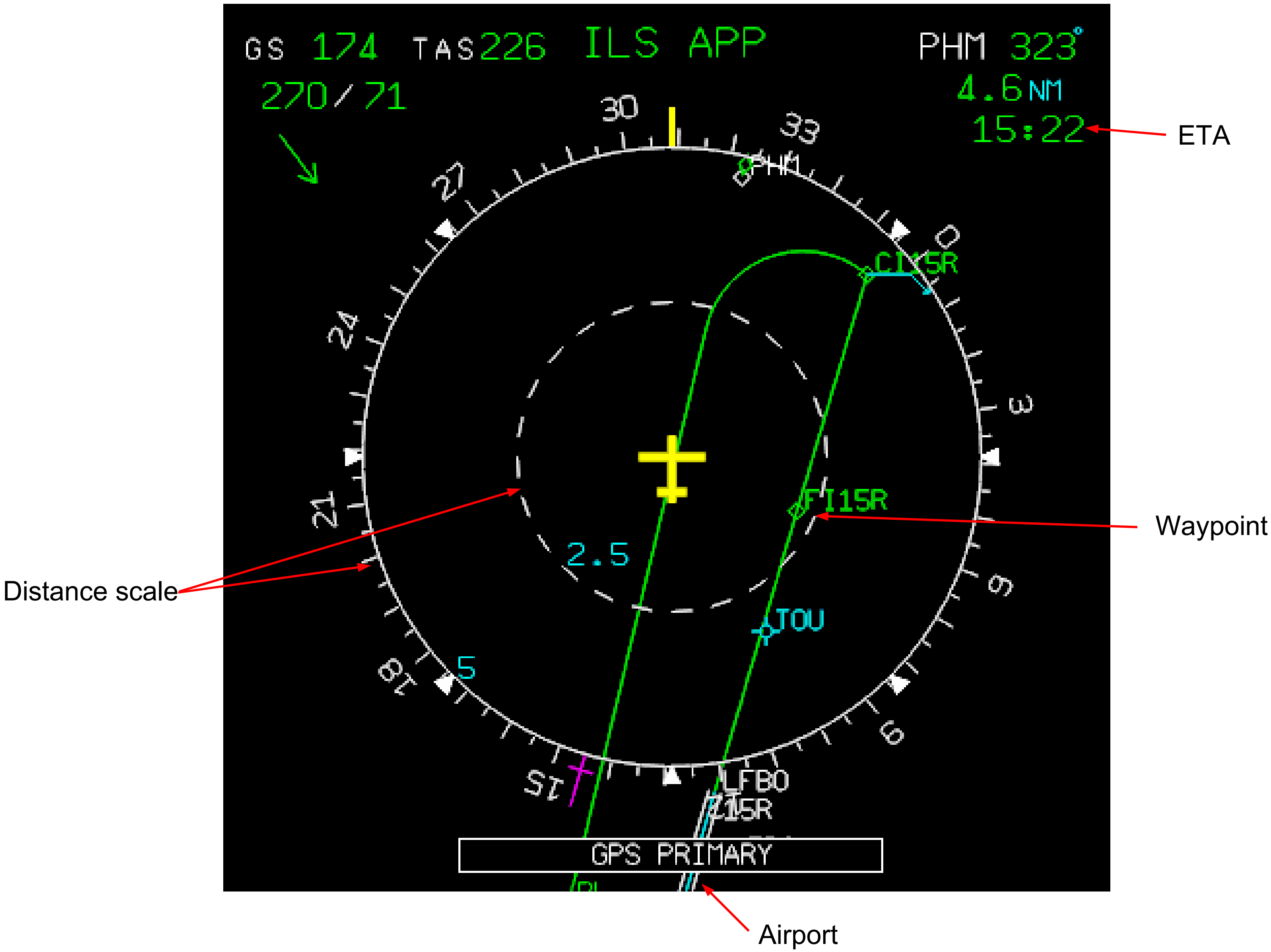
A318/A319/A320/A321 EIS - ND: ROSE / VOR Mode



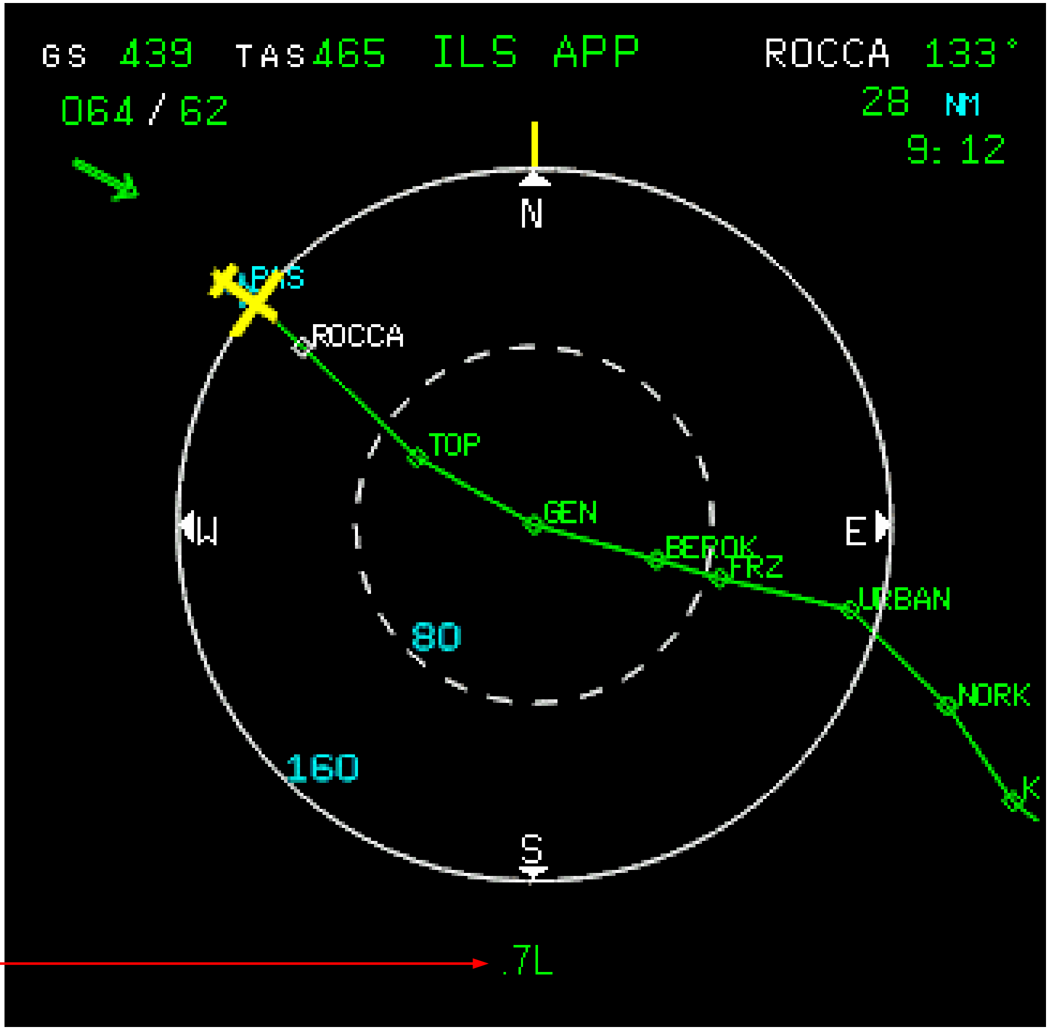
A318/A319/A320/A321 EIS - ND: ROSE / ILS Mode



A318/A319/A320/A321 EIS - ND: ROSE / NAV Mode



A318/A319/A320/A321 EIS - ND: PLAN Mode



Cross track error

A318/A319/A320/A321 EIS - ND: TCAS (optional)

Traffic advisory:
AMBER

Resolution advisory:
RED

Proximate aircraft:
WHITE

Off scale intruder

A318/A319/A320/A321 EIS - ECAM

General

- The ECAM (Electronic Centralized Aircraft Monitor) is used for systems operations
- ECAM is based on the "**need to know"** concept. System data is displayed only when required.
  - Data processing is fully automatic and, as such, does not require any additional crew action or selection.
  - Permanent display of engine control parameters : Total fuel, flaps/slats, TAT, SAT, aircraft weight and CG, time.

Arrangement

- ECAM (EFIS) colour symbology

- Warnings	:	RED	for configuration or failure needing immediate action
- Cautions	:	AMBER	for configuration or failure needing awareness
- Indications	:	GREEN	for normal long term operations
		WHITE	for titling and guiding remarks
		BLUE	for actions to be carried out
		MAGENTA	for particular messages, e.g. inhibitions

- ECAM arrangement

Upper DU

- Engine primary indication
- Fuel quantity information
- Slats/flaps position
- Memo/configuration data or warning/caution messages

Lower DU

- Aircraft system synoptic diagram or status messages

ECAM Sound Symbology

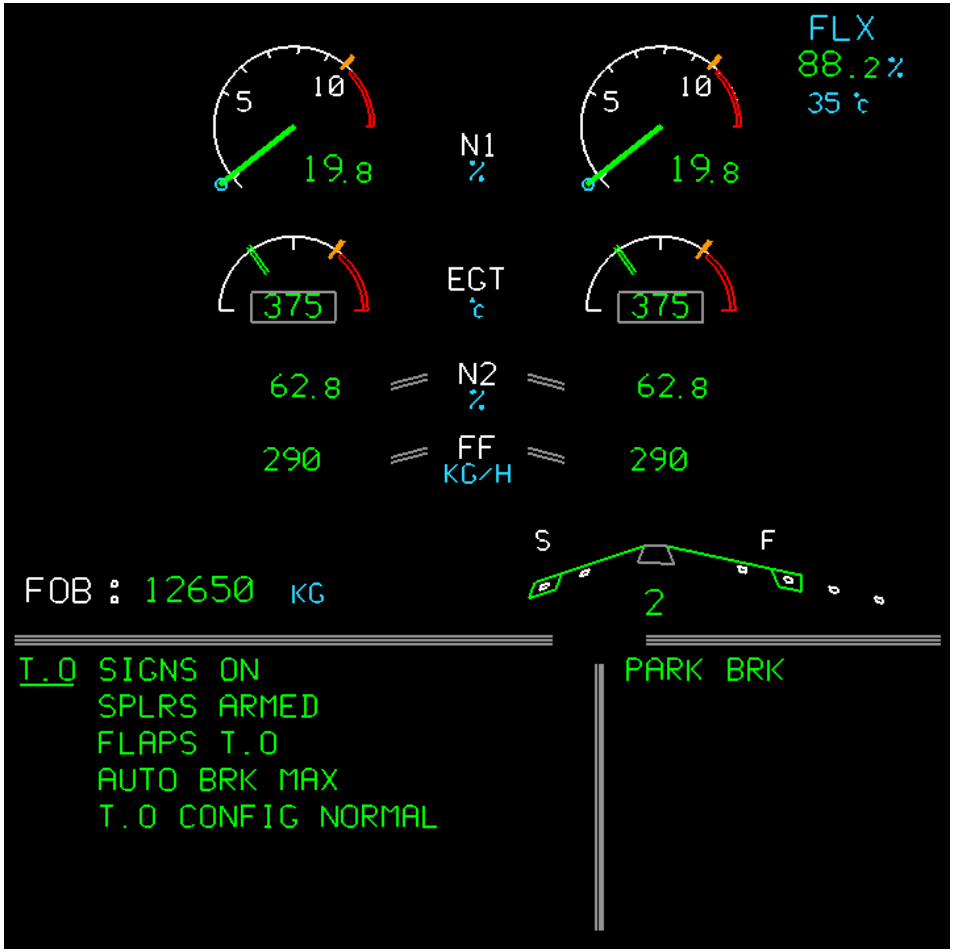
Warning signal	Condition	Duration
Continuous repetitive chime	Red warnings	Permanent
Single chime	Amber caution	0.5 second
Cavalry change	A/P disconnection by take-over pb	1.5 second
	A/P disconnection due to failure	Permanent
Click	Landing capability change	0.5 second (three pulses)
Cricket	Stall	Permanent
Intermittent buzzer	SELCAL call	Permanent
Continuous buzzer	Cabin call	Permanent
‘C’ chord	Altitude alert	1.5 second or Permanent
Auto call-out (synthetic voice)	Height announcement below 400ft	Permanent
Ground proximity warning (synthetic voice)	GWPS warning	Permanent

EIS 2

Primary engine indications

Fuel quantity indication

MEMO: landing



Flap / slats position indication

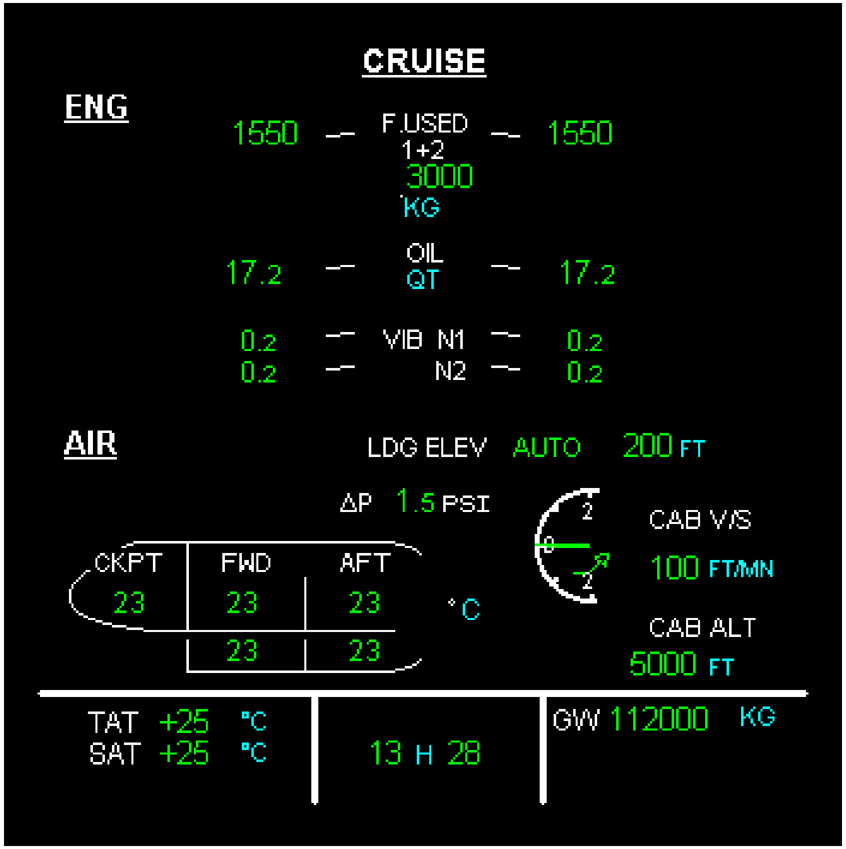
A318/A319/A320/A321 EIS - ECAM Upper Display

- **The ECAM upper DU can provide the following memo items for systems which can be use temporarily and for which no dedicated annunciator lights are provided.**
- **Specific memos for take-off and landing are also available when appropriate.**

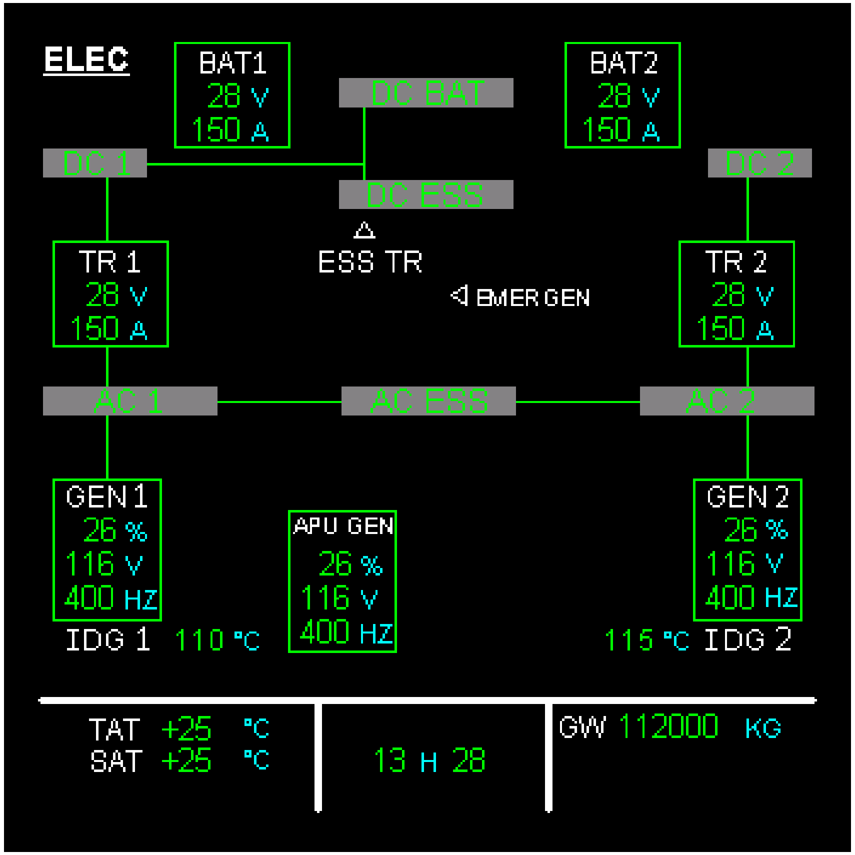
			TO MEMO	LDG MEMO
IRS IN ALIGN X MIN	SPEED BRK	SWITCHING PNL	AUTO BRK.......MAX	LDG GEAR.......DN
IRS ALIGNED	PARK BRK	GPWS FLAP 3	SIGNS ....ON	SIGNS ....ON
SEA BELTS	HYD PTU	ACARS STBY	SPLRS ....ARM	SPLRS ....ARM
NO SMOKING	RAT OUT	MAN LDG ELEV	FLAPS ....TO	FLAPS ....FULL
REFUEL G	EMER GEN	CRT TK FEEDG	TO CONFIG ..... TEST	or
OUTR CELL FUELXFRD	RAM AIR ON	FUEL X FEED	CABIN ....READY	CONFIG 3
STROBE LT OFF	ACARS CALL	T.O. INHIB		
N. WHEEL STEERG DISC	ACARS MSG.	LDG INHIB		
IGNITION	ENG A.ICE	LAND ASAP		
GND SPLRS ARMED	WING A.ICE			
GPWS FLAP MODE OFF	APU AVAIL	AUTO BRK { OFF / LO / MED / MAX		
	APU BLEED			
	LDG LT			
	BRK FAN			
	AUDIO 3 X FRD			

EIS 2

Cruise page



Electrical system page with advisory



A318/A319/A320/A321 EIS - ECAM Lower DU

- The ECAM lower DU presents either (one of twelve) system pages or status pages.

- Selection of **System page** is:

  - manual from the ECAM control panel, or

  - automatic :

    · in association with a warning/caution message,
    · with an advisory pulse message when a parameter drifts out of range
    · according to flight phase.

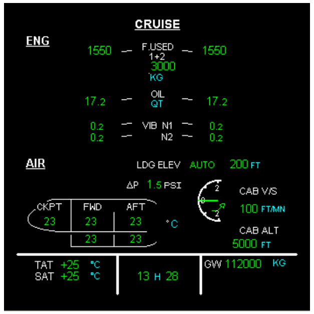
- 12 available pages:

  Air bleed,
  Air conditioning,
  Cabin pressurization,
  Electrical power supply – AC / DC,
  Flight controls,
  Fuel,
  Hydraulics,
  APU,
  Engine monitoring,
  Doors / oxygen,
  Braking (wheel, ground spoiler),
  Cruise.

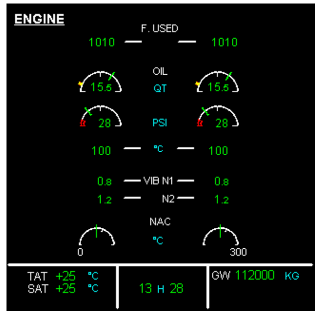
A318/A319/A320/A321 EIS - ECAM System Pages

EIS 2

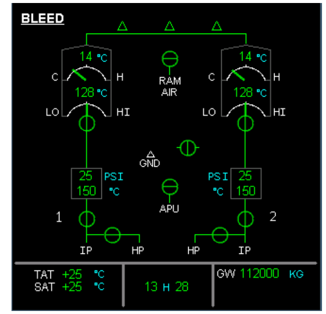
Cruise page



Engine page

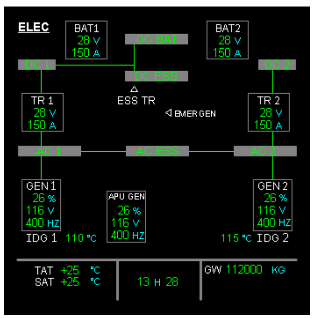


Air bleed page

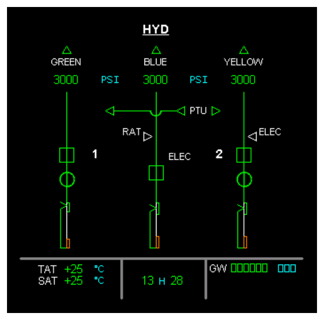


Cabin pressurization page

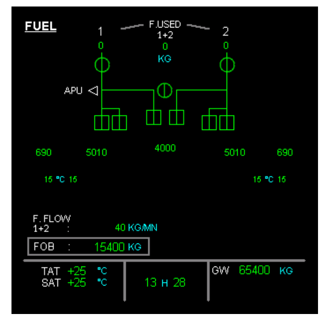
Electric page



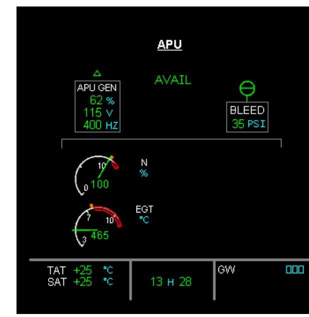
Hydraulic page



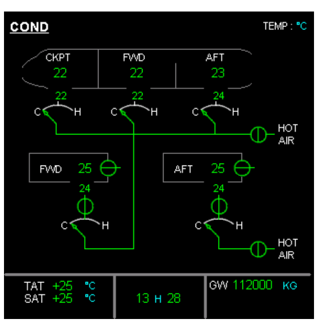
Fuel page



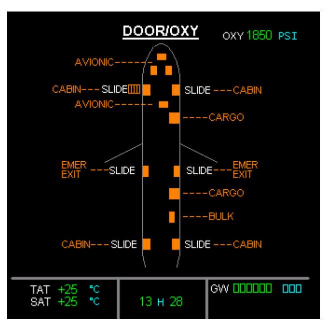
APU page



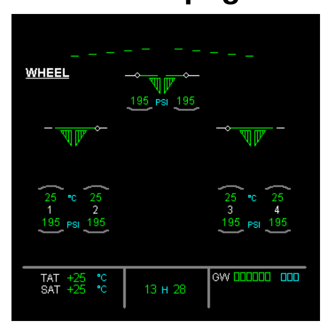
Air conditioning page



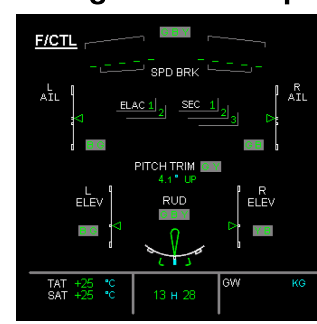
Doors/oxygen page

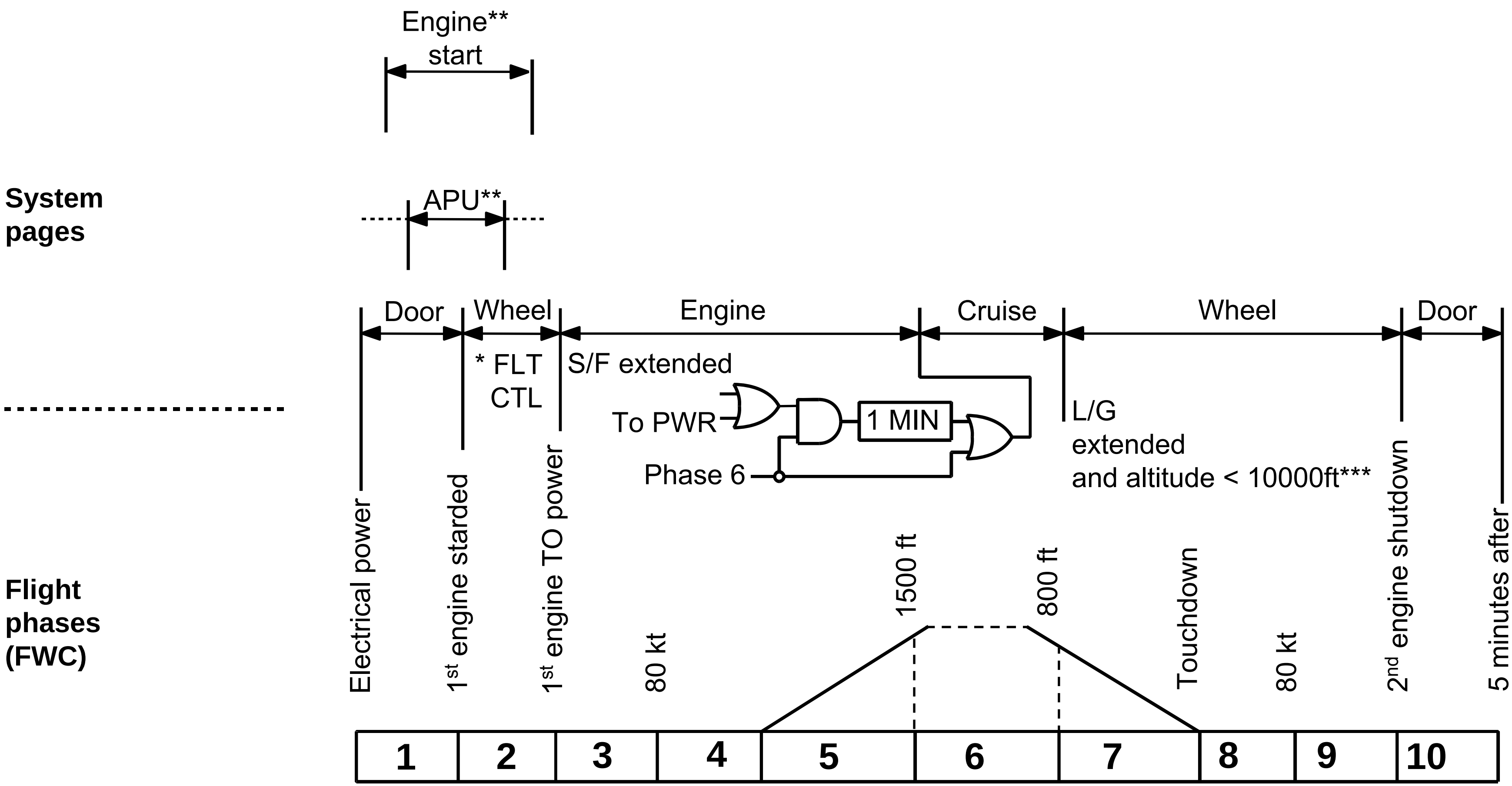


Wheel page



Flight controls page





* FLT CTL page replaces wheel page for 20 seconds when either sidestick is moved or when rudder deflection is above 22°.

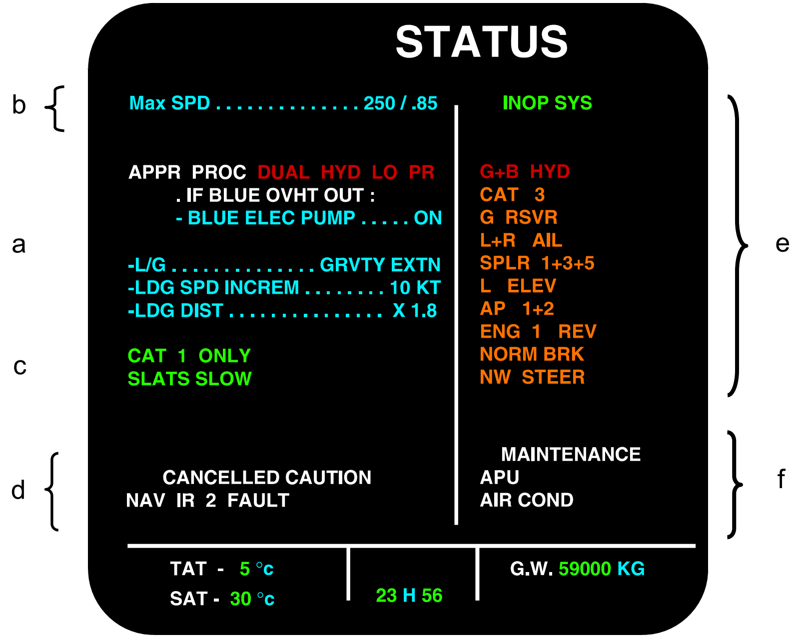
** APU page or EBG START page automatically displayed during start sequence.

*** 10000 or 16000 ft, depending on the MOD

Status Page

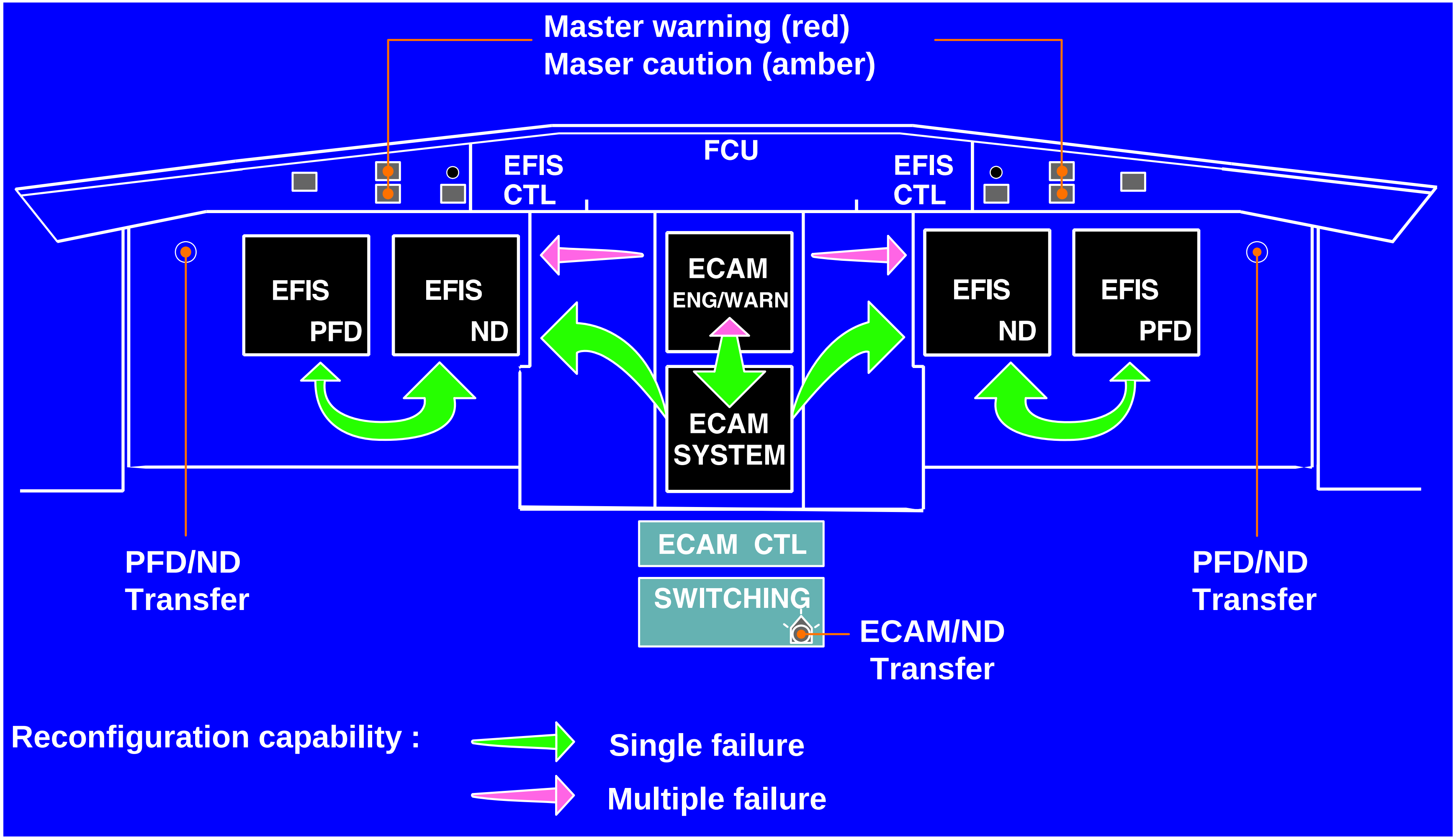
The operational summary of the aircraft status after a failure is displayed on the lower ECAM DU and includes:

(a) Postponable procedures not displayed on first page (blue)
(b) Limitations (speed, flight level…) (blue)
(c) Informations (green)
(d) Cancelled cautions or warnings (white)
(e) Inoperative systems (amber)
(f) Maintenance status (white)



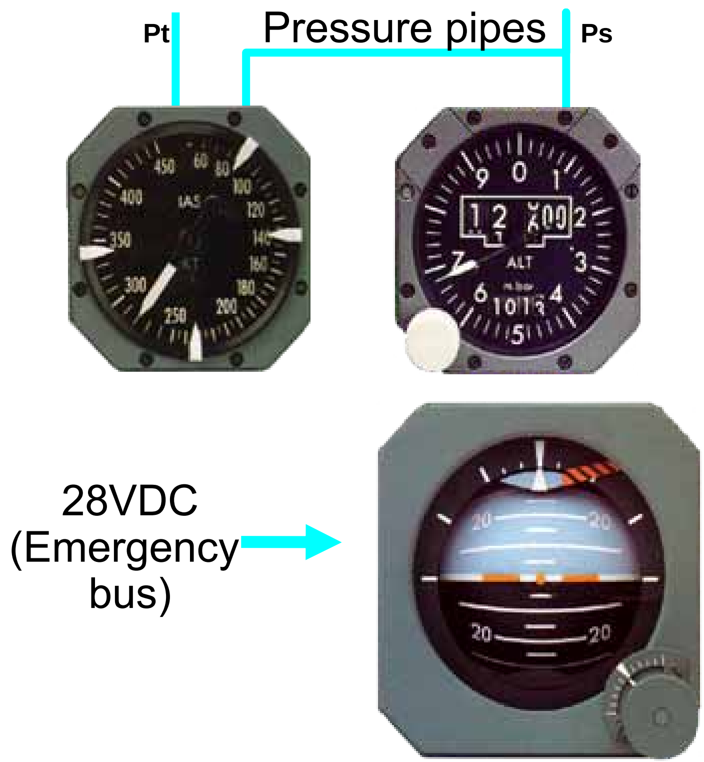
System page control

A318/A319/A320/A321 EIS– DUs Reconfiguration

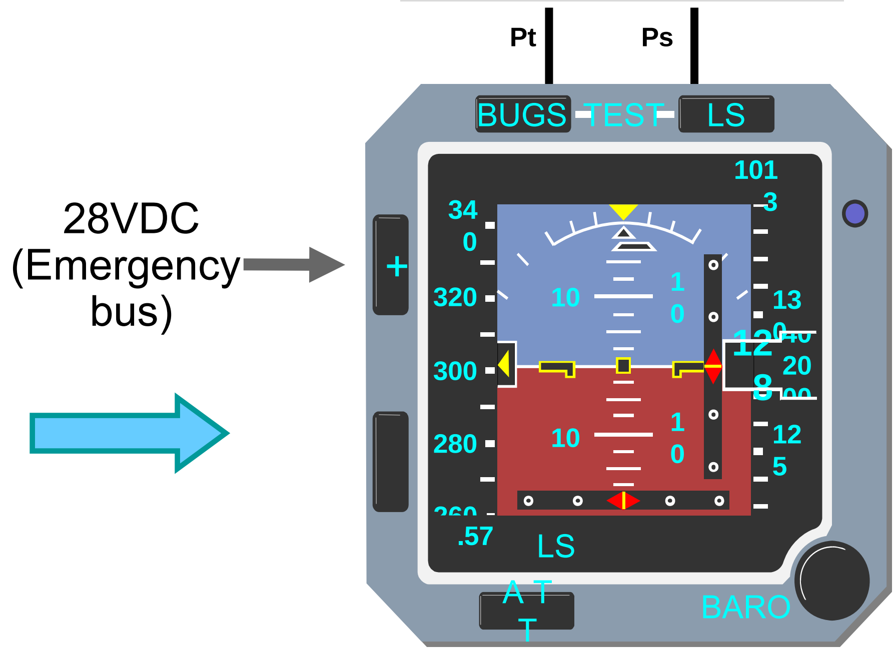


- The standby instruments (horizon, airspeed and altimeter) are replaced by one integrated Standby Instrument System called ISIS
- ISIS is basic on A318 and optional for the rest of Single-Aisle aircraft.

STANDARD INSTALLATION



ISIS INSTALLATION



Independent Failure Presentation Sequence

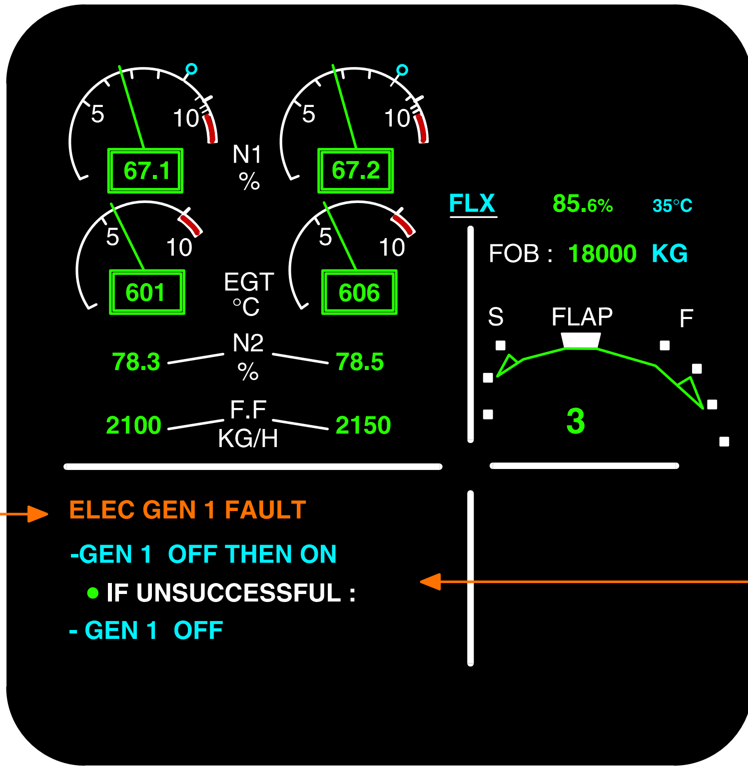
Example: electrical generator fault

A320 EIS – Independent Failure: Initiation

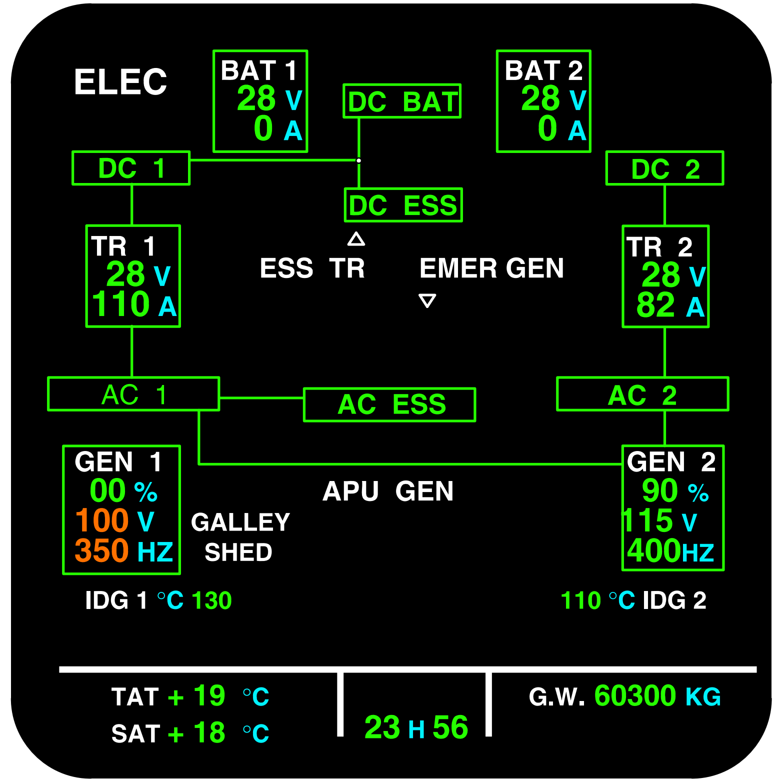
The following displays appear, provided no flight phase inhibition is active.

EIS 1

ECAM upper display



ECAM lower display: ELEC page



Failure identification

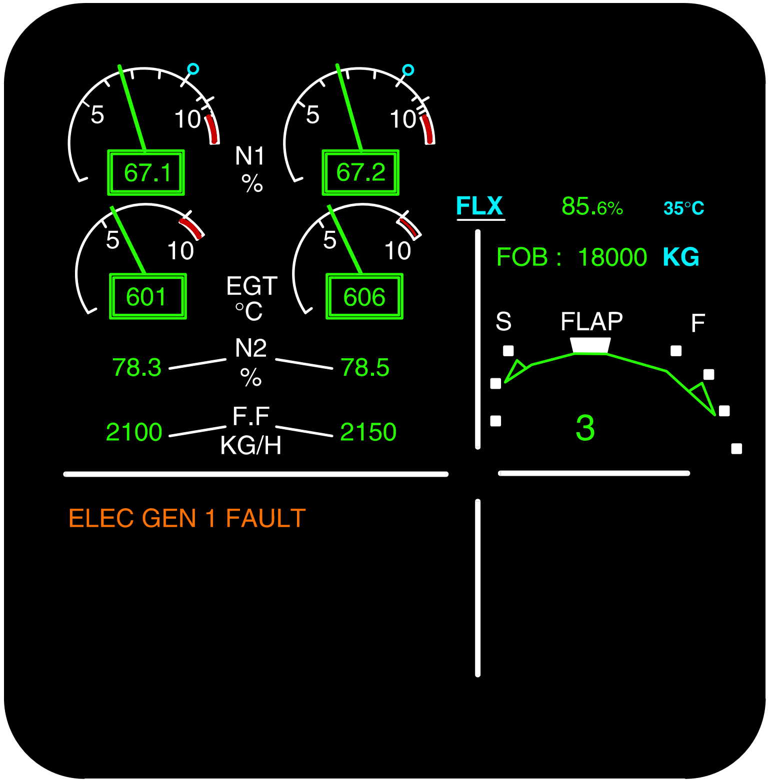
Corrective actions

The corresponding system page appears automatically

A319/A320/A321 EIS – Independent Failure: after corrective action

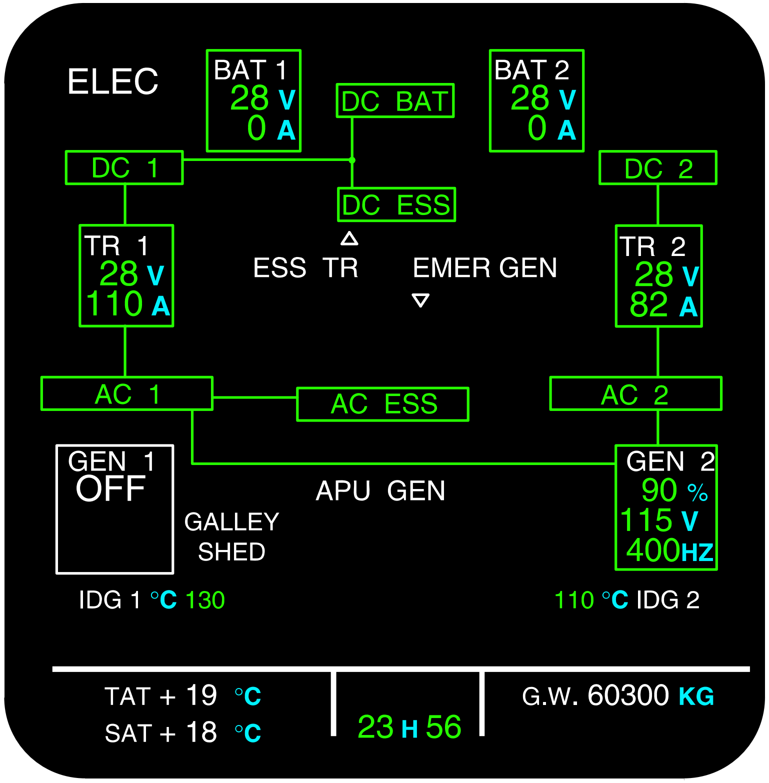
EIS 1

ECAM upper display



Actions lines automatically cleared when corresponding actions performed

ECAM lower display: ELEC page

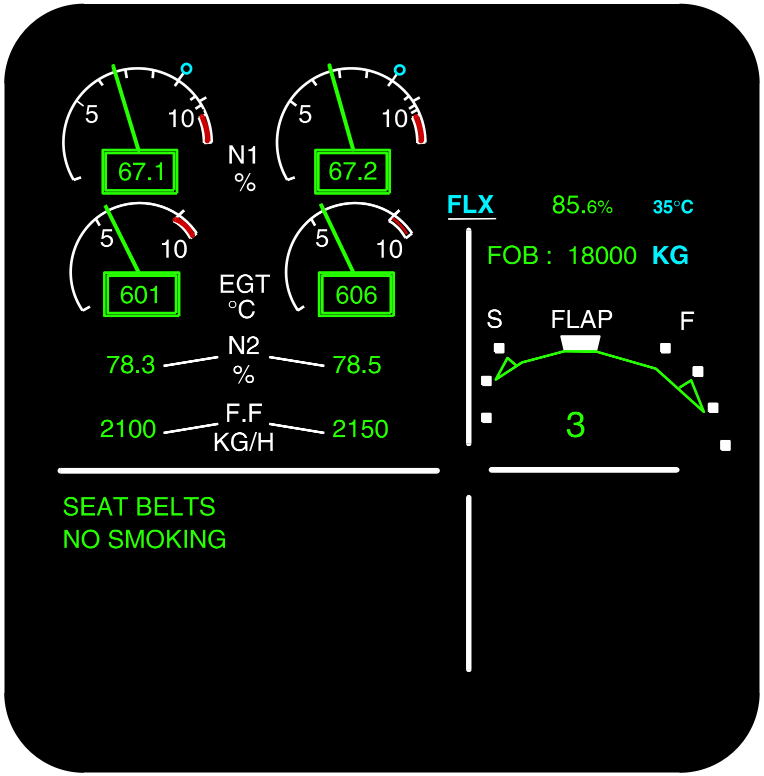


ELEC page changes according to the corrective action

A319/A320/A321 EIS – Independent Failure: after “clear”action

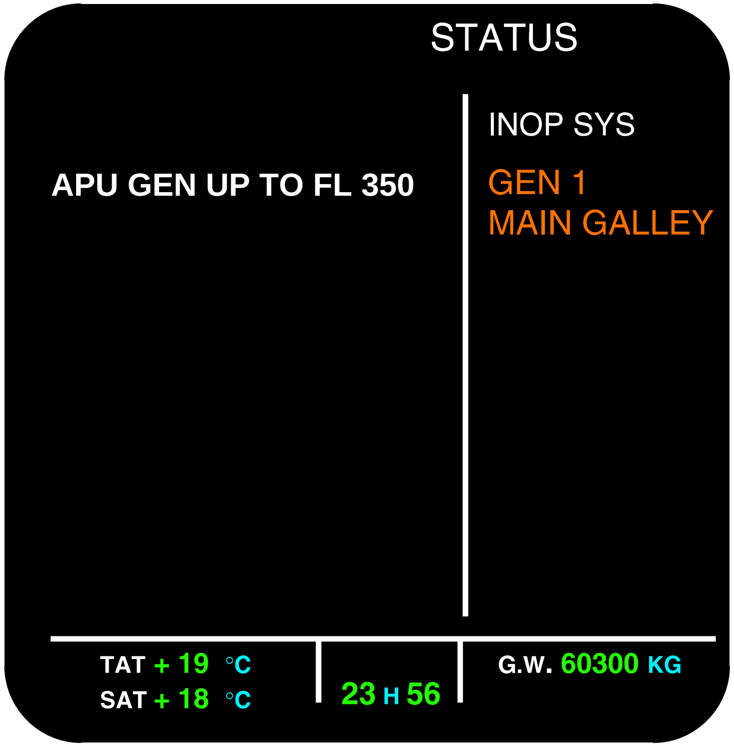
EIS 1

ECAM upper display



- Warning message is cleared
- Memo comes back

ECAM lower display



- Status page appears automatically
- When “clear” button is pressed again flight phase system page comes back

Primary / Secondary
Failure Presentation Sequence

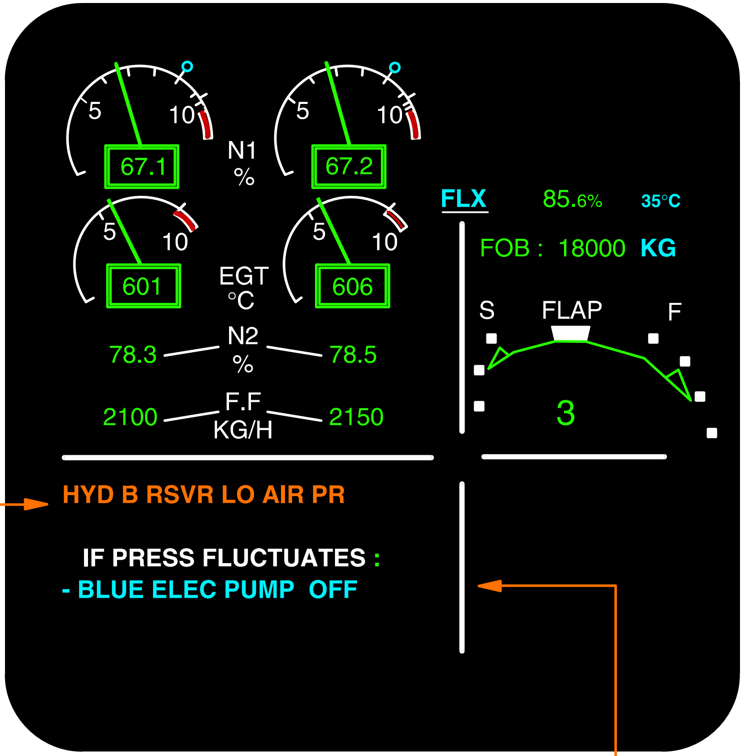
Example: Blue hydraulic reservoir low air pressure corrective action leading to primary failure: Blue hydraulic system low pressure

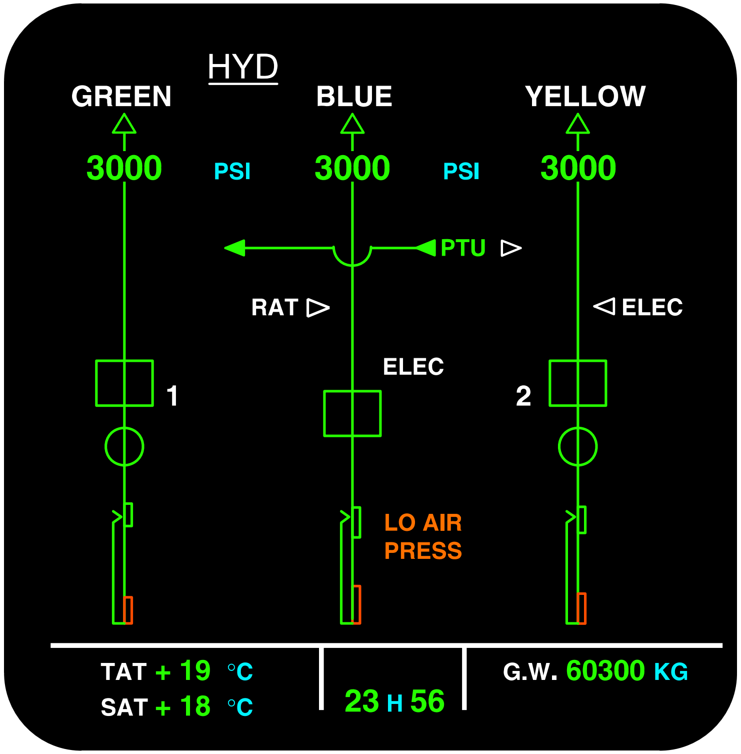
1st step : Independent Failure Detection

Upper Display

EIS 1

Lower Display: HYD page





Failure identification

Corrective action

The corresponding system page appears automatically

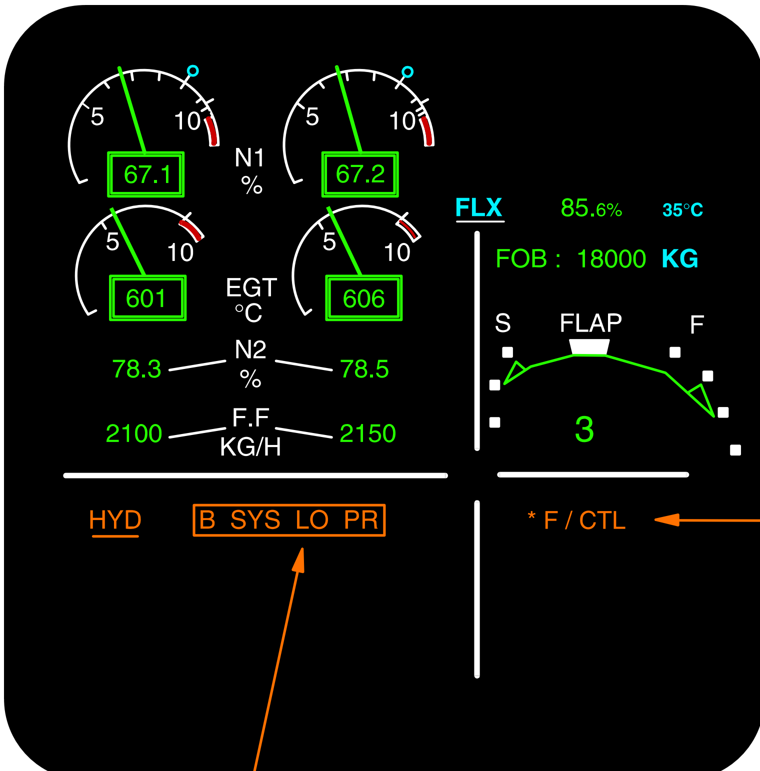
A320 – Primary / Secondary Failure: after corrective action

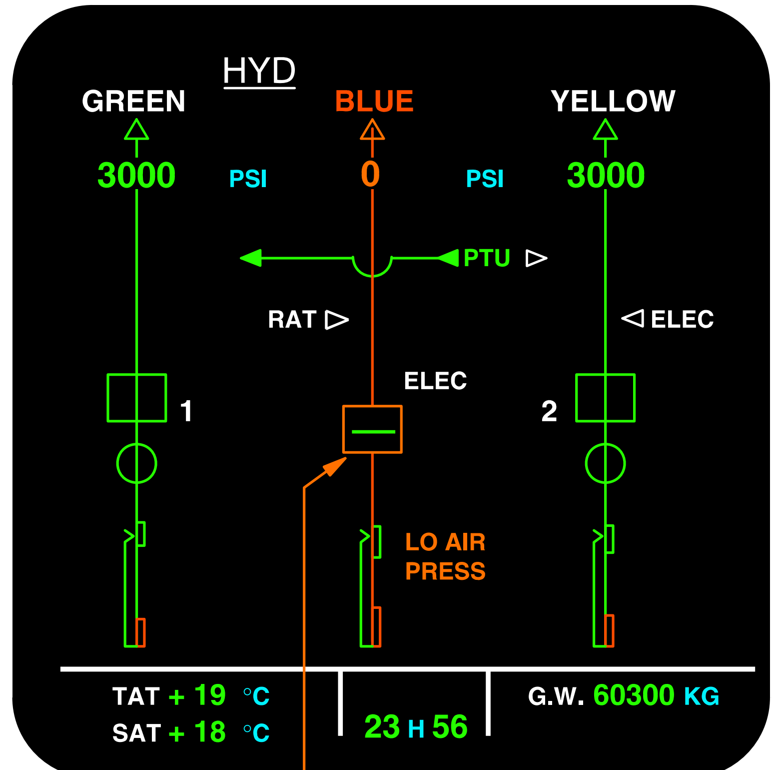
2st step : after performing the corrective action

Upper Display

EIS 1

Lower Display: HYD page





Display of resulting primary failure

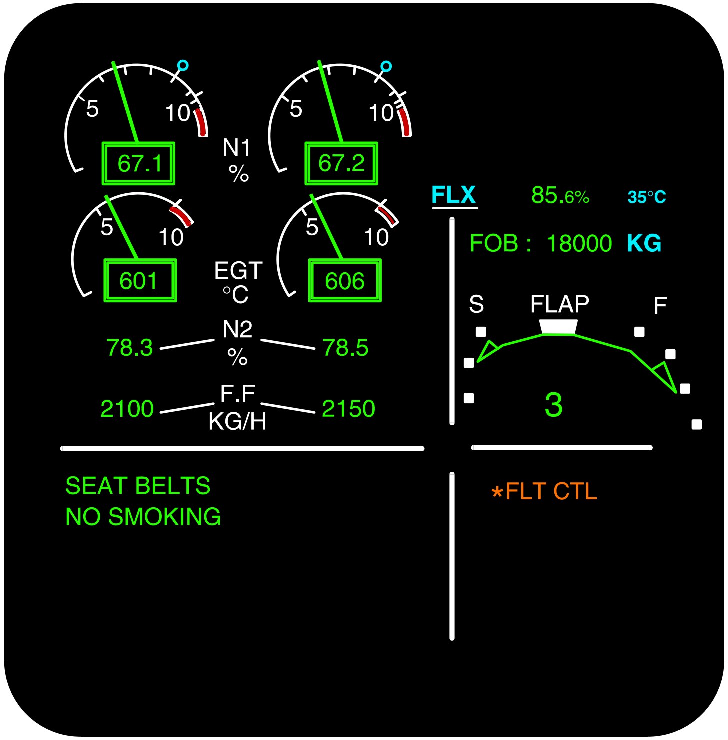
Resulting secondary failure is displayed

The corresponding system page is automatically updated

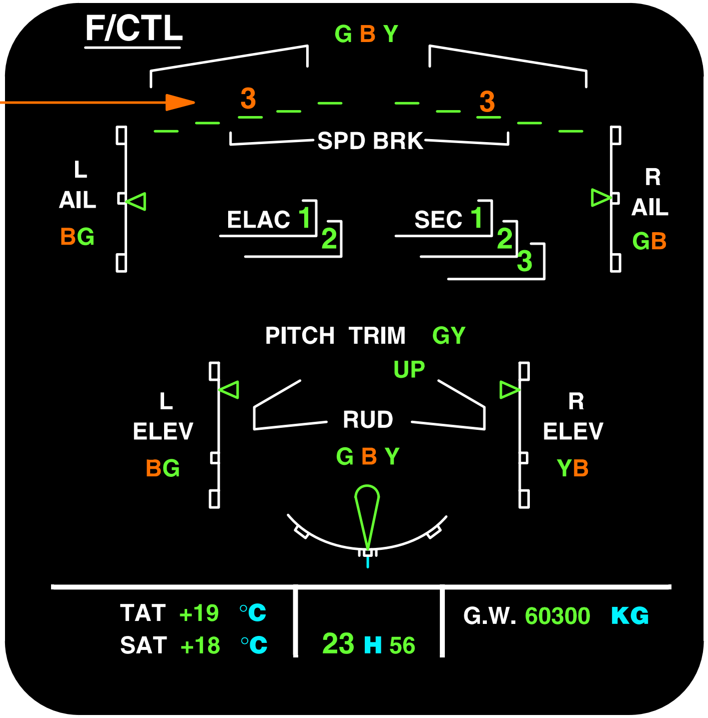
3rd step : first "CLEAR"

EIS 1

Upper Display



Lower Display: F / CTL page



Resulting secondary failure (spoiler fault and all actuator blue press indications amber) related to primary failure (Blue system low press)

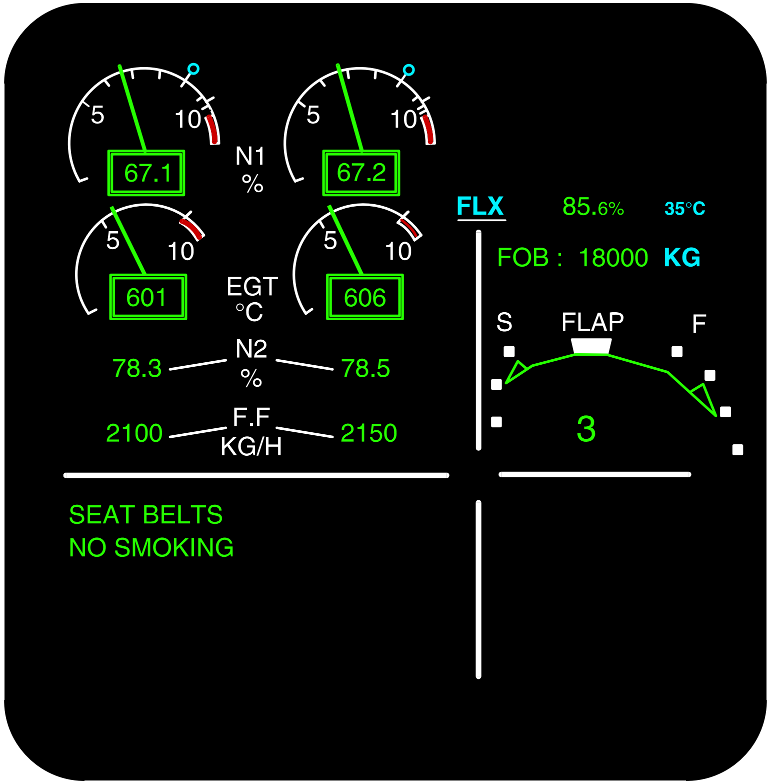
- Warning message is cleared
- Memo comes back

The system page corresponding to the secondary failure is automatically displayed

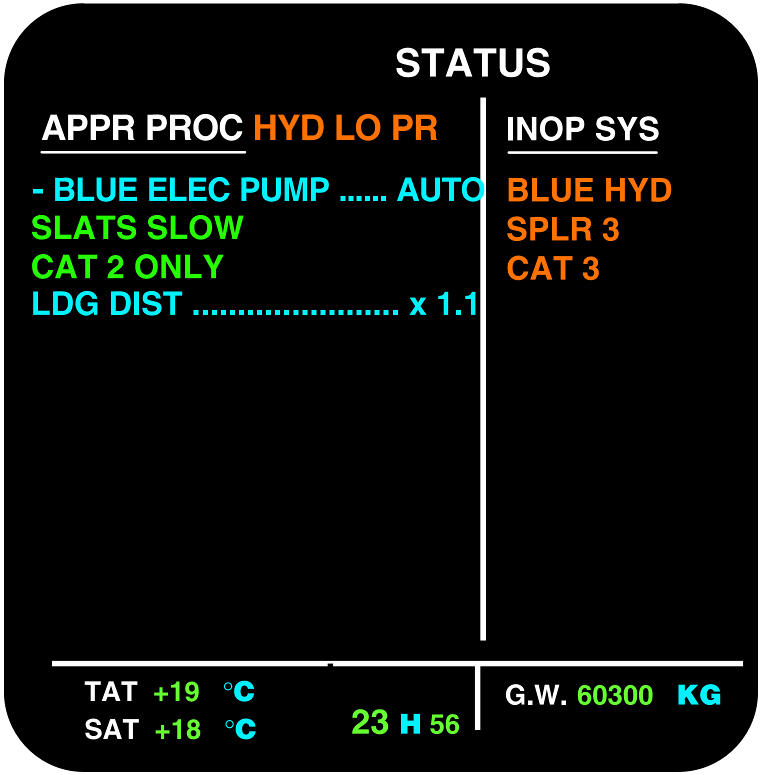
4th step : second “CLEAR”

EIS 1

Upper Display



Lower Display: status page

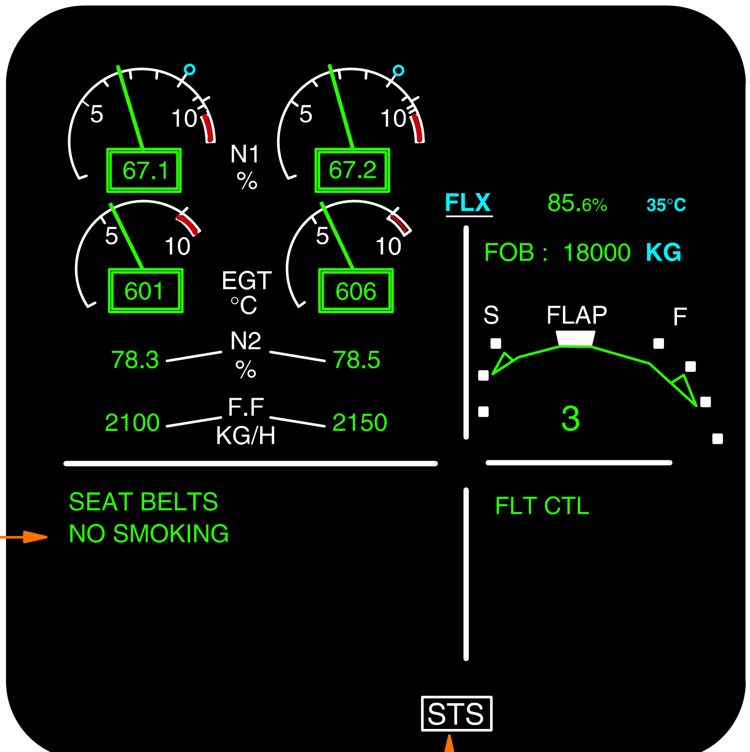


- Status page appears automatically after second “clear”

5th step : third “CLEAR”

EIS 1

Upper Display



Lower Display: cruise page

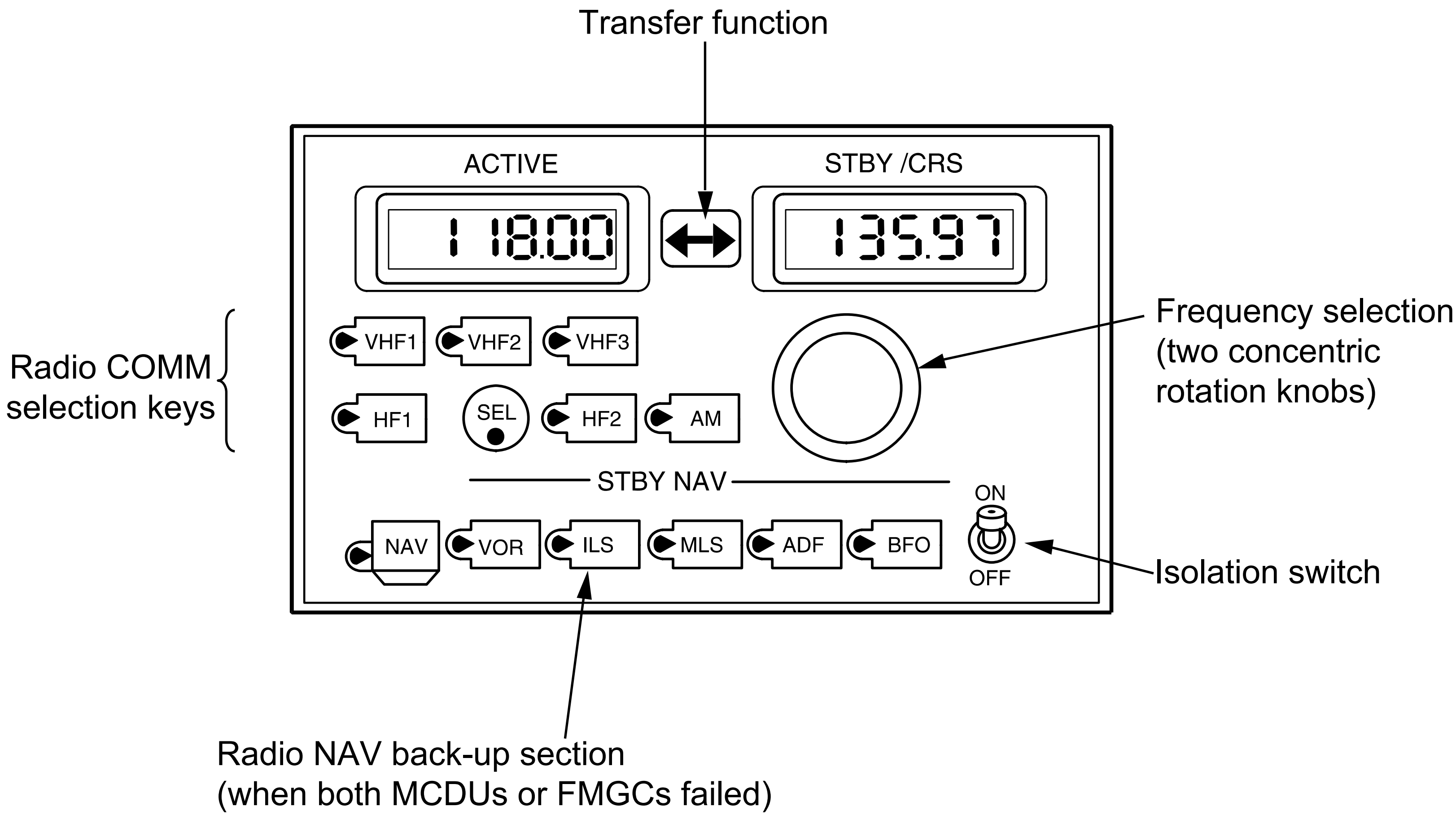
Display of entire memo

Status reminder

- When “clear” button is pressed for the third consecutive time, flight phase system page comes back

13. Radio Management and Communication

Radio Management Panel (RMP)



A318/A319/A320/A321 Radio Management Concept

- Radio Management Panel **(RMP)** system provides:

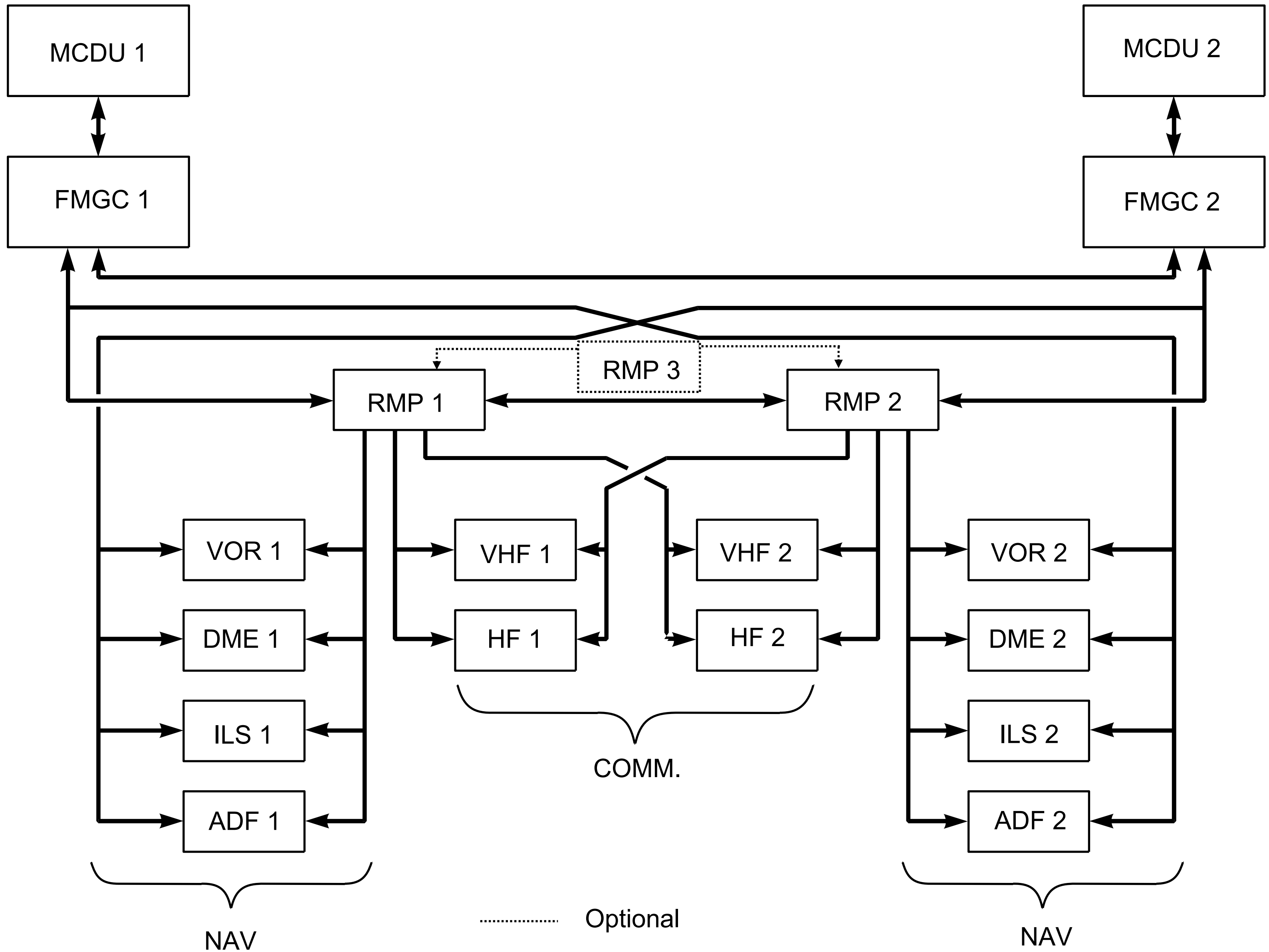
  - Crew control of all radio communication systems
  - Back-up of the two FMGCs for controlling all radio navigation systems

- Basic installation includes:

  - Two RMPs on pedestal
  - Full provision for installation of a third RMP on overhead panel

- The ATC transponder is tuned by a separate conventional control panel.

A318/A319/A320/A321 RMP Architecture



Communication Tuning

Any radio communication system can be tuned from any of two RMPs. In case of failure any RMP can take over from the other one.

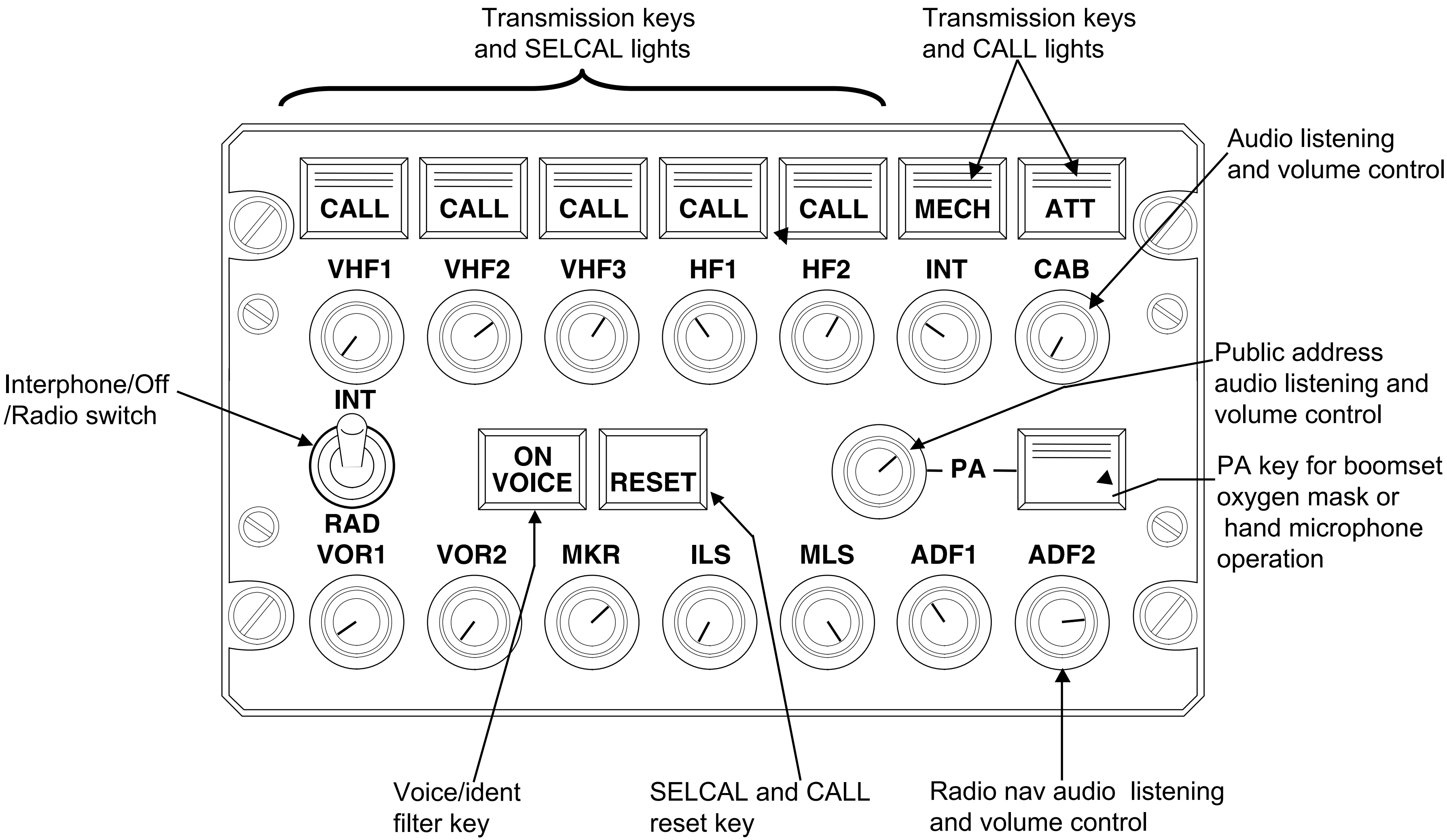
Navigation Tuning

Three different operating modes exist.

- Automatic : VOR/DME, ILS and ADF are automatically tuning controlled by the FMGS.
- Manual tuning : for selection if a specific frequency through the FMGS CDU without affecting the automatic function of the FMGS.
- Back-up tuning : when both FMGCs are inoperative or when an emergency electrical source is in operation, any NAV receiver may be tuned by the crew from any RMP ; each RMP controls on side receivers.

When one of both FMGCs is inoperative, the remaining one controls all receivers.

A318/A319/A320/A321 COMM – Audio Control Panel



The audio integrating system provides the management of all audio signals produced by and feeding the radio-communications, radio navigation and interphone systems :

- Basic installation includes :
  - Three Audio Control Panel **(ACP)** – two on pedestal, one on overhead panel
  - One Audio Management Unit **(AMU)** in avionics bay
  - One **SELCAL** code selector in avionics bay.
- Provision exists for supplementary ACP's
- All selections and volume adjustments carried out by crew through ACPs
- All ACPs are fitted for maximum capacity (three VHF, two HF, public address, calls, two VOR, two ADF, ILS and provision for MLS).
- Each ACP and associated AMU electronic card are fully independent and microprocessor controlled.

- **Cabin Intercommunication Data System (CIDS) Functions**

  CIDS allows to control:
  - Cabin and service interphone
  - Passenger address and lighted sign
  - Reading light and general cabin illumination
  - Emergency evacuation signalling
  - Lavatory smoke indication
  - Passenger entertainment music and video
  - Escape slide bottle pressure monitoring

- **CIDS Architecture**

  - Two identical director units installed in the avionics bay
  - A forward attendant panel for control of cabin systems
  - Two types of Decoder/Encoder Units (DEU)
    - Type A: installed on both sides of the cabin and connected to the top-lines, which perform the passenger functions.
    - Type B: installed above the ceiling panels in the cabin attendant areas and connected to the mid-lines, which provide cabin attendant functions.

- **New Generation of CIDS**

  - Increase integration of the different cabin functions
  - New Basic-CIDS, not interchangeable to today CIDS design (ICY 300)
  - New CIDS basic on A318

- **Principal Changes**

  - Integration of Vaccum System Controller (VSC) and Smoke Detection Controller Unit (SDCU) in the new CIDS director
  - Evolution of display

Current CIDS

New CIDS

PTP

FAP

14. Maintenance Centralized Fault Display System

General

Line maintenance of the electronic systems is based on the used of a Centralized Fault Display System **(CFDS)**.

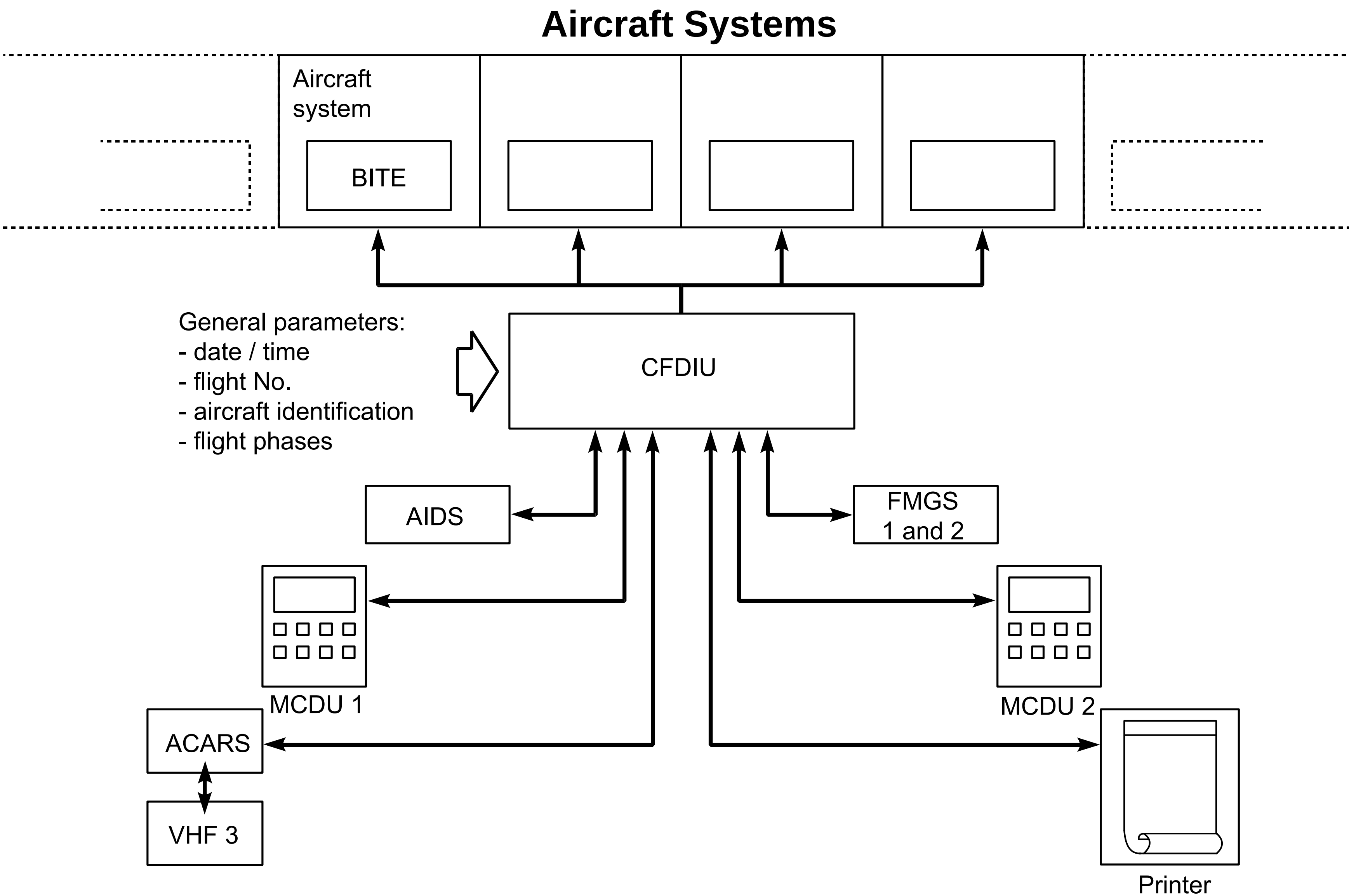
The purpose of the CFDS is to give maintenance technicians a central maintenance aid to intervene at system or subsystem level from MCDU (located in the cockpit :

- To read the maintenance information
- To initiate various tests.

Two levels of maintenance should be possible using the CFDS:

- At the line-stop (LRU change)
- In the hangar or at the main base (troubleshooting).

A318/A319/A320/A321 CFDS - Architecture



Advantages of the CFDS

A revised maintenance concept provides a:

- Reduction of the duration of operations
- Reduction of the maintenance crew training time
- Simplification of technical documentation
- Standardization of the equipment
- Simplification of the computers which no longer display any BITE ;

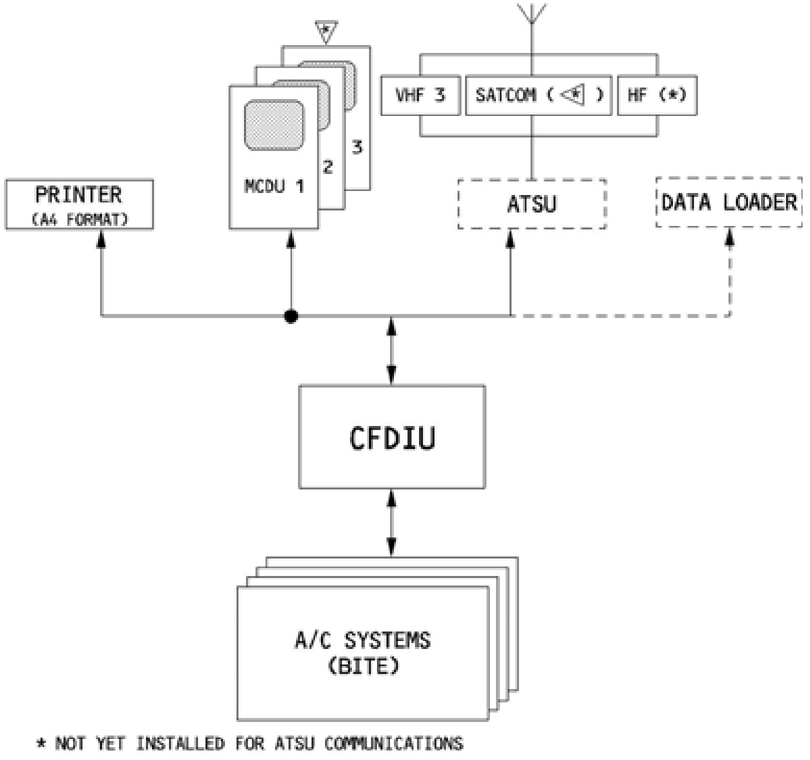
Integration of the CFDS

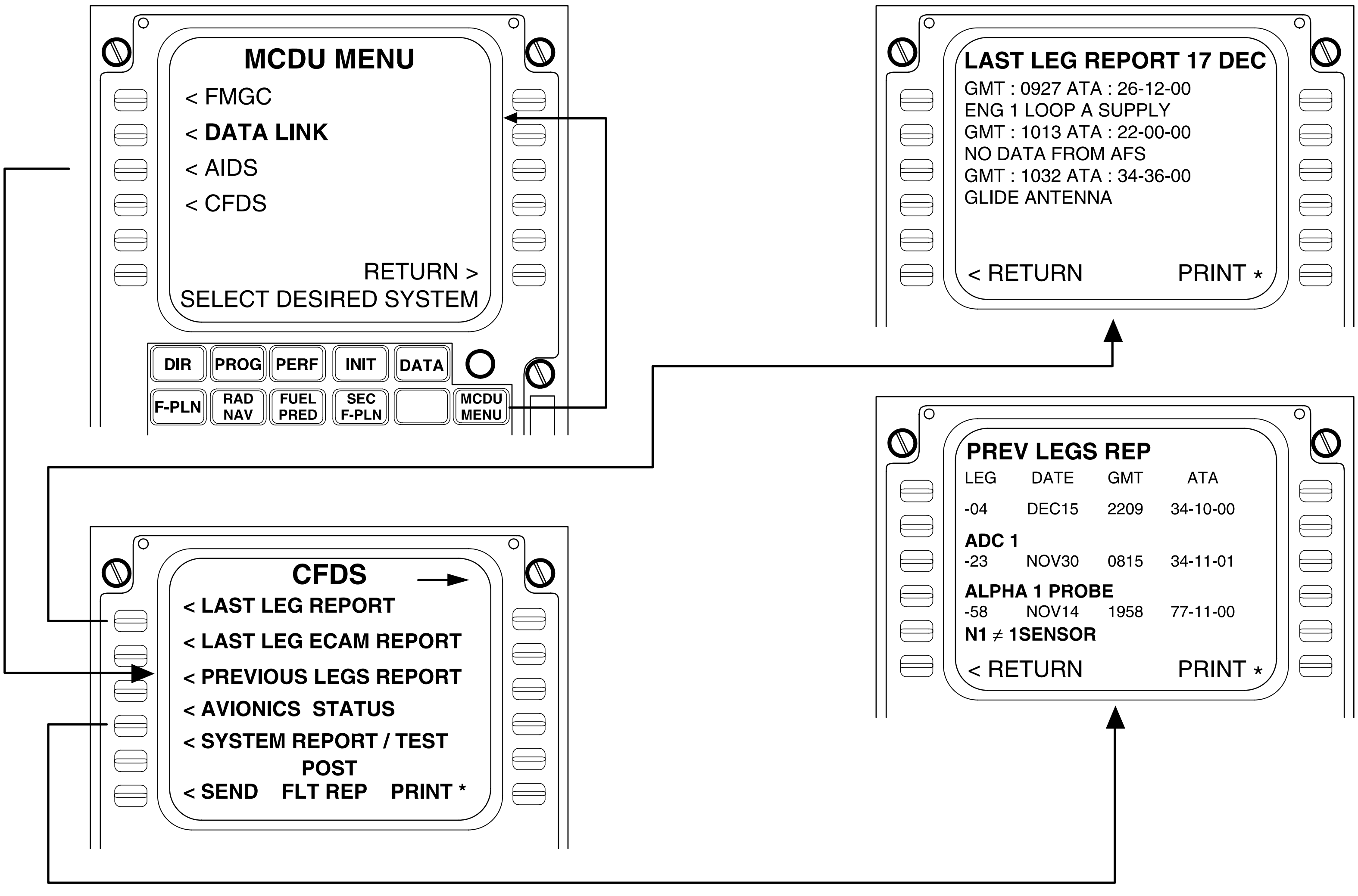
Integrated in the Maintenance and Recording Data System **(MRDS)** comprising:

- Basic equipment
  - A Centralized Fault Display Interface Unit **(CFDIU)**
  - A Digital Flight Data Recorder System **(DFDRS)** with its interface unit and its Flight Data Recorder
  - Two multipurpose CDUs **(MCDUS)** located on the pedestal.

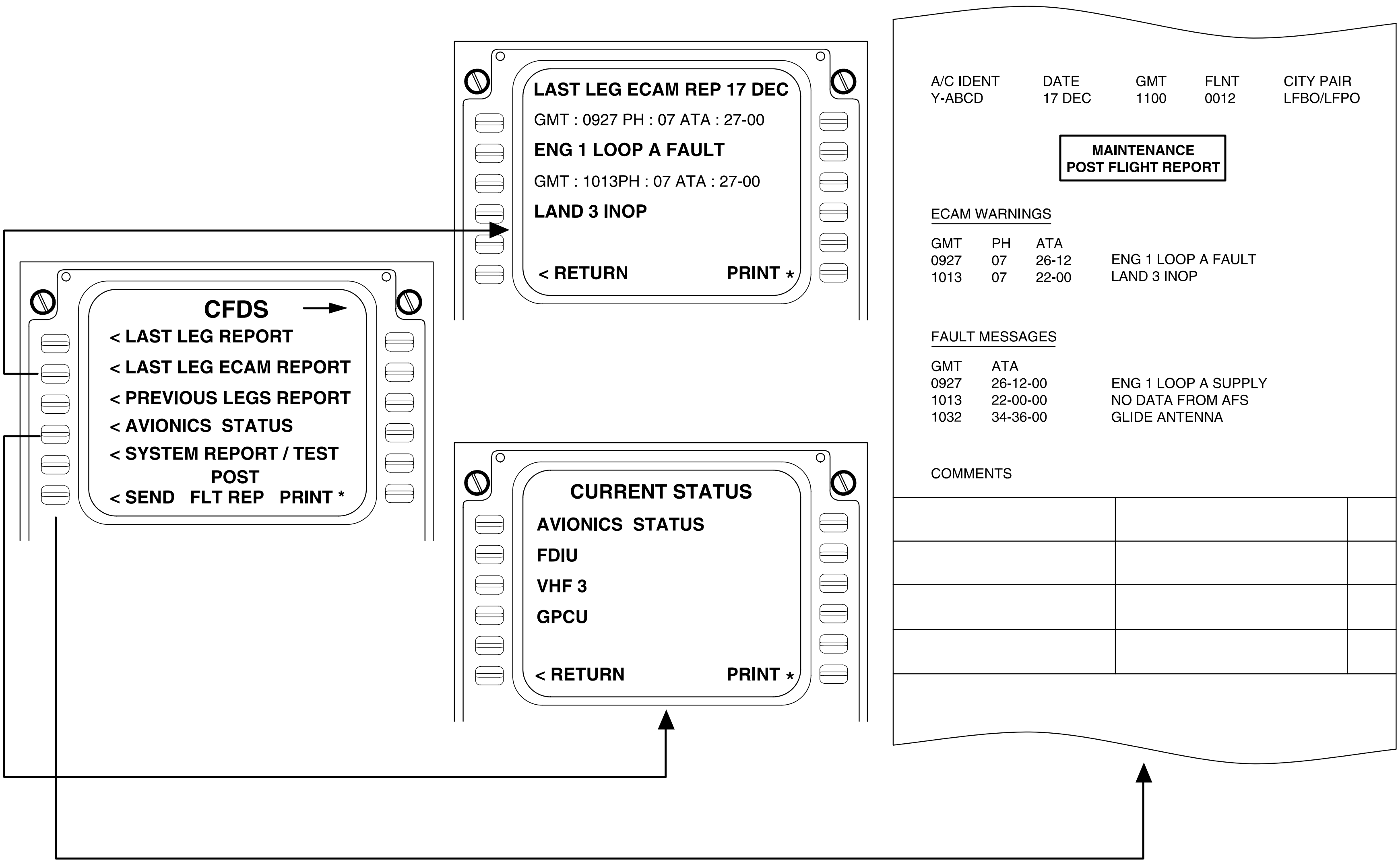
  Note: The MCDUS can be used for : FMGS, MRDS options (ACARS, AIDS).

- Optional equipment
  - A multi-use printer
  - A quick access recorder **(QAR)**
  - An **AIDS**

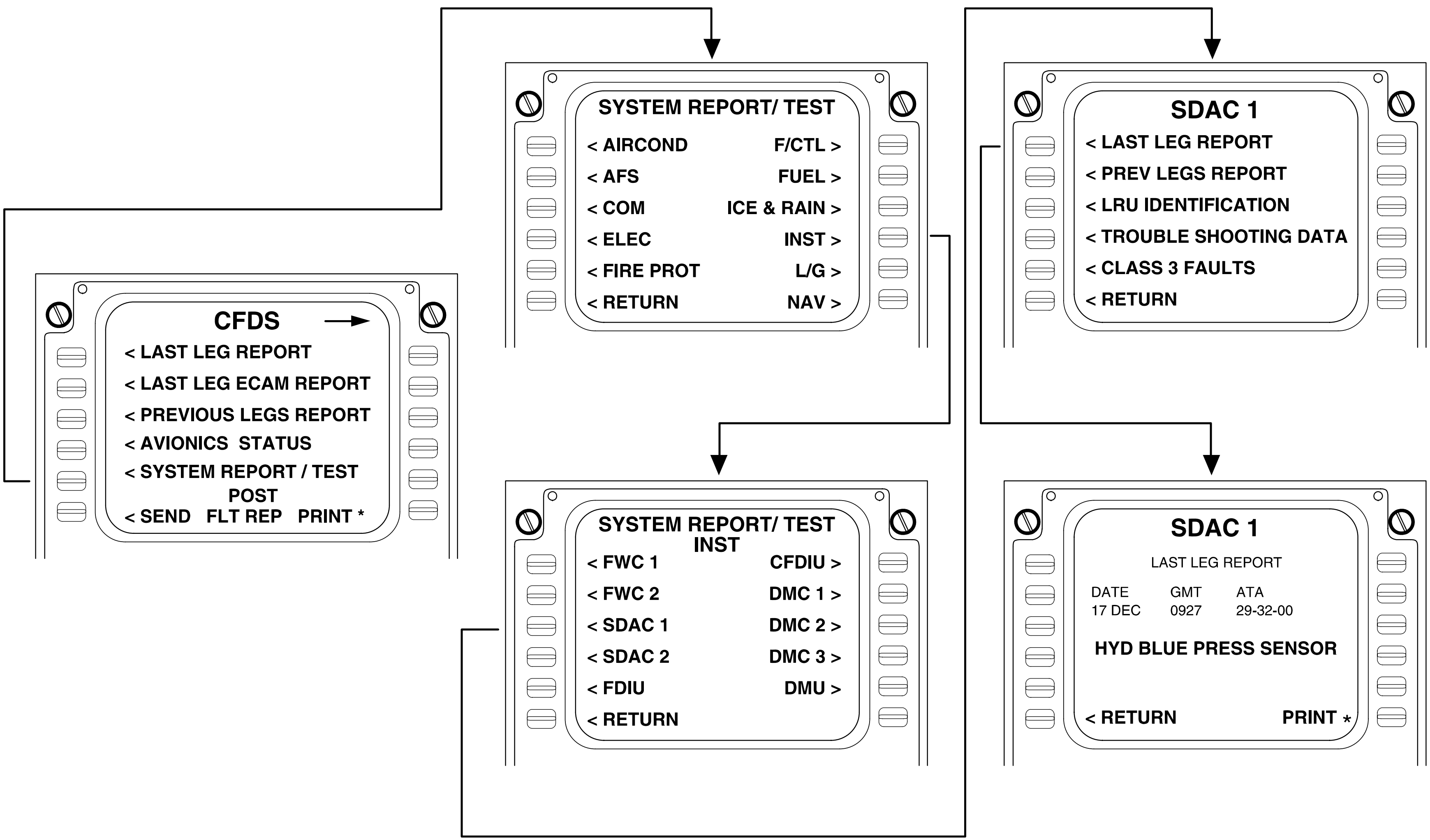



MCDU MENU
< FMGC
< DATA LINK
< AIDS
< CFDS
RETURN >
SELECT DESIRED SYSTEM
DIR
PROG
PERF
INIT
DATA
F-PLN
RAD NAV
FUEL PRED
SEC F-PLN
MCDU MENU
LAST LEG REPORT 17 DEC
GMT : 0927 ATA : 26-12-00
ENG 1 LOOP A SUPPLY
GMT : 1013 ATA : 22-00-00
NO DATA FROM AFS
GMT : 1032 ATA : 34-36-00
GLIDE ANTENNA
< RETURN
PRINT *
CFDS
< LAST LEG REPORT
< LAST LEG ECAM REPORT
< PREVIOUS LEGS REPORT
< AVIONICS STATUS
< SYSTEM REPORT / TEST
POST
< SEND
FLT REP
PRINT *
PREV LEGS REP
LEG DATE GMT ATA
-04 DEC15 2209 34-10-00
ADC 1
-23 NOV30 0815 34-11-01
ALPHA 1 PROBE
-58 NOV14 1958 77-11-00
N1 ≠ 1SENSOR
< RETURN
PRINT *

A318/A319/A320/A321 CFDS – Example of Use - 2



A318/A319/A320/A321 CFDS – Example of Use - 3



15. Fire Protection

Description

- A fire and overheat detection and extinguishing system is installed for:
  - Each engine
  - The APU

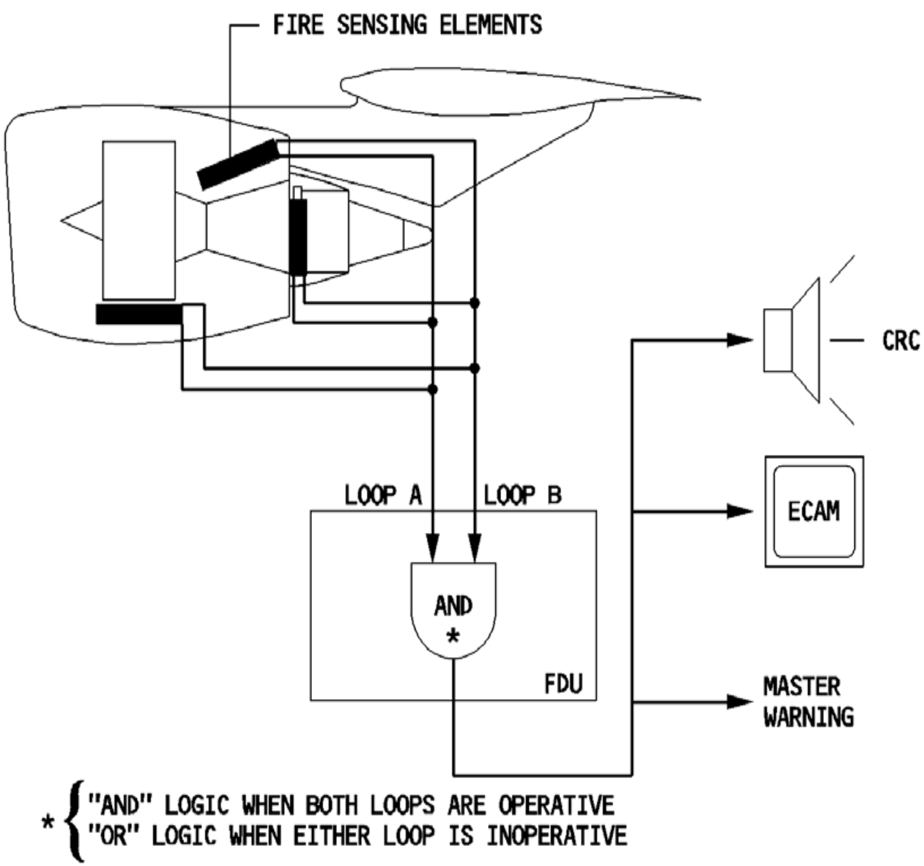
- Smoke detection and fire extinguishing systems are installed for:
  - The cargo compartments
  - The lavatories

- Smoke detection is also installed in the avionics bay.

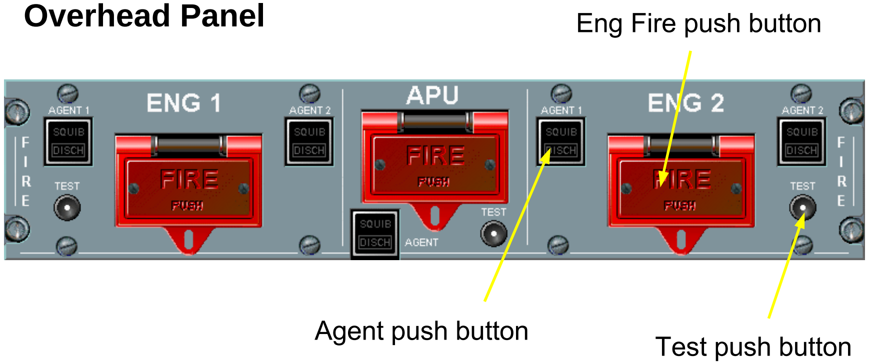
- Portable fire extinguishers are installed in:
  - The cockpit
  - The passenger cabin

A318/A319/A320/A321 – Engine and APU Fire Protection

Engine fire system

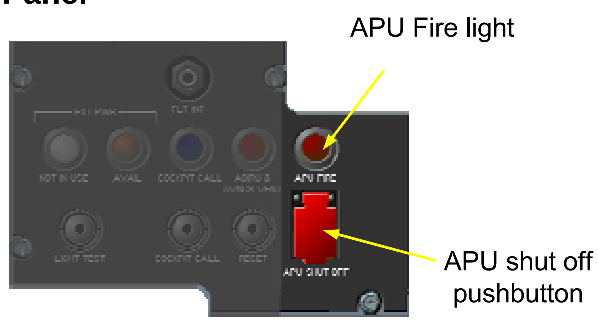


Overhead Panel



Pedestal Panel

External Power Panel



Architecture

Description

- The engines and the APU are protected by a continuously monitored dual-loop system.

- Loops A and B are mounted in parallel. Each consists of four detectors, each located in:
  - The engine fan sector
  - The pylon nacelle
  - The engine core
  - The APU

  Exact configuration depends on the engine type.

- The associated Fire Detection Unit (FDU) uses AND logic to signal a fire. It is connected to the ECAM and to the CFDS for fault detection.

Extinguishing

- Each engine is equipped with two extinguisher bottles.
- The APU is provided with a single-shot fire extinguisher system.
- Fire bottle are equipped with an electrically operated squib for agent discharge.
- The discharge is controlled from the control panel or from the ground for the APU.

Functions

Description

- When a sensing element is subjected to heat, it sends a signal to the FDU. As soon as both loops A and B detect temperature at a preset level, they trigger the fire warning system.

- Warning system is not affected by failure of a loop (break or loss of electrical supply).
  In case of failure of one loop, the second one secures the aircraft.

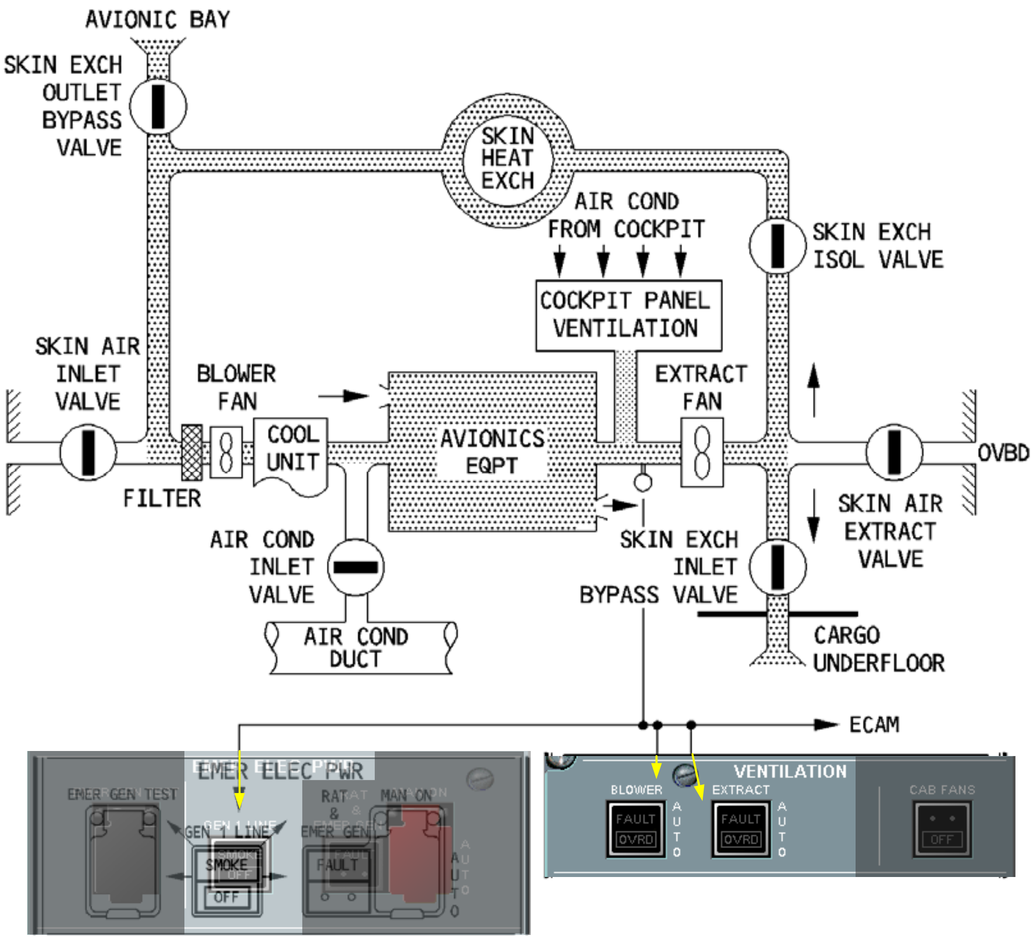
- If the system detects an APU fire while the aircraft is on the ground, it shuts down the APU automatically and discharges extinguishing agent.
  In flight, The flight crew controls the discharge of the fire extinguisher bottle, from the APU FIRE panel.

Fire Protection Controls

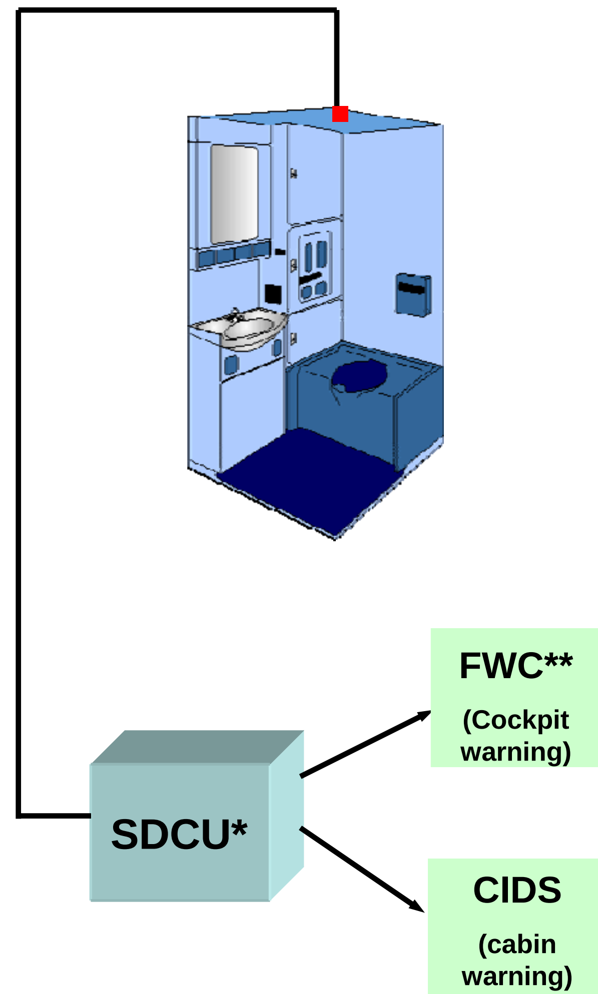
- The Engine fire push-button allows the aircraft systems (bleed, hydraulic, IDG systems) to be isolated from the affected engine and the fire extinguisher bottle to be armed.
- The APU fire push-button allows the extinguishing system to be armed and the shut-down of the APU.
- The Agent push-button provides bottle discharge (ENG FIRE pushbutton or APU FIRE having being pushed).

A318/A319/A320/A321 – Avionics Bay and Lavatory Fire Protection

Avionics Bay System



Lavatory System



* SDCU is integrated in the new CIDS on A318

** Flight Warning Computer

Avionics Bay System

- Smoke in the avionics bay is detected by a self-contained ionization type smoke detector. It is installed in the extraction duct of the avionics ventilation system.
- The smoke detector signal makes the ECAM display a warning in the cockpit.
- When it detects smoke for more than 5 seconds:
  - A single chime sounds.
  - The MASTER CAUTION lights, on the glareshield, light up.
  - The ECAM displays a caution on the E/WD.
  - The SMOKE light, on the EMER ELEC PWR panel, lights up.
  - The BLOWER and EXTRACT FAULT, on the VENTILATION panel, light up.

Lavatory System

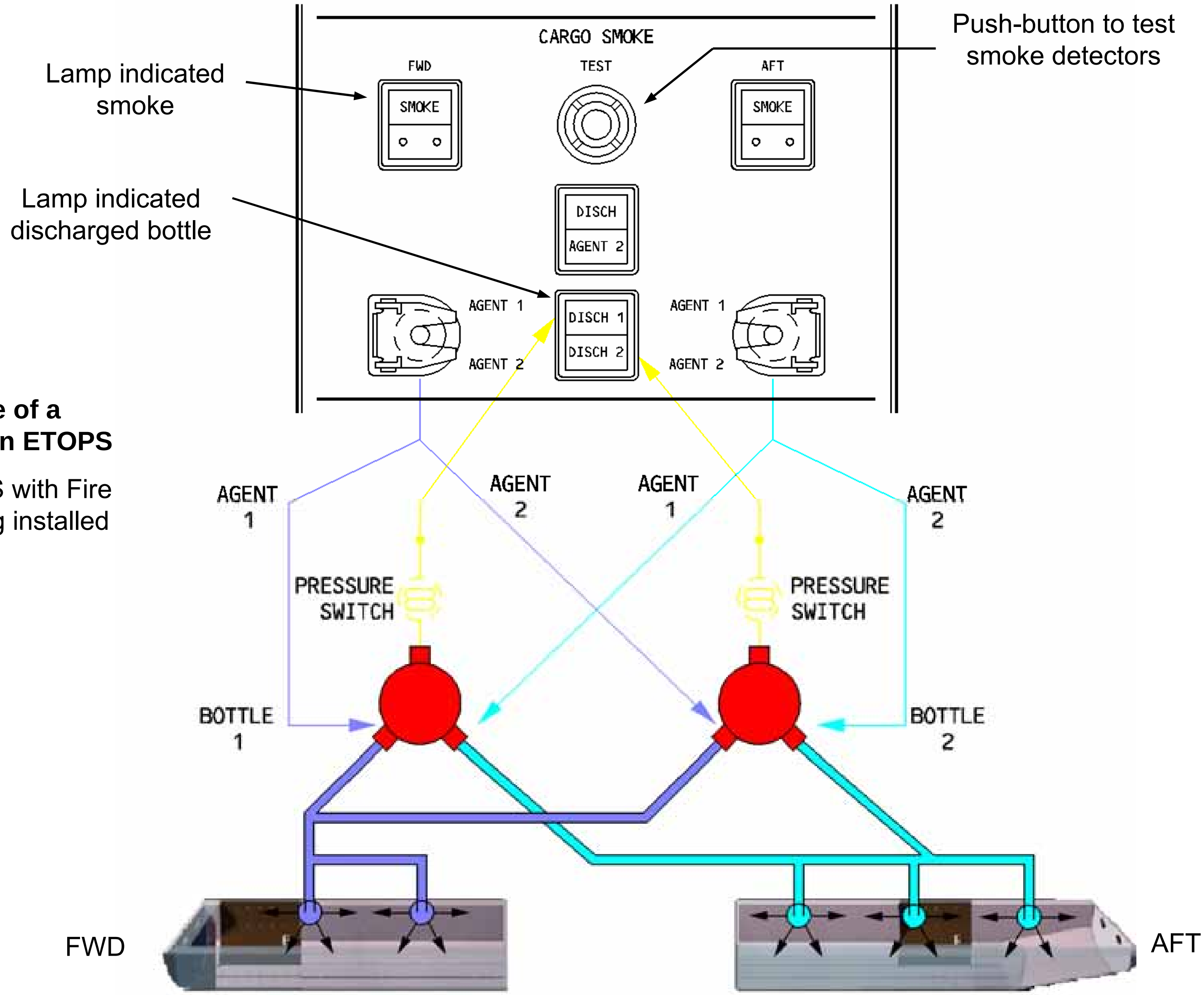
- **Smoke Detection**
  An ambient smoke detector is installed in the ceiling of each lavatory.
  Detectors are connected to the smoke detection data bus loop.

  - On A319/A320/A321: smoke warnings are transmitted by the SDCU to the flight deck (ECAM) and to the cabin (via CIDS).
  - On A318 and aircraft equipped with new CIDS system: SDCU is integrated in the CIDS which transmits signal to the FWC and generates indication in the cabin.
- **Waste Bin Fire Extinguishing**
  A fire extinguisher is installed in the waste bin compartment in each lavatory.
  Extinguishing agent is automatically discharged into the bin when the temperature within the bin reaches 72°C.

A318/A319/A320/A321 – Cargo Compartment Fire Protection

Example of a configuration ETOPS

A321 ETOPS with Fire Extinguishing installed



Cargo Compartment Fire Protection

- Smoke detection and fire extinguishing system are not basically installed. They are customizable system.

- **Smoke detection**

  All aircraft are equipped with an addressable smoke detection closed safety bus loop with centralized control and monitoring by a SDCU. Ceiling mounted cargo compartment smoke detectors are connected to this bus.

  The detectors are controlled and operated as dual loop systems. Smoke in one cavity activates the cargo smoke warning if both smoke detectors detect it, or if one smoke detector detects it while the other is inoperative.

  Smoke warnings are transmitted to the ECAM by the SDCU.

- **Fire Extinguishing**

  - To comply with class C cargo compartment requirements basic configurations a single shot fire extinguishing bottle is installed in the forward cargo hold to give 60 minutes protection.
  The contents of the bottle may be discharged into either the FWD or AFT holds thanks to nozzles.

  - Different certification ETOPS are possible. It allows to equip an aircraft with two fire extinguishing bottles.

- **Description ***

  - For the A318, A319, and A320 three extinguishing nozzles, one in the forward hold and two in the aft hold, are installed in ceiling cavities alongside the smoke detectors.

  - For the A321 there are 5 extinguishing nozzles, two in the forward hold and three in the aft hold.

  Two guarded "discharge" push buttons and two "smoke disch" indicators are provided, one of each for the forward and aft holds.

  The amber "disch" light illuminates when the bottle is discharged.

  On operation of the relevant discharge button, extinguishing agent is discharged into either the forward or aft cargo hold.

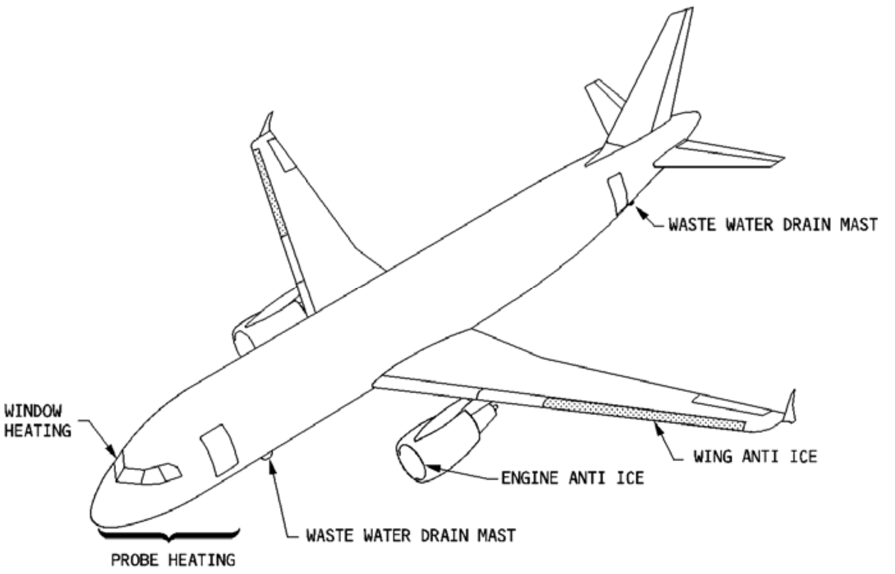
  The fire extinguishing bottle sizes are :
  - 630 cu in for the A318, A319, and A320
  - 800 cu in for the A321.

  * The equipment description correspond to a basic configuration, all these equipment are customizable.

16. Ice and Rain Protection

General

- The ice and rain protection system permits unrestricted operation of the aircraft in icing conditions or heavy rain.
- The three outboard leading edge slats of each wing and the air intake of the engines are protected by hot air from the bleed system.
- The cockpit windows, the probes, and the drain mast are electrically heated.
- Wipers and when necessary, fluid rain repellent, remove rain from the front windshield panels.



A318/A319/A320/A321 – Wing Anti-Ice System

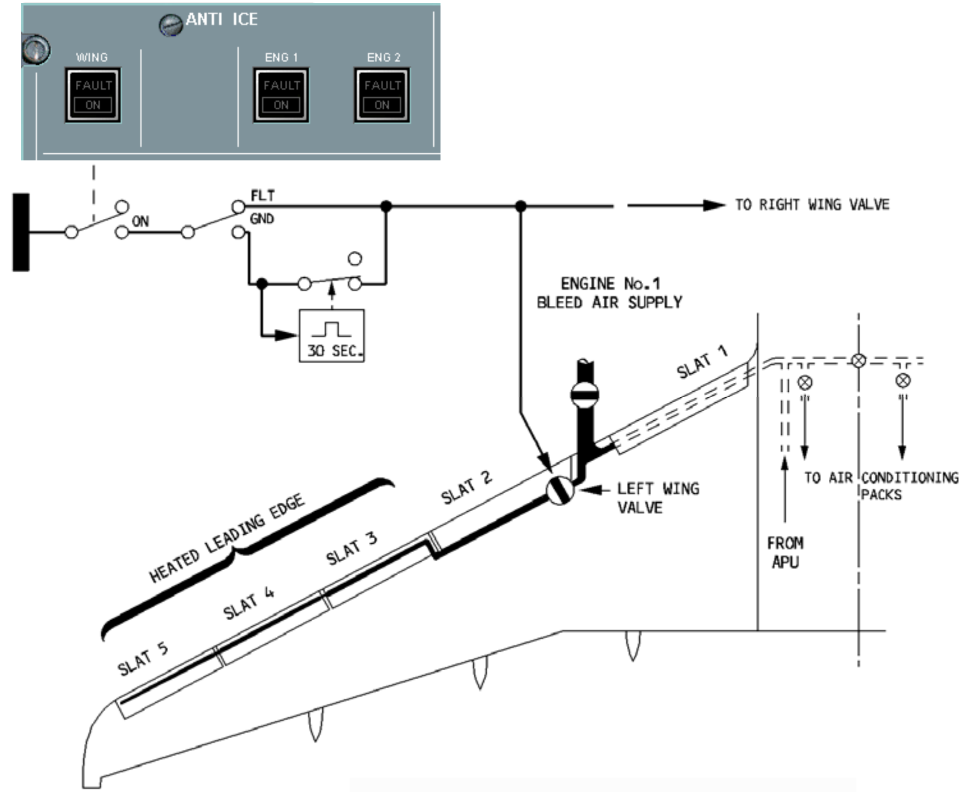
- In flight, hot air from the pneumatic system heats the three outboard slats (3-4-5) of each wing.
  The hot air supply is regulated by a wing anti-ice control valve for each wing.

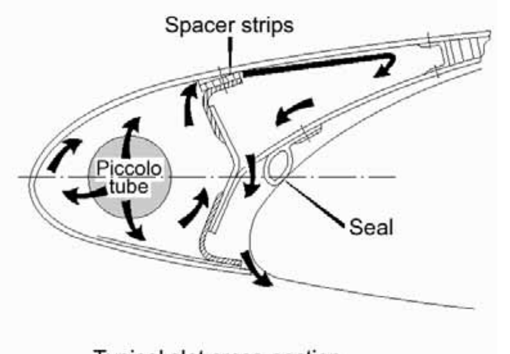
- One pushbutton controls the opening/closing of the two valves (one for each engine).

- On ground, the wing anti-ice system is inhibited, except for test purpose. To prevent slat overheat the test is automatically limited to 30 seconds.

- If the system detects a leak during normal operation, or if the electrical power supply fails, the affected side's wing anti-ice valve automatically closes

- When wing anti-ice is selected, the N1 (EPR) limit is automatically reduced, and the idle N1 (EPR) is automatically increased.

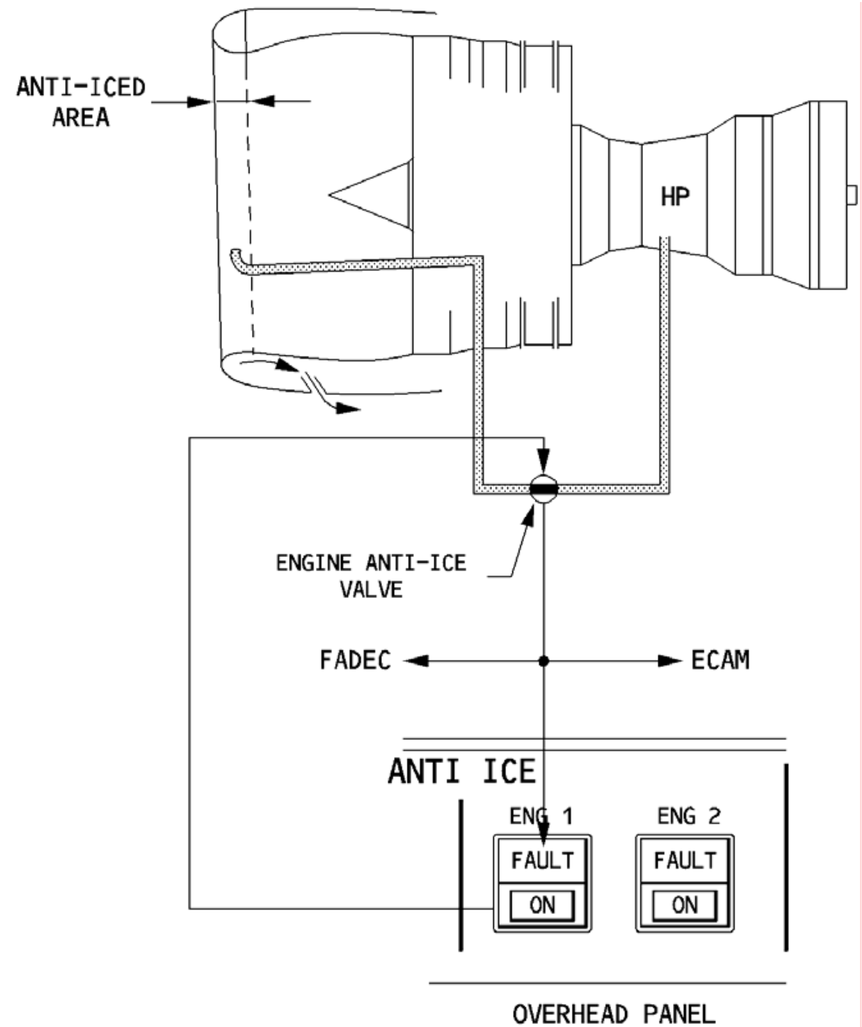




Typical slat cross-section

A318/A319/A320/A321 – Engine Anti-Ice System

- Each engine nacelle is anti-iced by an independent system that blows hot air taped from the High Pressure compressor.
- One shut-off valve is controlled by a push-button for each engine.
- The valve automatically closes, if air is unavailable (engine not running).
- The valve automatically opens, if electrical power fails.
- When an engine anti-ice valve is open, the N1 (EPR) limit is automatically reduced. If necessary, the idle N1 may automatically increase for both engines in order to provide the required pressure.



- Protection is provided for left and right front windshields (fogging and icing), left and right sliding side windows and fixed side windows (fogging).

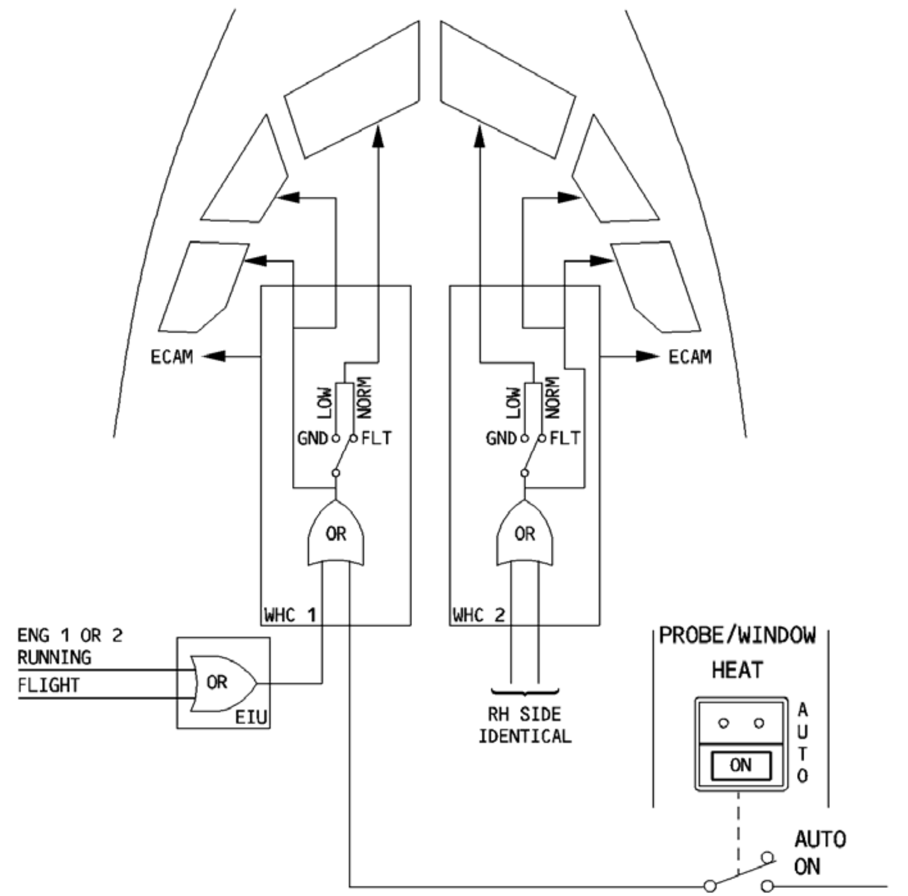
- Two independent Window Heat Computers (WHCs) (one for each side), control and regulate the heaters. The WHCs are connected to the ECAM and to the CFDS.

- On each side, temperature control for front windshield and lateral windows are independent. One spare temperature sensor is fitted on each window.

- Controlled heating is provided:
  - Automatically when at least one engine is running,or when the aircraft is in flight.
  - Manually, before engine start, when the flight crew switches ON the PROBE/WINDOW HEAT pushbutton switch.

- Windshield heating operates at low power on ground and at normal power in flight. The changeover is automatic.

- Only one heating level exists for the windows.



- **Probes Heating**

Electrical heating protects:
- Pitot heads
- Static ports
- Angle-Of-Attack probes (AOAs)
- Total Air Temperature (TAT) probes

Three independent Probe Heat Computers (PHCs) control and monitor the captain probes, F/O probes and standby probes.

The pitot, static and angle of attack probes are heated :
- Automatically when at least one engine is running,or when the aircraft is in flight.
- Manually,when the flight crew switches ON the PROBE/WINDOW HEAT pushbutton switch.

In emergency electrical configuration, the CAPT pitot probe remains heated.

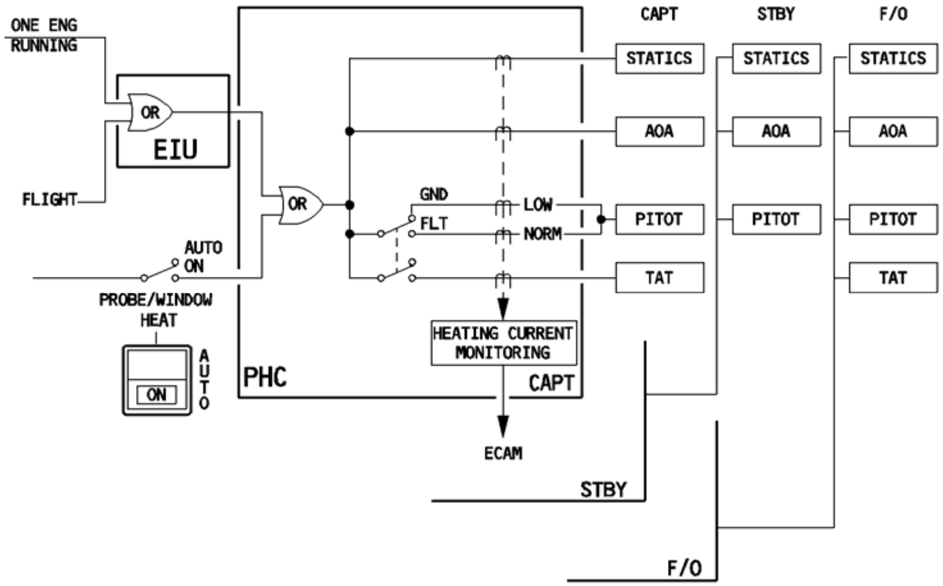
On the ground, the TAT probes are not heated and pitot heating operates at a low level (the changeover to normal power in flight is automatic).

- **Waste Water Lines/Drain Mast Heating**

The lavatory/galley waste water drain masts are electrically heated to prevent ice formation.

Heating is operative as soon as electrical power is available.

Two heating power levels are available (low on ground/high in flight).



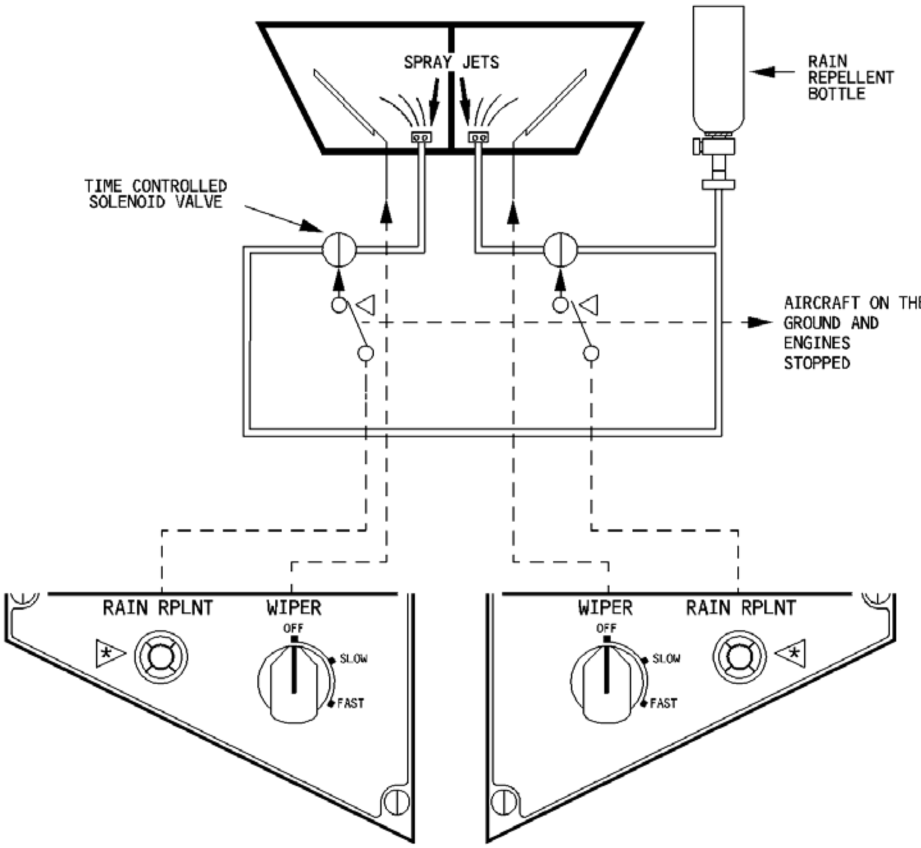
A318/A319/A320/A321 – Rain Removal System

- **Wipers**
  Each windshield panel is provided with an independently operated, electrically driven, two-speed wiper system, controlled from the overhead panel.

- **Rain Repellent**
  A rain repellent system is installed to improve the comfort of the flight crew in heavy rain.

  The flight crew can spray a rain repellent liquid on the windshields which eliminates the film of water on the windshield and facilitates the removal water droplets.

  Separate pushbuttons control rain repellent application on each side of the windshield.



17. Oxygen

General

The oxygen system consists of:

- A fixed oxygen system for the cabin
- A fixed oxygen system for the cockpit
- A portable oxygen system.

The oxygen system supplies adequate breathing oxygen to the crew and passengers in case of depressurization or presence of smoke or toxic gas.

Description

- The cabin's fixed oxygen system supplies oxygen to the occupants, in case of cabin depressurization.
- Chemical generators produce the oxygen.
- Each generator feeds a group of 2, 3, or 4 masks. Generators and masks are in containers above the passenger seats, in the lavatories, in each galley and at each cabin crew station.
- A gaseous oxygen system may be installed, instead of the chemical system. It consists of several interconnected cylinders, located in the cargo compartment, that store the oxygen and supply the latter to the masks containers in the cabin.

Operation

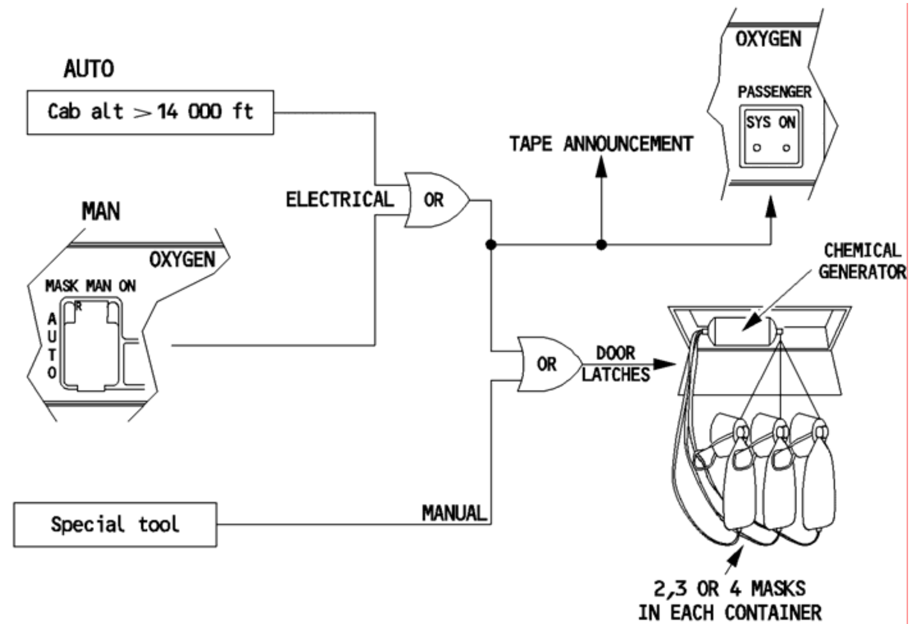
- Each container has an electrical latching mechanism that automatically opens to allow the masks to drop, if the cabin pressure altitude exceeds 14 000 ft (+0, –500 ft).
  The pilots can drop the masks at any time through the MASK MAN ON pushbutton on the overhead OXYGEN control panel.
  Flight crewmembers can override the automatic control: a manual release tool allows them to drop the masks manually in case of electrical failure.
  The PASSENGER SYS ON light of the OXYGEN panel comes on.

- When the masks are released, the passenger address system automatically broadcasts prerecorded instructions for their use.

- The generation of oxygen begins when the passengers pull the masks towards their seats.

- The chemical reaction used for oxygen generation creates heat. Therefore, smell of burning, smokes and cabin temperature increase may be associated with normal operation of the oxygen generators.

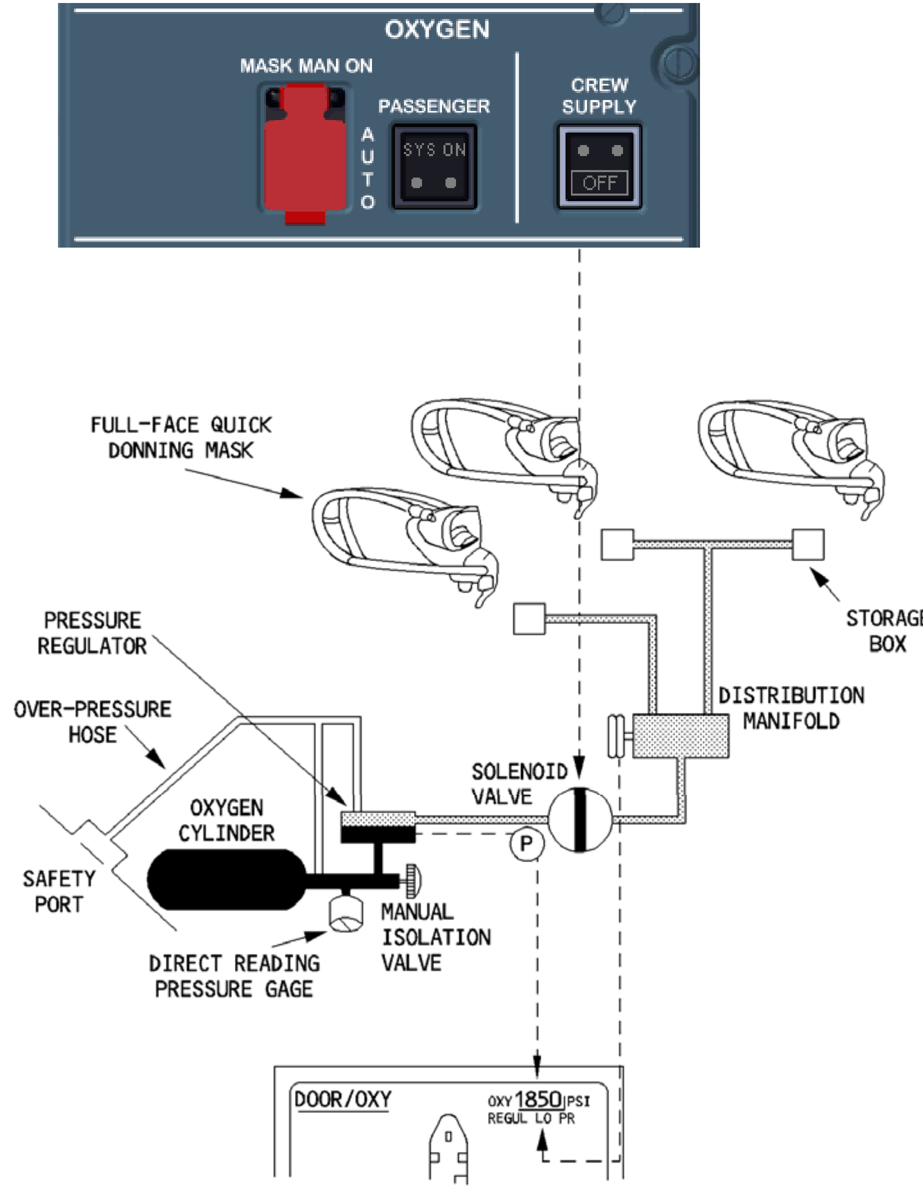
- The masks receive pure oxygen under positive pressure for about 15 minutes, until the generator is exhausted.



Description

The cockpit's fixed oxygen system consists of:

- One (or two, as installed) high-pressure cylinder in the left-hand lower fuselage.
- One (or two, as installed) pressure regulator, connected directly to the cylinder that delivers oxygen, at a pressure suitable for users.
- Two overpressure safety systems to vent oxygen overboard, through a safety port, if the pressure gets too high.
- A supply solenoid valve that allows the crew to shut off the distribution system, controlled by the CREW SUPPLY pushbutton switch on the OXYGEN overhead panel.
- Three (or four, as installed) full-face quick-donning masks, stowed in readily-accessible boxes adjacent to the crewmembers' seats (one at each seat).



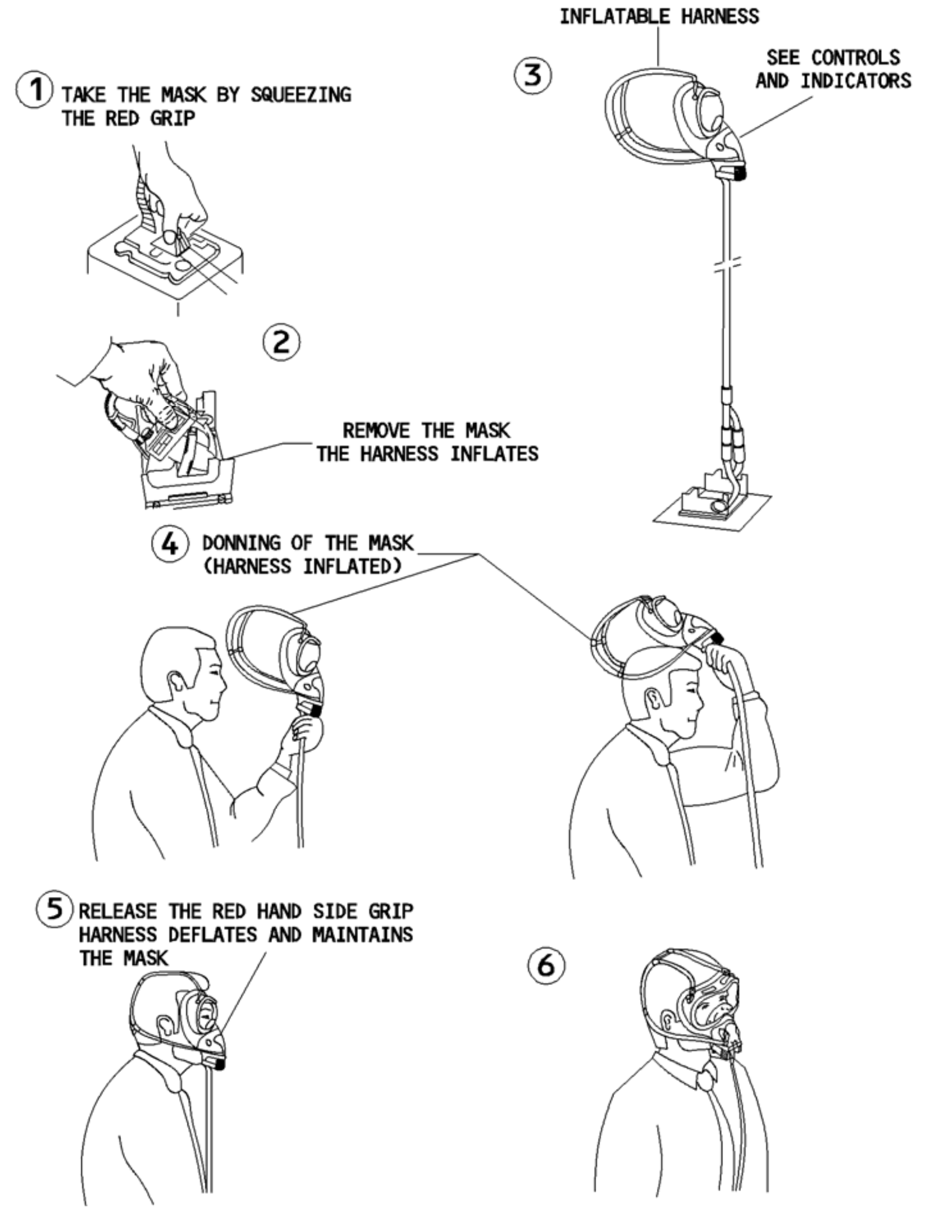
Operation

- The crewmember squeezes the red grips to pull the mask out of its box, and this action causes the mask harness to inflate.

- As soon as the left flap door of the stowage box opens, the mask is supplied with oxygen and, once it closes (mask still supplied with oxygen), the “OXY ON” flag appears on the stowage box.
  A yellow blinker flowmeter, located on the stowage box, flashes when oxygen is flowing.

- A mask-mounted regulator supplies a mixture of air and oxygen or pure oxygen, or performs emergency pressure control.
  With the regulator set to NORMAL, the user breathes a mixture of cabin air and oxygen up to the cabin altitude at which the regulator supplies 100 % oxygen. The user can select 100 %, in which case the regulator supplies pure oxygen at all cabin altitudes.

- The user can use the emergency overpressure rotating knob to receive pure oxygen at positive pressure, which eliminates condensation and prevents smoke, smell, or ashes, from entering the mask. Pressing this knob generates an overpressure for a few seconds. Turning this knob generates a permanent overpressure.



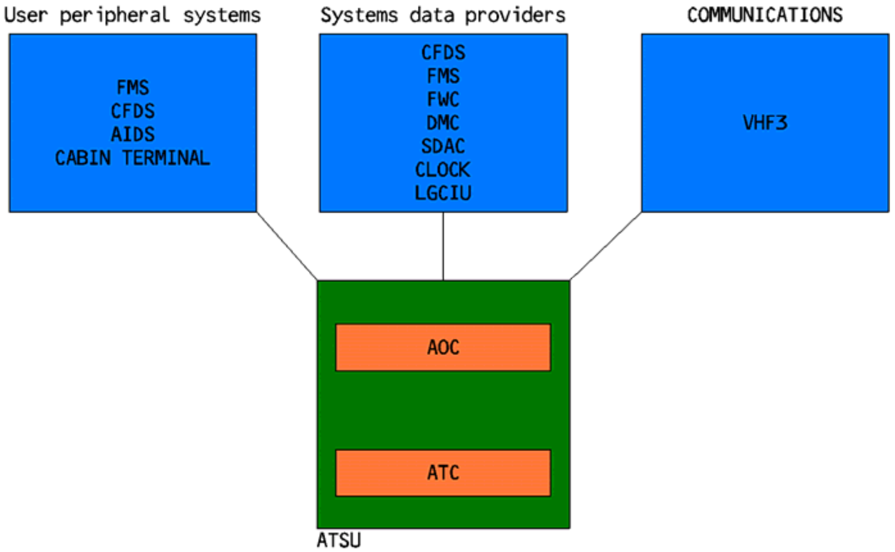
Portable Oxygen System

- The flight crew smoke hood on the left backside of the cockpit, ensures the eyes and respiratory system protection of one flight crewmember when fighting a fire and in case of smoke or noxious gas emissions or cabin depressurization.

18. Information System

- The information system manages the datalink communication and provides the crew with information coming from the airline.
- It consists mainly of an Air Traffic Service Unit (ATSU).
- The ATSU manages:
  - The Air-Ground communications
  - The exchange of information between the aircraft and the airline according to the Airline Operational Control (AOC) applications defined in the ATSU.
  - The information display via the MCDU.
  - The appropriate warning for crew information.

System Architecture



A318/A319/A320/A321 – ATSU

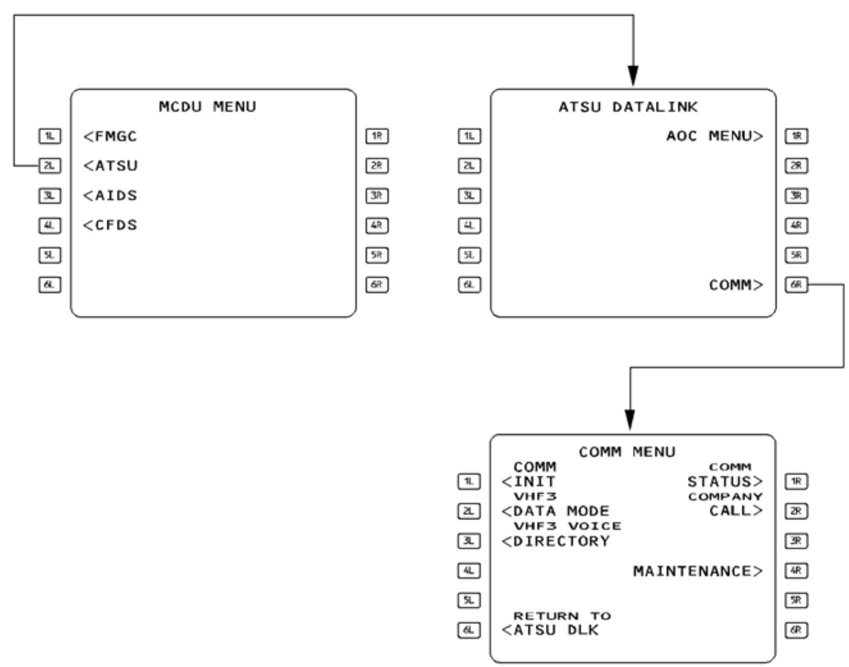
General

- The ATSU (Air Traffic Services Unit) has been introduced to support emerging ATC datalink functions.
- The ATSU hosts functions that were previously in ACARS MU/CMU.

  ACARS router:
  - To select communication media
  - To manage interface with aircraft ACARS user systems (FMS, CMS / CFDS, ACMS / AIDS).
- It also hosts:
  - Specific airline applications **(AOC software)** which are BFE in the ATSU, fully customizable
  - ACARS MU look-alike
  - To perform specific airline functions, such as :
    - OOOI
    - Delay
    - Load sheet
    - Fuel on board
    - Gate assignment,... reports.

Communication functions

- The ATSU communication function manages the Air-Ground communications either:
  - Automatically without pilot action,
  - Manually using MCDU pages and/or RMPs.
- The pilot controls the communications through the COMM MENU page on MCDU.



AOC Applications

- Two kinds of Airline Operational Control (AOC) applications are provided:
  - Remote AOC applications embedded in systems peripheral to ATSU (AIDS, CFDS, FMGC, CABIN TERMINAL)
  - Hosted AOC applications uploaded into the ATSU.

- **Remote Applications**

  - Flight Management System (FMGC)
  The FMGC interface allows to access the following data :
    - Wind data (F-PLN page)
    - Takeoff data (uplink only)
    - F-PLN initialization (uplink only)
    - Pre-flight,post-flight report and ACARS print/program (downlink only)

  - Centralized Fault Display System (CFDS)
  The CFDS interface allows to downlink the Post flight report (on the ground) or current flight report (in flight).

  - Aircraft Integrated Data System (AIDS)
  The AIDS interface provides ATSU with the data for the following applications:
    - Aircraft Performance Monitoring (APM)
    - Engine Condition Monitoring (ECM)
    - APU Health Monitoring (AHM)

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