Power Plant PW1100G Presentation

INTRODUCTION

• PW1100G:
- Dual-rotor
- Geared Turbofan (GTF) Engine
- Variable stator
- Ultra high bypass ratio turbo fan

The PW1100G engine is an axial flow, dual-rotor, geared fan, variable stator, ultra high bypass ratio power plant. The PW1100G engines power the A319, A320 and A321 aircraft of the Single Aisle New Engine Option (NEO) family. PW1100G engines are available in several thrust ratings. The geared turbo fan engine reduces fuel consumption, air pollution and noise.

• The Data Storage Unit (DSU) is used to change the thrust rating

Each engine comes with a Data Storage Unit (DSU) which is connected onto the Electronic Engine Control (EEC). It provides engine parameters, thus the possibility of changing the thrust rating.

A/C	A/C MODEL	ENG MODEL	MTO
A319	A319-171	PW1124G-JM	24.5 klbs
A319	A319-172	PW1122G-JM	22.9 klbs
A319	A319-173	PW1127G-JM	26.8 klbs
A320	A320-271	PW1127G-JM	26.8 klbs
A320	A320-272	PW1124G-JM	24 klbs
A321	A321-271	PW1133G-JM	32.7 klbs
A321	A321-272	PW1130G-JM	29.7 klbs

MTO: Maximum Take-off

PW1127G-JM

INSTALLATION

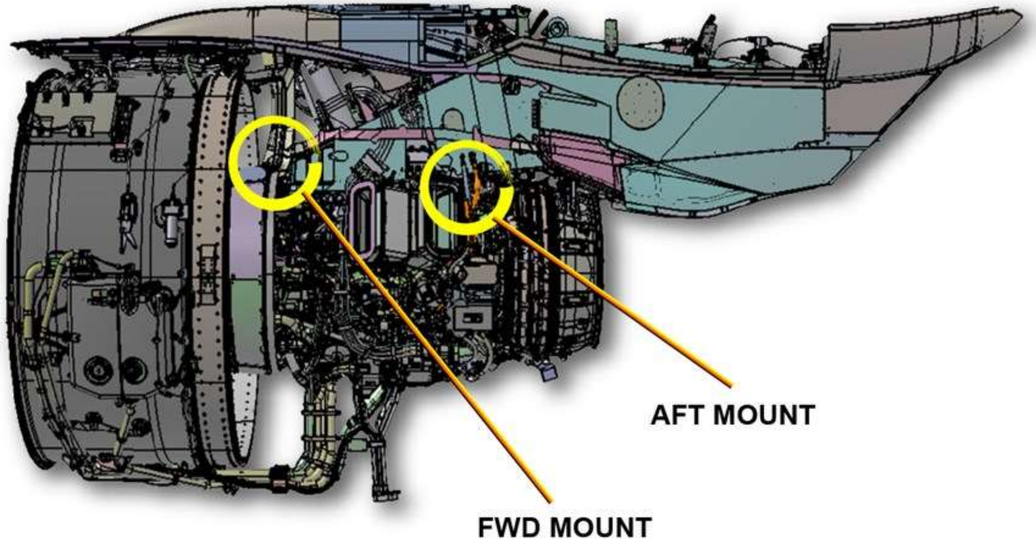
• Power plant installation:

- Engine
- Engine inlet cowl
- Fan cowls
- Thrust Reverser assemblies
- Exhaust nozzle and centerbody

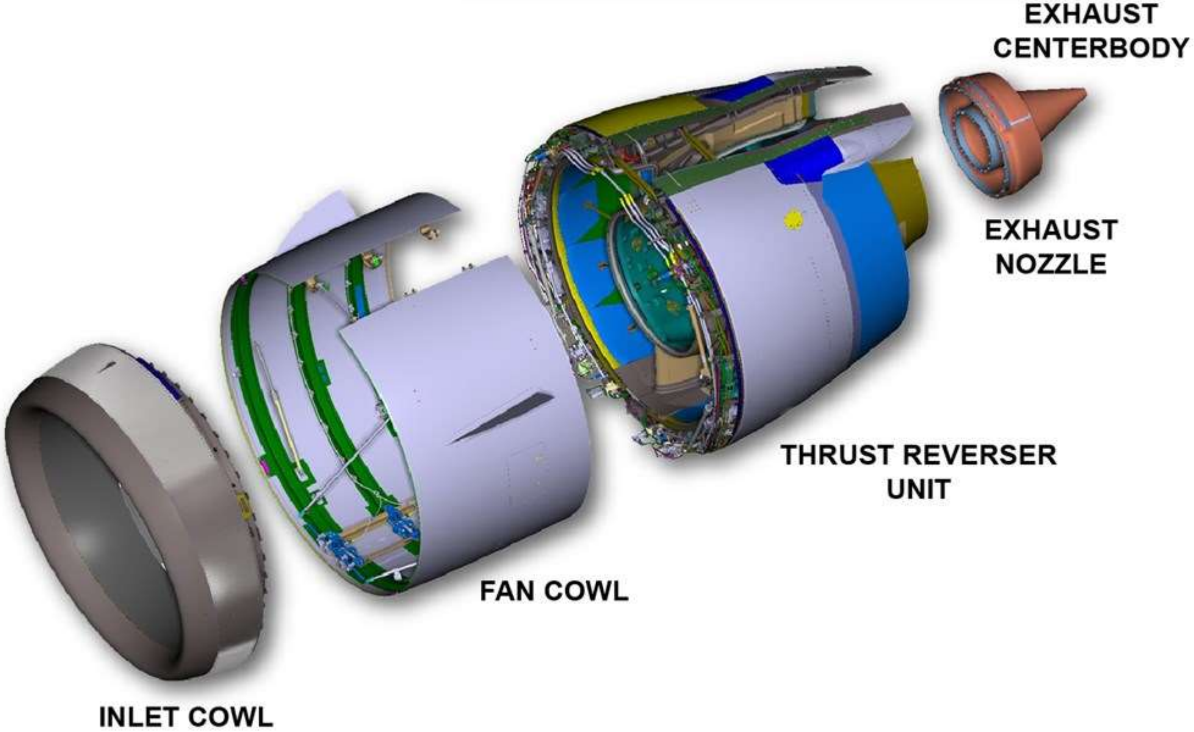
•2 engine mounts

The power plant installation includes the engine, the engine inlet cowl, the fan cowls, the thrust reverser assemblies and the exhaust nozzle and centerbody.

The engine is attached to the pylon by forward and aft mounts to transmit the engine and thrust loads. The pylon connects the engine to the wing structure. The forward engine mount is located on the Compressor Intermediate case. The rear engine mount is located on the Turbine Exhaust Case.


AFT MOUNT
FWD MOUNT


AIRBUS A320
PurePower PW1100G-JM

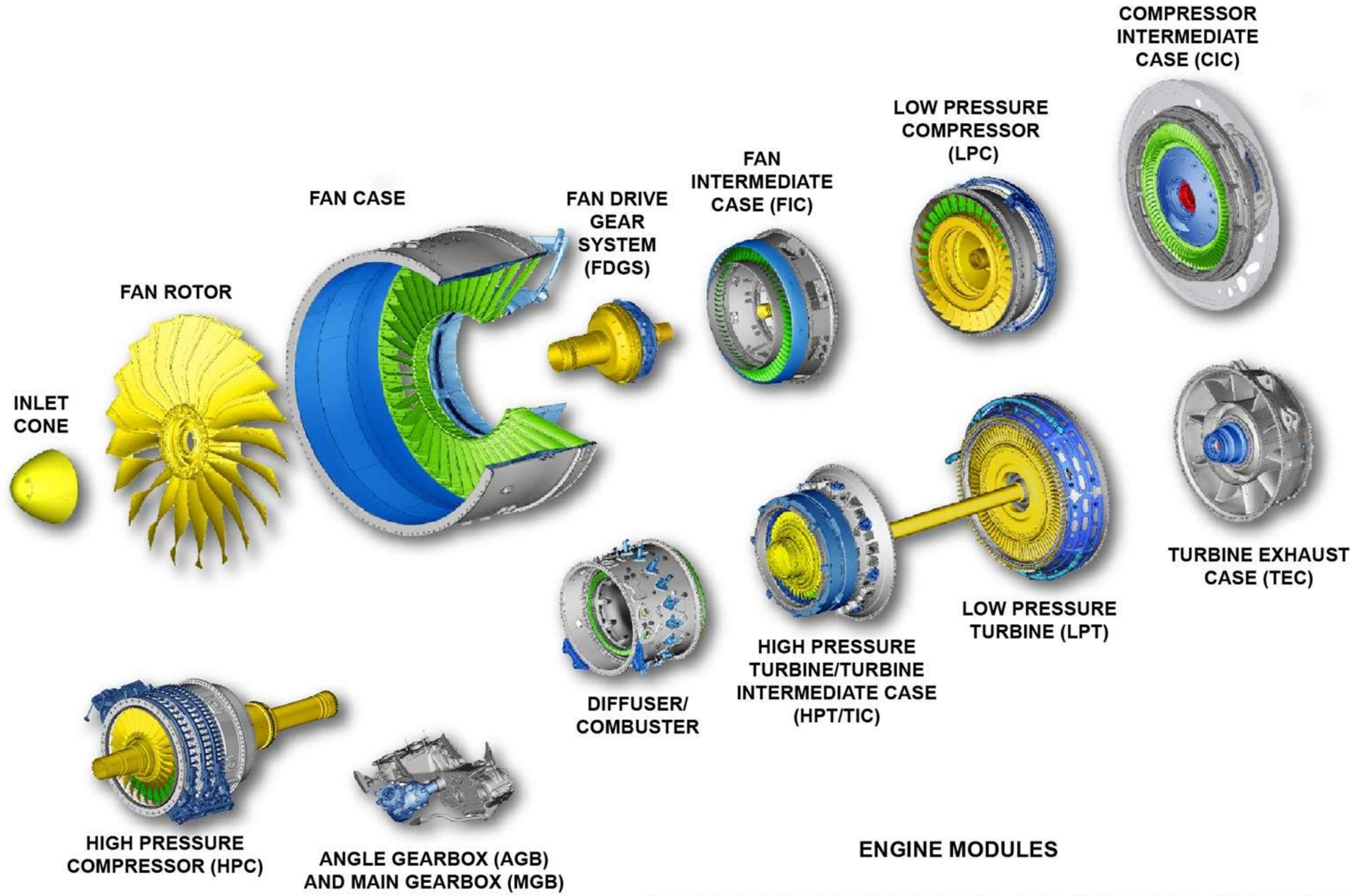

EXHAUST CENTERBODY
EXHAUST NOZZLE
THRUST REVERSER UNIT
FAN COWL
INLET COWL

MODULAR CONCEPT

• Identify PW11000G Engine modules

The PW1100G engine assembly modules are:

- Fan rotor
- Fan and Intermediate Case
- Fan Drive Gear System (FDGS)
- Low Pressure Compressor (LPC)
- Compressor Intermediate Case (CIC)
- High Pressure Compressor (HPC)
- Gearboxes under engine core
- Diffuser and combustor
- High Pressure Turbine (HPT)
- Turbine Intermediate Case (TIC)
- Low Pressure Turbine (LPT)
- Turbine Exhaust Case (TEC).



ENGINE MODULES

LP ROTOR, HP ROTOR AND COMBUSTION CHAMBER

• LP rotor:
- Forward fan
- FDGS
- LP compressor
- LP shaft
- LP turbine

•Indicated as N1 on ECAM

The Low Pressure (LP) rotor comprises a fan driven by the FDGS, the Low Pressure compressor and the LP shaft, all driven by the LP turbine. The speed of the LP rotor is indicated on the ECAM as N1.

• Air produced by fan known as secondary airflow

•FDGS

•Air produced by the 3-stage LP compressor is known as primary flow

•Fan and LP Compressor driven by 3-stage LP turbine

The fan supplies most of the engine thrust. The air produced by the fan is known as secondary airflow or bypass airflow.

To improve the propulsive efficiency and fuel consumption, the FDGS reduces the fan speed thanks to reduction gear mechanism.

The 3-stage Low Pressure (LP) compressor supplies air to the engine core. This is primary airflow. The LP compressor rotates at the same speed as the 3 stage LP turbine.

• HP rotor:
- 8 stage HP compressor
- Two stage HP turbine

•Indicated as N2 on ECAM

The High Pressure (HP) rotor is made up of 8 stage HP compressor driven by two stage HP turbine. The speed of the HP rotor is indicated on the ECAM as N2.

• LP rotor and HP rotor supported by bearings

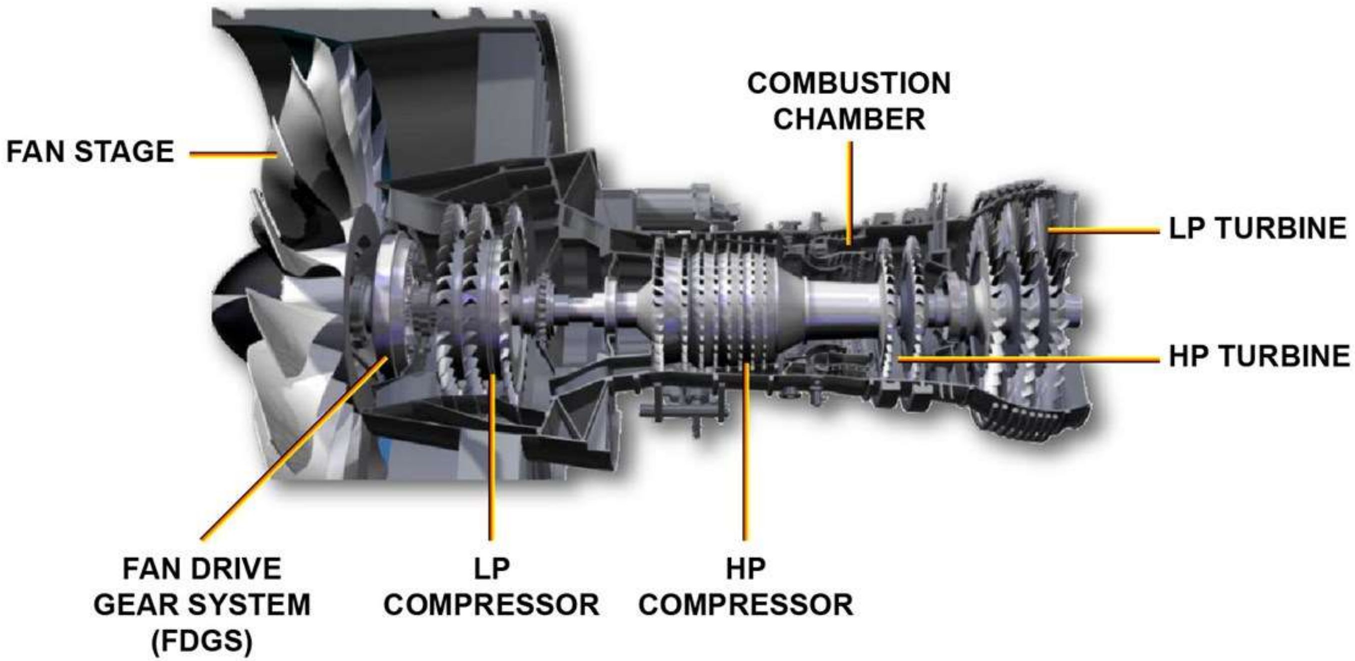
The LP and the HP rotors are supported by roller and ball bearings which are lubricated and cooled.

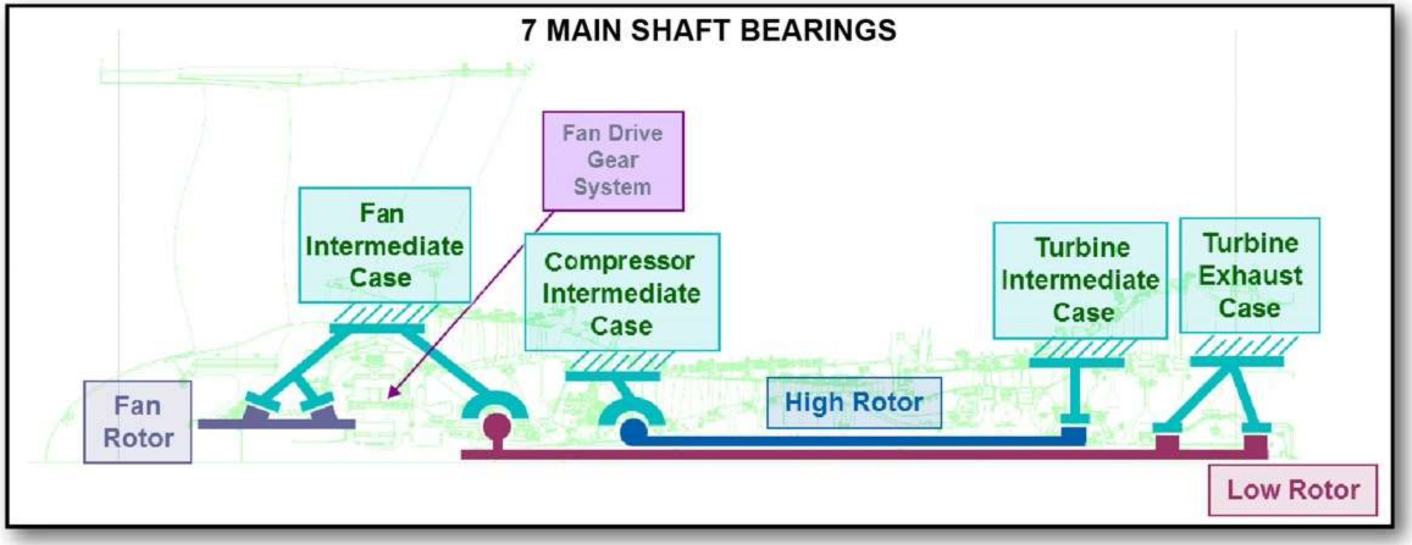
• Annular combustion chamber equipped with:
- 18 Fuel nozzles
- 2 igniter plugs

12 Duplex and 6 Simplex

The annular combustion chamber is installed between the HP compressor and HP turbine.

It has ports for 18 fuel nozzles and 2 igniter plugs.


COMBUSTION CHAMBER
FAN STAGE
LP TURBINE
HP TURBINE
FAN DRIVE GEAR SYSTEM (FDGS)
LP COMPRESSOR
HP COMPRESSOR


7 MAIN SHAFT BEARINGS
Fan Drive Gear System
Fan Intermediate Case
Compressor Intermediate Case
Turbine Intermediate Case
Turbine Exhaust Case
Fan Rotor
High Rotor
Low Rotor

TRANSFER & ACCESSORY GEARBOXES

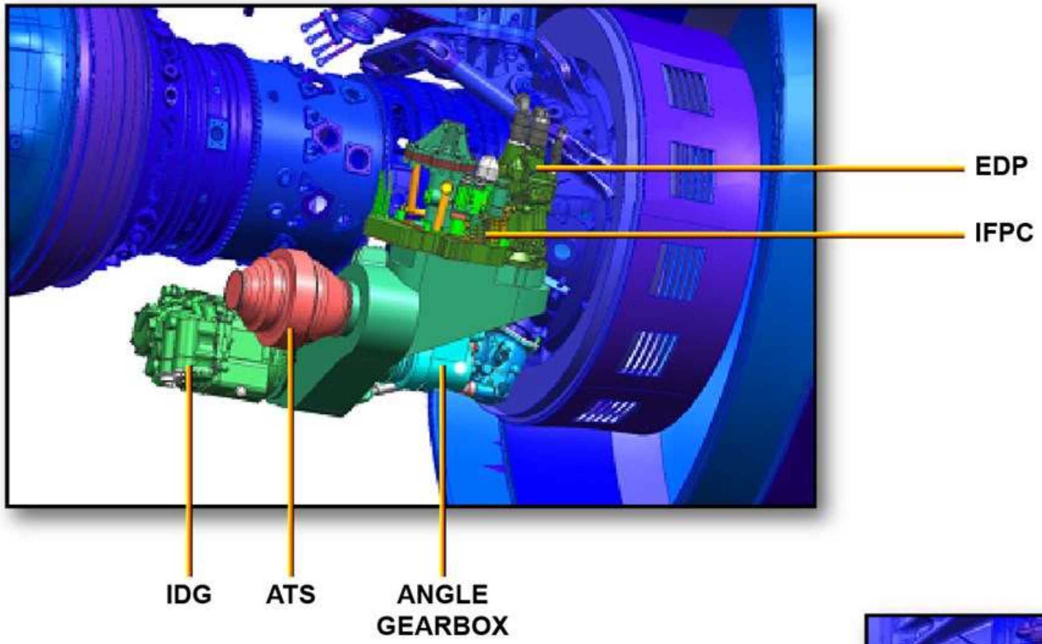
• Driven by HP compressor

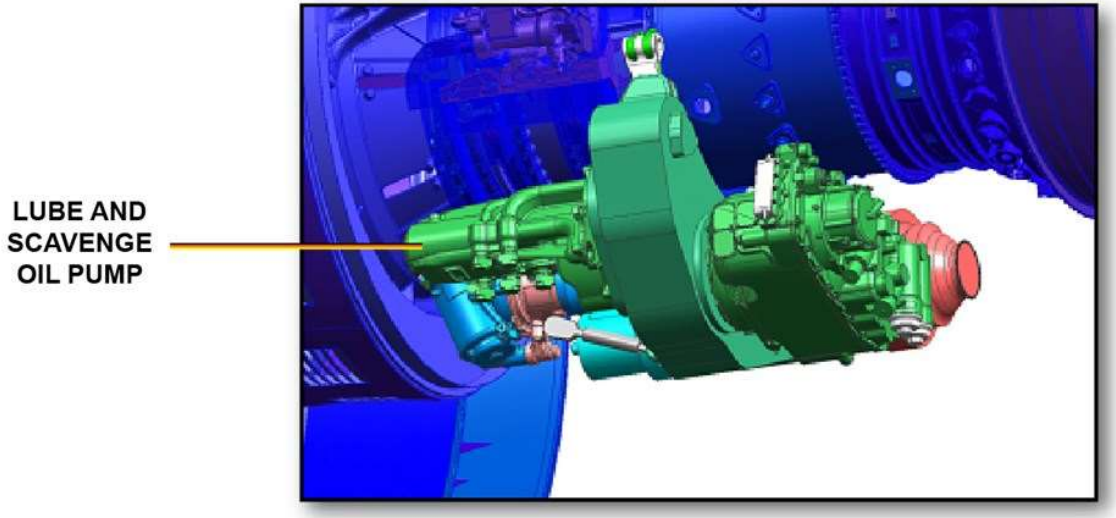
•Gearbox drives:

- Fuel pumps
- Oil pumps
- Hydraulic pumps
- Integrated Drive Generator
- Dedicated alternator

The accessory gearbox is installed under the core engine and is driven by the HP rotor through the Angle gearbox.
The fuel pumps, oil pumps, hydraulic pump, Integrated Drive Generator (IDG) and FADEC alternator are all driven by the gearbox.

• Air turbine starter drives HP rotor through gearboxes
During engine starting, the air turbine starter rotates the HP compressor through the gearboxes.





ATS: Air Turbine Starter
EDP: Engine Driven Pump
IDG: Integrated Drive Generator
IFPC: Integrated Fuel Pump and Control

PROPULSION CONTROL SYSTEM (PCS)

• Propulsion Control System (PCS) is composed of:
- FADEC System with EEC and Prognostic Health Monitoring Unit (PHMU)
- EIU

•Full range of control given by the FADEC

The Propulsion Control System (PCS) regroups the following subsystems:

- The FADEC system consists of an Electronic Engine Control (EEC) and a Prognostic Health Monitoring Unit (PHMU),
- The Engine Interface Unit (EIU).

In order to increase engine reliability and efficiency, the FADEC gives the full range of engine control to achieve steady state and transient engine performances when operated in combination with aircraft subsystems.

• Engines controlled by EEC
- Dual-channel computer

•EEC gives engine control and engine monitoring

•Power supplies by the FADEC alternator driven by the gearbox

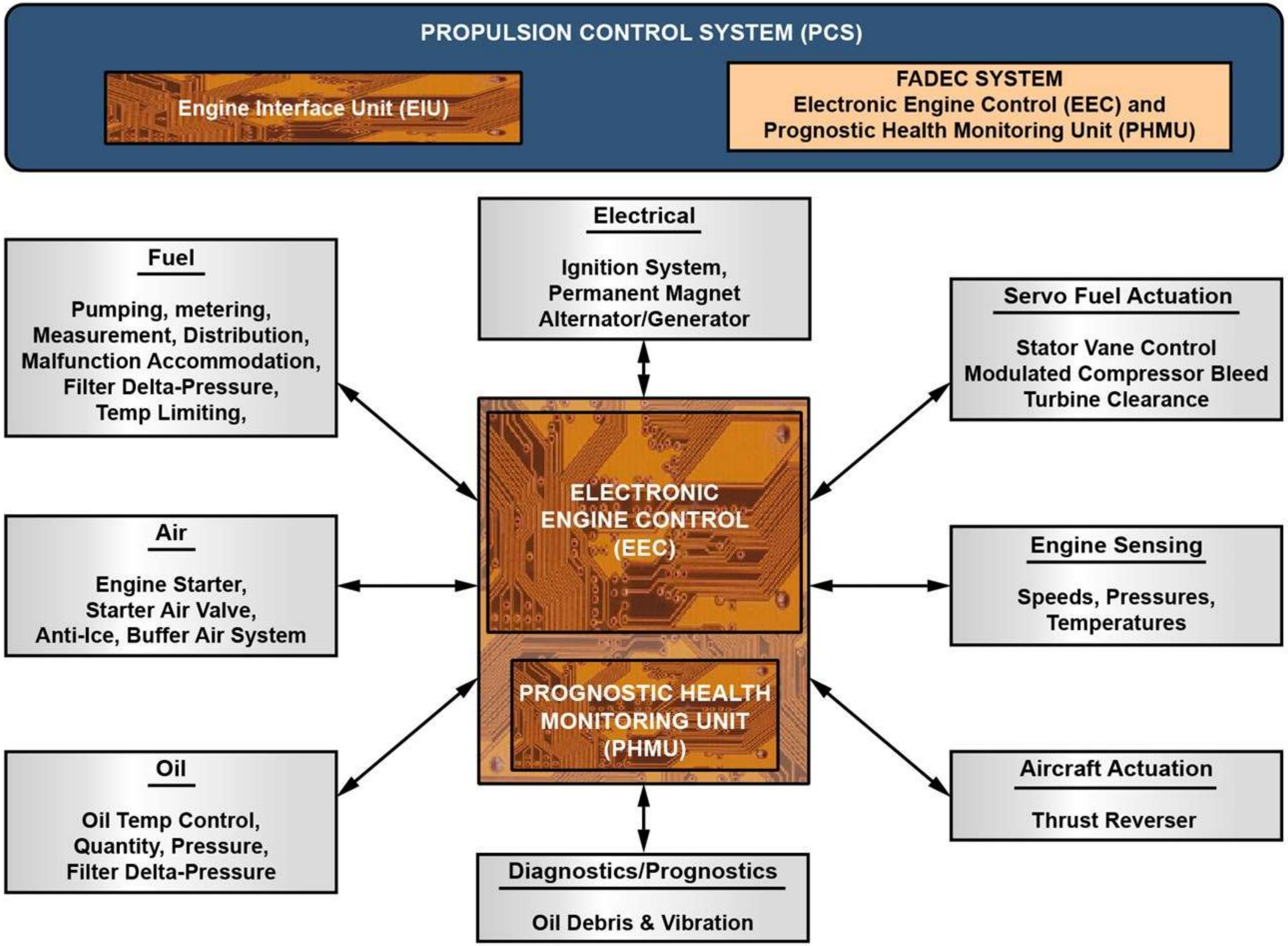
The EEC controls the operation of the following:

- Engine control for thrust setting in Manual and Auto thrust Modes,
- Thrust Control Malfunction protection,
- Engine airflow control,
- Combustor fuel metering valve,
- Control and monitoring sensing,
- Ignition and starting systems,
- Command and monitoring of the thrust reverser system,
- Fault detection, isolation, annunciation and transmission to the A/C (BITE).

When the engine is running, power for FADEC operation is supplied by a dedicated alternator driven by the gearbox.

• PHMU monitoring unit for:
- Engine vibration, oil debris monitoring

The PHMU interfaces with the EEC. It monitors the Engine vibrations and the Oil debris


PROPULSION CONTROL SYSTEM (PCS)
Engine Interface Unit (EIU)
FADEC SYSTEM
Electronic Engine Control (EEC) and
Prognostic Health Monitoring Unit (PHMU)
Electrical
Ignition System,
Permanent Magnet
Alternator/Generator
Fuel
Pumping, metering,
Measurement, Distribution,
Malfunction Accommodation,
Filter Delta-Pressure,
Temp Limiting,
Servo Fuel Actuation
Stator Vane Control
Modulated Compressor Bleed
Turbine Clearance
ELECTRONIC
ENGINE CONTROL
(EEC)
Air
Engine Starter,
Starter Air Valve,
Anti-Ice, Buffer Air System
Engine Sensing
Speeds, Pressures,
Temperatures
PROGNOSTIC HEALTH
MONITORING UNIT
(PHMU)
Oil
Oil Temp Control,
Quantity, Pressure,
Filter Delta-Pressure
Aircraft Actuation
Thrust Reverser
Diagnostics/Prognostics
Oil Debris & Vibration

EIU

• EIU for each engine

•The EIU is an interface concentrator

•The main functions of the EIU are:

- To concentrate data from cockpit panels and different aircraft systems
- To give to the FADEC system some necessary logic and information from aircraft systems (example: flight/ground status)

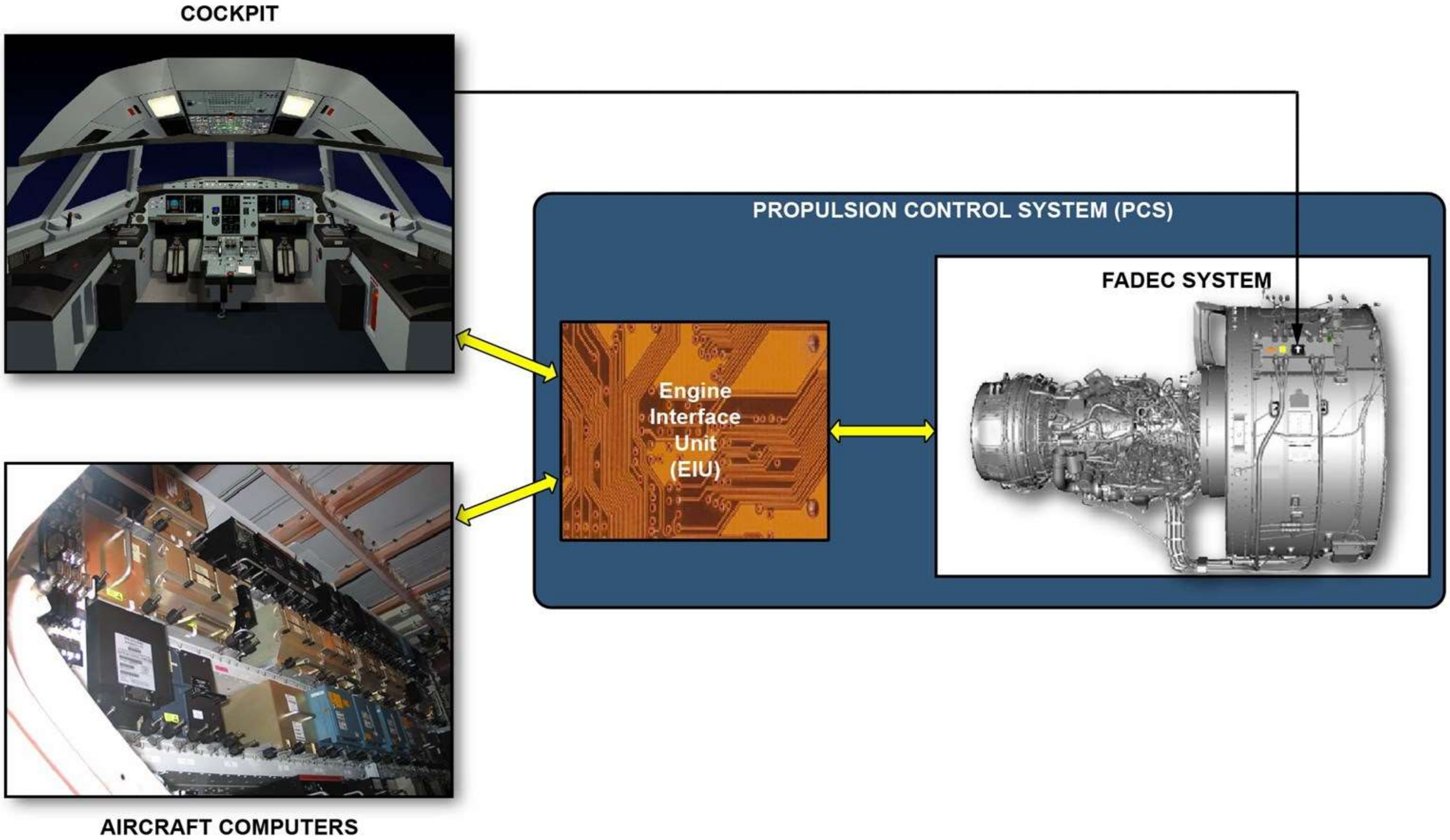
The EIU is an interface concentrator between the airframe and the corresponding engine. Two EIUs are installed in the A/C. EIU-1 interfaces with Engine 1 and EIU-2 interfaces with Engine 2.

The main functions of the EIU are:

- To concentrate data from cockpit panels and different aircraft systems to the associated EEC on each engine,
- To ensure the segregation of the two engines,
- To give to the airframe the necessary logic and information from engine and to other systems (APU, ECS, Bleed Air, Maintenance),
- To give to the FADEC system some necessary logic and information from systems (example: flight/ground status).

• Additional EIU function: Monitoring of fan cowl latches by proximity switches

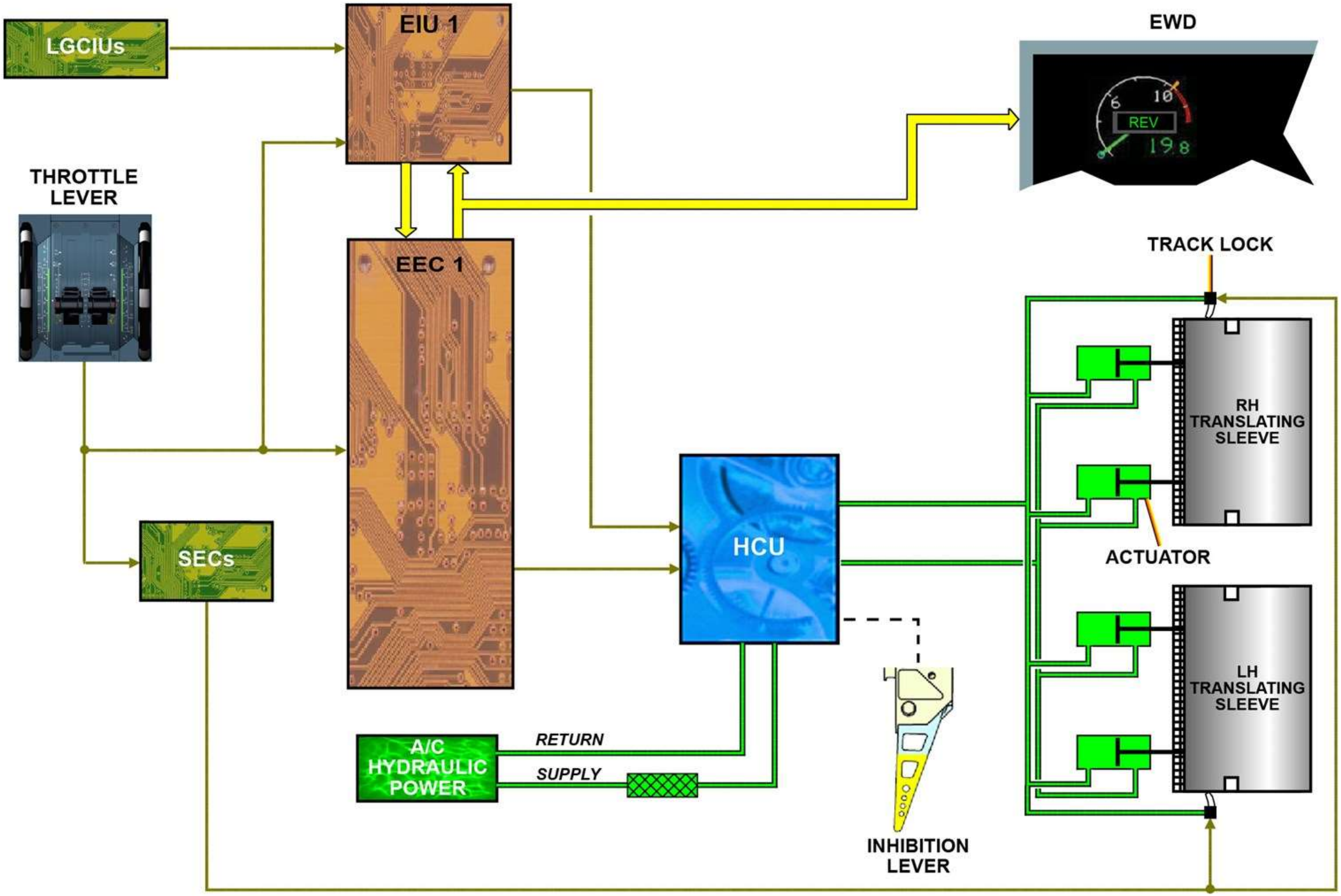
The Fan Cowl latches of the A320 NEO are monitored by proximity switches which send their position signals to the EIU. The EIU transfers signals to the FWC for associated cockpit warnings based on specific logic conditions.


COCKPIT
PROPULSION CONTROL SYSTEM (PCS)
FADEC SYSTEM
Engine
Interface
Unit
(EIU)
AIRCRAFT COMPUTERS

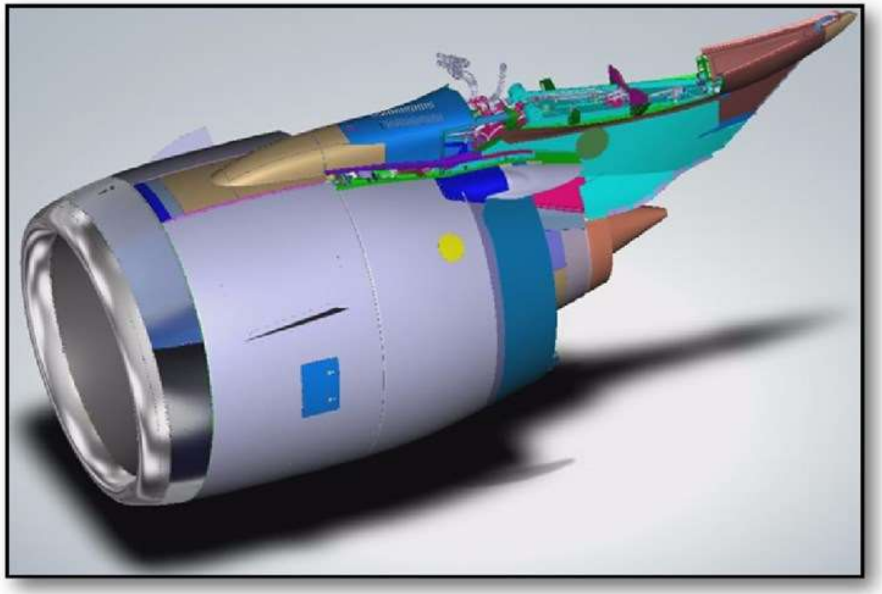
THRUST REVERSER SYSTEM

• Controlled by EEC, EIU, SEC
  - Manually selected through the throttle control levers
  - Translating sleeves, blocker doors with cascade vanes
  - HCU

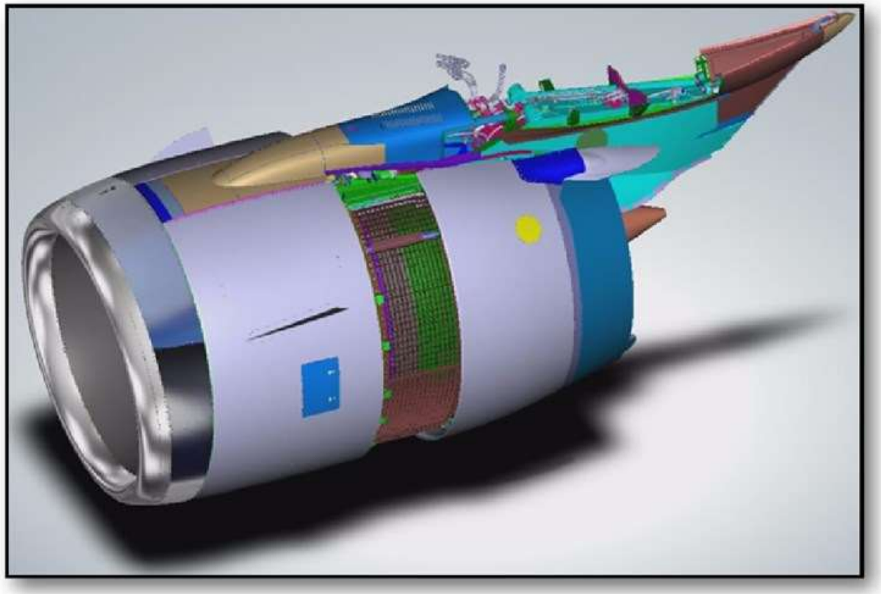
The flight crew manually selects reverse thrust by lifting the latching levers on the throttle control levers. The thrust reverser system comprises of 2 translating sleeves, 10 blocker doors with cascade vanes per engine. The EEC in accordance with the EIU control valves inside the Hydraulic Control Unit (HCU) for deploy and stow sequences.
HCU supplies hydraulic power to operate thrust reverser actuators.
The SEC computers authorize unlocking of Track Locks.
For maintenance or dispatch the reverser system can be inhibited.
The de-activation lever access is on LH Fan cowl side.


LGCIUs
EIU 1
EWD
6
10
REV
19.8
THROTTLE LEVER
EEC 1
TRACK LOCK
RH TRANSLATING SLEEVE
HCU
ACTUATOR
SECs
LH TRANSLATING SLEEVE
A/C HYDRAULIC POWER
RETURN
SUPPLY
INHIBITION LEVER

•Available only on ground
Reverse thrust is only available on the ground



TR STOWED

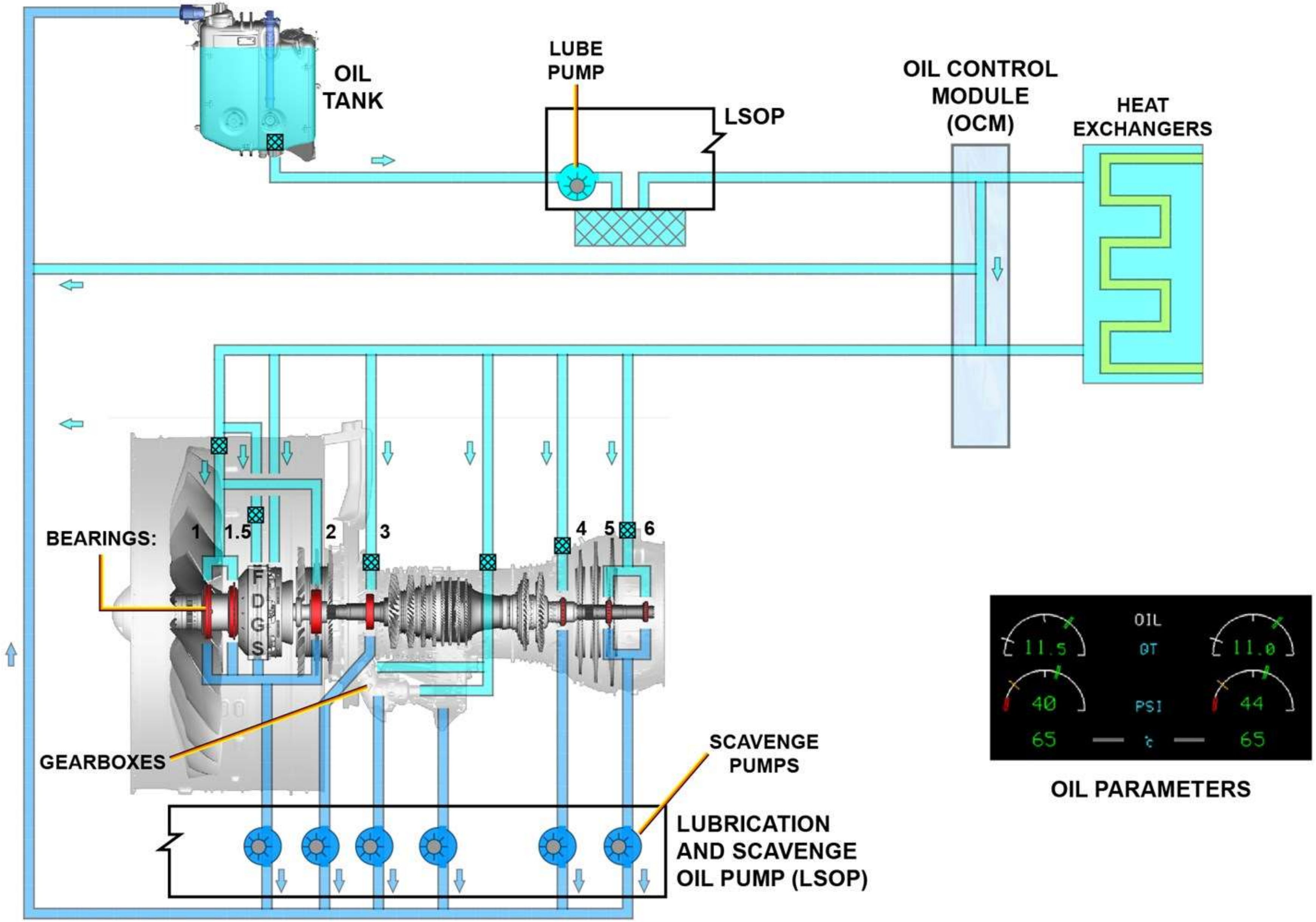


TR DEPLOYED

OIL SYSTEM

- Oil system composed of:
  - An oil tank
  - Oil pumps (in LSOP)
  - Oil Control Module (OCM)
  - Filters and heat exchangers
- Lubricates the bearings, FDGS, gearboxes and accessories
- Oil parameters are monitored

The oil system comprises of an Oil tank, oil pumps located within the Lubrication and Scavenge Oil Pump unit (LSOP), Oil Control Module (OCM), filters and heat exchangers.
The oil is used to lubricate and cool the bearings, the Fan Drive Gear System (FDGS), gearboxes and accessories.
The supply oil, cooled oil and the return oil parameters are monitored for ECAM warnings and indications.



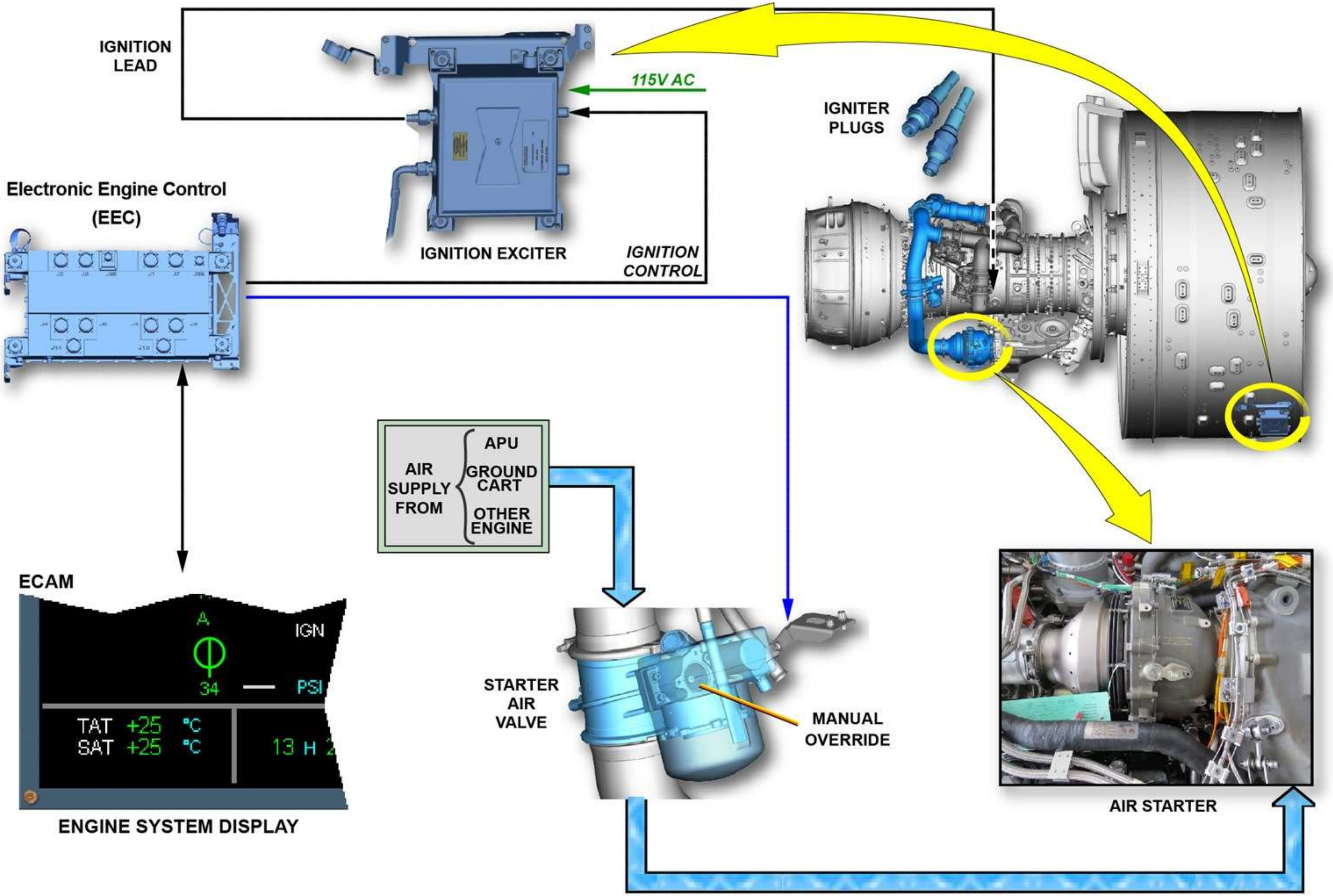
OIL PARAMETERS

IGNITION AND STARTING SYSTEMS

• System composed of:

- An air turbine starter
- A starter air valve
- An ignition exciter
- 2 igniter plugs

The Engine starting system is used for normal engine starts, in-flight restarts and ground monitoring.
The EEC controls the Starter Air Valve (SAV) to supply air to the Starter for initial N2 rotation.
Then the EEC controls the ignition for combustion starting.
Parameters are displayed on the ECAM during the sequence.
Note: The SAV has a manual override function.


IGNITION LEAD
115V AC
IGNITER PLUGS
Electronic Engine Control (EEC)
IGNITION EXCITER
IGNITION CONTROL
AIR SUPPLY FROM
APU
GROUND CART
OTHER ENGINE
ECAM
A
IGN
34
PSI
TAT +25 °C
SAT +25 °C
13 H
ENGINE SYSTEM DISPLAY
STARTER AIR VALVE
MANUAL OVERRIDE
AIR STARTER

CONTROL AND INDICATING

• Control panels and Indications

This section will highlight the control panels and indications for the engines.

CONTROL PANELS

• Engines controlled by throttle control levers
    • Manual movement only

The engines are controlled by throttle control levers which are installed on the center pedestal. They can only be moved manually.

• 2 latching levers for reverse operation

For reverse thrust operation, two latching levers let the throttle control levers move rearward into the reverse thrust section.

•Normal thrust mode: autothrust

•Autothrust disconnected by 2 red instinctive disconnect P/B

The A320 family aircraft normally operate in the auto thrust mode, when in flight.

The autothrust can be disconnected with an instinctive disconnect pushbutton (2 red buttons are installed on the outside of the lever).

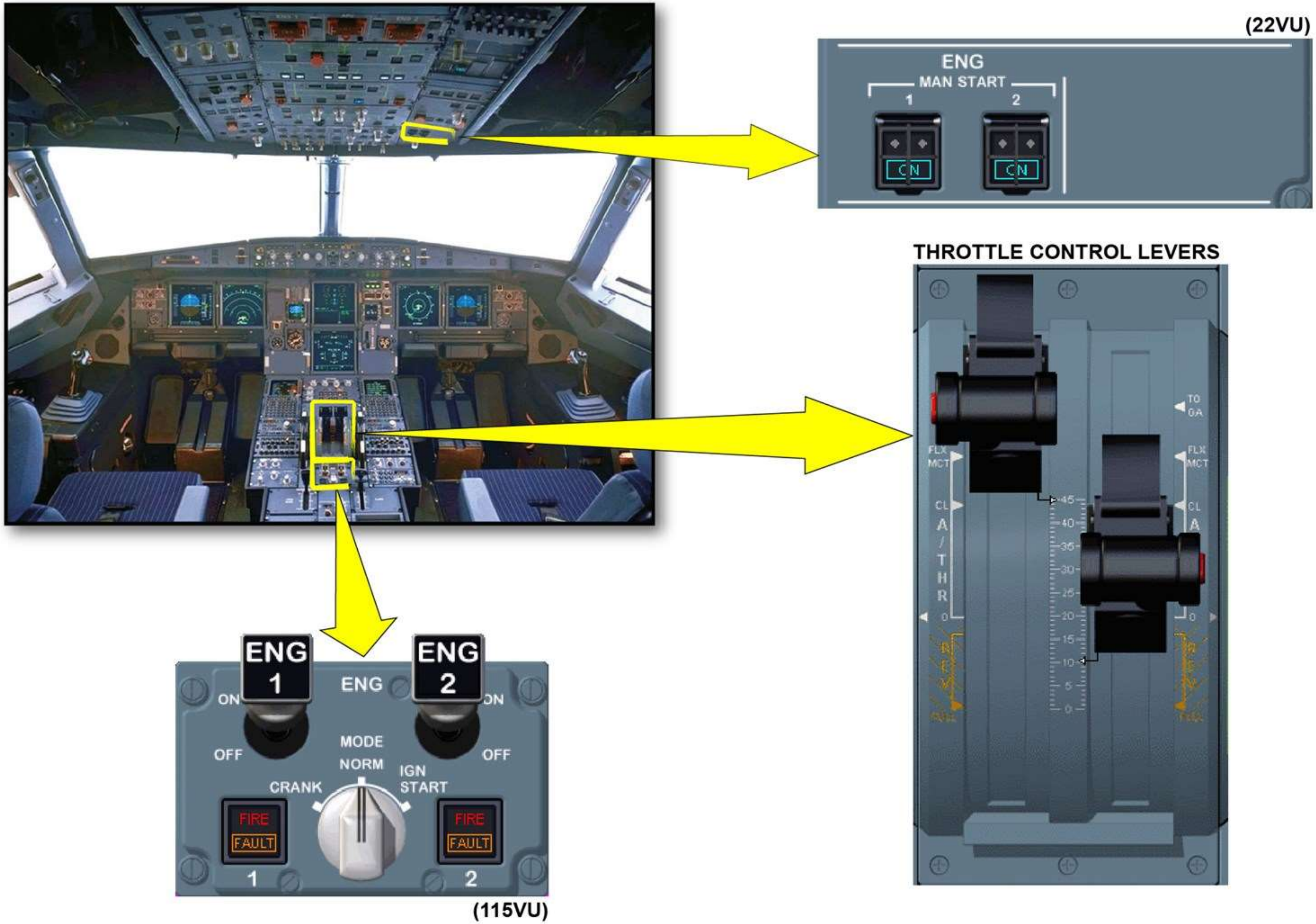
This lets the engines be controlled in manual thrust mode.

• Engine starting and shutdown panel on center pedestal

The controls for engine starting and shutdown are installed on the center pedestal immediately behind the throttle control levers.

• Manual start panel on the overhead panel

The engine MAN START switches are installed on the overhead panel. These switches are used to start an engine during a manual start procedure. They are also used during a dry or wet motoring procedure.


(22VU)
ENG
MAN START
1
2
ON
ON
THROTTLE CONTROL LEVERS
TO GA
FLX MCT
CL
A/THR
0
REV
FULL
45
40
35
30
25
20
15
10
5
0
ENG 1
ENG 2
ENG
ON
ON
OFF
OFF
MODE
NORM
CRANK
IGN START
FIRE
FAULT
FIRE
FAULT
1
2
(115VU)

ECAM ENGINE

• Primary parameters displayed on upper ECAM
•Secondary parameters displayed on lower ECAM

The engine primary parameters are permanently displayed on the upper ECAM.
The engine secondary parameters are presented on the lower ECAM ENGINE page when selected or displayed automatically during engine start or a fault.

• Cruise page

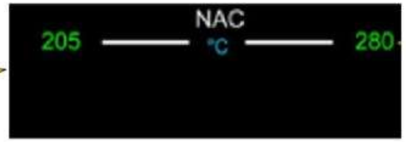
Some engine parameters are permanently displayed on the CRUISE page in flight.

UPPER ECAM EWD

DURING REVERSE THRUST

CRUISE PAGE

LOWER ECAM SD



ABOVE ADVISORY THRESHOLD

DURING ENGINE START

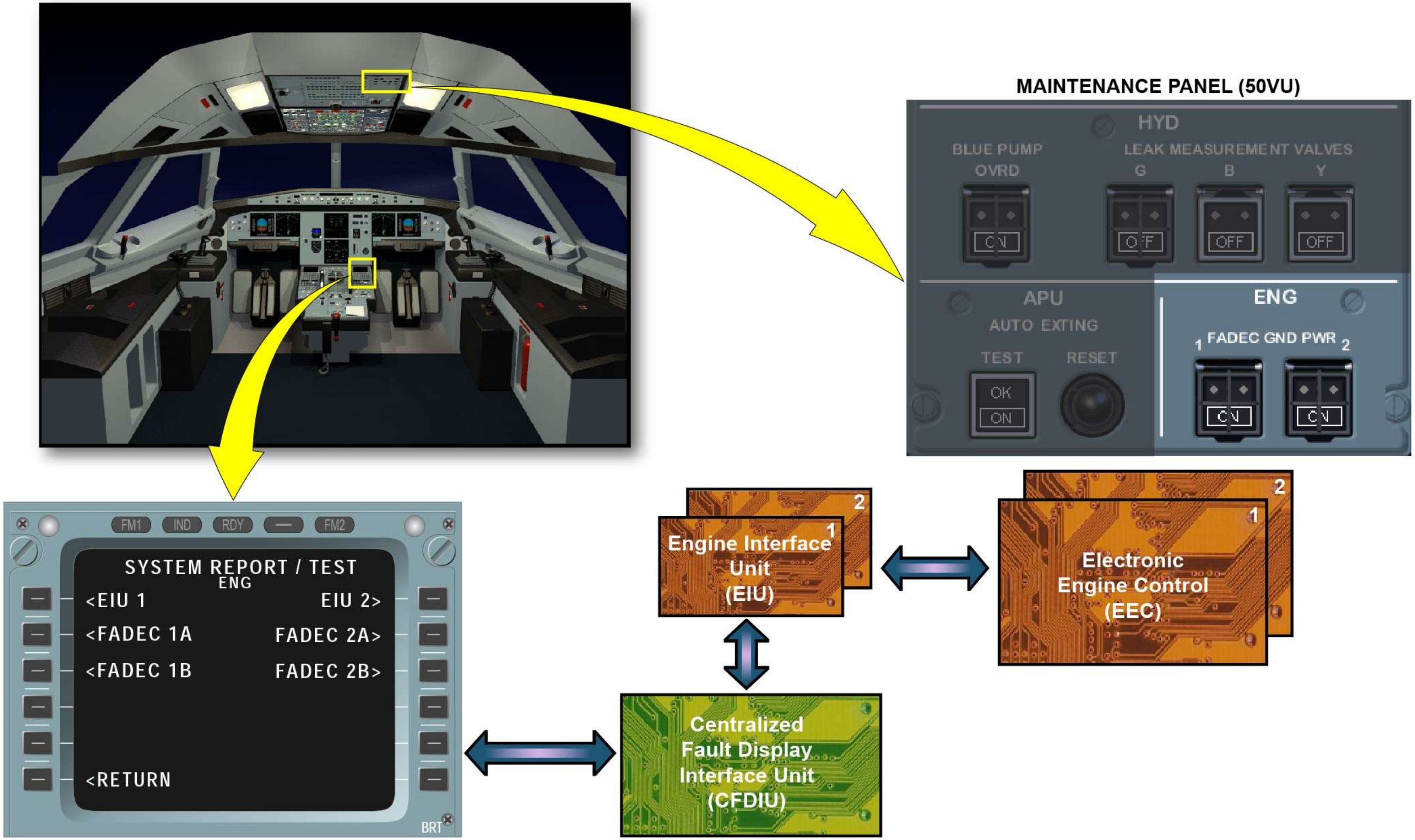
MAINTENANCE/TEST FACILITIES

- ENG FADEC GND PWR used to supply the PCS when engines not running
- MCDU used for tests and trouble shooting

On the maintenance panel, the ENG FADEC GND PWR permits to supply the FADEC system for maintenance tasks, when the engines are not running.

The MCDU is used to do PCS tests and for trouble shooting monitored components (computers, sensors, actuators).

The PHMU is tested through the EEC Bite.


MAINTENANCE PANEL (50VU)
HYD
BLUE PUMP OVRD
ON
LEAK MEASUREMENT VALVES
G
B
Y
OFF
OFF
OFF
APU
AUTO EXTING
TEST
RESET
OK
ON
ENG
1 FADEC GND PWR 2
ON
ON
FM1
IND
RDY
FM2
SYSTEM REPORT / TEST
ENG
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN
BRT
2
1
Engine Interface Unit (EIU)
2
1
Electronic Engine Control (EEC)
Centralized Fault Display Interface Unit (CFDIU)

SAFETY PRECAUTIONS

• AMM safety procedures obedience

When you work on aircraft, make sure that you obey all the Aircraft Maintenance Manual (AMM) safety procedures.
This will prevent injury to persons and/or damage to the aircraft. Here is an overview of main safety precautions related to the engines.

• Engine areas must be clear

Make sure that all engine danger areas are as clear as possible to prevent damage to the engine, the aircraft or persons in the area.
Be careful: The entry corridor will be closed when the engine power is above the minimum.

• Fire fighting equipment available

Make sure that you have fire-fighting equipment available.

• Do not try to stop fan by hand

Do not try to stop the fan from turning by hand.

• Engine shutdown at least 5 min before removing oil tank filler cap

After engine shutdown, let the oil tank pressure bleed off for a minimum of 5 minutes before you remove the tank filler cap. If you do not, pressurized oil can flow out of the tank and cause dangerous burns.

• Engine shutdown at least 5 minutes before maintenance done on the ignition system

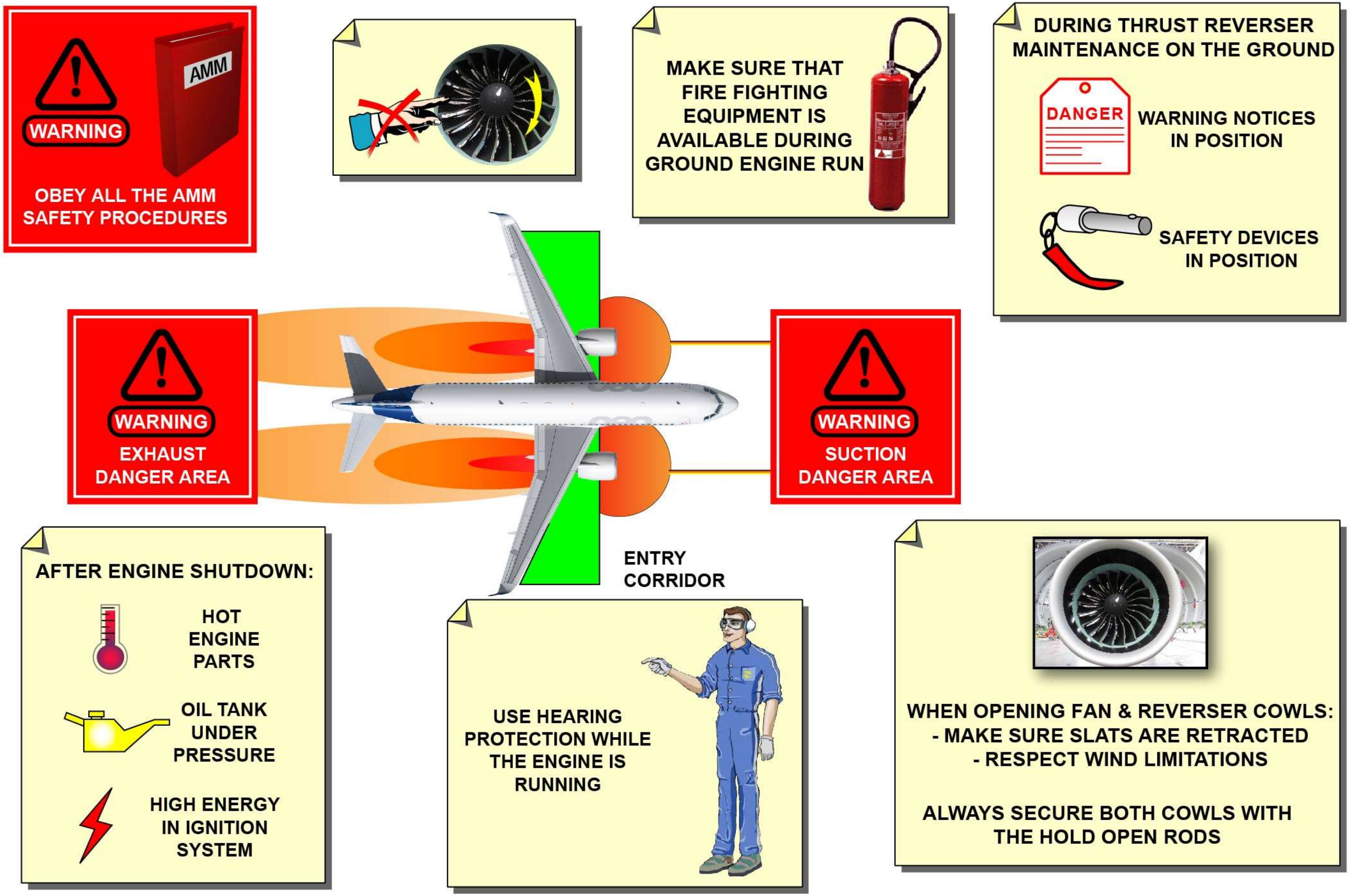
The engine ignition system is an electrical system with high energy. You must be careful to prevent electrical shock. Injury or death can occur. Do not do maintenance on the ignition system while the engine operates.
Make sure that the engine shutdown occurred more than 5 minutes ago before you continue with the maintenance procedure.

• Deactivate thrust reverser

Make sure that the thrust reverser is deactivated during maintenance. If not, the thrust reverser can operate accidentally and cause injury to personnel and/or damage to the reverser.

• Respect wind limitations and opening/closing sequence

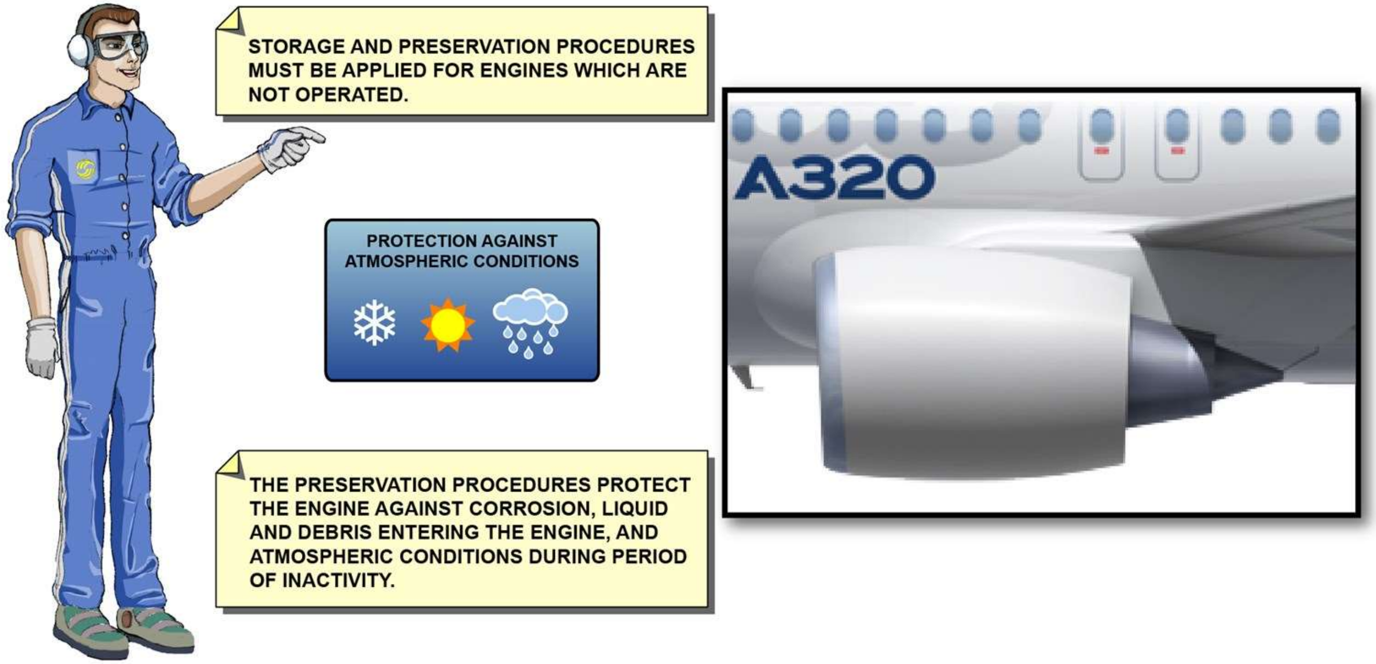
When opening the engine cowls:
o Respect the wind limitations and the opening/closing sequence,
o Always secure cowls with the hold-open rods,
o Make sure that the slats are retracted and install a warning notice to prevent slat operation.


WARNING
AMM
OBEY ALL THE AMM SAFETY PROCEDURES
MAKE SURE THAT FIRE FIGHTING EQUIPMENT IS AVAILABLE DURING GROUND ENGINE RUN
DURING THRUST REVERSER MAINTENANCE ON THE GROUND
DANGER
WARNING NOTICES IN POSITION
SAFETY DEVICES IN POSITION
WARNING
EXHAUST DANGER AREA
WARNING
SUCTION DANGER AREA
ENTRY CORRIDOR
AFTER ENGINE SHUTDOWN:
HOT ENGINE PARTS
OIL TANK UNDER PRESSURE
HIGH ENERGY IN IGNITION SYSTEM
USE HEARING PROTECTION WHILE THE ENGINE IS RUNNING
WHEN OPENING FAN & REVERSER COWLS:
- MAKE SURE SLATS ARE RETRACTED
- RESPECT WIND LIMITATIONS
ALWAYS SECURE BOTH COWLS WITH THE HOLD OPEN RODS

STORAGE AND PRESERVATION

- No operation
- Protection against corrosion, liquid, debris and atmospheric conditions

Storage and preservation procedures must be applied to engines which are not operated. The preservation procedures protect the engine against corrosion, liquid and debris entering the engine, and atmospheric conditions during period of inactivity.



CAUTION

UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL OR EQUIVALENT BE SPRAYED INTO THE ENGINE INLET, CORE COMPRESSOR OR TURBINE, OR ENGINE EXHAUST. DIRT PARTICLES DEPOSITED ON THE WET BLADES AND VANES MAY ADVERSELY AFFECT ENGINE PERFORMANCE DURING SUBSEQUENT OPERATION.

Power Plant System Component Location (PW1100G)

SYSTEM OVERVIEW
Comp loc ENG 1 LH
OIL Tank Fill Cap
START Air Valve/Starter
FAN & REV Cowls
Air valves
T/R Cowl Inhib Level
EEC

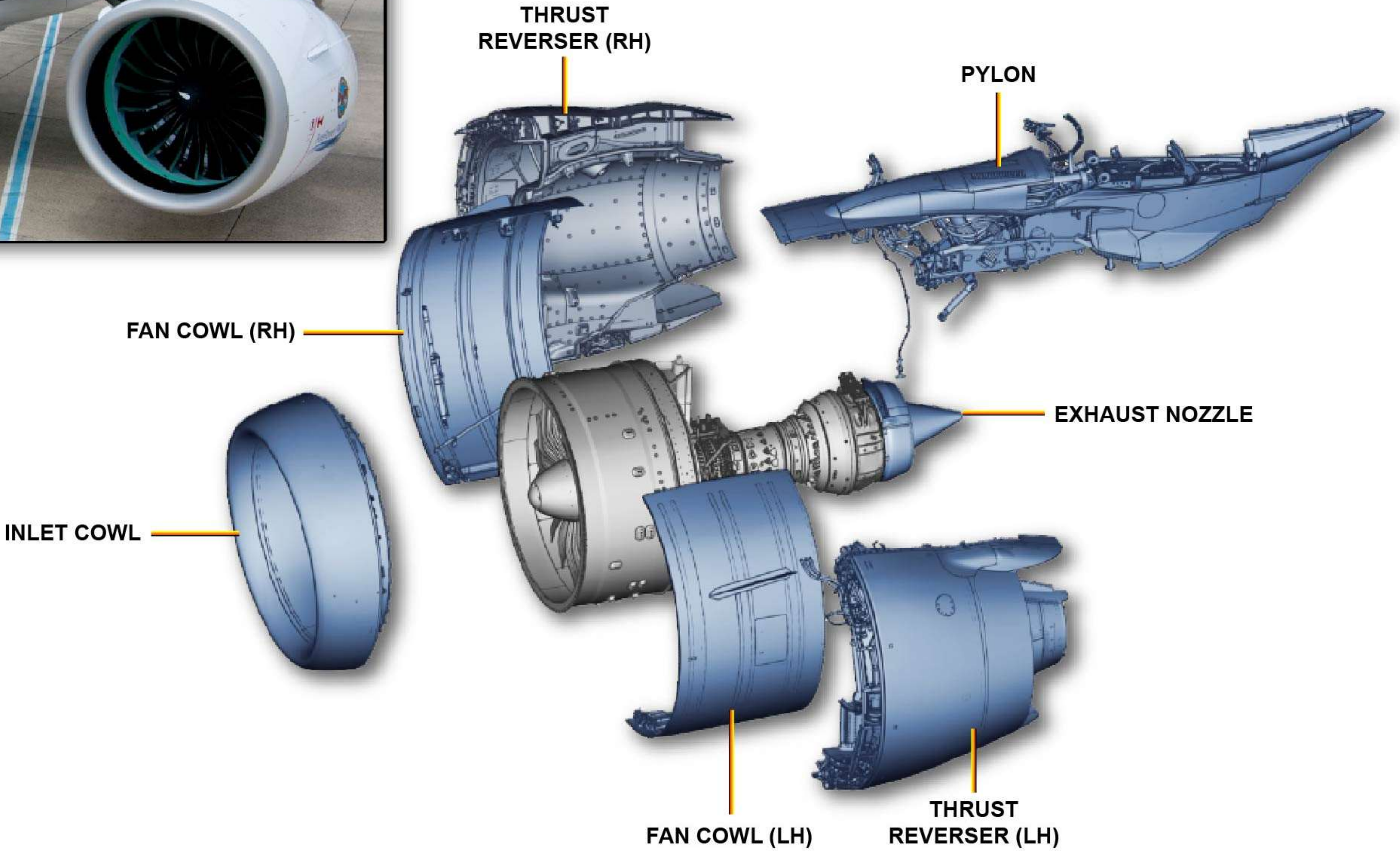
• Thrust range is from 24,000 to 33,000 lbs
The PW1100G engine is an axial flow, dual-rotor, geared fan, variable stator, ultra high bypass ratio power plant.
The PW1100G engines power the A319, A320 and A321 aircraft of the A320 NEO family. PW1100G engines are available in several thrust ratings.
The geared turbo fan engine provides improved fuel efficiency and reduces engine noise. It also reduces the CO_2 and NO_x emissions.
All the engines are basically the same. The Data Storage Unit (DSU) on the Electronic Engine Control (EEC) provides the possibility of changing the thrust rating.

• Power plant installation:

- Nacelle
- Inlet
- Exhaust
- Reverser

•2 engine mounts connect engines to pylon
The power plant installation includes the engine, the engine inlet, the exhaust, the fan cowls and the reverser assemblies. The pylon connects the engine to the wing structure. The engine is attached to the pylon by FWD and AFT mounts.


A320


THRUST
REVERSER (RH)
PYLON
FAN COWL (RH)
EXHAUST NOZZLE
INLET COWL
FAN COWL (LH)
THRUST
REVERSER (LH)

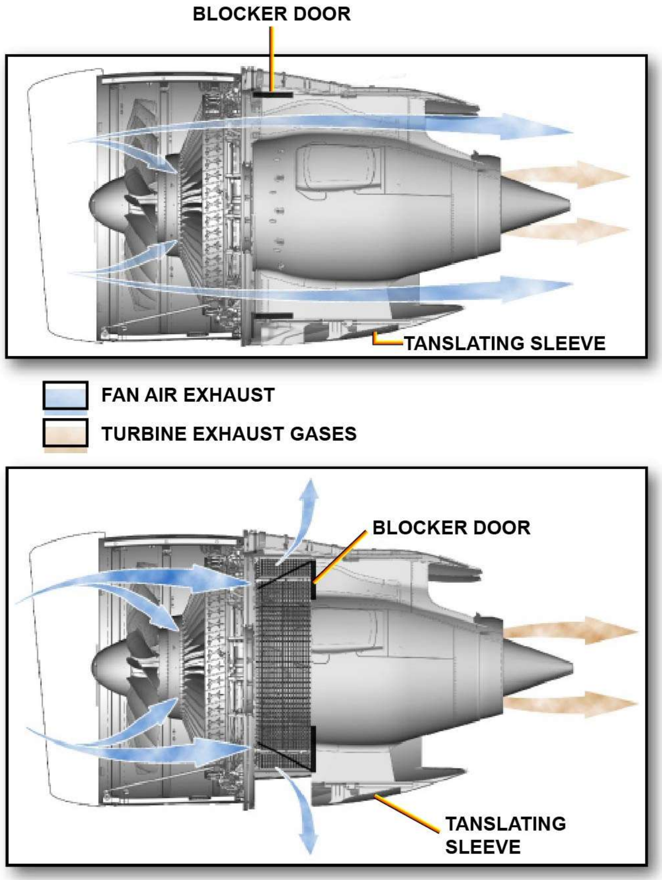
THRUST REVERSER SYSTEM

- 2 Hydraulically translating sleeves operated from cockpit
- Translating sleeve moves aft during deployment
    - Redirect the engine fan airflow

The thrust reverser system operated from the cockpit consists of 2 hydraulically operated translating sleeves.
When the translating sleeve moves aft during deployment, it lifts blocker doors that redirect the engine fan airflow.

STOW MODE

DEPLOY MODE



COMPONENT LOCATION

•Locations of engine components

The engine system components are at the following locations.

FADEC

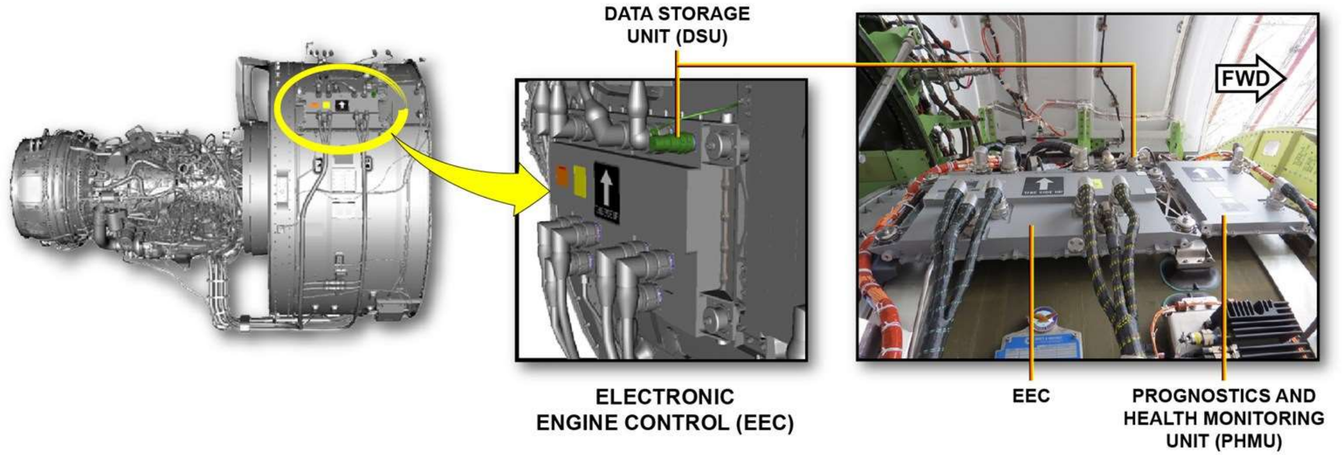
• EEC on RH side of fan case

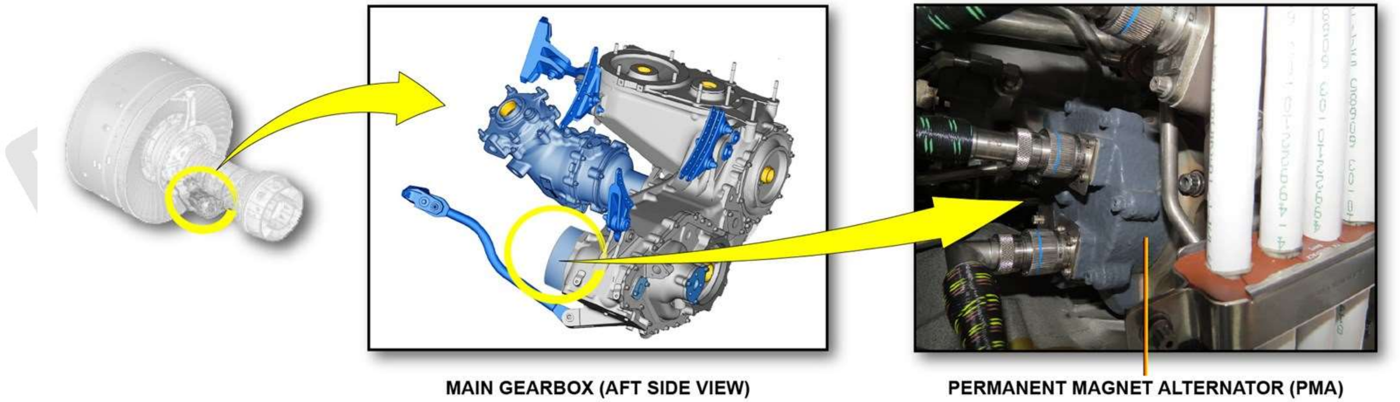
•FADEC alternator on the gearbox

The EEC and Prognostics and Health Monitoring Unit (PHMU) are on the RH side of the fan case.

The DSU is onto the top of the EEC on Channel A side and connected to the engine case bracket by a lanyard.

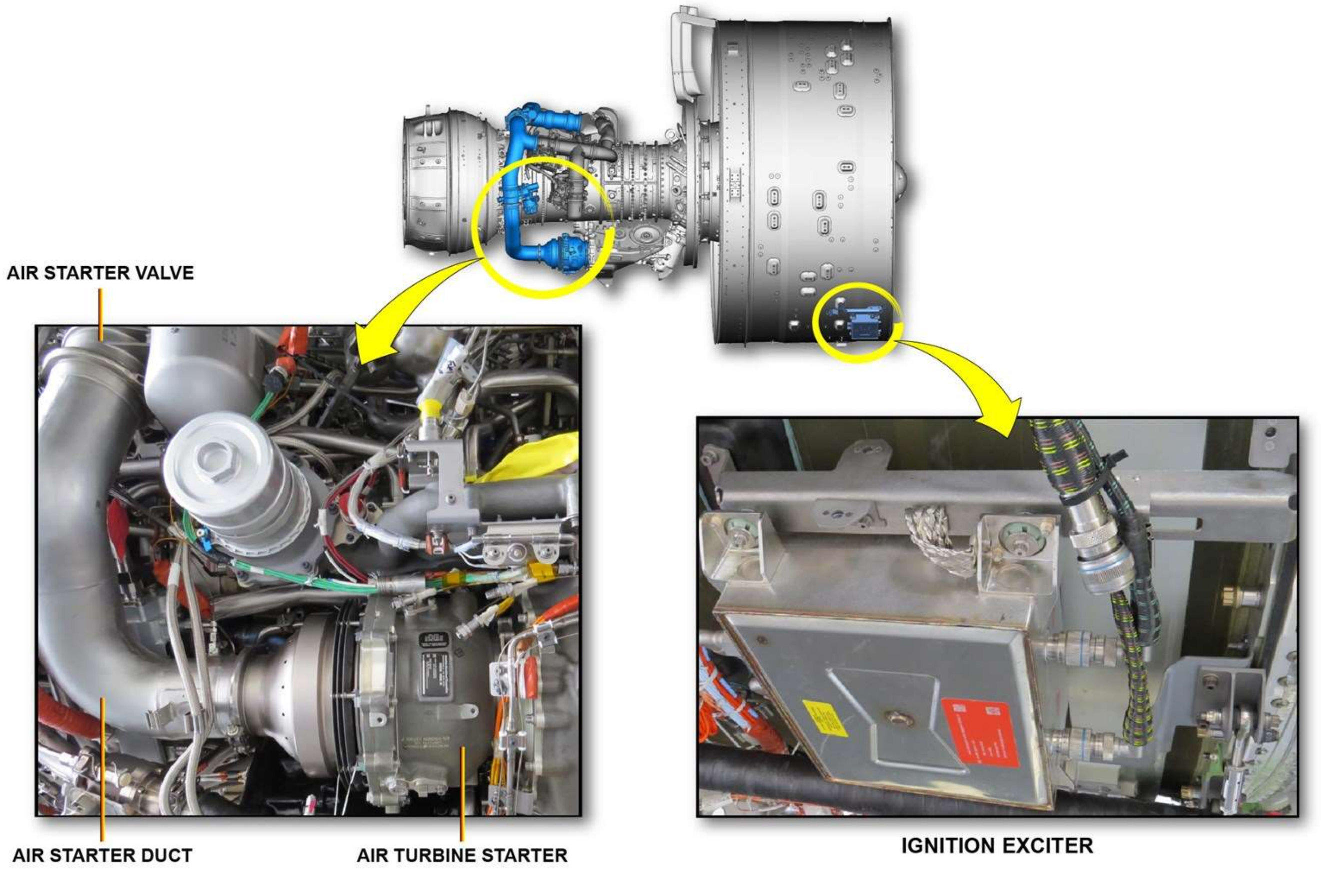
The FADEC Permanent Magnet Alternator (PMA) is on the forward face of the main gearbox.





IGNITION & STARTING

•1 ignition exciter box on RH side of engine fan case
•Starter on RH side of main gearbox
One ignition exciter box is on the RH side of the engine fan case at 5 o'clock.
The air turbine starter is at 5 o'clock aft of the main gearbox.

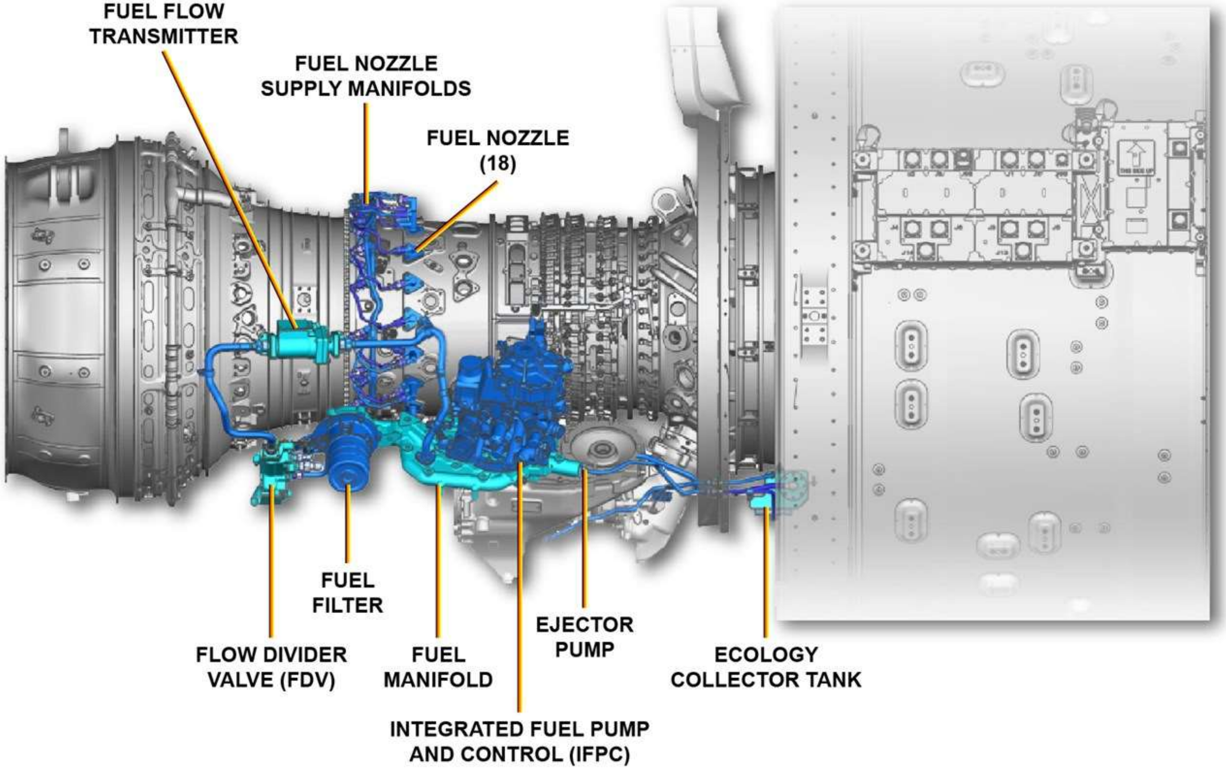


FUEL

• Primary components on RH side in core case
•IFPC on the main gearbox

The primary components of the fuel system are on the RH side of the engine core.
The Integrated Fuel Pump and Control (IFPC) is attached with bolts to the fuel manifold on the right side of the main gearbox at the 3 o'clock position.

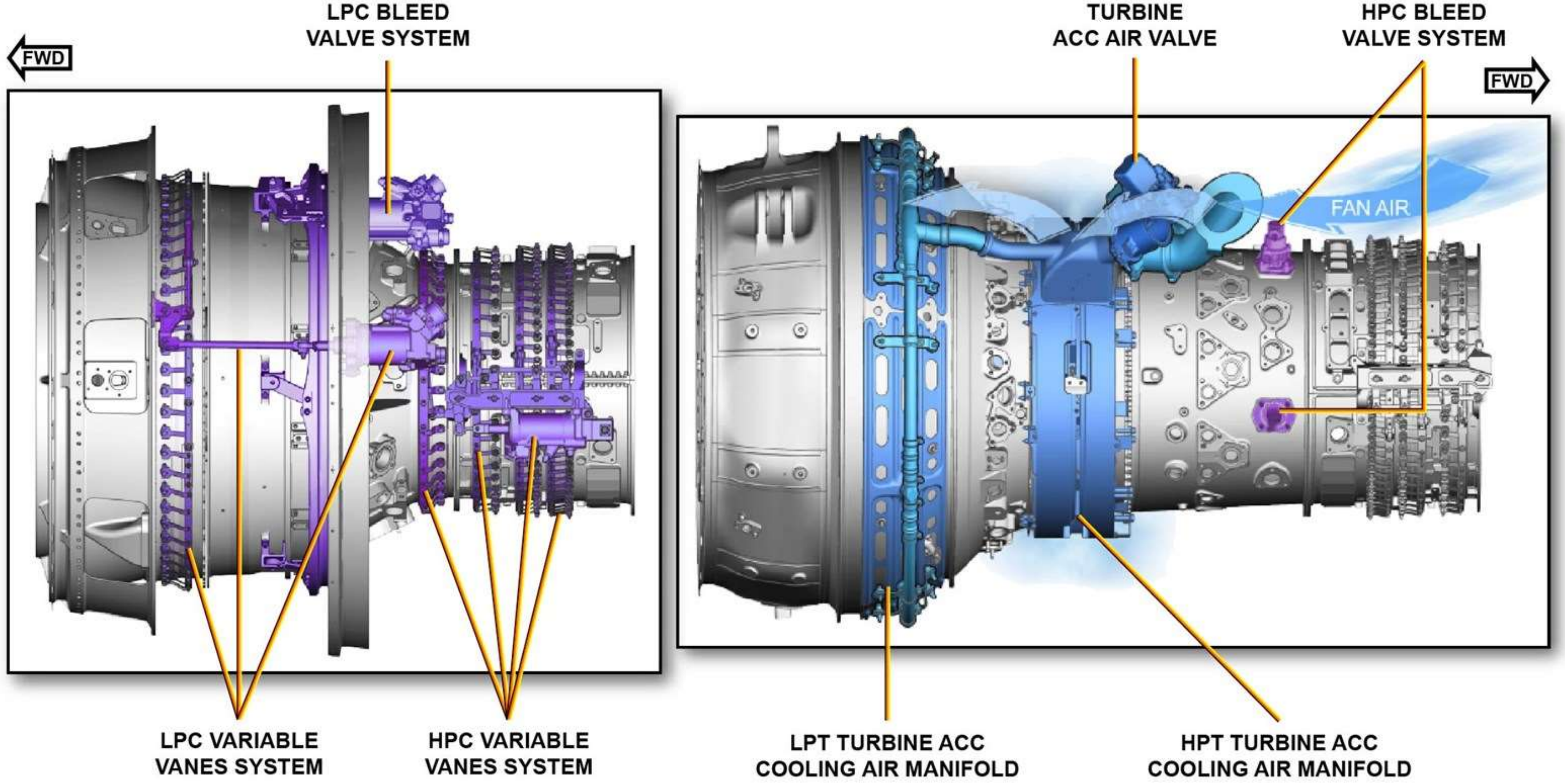
FUEL DISTRIBUTION SYSTEM (RIGHT SIDE)



AIR

- Compressor control
- Turbine case cooling

The next picture shows the compressor airflow control and the turbine case cooling systems.

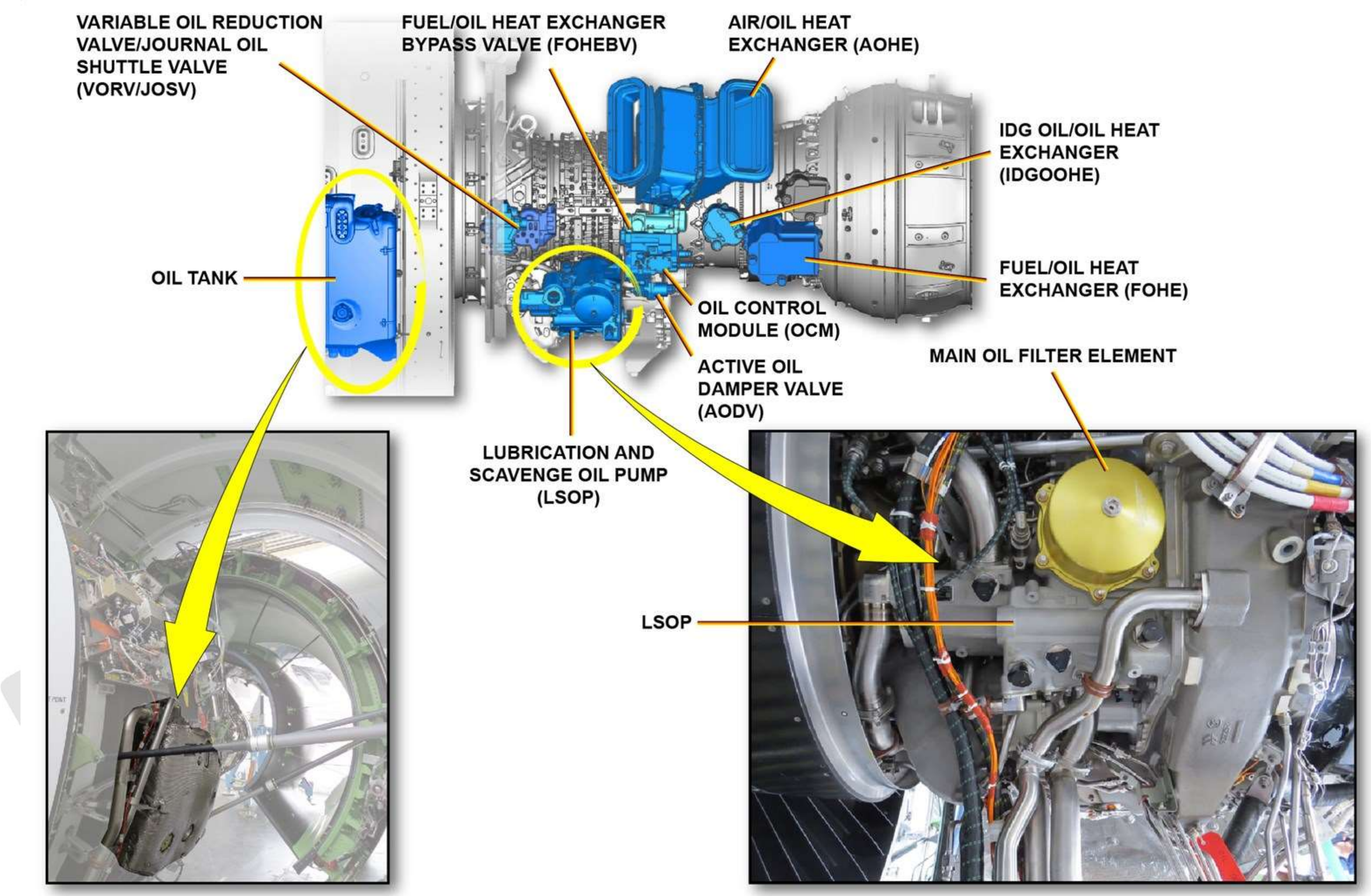


ACC: Active Case Cooling
HPC: High Pressure Compressor
HPT: High Pressure Turbine
LPC: Low Pressure Compressor
LPT: Low Pressure Turbine

OIL

• Oil tank, LSOP and filter

The engine oil tank is attached with frangible mounts to the fan case on the left hand side of the engine at the 9 o'clock position.
The Lubrication and Scavenge Oil Pump (LSOP) is attached to the rear of the main gearbox at the 7 o'clock position.



THRUST REVERSER

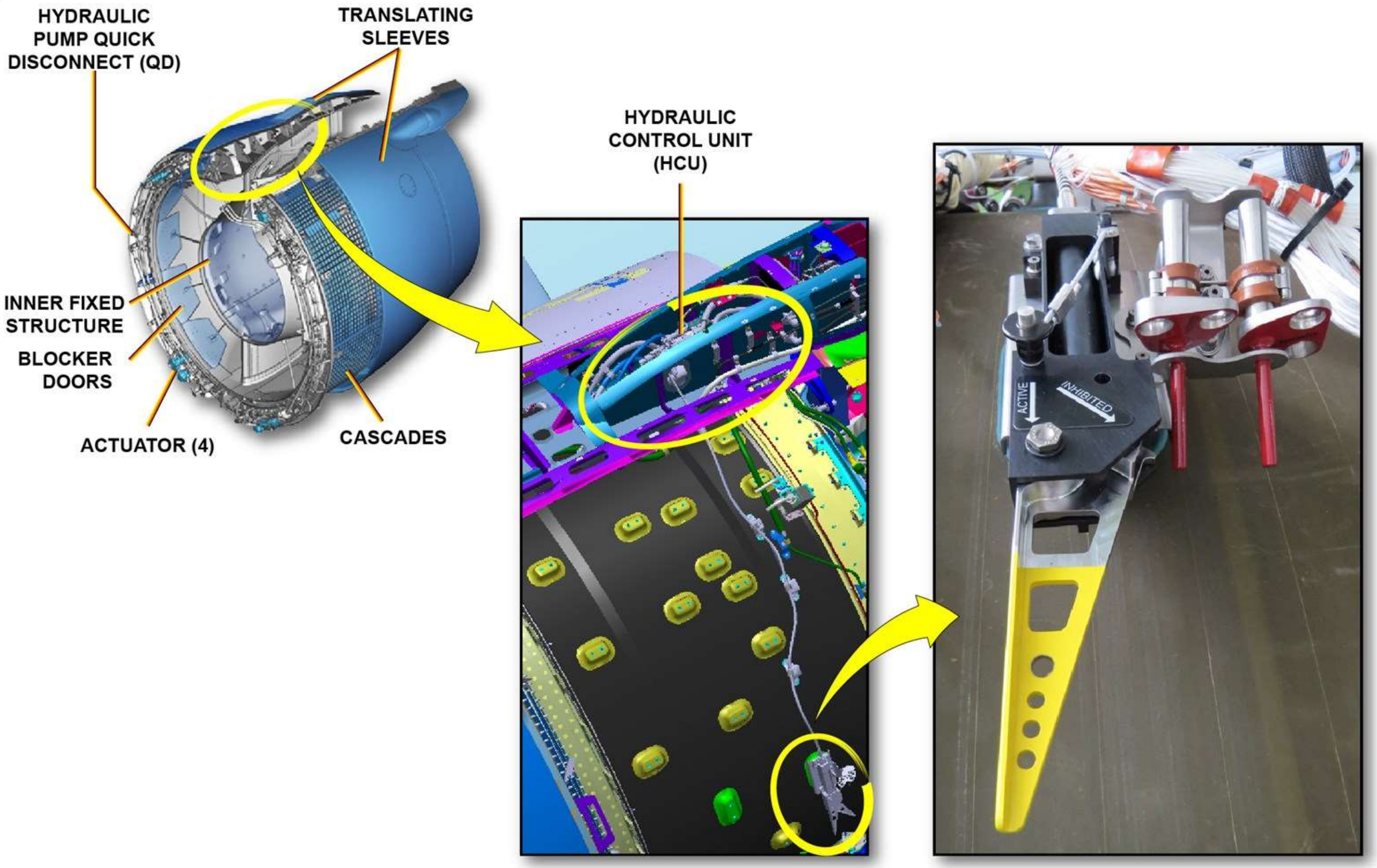
• Translating sleeves

•HCU installed in the front lower part of the pylon

Two translating sleeves are hydraulically operated. The Hydraulic Control Unit (HCU) is installed on the pylon.

On the A320NEO PW1100G, the HCU is made of an Isolation Control Unit (ICU) and a Directional Control Unit (DCU) attached together.

Reverser inhibition is possible via a remote lever.



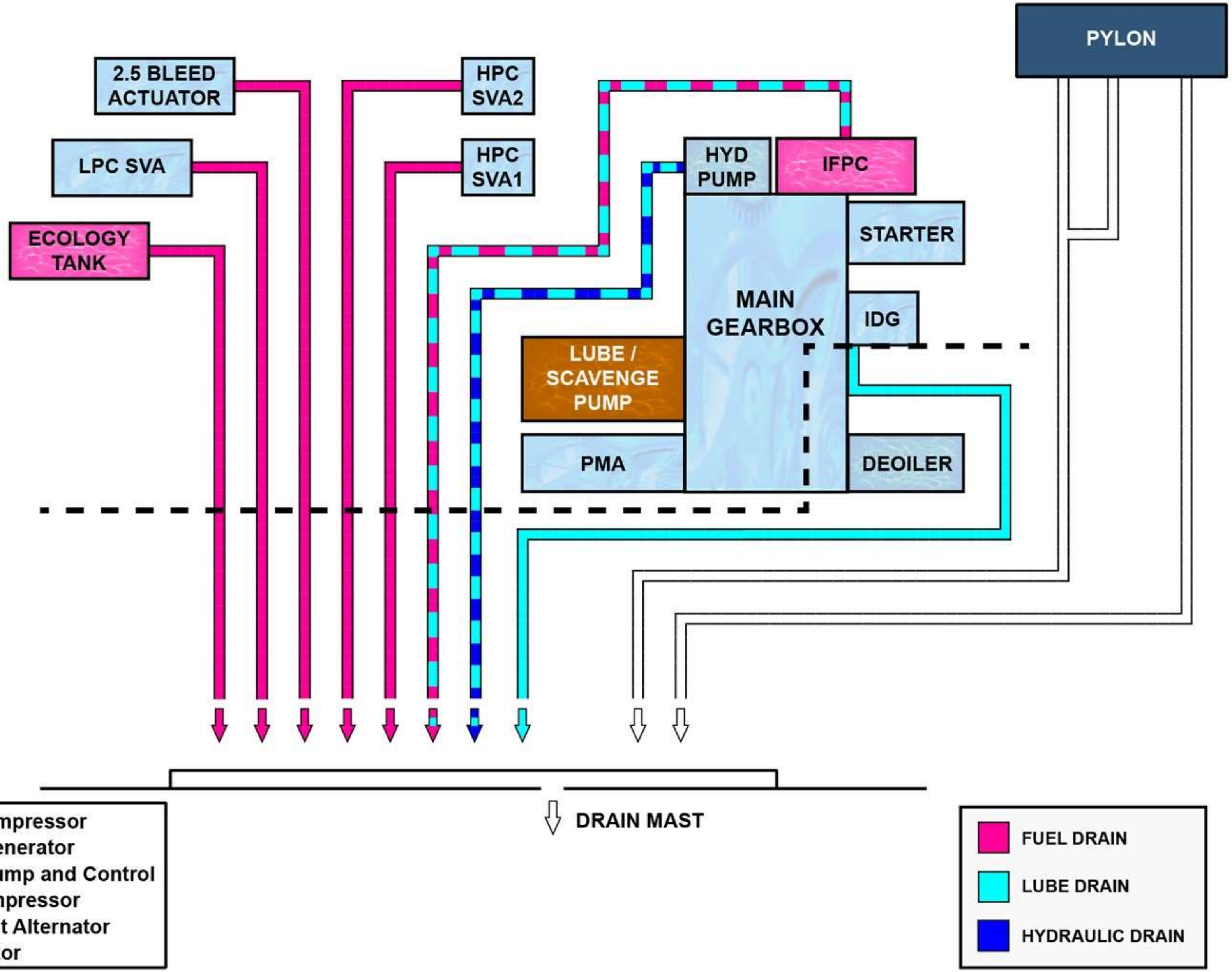
INHIBITION REMOTE LEVER

Power Plant Drain Presentation

PYLON & ENGINE DRAINS

•Fluids from engine and pylon exit through a drain mast
•10 drain tubes

The fluids from the engine and pylon exit the nacelle through a drain mast.
The drains system provides a controlled leak path exit to the 6 o'clock position of the nacelle for hydraulic, oil and fuel systems.
The drains system is comprised of the upper pylon drains hoses, lower drains through the nacelle bifurcation and the scupper drains assembly attached to the fan case providing drainage for the oil reservoir.
At the lower bifurcation, lateral, core and aft support for the 10 drains tubes is provided through the mid-clamp support attached to the Nacelle Anti-Icing (NAI) flag and through the latch beam seal interface.

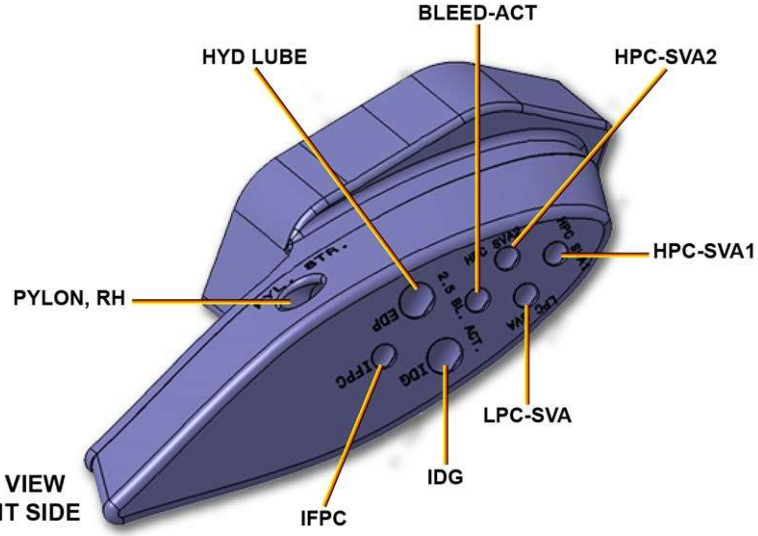


HPC: High Pressure Compressor
IDG: Integrated Drive Generator
IFPC: Integrated Fuel Pump and Control
LPC: Low Pressure Compressor
PMA: Permanent Magnet Alternator
SVA: Stator Vane Actuator

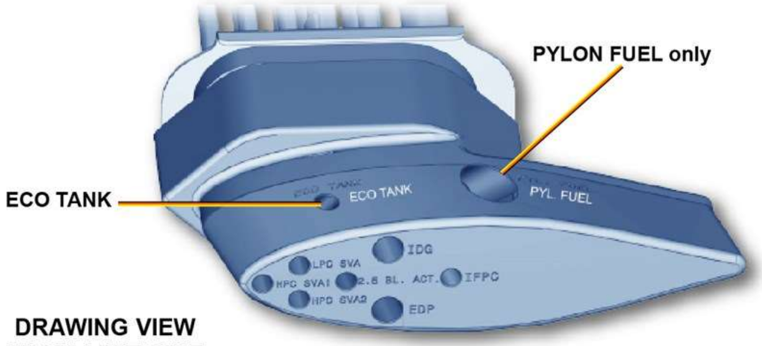
DRAIN MAST

• 6 O'clock position: aerodynamic drain mast for inspection of drain tubes

At the 6 o'clock position an aerodynamic drain mast protrudes below the nacelle surface. The drain mast also has exit holes on the sides and bottom surface which are identified to enable trouble shooting of the leaking components.



DRAWING VIEW FROM RIGHT SIDE



DRAWING VIEW FROM LEFT SIDE

HPC-SVA: High Pressure Compressor - Stator Vane Actuator
IDG: Integrated Drive Generator
IFPC: Integrated Fuel Pump and Control

Power Plant Installation Description and Operation

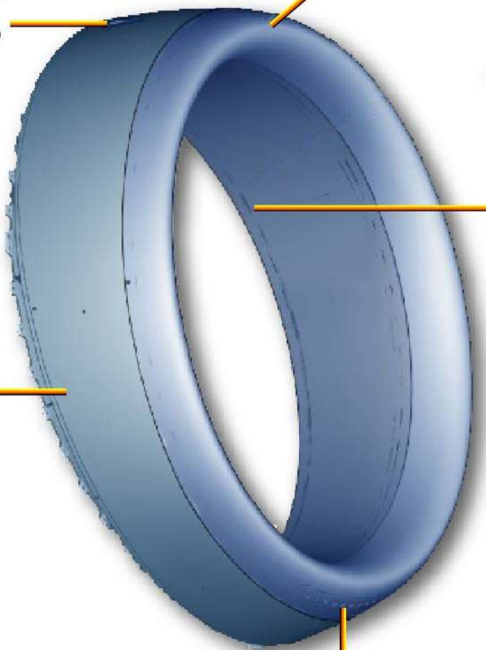
INLET COWL

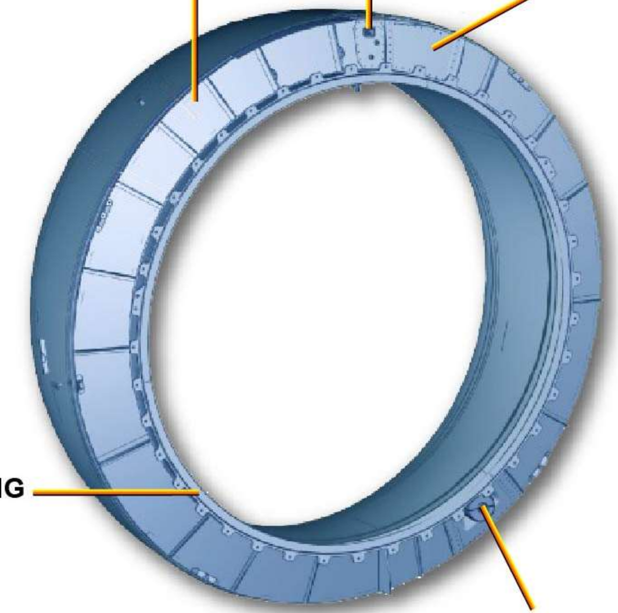
•Inlet cowl components:

- Acoustical inner barrel, outer barrel, forward bulkhead, aft bulkhead and nose lip

The inlet cowl is composed of an inner barrel, outer barrel, forward bulkhead, aft bulkhead and a nose lip.
The inner barrel has acoustic liners for noise suppression. It also accommodates the T2 probe.
The outer barrel has a small flush inlet vent scoop located at 12 o' clock position to provide ram air for fan compartment cooling.
It also has Nacelle Anti Ice Exhaust Ports at the 6 o' clock position.
The inner and outer barrels are made of composite material.
The forward and aft bulkhead provides support and rigidity to the structure.
The inlet lip is made of a single piece aluminium alloy for engine anti-ice purpose.
• Nacelle has installation for interphone jack
It includes installation of interphone jack for service interphone.

• Inlet cowl is attached to the engine at the attach ring
For removal and installation, the inlet cowl is attached to the engine at the attach ring with 40 bolts.


INLET LIP
FAN COMPARTMENT INLET VENT SCOOP
INNER BARREL
OUTER BARREL
THERMAL ANTI-ICE DUCT VENT


FAN COMPARTMENT COOLING VENT
AFT BULKHEAD
T2 ACCESS PANEL
ATTACH RING
THERMAL ANTI-ICE (TAI) DUCT

AIR INTAKE FUNCTIONS

• Main function:

- Guide the airflow into the engine

The main function of the inlet cowl is to guide the airflow into the engine inlet and to permit an aerodynamic airflow over the outer surface of the engine.

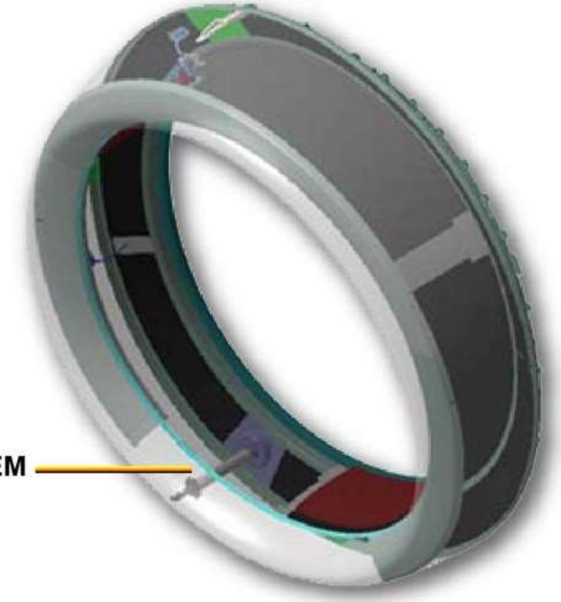
• Ice protection:

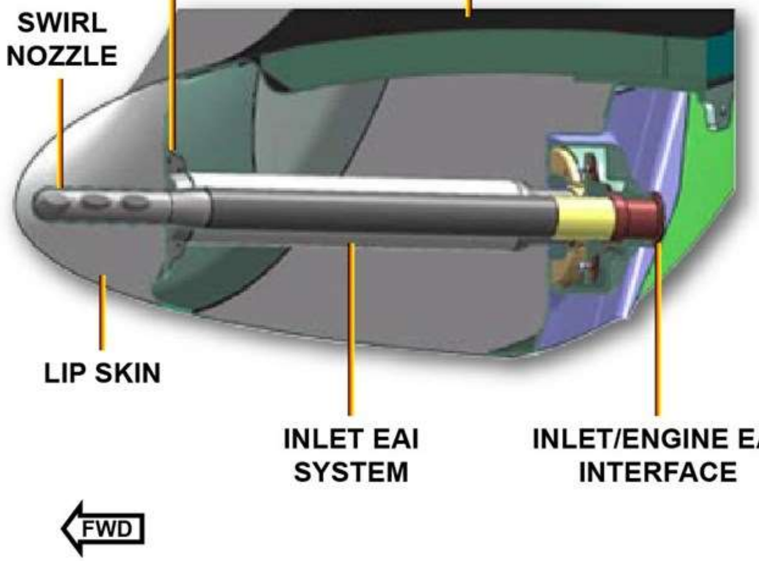
- Hot bleed air prevents ice build-up

When the engine anti icing is selected to ON from the cockpit overhead panel, hot bleed air from the engine is ducted to the cowl nose lip to prevent ice build-up. The hot air enters to the inlet lip through a dedicated duct at the 4 o' clock position in the outer bulkhead. The air then exhausts overboard through a flush exit ports at the 6 o' clock position in the outer barrel.

• Lightning protection system incorporated

The outer barrel has an impregnated copper screen layer for protection against lightning strike.


NAI SYSTEM


NOZZLE/BULKHEAD
FWD JOINT
INNER BARREL
SWIRL
NOZZLE
LIP SKIN
INLET EAI
SYSTEM
INLET/ENGINE EAI
INTERFACE
FWD

FAN COWL DOORS

• Two fan cowl doors to contain the fan case

There are two fan cowl doors to enclose the fan case and provide aerodynamic smoothness around the engine.

• 3 hinges support each door at the pylon

•3 latches latch the door assembly along the bottom centerline

•Mounting mechanism and visual indicators on three latches ensure that they are properly closed and secured

They are attached to the pylon by three hinges with hinge pins.

The door assembly is latched along the bottom centerline by three latches. These latches have a mounting mechanism and visual indicators to ensure that they are properly secured.

Proximity sensors are installed on each latch which sends its position signal to the Engine Interface Unit (EIU) for generating necessary warning.

• Door components

The door can be opened manually. Each door is provided with 2 telescopic hold open rods, for opening.

The fan cowl door rests on 4 axial locators, when closed.

It also has hoist points, for removal and installation.

Aerodynamic strakes are mounted on the fan cowls to improve aircraft performance during manoeuvres.

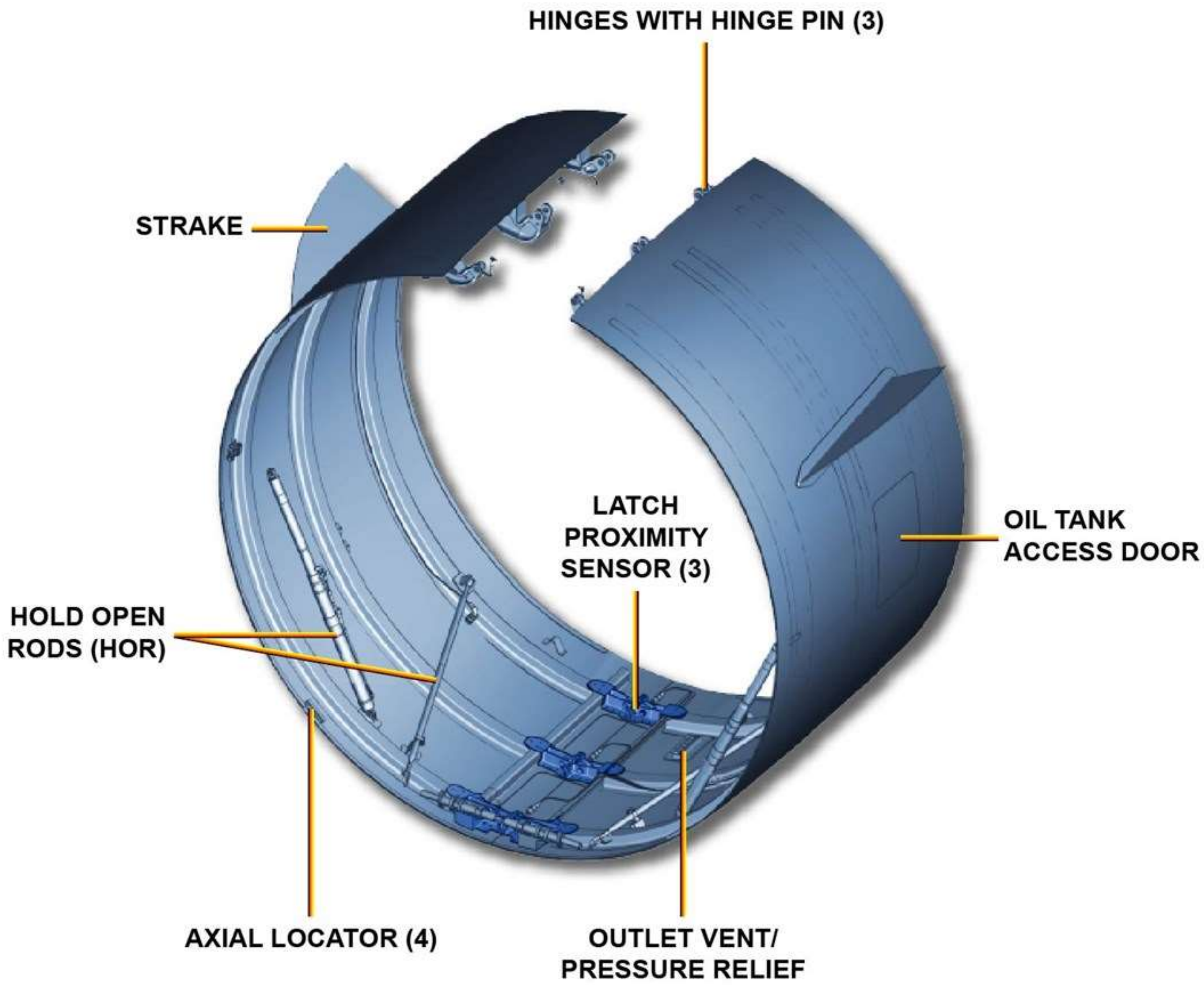
• Access door on LH fan cowl door for engine oil servicing and thrust reverser HCU de-activation

Access doors on the LH side fan cowl door facilitates engine oil servicing and the Thrust reverser Hydraulic Control Unit (HCU) de-activation without opening the fan cowl.

• Vent/Drain port

A vent grill near the 6 o' clock position permits the air to escape out in case of damage of the anti-ice duct. The same is used for draining any fluids in and around the fan case.


PW1100G-JM

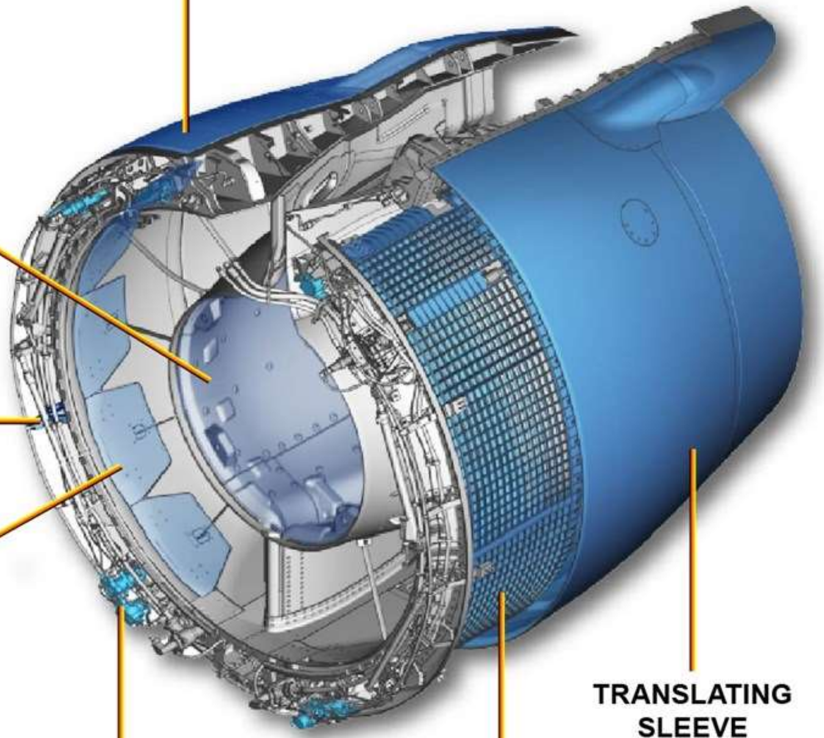

HINGES WITH HINGE PIN (3)
STRAKE
LATCH PROXIMITY SENSOR (3)
OIL TANK ACCESS DOOR
HOLD OPEN RODS (HOR)
AXIAL LOCATOR (4)
OUTLET VENT/ PRESSURE RELIEF

THRUST REVERSER COWL DOORS

•Thrust reverser cowl doors are in two halves and include translating sleeves, actuators, blocker doors and cascades
•C ducts enclose engine core components and gear boxes
The thrust reverser cowl doors (or "C" Ducts) are in two halves. Each half includes one translating sleeves, two actuators, five blockers doors and cascades.
The thrust reverser cowls provide a smooth air flow around the engine area and enclose the engine core components, gear boxes and pipelines.

•Supported by 3 hinges at the pylon
•Assembly latched along the bottom centerline by 7 latches
Each half is supported by 3 hinges at the pylon. The assembly is latched along the bottom centerline by seven latches.

• Each half has hoist points, opening actuator for maintenance, removal / installation purposes
Each half is provided with:
- Hoist points to install a handling sling for removal and installation,
- 1 opening actuator operated externally using a hydraulic hand pump for opening the thrust reverser cowl for maintenance
- 1 hold open rod mounted on the fan case for opening.


TRANSLATING SLEEVE
(RIGHT HAND)
INNER FIXED STRUCTURE
HYDRAULIC PUMP QUICK
DISCONNECT (QD)
BLOCKER DOORS
ACTUATOR (4)
CASCADES
TRANSLATING
SLEEVE
(LEFT HAND)

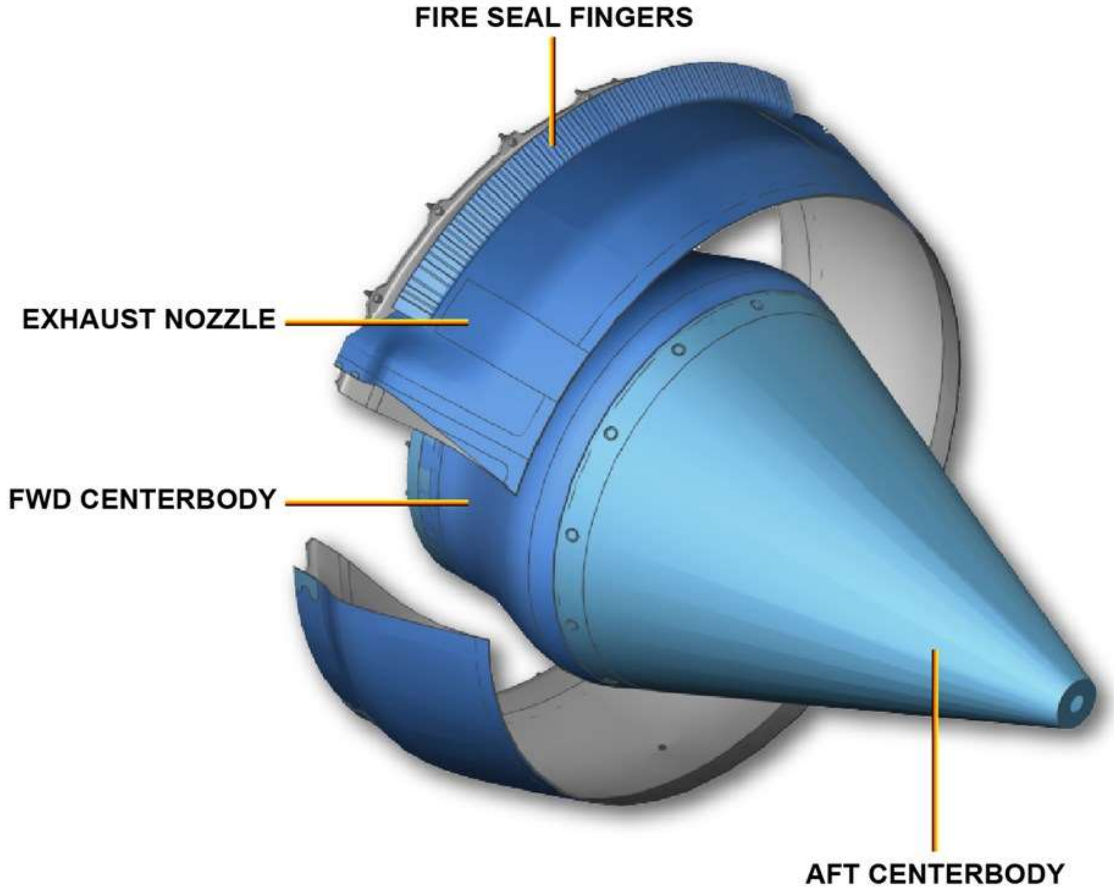
EXHAUST NOZZLE

• The exhaust nozzle is formed by the center bodies and nozzle assembly
•Fire seal fingers on the top of exhaust nozzle prevents flame from entering core compartment
•It accommodates the drain outlet to expel hazardous fluids and vapors

The exhaust nozzle is formed by the center bodies and nozzle assembly. The annular passage between the exhaust nozzles and the centerbodies provide a smooth exit of the exhaust gas flow.

The fire seal fingers (turkey feathers) at the top of the exhaust nozzle prevents any flame from entering the core compartment area in the event of fire.

The centerbody also accommodates the drain outlet to expel hazardous fluids and vapors. These drains are located at the 6 o' clock position on the forward and aft center bodies.


FIRE SEAL FINGERS
EXHAUST NOZZLE
FWD CENTERBODY
AFT CENTERBODY

ENGINE MOUNTS

• Engine mounted on pylon by forward and aft mounts

The engine is mounted to the pylon by the forward and aft mounts. They transfer the engine and thrust loads.

• Forward mount assembly bears engine thrust, vertical and lateral loads
•It is attached to the engine at Compressor Intermediate Case
•It is attached to the pylon by four bolts

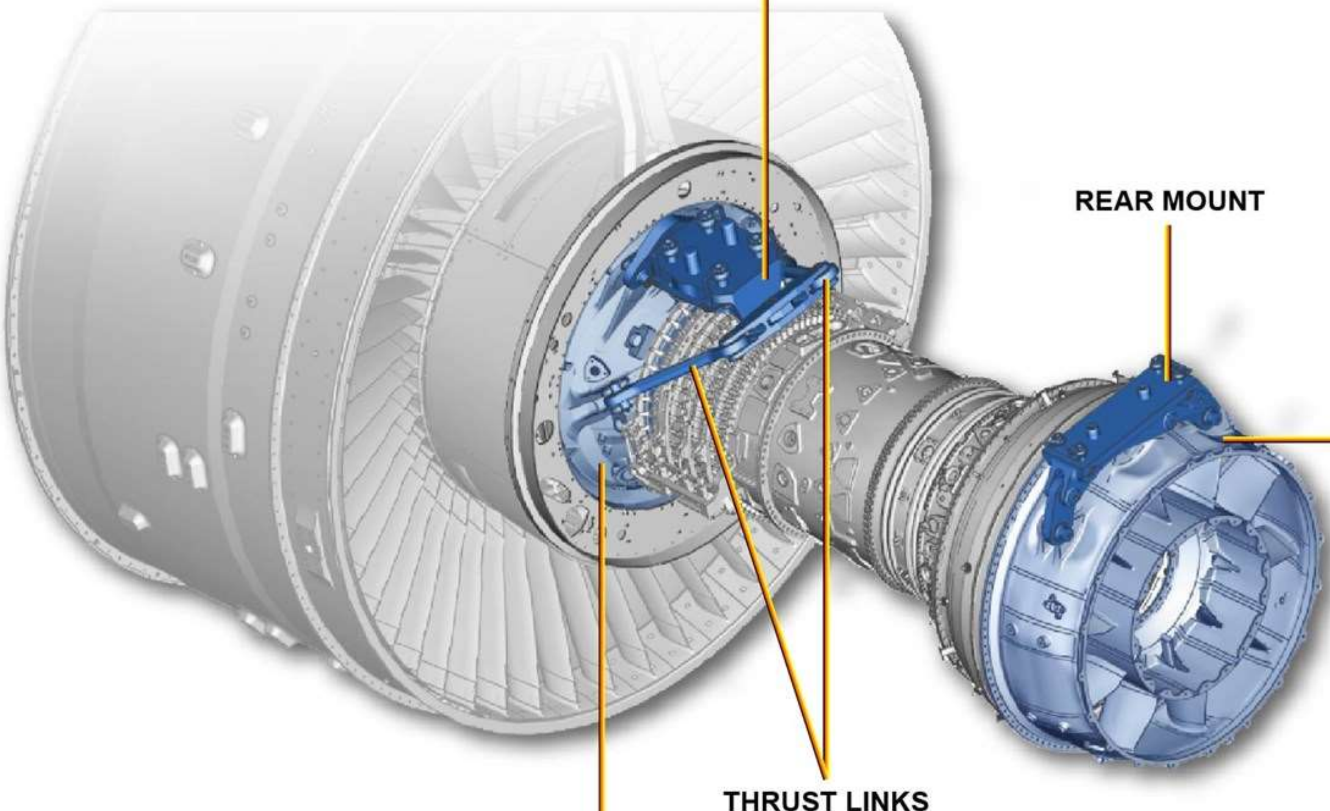
The forward mount assembly bears the engine thrust, vertical and lateral loads. The forward mount is attached to the engine at the Compressor Intermediate Case at 12 o' clock position. The forward mount is attached to the pylon by the help of four attachment bolts.

• The thrust link assemblies attached to the forward mount take the lateral loads

The thrust link assemblies attached to the forward mount take the lateral loads. They are attached to the forward mount through a balance beam. They are attached to the Compressor Intermediate Case at 09:30 and 02:30 position.

• Aft mount assembly takes the vertical and radial loads
•It is attached to the engine at the Turbine Exhaust Case (TEC)
•It is attached to the pylon by four bolts

The aft mount assembly bears the engine vertical and radial loads. It is attached to the engine at the Turbine Exhaust Case (TEC) at 12 o' clock position. It is attached to the pylon by four bolts.


FORWARD MOUNT
REAR MOUNT
TURBINE EXHAUST CASE (TEC)
THRUST LINKS
COMPRESSOR INTERMEDIATE CASE (CIC)

Engine System Description and Operation

ENGINE CHARACTERISTICS

• A319, A320 and A321 Aircraft fitted with two PW1100G-JM turbofan engines
•Thrust between 22000 lbs (10000 kg) and 33000 lbs (14900 kg) depending on DSU
The Airbus A319, A320 and A321 aircrafts are powered by two PW1100G-JM turbofan engines.
This engine can produce a thrust from 22000 lbs (10000 kg) to 33000 lbs (14900 kg) depending on the aircraft version set by the Data Storage Unit (DSU) which is connected to the Electronic Engine Control (EEC).

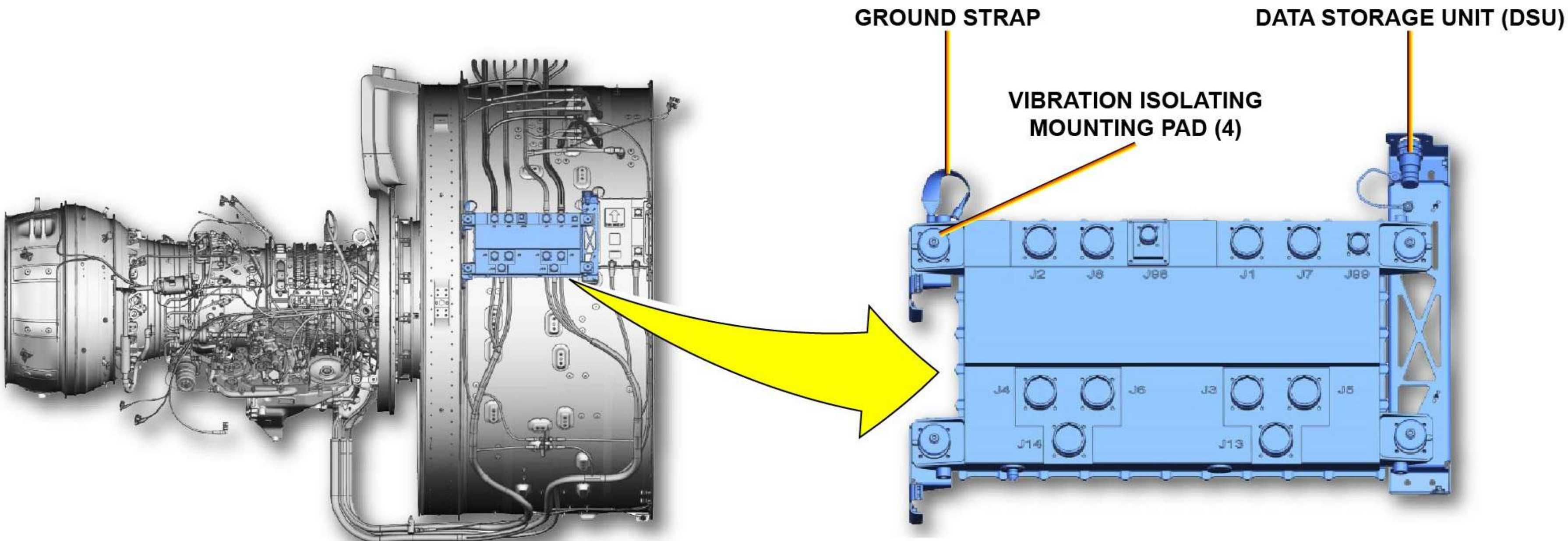
• Ultra high bypass engine with FDGS
•Bypass ratio of 12:1
The PW1100G-JM is a twin spool Ultra high bypass turbofan engine with the Fan Drive Gear System (FDGS) which enables the fan and the Booster Compressor to rotate at different speed thus improving engine efficiency.
The bypass ratio of this engine is 12:1.

ENGINE CONTROL

• FADEC provides:
  - Engine control and monitoring (consisting of EEC with two independent channels, sensors, actuators)
  - Help for trouble shooting and maintenance

The engine includes a Full Authority Digital Engine Control (FADEC) system consisting of the EEC with two independent channels, sensors, actuators and other peripheral components on the engine. The FADEC system provides engine control, engine monitoring and help for maintenance and trouble shooting.

A/C	A/C model	ENG model	TakeOff Thrust
A319	A319-171	PW1121G-JM	21.5 Klbs
A319	A319-172	PW1122G-JM	22.9 Klbs
A319	A319-173	PW1127G-JM	26.8 Klbs
A320	A320-271	PW1127G-JM	26.8 Klbs
A320	A320-272	PW1124G-JM	24 Klbs
A321	A321-271	PW1133G-JM	32.7 Klbs
A321	1321-272	PW1130G-JM	29.7 Klbs



ENGINE MODULES

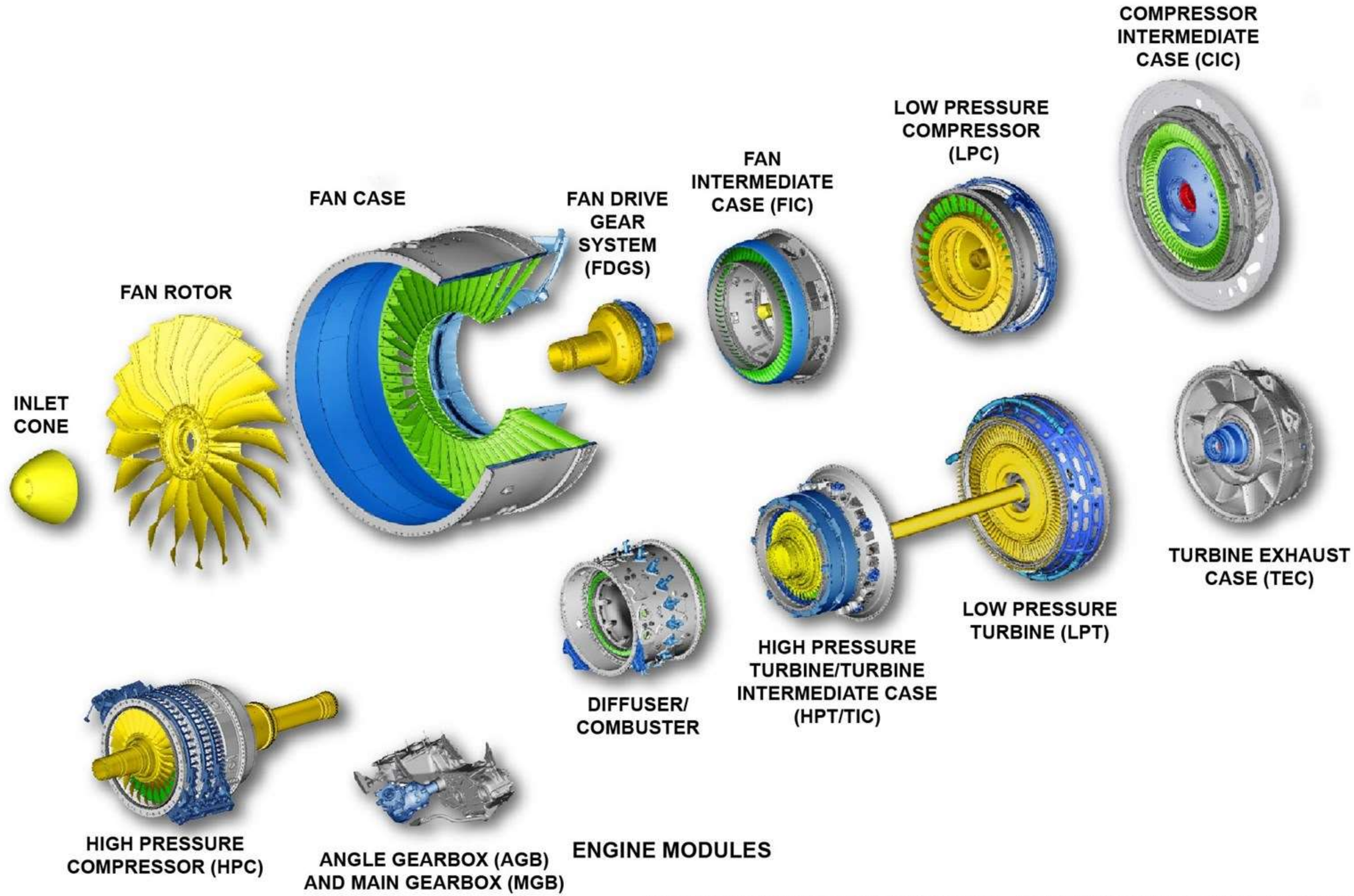
•Single stage fan rotor, 3 stage LP Compressor, 8 stage HP Compressor, 2 stage HP turbine and 3 stage LP turbine

•Modular concept

The engine rotor comprises of a single stage fan rotor, 3 stage LP Compressor, 8 stage HP Compressor, 2 stage HP turbine and 3 stage LP turbine. The engine is built on a modular concept.

The different modules are:

- Fan rotor,
- Fan case,
- FDGS,
- Fan Intermediate Case (FIC),
- Low Pressure Compressor (LPC),
- Compressor Intermediate Case (CIC),
- High Pressure Compressor (HPC),
- Diffuser and combustor,
- High Pressure Turbine (HPT),
- Turbine Intermediate Case (TIC),
- Low Pressure Turbine (LPT),
- Turbine Exhaust Case (TEC),
- Angle and Main Gear boxes.

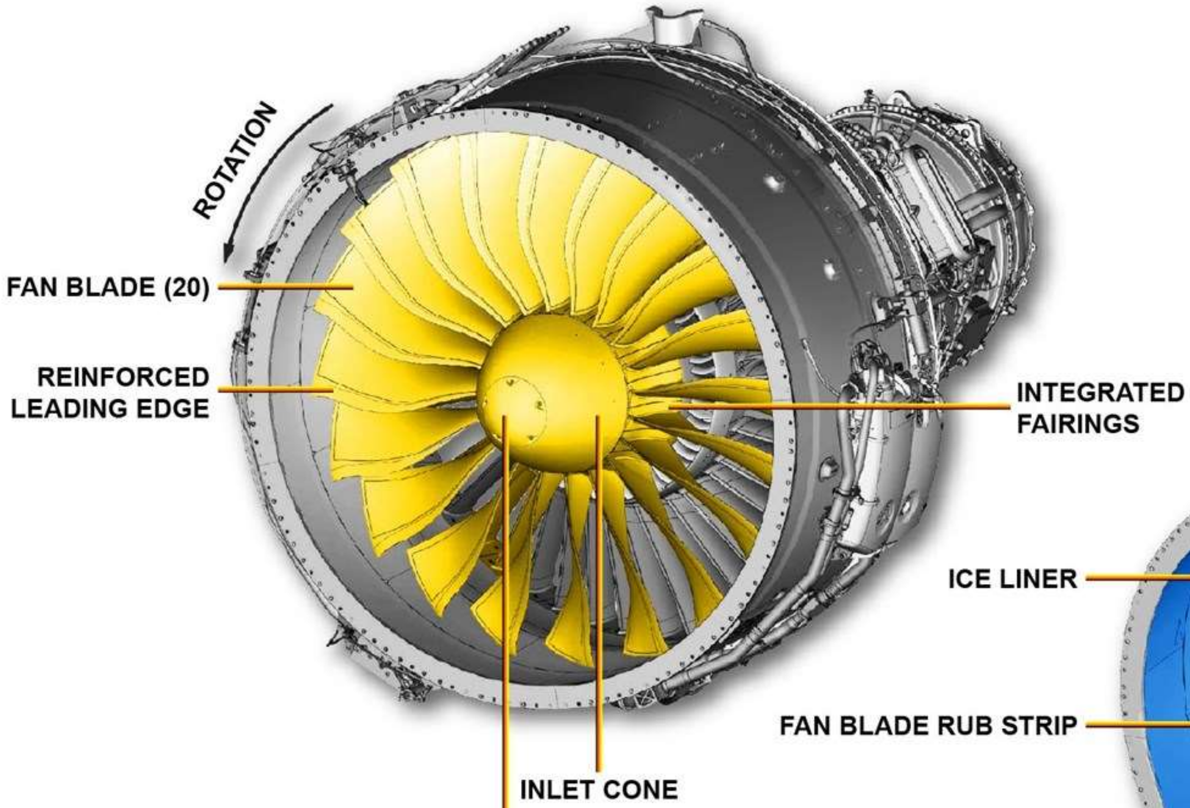


ENGINE MODULES

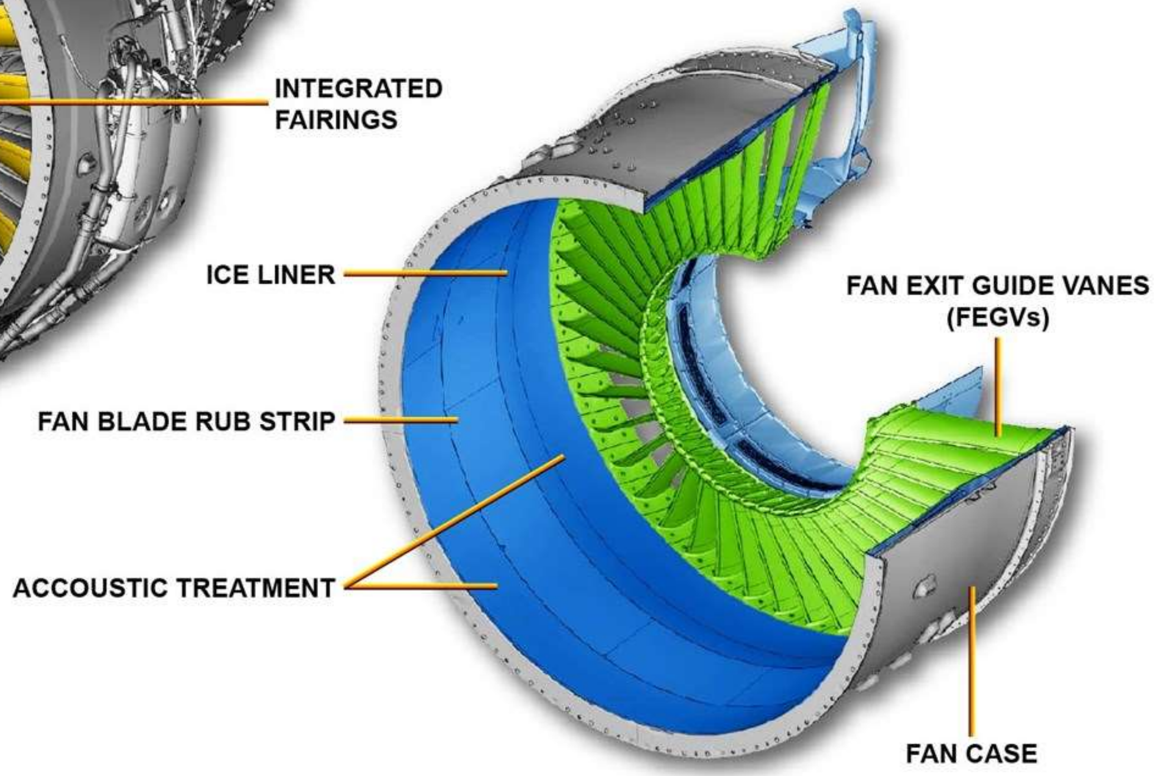
FAN ROTOR AND FAN CASE

• The fan rotor contributes to 90% of the thrust
•It comprises of fan drive shaft, inlet cone and 20 wide chord fan blades
•The inlet cone forward of the fan blades is anti-iced using compressor bleed air
The Fan rotor contributes to approximately 90% of the thrust.
The fan rotor comprises of the fan drive shaft, inlet cone and 20 wide chord fan blades. The fan blades are made of aluminium alloy honeycomb structure and reinforced by Titanium leading edges.
The fan rotational speeds being lower helps in reducing rotational loads and bird strike fan damage.
The fan rotates in a clockwise direction as viewed from the aft looking forward.
The inlet cone is made of composite material and is anti-iced with a continuous airflow from of the 2.5 compressor stage.

• The fan case provides the passage for the bypass air flow
•It comprises 48 FEGV's
•It is made of composite material (Kevlar) and has acoustic liners, ice liners and rubbing strips
The fan case provides an annular path for the bypass air flow.
The case is made of single piece composite material (Kevlar). It holds the outer edge of the Fan Exit Guide Vanes (FEGV).
The inner walls behind the fan blade area are provided with acoustic liners for noise reduction.
A rubberized strip along the fan blade area helps in minimizing the gap and prevents contact between the blades and the case.



FAN ROTOR

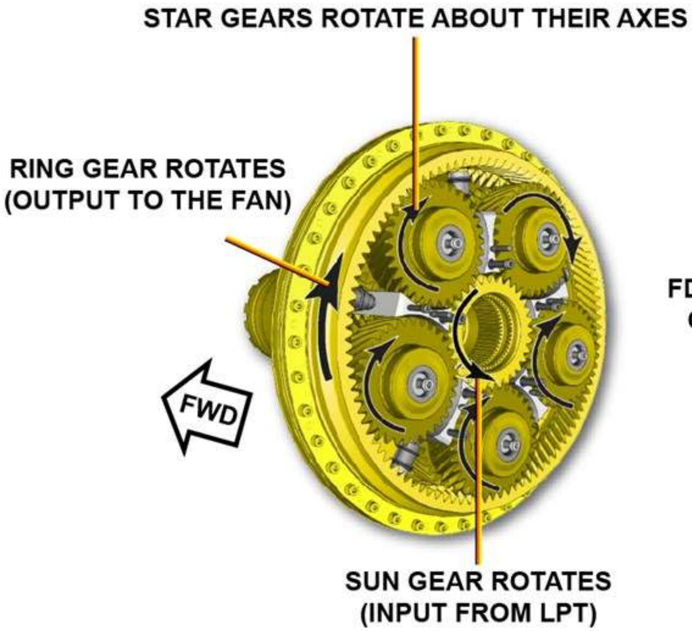


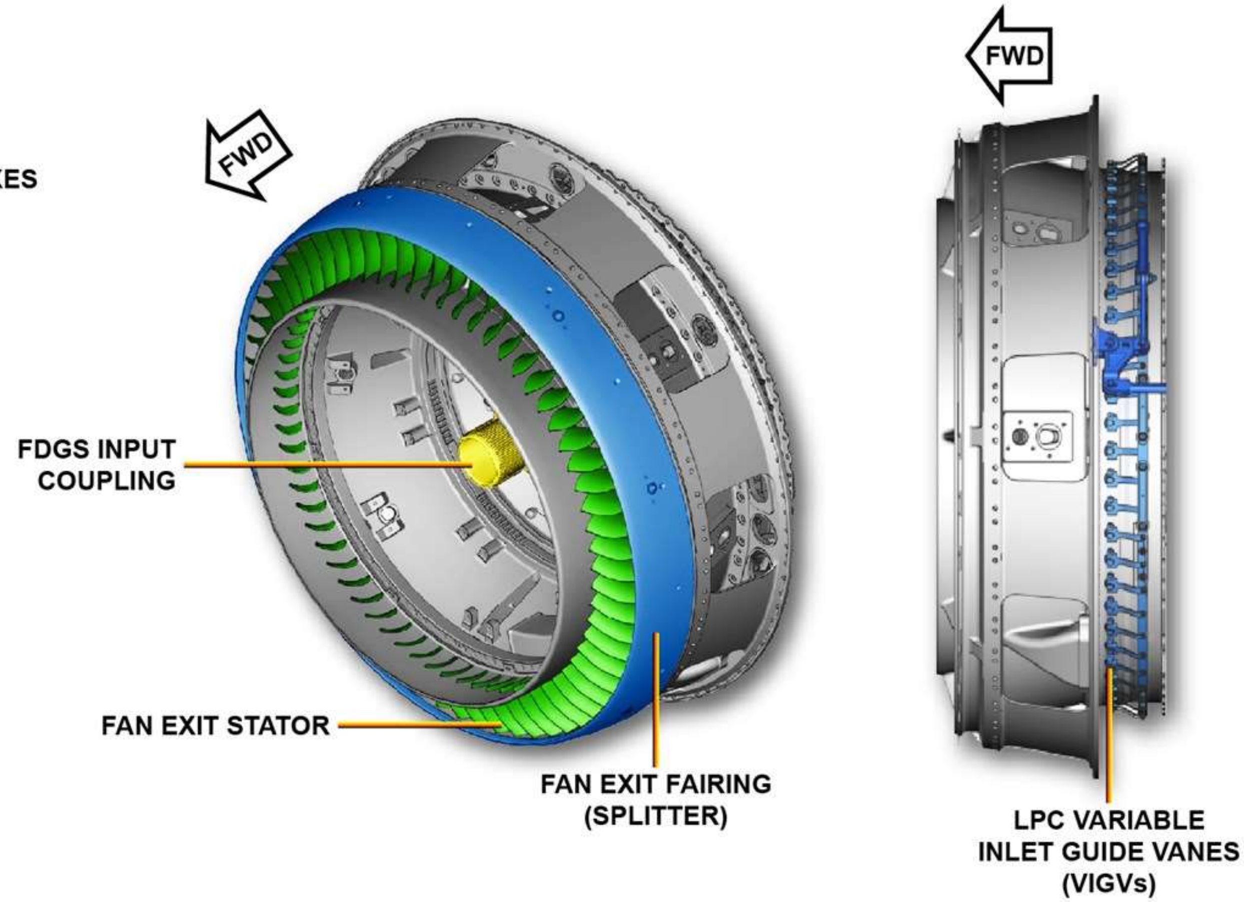
FAN CASE ASSEMBLY

FAN DRIVE GEAR SYSTEM (FDGS) AND FAN INTERMEDIATE CASE

• FDGS allows the fan and the LPC to rotate at different speeds
•FDGS is a reduction gear mechanism which helps in improving the engine efficiency
The FDGS allows the fan to be driven by the LP shaft at a lower speed.
The FDGS is a reduction gear mechanism which comprises of a central sun gear and five planetary gears arranged like a star.
It helps in reducing the fan rotating speed and permits the LPC to rotate at a higher speed. This helps in improving engine performance and efficiency.
The ratio of the LPC speed: fan speed is approximately 3:1.
The LPC rotates in the opposite direction of the fan rotor.

• The FIC supports the FDGS and the bearings No.1, 1.5 and 2
•It supports the inner edge of the fan exit stators and support fairings
•It has a single stage VIGVs controlled by EEC to direct the air to the LPC at the correct angle
The FIC supports the FDGS and the bearings No. 1, 1.5 and 2.
It also supports the inner edge of the Fan Exit Guide Vanes (FEGVs) and the support fairings.
It houses a single stage Variable Inlet Guide Vanes (VIGVs) which direct the air to the LP Compressor at the correct angle.
The VIGV's are controlled by the EEC.





FAN DRIVE GEAR SYSTEM

FAN INTERMEDIATE CASE

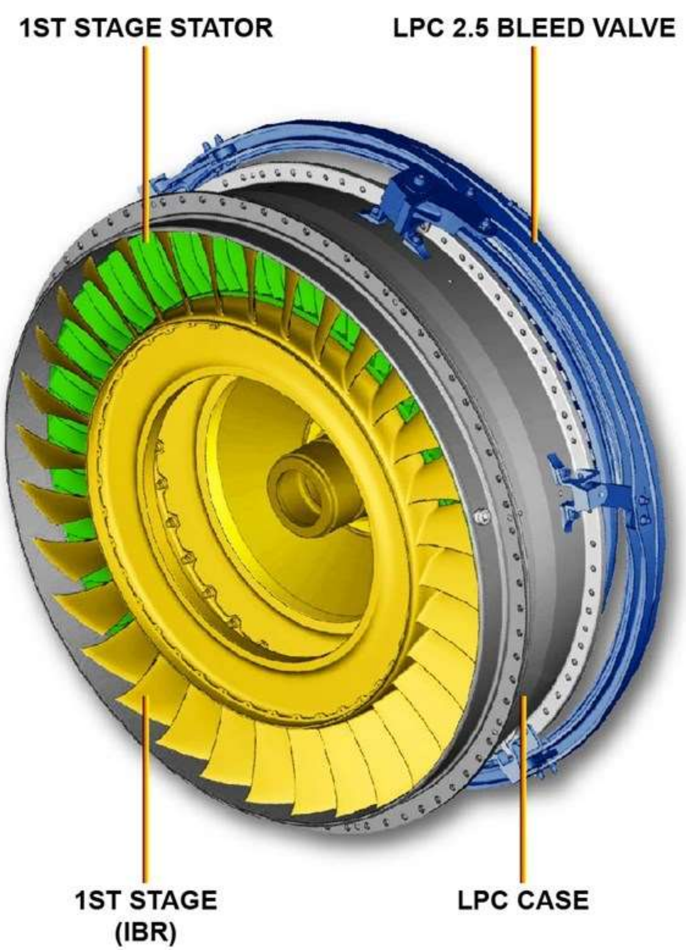
LOW PRESSURE COMPRESSOR AND COMPRESSOR INTERMEDIATE CASE

• The LPC comprises of 3 stages of axial flow compressor with integrally bladed rotor, stators and the LPC case
•It is connected to the FDGS to the front and the LP turbine shaft splines at the rear
•It rotates counter clockwise viewed from the rear
•It houses the 2.5 stage bleed valve at the rear which releases the air during engine operation

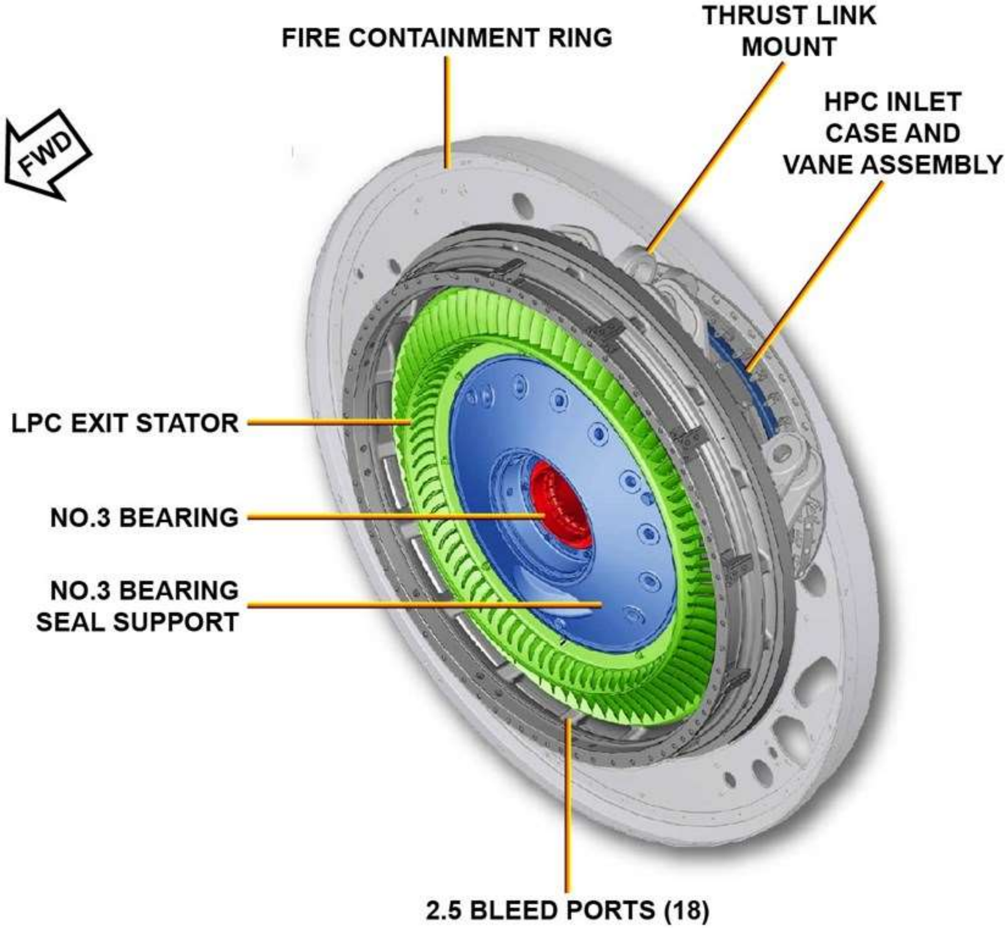
The LPC comprises of 3 stages of axial flow compressor with integrally bladed rotor, stators and the case.
It is connected to the FDGS to the front and the LP turbine shaft splines at the rear.
It rotates counter clockwise viewed from the rear.
It acts as a super charger to pressurize the air before it enters into the HPC.
It houses the 2.5 stage bleed valve at the rear which releases the air during engine operation to prevent surge and stall conditions.

• The forward engine mounts are mounted on the CIC
•It supports bearing No. 3 and provides ports for 2.5 stage bleed to join the fan air flow

The forward engine mounts are mounted on the CIC.
The CIC transmits the engine core airflow from the LPC to the HPC.
It supports the bearing No.3 and also provides the ports for the 2.5 stage bleed air flow to join the fan air flow.



LOW PRESSURE COMPRESSOR

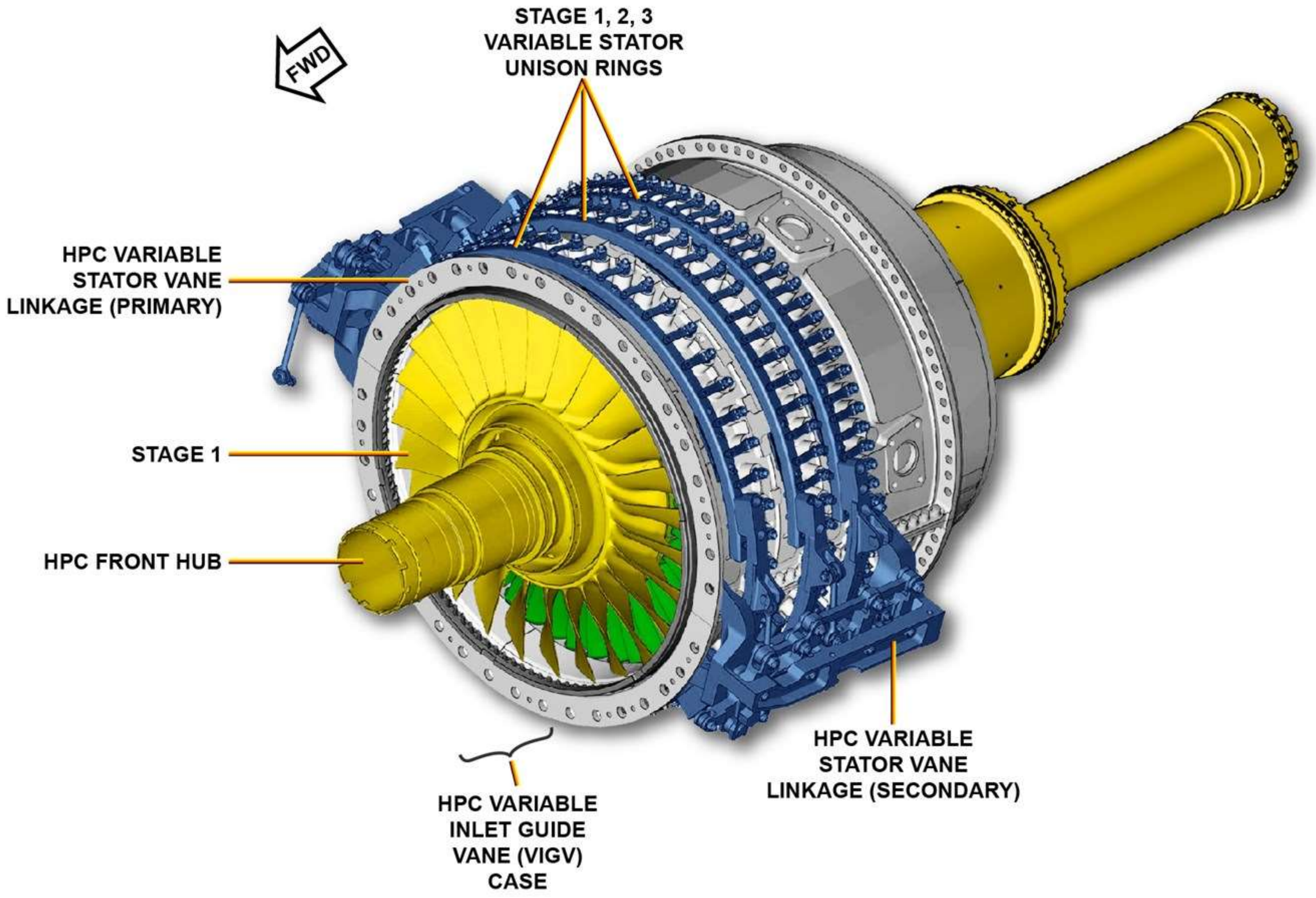


COMPRESSOR INTERMEDIATE CASE

HIGH PRESSURE COMPRESSOR ROTOR

• HPC comprises of 8 stages axial flow compressor and the shaft which are driven by the HP turbine
•A single stage of VIGV and the first three stages of VSVs of the HPC stators ensure a smooth entry of air to the HPC
•The VIGVs and VSV stator vanes are operated by the primary and secondary actuators controlled by the EEC
•HP Stage 3 and stage 8 bleed air pick-up

The HPC comprises of eight stages axial flow compressor and the shaft which are driven by the HP turbine.
A single stage of Variable Inlet Guide Vane (VIGV) and the first three stages of Variable Stator Vanes (VSVs) of the HPC stators ensure a smooth entry of air to the HPC. Each stage of the variable stators is connected by the unison rings.
The VIGVs and VSV stator vanes are operated by the primary and secondary actuators controlled by the EEC.
The HP Compressor supplies air from Stage 3 and stage 8 to the aircraft systems.



HIGH PRESSURE COMPRESSOR

DIFFUSER AND COMBUSTION CHAMBER ASSEMBLY

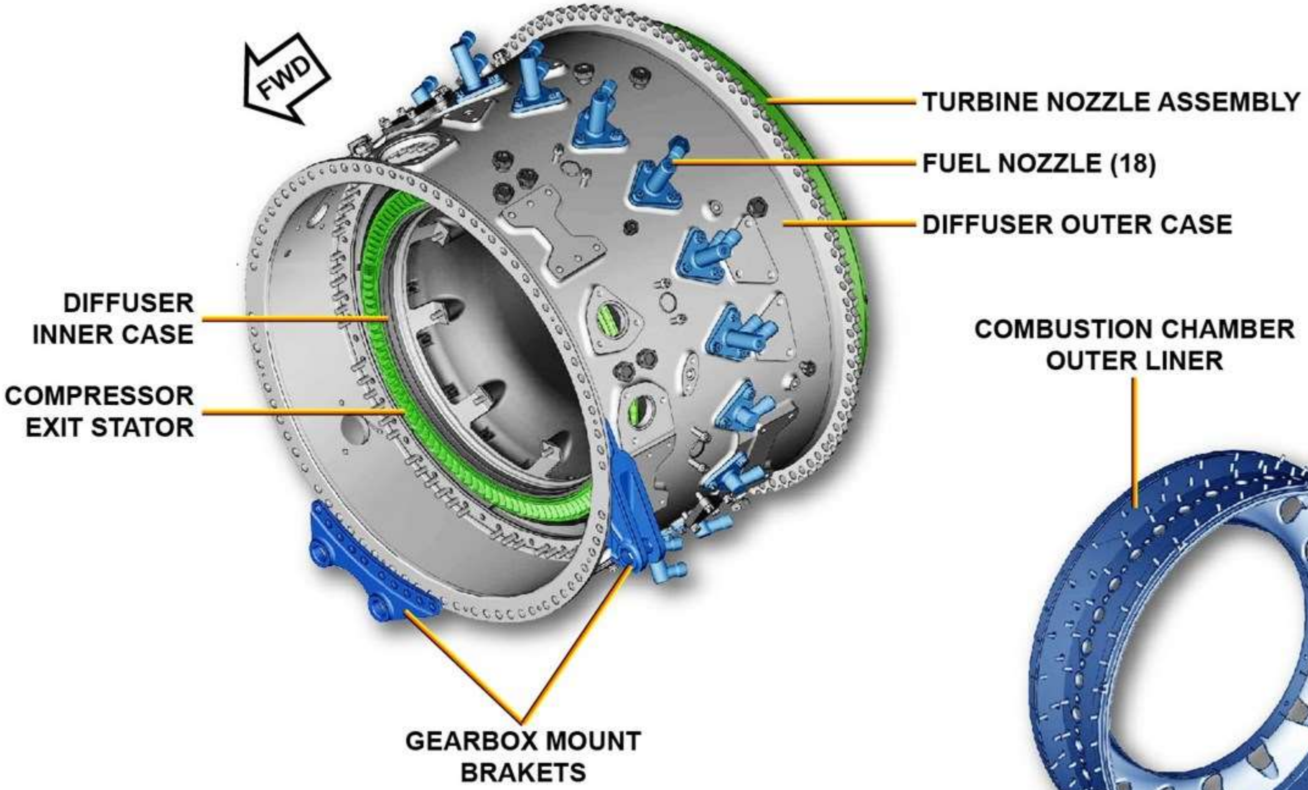
- Assy with diffuser, annular combustion chamber and turbine nozzle assembly; provides the brackets for mounting the MGB
- The annular combustion chamber houses 18 fuel nozzles (6 Simplex and 12 Duplex) and 2 igniter plugs
- The new technology, high efficiency design of the combustion chamber helps in reducing CO2 and NOx emissions

The unit houses the diffuser, the annular combustion chamber and the turbine nozzle assembly. It also provides the brackets for mounting the Main Gear Box (MGB).

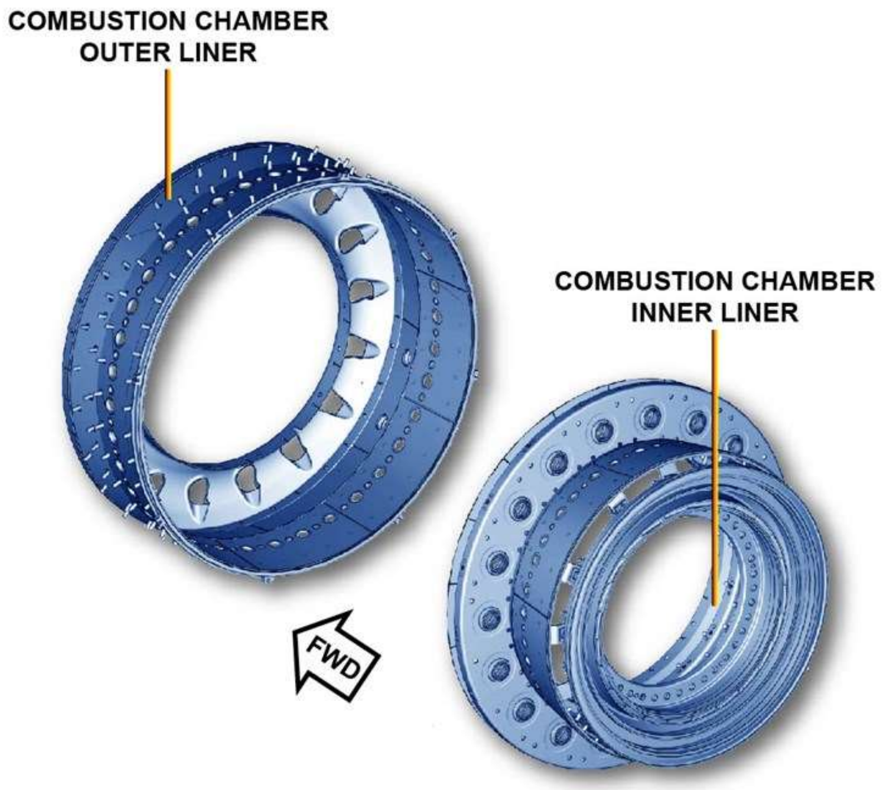
The diffuser converts the kinetic energy of the air coming out of the HPC into pressure energy before it is fed into the combustion chamber.

The annular combustion chamber houses 18 fuel nozzles (6 Simplex and 12 Duplex) and 2 igniter plugs and supports effective combustion of the air/fuel mixture.

The new technology high efficiency design of the combustion chamber also helps in reducing CO2 and NOx emissions.



DIFFUSER



COMBUSTION CHAMBER

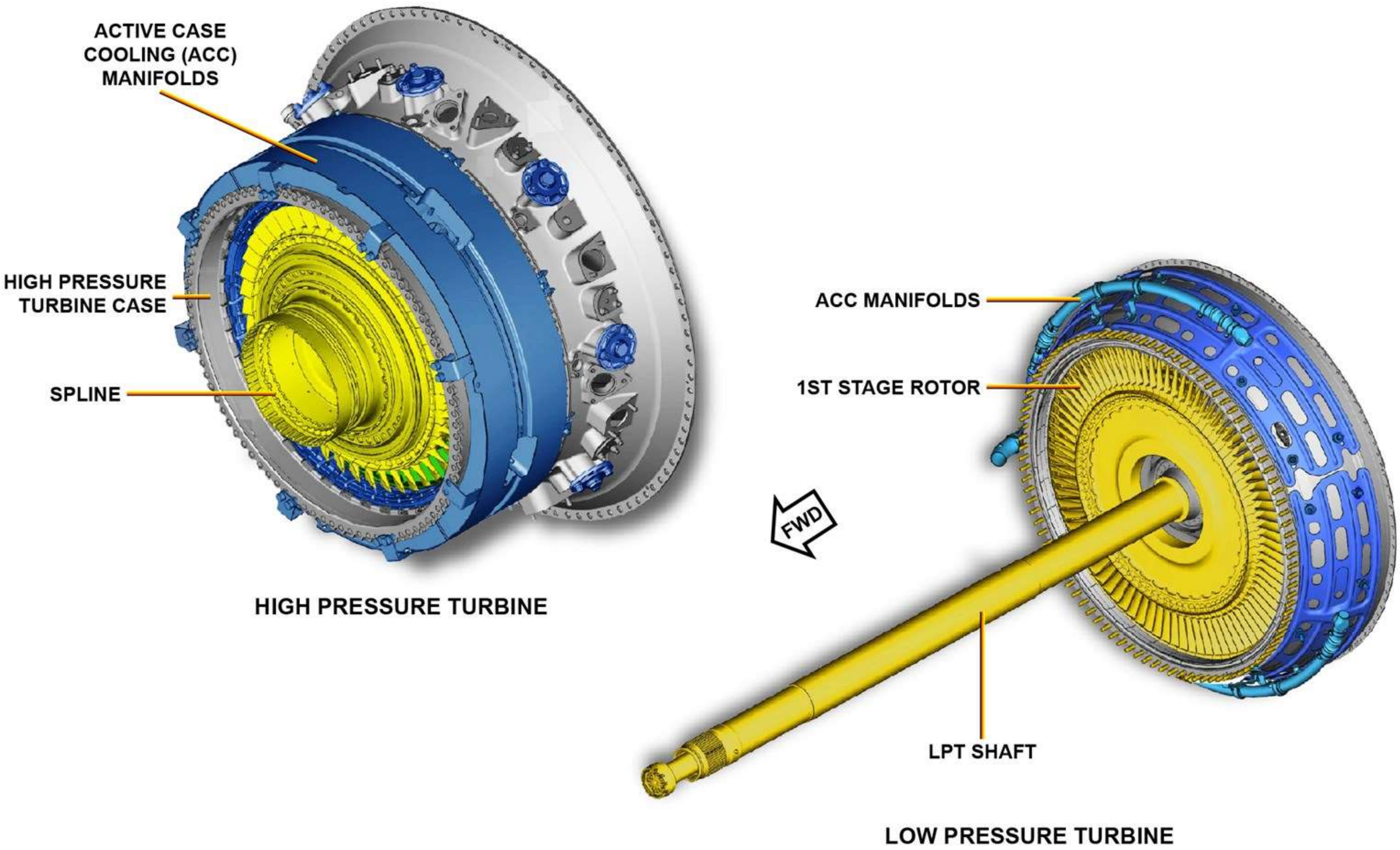
HIGH PRESSURE AND LOW PRESSURE TURBINES

• 2 stage axial flow HP Turbine
•HP Turbine drives the HP Compressor
•TIC - No 4 Bearing

The HP Turbine is made of two stage axial flow turbine, two stage stator and turbine case.
The HP turbine unit has splines which attaches it to the HP Compressor shaft.
HP Turbine drives the HP Compressor.
Integrated in the HPT assembly is the TIC which directs the HP Turbine airflow to align with the LP Turbine. It supports the n�4 bearing.

• 3 stage LPT
•LPT drives the LPC and the FDGS
•Turbine cases ACC cooling manifolds for blade tip clearance

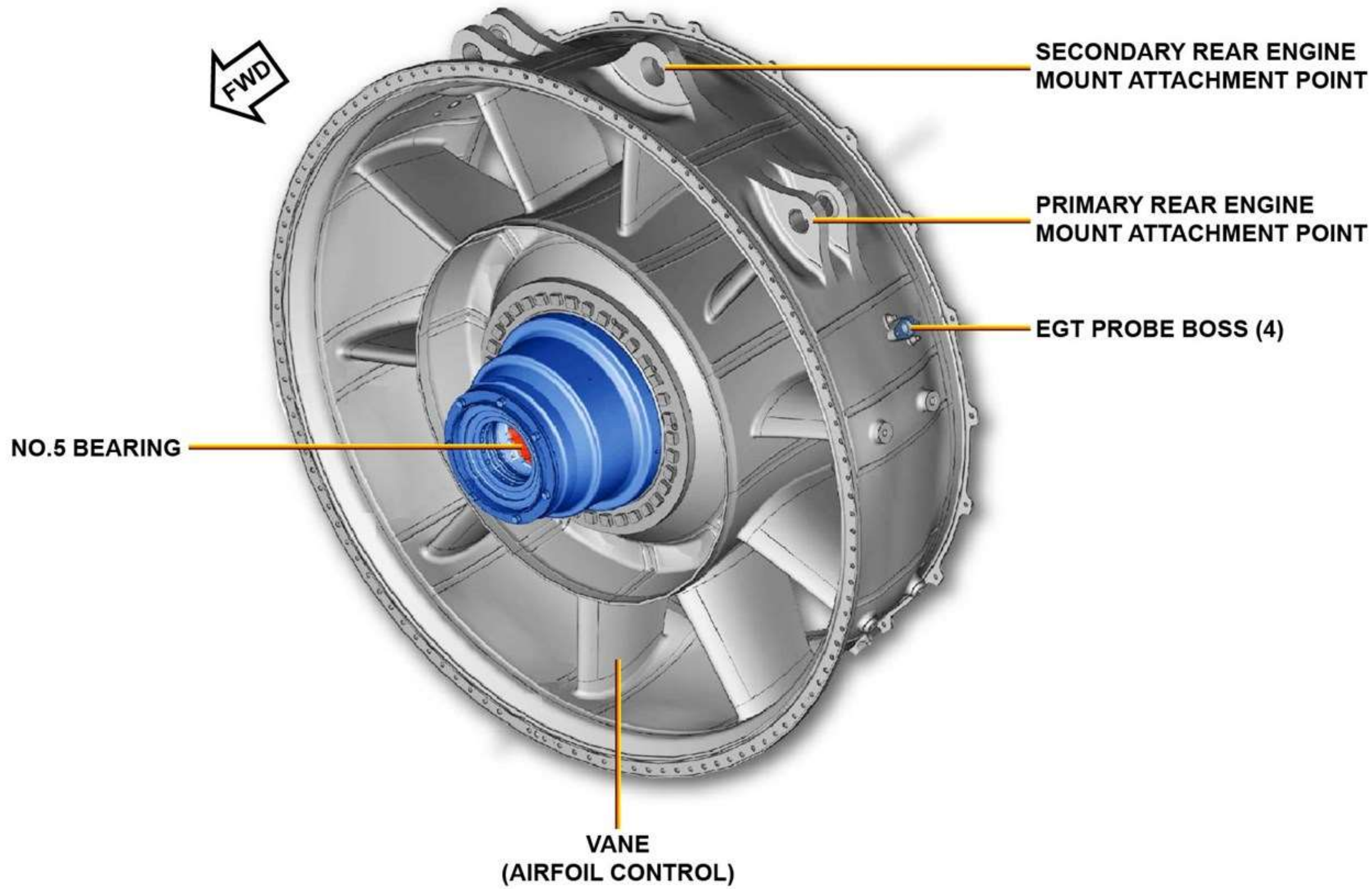
The LP Turbine module comprises of three stage rotor assembly, LP rotor shaft, stators and the turbine case.
It drives the LP Compressor and the FDGS.
The HP and LP turbine cases have Active Case Cooling (ACC) cooling manifolds around to control blade tip clearance.


ACTIVE CASE COOLING (ACC) MANIFOLDS
HIGH PRESSURE TURBINE CASE
SPLINE
HIGH PRESSURE TURBINE
FWD
ACC MANIFOLDS
1ST STAGE ROTOR
LPT SHAFT
LOW PRESSURE TURBINE

TURBINE EXHAUST CASE

- It supports the rear roller bearings 5 and 6
- Attachment point for the rear engine mount
- 4 EGT thermocouples

The TEC permits an exit path for the gas flow coming out of the turbines.
It supports the rear roller bearings 5 and 6.
The TEC provides the attachment point for the rear engine mount.
It houses four Exhaust Gas Turbine (EGT) thermocouples.



TURBINE EXHAUST CASE

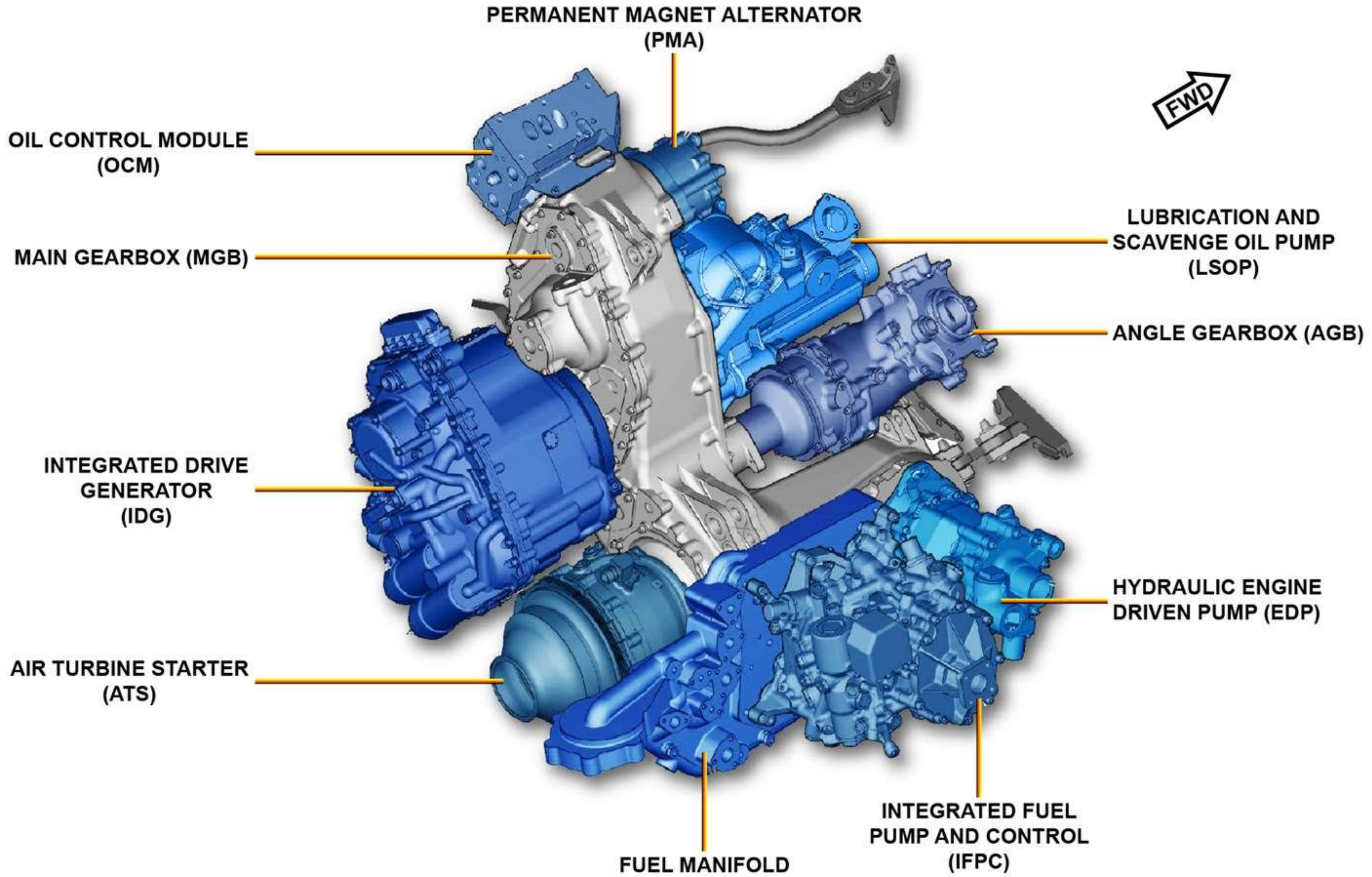
ENGINE GEAR BOX

• EGB comprises of two units: MGB and the AGB
•MGB is attached to the core engine
•It provides the drive to the hydraulic pump, Fuel Pump, IDG, PMA and de-oiler
•A crank pad to turn the HP rotor is located on the RH front side of the MGB, underneath the EDP
•The Air Starter mounted on the right side aft of the MGB
•During engine start the drive is transmitted through the MGB and AGB to drive the HPC

The Engine Gear Box (EGB) comprises of two units: the MGB and the Angle Gear Box (AGB).
MGB is attached to the core engine at 4:00 and 9:00.
It provides the drive to the hydraulic pump, Fuel Pump, Integrated Drive Generator (IDG), Permanent Magnet Alternator (PMA) and de-oiler.
A crank pad to turn the HP rotor is located on the RH front side of the MGB, underneath the Engine Driven Pump (EDP).
The Air Starter is mounted on the right side aft of the MGB. During engine start the drive is transmitted through the MGB and AGB to drive the HP Compressor.

• AGB is located 6:00 forward of the MGB
•The AGB is connected to the HP rotor by bevel gears and the tower shaft

The AGB is located forward of the MGB in the core engine area.
The MGB is connected to the AGB through a lay shaft.
The AGB is connected to the HP rotor by bevel gears and the tower shaft.



MAIN GEARBOX WITH ACCESSORIES

AERODYNAMIC STATIONS AND BOROSCOPIC PORTS

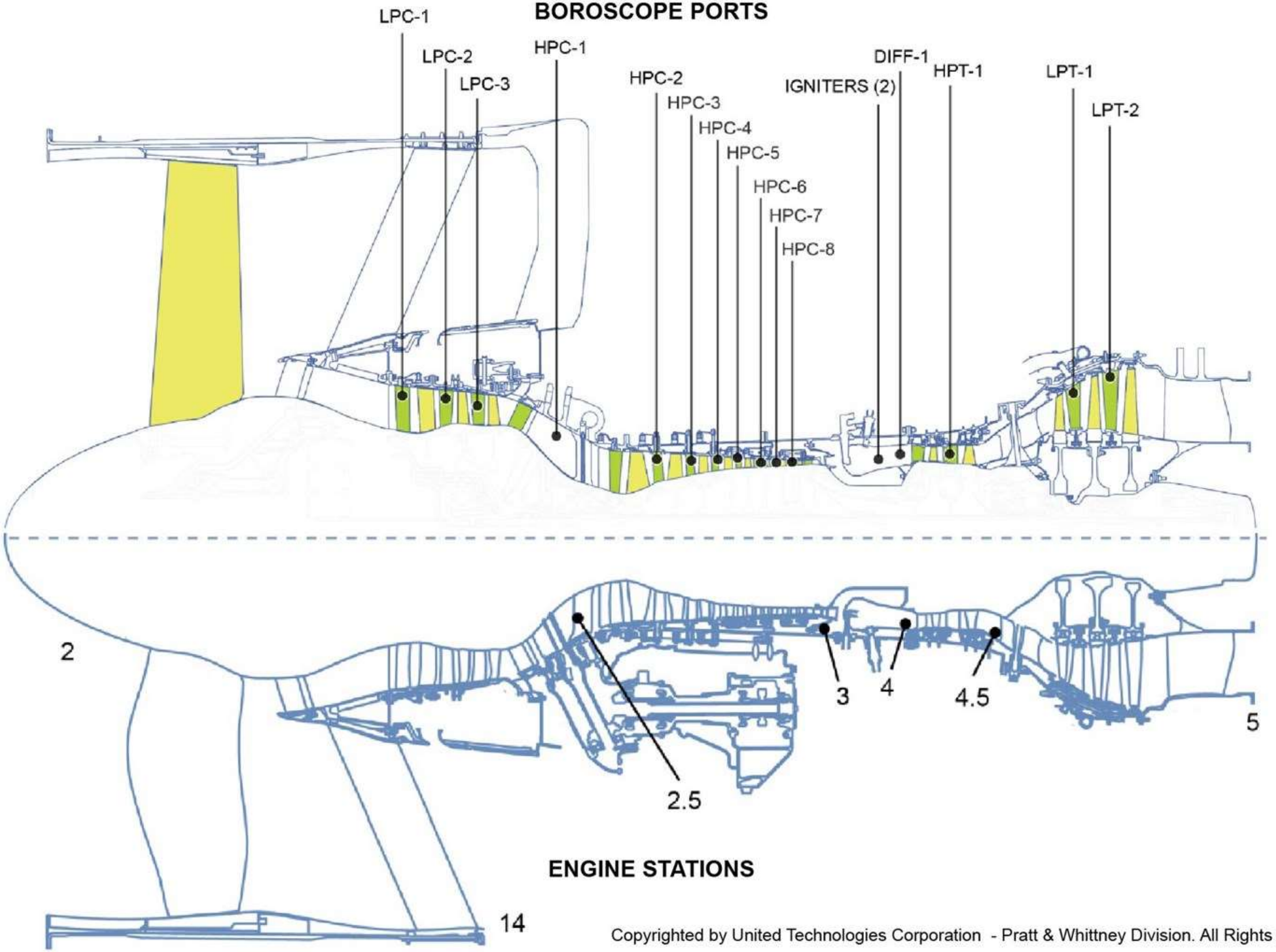
• Several boroscopic ports for preliminary gas path inspection without engine disassembly
•Each stage of the rotor both compressor and turbine has ports at different position
•Igniter plug ports used as boroscopic ports

Several boroscopic ports are provided for preliminary inspection of the gas path without engine disassembly.
Each stage of the rotor, both compressors and turbines have boroscopic ports located at different positions on the engine case.
Igniter plugs ports are used to inspect the combustion chamber liners, fuel nozzles and first stage nozzle guide vanes.

• Main aerodynamic stations

The main aerodynamic stations are identified in the gas path. Some stations have pressure and/or temperature sensors for engine monitoring.

BOROSCOPE PORTS



ENGINE STATIONS

ENGINE BEARINGS

• Engine bearings provide reduce rolling friction and supports the rotor axially and radially within the structure
•There are five bearing compartments containing a total of seven bearing
•No. 1 and 1.5 are tapered roller bearing and are used to support the fan rotor and FDGS
•No. 2 and 3 are ball bearing and support the front part of LP and HP rotor respectively
•No. 4 is roller bearing and support the rear of N2
•No.5 and 6 are roller bearing and support the rear of N1 rotor
•The bearing compartment are lubricated, cooled and cleaned by engine oil
•Bearing compartments are sealed using carbon seals to prevent oil leakage

The engine bearings provide reduce rolling friction and supports the rotor axially and radially within the structure.
It bears the different loads of the rotating shaft.
There are five bearing compartments containing a total of seven bearing.
No. 1 and 1.5 are tapered roller bearing and are used to support the fan rotor and FDGS.
No. 2 and 3 are ball bearings and support the front part of LP and HP rotor respectively.
No. 4 is roller bearing and support the rear of N2.
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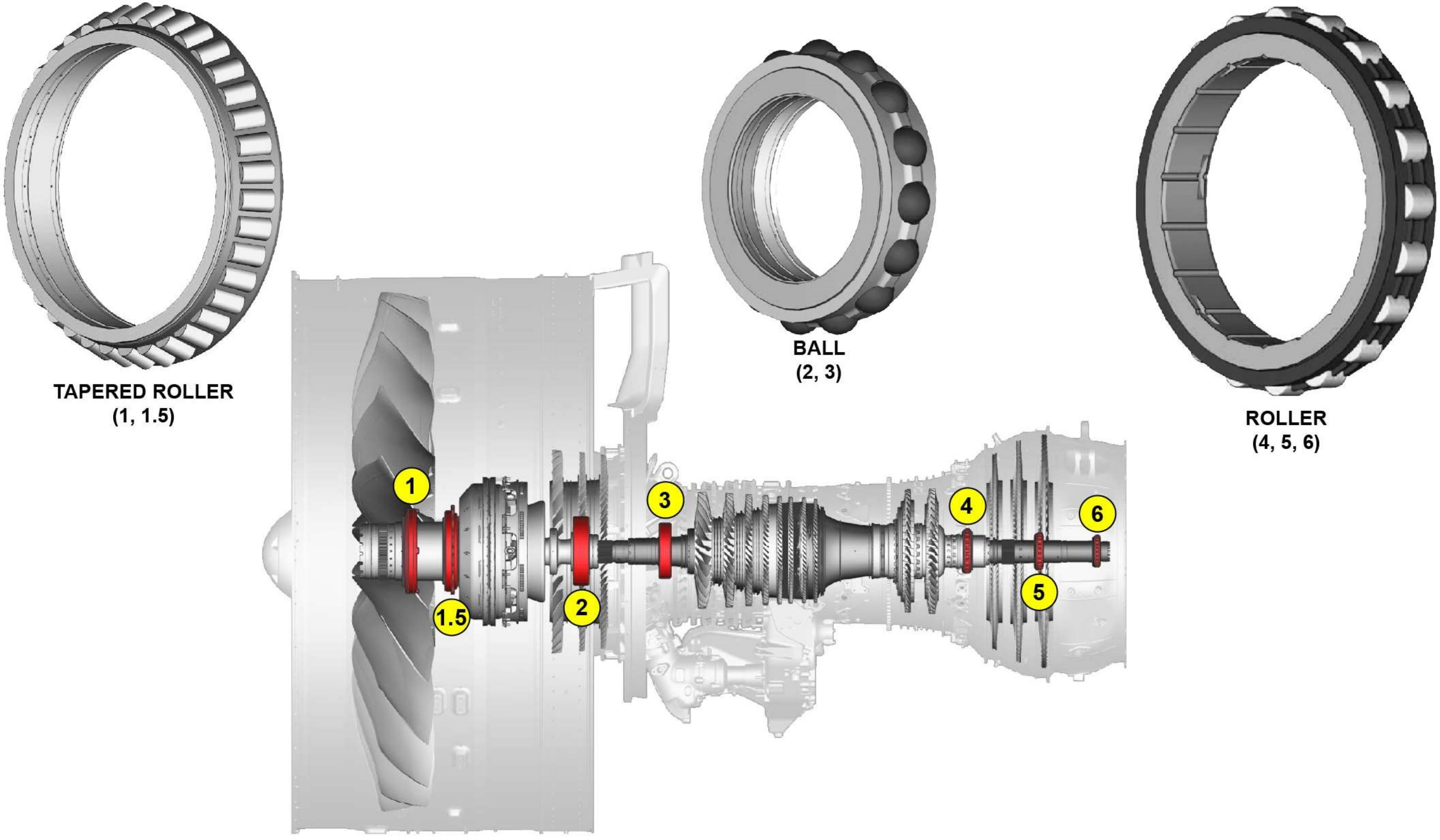
The bearing compartment are lubricated, cooled and cleaned by engine oil.
Bearing compartments are sealed using carbon seals to prevent oil leakage.



MAIN ENGINE BEARING LOCATIONS

Engine Fuel System Description and Operation

FUEL DISTRIBUTION

Comp loc ENG 1 LH

IFPC

Comp loc ENG 1 LH

FOHE

• Fuel distribution system supplies:

- FF to combustion chamber
- Pressurized fuel to engine components (Servo fuel for air valves)
- Cooling fuel for engine and IDG oil

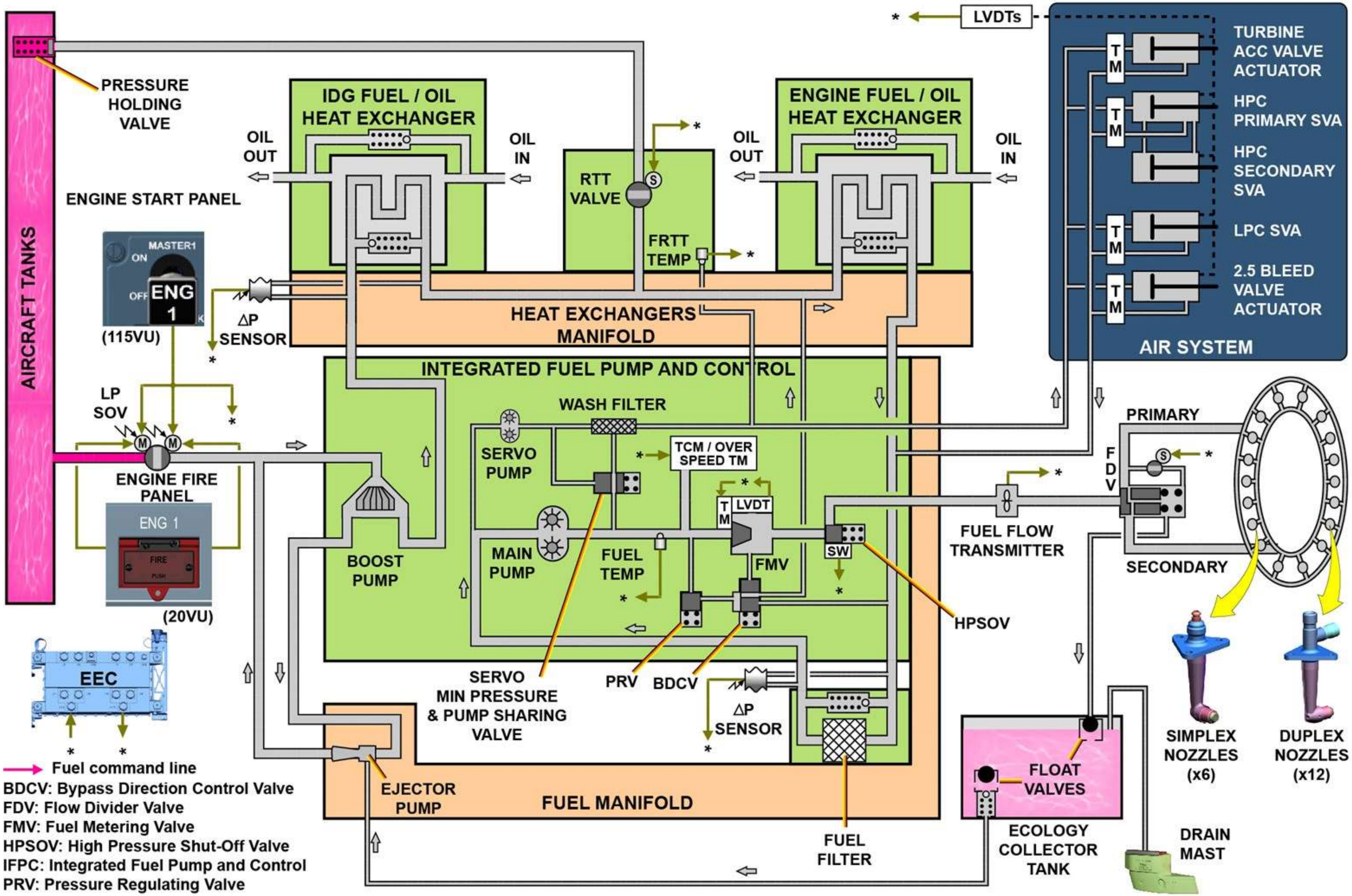
The fuel distribution system supplies fuel from tanks to the engines. The fuel is metered, filtered and supplied at the pressure and flow rate necessary to enable stable engine operations during all the phases. The metered Fuel Flow (FF) is sent to the fuel nozzles for combustion, and pressurized fuel is supplied to the fuel-operated actuators of the engine (e.g. Air valves). The fuel is also heated to prevent ice formation and used to cool engine oil and Integrated Drive Generator (IDG) oil.

• Fuel distribution system consists of:

- IFPC
- Fuel manifold
- Fuel/Oil Heat exchanger
- Fuel filter
- Flow divider & dump valve
- Fuel nozzles
- Ecology collector tank
- Return-To-Tank valve

The distribution system consists of:

- The Integrated Fuel Pump and Control (IFPC),
- A fuel manifold,
- Fuel/Oil Heat Exchangers (FOHEs),
- A fuel filter,
- Flow Divider Valve (FDV),
- Fuel nozzles,
- Ecology collector tank,
- Return-To-Tank (RTT) valve.



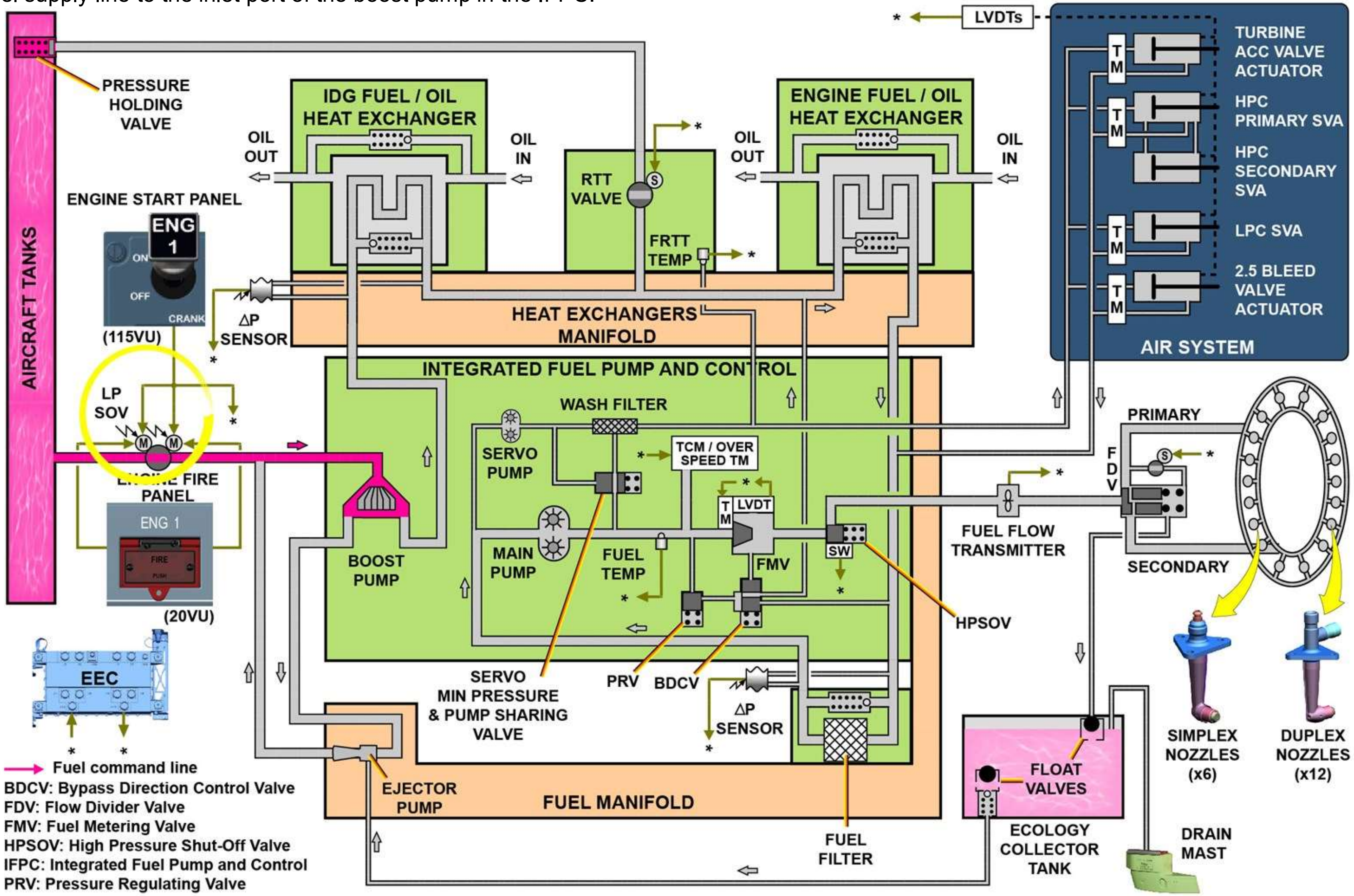
Fuel command line

BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

FUEL FEED FROM AIRCRAFT

- ENGine MASTER Lever is selected ON
    - ENG LP VALVE opens
    - Fuel from A/C tanks to IFPC through main fuel supply line

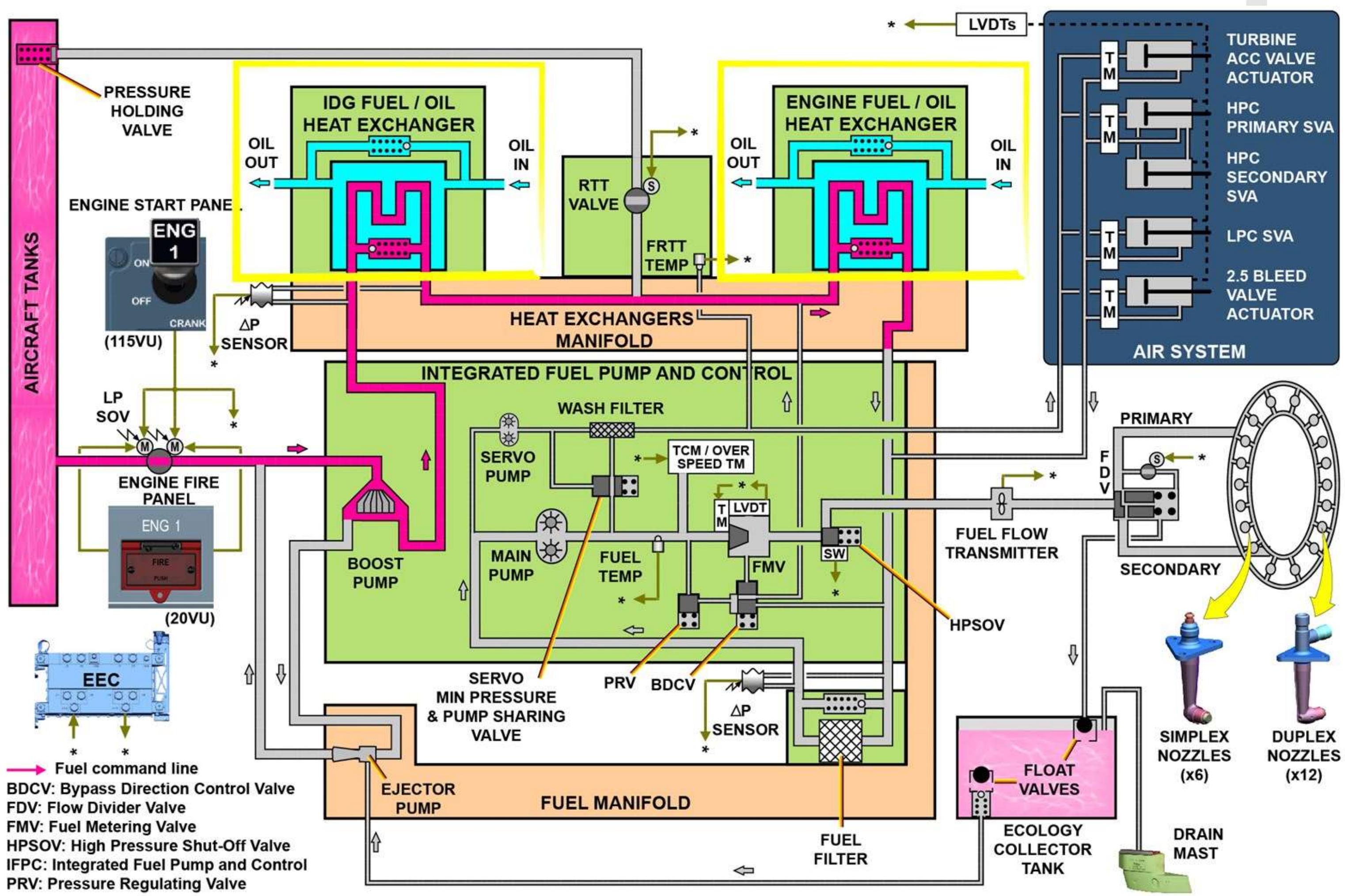
When the ENGine MASTER Lever is selected ON, the Low Pressure Shut-Off Valve (LPSOV) opens and fuel from the aircraft tanks flows through the main fuel supply line to the inlet port of the boost pump in the IFPC.



HEAT EXCHANGERS AND FUEL RETURN TO TANK

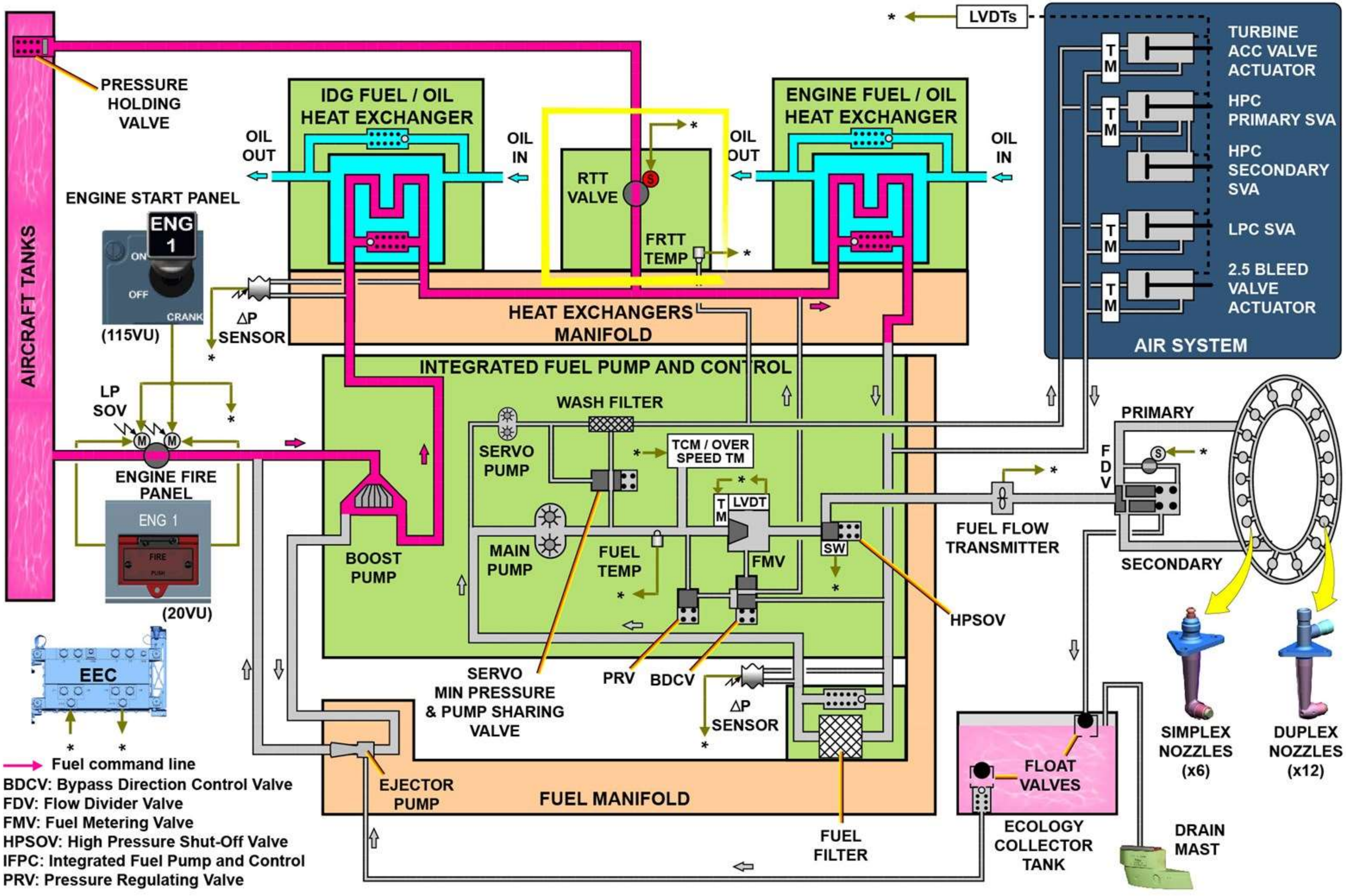
- Fuel from boost pump cools IDG FOHE and engine FOHE
- Fuel from engine FOHE to fuel filter

The boost pump sends LP fuel from the engine fuel supply line to the IDG FOHE. Fuel flow is used to cool down the IDG oil through the IDG FOHE and the engine oil through the engine FOHE. In turn, fuel is heated and de-iced.
Fuel from the engine FOHE is then sent to the fuel filter.



- FRV and FRTT Temperature sensor
- FRV controls fuel flow back to the aircraft tanks
- FRV controlled by EEC depending on fuel temperature

The Fuel Return-To-Tank (FRTT) module contains the Fuel Return Valve (FRV) and the FRTT Temperature sensor.
The FRV controls fuel to flow back to the aircraft tanks from downstream of the IDG FOHE and before it enters the engine FOHE as part of the fuel heat management system. The FRV is controlled by the Electronic Engine Control (EEC) depending on the fuel temperature.
The FRV is closed by default and is only open when required to maintain Thermal Management System (TMS) limits.
The failsafe position of the FRV (i.e. solenoid de-energized) is closed.
The maximum allowable return to tank fuel flow shall be 1500 kg/h (3300 lb/h).
The FRV is commanded to closed if the fuel temperature exceeds 97.8�C for more than 10 minutes.



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INTEGRATED FUEL PUMP AND CONTROL

• Electronically controlled unit composed of:
  - Fuel metering component
  - Fuel pump

•Uses a dual coil torque motor and solenoids to control fuel flow

The IFPC is an electronically controlled unit which integrates the fuel metering components and the fuel pumps in a single unit to limit the space and the number of external tubes required for the system. The IFPC uses dual coil torque motors and solenoids to control hydro-mechanical valves in relation to the fuel flow. The Main Gearbox (MGB) turns the IFPC input shaft which drives the fuel pump boost-stage, the main fuel pump and servo pump.

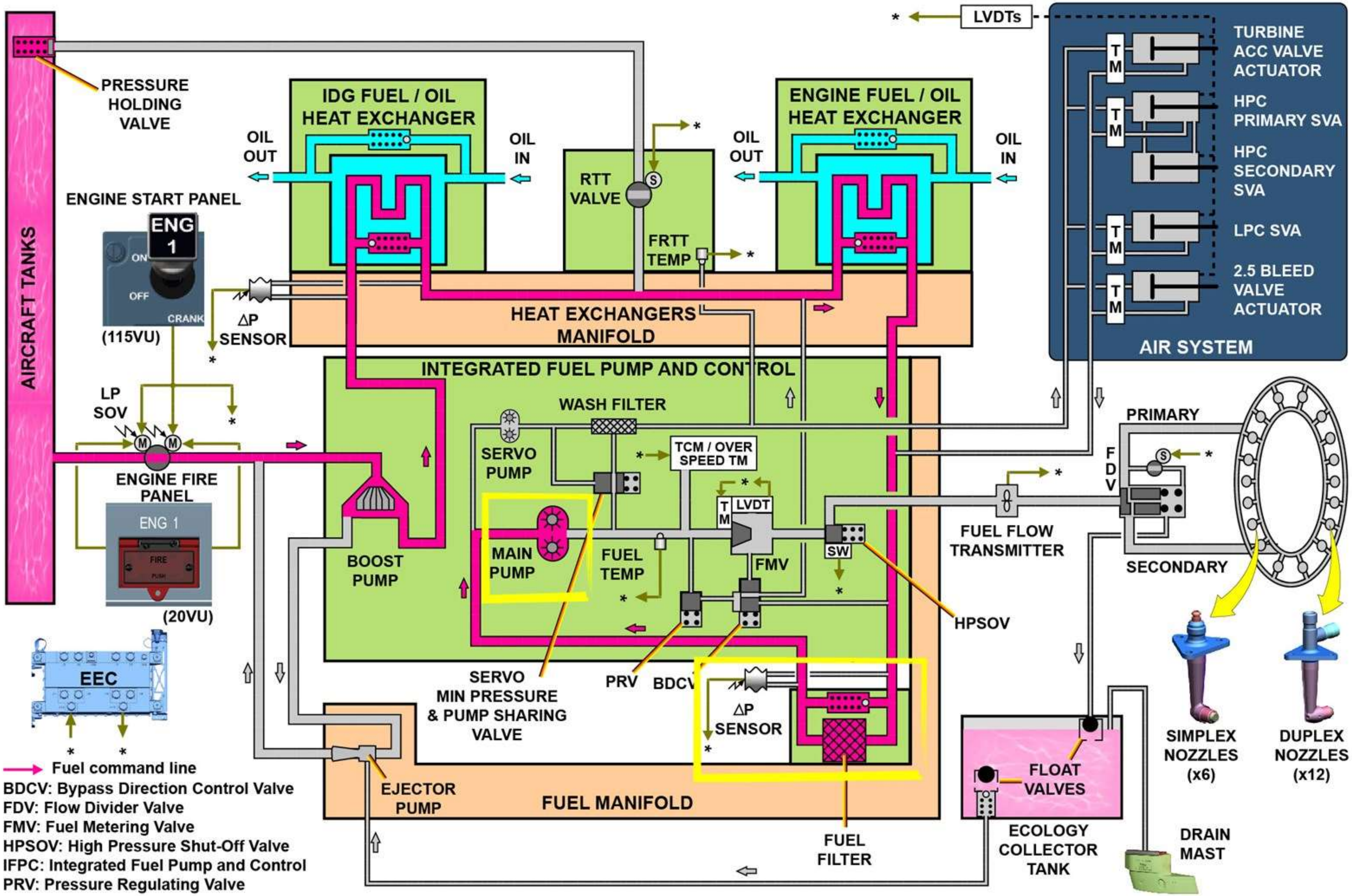
FUEL FILTER AND MAIN PUMP

• Fuel from engine FOHE filtered

The heated fuel from the engine FOHE is directed through the fuel filter. The filter element is a disposable filter located in a housing attached on the fuel manifold. The filter is monitored by a differential pressure transmitter. The filter housing is fitted with a bypass valve in case of filter element clogging. The filter element is a disposable 20 micron filter.

• Gear-stage fuel pump sends HP fuel to fuel metering valve

The fuel exits the fuel filter and flows to the inlet port of the main fuel pump. The main fuel pump is a single-stage gear pump, which increases the fuel pressure and sends the pressurized fuel to the Fuel Metering Valve (FMV).



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FUEL METERING VALVE AND HIGH PRESSURE SHUT-OFF VALVE

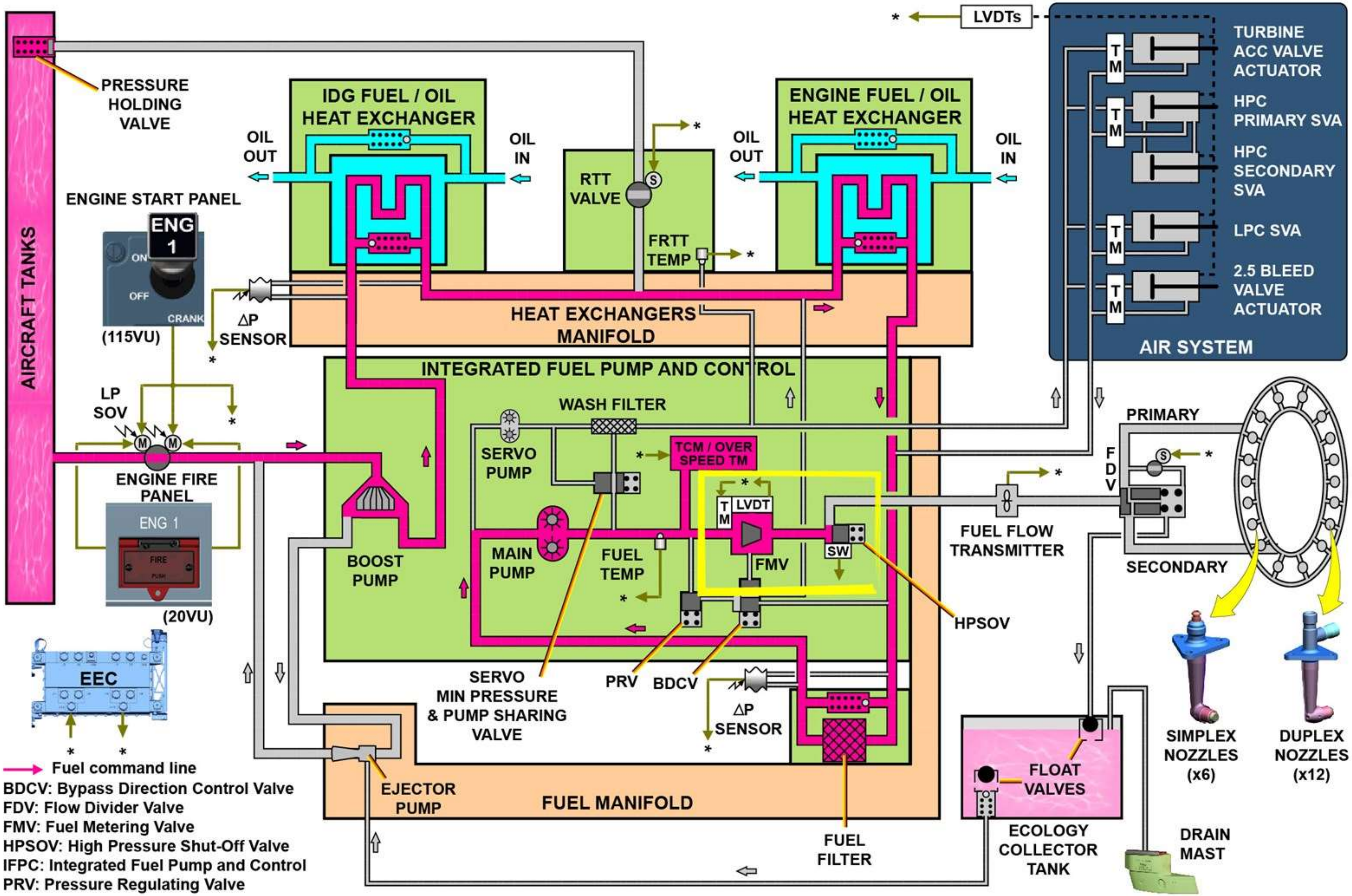
- FMV
    - Torque Motor positions the FMV in the desired position

The EEC controls a dual Torque Motor (TM) which positions the FMV in the desired position. The close loop monitoring is ensured by the EEC using the valve LVDT feedback signals.

- HPSOV
    - Open or Closed depending on the fuel pressure at HPSOV
    - Fuel pressure controlled by TCM/Overspeed TM

The HPSOV is spring-loaded closed in absence of pressure at the front side.
The valve has two open positions: Normal and Reduced (cutback control in case of TCM in flight or during flare).

The fuel from the FMV is directed to the High Pressure Shut-Off Valve (HPSOV). The fuel pressure at the back side of the HPSOV is controlled by the Thrust Control Malfunction (TCM)/Overspeed TM and allows the valve to open or close.



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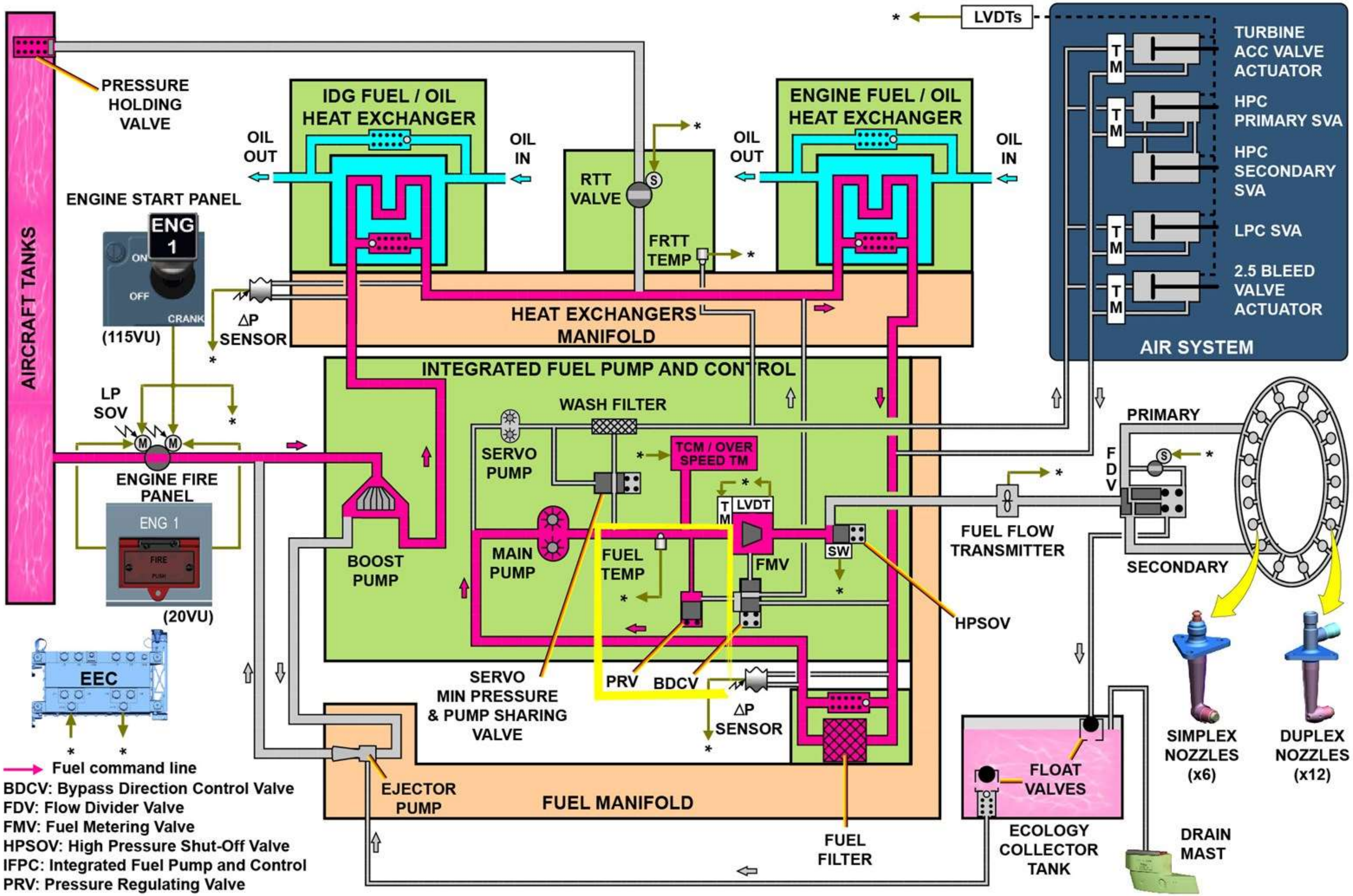
PRV: Pressure Regulating Valve

PRESSURE REGULATING VALVE AND BYPASS DIRECTIONAL CONTROL VALVE

- PRV
  - Maintains a constant fuel pressure drop across the FMV

The PRV is spring-loaded closed.

Inside the IFPC, the fuel from the main pump is directed to the FMV and to the Pressure Regulating Valve (PRV). The purpose of the PRV is to maintain a constant fuel pressure drop across the FMV to ensure the correct fuel flow and acceleration for the engine.



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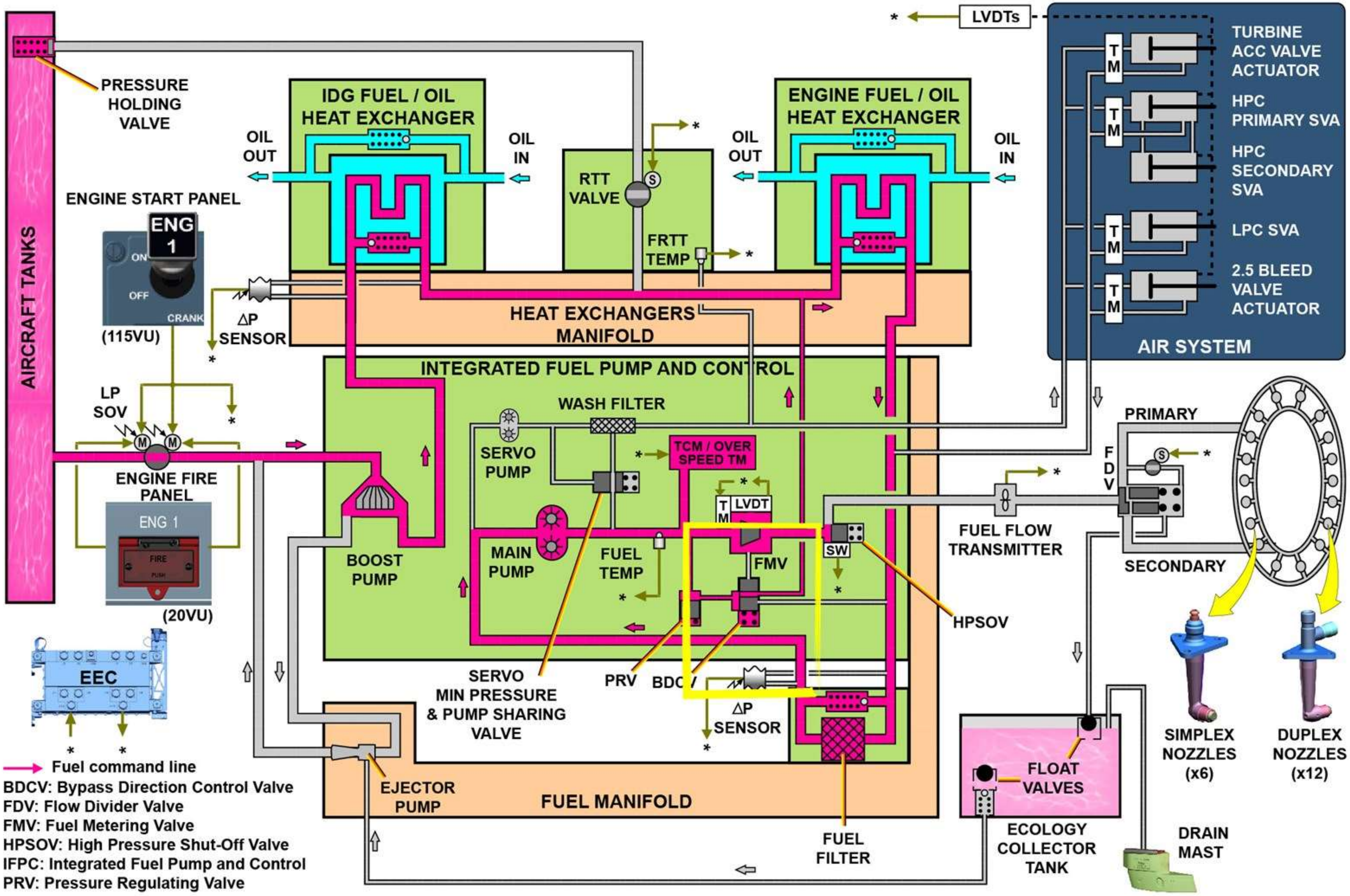
•BDCV

- Depending on fuel pressure: Sends fuel to engine FOHE or to Fuel filter

Low power < FF = 550 kg/h < High power
The BDCV is spring loaded in the "low engine power" position.

Pressurized fuel that passes through the PRV is directed to the BDCV. The BDCV directs fuel by-passed by the PRV to the engine FOHE at low engine power or when the fuel temperature is low to help in maintaining the engine oil and fuel within operating limits.
At high power, the BDCV returns the recirculation flow downstream of the FOHE



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EEC CONTROL

• HPSOV
  - Controlled by EEC via TCM/Overspeed TM
  - 2 proximity sensors provide feedback to EEC

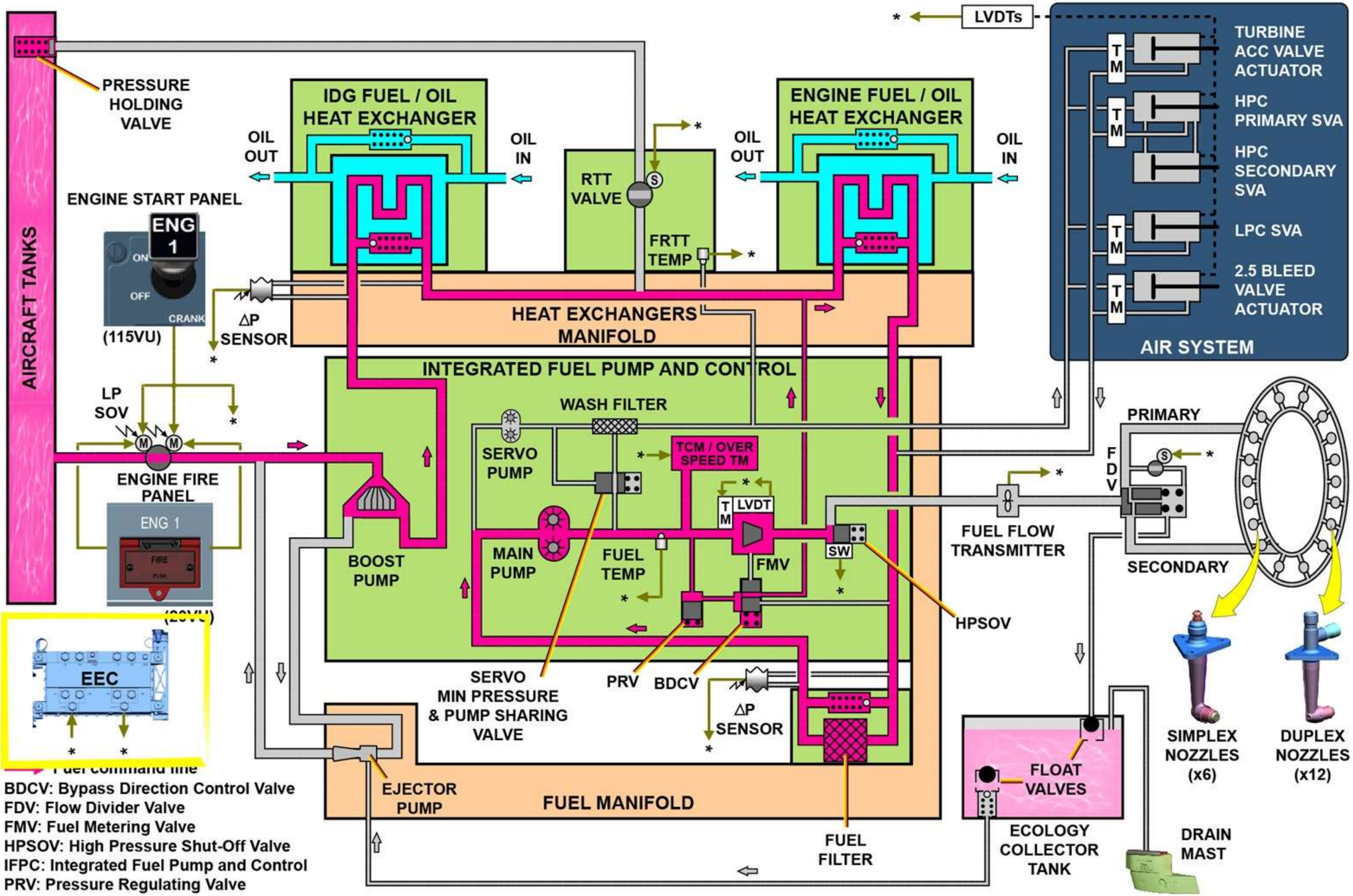
The EEC controls the dual TCM/Overspeed TM for HPSOV positioning.
It monitors the valve fully closed position with the two proximity switches.

• FMV
  - Controlled by EEC via a Torque Motor
  - Feedback sent by LVDT to EEC

The EEC also controls the FMV position via a dual channel Torque Motor (TM).
A dual channel Linear Variable Differential Transducer (LVDT) provides the FMV position to the EEC.

• Servo fuel Torque Motors
  - Feedback sent by LVDT to EEC

For the air system, the EEC controls the fuel-operated actuators with dual channel TMs and it monitors their position thanks to LVDT position feedbacks.



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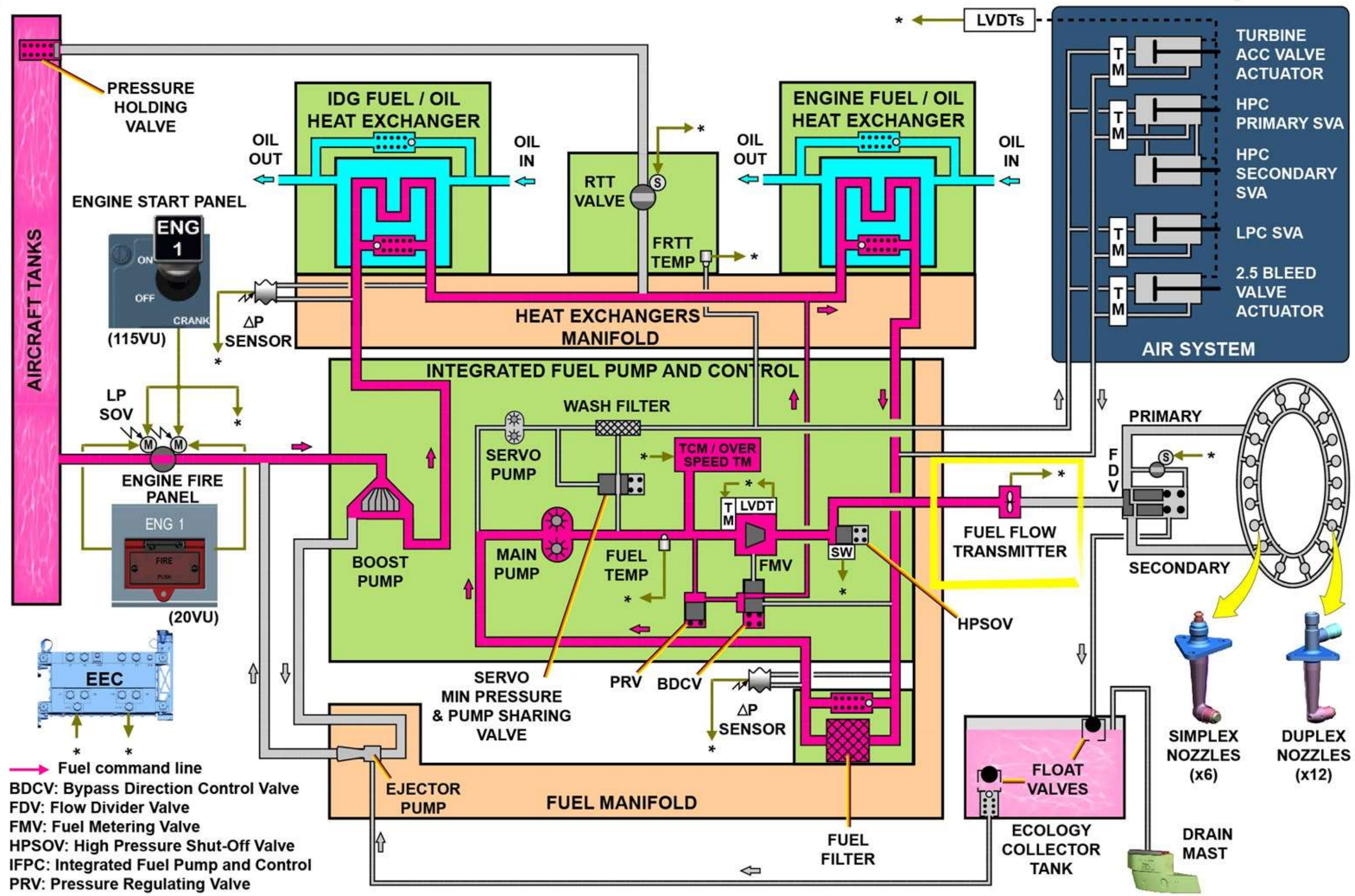
FUEL FLOW TRANSMITTER, FLOW DIVIDER VALVE AND FUEL NOZZLES

•Sends fuel flow rate to EEC and directs fuel to FDV

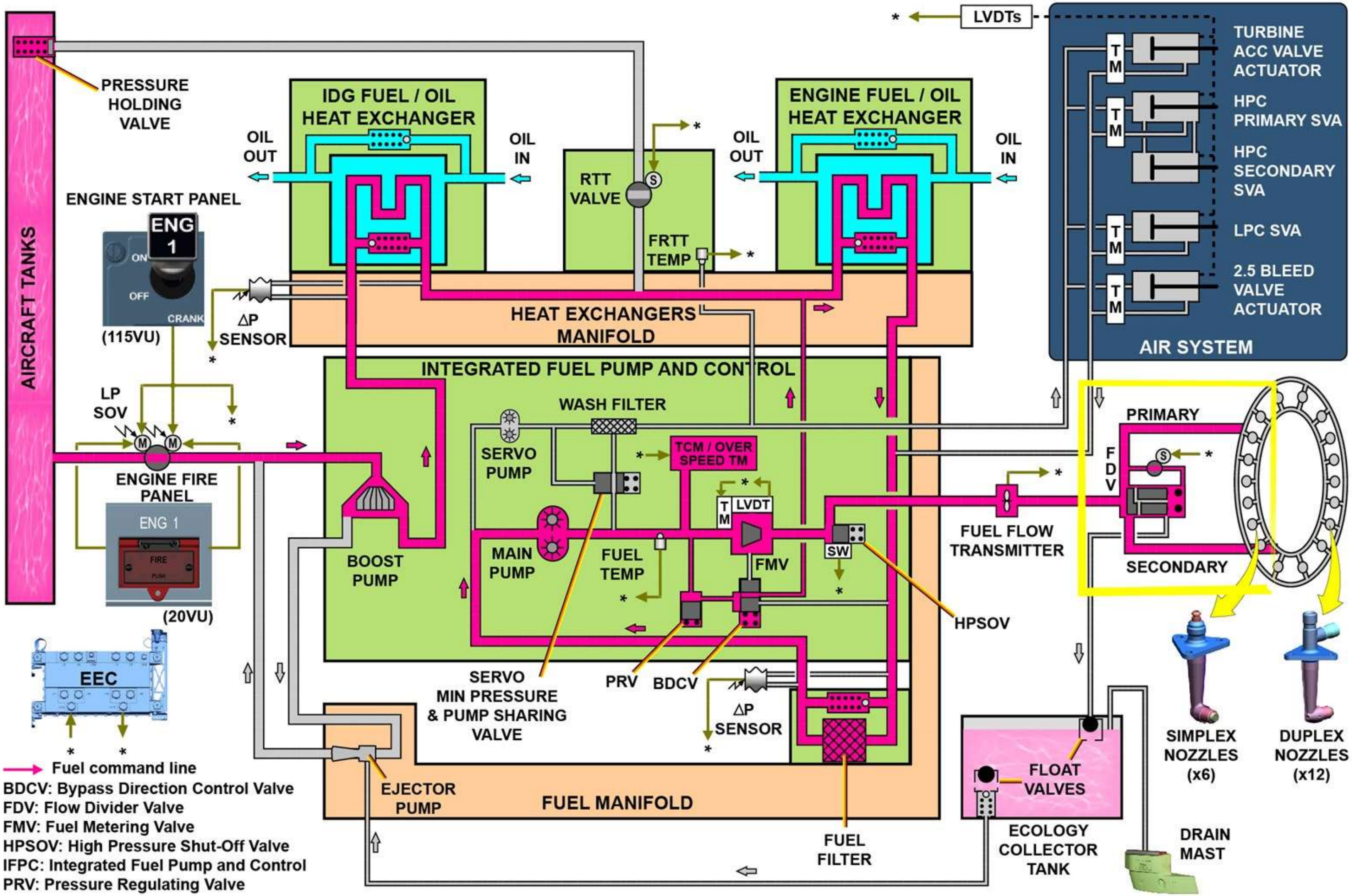
The metered fuel from the FMV crosses the HPSOV and flows to the fuel flow transmitter.

The fuel flow transmitter sends the fuel flow rate to the EEC channel A and directs fuel to the Flow Divider Valve (FDV).



•EEC commands FDV opening
During engine start, FDV Solenoid de-energized, control valve open = FDV partially open to allow more fuel supply for primary.
Above idle, FDV solenoid energized, control valve closed = FDV open for even fuel supply for primary and secondary.
At shutdown, FDV solenoid de-energized, control valve open = FDV close by spring to allow primary and secondary drainage.

The EEC commands the FDV opening during starting to improve fuel atomization.
During engine start, the FDV sends most of fuel to the primary manifold.
Above idle, the FDV evenly divides metered fuel flow between the primary and secondary fuel manifolds.
At shutdown, the FDV is spring loaded closed to allow primary and secondary manifold drainage.
The FDV is fitted with a metal screen strainer that can be bypassed in case of blockage.



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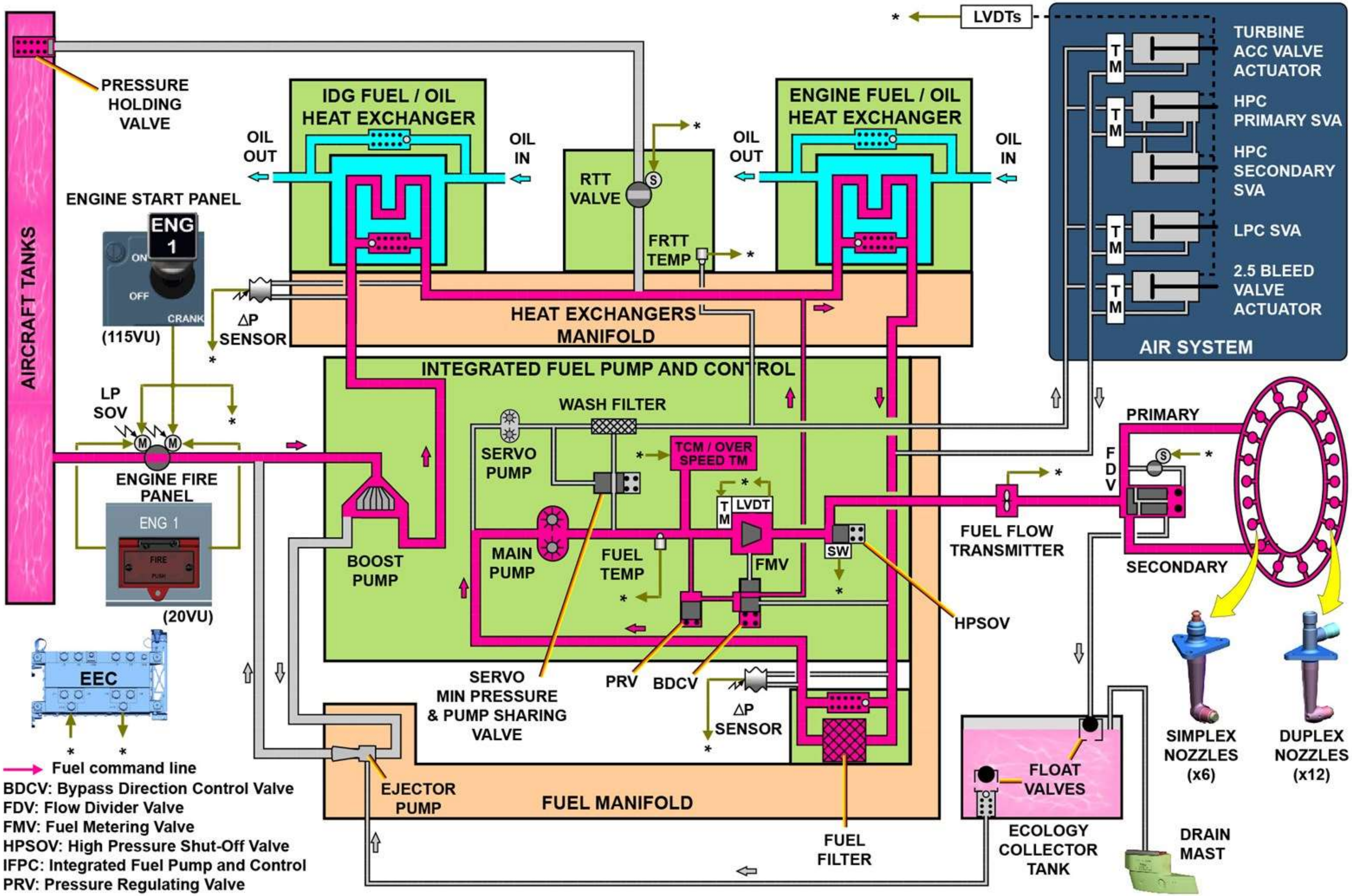
•Fuel nozzles atomize fuel inside the combustor:

- 12 duplex nozzles (primary and secondary fuel flow paths)
- 6 simplex nozzles (secondary fuel flow path)

There are 18 fuel nozzles mounted to the outer diffuser case. All the nozzles atomize fuel inside the combustor. Twelve of them are duplex nozzles featuring both a primary and a secondary fuel flow paths while six others are simplex nozzles providing only a secondary fuel flow path.



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SERVO FUEL AND SERVO MINIMUM PRESSURE AND PUMP SHARING VALVE

• Servo pump sends pressurized fuel to engine component actuators

•Pressurized fuel sent to:

- LPC SVA
- LPC 2.5 BVA
- Turbine ACC valve
- HPC SVAs (primary and secondary)

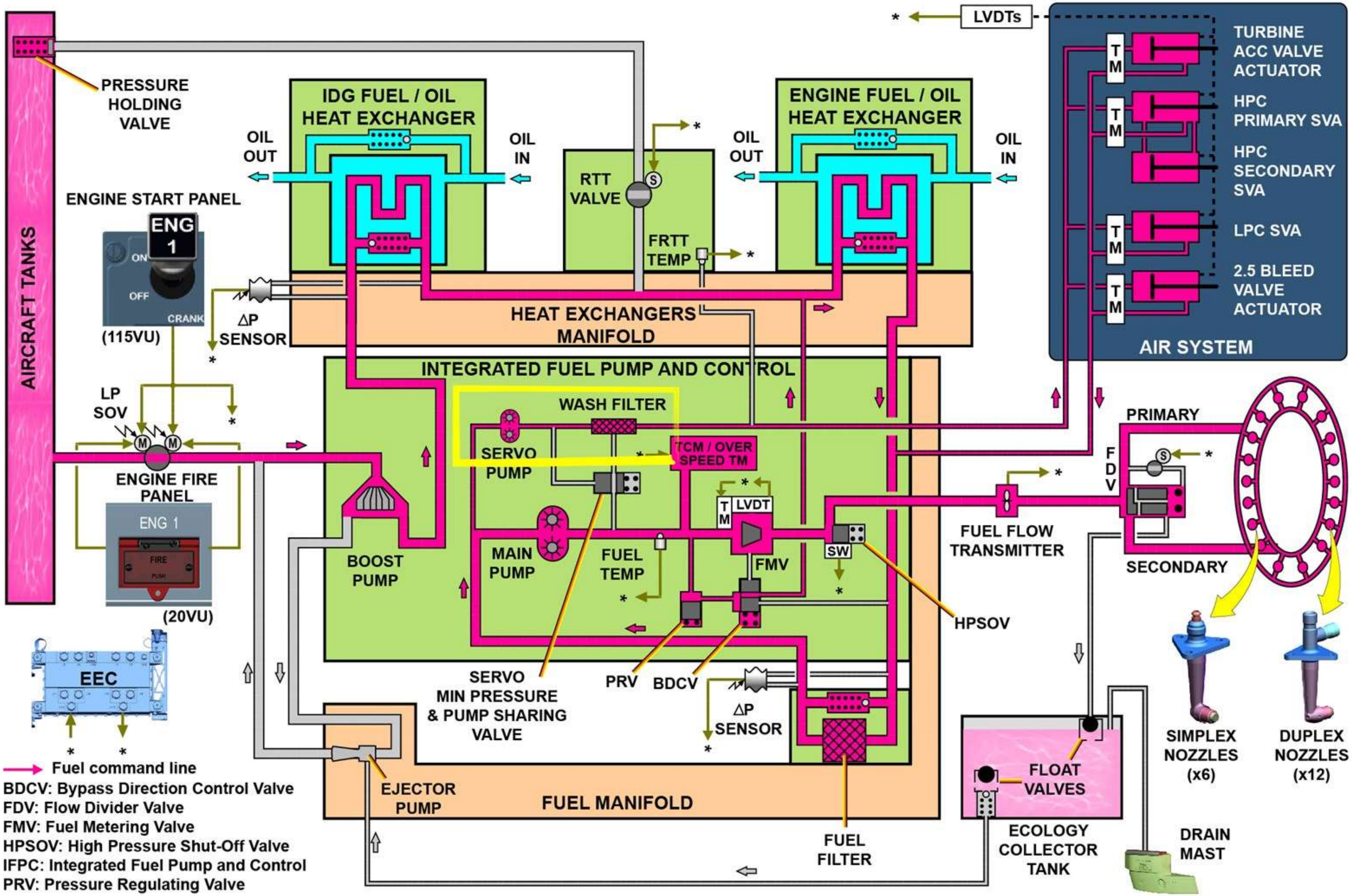
•Fuel from actuators returned back to main pump and servo pump inlet

The servo pump housed in the IFPC is a gear-stage pump which sends pressurized fuel to a wash filter. Fine filtered, pressurized fuel from the wash filter is supplied to the engine air system actuators where it is used as servo and muscle pressure to position the actuator pistons.

These actuators are:

- the Low Pressure Compressor (LPC) Stator Vane Actuator (SVA),
- the LPC (2.5) Bleed Valve Actuator (BVA),
- the turbine Active Case Cooling (ACC) valve,
- and the High-Pressure Compressor (HPC) SVAs (primary and secondary).

The fuel from the actuators is filtered again before it returns back to main pump and servo pump inlet.


LVDTs
TURBINE ACC VALVE ACTUATOR
HPC PRIMARY SVA
HPC SECONDARY SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
TM
PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
ENGINE FUEL / OIL HEAT EXCHANGER
RTT VALVE
FRTT TEMP
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LP SOV
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
LVDT
FMV
SW
HPSOV
PRIMARY
FDV
SECONDARY
FUEL FLOW TRANSMITTER
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
FLOAT VALVES
ECOLOGY COLLECTOR TANK
DRAIN MAST
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
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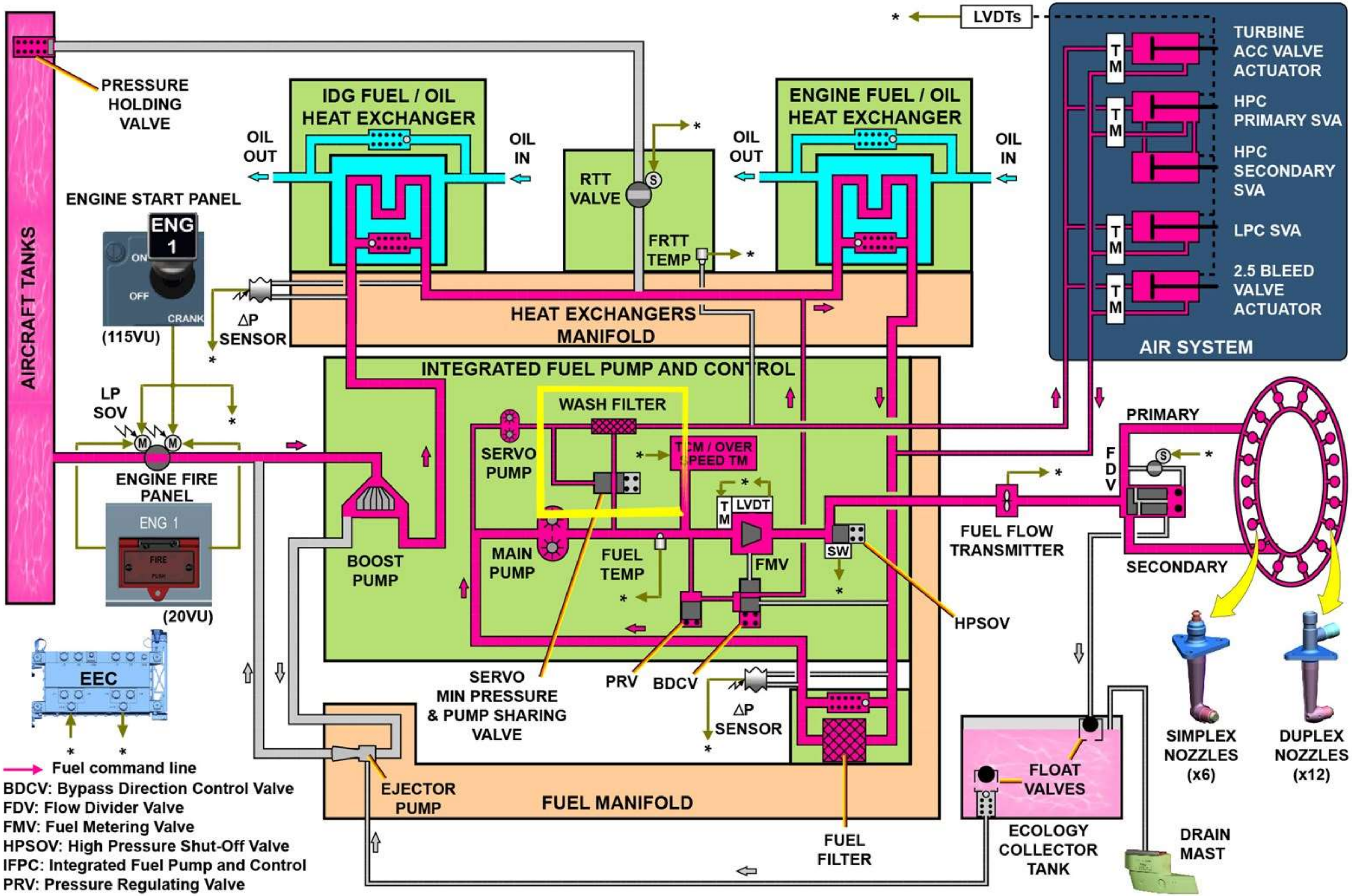
PRV: Pressure Regulating Valve

•Spring loaded valve
•Provide the servo fuel circuit with enough fuel pressure from main pump during start
During start and windmill start conditions, the Servo Min Pressure and Pump Sharing Valve is in the open position, directing a portion of pressurized fuel from the Main Pump away from the FMV and to the five actuators because the servo pump does not provide sufficient fuel pressure.
During engine operation at all other power conditions, the Servo Pump fuel pressure is high enough to drive the actuators and move the Servo Min Pressure and Pump Sharing Valve spring loaded spool valve to the closed position to direct all fuel from the Main Pump to the FMV.

The Servo Minimum Pressure and Pump Sharing Valve is a spring loaded valve that provides the five air system actuators with main pump fuel pressure when servo pump fuel pressure is not enough during start.



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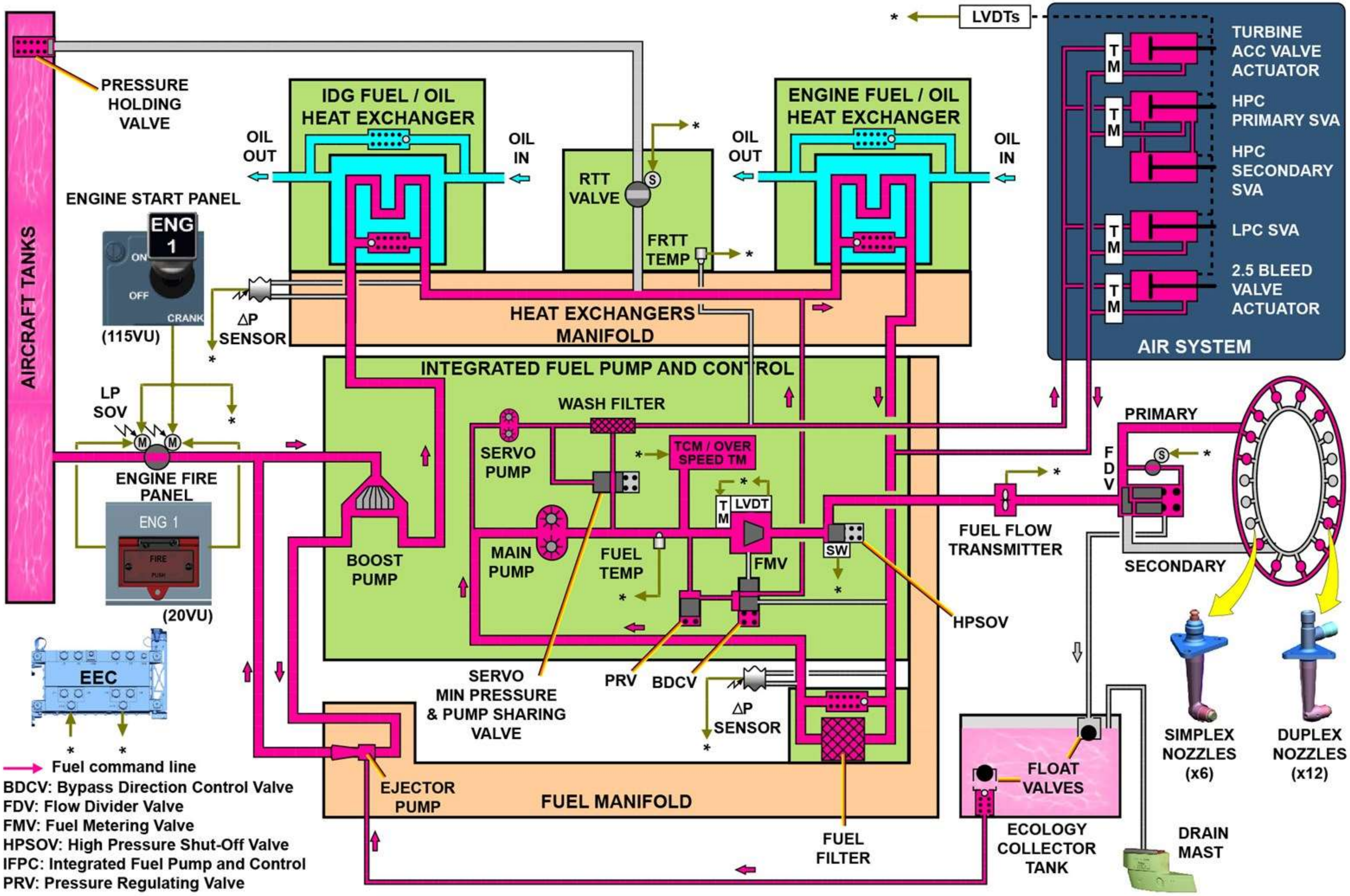
STARTING

- Servo Minimum Pressure & Pump Sharing Valve is open
    - Portion of pressurized fuel directed to component actuators
- PRV partly open
- BDCV directs the fuel flow to the heat exchanger
- FMV & HPSOV open
- FDV is partly open

During starting, the servo pump fuel pressure is not enough to control the air system actuators and to close the Servo Minimum Pressure and Pump Sharing Valve. In this position, the Servo Minimum Pressure and Pump Sharing Valve directs a portion of pressurized fuel from the main pump to the five actuators. The other portion of fuel from the main pump is sent to the PRV and to the FMV. The PRV opens partly and directs the excess of fuel flow to the BDCV which is spring loaded to send it to the engine FOHE.

The EEC opens the FMV and let the fuel to flow to the HPSOV which also opens and sends fuel to the fuel flow transmitter. The pressurized fuel opens the FDV. The FDV partly opens and sends most of fuel to the primary fuel nozzles.



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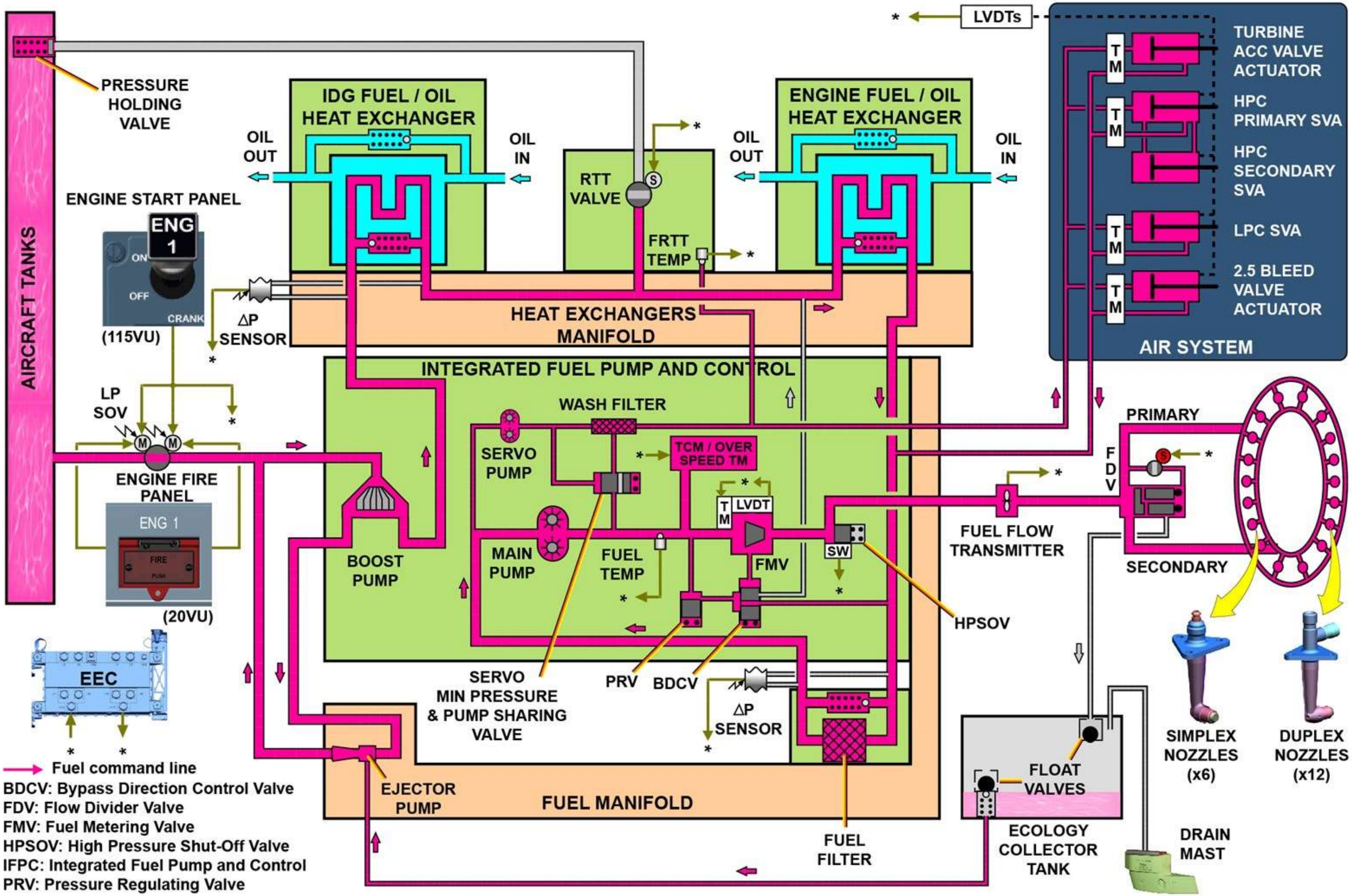
ACCELERATION

• Fuel pressure increase
•FMV opens more and BDCV starts moving
•FDV evenly divides metered fuel flow between primary and secondary fuel nozzles

As the pumps rotation speed increases with the engine acceleration, the fuel pressure also increases. The FMV opens more and as a consequence the fuel pressure pushes the BDCV out of its rest position to direct the excess fuel flow to the fuel filter. The FDV also opens more and evenly divides metered fuel flow between the primary and secondary fuel nozzles.
In parallel, the fuel pressure from the servo pump increases and pushes the Servo Minimum Pressure and Pump Sharing Valve, segregating the burn flow from the servo fuel.


LVDTs
TURBINE ACC VALVE ACTUATOR
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HPC SECONDARY SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
T M
PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
S
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
M
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
HPSOV
PRIMARY
FDV
SECONDARY
FUEL FLOW TRANSMITTER
EEC
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PRV
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EJECTOR PUMP
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FUEL FILTER
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SHUTDOWN

NORMAL SHUTDOWN

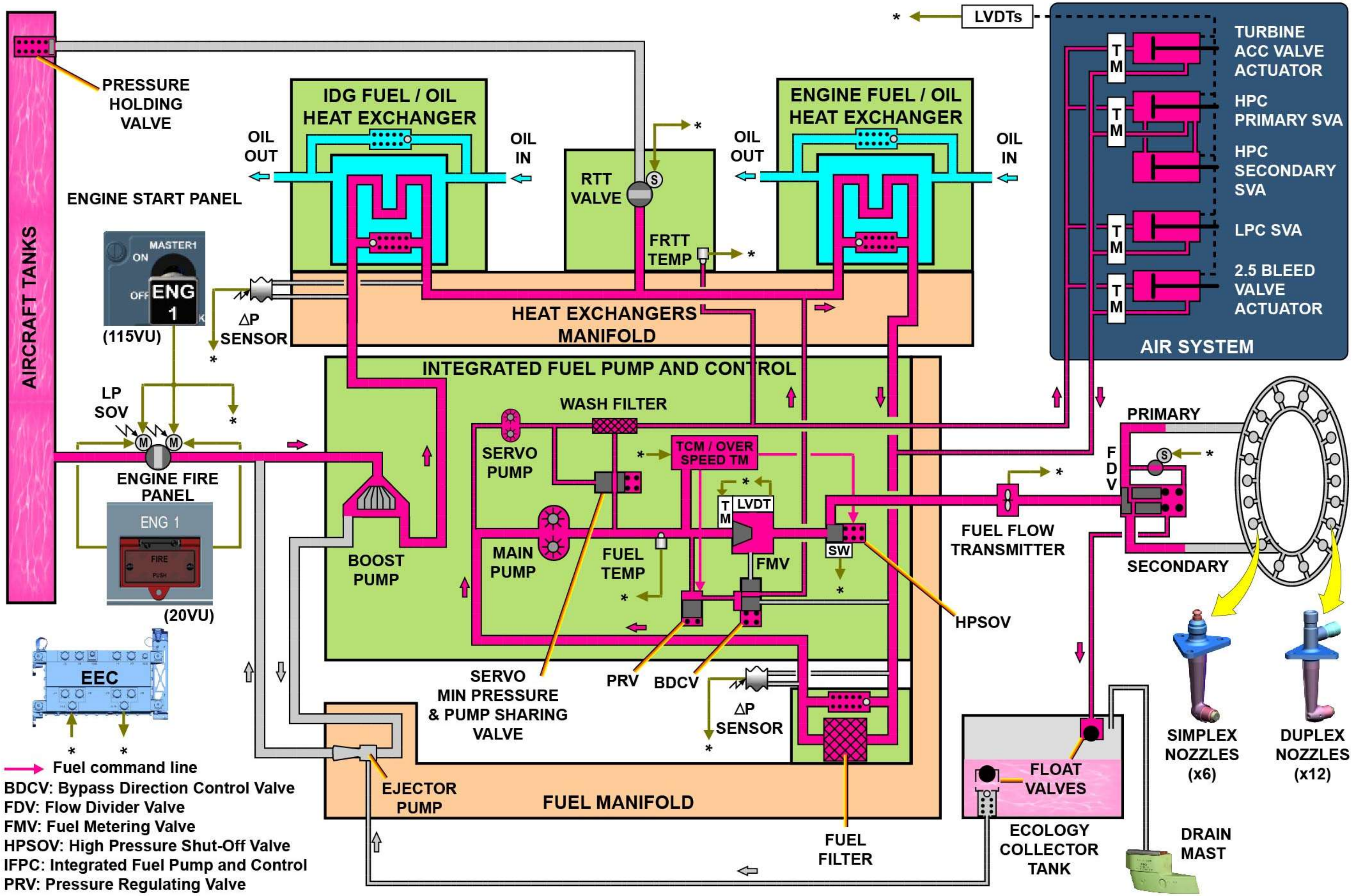
• LP SOV, FMV, HPSOV and FDV are closed
•PRV is fully open
•BDCV directs the fuel flow to the heat exchanger
•Servo Minimum Pressure & Pump Sharing Valve opens
•TCM/OVRSPD TM no longer supplied

During a normal engine shutdown, the Master Lever controls the LPSOV to close and sends a shutdown signal to the EEC.
As a consequence, the EEC controls the TCM/overspeed TM that directs fuel pressure to the back side of the HPSOV to close it and stop the fuel flow to the engine. In the same time, the PRV is controlled fully open to bypass the main pump fuel flow away from the FMV to the FOHE.
After the HPSOV is confirmed closed by the proximity switches, the EEC tests the FMV via its TM then closes it.

• Ecology tank collects fuel that drain from FDV after engine shutdown
  - Can hold fuel from one engine shut down
  - When full, inlet float valve closes

•Ejector pump draws fuel from ecology tank back to boost pump at engine start up

At engine shutdown, residual fuel in the manifolds downstream of the FDV is drained back through the FDV to an ecology collector tank.
The collected fuel remains in the ecology collector tank until the next engine start when the fuel is drawn back into the fuel system.
During shutdown, the fuel pressure from the IFPC is reduced and the FDV closes to prevent fuel from entering the combustor and to drain any fuel remaining in both the primary and secondary fuel lines to the ecology collector tank.
The ecology collector tank has enough space to receive fuel from a single engine shutdown. The tank has an inlet float valve which closes when the tank has reached its maximum capacity. This prevents the tank from overfilling and spilling fuel out following an aborted start.
At next engine start up, the ejector pump draws the fuel from the ecology collector tank back to the IFPC boost pump. The tank has an outlet float valve which closes when the tank has reached its minimum capacity and a check valve to avoid fuel transfer from the suction line.

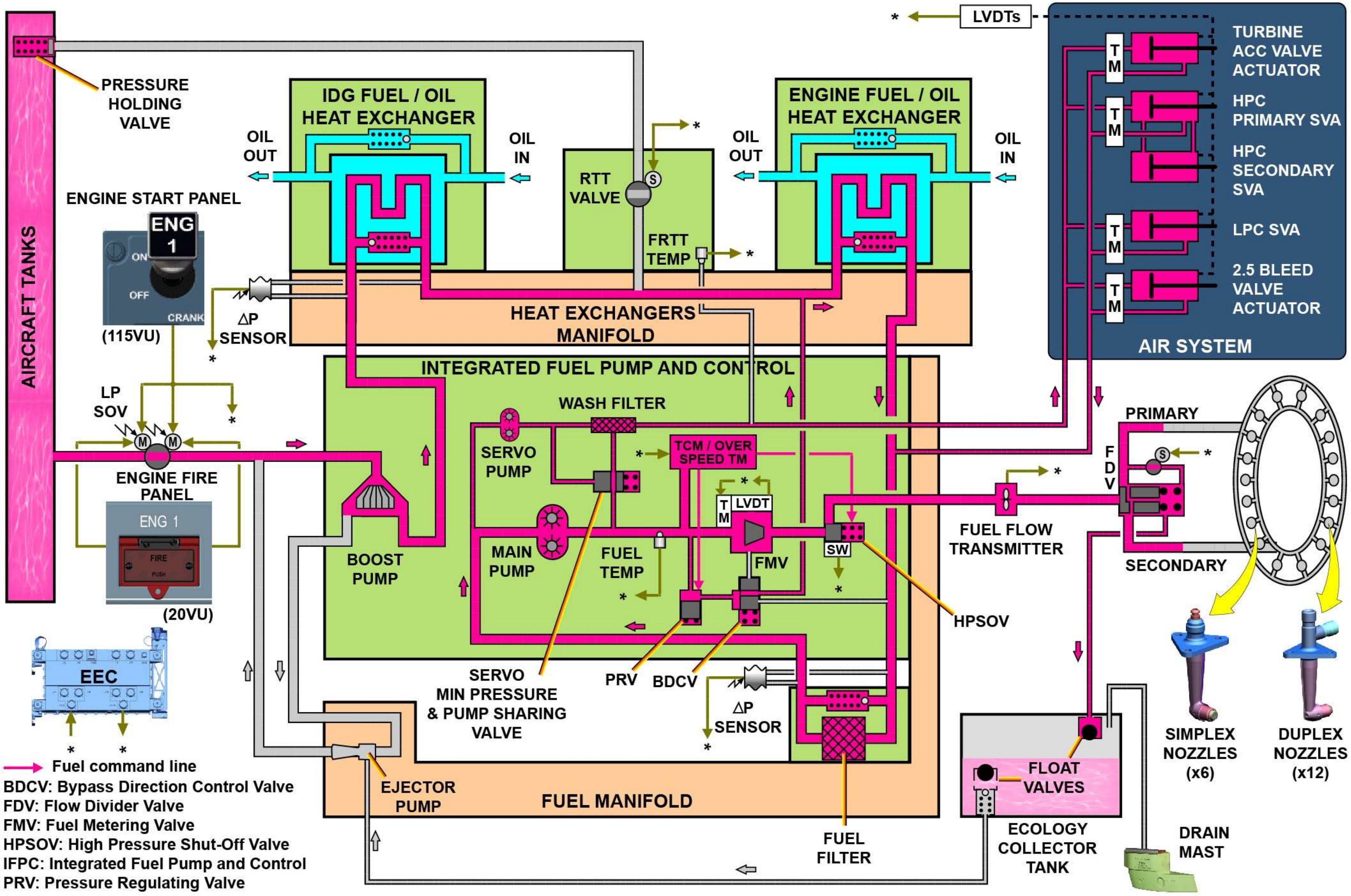

LVDTs
TURBINE ACC VALVE ACTUATOR
HPC PRIMARY SVA
HPC SECONDARY SVA
LPC SVA
2.5 BLEED VALVE ACTUATOR
AIR SYSTEM
T M
PRESSURE HOLDING VALVE
AIRCRAFT TANKS
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
RTT VALVE
FRTT TEMP
ENGINE FUEL / OIL HEAT EXCHANGER
ENGINE START PANEL
MASTER1
ON
OFF
ENG 1
(115VU)
ΔP SENSOR
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
(20VU)
BOOST PUMP
MAIN PUMP
FUEL TEMP
FMV
SW
HPSOV
PRIMARY
FDV
SECONDARY
FUEL FLOW TRANSMITTER
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
FLOAT VALVES
ECOLOGY COLLECTOR TANK
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
DRAIN MAST
Fuel command line
BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

ABNORMAL SHUTDOWN

- Overspeed, Shaft shear, TCM
- TCM event on ground
- Engine shutdown
- TCM event in flight
- Engine keeps running

Overspeed detection limits: 105% for N1, 105% for N2.
Shaft shear detection logic is only active at high power settings and is based on deceleration rates.
TCM detection leads to fuel flow reduction in flight (cutback position of HPSOV to limit thrust).

The abnormal shutdown is initiated in case of an overspeed (N1 or N2), shaft shear (fan, LP or HP) or Thrust Control Malfunction (TCM) event detected on ground.
In such case, the TCM/overspeed TM directs fuel pressure to the back side of the HPSOV and of the PRV. This causes the PRV to open and stop fuel flow to the FMV, allowing rapid closure of the HPSOV and rapid engine shutdown.
Fuel flow through the PRV is directed to the BDCV and then to the engine FOHE.
This shutoff method is independent from the FMV control.
In flight, if a TCM event malfunction occurs, the engine keeps running.



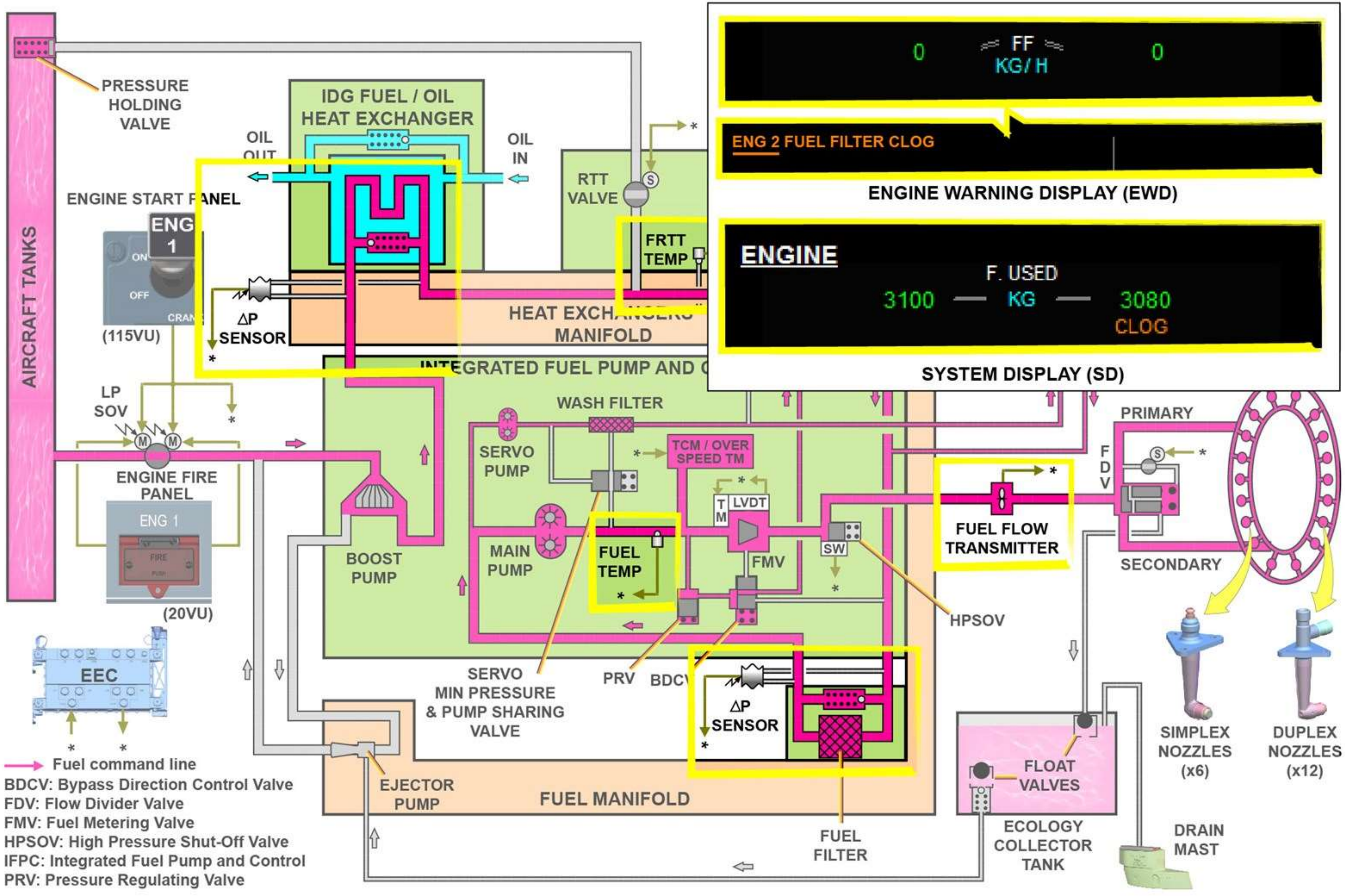
Fuel command line
BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

FUEL INDICATING

• Monitoring of:
  - Fuel flow with fuel flow transmitter
  - Fuel filter clog warning with FFDP
  - Engine fuel temperature with temperature sensor

•Fuel temperature enables EEC to control the oil flow through FOHE
- Fuel used is computed by EIS and reset when engine starts on ground
- FUEL FILTER CLOG = Fuel filter is clogged (in by-pass, delta P > 25 psi)
- FUEL FILTER DEGRAD = Fuel filter is partially clogged
- FUEL SENSOR FAULT = Fuel filter dP sensor is lost
- HEAT EXCHANGR CLOG = IDG oil-fuel exchanger is clogged (in by-pass)
- FUEL SENSOR FAULT = IDG FOC dP sensor is lost
- HOT FUEL = Fuel temperature has exceeded its limit (160 �C)
- FUEL HEAT SYS = RTTV is failed open
- HEAT SYS DEGRADED = The position feedback of the RTTV is failed
- HEAT SYS FAULT = Heat management system is inoperative

The engine fuel indicating monitors the system condition and provides the system status to the cockpit displays.
The fuel flow transmitter sends signals to the EEC which enables the calculation of the fuel flow to the combustor.
The fuel flow is a primary engine parameter and is displayed on the EWD permanently. The EEC also sends this data for the fuel used computation and display on the System Display (SD).
The Fuel Filter Differential Pressure (FFDP) sensor measures the differential pressure across the fuel filter.
This helps to detect if the filter is partially or totally clogged.
According to the received value, the EEC will generate various warnings on the EWD: ENG X FUEL FILTER DEGRAD or ENG X FUEL FILTER CLOG or ENG X FUEL SENSOR FAULT and on the SD: CLOG.
The IDG Fuel-Oil Heat Exchanger (FOHE) differential pressure sensor is used to sense the differential pressure on the fuel side of the FOHE and send a signal to the EEC in case of clogging detection. According to the status, the EEC will generate various warnings on the EWD: ENG X HEAT EXCHANGR CLOG or ENG X FUEL SENSOR FAULT.
For monitoring and Thermal Management System control by the EEC, the fuel temperature is sensed by two dual channel temperature sensors.
The fuel temperature sensor is used for the control of the heat exchangers (Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV)).
The Fuel Return To Tank (FRTT) temperature sensor is used for the RTTV control.
The engine fuel temperature is not directly displayed in the cockpit but, according to the status, the EEC will generate various warnings on the EWD: ENG X HOT FUEL or ENG X FUEL HEAT SYS or ENG X HEAT SYS DEGRADED or ENG X HEAT SYS FAULT.



AIRCRAFT TANKS
PRESSURE HOLDING VALVE
IDG FUEL / OIL HEAT EXCHANGER
OIL OUT
OIL IN
ENGINE START PANEL
ENG 1
ON
OFF
(115VU)
ΔP SENSOR
RTT VALVE
FRTT TEMP
HEAT EXCHANGERS MANIFOLD
INTEGRATED FUEL PUMP AND CONTROL
LP SOV
ENGINE FIRE PANEL
ENG 1
FIRE
(20VU)
WASH FILTER
SERVO PUMP
TCM / OVER SPEED TM
LVDT
TM
MAIN PUMP
FUEL TEMP
FMV
SW
BOOST PUMP
HPSOV
FUEL FLOW TRANSMITTER
PRIMARY
SECONDARY
FDV
EEC
SERVO MIN PRESSURE & PUMP SHARING VALVE
PRV
BDCV
ΔP SENSOR
EJECTOR PUMP
FUEL MANIFOLD
FUEL FILTER
FLOAT VALVES
ECOLOGY COLLECTOR TANK
SIMPLEX NOZZLES (x6)
DUPLEX NOZZLES (x12)
DRAIN MAST
0
FF
KG/ H
0
ENG 2 FUEL FILTER CLOG
ENGINE WARNING DISPLAY (EWD)
ENGINE
F. USED
3100
KG
3080
CLOG
SYSTEM DISPLAY (SD)
Fuel command line
BDCV: Bypass Direction Control Valve
FDV: Flow Divider Valve
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut-Off Valve
IFPC: Integrated Fuel Pump and Control
PRV: Pressure Regulating Valve

Propulsion Control System (PCS) Principle

GENERAL

• PCS = EIU + FADEC (EEC + PHMU)

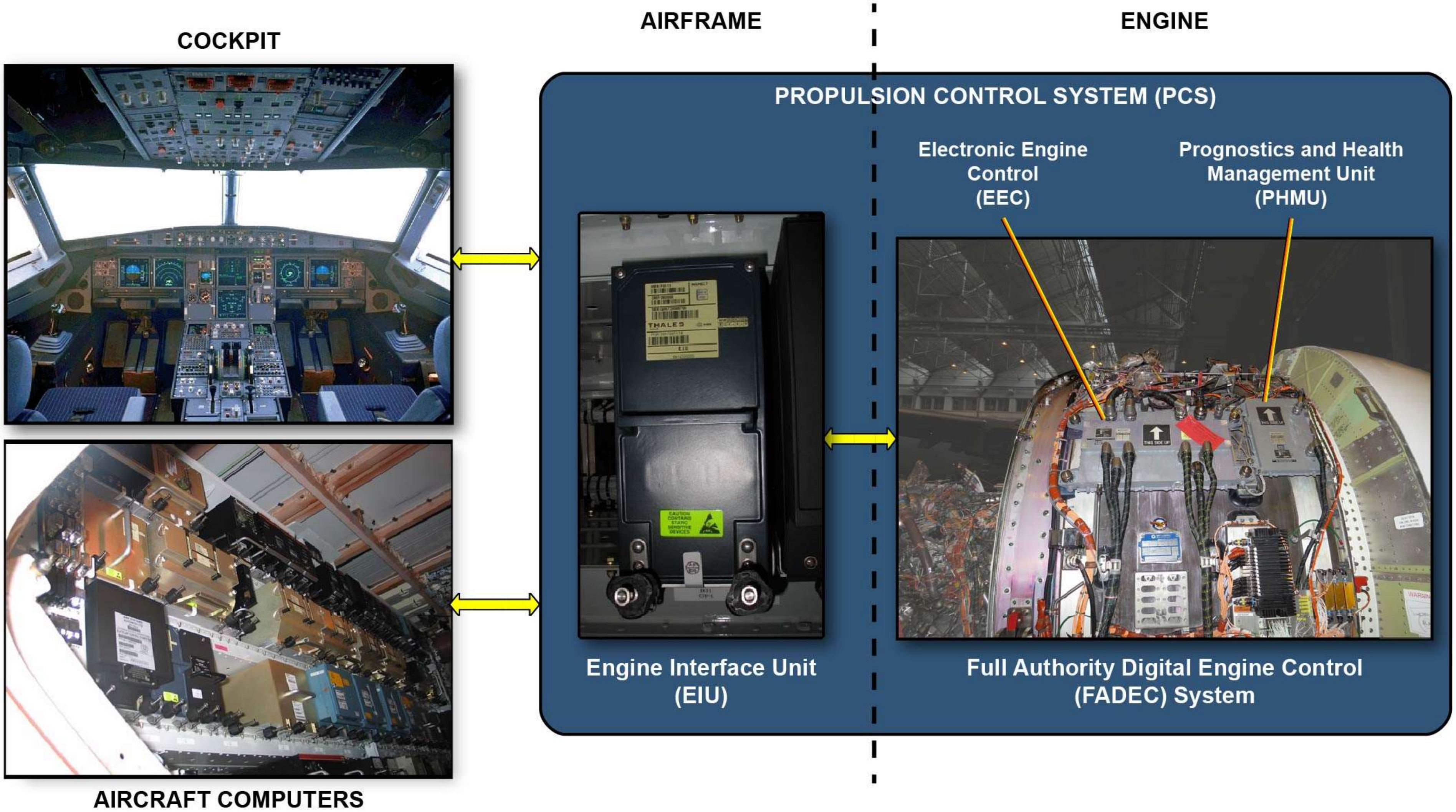
•EIU is located in the avionics bay

The Propulsion Control System (PCS) consists in Engine Interface Unit (EIU) and FADEC System which includes Electronic Engine Control (EEC) and Prognostics and Health Management Unit (PHMU).

Each EIU is dedicated to an engine. EIU 1 and 2 are located in the aircraft avionics bay 80VU.

The EEC and PHMU are attached to the engine fan case assembly at 2:30.

Both EEC & PHMU are vibration-isolated units, which are cooled by natural convection.

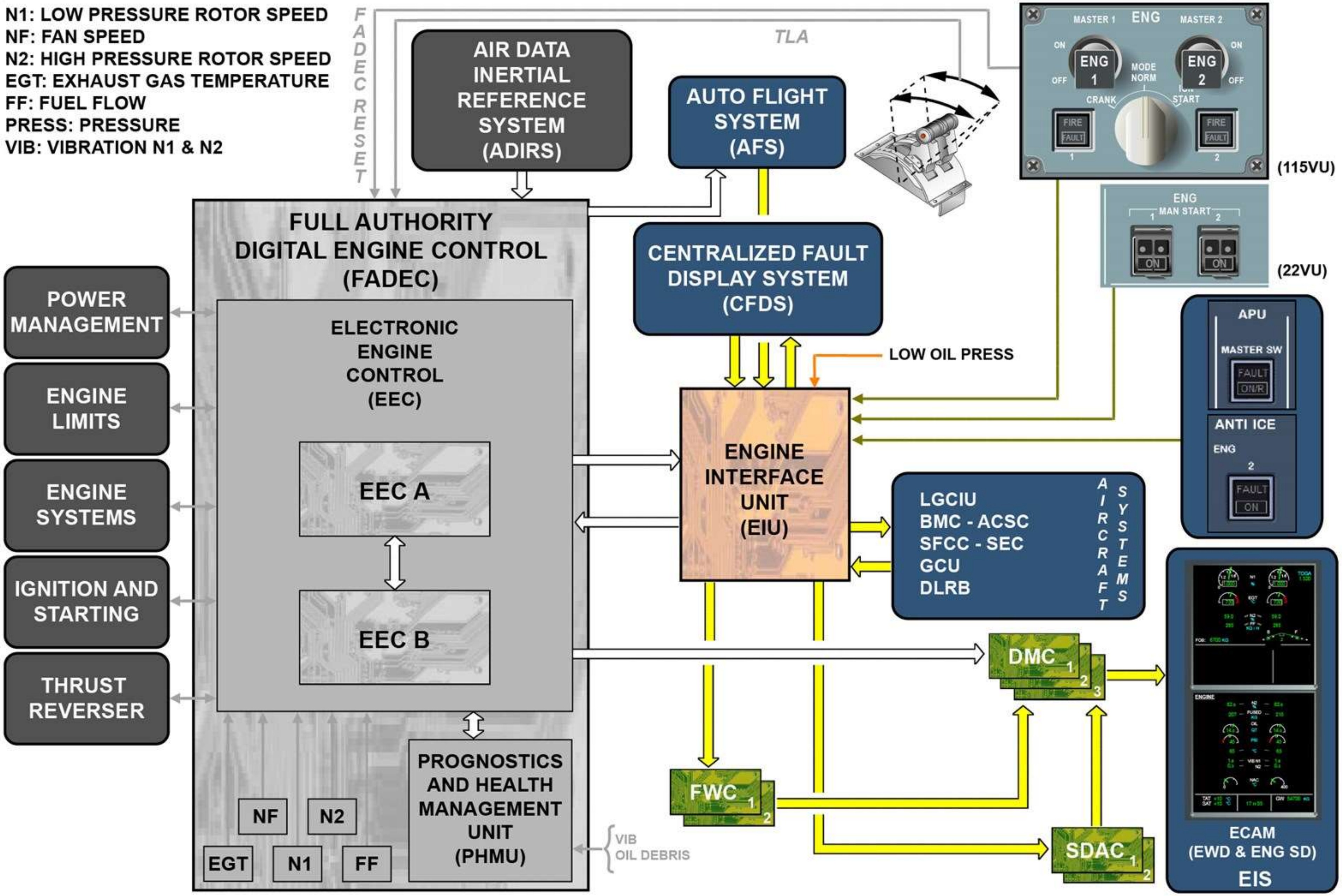

COCKPIT
AIRFRAME
ENGINE
PROPULSION CONTROL SYSTEM (PCS)
Electronic Engine Control (EEC)
Prognostics and Health Management Unit (PHMU)
Engine Interface Unit (EIU)
Full Authority Digital Engine Control (FADEC) System
AIRCRAFT COMPUTERS

ENGINE INTERFACE UNIT

•EIU interfaces the corresponding EEC with Airframe systems

Each EIU is an interface concentrator between the airframe and the corresponding EEC on the engine.
It ensures the segregation of the 2 engines and aircraft electrical power supply to the FADEC.
It concentrates data from or to the cockpit panels and displays.
It gives logics and information to or from other aircraft systems as Flight/Ground from Landing Gear Control and Interface Unit (LGCIU).

N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2



FADEC

• FADEC includes:
- EEC
- PHMU
- Sensors for control and monitoring

•FADEC manages engine thrust, optimizes the performance

The FADEC consists in a dual channel EEC with crosstalk and failure detection, a PHMU and sensors used for control and monitoring.

The FADEC system manages the engine thrust and optimizes the performance.

• EEC interfaces with A/C systems through the EIU

The EEC interfaces with most of the A/C systems through the EIU.

• EEC sends parameters to the ECAM through DMCs

•Vibration parameters are sent by the PHMU

The FADEC controls the engine parameters displayed in the cockpit.

The primary parameters (N1, N2, Exhaust Gas Temperature (EGT) and Fuel Flow (FF)) are sent by the EEC to the ECAM through Display Management Computers (DMCs).

The engine system page shows secondary parameters: oil quantity, pressure and temperature.

The vibration figures are communicated by the PHMU to the EEC.

The Flight Warning System (FWS) will gather necessary information directly from EEC, EIU, System Data Acquisition Concentrator (SDAC) and generates associated messages on Engine/Warning Display (EWD).

N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
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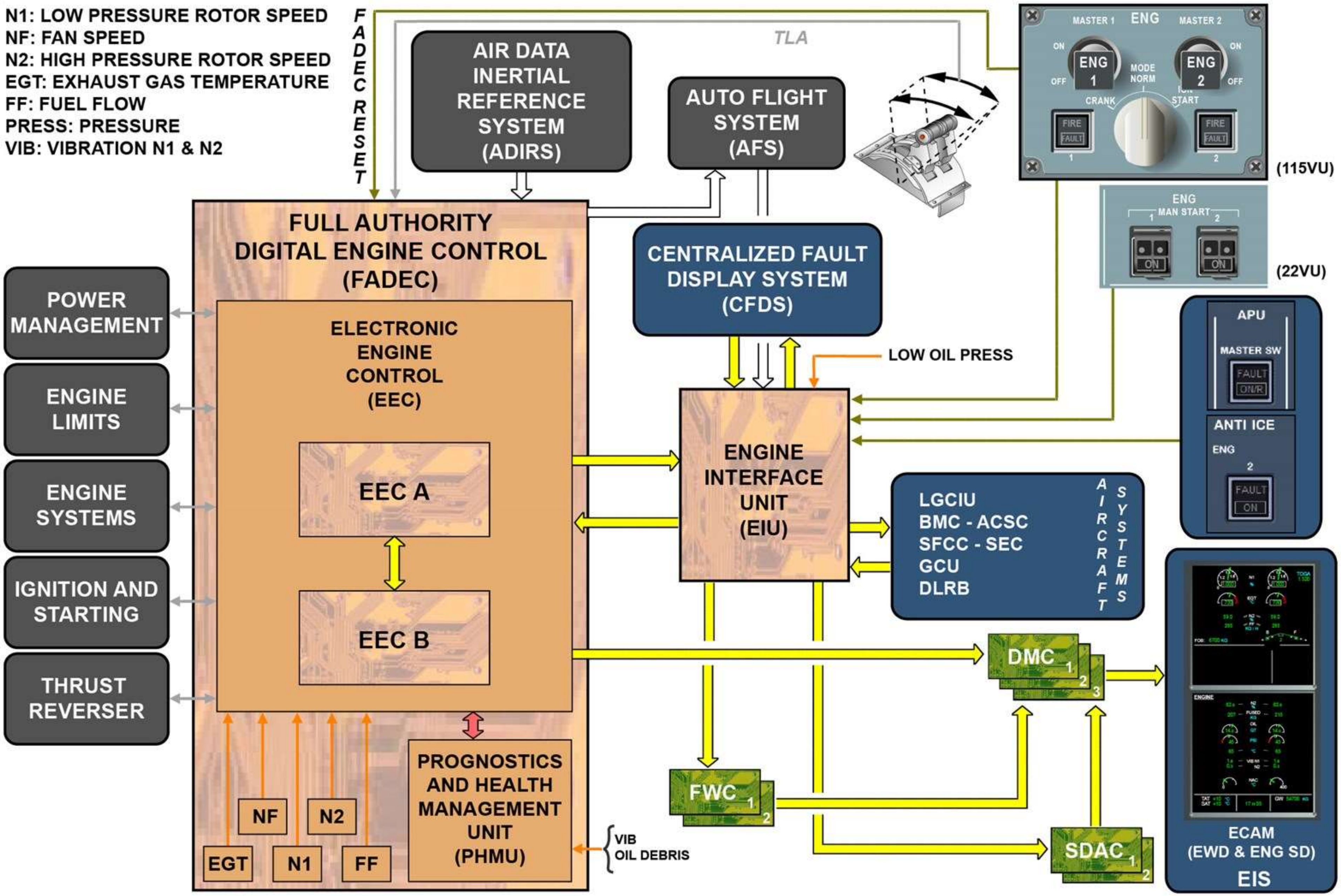
VIB: VIBRATION N1 & N2



POWER MANAGEMENT

•EEC direct link to ADIRS, AFS, TLA

•FADEC provides:

- Engine thrust control: Manual mode with TLA/Autothrust mode generated by the AFS

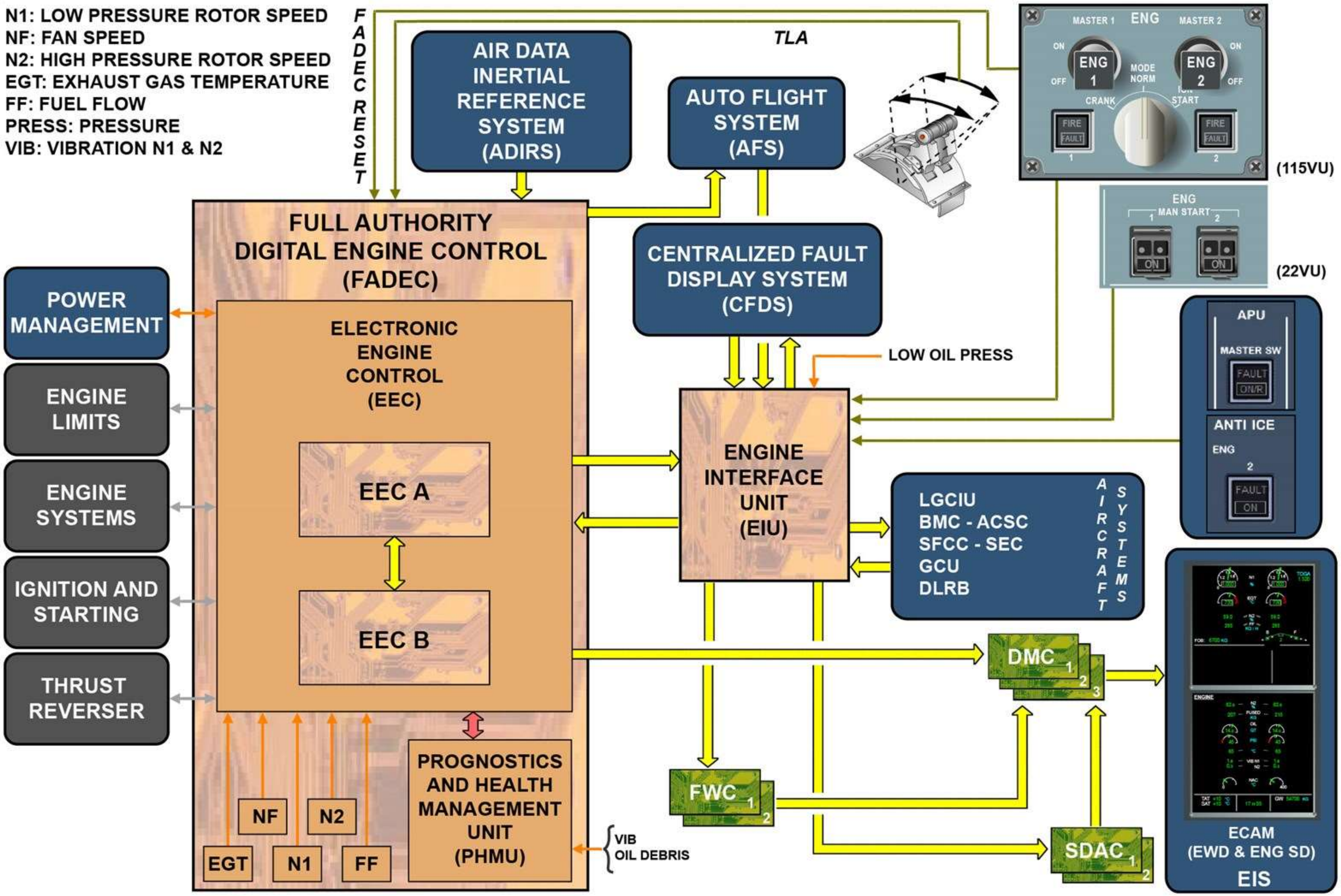
The FADEC provides automatic engine thrust control and thrust parameter limit computation.
The EEC uses air data parameters from Air Data/Inertial Reference System (ADIRS) for rating calculations.
The FADEC manages power according to two thrust modes:
- manual mode depending on Throttle Lever Angle (TLA),
- autothrust mode depending on autothrust function generated by the Auto Flight System (AFS).

•FADEC provides minimum and approach idle

•Idle speed modulated according to:

- Air conditioning demand
- Wing and engine anti-ice demand
- Oil temperature

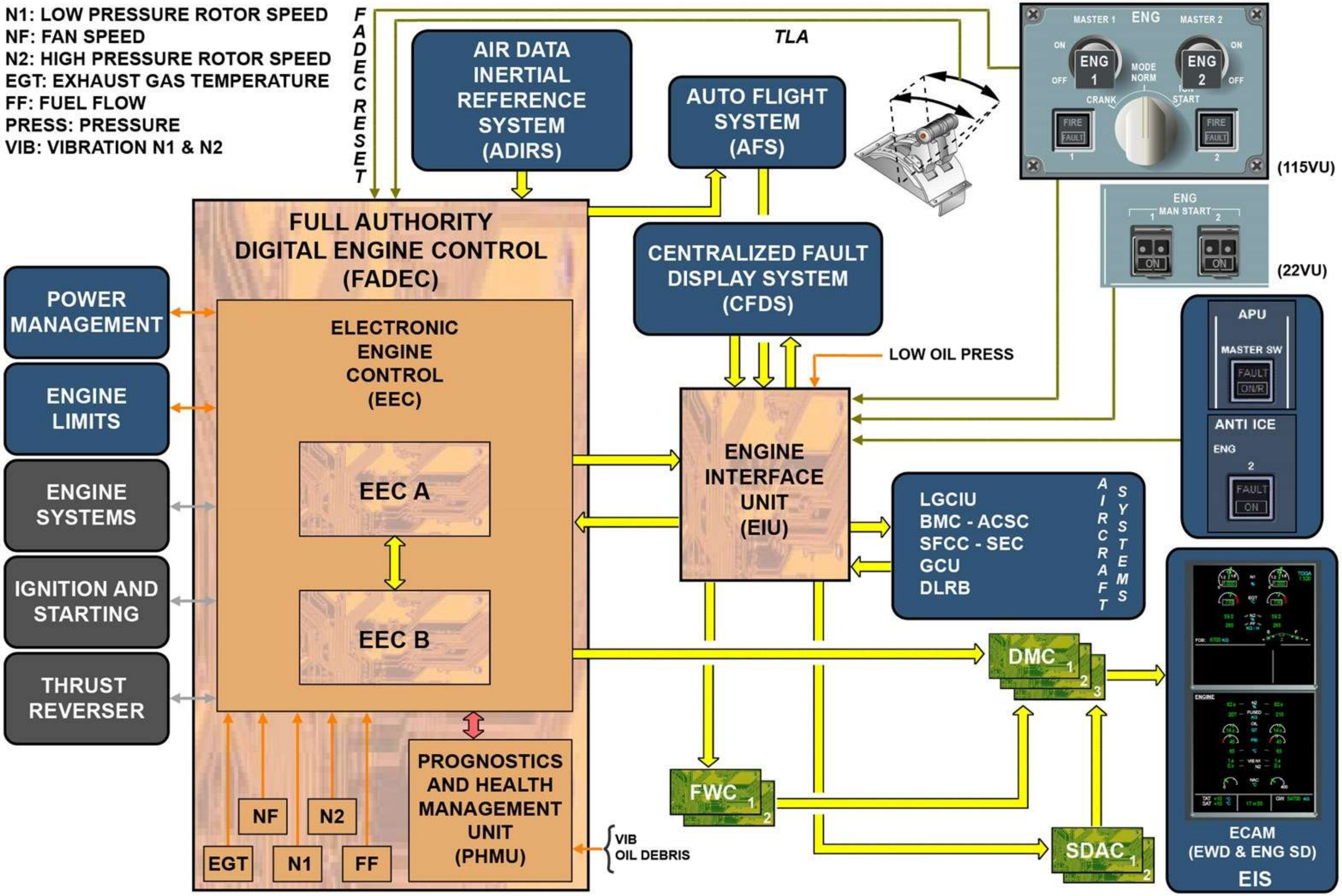
The FADEC also provides two idle mode selections: minimum idle and approach idle.
If the aircraft is on ground and extend the slats the engine will stay at minimum idle but in flight it will go to approach idle. The idle can also be modulated up to approach idle depending on: Air conditioning demand, wing anti-ice demand, engine anti-ice demand and oil temperature (for Integrated Drive Generator (IDG) cooling).


N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
AUTO FLIGHT SYSTEM (AFS)
TLA
MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
ENG 2
MODE
NORM
CRANK
IGN START
FIRE
FAULT
(115VU)
ENG MAN START
ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
ENGINE INTERFACE UNIT (EIU)
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

ENGINE LIMIT PROTECTION

•FADEC provides overspeed protection for N1, N2 (105%)
•Shaft shear detection
•FADEC monitors overheat

The FADEC ensures engine integrity protection. It provides overspeed protection for N1 and N2 or rotor shaft shear by driving to close the Thrust Control Malfunction (TCM)/Overspeed torque motor in the Integrated Fuel Pump and Control (IFPC).
Shaft shear detection logic is only active at high power settings.
It ensures overheat protection by monitoring EGT, nacelle and EEC temperature.


N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
EGT: EXHAUST GAS TEMPERATURE
FF: FUEL FLOW
PRESS: PRESSURE
VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
TLA
AUTO FLIGHT SYSTEM (AFS)
MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
ENG 2
MODE
NORM
CRANK
START
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ENG
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ELECTRONIC ENGINE CONTROL (EEC)
EEC A
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CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
POWER MANAGEMENT
ENGINE LIMITS
ENGINE SYSTEMS
IGNITION AND STARTING
THRUST REVERSER
ENGINE INTERFACE UNIT (EIU)
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
ON
LGCIU
BMC - ACSC
SFCC - SEC
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

ENGINE SYSTEM CONTROL

- FADEC controls:
    - FF
    - Airflow
    - BITE and health monitoring
    - Nacelle Anti-ice

The FADEC provides optimal engine operation by controlling:
- combustor metering valve and fuel flow,
- compressor airflow and turbine case cooling,
- thermal management (oil cooling, fuel heating),
- control and monitoring sensors,
- BITE (fault detection, isolation, annunciation and transmission to the aircraft),
- nacelle anti-ice.

N1: LOW PRESSURE ROTOR SPEED
NF: FAN SPEED
N2: HIGH PRESSURE ROTOR SPEED
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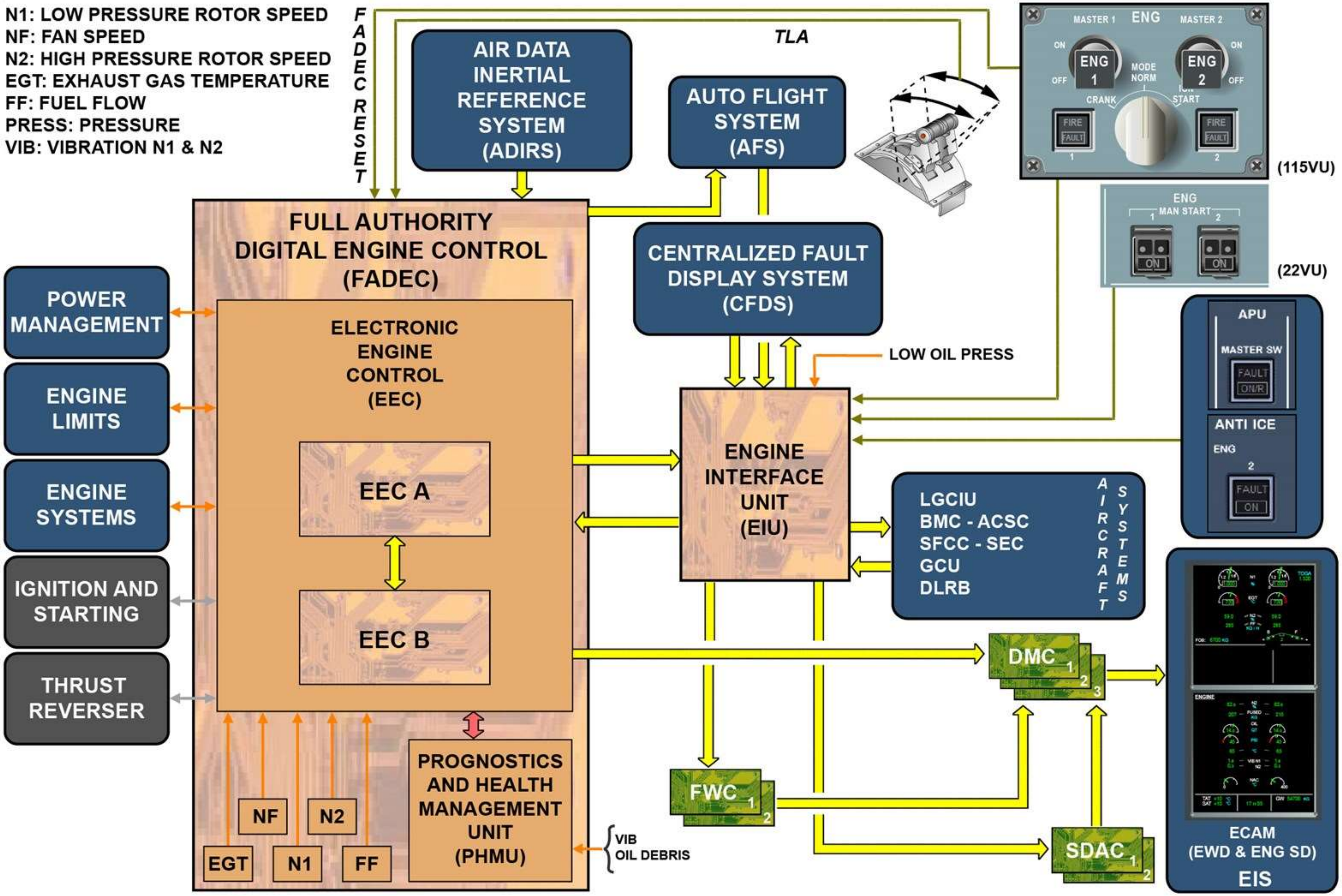
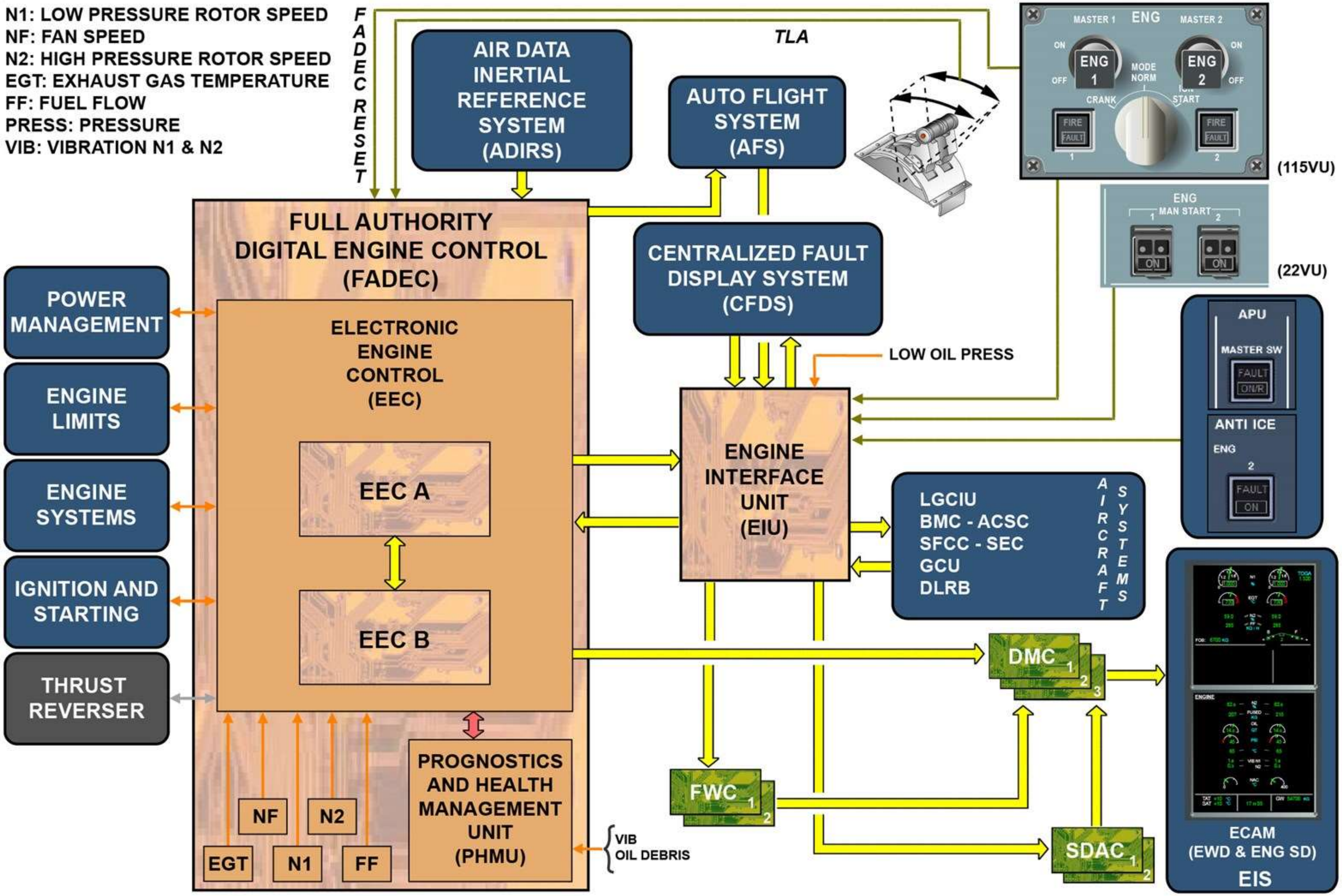


STARTING AND IGNITION CONTROL

• FADEC controls engine start sequence (auto & manual)
•FADEC monitors N1, N2, EGT, oil parameters
•FADEC can abort or recycle engine start

The FADEC controls the engine start sequence in automatic or manual mode when initiated from the control panels.
It monitors N1, N2, EGT and oil parameters and then can abort or recycle an engine start.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VIB: VIBRATION N1 & N2
FADEC RESET
AIR DATA INERTIAL REFERENCE SYSTEM (ADIRS)
TLA
AUTO FLIGHT SYSTEM (AFS)
MASTER 1
ENG
MASTER 2
ENG 1
ENG 2
MODE NORM
CRANK
IGN START
FIRE FAULT
(115VU)
ENG MAN START
ON
(22VU)
FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)
ELECTRONIC ENGINE CONTROL (EEC)
EEC A
EEC B
CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)
LOW OIL PRESS
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG
2
FAULT
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POWER MANAGEMENT
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IGNITION AND STARTING
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LGCIU
BMC - ACSC
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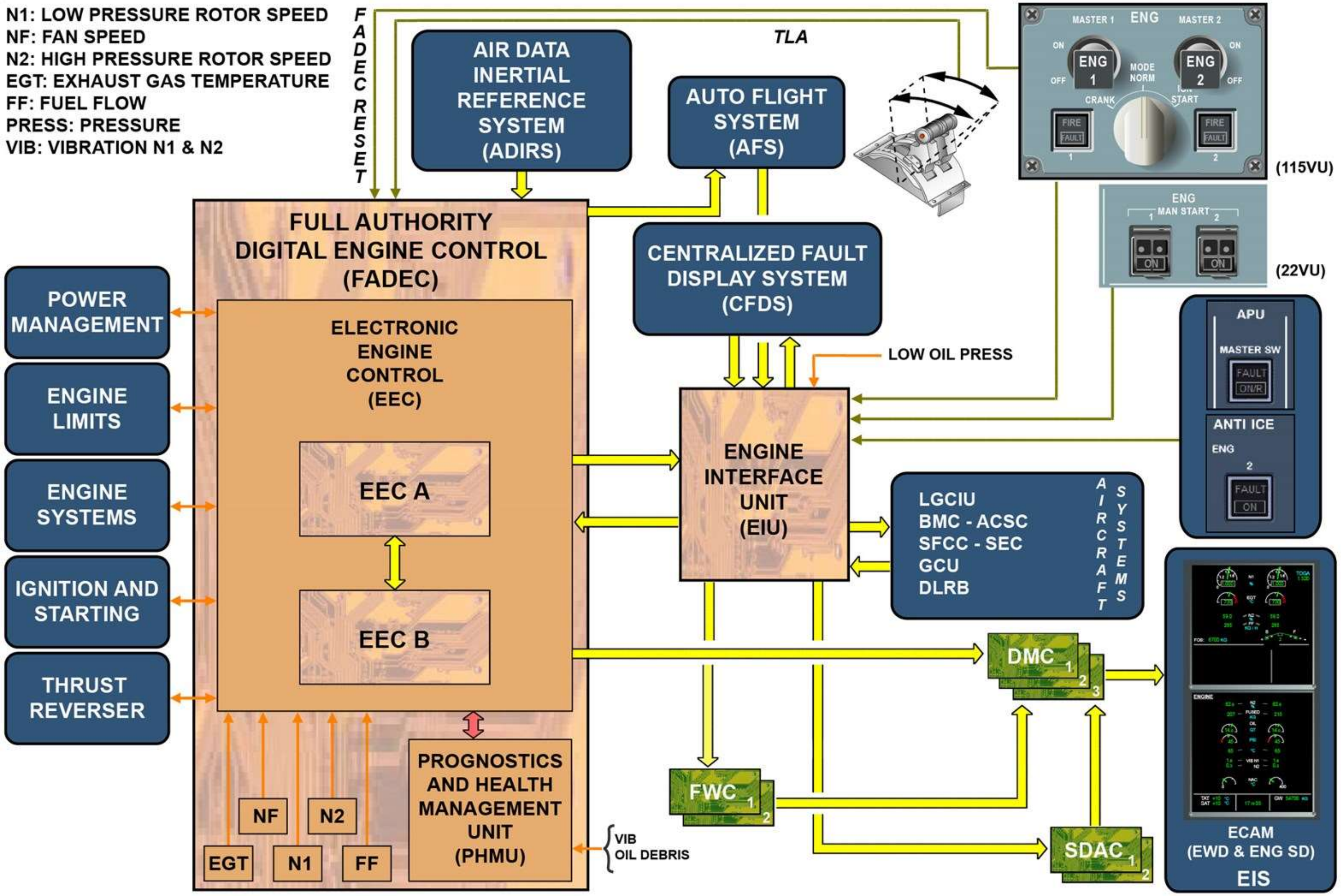
GCU
DLRB
AIRCRAFT SYSTEMS
DMC 1 2 3
FWC 1 2
SDAC 1 2
PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)
VIB
OIL DEBRIS
NF
N2
EGT
N1
FF
ECAM (EWD & ENG SD)
EIS

THRUST REVERSER

FADEC supervises thrust reverser operation

The FADEC supervises the thrust reverser operation



FADEC Architecture

ARCHITECTURE

• FADEC = EEC + PHMU + peripherals

The FADEC consists in the Electronic Engine Control (EEC), the Prognostic and Health Monitoring Unit (PHMU) and peripherals (sensors and output drivers).

EEC

• EEC with two independent channels and a data memory plug (DSU)

•Data is sent internally between the 2 channels by a crosstalk data link

The EEC is a microprocessor controlled digital unit with two independent control channels identified as channel A and B.

Each channel has its own processors, power supply, program memory, selected input sensors and output drivers.

In addition to input/output redundancy (for comparison and backup), data is sent internally between the two channels by a crosstalk data link.

Each channel receives inputs from the A/C and FADEC system sources. Thus, each channel can monitor and control the operation of the engine and transmit engine data to the A/C and to engine subsystem duplicated controls (torque motors and solenoids).

Each channel has two processors: a control processor and a protection processor.

EEC channels A and B are housed in one assembly but are physically divided by a two-piece modular design. Each channel module has one printed circuit board module, the input/output interconnect modules and one pressure sensor.

Five electrical connectors are used in each channel module to connect wiring from the engine, aircraft and nacelle.

The EEC also has a connector to test the unit and a connector for the Data Storage Unit (DSU).

Pamb sensor on channel A and PS14 sensor on channel B.

DSU

• DSU connected to EEC channel A for:

- Engine identification and rating
- Engine trim data storage
- Detected failures storage

The DSU is a data memory plug attached to the engine case bracket by a lanyard and connected on the EEC channel A for engine identification and rating, engine trim data storage and detected failures storage.

DSU data are shared by both EEC channels: Engine thrust rating, N1 modification data, Engine performance package, Engine serial number. N1 modification data is identified by a class number. The engine part number and class number are stamped on the DSU and on the engine identification plate (on the fan case at the 4 o'clock position).

DSU memorizes oil pollution exceedance, engine trim balance solutions.

If the DSU is not installed, the engine cannot start. The EEC will continue to operate even if the DSU disconnects while the aircraft is in flight.

PHMU

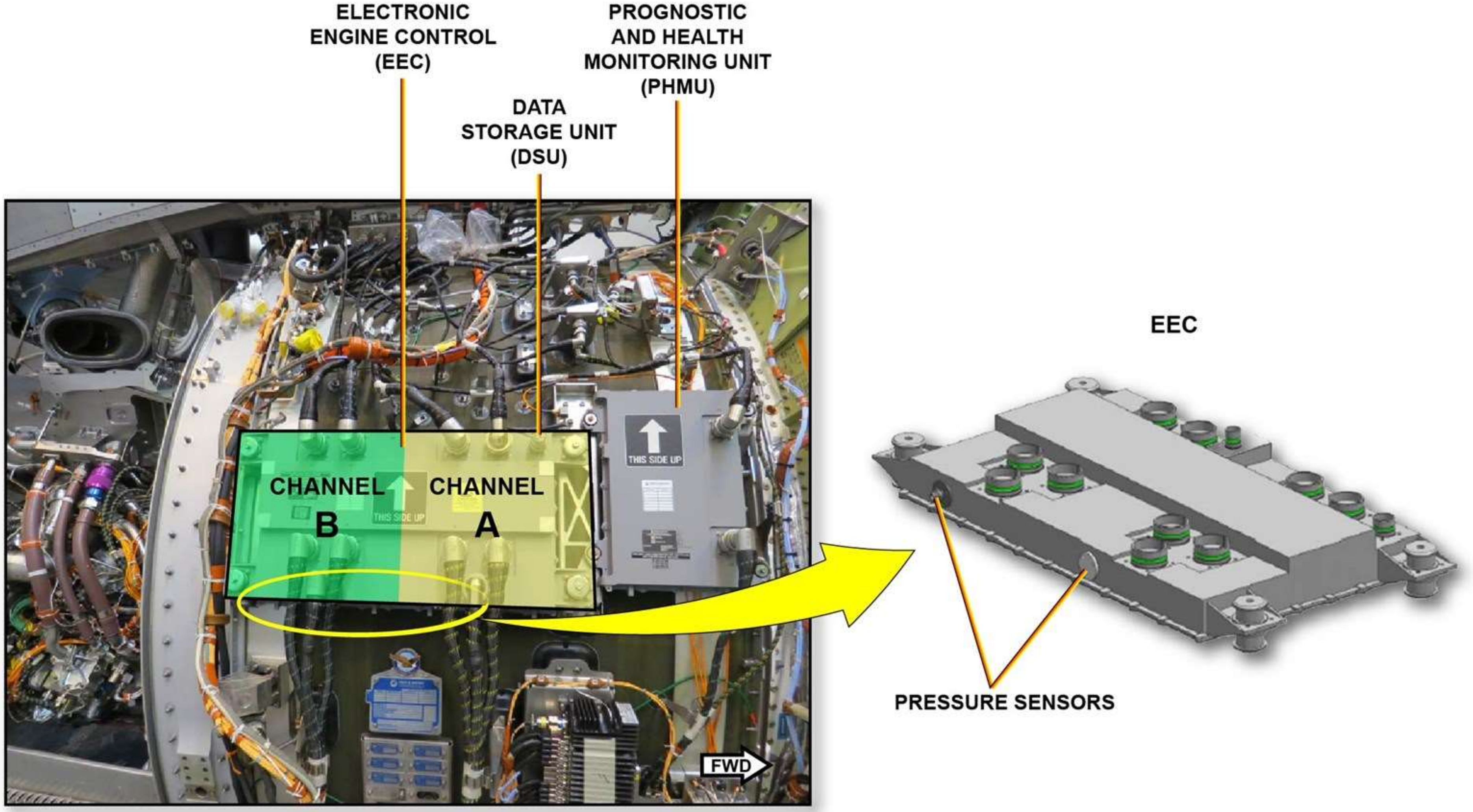
• PHMU performs engine health monitoring functions (vibration, oil pollution)

The PHMU is a single channel component with internal software that performs the following engine health monitoring functions:

- Vibration analysis,
- Engine trim balance solution computation,
- Oil Debris Monitoring (ODM),
- Auxiliary Oil Pressure (AOP) signal conversion.

It uses data provided by several engine sensors and by the EEC and sends back the computed data to the EEC through CAN buses. Two connectors are used for the data exchange.

One connector for EEC exchange and one for vibration, ODM and AOP sensors collection.


ELECTRONIC ENGINE CONTROL (EEC)
PROGNOSTIC AND HEALTH MONITORING UNIT (PHMU)
DATA STORAGE UNIT (DSU)
CHANNEL B
CHANNEL A
THIS SIDE UP
FWD
EEC
PRESSURE SENSORS

PROCESS

• FADEC operations respond to a demand from:
  - A/C
  - internal EEC schedules

•Take into account input from A/C and engine sensors

•Control loop:
  - One EEC channel elaborates single command sent to engine subsystem
  - Command followed (monitoring the dual feedback from subsystem)

Most of the FADEC operations are based on the same principle, they respond to a demand from the A/C or from the EEC internal schedules, and they take into account input parameters from the A/C and from the engine sensors. Most of the sensors and output drivers are duplicated for redundancy and segregated to each EEC channel.
For a control loop, one EEC channel elaborates a single command signal sent to an engine subsystem control and it makes sure that its command has been followed by monitoring the dual feedback from this engine subsystem. The EEC also continuously performs integrity test of its control circuits.

• 1st operating mode is Active-Standby mode:
  - Both channels healthy
  - Only 1 EEC channel has full authority over all engine functions
  - This channel is identified as the preferred channel

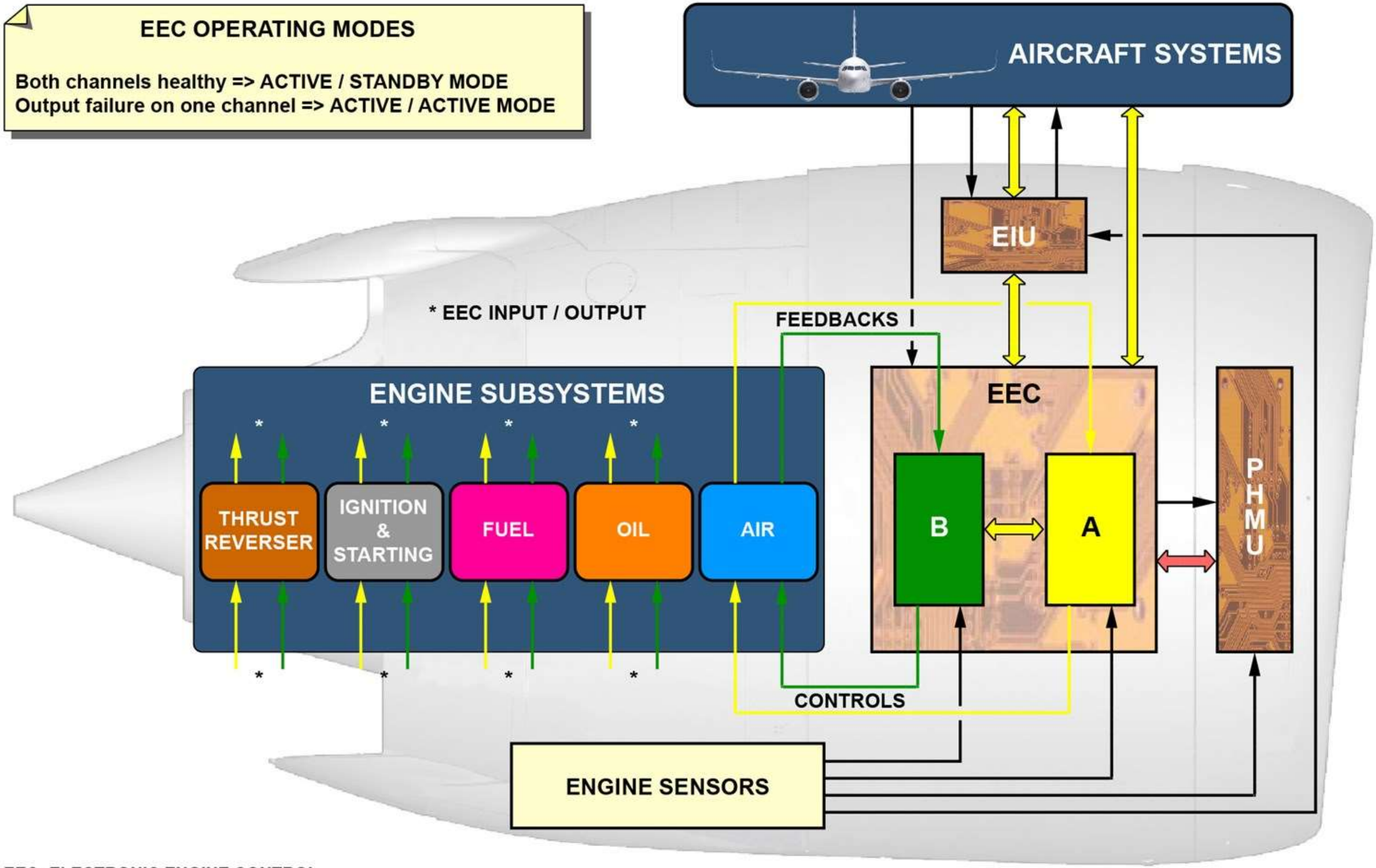
When fully operational, the EEC starts and operates in an Active-Standby mode. Under this control scheme, only one channel of the EEC has full authority over all engine functions and is identified as the preferred channel. The preferred channel is alternated upon every engine shutdown for the next engine start.
If a feedback fault is detected in the preferred channel, the data is retrieved from the standby channel via the crosstalk data link.

• 2nd operating mode is Active- Active mode:
  - Output failure on one channel
  - Both channels engaged simultaneously
  - Either channel can control any of the output drivers independently

If an output driver fault is detected, the EEC switches from Active-Standby mode to Active-Active mode. This allows either channel to control any of the output drivers independently, regardless of which channel is the preferred channel.
This control mode allows both channels to be engaged simultaneously and to manage different engine functions, providing an effective fault accommodation strategy. If the crosstalk data link is lost, each channel maintains its current controls prior the failure.
If the engine subsystem control loop is no more possible (by any channel), the subsystem control is set to its failsafe position.

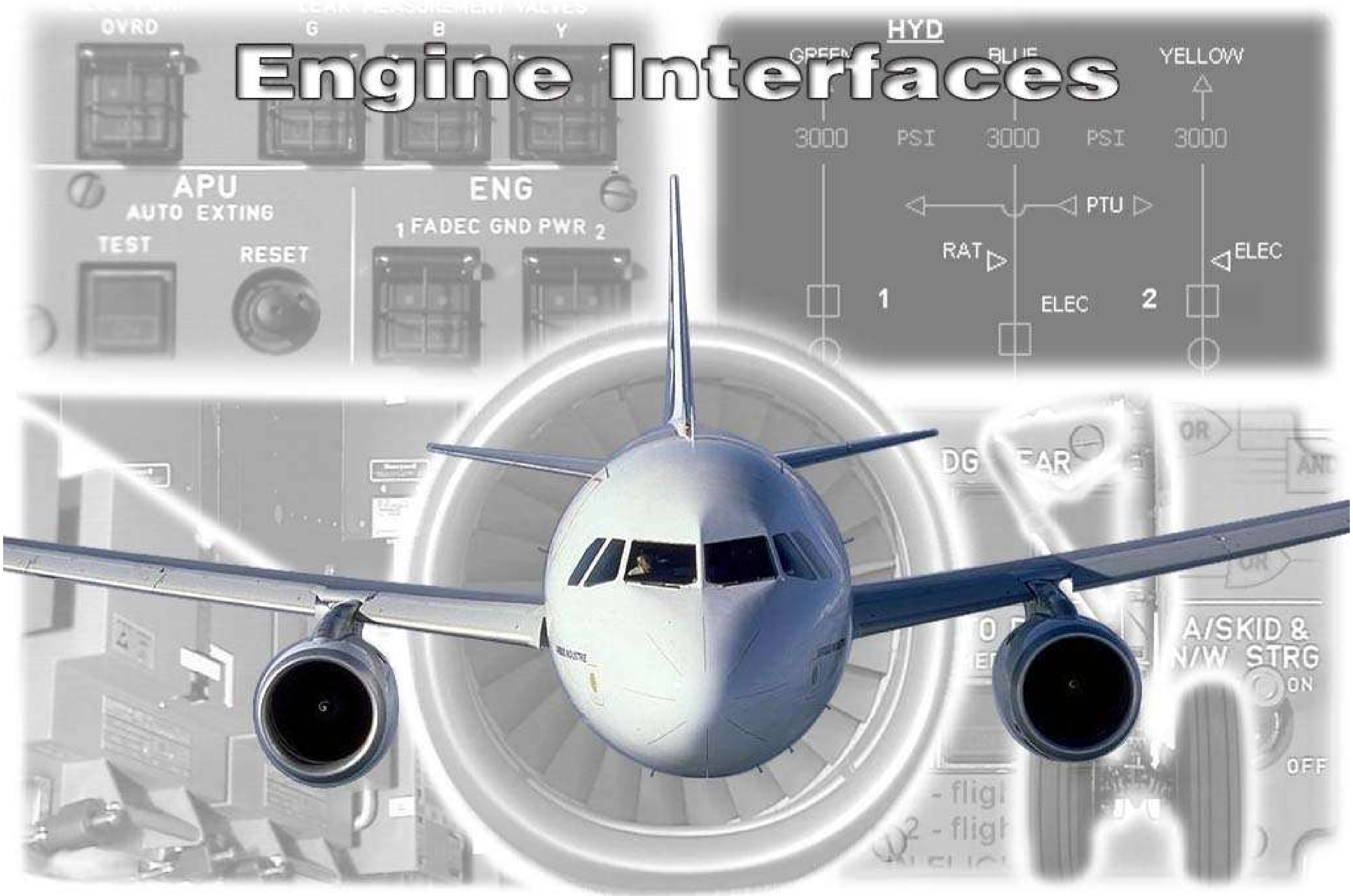
EEC OPERATING MODES

Both channels healthy => ACTIVE / STANDBY MODE
Output failure on one channel => ACTIVE / ACTIVE MODE



EEC: ELECTRONIC ENGINE CONTROL
EIU: ENGINE INTERFACE UNIT
PHMU: PROGNOSTIC AND HEALTH MONITORING UNIT

Engine Interfaces

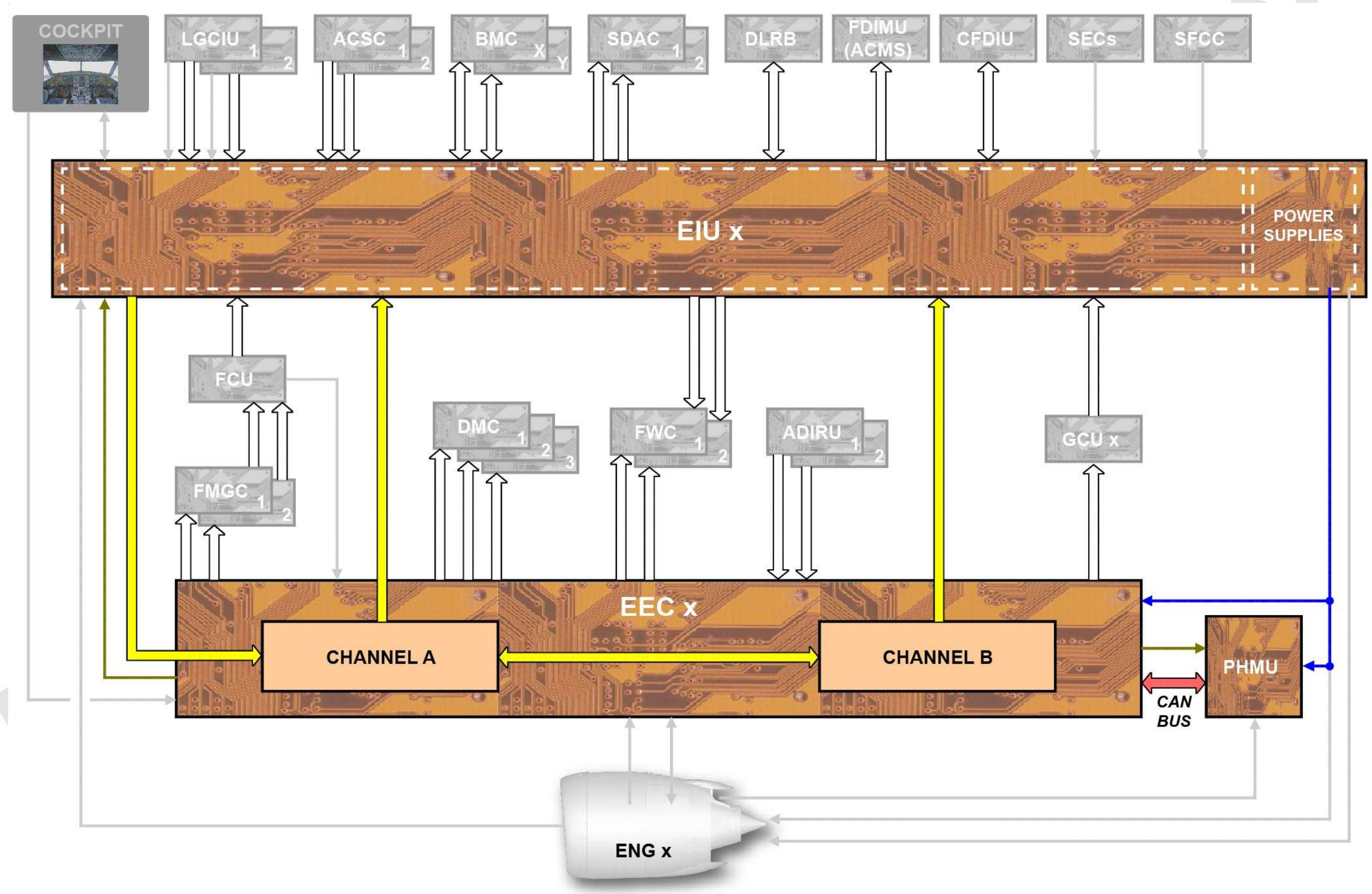


GENERAL

• PCS = EIU + FADEC (EEC+PHMU)

In order to provide a full range of engine control and monitoring, the Propulsion Control System (PCS) exchanges data within its own computers (Engine Interface Unit (EIU), Electronic Engine Control (EEC), Prognostic and Health Monitoring Unit (PHMU)) and with the other aircraft systems computers. The EIU is the main interface with the aircraft systems.

Inputs or outputs are transmitted on a digital, analog or discrete format.



PCS INTERFACES

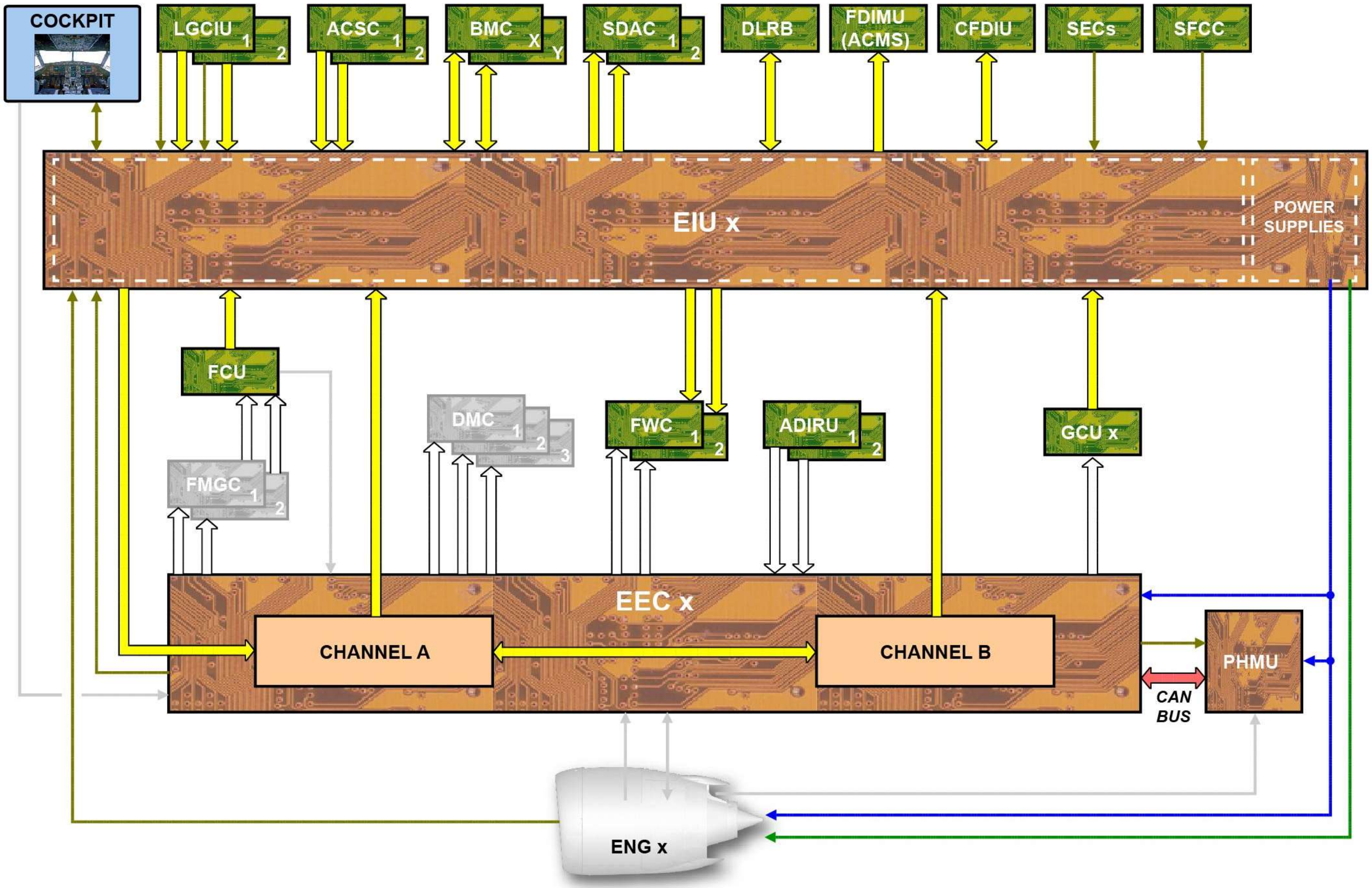
• EIU performs bus transfer
  • EIU digital inputs
  • EIU digital outputs

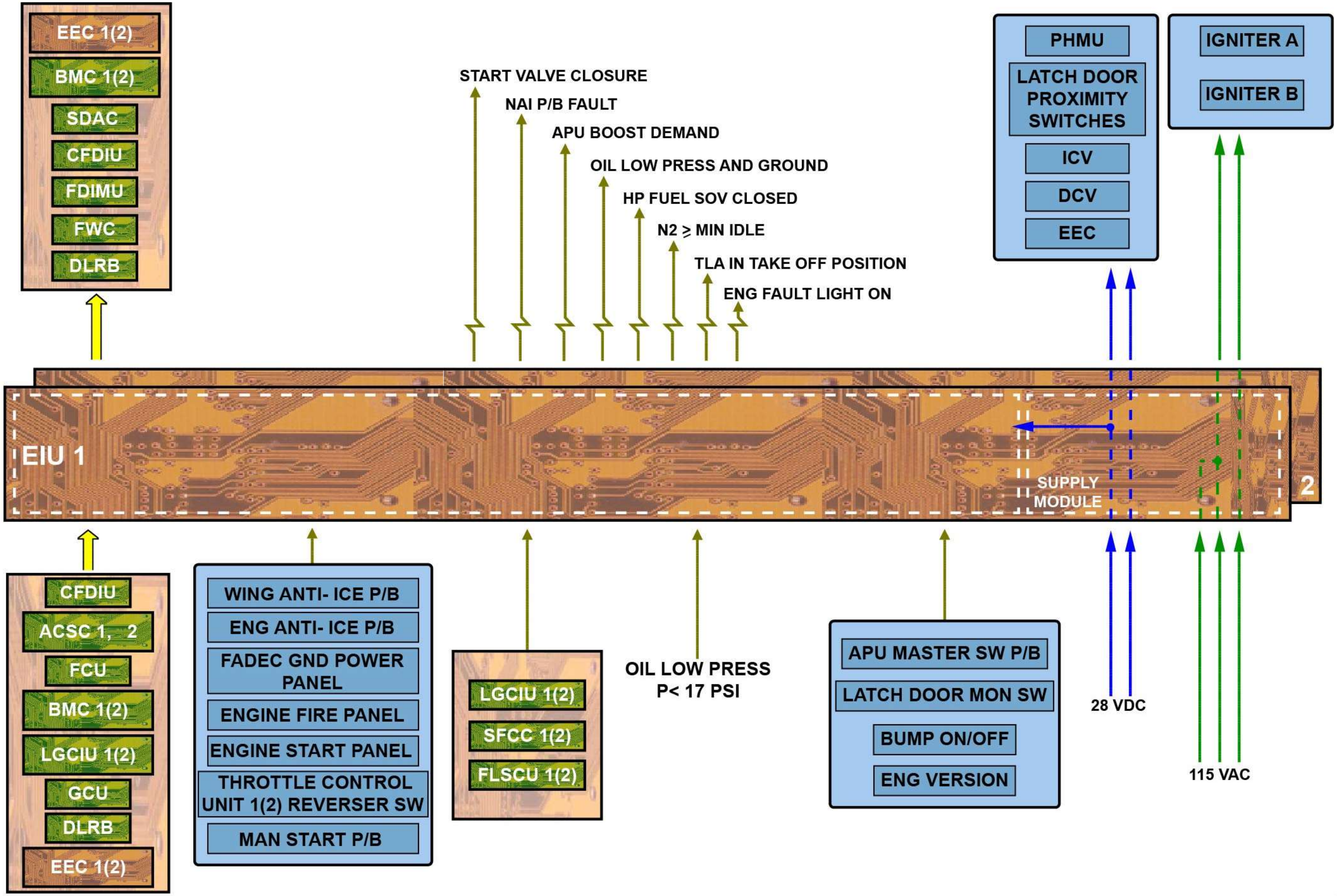
The EIU performs the following bus transfer.
EIU digital inputs from:
GCU #: for idle modulation based on Integrated Drive Generator (IDG) load.
DLRB: for EIU dataloading.
ACSC 1/2: for bleed decrement computation.
CFDIU: for BITE purposes (Normal Mode and Menu Mode).
BMC 1/2: for bleed computation.
LGCIU 1/2: for flight/ground status computation.
FCU: for Autothrust function and Thrust Control Malfunction (TCM) protection in flare.
EIU digital outputs to:
ADIRU 1/2: for air data correction.
CFDIU: for BITE purposes (Normal Mode and Menu Mode).
DLRB: for EIU dataloading.
SDAC 1/2: for engine parameters acquisition.
FDIMU (ACMS): for condition monitoring and troubleshooting purpose.
BMC #: for bleed computation
FWC 1/2: for warnings display.

• EIU performs discrete exchange
  • EIU discrete inputs
  • EIU discrete outputs

The EIU performs the following discrete exchange.
EIU discrete inputs from:
From cockpit controls:
- Master lever ON/OFF
- Throttle position (switches): for thrust reverser operation.
- Rotary selector Ignition/Auto/Crank
- Wing De-Ice P/B OFF: for bleed decrement computation.
- Nacelle Anti-Ice P/B ON/OFF: for Nacelle Anti-Ice (NAI) control and bleed decrement computation.
- Fire handle ON: for engine isolation.
- Manual Engine Start P/B ON
- FADEC Ground Power ON
- Bump ON/OFF
- APU Master Switch ON/OFF: for bleed decrement computation.
From LGCIUs:
- LH Landing Gear compressed: for flight/ground status computation.
- RH Landing Gear compressed: for flight/ground status computation.
- Nose Landing Gear (NLG) compressed: for flight/ground status computation.
From SECs:
- Ground Spoiler OUT
- TLA < -3 deg
From SFCC:
- Flaps and Slats lever retracted
From engine:
- FRTTV Selected OFF (EEC)
- Low Oil Pressure sensor: for OIL LO PRES warning.
- Engine position and type
- Latch Door Monitoring Proximity Switches.

EIU discrete outputs:
Fuel HPSOV Closed
N2 Not Below Idle
TLA in Take Off Position
Start Valve Closure
APU Boost Command
Master Lever Fault Light
Oil Low pressure and Ground
NAI P/B Fault Light
Latch Door Monitoring Proximity Switches
• EIU provides power supplies
The EIU provides the following power supplies.
EIU power supply outputs to:
PHMU (28V DC).
Hydraulic pump depressurization solenoid (28V DC).
EEC channels (28V DC).
Igniters (115V AC).
Thrust reverser Valves (28V DC for ICV & DCV).


COCKPIT
LGCIU 1 2
ACSC 1 2
BMC X Y
SDAC 1 2
DLRB
FDIMU (ACMS)
CFDIU
SECs
SFCC
EIU x
POWER SUPPLIES
FCU
DMC 1 2 3
FWC 1 2
ADIRU 1 2
GCU x
FMGC 1 2
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN BUS
ENG x


EEC 1(2)
BMC 1(2)
SDAC
CFDIU
FDIMU
FWC
DLRB
START VALVE CLOSURE
NAI P/B FAULT
APU BOOST DEMAND
OIL LOW PRESS AND GROUND
HP FUEL SOV CLOSED
N2 ≥ MIN IDLE
TLA IN TAKE OFF POSITION
ENG FAULT LIGHT ON
PHMU
LATCH DOOR PROXIMITY SWITCHES
ICV
DCV
EEC
IGNITER A
IGNITER B
EIU 1
SUPPLY MODULE
2
CFDIU
ACSC 1, 2
FCU
BMC 1(2)
LGCIU 1(2)
GCU
DLRB
EEC 1(2)
WING ANTI- ICE P/B
ENG ANTI- ICE P/B
FADEC GND POWER PANEL
ENGINE FIRE PANEL
ENGINE START PANEL
THROTTLE CONTROL UNIT 1(2) REVERSER SW
MAN START P/B
LGCIU 1(2)
SFCC 1(2)
FLSCU 1(2)
OIL LOW PRESS P< 17 PSI
APU MASTER SW P/B
LATCH DOOR MON SW
BUMP ON/OFF
ENG VERSION
28 VDC
115 VAC

•EEC provides power supplies

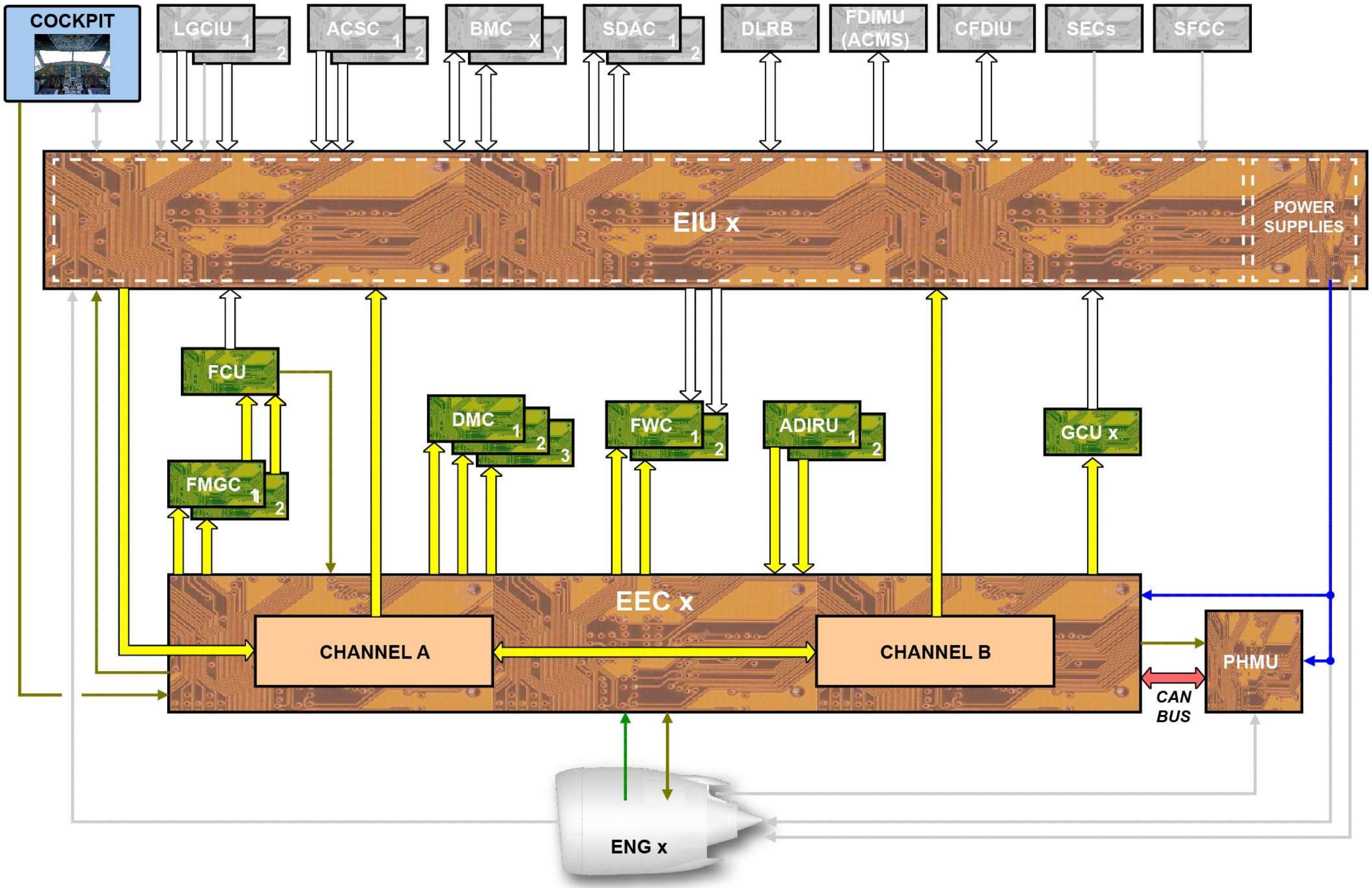
- EEC digital inputs
- EEC digital outputs

Unless specified differently, signals are dual (from/to both EEC channels).
The EEC performs the following bus transfer.
EEC digital inputs from:
EIU # (channel A): for aircraft data exchange.
ADIRU 1/2: for engine control (alt, TAT, PT, CAS, Mn).
PHMU: for vibration monitoring and trim balancing.
EEC digital outputs to:
EIU #: for engine data exchange.
FMGC 1/2: for Autothrust function and TCM protection in flare.
PHMU: for vibration monitoring and trim balancing.
DMC 1/2/3: for parameters, faults and warnings display.
FWC 1/2: for warnings display.
GCU #: for power supply management.

• EEC provides discrete/analog exchange

- EEC discrete/analog inputs
- EEC discrete/analog outputs

The EEC performs the following discrete/analog exchange.
EEC discrete/analog inputs from:
Cockpit controls:
Master lever OFF: for shutdown and reset.
Throttle position (resolvers): for manual and auto thrust control.
Autothrust disconnect P/B (ch B)
FADEC Ground Power OFF
Nacelle Anti-Ice P/B ON/OFF: for NAI control and bleed decrement computation.
FCU:
Autothrust engagement (ch B)
SECs:
TCM ground operation
Engine:
Engine sensors and subsystems feedbacks
Engine position (ch A).
EEC discrete/analog outputs to:
PHMU:
Nf (ch B), N1 (ch A), N2 (ch A)
Engine subsystems:
Control signals
EIU:
FRTTV Selected OFF.


COCKPIT
LGCIU 1 2
ACSC 1 2
BMC X Y
SDAC 1 2
DLRB
FDIMU (ACMS)
CFDIU
SECs
SFCC
EIU x
POWER SUPPLIES
FCU
FMGC 1 2
DMC 1 2 3
FWC 1 2
ADIRU 1 2
GCU x
EEC x
CHANNEL A
CHANNEL B
PHMU
CAN BUS
ENG x

FADEC INTERFACES

•Dual signals (from/to both EEC channels)
Unless specified differently, signals are dual (from/to both EEC channels).
The EEC is the main controller and monitoring device over the engine subsystems.

AIR SYSTEM

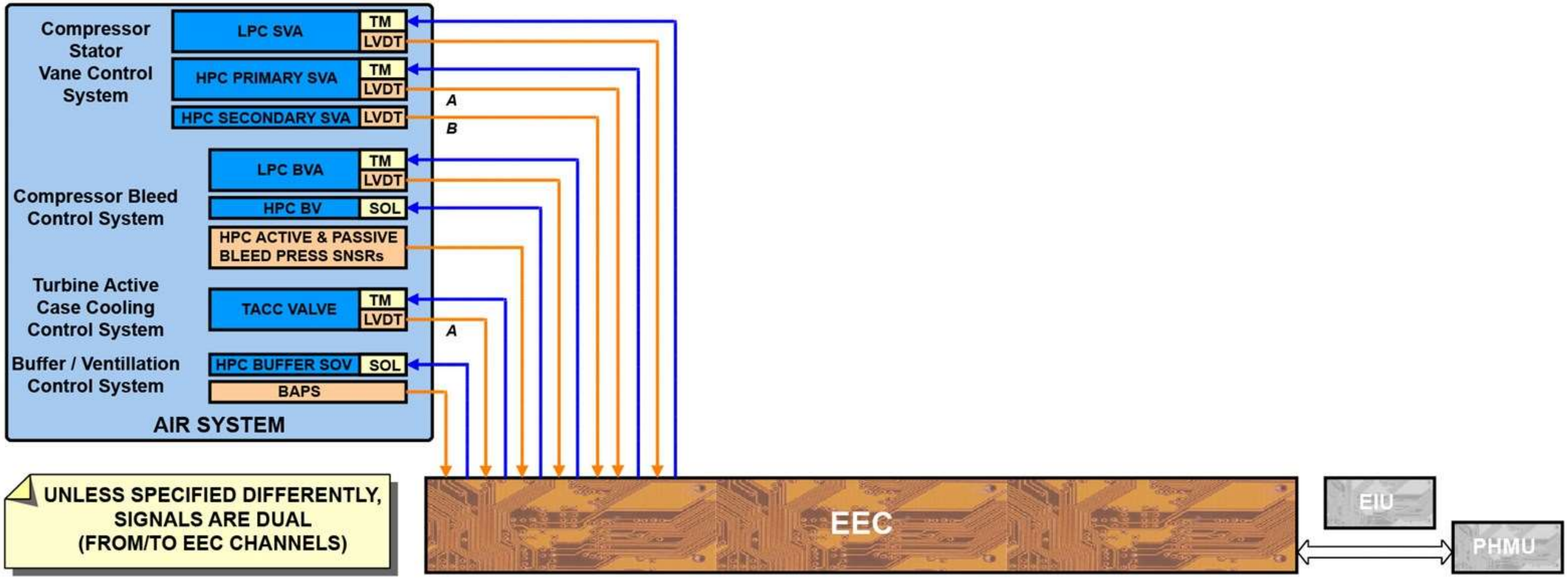
• EEC sends and receives data to/from:
  - Compressor Stator Vane Control System
  - Compressor Bleed Control System
  - TACC Control System
  - Buffer/Ventilation Control System

For the air system management, the EEC sends and receives the following data.
Compressor Stator Vane Control System:
- LPC SVA TM control signal,
- HPC master SVA Torque Motor (TM) control signal,
- LPC SVA, HPC master and slave SVAs LVDT feedback signal.

Compressor Bleed Control System:
- LPC Bleed Valve Actuator (BVA) TM control signal,
- LPC BVA LVDT feedback signal,
- HPC BV solenoid control signal,
- HPC active and passive bleed pressure sensors.

Turbine Active Case Cooling Control System:
- TACC Valve TM control signal,
- TACCV LVDT feedback signal (ch A).

Buffer/Ventilation Control System:
- HPC Buffer Shut Off Valve (SOV) solenoid feedback signal,
- Buffer Air Pressure Sensor (BAPS) feedback signal.



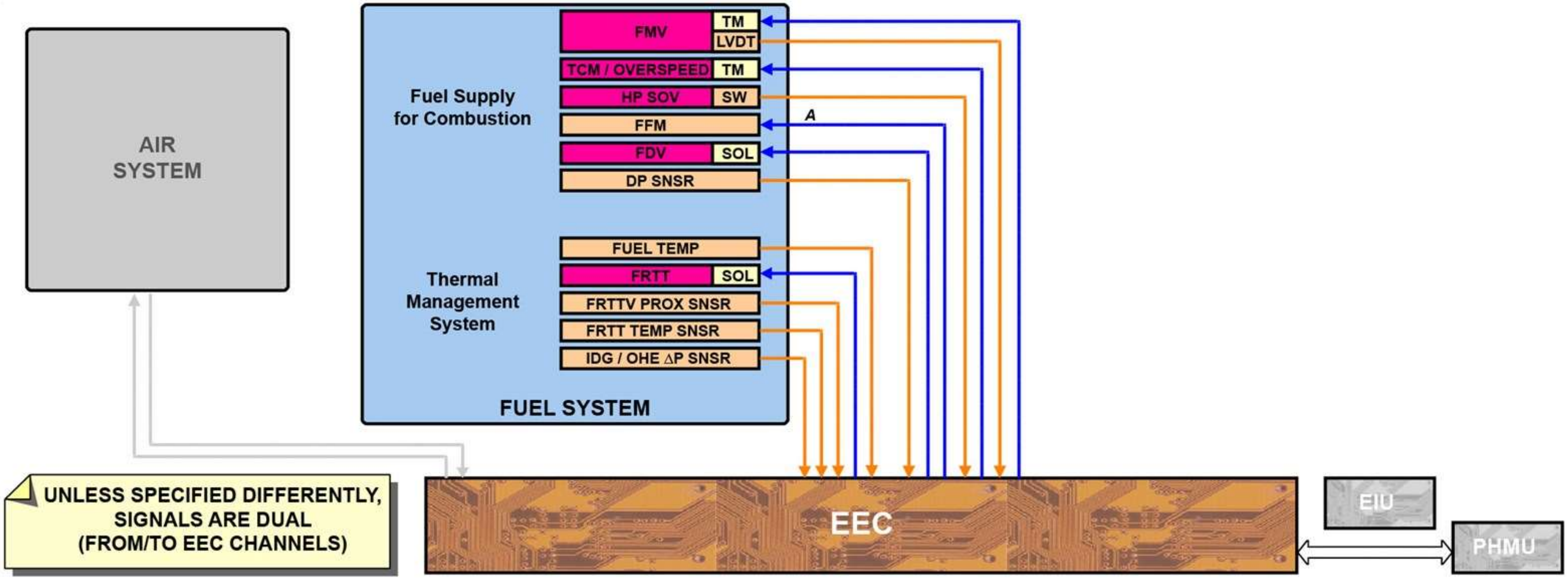
Compressor Stator Vane Control System
LPC SVA
TM
LVDT
HPC PRIMARY SVA
TM
LVDT
A
HPC SECONDARY SVA
LVDT
B
LPC BVA
TM
LVDT
Compressor Bleed Control System
HPC BV
SOL
HPC ACTIVE & PASSIVE BLEED PRESS SNSRs
Turbine Active Case Cooling Control System
TACC VALVE
TM
LVDT
A
Buffer / Ventillation Control System
HPC BUFFER SOV
SOL
BAPS
AIR SYSTEM
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

FUEL SYSTEM

• EEC sends and receives data:
  - Fuel supply for combustion
  - Thermal Management System

For the fuel system management, the EEC sends and receives the following data.
Fuel Supply for combustion:
- Fuel Metering Valve (FMV) TM control signal,
- FMV LVDT feedback signal,
- TCM / Overspeed TM control signal,
- HP Shut Off Valve proximity switch feedback signal,
- Fuel Flow Meter (FFM) control signal (ch A),
- Flow Divider Valve (FDV) solenoid control signal,
- Fuel Filter Differential Pressure Sensor feedback signal.

Thermal Management System:
- Bypass Direction Control Valve (BDCV) solenoid control signal,
- Fuel Temperature sensor feedback signal,
- Fuel Return To Tank (FRTT) Valve solenoid control signal,
- FRTTV Proximity Switch feedback signal,
- FRTT Temperature Sensor feedback signal,
- IDG Fuel/Oil Heat Exchanger Differential Pressure Sensor feedback signal.


AIR SYSTEM
Fuel Supply for Combustion
FMV
TM
LVDT
TCM / OVERSPEED
TM
HP SOV
SW
A
FFM
FDV
SOL
DP SNSR
Thermal Management System
FUEL TEMP
FRTT
SOL
FRTTV PROX SNSR
FRTT TEMP SNSR
IDG / OHE ΔP SNSR
FUEL SYSTEM
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU

OIL SYSTEM

• EEC sends and receives data:
  - Oil Supply
  - Oil monitoring

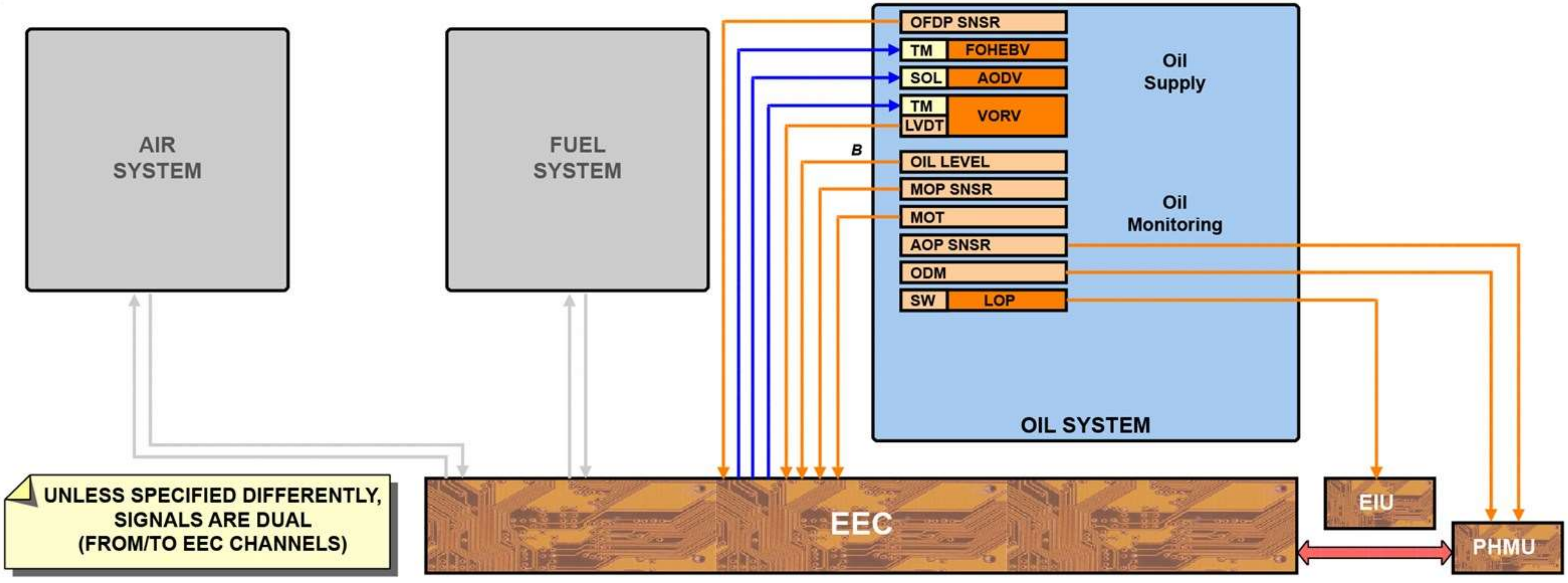
For the oil system management, the EEC sends and receives the following data:

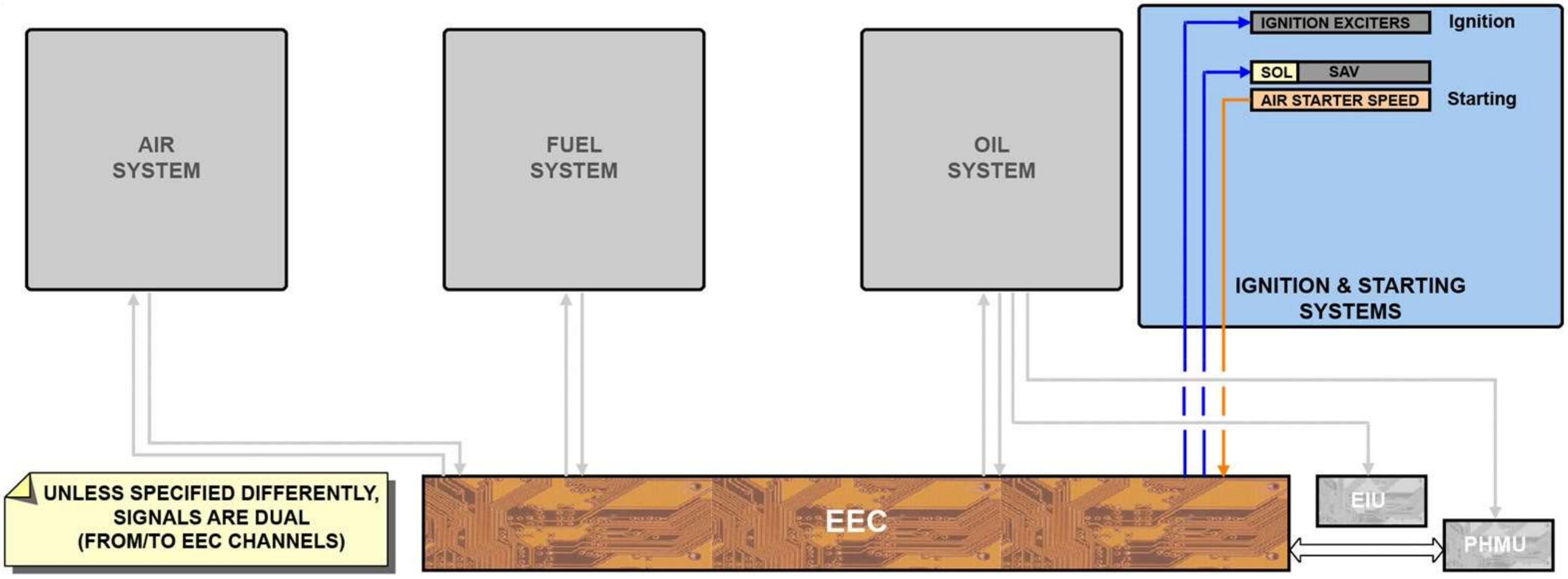
Oil Supply:

- Oil Filter Differential Pressure sensor feedback signal,
- Fuel Oil Heat Exchanger Bypass Valve (FOHEBV) TM control signal,
- Active Oil Damper Valve (AODV) solenoid control signal,
- Variable Oil Reduction Valve (VORV) TM control signal,
- VORV LVDT feedback signal.

Oil Monitoring:

- Oil Level (OL) sensor feedback signal (ch B),
- Main Oil Pressure (MOP) sensor feedback signal,
- Main Oil Temperature (MOT) sensor feedback signal,
- Auxiliary Oil Pressure (AOP) sensor feedback signal via PHMU,
- Oil Debris Monitoring (ODM) sensor feedback signal (ch A) via PHMU,
- Low Oil Pressure (LOP) switch feedback signal to the EIU.


AIR SYSTEM
FUEL SYSTEM
OFDP SNSR
TM
FOHEBV
SOL
AODV
TM
LVDT
VORV
Oil Supply
B
OIL LEVEL
MOP SNSR
MOT
AOP SNSR
ODM
SW
LOP
Oil Monitoring
OIL SYSTEM
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU



IGNITION AND STARTING SYSTEMS

- EEC sends and receives data:
    - Ignition (Exciter)
    - Starting

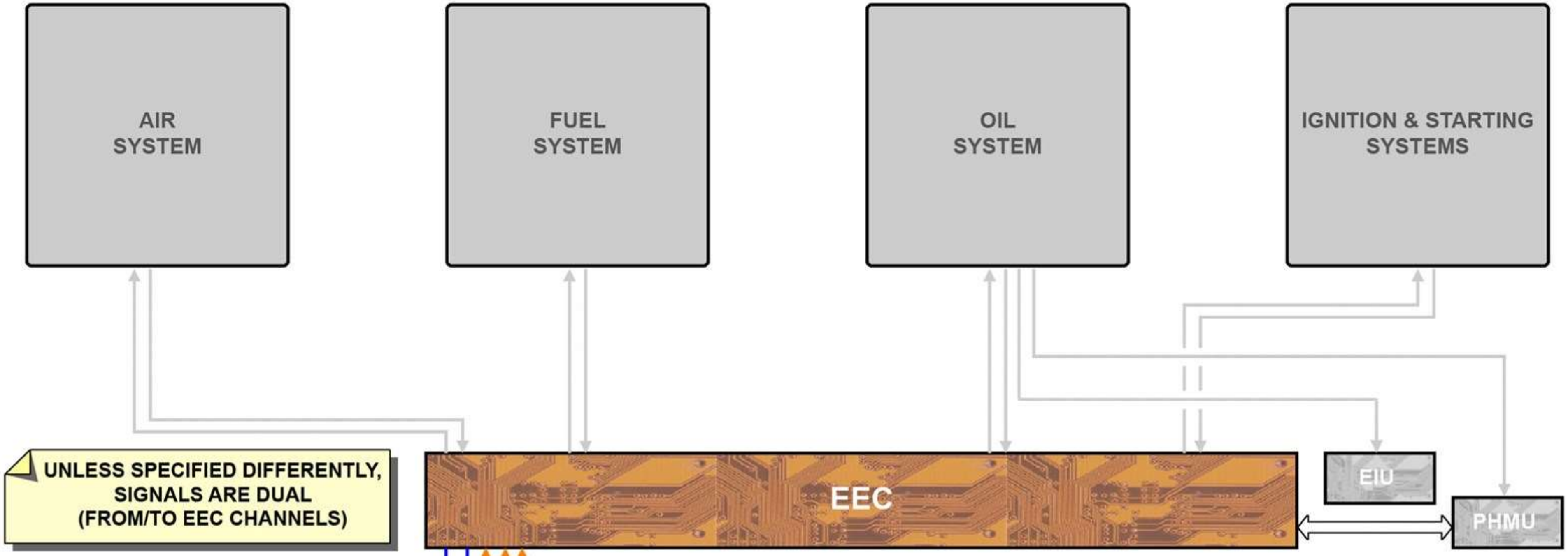
For the ignition and starting systems management, the EEC sends and receives the following data:

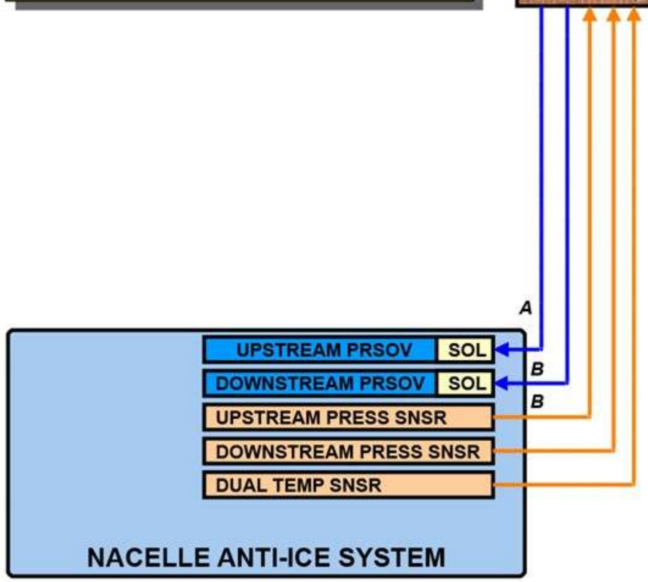
Ignition:

- Ignition Exciter control signal (2 pairs).

Starting:

- Starter Air Valve (SAV) solenoid control signal,
- Air starter speed sensor feedback signal.





NACELLE ANTI-ICE SYSTEM

- The EEC sends and receives data:
  - NAI

For the Nacelle Anti Ice system management, the EEC sends and receives the following data:

NAI:

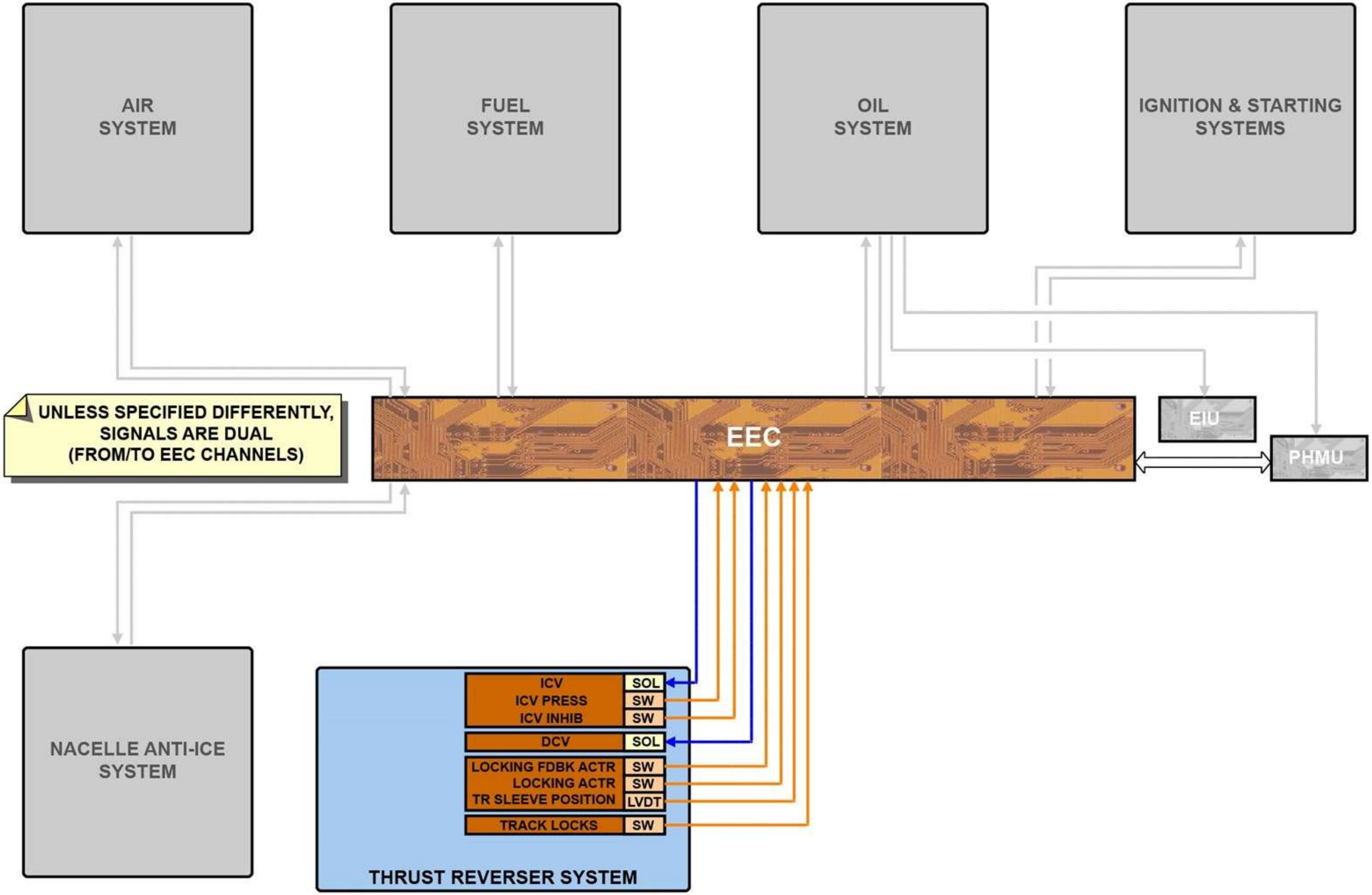
- Upstream PRSOV solenoid control signal (ch B),
- Downstream PRSOV solenoid control signal (ch A),
- Upstream pressure sensor feedback signal (ch B),
- Downstream pressure sensor feedback signal,
- Dual temperature sensor feedback signal.

THRUST REVERSER SYSTEM

• The EEC sends and receives data:
  - Thrust Reverser

For the thrust reverser system management, the EEC sends and receives the following data.
Thrust Reverser:
- Isolation Control Valve (ICV) solenoid control signal by EIU and EEC,
- ICV pressurized proximity switch feedback signal,
- ICV inhibition proximity switch feedback signal,
- Directional Control Valve (DCV) solenoid control signal by EIU and EEC,
- Locking Feedback Actuators primary lock proximity switch feedback signal,
- Locking Actuators primary lock proximity switch feedback signal,
- Locking Feedback Actuators LVDT feedback signal,
- Track Locks proximity switch feedback signal.

Note: Track Lock Valve (TLV) solenoids are controlled independently by SEC.


AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
NACELLE ANTI-ICE SYSTEM
ICV
ICV PRESS
ICV INHIB
SOL
SW
SW
DCV
SOL
LOCKING FDBK ACTR
LOCKING ACTR
TR SLEEVE POSITION
SW
SW
LVDT
TRACK LOCKS
SW
THRUST REVERSER SYSTEM

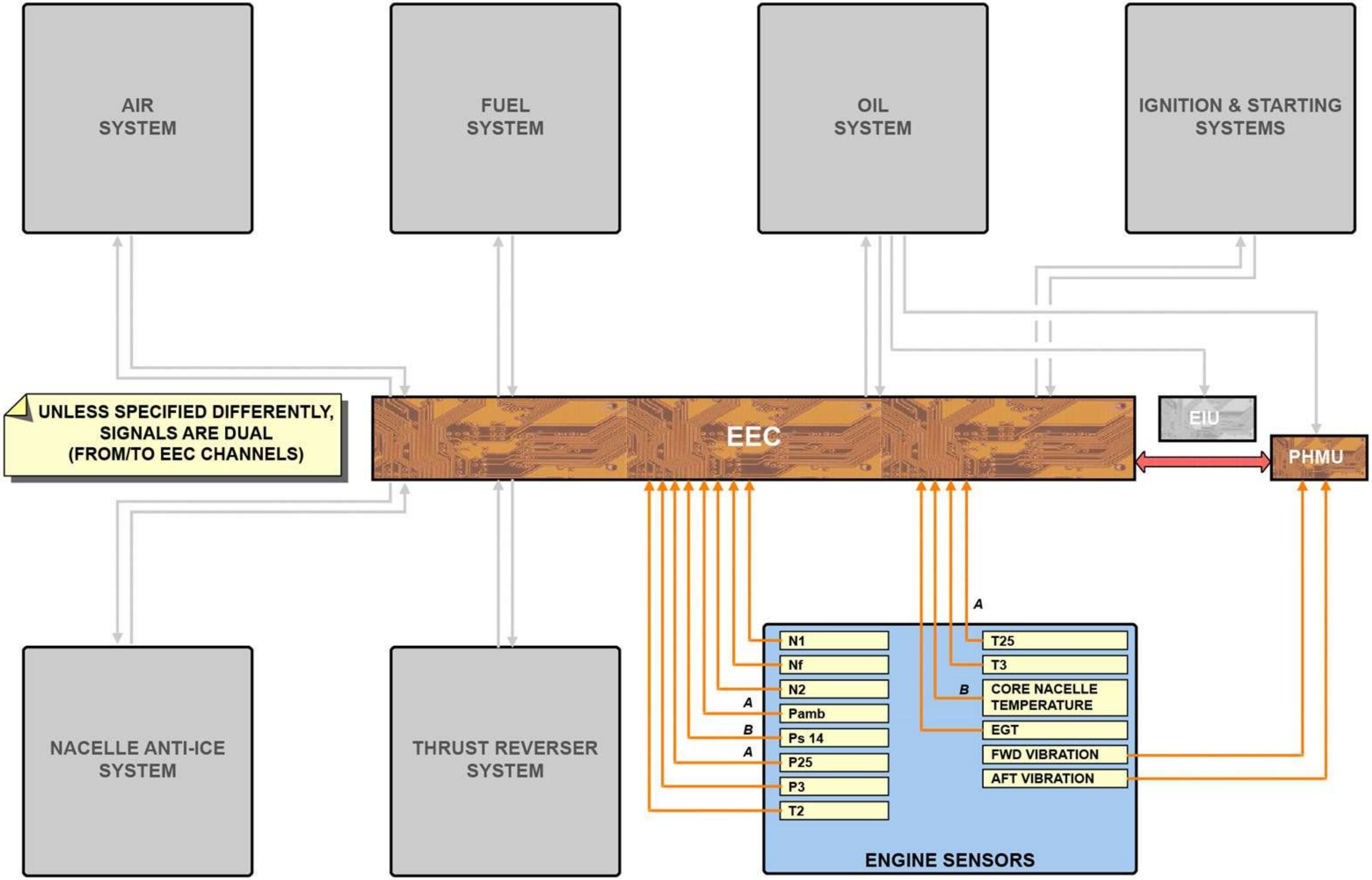
ENGINE SENSORS

• The EEC sends and receives data:
    • Engine sensors

For the engine control and monitoring, the EEC receives the following data.

Engine Sensors:

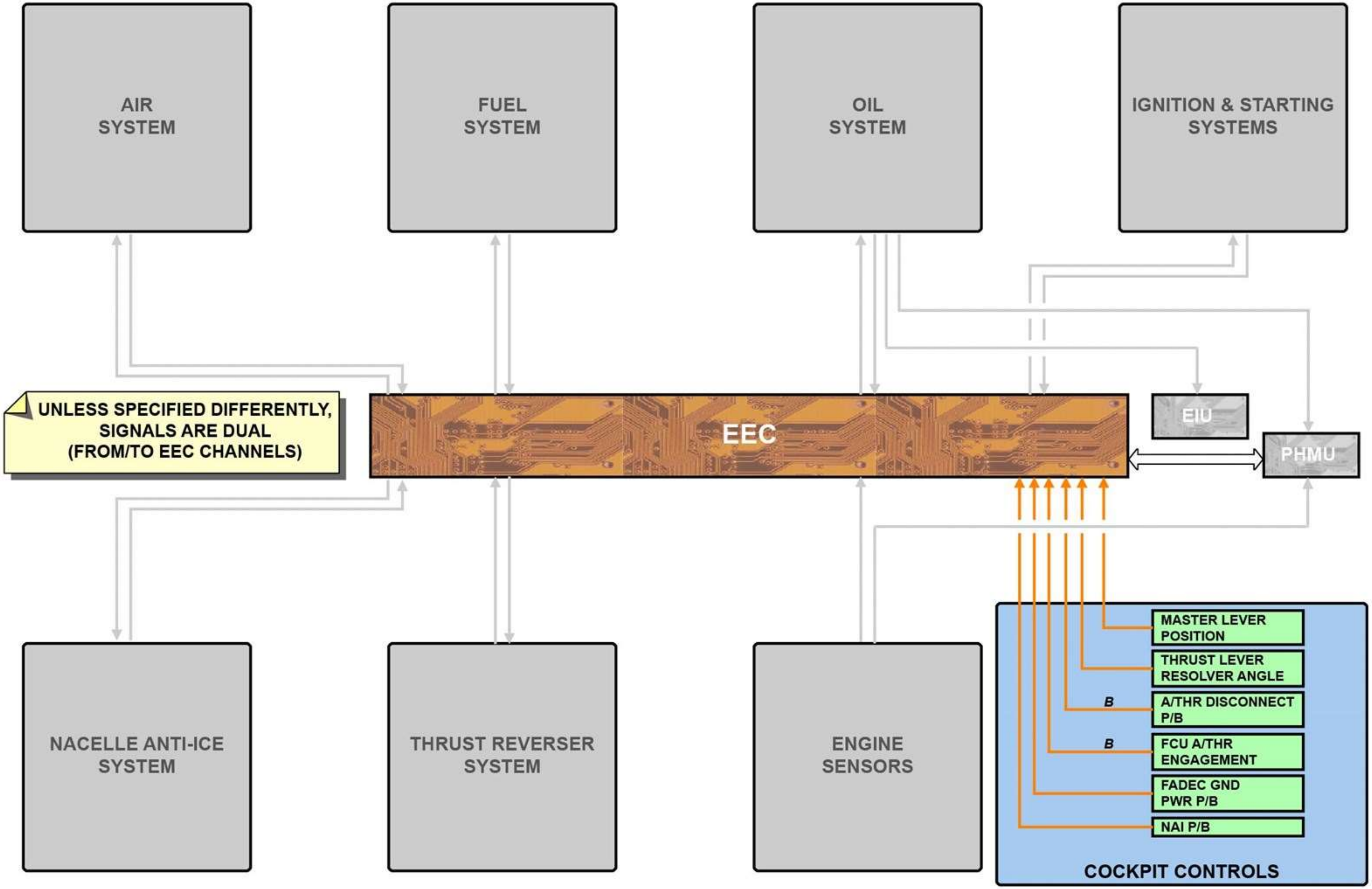
- N1 feedback signal,
- Nf feedback signal,
- N2 feedback signal,
- P ambient feedback signal (ch A),
- Ps14 feedback signal (ch B),
- P25 feedback signal (ch A),
- P3 feedback signal (2 pairs),
- T2 feedback signal,
- T25 feedback signal (ch A),
- T3 feedback signal,
- Core Nacelle Temperature feedback signal (ch B),
- EGT feedback signal (2 pairs),
- Forward Vibration feedback signal to PHMU,
- Aft Vibration feedback signal to PHMU.


AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
NACELLE ANTI-ICE SYSTEM
THRUST REVERSER SYSTEM
N1
Nf
N2
A
Pamb
B
Ps 14
A
P25
P3
T2
A
T25
T3
B
CORE NACELLE TEMPERATURE
EGT
FWD VIBRATION
AFT VIBRATION
ENGINE SENSORS

COCKPIT CONTROLS

• The EEC receives data:
    • Cockpit controls

For the engine control, the EEC receives the following data.
Cockpit Controls:
- Master Lever position,
- Thrust Lever resolver angle,
- Auto Thrust (A/THR) Disconnect P/B (ch B),
- Flight Control Unit (FCU) A/THR engagement (ch B),
- FADEC Ground Power P/B,
- NAI P/B.


AIR SYSTEM
FUEL SYSTEM
OIL SYSTEM
IGNITION & STARTING SYSTEMS
UNLESS SPECIFIED DIFFERENTLY, SIGNALS ARE DUAL (FROM/TO EEC CHANNELS)
EEC
EIU
PHMU
NACELLE ANTI-ICE SYSTEM
THRUST REVERSER SYSTEM
ENGINE SENSORS
MASTER LEVER POSITION
THRUST LEVER RESOLVER ANGLE
B
A/THR DISCONNECT P/B
B
FCU A/THR ENGAGEMENT
FADEC GND PWR P/B
NAI P/B
COCKPIT CONTROLS

FADEC
Electrical Power Supply Control

EEC

• EEC supply:

- N2 < 10%: A/C back-up power
- N2 > 10%: dedicated alternator (PMA)

The Electronic Engine Control (EEC) is electrically supplied by the A/C electrical network when high pressure rotor speed (N2) is below 10% or when the dedicated Permanent Magnet Alternator (PMA) has failed, and then by its dedicated PMA when N2 is above 10%.

AIRCRAFT POWER

• Channels independently supplied by 28V DC

•A/C 28V DC permits:

- FADEC automatic ground check
- Engine starting
- Powering EEC while engine reaches 10% of N2

The EEC is supplied by the A/C electrical power network when N2 is below 10%. Each channel is independently supplied by the A/C 28V DC through the Engine Interface Unit (EIU).

The aircraft 28V DC permits the EEC to:

- automatic ground check of the Full Authority Digital Engine Control (FADEC) system when the engine is not running, that is to say FADEC GrouND PoWeR ON for interactive tests and data loading,
- control starting: MASTER lever ON or mode selector on IGNition or CRANK, Starter Air Valve (SAV),
- control the thrust reverser system.

NOTE: The EIU takes its power from the same bus bar as the EEC

PMA SUPPLY

• PMA directly supplies EEC when N2>10%

•Each channel:

- Supplied with 3-phase AC
- One transformer rectifier provides 28V DC

As soon as the engine is running above 10% of N2, its PMA directly supplies each EEC channel with three-phase AC power. Two transformer rectifiers provide 28V DC power supply to channels A and B. Switching between the A/C 28V DC supply and the dedicated alternator power supplies is done automatically by the EEC.

AUTO DEPOWERING

• FADEC AUTO depowered on GND

•EEC AUTO depowering occurs on GND:

- 5 min after A/C power-up
- 5 min after engine shutdown

The FADEC is automatically depowered on the ground, through the EIU, after engine shutdown.

The EEC automatic depowering occurs on the ground:

- 5 min after A/C power-up,
- 5 min after engine shutdown.

Power is not cut-off if Centralized Fault Display System (CFDS) EEC menus are active or Data Loading going on (software upload/memory dump).

NOTE: An action on the ENGine FIRE P/B provides EEC power cut-off from the A/C network.

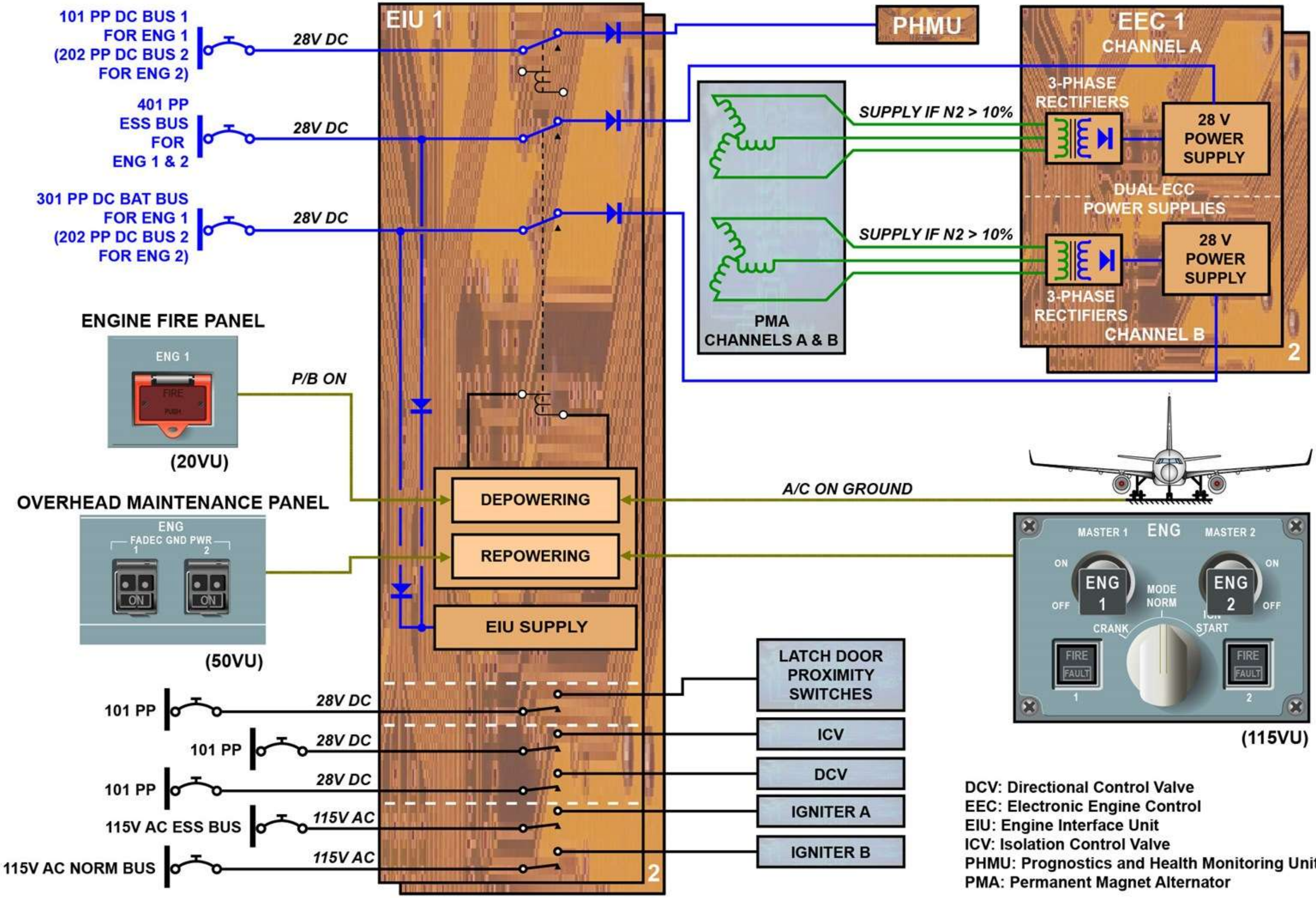
MANUAL REPOWERING

• ENG FADEC GND PWR panel permits FADEC power supply to be restored on GND

•ENG FADEC GND PWR P/B is ON: EEC recovers its power supply

For maintenance purposes and Multipurpose Control and Display Unit (MCDU) engine tests, the ENGine FADEC GrouND PoWeR panel permits FADEC power supply to be restored on the ground with engines shut down. When the corresponding ENGine FADEC GrouND PoWeR P/B is pressed ON the EEC recovers its power supply.

NOTE: The FADEC is also repowered as soon as the engine start selector is in IGNition/START or CRANK position, or the MASTER lever is selected ON.

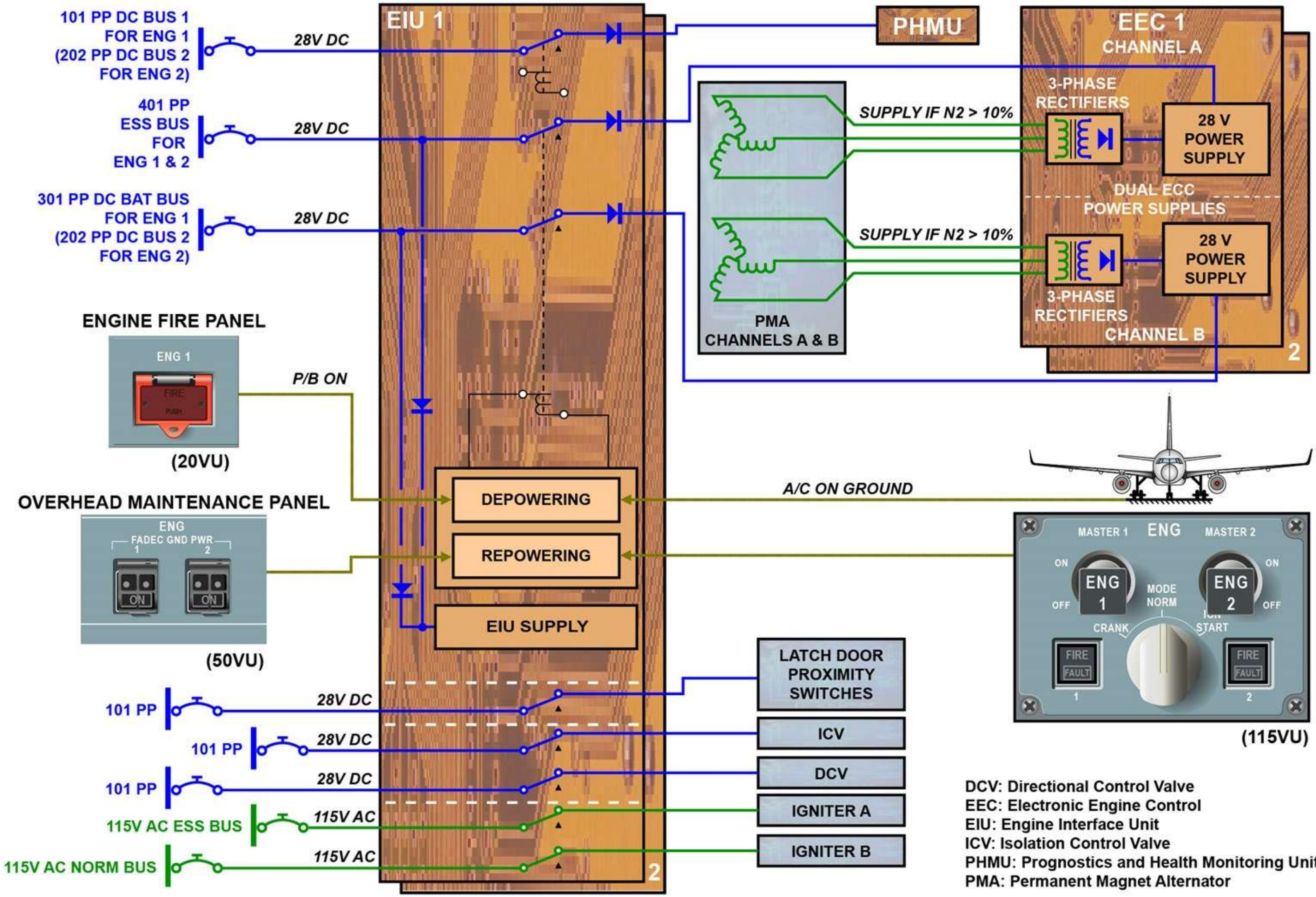


DCV: Directional Control Valve
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ICV: Isolation Control Valve
PHMU: Prognostics and Health Monitoring Unit
PMA: Permanent Magnet Alternator

SUBSYSTEMS POWER SUPPLY

- 28V DC:
  - PHMU
  - Fan Cowl Door latch prox SWs
  - DCV - ICU
- 115V AC: Igniters

The Prognostics and Health Monitoring Unit (PHMU) receives aircraft 28V DC directly from the aircraft normal DC power bus through the EIU. The de-powering conditions are the same as the EEC.
The Fan cowl door proximity switches are supplied by another bus in 28V DC.
Power is also transferred to the reverser system valves for Directional Control and Isolation.
Each starting igniter is independently supplied with 115V AC.



DCV: Directional Control Valve
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ICV: Isolation Control Valve
PHMU: Prognostics and Health Monitoring Unit
PMA: Permanent Magnet Alternator

Ignition and Starting System Presentation

GENERAL

• 2 independent ignition systems including
  - 1 Ignition exciter, 2 coaxial shield ignition leads and 2 igniter plugs

•Start system:
  - Starter Air Valve
  - Starter

The Ignition system provides the electrical spark needed to start or continue engine combustion. The ignition system is made up of two independent systems. The Ignition system includes an ignition exciter, two coaxial shield ignition leads and two igniter plugs.
The Starting system drives the engine High Pressure (HP) rotor at a speed high enough for a ground or in flight start to be initiated. The start system is made up of the electrical Starter Air Valve (SAV) and the pneumatic starter. Air bleed is taken from the aircraft pneumatic system for engine start (Auxiliary Power Unit (APU) bleed, external pneumatic cart, other engine bleed).

CONTROL AND INDICATING

• EEC controls:
  - Ignition
  - Starting

•ECAM indications

The Electronic Engine Control (EEC) controls the ignition during automatic start and manual start. 115 V AC from aircraft electrical system is supplied to the ignition exciter which provides the necessary voltage to the igniter plugs to generate the spark for combustion.
The EEC controls the starting through the SAV during automatic start and manual start.
The operation of the SAV and of the ignition system is displayed on the ENGINE ECAM page.

AUTOMATIC START

• EEC opens the SAV then ignition exciter is energized
•Full protection by EEC

During an automatic start, the EEC opens the SAV to motor the engine for start. The ignition exciter is then energized when the HP rotor speed is nominal. The EEC provides full protection during the start sequence. When the automatic start is completed, the EEC closes the SAV and cuts off the ignition. In case of an incident during the automatic start the EEC makes a second attempt or aborts the start procedure.

MANUAL START

• MANual START P/B pressed => start valve opens
•MASTER control lever is set to ON => ignition system is energized

During a manual start, the SAV opens when the engine MANual START P/B is pressed in, then the ignition system is energized when the MASTER control lever is set to the ON position.
NOTE: there is no automatic shutdown function or second attempt in MANUAL START.

CRANKING

• Engine motoring for cranking

Engine motoring could be performed for dry cranking or wet cranking sequences.
NOTE: during cranking ignition is inhibited.

CONTINUOUS IGNITION

• Continuous ignition via EEC manually or automatically

With engine running, continuous ignition can be selected via the EEC either manually using the rotary selector or automatically by the Full Authority Digital Engine Control (FADEC) during specific conditions.

SAFETY PRECAUTIONS

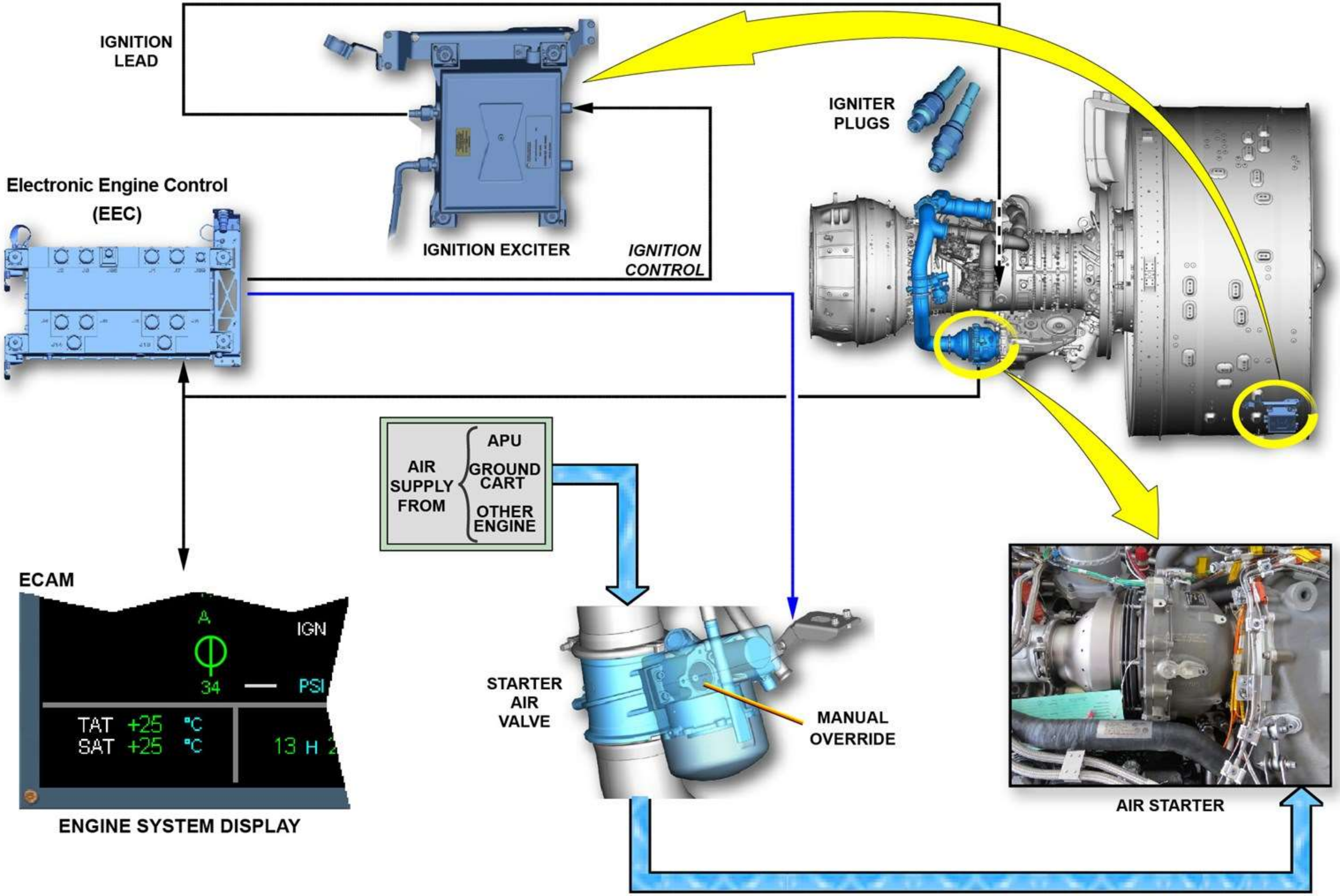
• Working area safety precautions

Safety precautions have to be taken prior to working in this area.
WARNING: THE IGNITION EXCITER PROVIDES HIGH ENERGY PULSES THROUGH THE IGNITION LEADS TO THE 2 IGNITERS PLUGS.

MAINTENANCE PRACTICES

• Manual override of the start valve for dispatch

To increase A/C dispatch reliability, the SAV is equipped with a manual override. For this manual operation, the mechanic has to be aware of the engine safety zones.


IGNITION
LEAD
IGNITION EXCITER
IGNITION
CONTROL
IGNITER
PLUGS
Electronic Engine Control
(EEC)
AIR
SUPPLY
FROM
APU
GROUND
CART
OTHER
ENGINE
ECAM
A
34
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H
ENGINE SYSTEM DISPLAY
STARTER
AIR
VALVE
MANUAL
OVERRIDE
AIR STARTER

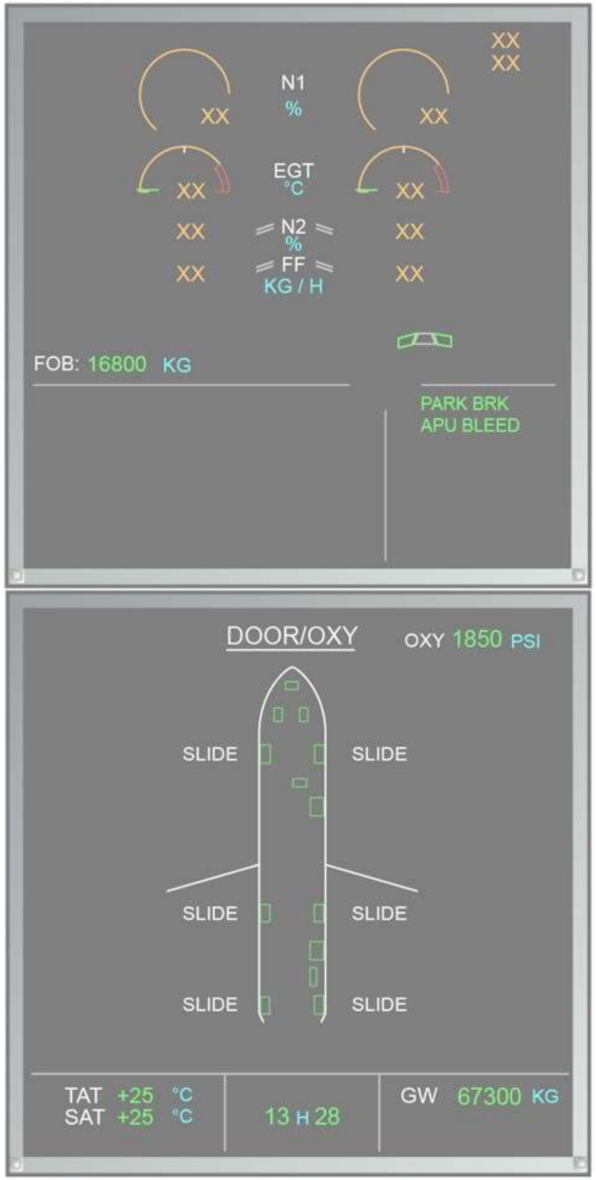
Ignition and Starting System Description and Operation (Me)

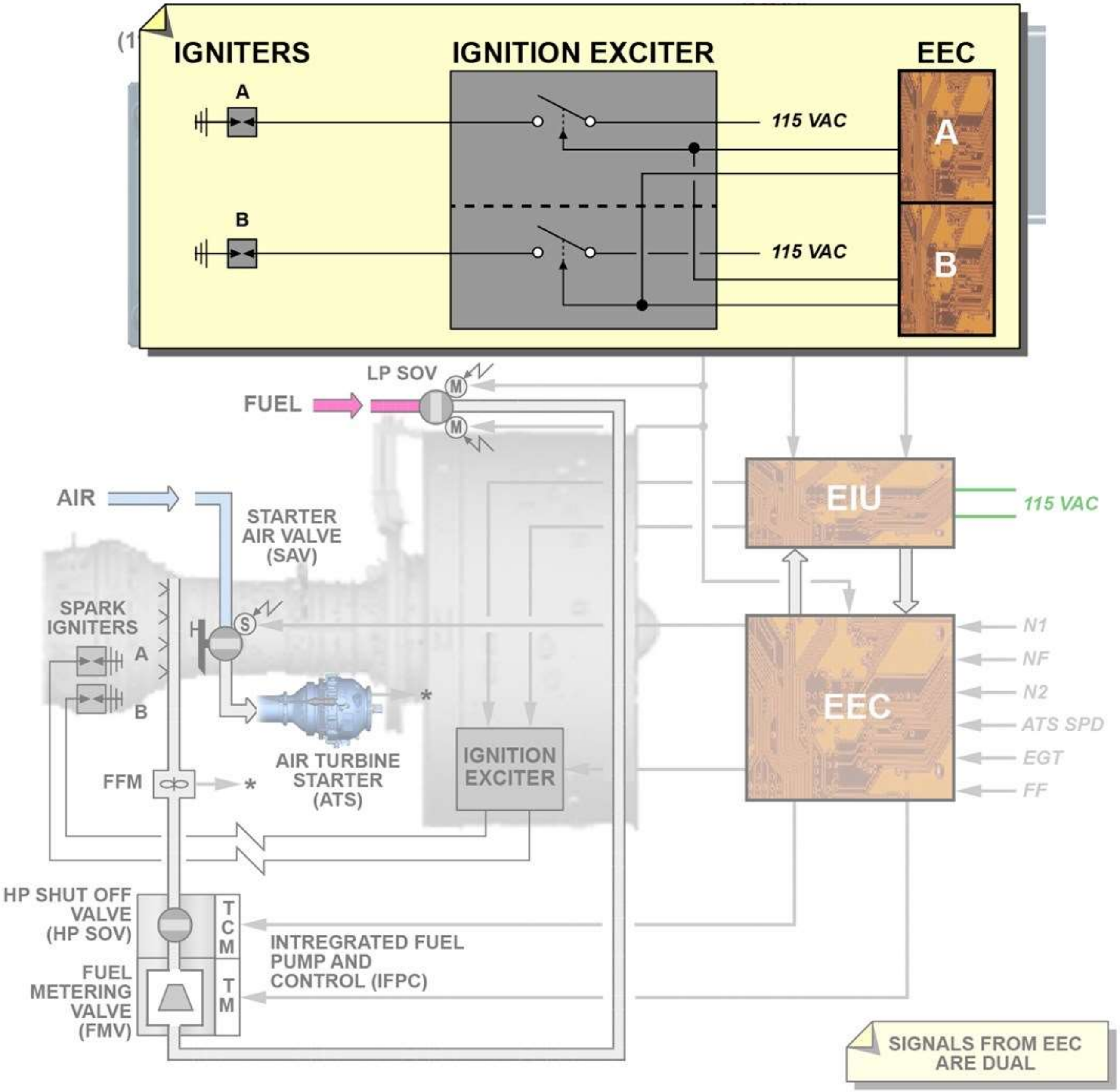
GENERAL
Comp loc ENG 1 LH
IGNITER Box
IGN Plug
Air starter

• EEC controls and monitors Starting & Ignition
•Starting modes: Auto or Manual
•Cranking: Dry or Wet
The Electronic Engine Control (EEC) controls and monitors the Starting and Ignition systems for engine starting, cranking, and ignition selection, on ground and in flight.
For engine starting, two modes are available; automatic or manual.
Both modes can be used on ground or in flight but in flight sequence are less protective to enhance the restart capability.
The EEC requests the EIU to control the hydraulic pump depressurization to help sustain sufficient windmill speed for in-flight starting that do not require starter assistance and to enhance quick relight response on extended fuel interruptions.
For engine cranking, two sequences can be manually selected: dry or wet.
The EEC controls the starting and ignition components according to cockpit commands and protective logics.
The main engine parameters to be monitored during starting are displays on the E/WD (N1, EGT, N2, Fuel Flow) and on the SD (Oil Press, IGN system, Starter Air Valve position and available pneumatic pressure).

• Ignition system consists of
  • 1 ignition exciter
  • 2 spark igniters
The ignition system is composed of a dual channel ignition exciter supplying two spark igniter plugs.
Each plug and corresponding circuit (identified as system A and system B) can be used at the same time or alternately to detect dormant failures.
The EEC controls the ignition by providing command signals to the internal relays of the ignition exciter, whereas the EIU supplies 115 Volt power supply to the ignition exciter.
The EEC tests every ignition circuit every 4 starts according to the sequence: EEC A + IGN A, EEC B + IGN A, EEC A + IGN B, EEC B + IGN B.

ECAM EWD


XX
XX
N1
%
XX
XX
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG

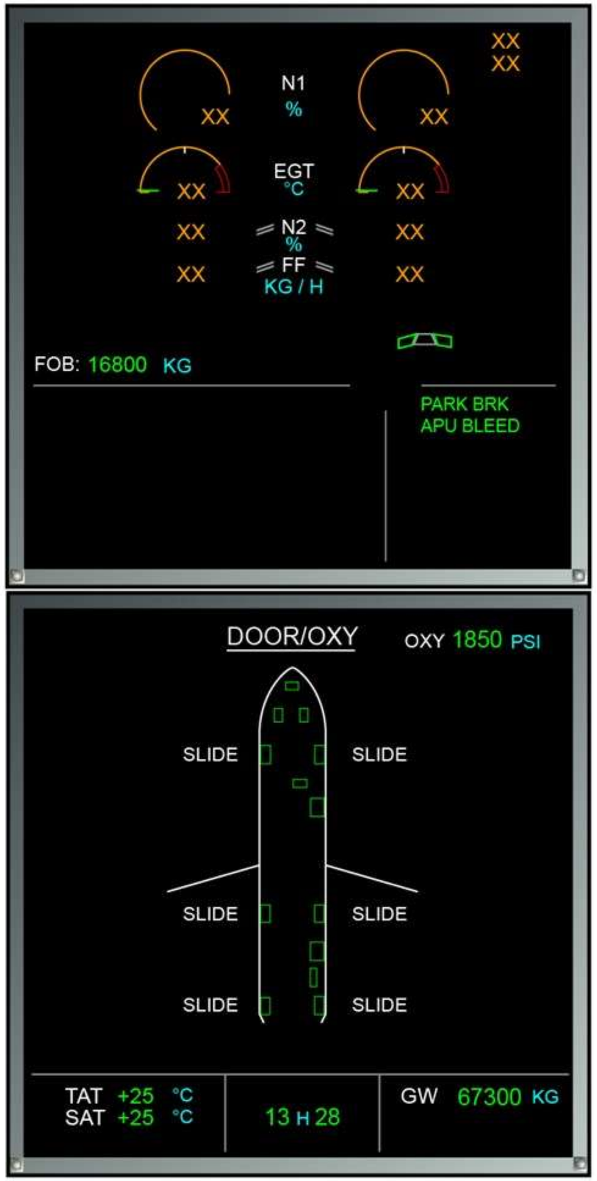

IGNITERS
IGNITION EXCITER
EEC
A
B
115 VAC
115 VAC
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
AIR TURBINE STARTER (ATS)
FFM
IGNITION EXCITER
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
SIGNALS FROM EEC ARE DUAL

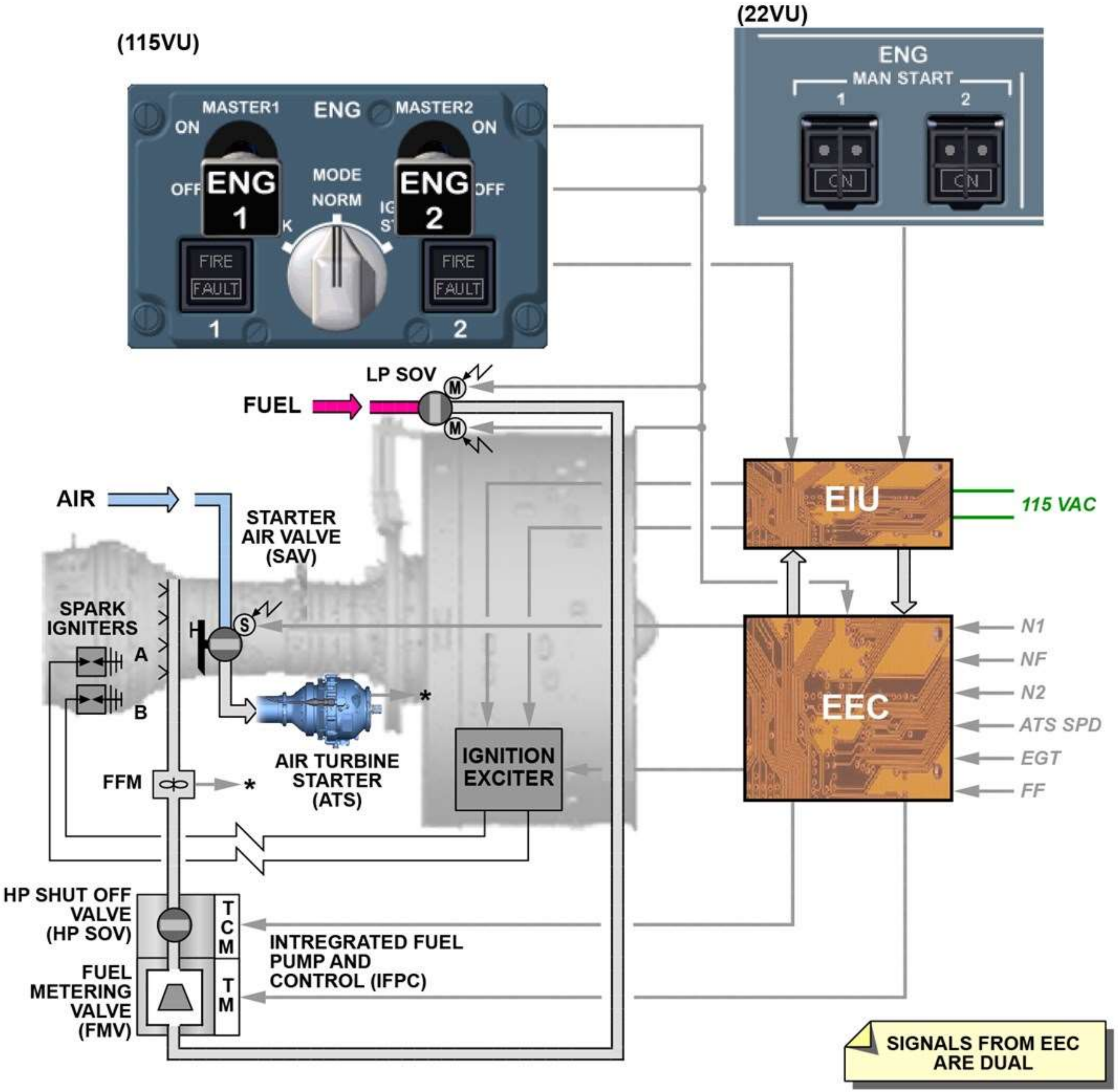
•Starting system consists of
- 1 SAV
- 1 ATS

The starting system consists of a Starter Air Valve (SAV), air duct and an Air Turbine Starter (ATS).
The SAV is electrically controlled by the EEC and pneumatically operated.
The ATS is attached to the aft of the main gearbox at the 5 o'clock position. It is fitted with a speed sensor which is used for system control and monitoring by the EEC.
The pressurized air supply to the starting components is provided by one of the following sources:
- Auxiliary Power Unit (APU) bleed,
- external pneumatic ground cart,
- engine bleed from the opposite engine.

The SAV is butterfly type valve fitted with an integral dual-coil solenoid and a 3/8' socket for manual override.
The starter shares oil with the engine oil system and houses 16 ounces of oil internally. It is fitted with a magnetic chip collector.
Max starter speed = 9000 rpm. Starter re-engagement speed = 20% N2.

ECAM EWD


XX
XX
N1
%
XX
XX
EGT
°C
XX
XX
N2
%
XX
XX
FF
KG / H
XX
XX
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG


(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
LP SOV
FUEL
M
M
AIR
STARTER AIR VALVE (SAV)
S
SPARK IGNITERS
A
B
AIR TURBINE STARTER (ATS)
*
FFM
*
IGNITION EXCITER
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
HP SHUT OFF VALVE (HP SOV)
TCM
FUEL METERING VALVE (FMV)
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
SIGNALS FROM EEC ARE DUAL

AUTOMATIC START

• Automatic start conditions:

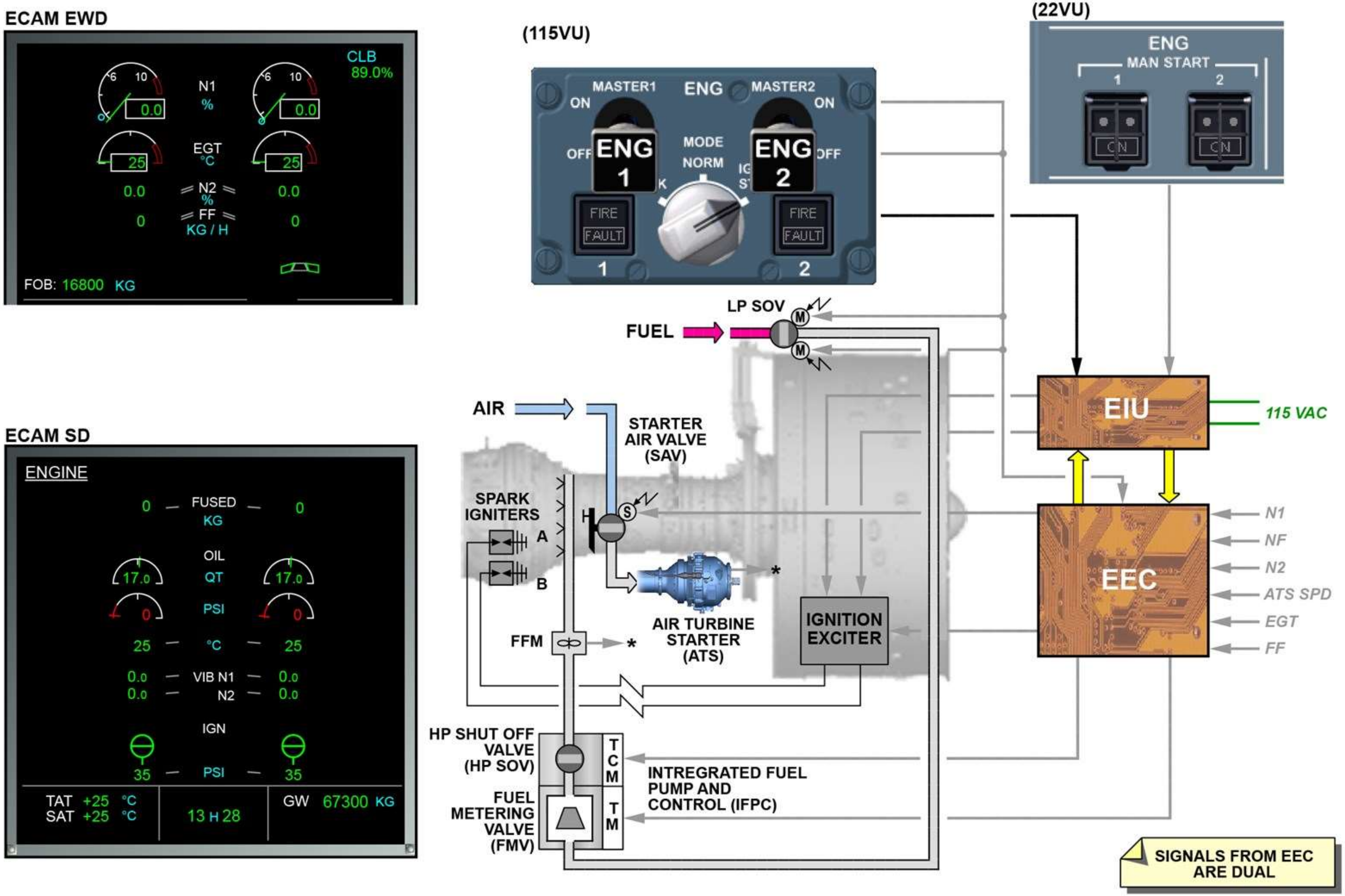
- Engine not running
- Rotary selector to IGN/START
- Master lever ON
- ENG MAN START P/B OFF

The EEC shall enter the automatic start mode when all of the following conditions are true:
- the engine is not running, and
- the selected rotary selector is set to IGN/START, and
- the selected ENG MASTER lever is set to ON, and
- the ENG MAN START pushbutton is OFF.

• ENGINE page on ECAM:

- IGN indication
- SAV position
- Bleed pressure

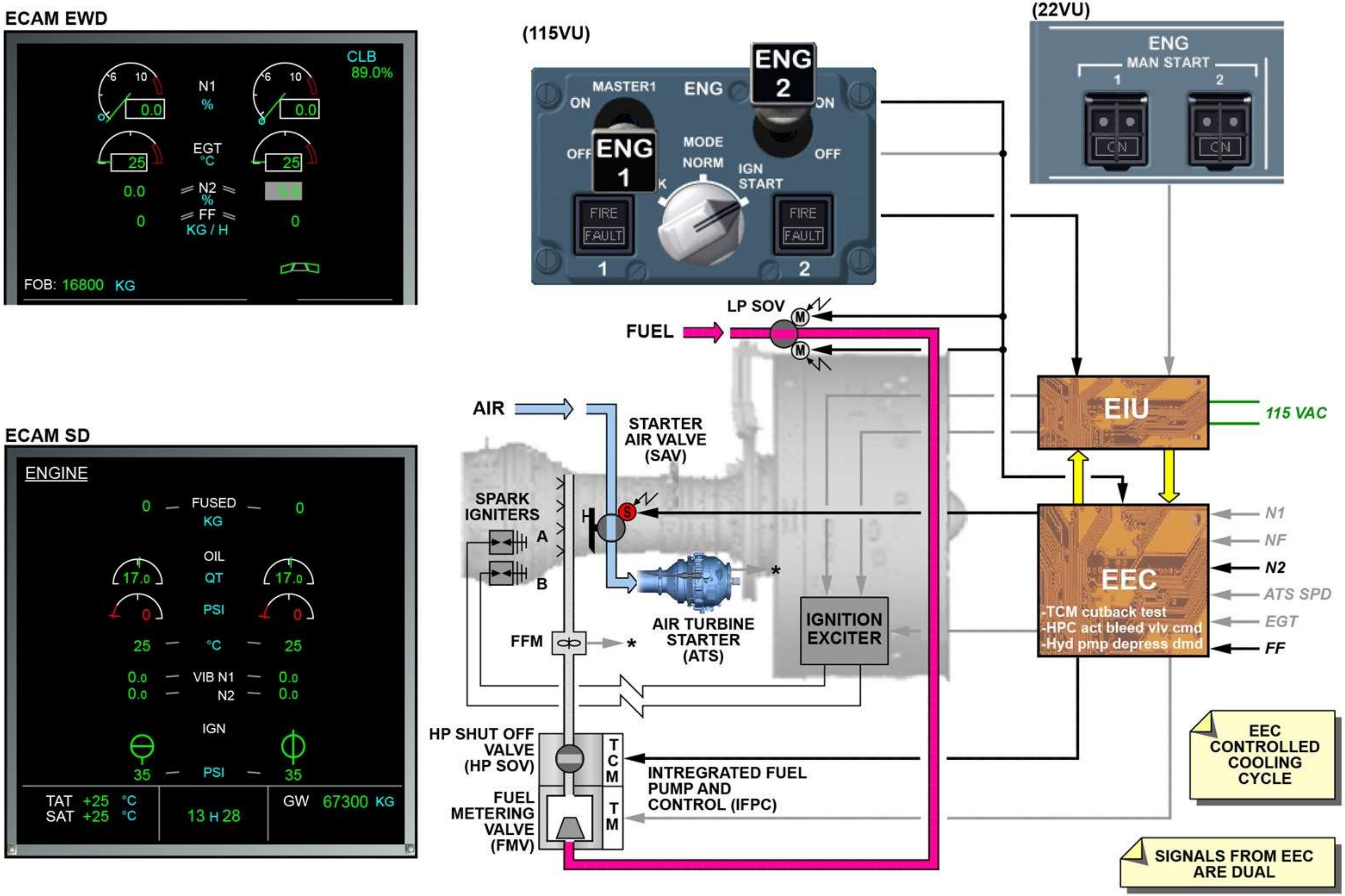
When the ENG MODE rotary selector is set to IGN/START position, FADEC is powered up.
The ENGINE page is automatically shown on the System Display (SD) page of the ECAM system.
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.
At the same time, the APU bleed demand will increase and the pack valves will close.
A minimum air pressure is required to ensure an effective start sequence (25 Psi minimum).


ECAM EWD
CLB
89.0%
N1
%
0.0
0.0
EGT
°C
25
25
N2
%
0.0
0.0
FF
KG / H
0
0
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
0
0
OIL
QT
17.0
17.0
PSI
0
0
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
FFM
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
T
C
M
T
M
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

•ENG MASTER lever to ON = Automatic starting sequence begins
As soon as the ENG MASTER lever is set to ON position, the LPSOV opens and the automatic starting sequence begins.

The EEC will automatically control the:
- Thrust Control Malfunction (TCM) cutback test,
- HPC active bleed valve (opening and closing),
- Hydraulic pump depressurizing (via EIU) if necessary during in flight restart,
- SAV (opening and closing),
Depending on engine condition, the EEC might initiate a cooling cycle.
- Igniters (one or two, on and off),
- Fuel Flow (FMV and HPSOV opening).
First, the EEC energizes the SAV solenoid. This supplies the starter with aircraft pneumatic pressure.
The position of the SAV is confirmed open at the bottom of the ENGINE page thanks to the ATS speed sensor feedback.
Consequently, the N2 begins to increase.

The TCM Cutback test is done in two phases:
1. Phase 1:
a. The Overspeed torque motor is commanded to Cutback,
b. The Fuel Metering Valve is commanded to a low fuel flow rate (~ 50 kg/h),
c. The Overspeed Shutoff Valve should stay in the closed position.
2. Phase 2:
a. The Overspeed torque motor is de-energized,
b. The Overspeed Shutoff Valve should move to the open position.
Rq: The EEC tests the TCM Shutdown function via the Overspeed spooldown test, performed during pilot commanded on-ground engine shutdowns.


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
OIL
QT
PSI
°C
VIB N1
N2
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ENG 2
ENG 1
MODE
NORM
IGN
START
FIRE
FAULT
(22VU)
ENG
MAN START
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
FFM
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
-TCM cutback test
-HPC act bleed vlv cmd
-Hyd pmp depress dmd
N1
NF
N2
ATS SPD
EGT
FF
EEC
CONTROLLED
COOLING
CYCLE
SIGNALS FROM EEC
ARE DUAL

•18% N2:

- Fuel flow
- Igniter on

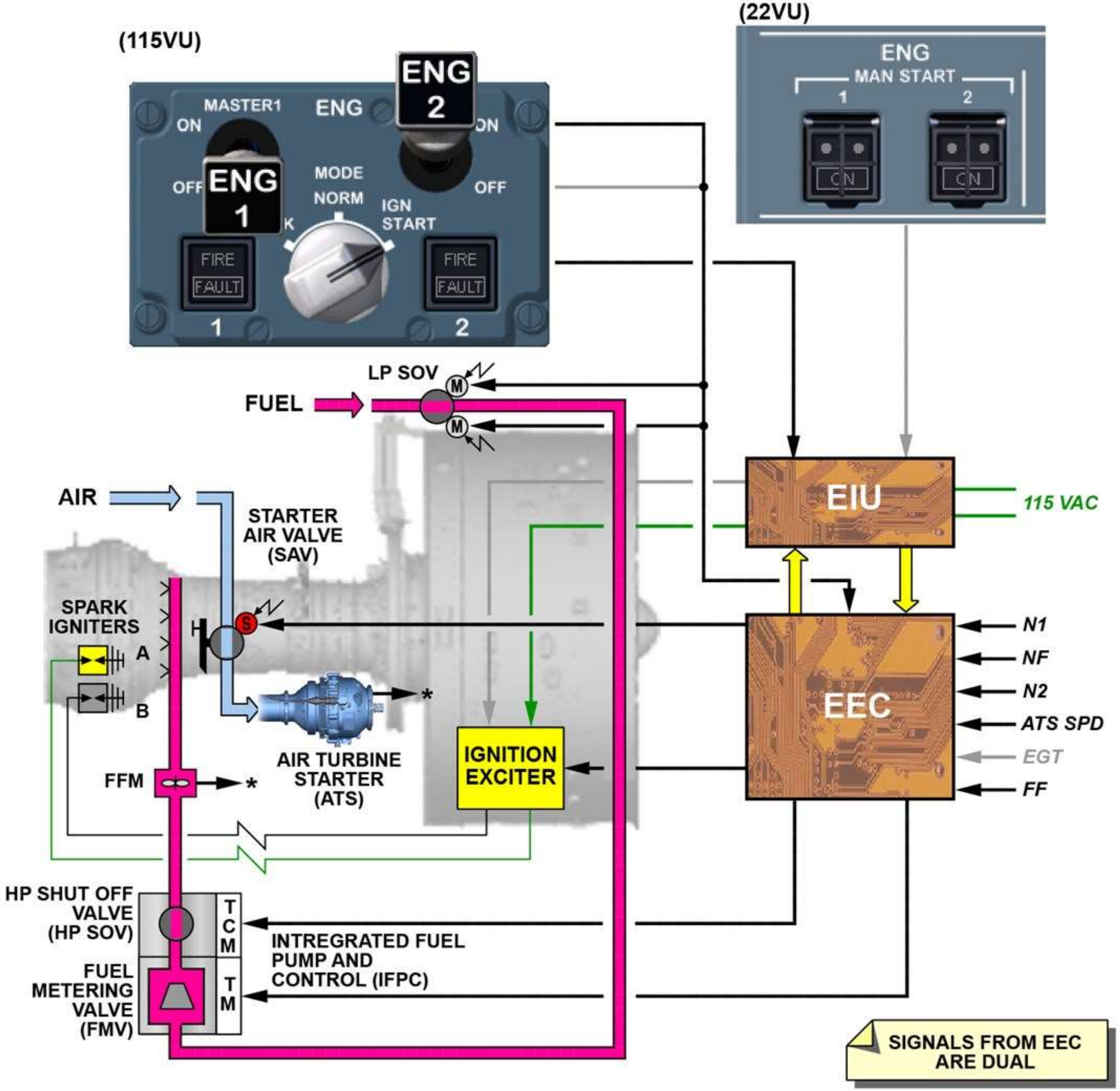
•EEC:

- Determines that engine is capable of light up
- Selects ignition system A or B

When the engine reaches the minimum fuel pressurization speed (18% N2), the EEC activates one igniter and controls the appropriate fuel flow to the burner.
On the SD ENGINE page, the corresponding spark igniter system (A or B) controlled by the EEC comes into view.
On the E/WD, the FF increases.
Fuel is sent to the burner via the Fuel Metering Valve (FMV) and the High Pressure Shut Off Valve (HPSOV) in the Integrated Fuel Pump and Control (IFPC).
The in-flight fuel pressurization speed is 5% N2.

ECAM EWD

ECAM SD

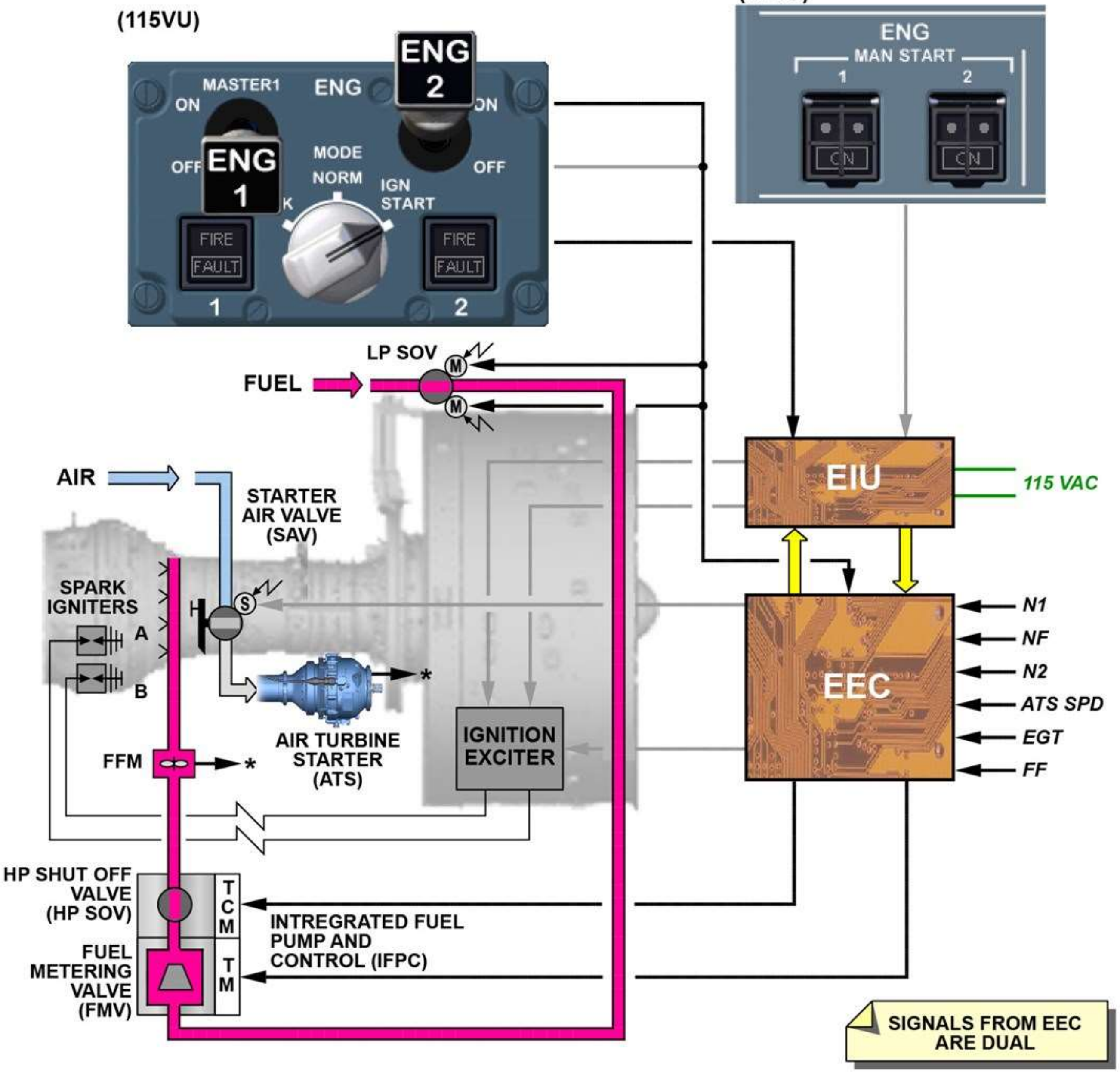


•EEC monitors EGT & N2 to provide correct fuel flow
The EEC monitors the Exhaust Gas Temperature (EGT) and N2 according to their schedules to provide the correct fuel flow for a good acceleration.
When N2 reaches 51% N2, the automatic start sequence ends when the EEC controls the SAV to close and the igniter to OFF.
The engine continues to accelerate and stabilizes at idle speed.
The usual standard parameters are:
- N1 = 19%,
- N2 = 58%,
- EGT = 440 �C,
- FF = 227 kg/h.
If the second engine has to be started, the ENG MODE rotary selector should stay on the IGN/START position.
This will avoid activating the continuous ignition on the running engine if the selector is cycled to NORM and again to IGN/START.
When both engines are running, the selector is set back to NORM, the WHEEL page will appear instead of the ENGINE page if at least one engine running.
N1 Red Line (100% of N1 = 10,000 RPM)
N2 Red Line (100% of N2 = 22,500 RPM)
•11 Automatic start abort
Automatic start abort:
The EEC has the authority to abort a start only on the ground.
The EEC will abort the start, dry motor the engine for 30 seconds and attempt a single start for the following reasons:
- no light up (EGT low and constant),
- no N2 acceleration (hung start),
- EGT reaches starting limit (impending hot start).
NOTE: The maximum EGT during start sequence is 1018 �C.
Fuel Depulse = when an impending hot start or a surge is detected, the EEC controls the fuel supply by cycling fuel OFF and back ON (fuel off for 2 seconds, then back on for 12 seconds for two successive cycles, for a total of 28 seconds).
The EEC will abort a start, dry motor the engine for 30 seconds and not attempt a restart for the following conditions:
- Failure of automatic restart,
- N1 locked rotor,
- EEC unable to command both igniters,
- Loss of EGT indication (T5 sensors failed),
- EEC unable to control fuel flow.
The EEC will also abort a start, will not dry motor the engine and will not attempt a restart if the starter duty cycle is exceeded.
• Manual start abort
Manual start abort:
The automatic start sequence can be manually aborted by selection of the ENG MASTER lever to OFF position.
This leads to:
- SAV closure,
- Igniter(s) off,
- FMV, LP and HP fuel shut-off valves closure.

NOTE: EEC does not dry motor the engine when an automatic start is manually aborted.

ECAM EWD

ECAM SD



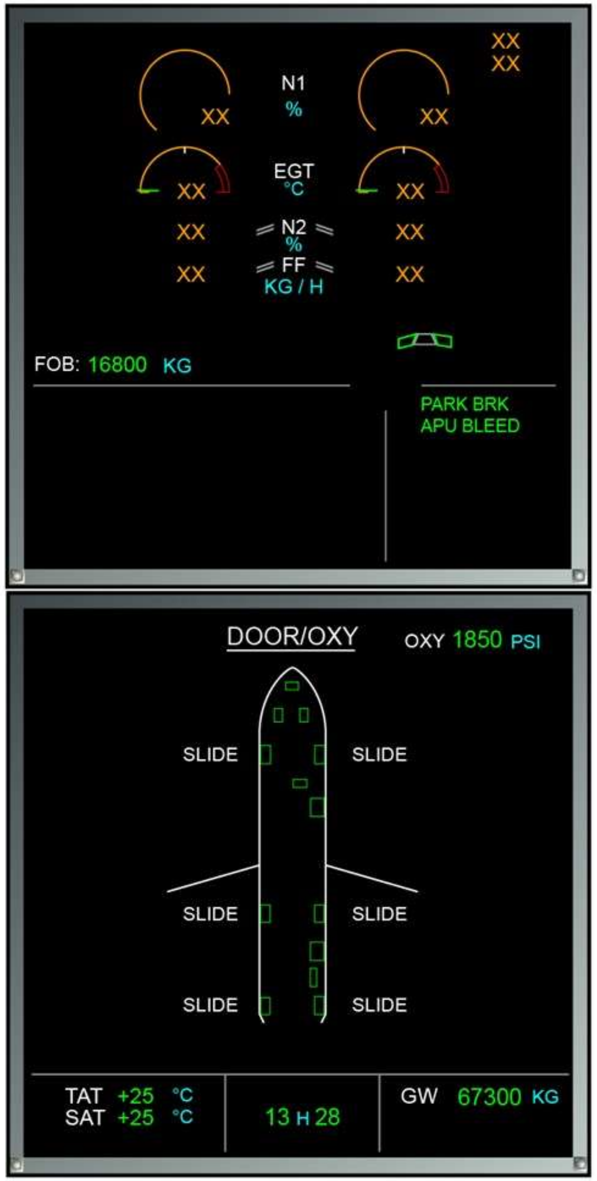
MANUAL START

•EEC controls:

- SAV
- Fuel
- Igniters

A manual engine start procedure is included in the EEC engine starting logic.
In the manual start mode, engine starting control is under limited authority of the EEC.
The SAV, fuel, and ignition are controlled from the cockpit via the EEC.

ECAM EWD


XX
XX
N1
%
XX
XX
EGT
°C
XX
XX
XX
N2
%
XX
XX
FF
KG / H
XX
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
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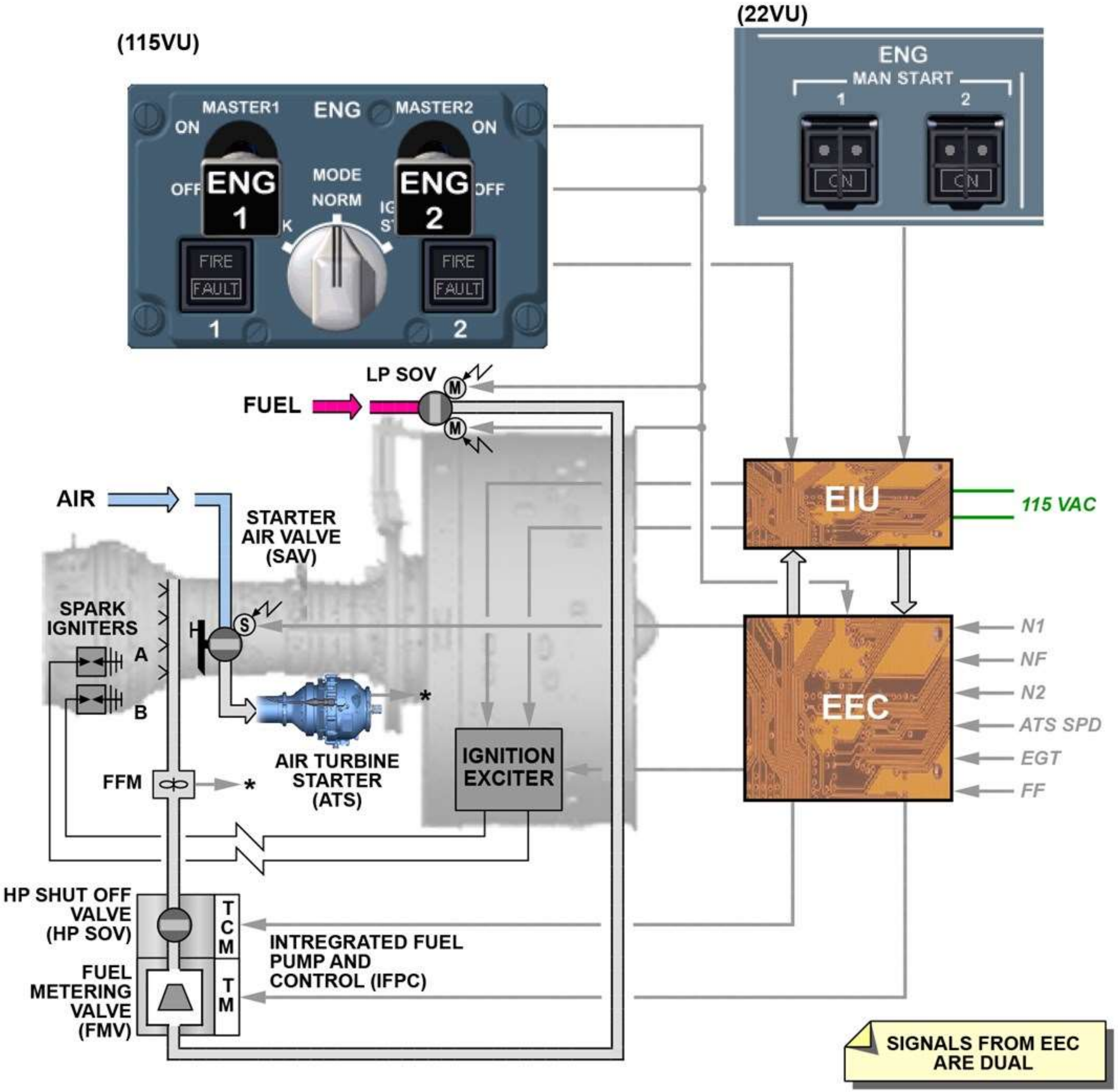
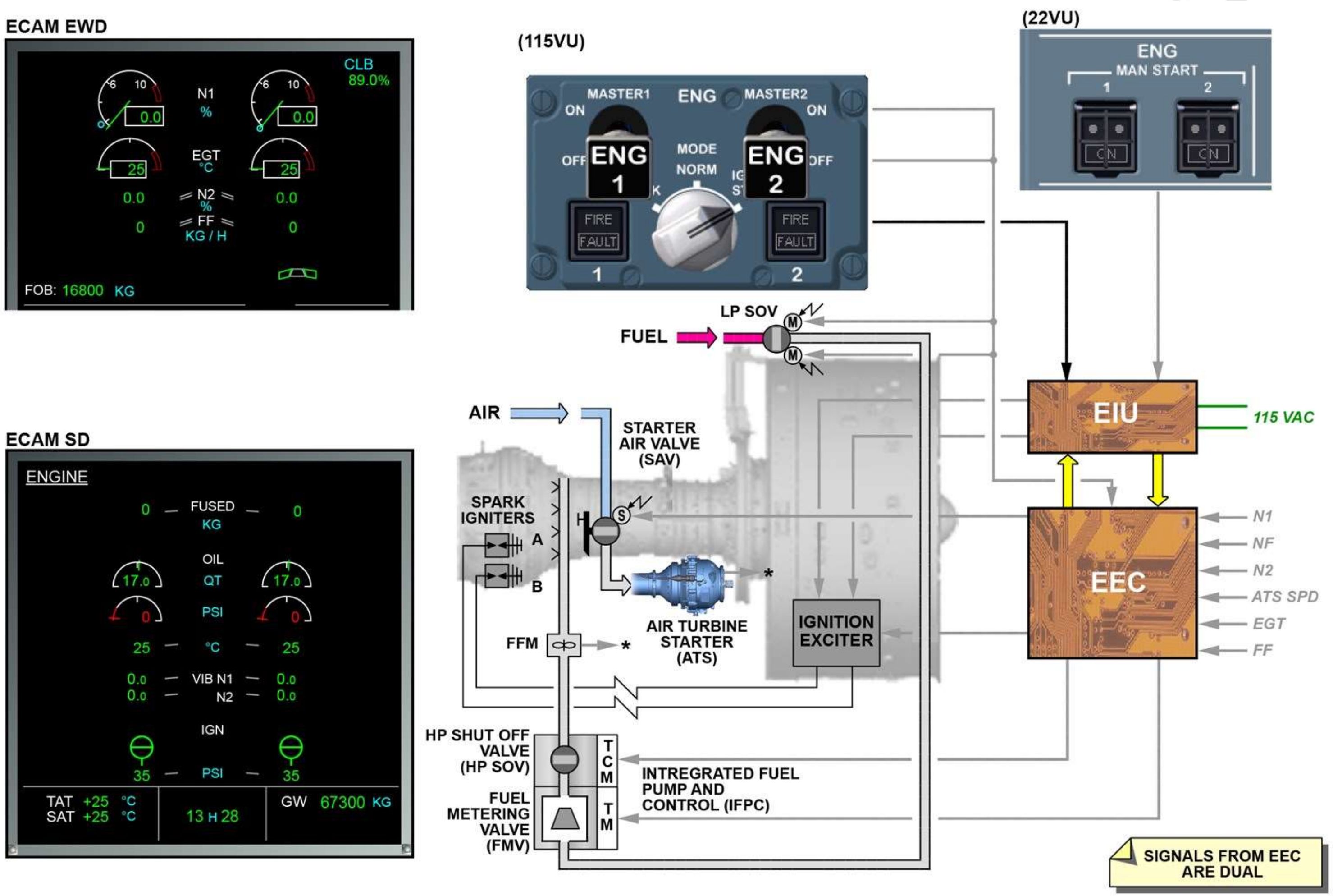
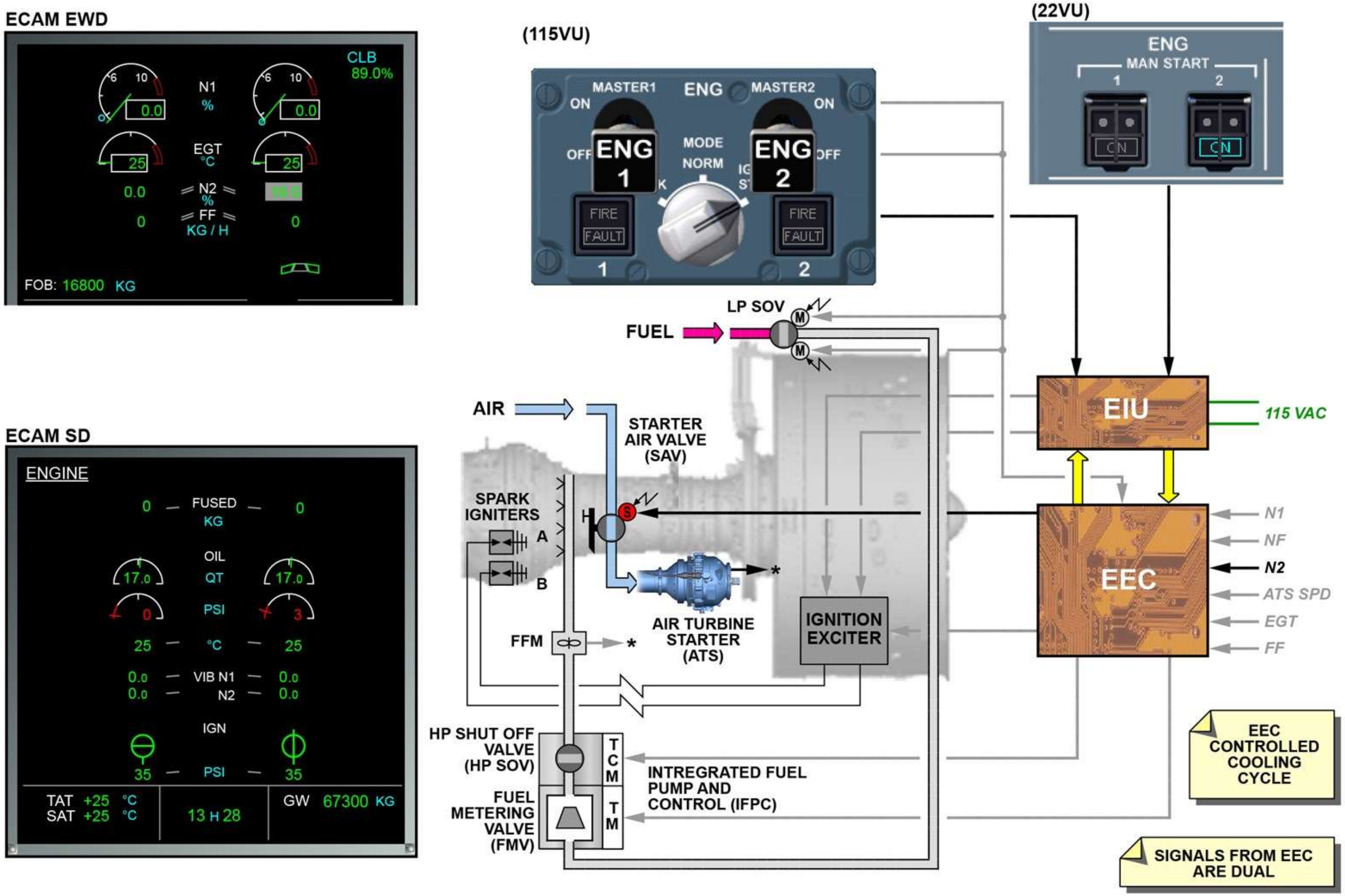
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG


(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
H
S
M
M
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
FFM
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
T C M
T M
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

•Rotary selector to IGN/START = FADEC on and identifies start
Bleed air source being available, a manual start sequence is commanded by first setting the rotary selector to the IGN/START position to power and signal the EEC.
The ENGINE page appears on the SD page of the ECAM.
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.
At the same time, the APU bleed demand will increase and the pack valves will close.



•ENG MAN START P/B ON = SAV opened
•Cooling cycle depending on engine condition
The next action is to engage the ENG MAN START push-button to the ON position. This will lead the EEC to open the SAV. Depending on engine condition, the EEC might initiate a cooling cycle.



•ENG MASTER ON = Fuel flow & both igniters ON
•EEC monitors EGT & N2 but no EGT limit protection
When N2 is above the minimum fuel pressurization speed (on-ground approximately 18% N2), the ENG MASTER lever is set to the ON position. The EEC commands fuel flow and both igniters simultaneously.

• EEC monitors EGT & N2 to provide the correct FF
•EGT limit protection is inactive
The EEC monitors the EGT and N2 according to their schedules to provide the correct fuel flow but EGT limit protection is inactive.
When N2 reaches 51% N2, the manual start sequence automatically ends when the EEC controls the SAV to close and the igniters to OFF.
The engine continues to accelerate and stabilizes at idle speed.
Both automatic and manual starting modes are available for in-flight restart using the same procedures as on ground.
When auto start is selected in flight, if windmill speed or N2 are not sufficient, the EEC will commands the assistance of the starter.
When manual start is selected in flight, the EEC will always command a starter-assisted air start unless the engine N2 speed is above the starter cutout speed, which is function of Total Air Temperature (ex: from 11000 rpm at -40�C to 12000 rpm at 30�C).
When commanding Automatic or Manual Start in flight, the EEC shall not have the authority to perform an auto-restart or to abort a starting sequence.
In case of failure of the SAV command, the EEC logic is compatible with the manual actuation of the SAV by the ground crew without any additional signal.

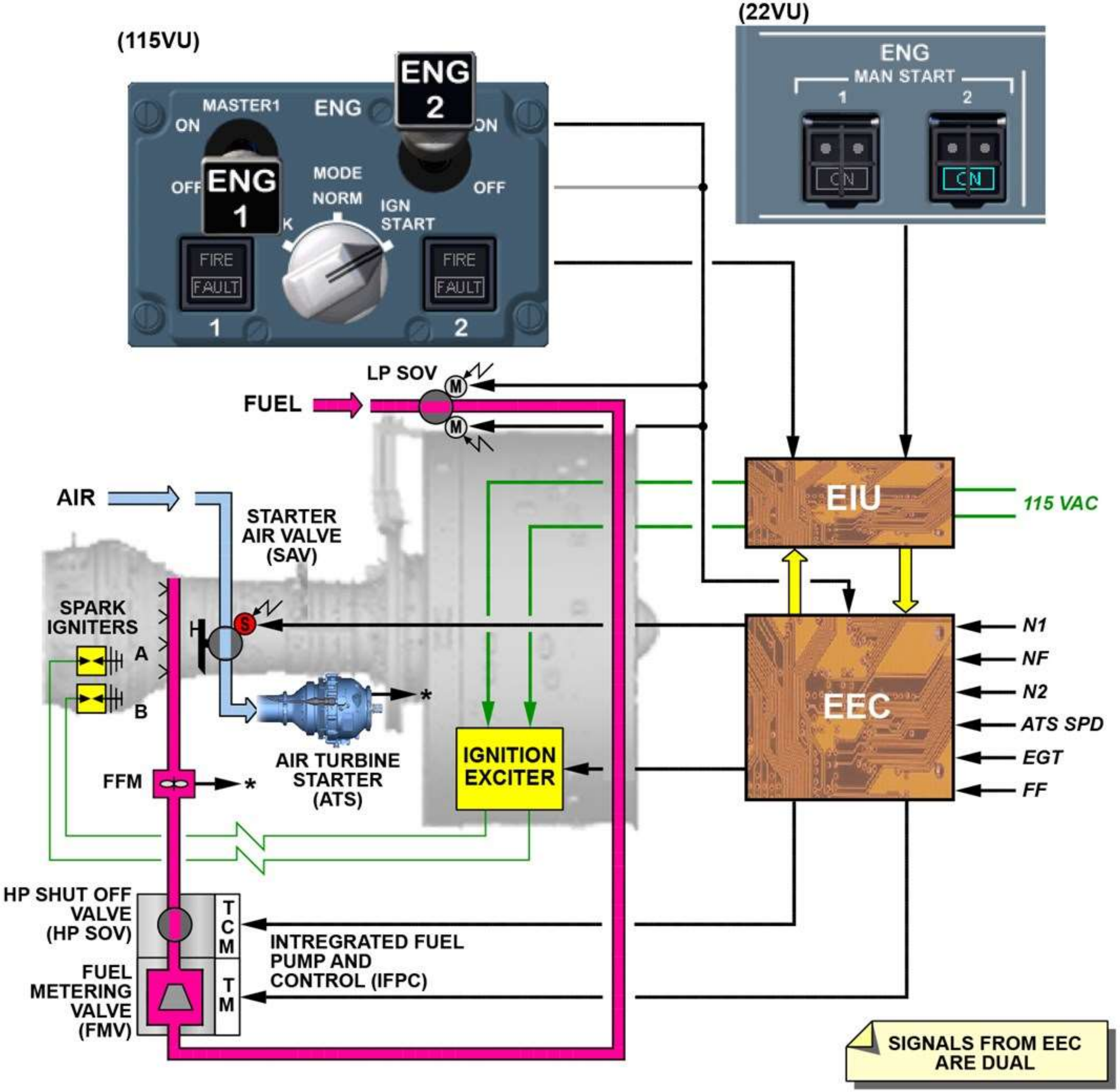
• Manual start abort
•Interruption if:
- ENG MAN START OFF before master lever ON or
- Master lever OFF

•EEC commands:
- SAV closure
- Igniters de-energized
- Fuel flow off

Manual start abort:
When a manual engine start has been initiated on ground or in flight, it shall be interrupted by either:
- de-selecting the ENG MAN START push-button before the ENG MASTER lever is commanded ON, or
- selecting ENG MASTER lever back to OFF position after it has already been selected ON.
Interruption of a manual start shall result in the following EEC commands:
- SAV closure,
- igniters off,
- FMV and HP fuel shut-off valve closure.

ECAM EWD

ECAM SD



CONTINUOUS IGNITION

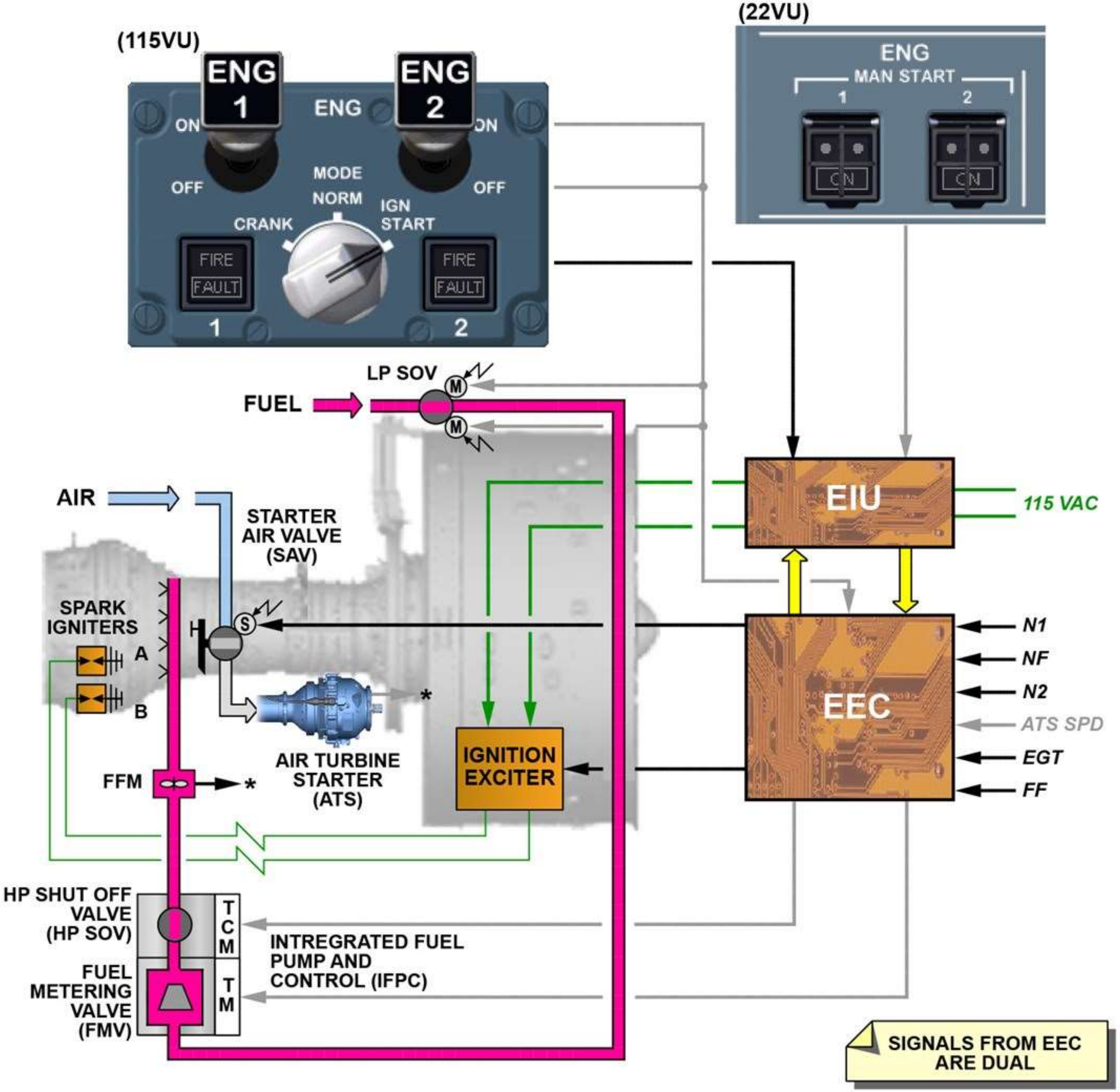
• Continuous ignition is manually selected or automatically controlled
•Both igniters are active
Continuous ignition is manually selected or automatically controlled by the FADEC.
During continuous ignition both igniters are active.

• Manual command
Manual command:
Once the engine is running and above idle, the pilot can manually command continuous ignition at any time by moving the rotary selector to the IGN/START position.
Following a ground start, the rotary selector must be moved back to NORM before continuous ignition can be manually selected by moving it back to IGN/START position.
Continuous ignition shall remain commanded by the EEC until the rotary selector is moved back to NORM.
In the event that data position of the rotary selector sent by Engine Interface Unit (EIU) to EEC is not available or invalid, the EEC shall use the last valid value of the rotary selector position if the aircraft is on ground until a valid configuration is received again.

• Automatic command
Automatic command:
The EEC automatically commands continuous ignition at the following conditions:
- If an engine flameout is detected in flight, or during takeoff, igniters are kept on for a minimum of 30 seconds after the engine has recovered from the flameout and reached idle,
- If a surge is detected in flight or during takeoff, igniters are powered until 30 seconds after the surge recovers,
- If the EEC detects a quick relight (Master Lever cycled from ON to OFF and back to ON in flight),
- If TCM Cutback is commanded.
Automatic continuous ignition shall be inhibited if the burner pressure (PB) is above 150 psi (the nominal deteriorated igniter quench point) to preserve igniter life.

ECAM EWD

ECAM SD



ENGINE CRANK
DRY CRANK

• Two modes of cranking
  • Dry cranking
  • Wet cranking

•Dry crank if ENG not running and A/C on ground

Cranking function is used to motor the engine on the ground for a short time with the use of the starter.
There are two cranking modes:
- dry cranking,
- wet cranking.

Cranking sequence should not exceed 15 min.

• Rotary selector to CRANK:
  • EEC powered up
  • Ignition OFF
  • ENGINE Page on ECAM

The dry cranking procedure is used to motor the engine to remove unburned fuel from the combustion chamber or cool down the engine or for some fuel or oil leak tests.
The EEC shall enter the engine dry crank sequence when all of the following conditions are true:
- the engine is not running and,
- the aircraft is on ground and,
- the rotary selector is set to CRANK.

This will power up the EEC and isolate both ignition systems.
The ENGINE page appears automatically on the ECAM SD.

• ENG MAN START P/B ON:
  • SAV opens

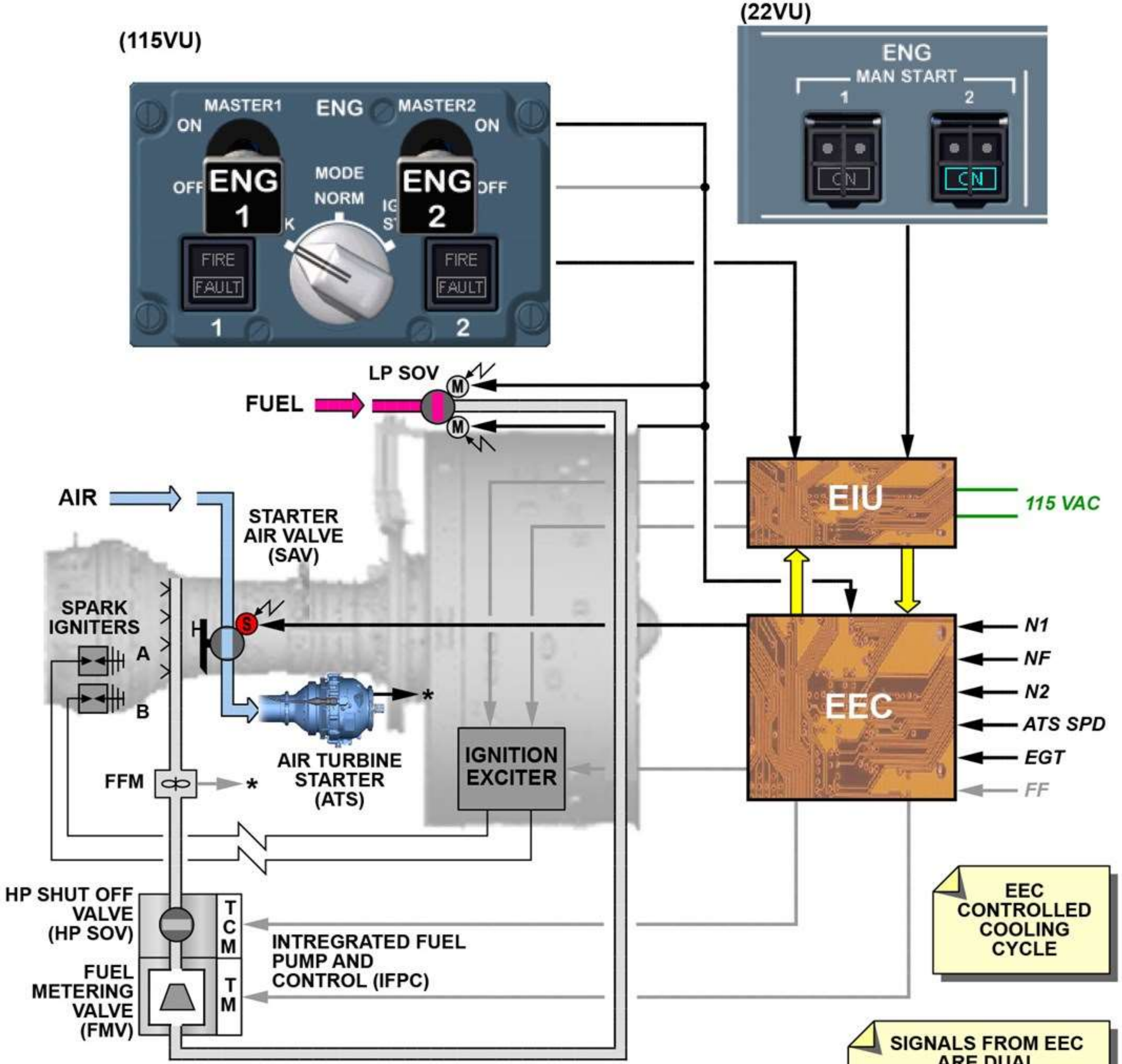
When the ENG MAN START P/B is set to ON, the EEC commands the SAV to open.

• Interruption:
  • ENG MAN START P/B OFF
  • ENG MODE rotary selector to NORM

The dry motoring can be interrupted at any time by pushing the ENG MAN START pushbutton to OFF or positioning the ENG MODE rotary selector to NORM position.
The usual starter duty cycle is 3 starter crank cycles or 4 minutes maximum of continuous cranking. A 30 minutes cool down period is necessary for additional use.
WARNING: the EEC is able to initiate a start sequence immediately following a dry motoring sequence by setting the ENG MODE rotary selector to IGN/START position and the ENG MASTER control lever to ON position.
C/B 1KC1(2) should be open to open the related LP valve and let fuel flow to the IFPC.
Max motoring speed = 30% N2 (TBC).

ECAM EWD

ECAM SD

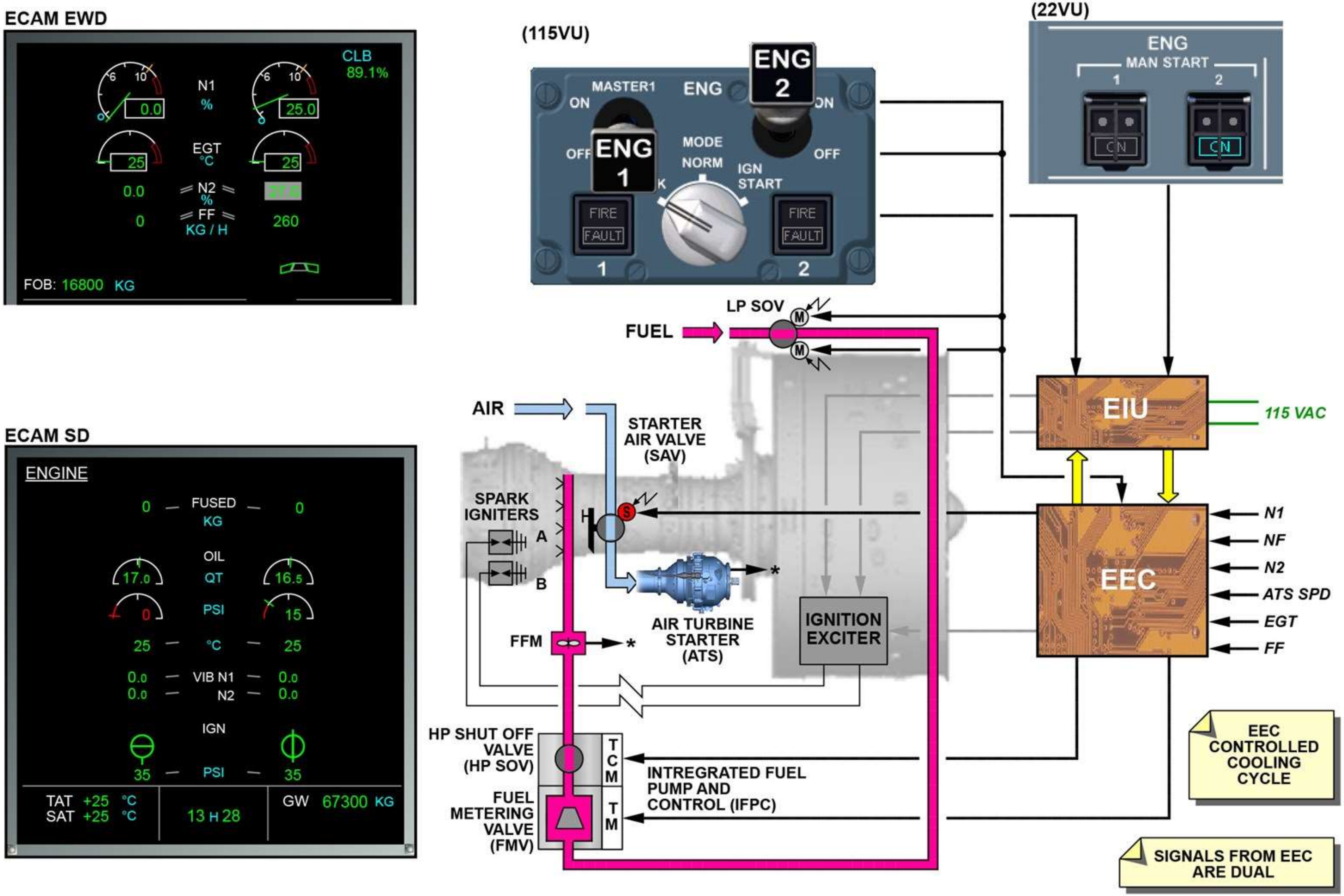


WET CRANK

• Wet cranking to check for leaks in fuel or oil systems
•Fuel flow commanded
•No ignition
•Fuel to IFPC, actuator pressure lines, engine manifolds, nozzles, and combustion chamber

The wet cranking procedure is used to motor the engine for specific fuel or oil leak tests.
The fuel flow is commanded but both ignition systems are isolated. The fuel goes through the IFPC to the actuator fuel pressure lines, the engine fuel manifolds (primary fuel lines only), and nozzles. Fuel is then sprayed in the combustion chamber.
The first steps of the wet crank sequence are the same as the ones for the dry crank:
- the engine is not running,
- the aircraft is on ground,
- the rotary selector is set to CRANK (EEC powered, both ignition systems isolated, ENGINE page appears),
- the ENG MAN START P/B is set to ON. (SAV opening).

When N2 speed stabilizes, the ENG MASTER lever is set to the ON position to command the fuel flow.
After 15 seconds, the ENG MASTER lever is set to the OFF position to cut the fuel supply.
The SAV command is maintained 30 seconds to blow all the fuel from the engine.
The wet motoring ends by pushing the ENG MAN START pushbutton to OFF or/and positioning the ENG MODE rotary selector to NORM position.
By design, the fuel pump may not supply adequate pressure at low speed; therefore the software shall not turn fuel on below the minimum fuel pressurization speed.
After a wet crank, an engine run of 5 minutes is necessary as per AMM procedure.


ECAM EWD
N1
%
CLB
89.1%
0.0
25.0
EGT
°C
25
25
N2
%
0.0
FF
KG / H
0
260
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
0
0
OIL
QT
17.0
16.5
PSI
0
15
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
EEC
CONTROLLED
COOLING
CYCLE
SIGNALS FROM EEC
ARE DUAL

Start Failures Description and Operation (Me)

AUTO-RESTART

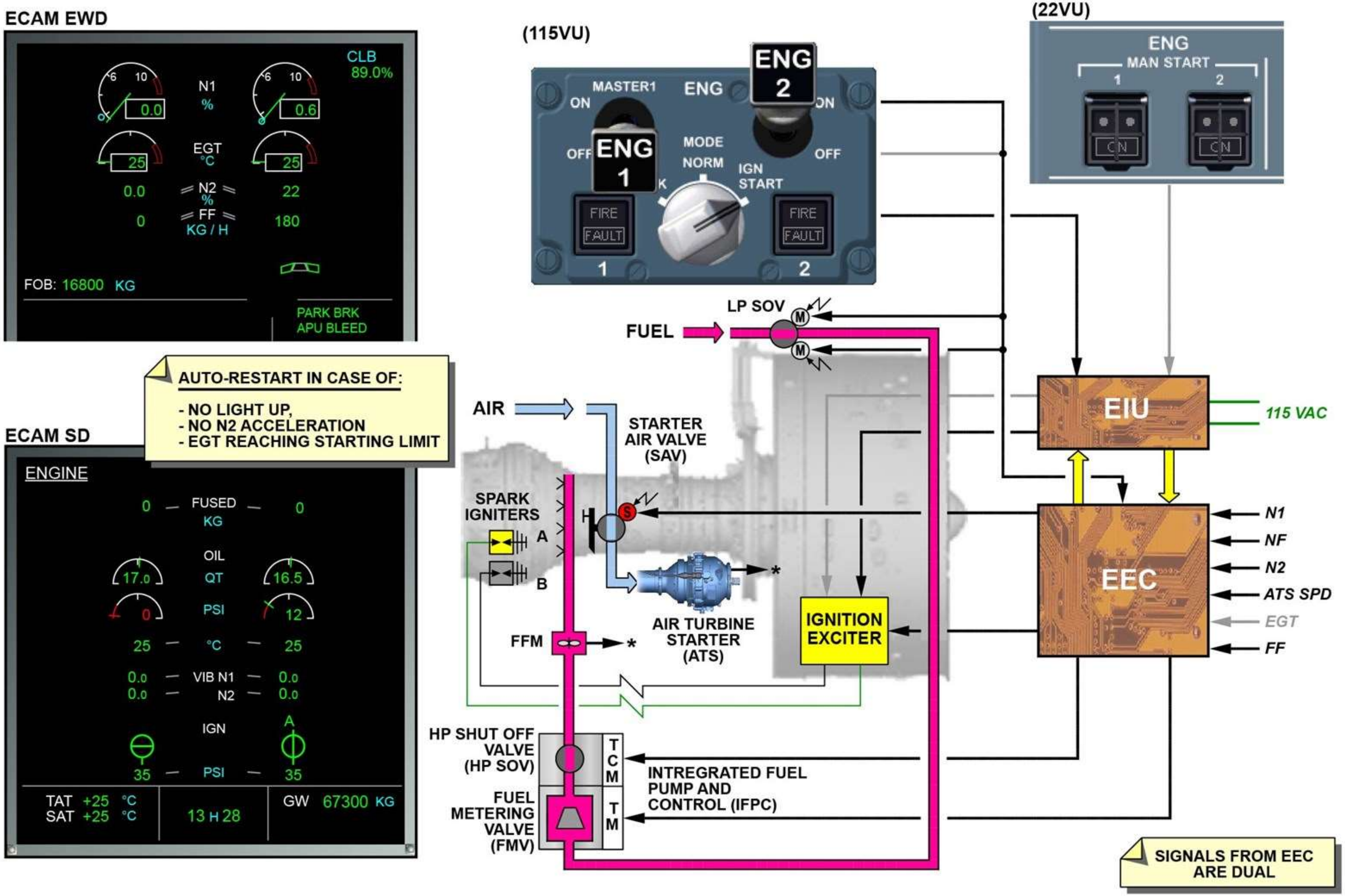
EEC abort auto start, dry motor & single auto start if:

- No light up
- No N2 acceleration
- EGT reaches starting limit

The Electronic Engine Computer (EEC) will abort the automatic start, dry motor the engine for 30 seconds and attempt a single auto-restart for the following reasons:
- No light up (Exhaust Gas Temperature (EGT) low and constant),
- No N2 acceleration (hung start),
- EGT reaches starting limit (impending hot start or surge).

The EEC will abort the automatic start, dry motor the engine for 30 seconds and not attempt a single auto-restart for the following conditions:
- Failure of auto-restart,
- N1 locked rotor,
- EEC unable to command both igniters,
- Loss of EGT indication,
- EEC unable to control fuel flow.

The EEC will also abort the automatic start, will not dry motor the engine and will not attempt a restart if the starter duty cycle is exceeded on ground.


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22
0
FF
KG / H
180
FOB: 16800 KG
PARK BRK
APU BLEED
AUTO-RESTART IN CASE OF:
- NO LIGHT UP,
- NO N2 ACCELERATION
- EGT REACHING STARTING LIMIT
ECAM SD
ENGINE
0 FUSED 0
KG
OIL
17.0
QT
16.5
0
PSI
12
25 °C 25
0.0 VIB N1 0.0
0.0 N2 0.0
IGN
A
35 PSI 35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
FFM
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
SIGNALS FROM EEC
ARE DUAL

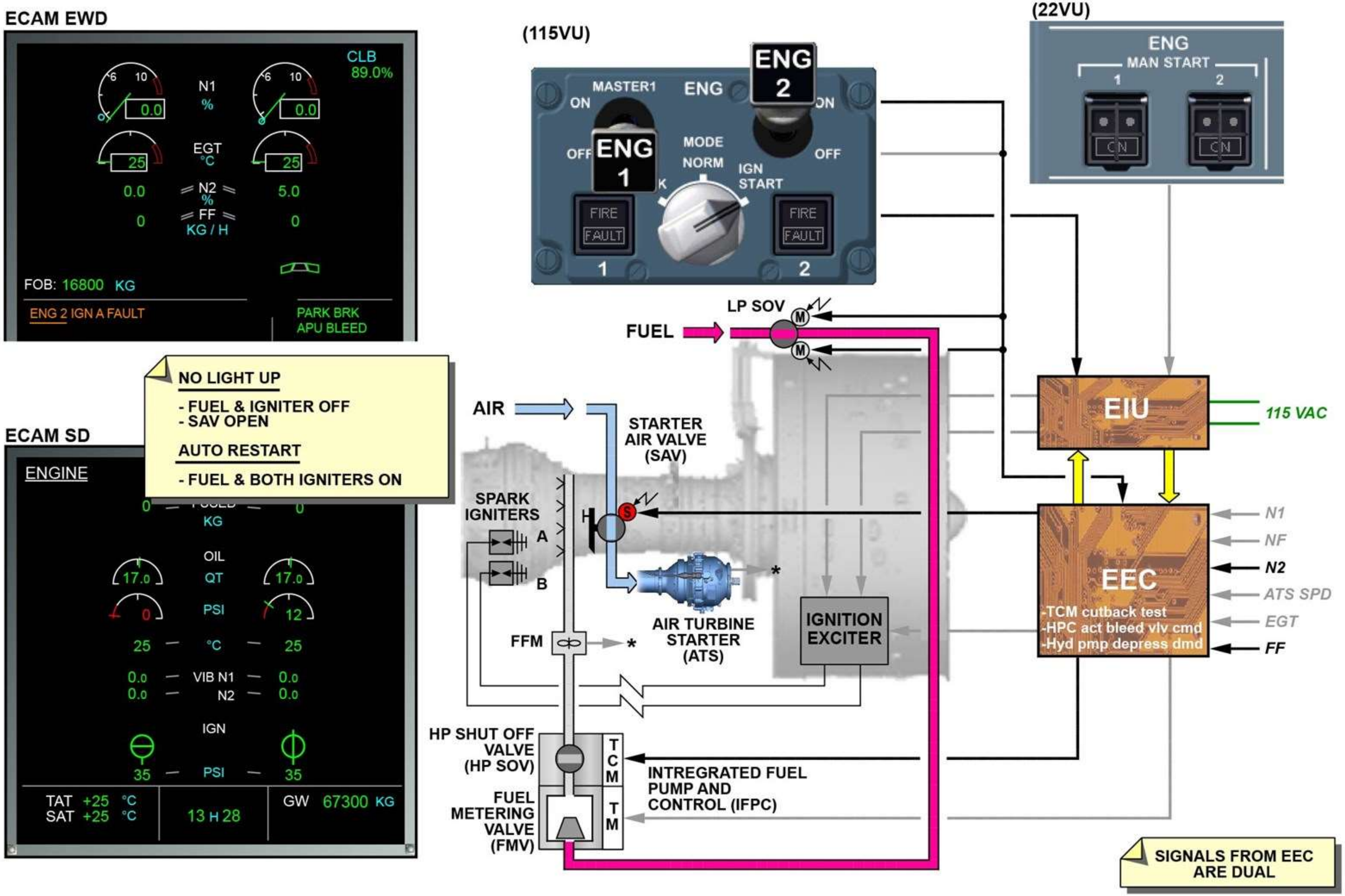
NO LIGHT UP

- In case of a low EGT, EEC:
  - Shuts down the fuel supply & selected igniter
  - Generates the ECAM alerts
  - Maintains the SAV open to clear fuel vapors & cool the turbine
  - Controls simultaneously FF & both igniters
  - Switches the igniters OFF & controls the SAV closure, when N2 reaches the starter cutout speed or light up confirmed
- Engine continues to accelerate to stabilize at idle speed

- If auto-restart fails:
  - Start is aborted
  - EEC generates ECAM alerts

If during an automatic start, the EEC identifies a low EGT:
- It shuts down the fuel supply and the selected igniter,
- It generates the ECAM alert "ENG x IGN A(B) FAULT",
- It maintains the Starter Air Valve (SAV) open to clear fuel vapors and cool the turbine for 30 seconds,
- Then it controls simultaneously the fuel flow and both igniters,
- When N2 reaches the starter cutout speed (or the light up is confirmed), it switches the igniters off and controls the SAV closure 1 seconds after (or 1 seconds after the starter duty cycle is exceeded).

The engine continues to accelerate and stabilizes at idle speed.
If this auto-restart attempt fails, the start is aborted and the EEC will generate the ECAM alerts "ENG x START FAULT (IGNITION FAULT)" and "ENG x IGN A+B FAULT".


ECAM EWD
N1
%
CLB
89.0%
0.0
0.0
EGT
°C
25
25
0.0
N2
%
5.0
0
FF
KG / H
0
FOB: 16800 KG
ENG 2 IGN A FAULT
PARK BRK
APU BLEED
NO LIGHT UP
- FUEL & IGNITER OFF
- SAV OPEN
AUTO RESTART
- FUEL & BOTH IGNITERS ON
ECAM SD
ENGINE
KG
OIL
QT
17.0
17.0
PSI
0
12
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG
1
ENG
2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
EIU
115 VAC
EEC
-TCM cutback test
-HPC act bleed vlv cmd
-Hyd pmp depress dmd
N1
NF
N2
ATS SPD
EGT
FF
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
SIGNALS FROM EEC
ARE DUAL

IMPENDING HOT START

• In case of impending hot start during auto start, EEC:
  - Maintains the SAV open
  - Maintains the selected igniter ON
  - Controls a depulse procedure
  - Generates ECAM alert

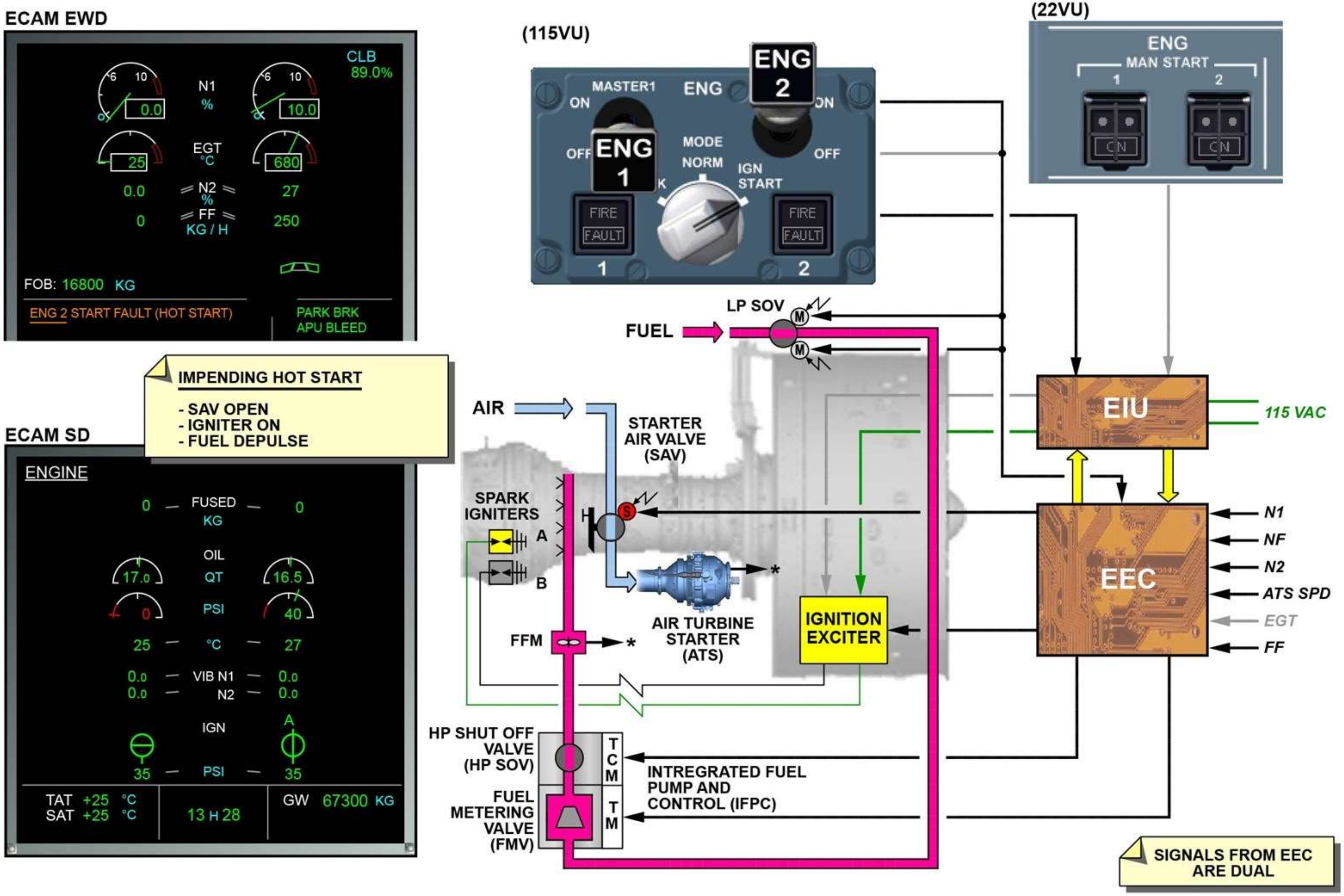
•If fault disappears:
  - Starting sequence goes on

•If fault is still present, EEC:
  - Shuts down fuel supply & igniter
  - Performs a dry motor

•If auto-restart fails, EEC:
  - Aborts the start
  - Generates ECAM alert

If during an automatic start, the EEC identifies an impending hot start, it maintains the SAV open, the selected igniter on and controls a fuel depulse procedure: it cycles fuel off for 2 seconds and back on for 12 seconds via the Fuel Metering Valve (FMV) for a maximum of 28 seconds to lower EGT below the limit. The EEC will generate the ECAM alert "ENG x START FAULT (HOT START)".

If the fault disappears, the starting sequence goes on normally up to the engine stabilizes at idle speed.
If the fault is still present, the EEC shuts down the fuel supply and the igniter, performs a dry motor for 30 seconds and attempts a single auto-restart.
If this auto-restart attempt fails, the start is aborted and the EEC will generate the ECAM alert "ENG x START FAULT (EGT OVERLIMIT)"
- The maximum EGT during start sequence is 997� C (TBC).
- The EGT amber line is 1043� C and red line is 1083� C.
- The EEC does not automatically abort an abnormal manual start except in case of hot start condition on ground. This will lead to generate the ECAM alert "ENG x EGT EXCEEDED DURING AIR START" with a NOGO condition at the arrival.


ECAM EWD
CLB
89.0%
N1
%
0.0
10.0
EGT
°C
25
680
0.0
N2
%
27
0
FF
KG / H
250
FOB: 16800 KG
ENG 2 START FAULT (HOT START)
PARK BRK
APU BLEED
IMPENDING HOT START
- SAV OPEN
- IGNITER ON
- FUEL DEPULSE
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
40
25
°C
27
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
FFM
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
SIGNALS FROM EEC
ARE DUAL

STARTER TIME EXCEEDED

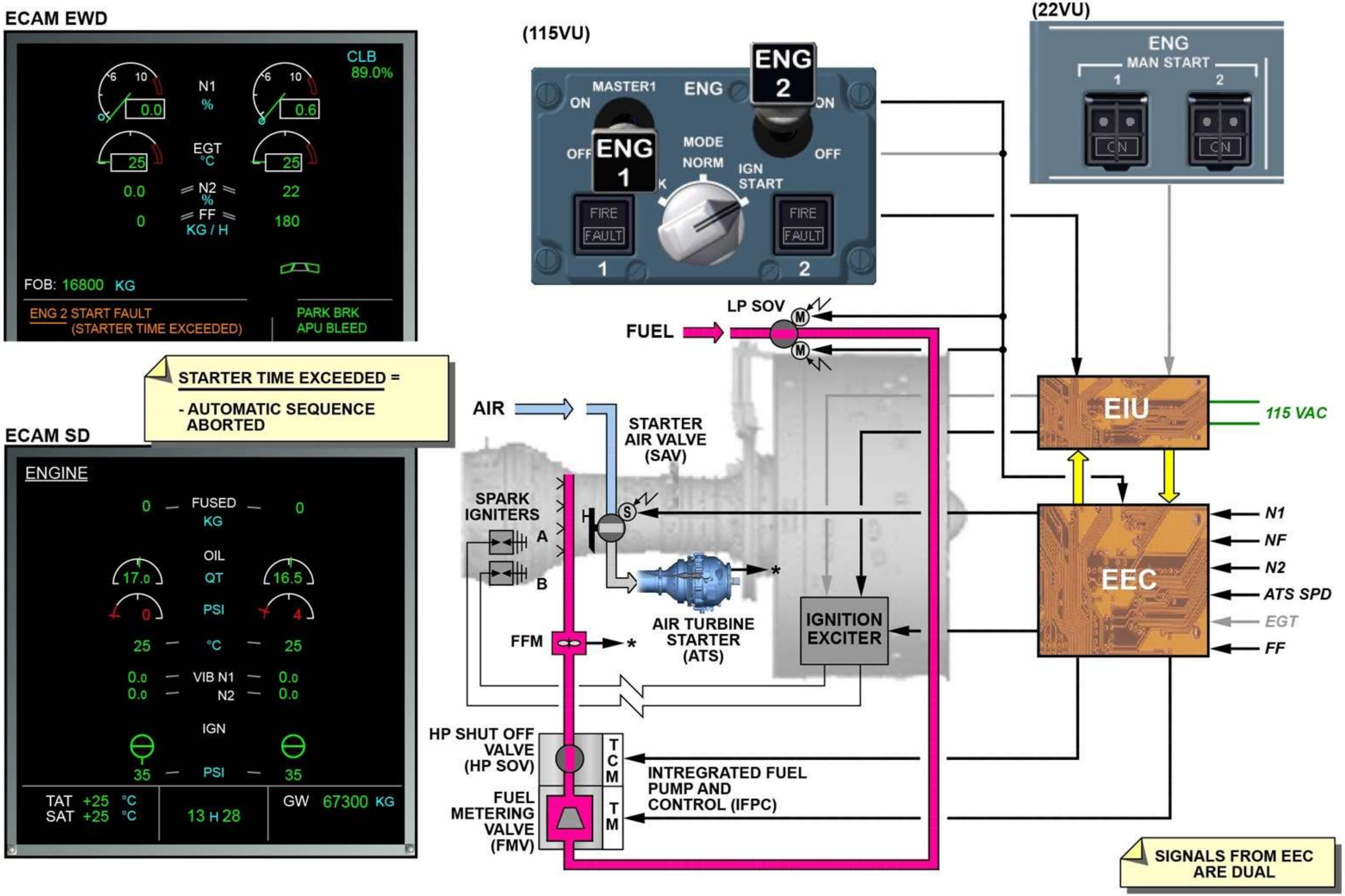
• EEC generates ECAM alert

•EEC aborts automatic sequence

If during a start or a crank sequence, the EEC identifies an excessive starter duty, it will generate the ECAM alert "ENG x START FAULT (STARTER TIME EXCEEDED)" and abort the automatic sequence.

The starter has been running (as determined by NS) for more than 900 seconds (TBC) with N2 < 44 %, OR

The starter has been running (as determined by NS) for more than 60 seconds (TBC) with N2 > 44%.


ECAM EWD
N1 %
0.0
0.6
CLB
89.0%
EGT °C
25
25
0.0
N2 %
22
0
FF KG / H
180
FOB: 16800 KG
ENG 2 START FAULT
(STARTER TIME EXCEEDED)
PARK BRK
APU BLEED
STARTER TIME EXCEEDED =
- AUTOMATIC SEQUENCE ABORTED
ECAM SD
ENGINE
0
FUSED KG
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
ON
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
FFM
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

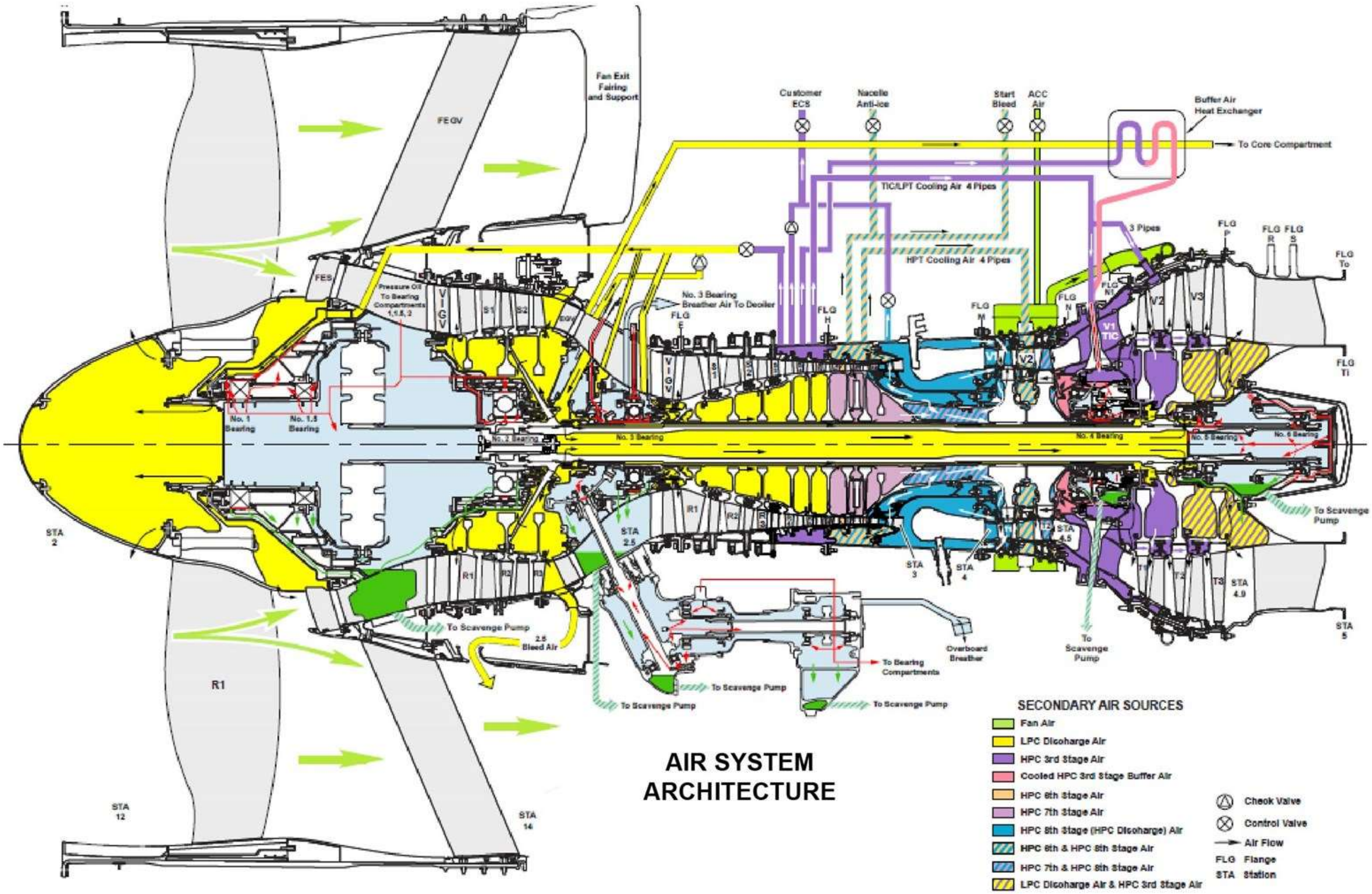
Air System Description and Operation

GENERAL

• Control of:
- Compressor airflow
- Turbine clearances
- Cooling, pressurizing and ventilation airflows

•Main sources:
- Fan and LPC discharge air
- HPC 3rd and 6th stages air

The engine air system makes sure that the compressor airflow and turbine clearances are controlled.
The system also deals with the cooling, pressurizing and ventilation airflows.
External and internal tubing is used to achieve the various functions.
The main air sources are the fan discharge air, Low Pressure Compressor (LPC) discharge air, High Pressure Compressor (HPC) 3^{rd} stage air and HPC 6^{th} stage air.



AIR SYSTEM ARCHITECTURE

COMPRESSOR AIRFLOW CONTROL

Comp loc ENG 1 LH

LPC SVA

HPC SVA primary

HPC SVA secondary

- Comprises of 2 subsystems:
  - Compressor Stator Vane Control System
  - Compressor Bleed Control System

The compressor control system optimizes the compressor performance and its stability during engine start, transient and reverse thrust operations.

The two subsystems that comprise the compressor control system are the:

- Compressor Stator Vane Control System,
- Compressor Bleed Control System.

STATOR VANE CONTROL SYSTEM

- Consists of:
  - 1st stage LPC stator vanes
  - IGV of the HPC and the 1st, 2nd and 3rd HPC stages
- LPC SVA and primary HPC SVA have:
  - Dual coil torque motor
  - Fuel operated EHSV
- Secondary HPC SVA is a slave of the primary
- SVA LVDTs transmit piston position to each EEC channel

The first stage LPC stator vanes and the HPC Inlet Guide Vanes (IGV) and the 1st, 2nd and 3rd HPC stages have variable stator vanes.

The Electronic Engine Control (EEC) controls the vanes positioning to adjust the compressor airflow via three Stator Vane Actuators (SVAs) and mechanical linkages. Each of the LPC SVA and the primary HPC SVA comprises an electrically controlled dual coil torque motor and a fuel operated Electro-Hydraulic Servo Valve (EHSV). The secondary HPC SVA is a slave of the primary. The three SVA Linear Variable Differential Transformers (LVDTs) transmit the piston position to each EEC channel individually.

The LPC SVA is mounted at the 10 o'clock position on the aft side of the intermediate case firewall.

The HPC SVA primary is mounted at the 3 o'clock position on the high pressure compressor case.

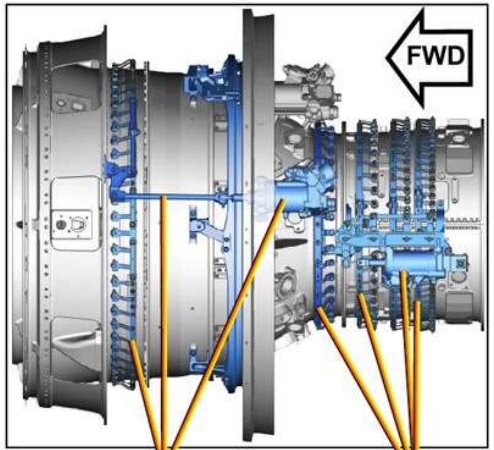
The HPC SVA secondary is mounted at the 9 o'clock position on the high pressure compressor case.

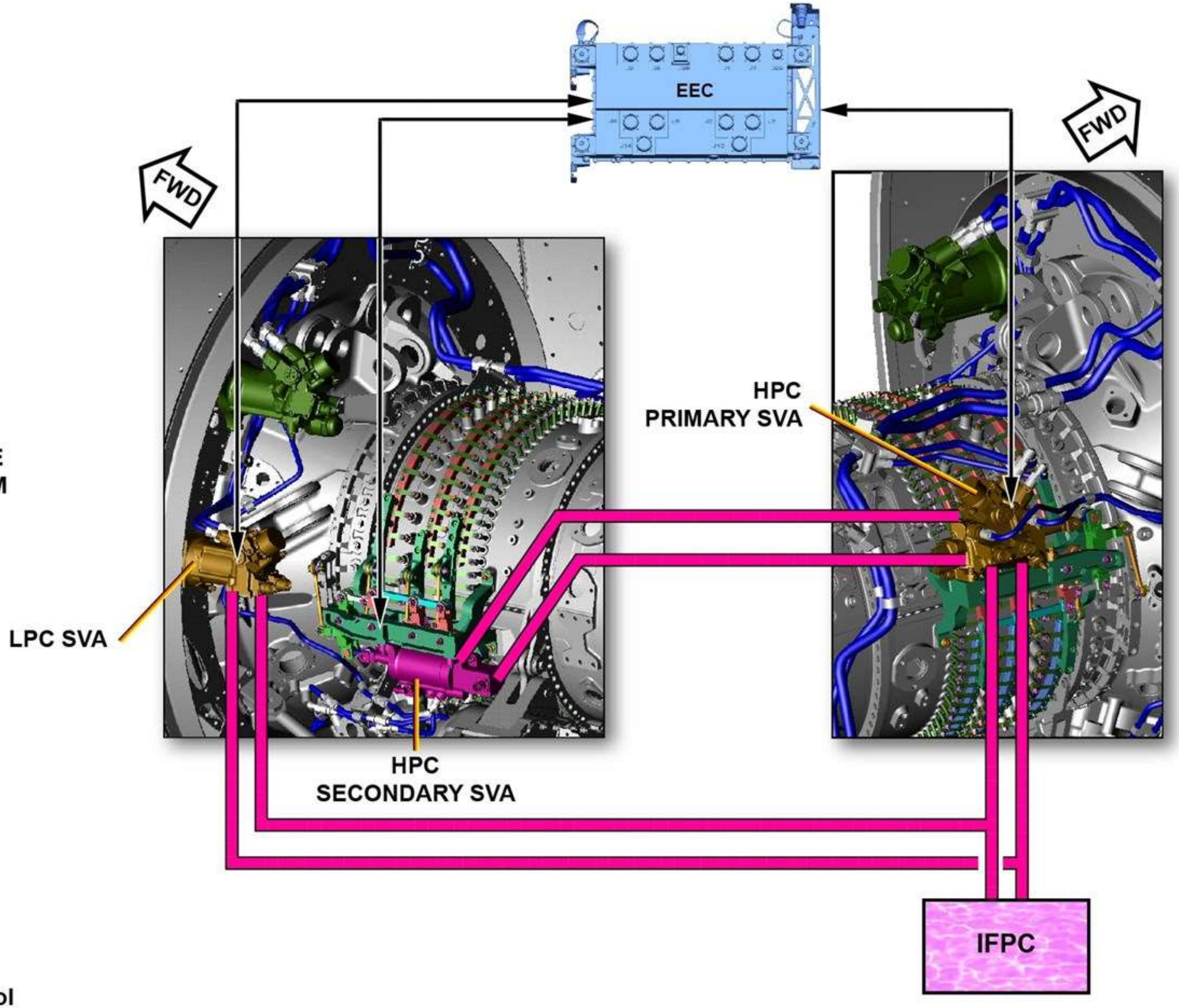
The SVA positions the variable vanes as a function of N1, N2, T2 and T2.5.

The SVA fail-safe position is fully retracted (vanes open).

The LPC vanes are fully open during engine start and takeoff.

The HPC vanes are closed during engine start and idle and open during takeoff





Servo Fuel line
EEC: Electronic Engine Control
HPC: High Pressure Compressor
IFPC: Integrated Fuel Pump and Control
LPC: Low Pressure Compressor
SVA: Stator Vane Actuator

COMPRESSOR AIRFLOW CONTROL SYSTEM

BLEED CONTROL SYSTEM

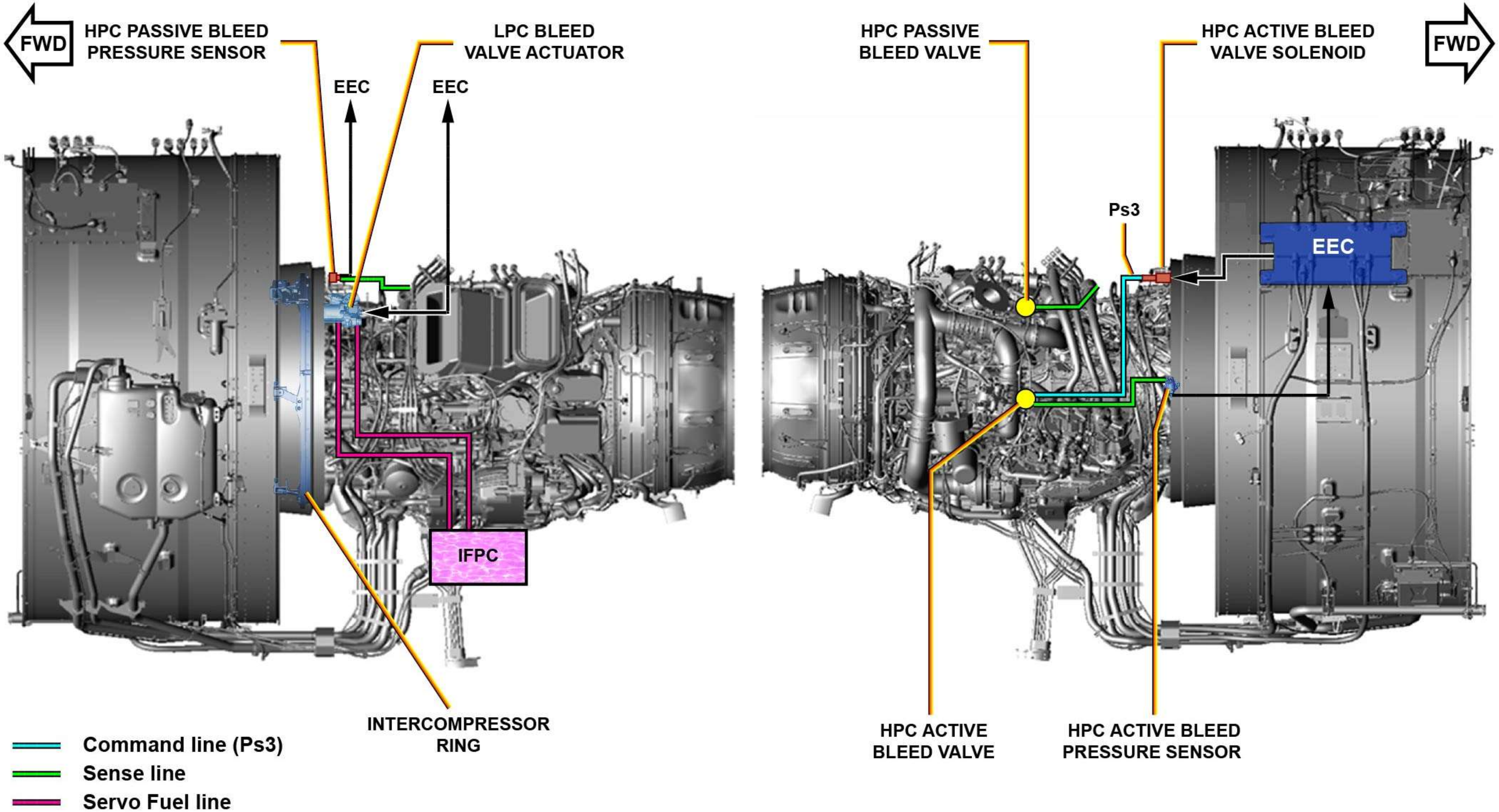
Comp loc ENG 1 LH
LPC BVA
HPC BV active
HPC BV passive

- Comprises:
    - 1 LPC BVA
    - 2 HPC bleed valves
- LPC BVA has:
    - A dual coil torque motor
    - A fuel operated EHSV
- Actuator LVDT transmits piston position to each EEC channel

The compressor bleed control system comprises one LPC Bleed Valve Actuator (BVA) and two HPC bleed valves.
The LPC bleed system is used to control the LPC discharge 3rd stage airflow into the fan discharge.
The EEC modulates the LPC BVA and mechanical linkages accordingly.
The LPC BVA comprises an electrically controlled dual coil torque motor and a fuel operated EHSV.
The actuator LVDT transmits the piston position to each EEC channel individually.
The LPC BVA is mounted at the 9 o'clock position on the aft side of the intermediate case firewall.
The LPC BVA positions the intercompressor ring (station 2.5) as a function of N1, N2, T2, Mn, TLA and altitude.
The LPC bleed valve is fully open during engine start, idle, rapid deceleration, reverse operation or surge.
It closes progressively as the power increases. Its fail safe position is fully open.

- HPC bleed system controls the HPC 6th stage airflow
- Two ON-OFF HPC bleed valves: 1 active, the other is passive
    - Active valve is controlled closed by EEC
    - Passive valve closes when the pressure inside the HPC is high enough

The HPC bleed system is used to control the HPC 6th stage airflow into the core area.
The system has two ON-OFF HPC bleed valves; one is active, the other passive, and both spring-loaded open and pneumatically closed at certain engine operating conditions.
The active valve is EEC controlled closed through the HPC bleed valve solenoid thanks to Ps3 pressure.
The passive valve closes when the pressure inside the HPC is high enough to force the spring loaded valve closed.
Both are monitored by the EEC thanks to two dedicated pressure sensors.
The Active HPC bleed valve is mounted at the 8 o'clock position on the diffuser case.
The HPC bleed valve controller positions the active HPC bleed valve as a function of N2, T2 and T2.5.
The active HPC bleed valve is open during engine start up to idle, and then closes under EEC control.
Its fail safe position is open.
Passive HPC bleed valve is mounted at the 2 o'clock position on the diffuser case.
The passive HPC bleed valve is open during engine start and starts to close before idle.



EEC: Electronic Engine Control
HPC: High Pressure Compressor
IFPC: Integrated Fuel Pump and Control
LPC: Low Pressure Compressor

BLEED CONTROL SYSTEM

TURBINE ACTIVE CASE COOLING SYSTEM

Comp loc ENG 1 LH

TACC valve

- Turbine ACC system cools and controls the expansion of the turbine case
    - Improves the fuel efficiency
    - Extends the turbine case life
- EEC modulates turbine ACC air valve to discharge airflow around LP and HP turbine cases
- Turbine ACC air valve comprises:
    - An electrically controlled SSSV
    - A fuel operated actuator
- An LVDT transmits piston position to EEC channel A

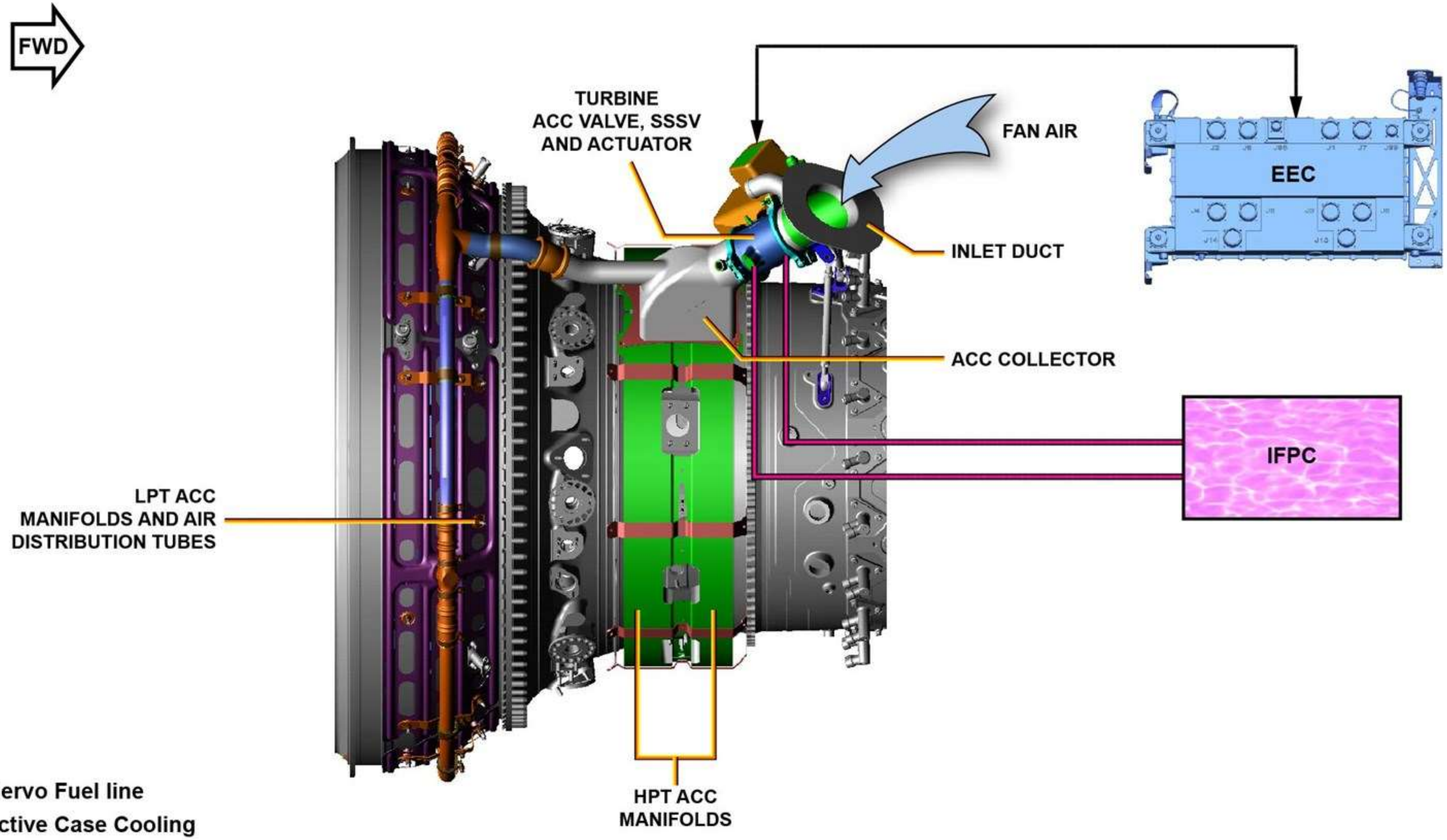
The Turbine Active Case Cooling (ACC) system cools and controls the expansion of the turbine case to match the radial expansion of the rotary parts; this improves the fuel efficiency and extends the turbine case life.

The EEC modulates the turbine ACC air valve to let some fan air flow be discharged via manifolds and tubes around the LP and HP turbine cases. The turbine ACC air valve comprises an electrically controlled Single Stage Servo Valve (SSSV) and a fuel operated actuator that operates the butterfly. An LVDT transmits the piston position to the EEC channel A.

The Turbine ACC air valve is mounted at the 3 o'clock position above the combustion chamber case.

The SSSV positions valve as a function of N2 and Altitude.

Its fail safe position is closed.



Servo Fuel line

ACC: Active Case Cooling

EEC: Engine Electronic Control

HPT: High Pressure Turbine

IFPC: Integrated Fuel Pump and Control

LPT: Low Pressure Turbine

SSSV: Single Stage Servo Valve

TURBINE ACTIVE CASE COOLING SYSTEM

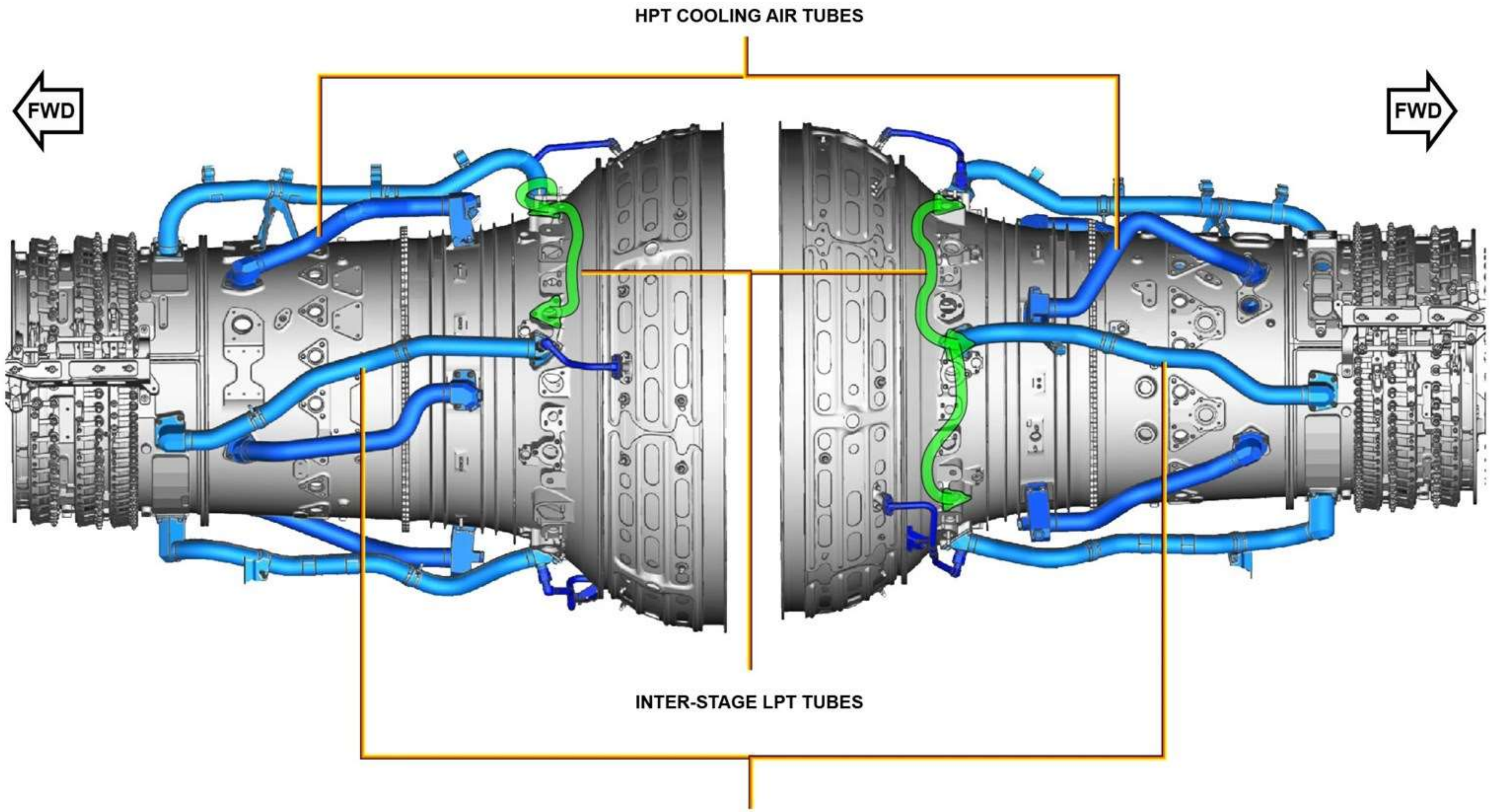
TURBINE COOLING AIR SYSTEM

- Provides a continuous flow of cooling air inside the turbine cases
- Comprises of 19 external tubes or jumpers
- Calibrated HPC bleed air directed to:
  - HPT 2nd stage vanes
  - Inter-stage HPT cavity
  - TIC Stator Vanes
  - LPT case outer cavity and LPT rotor inter-stage cavities

The Turbine Cooling Air (TCA) System is a passive system that provides a continuous flow of cooling air inside the turbine cases.

The system consists of 19 external tubes or jumpers that direct calibrated HPC bleed air (3rd and 6th stages) to the followings:

- High Pressure Turbine (HPT) 2nd stage vanes,
- Inter-stage HPT cavity,
- Turbine Intermediate Case (TIC) Stator Vanes, including the inner and outer diameter cavities,
- Low Pressure Turbine (LPT) case outer cavity and LPT rotor inter-stage cavities.



HPT: High Pressure Turbine

LPT: Low Pressure Turbine

TIC: Turbine Intermediate Case

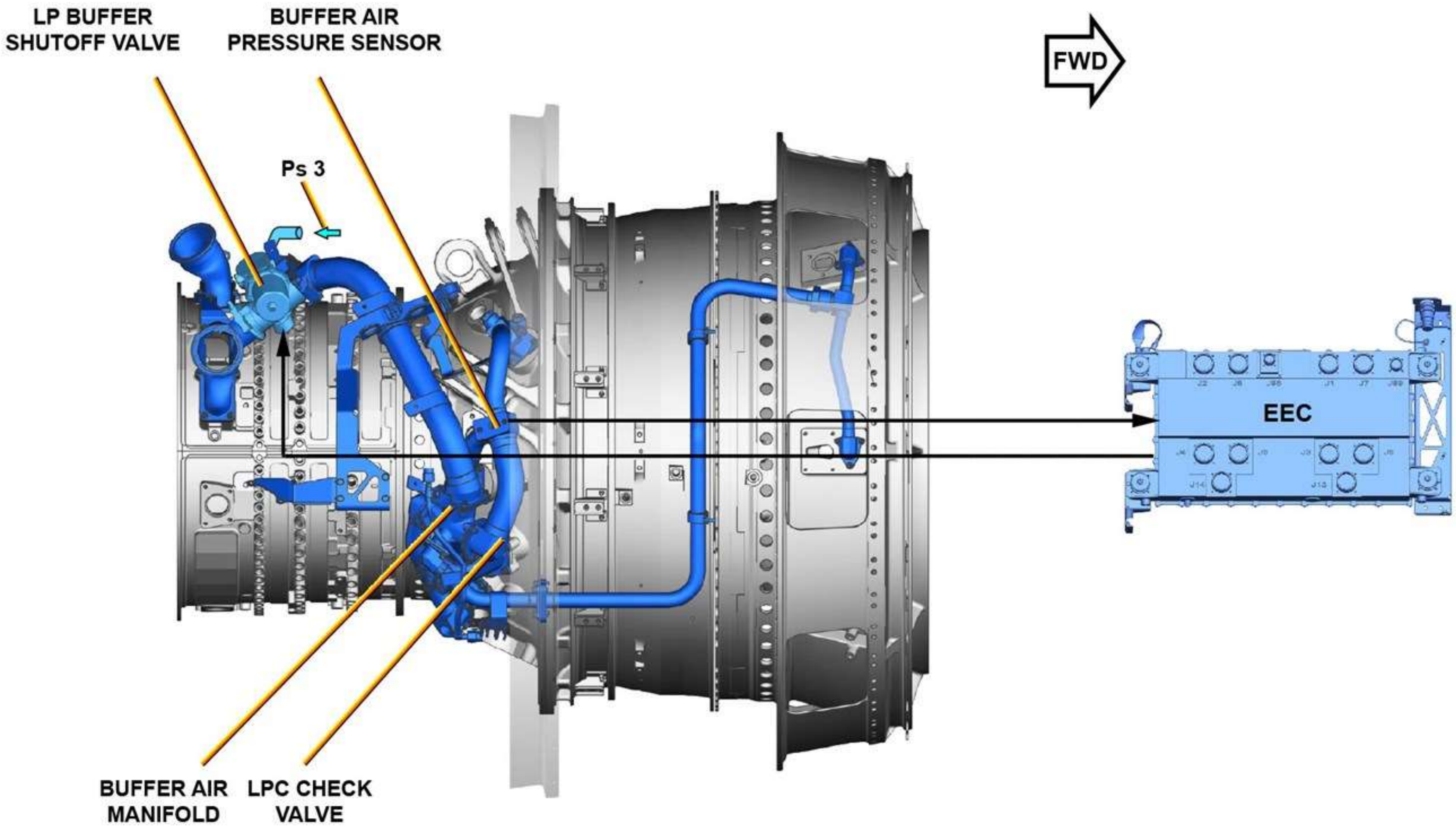
TURBINE COOLING AIR SYSTEM

ENGINE BEARING COOLING SYSTEM
Comp loc ENG 1 LH
LP buffer SOV
BAHE

• Provides cooling buffer air to the engine main bearing compartments
•Supplies sealing air to prevent oil leakage
The engine bearing cooling system provides cooling buffer air to the engine main bearing compartments and supplies sealing air to prevent oil leakage. It consists of:
- the buffer/ventilation system for bearing numbers 1, 1.5, 2, 3, 5 and 6,
- the engine bearing cooling system for bearing number 4.

BUFFER / VENTILATION SYSTEM
•Compartment of bearings number 1, 1.5, 2, 3, 5 and 6 plus FDGS cooled and pressurized by:
- HPC 3rd stage at low power
- 2.5 bleed air valve at high power

•LP buffer shutoff valve open by EEC controlled HPC buffer shutoff valve solenoid
•BAPS provides buffer air pressure signal to both EEC channels
The compartments of bearings number 1, 1.5, 2, 3, 5 and 6 plus the Fan Drive Gear System (FDGS) are cooled and pressurized by the HPC 3rd stage through the LP buffer shutoff valve at low power or by the 2.5 bleed air valve at high power through the LPC check valve.
The LPC check valve is a passive device that is open until the HPC 3rd stage pressure delivered by the LP buffer shutoff valve is higher than the 2.5 pressure, to prevent a reverse flow.
The LP buffer shutoff valve is open through the integrated EEC controlled HPC buffer shutoff valve solenoid thanks to Ps3 pressure.
The cooling buffer air is distributed to the bearing compartments via external and internal tubing, including LP shaft.
For monitoring, the Buffer Air Pressure Sensor (BAPS) provides a buffer air pressure signal to both EEC channels.
The LP buffer shutoff valve is mounted at the 2 o'clock position on the HPC split case.
The valve comprises a solenoid and a butterfly pneumatically operated by a piston, it is spring loaded and failsafe closed.
The BAPS is mounted at the 3 o'clock position on the rear side of the Compressor Intermediate Case Firewall.



Command line (Ps3)

EEC: Electronic Engine Control

LPC: Low Pressure Compressor

BUFFER / VENTILATION SYSTEM

NUMBER 4 BEARING COOLING SYSTEM

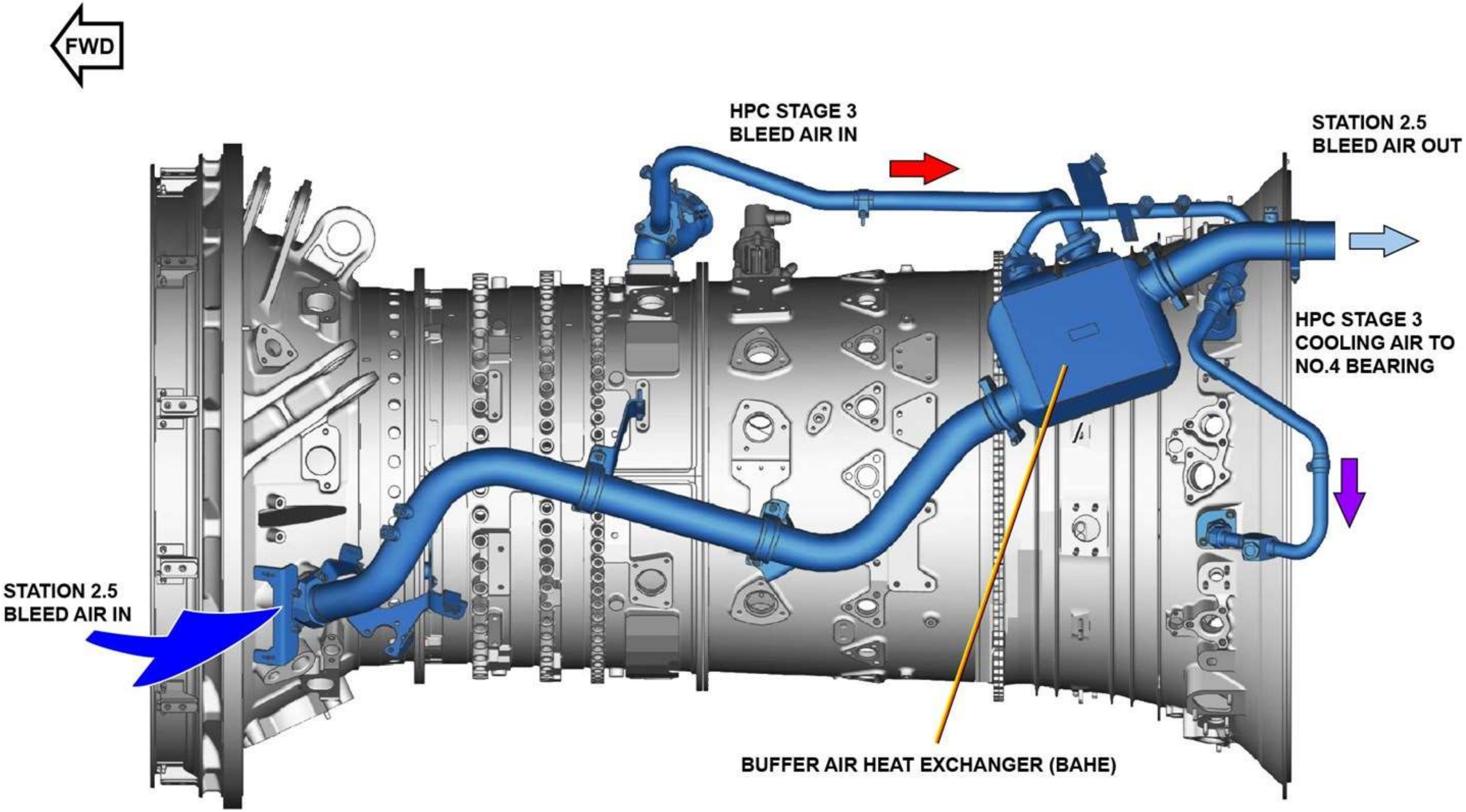
• BAHE:

  - Uses station 2.5 bleed air to cool HPC 3rd stage air
  - Delivers cooled air to number 4 bearing housing

•Station 2.5 air exiting BAHE is routed into the Core Compartment area

The Buffer Air Heat Exchanger (BAHE) uses station 2.5 bleed air to cool HPC 3rd stage air before it is delivered to the number 4 bearing housing. The station 2.5 air exits the BAHE and is routed into the Core Compartment area.

The BAHE is mounted at the 9 o'clock position on the diffuser case.



HPC: High Pressure Compressor

ENGINE BEARING COOLING SYSTEM

COMPARTMENT COOLING

• Ensures ventilation of:
  - The fan compartment
  - The core compartment and dedicated components inside

The compartment cooling system ensures the ventilation of the fan compartment, the core compartment and dedicated components inside the core compartment.

• Fan compartment cooling is achieved through a passive ventilation system

•Outside airflow:
  - Enters through the top scoop of the fan case
  - Exhausts through bottom holes and gabs of the fan cowls

The cooling of the fan compartment is achieved through a passive ventilation system. Outside airflow circulates from the top scoop around the fan case and exhausts through bottom holes and gabs of the fan cowls.

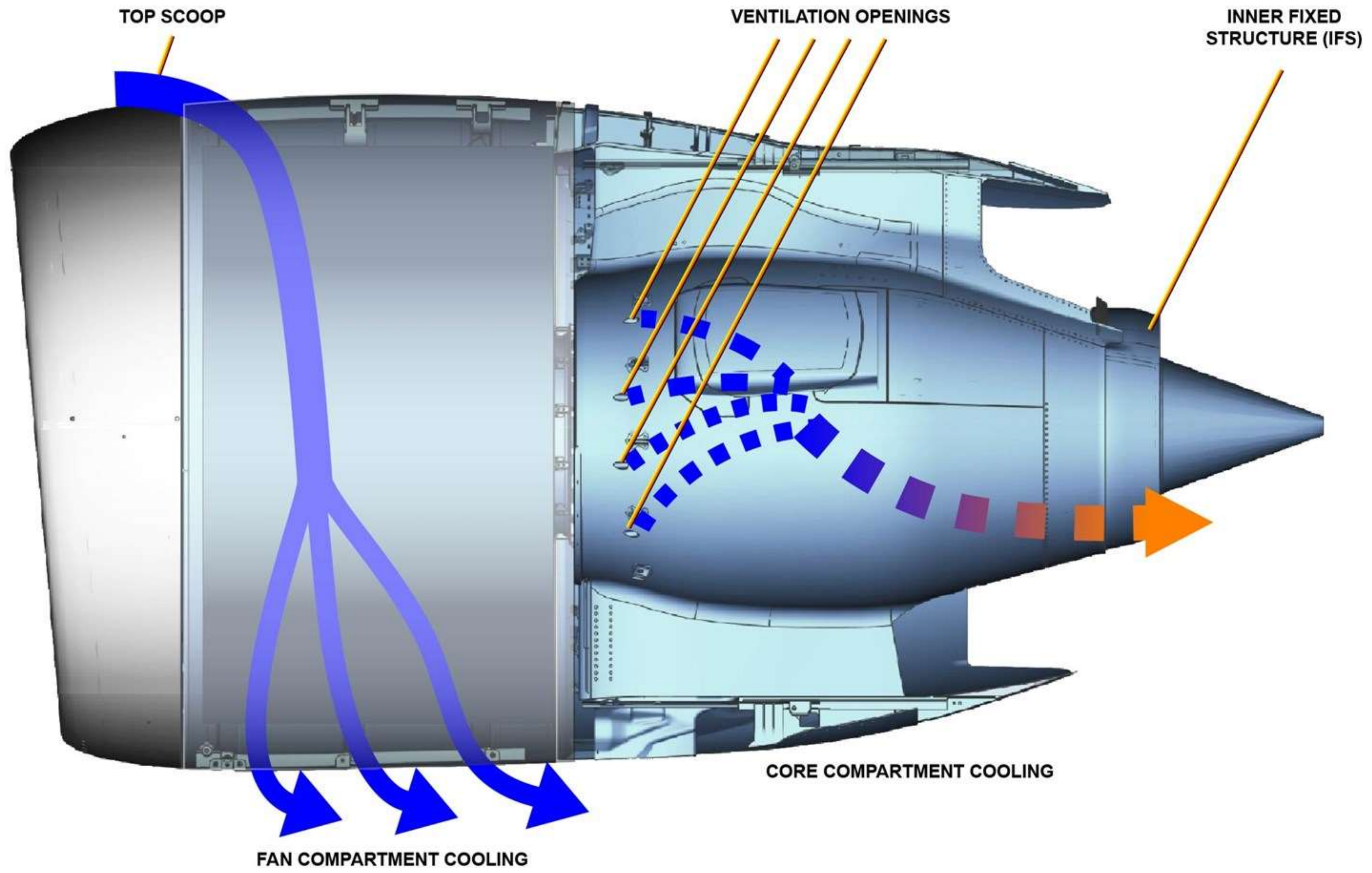
• Core compartment cooling is achieved through a passive ventilation system

•Fan bypass airstream is directed to:
  - Nacelle core
  - Ignition leads
  - Igniter plugs
  - ECS bleed valves

•Air exhausts through bottom holes and gabs of the IFS trailing edge

•Additional tubes for the cooling of the ACC Valve, SAV and FDV

The cooling of the core compartment is achieved through a passive ventilation system. Fan bypass airstream is directed to the nacelle core, ignition leads, igniter plugs and Environmental Control System (ECS) bleed valves through openings on the inner contour of the thrust reverser cowl doors and exhausts through bottom holes and gabs of the Inner Fixed Structure (IFS) trailing edge. Additional tubes are dedicated for the cooling of the ACC Valve, Starter Air Valve (SAV) and the Flow Divider Valve (FDV).



COMPARTMENT COOLING SYSTEM

Throttle Control System Description

THROTTLE CONTROL LEVER

• Throttle control lever:
  - A throttle control lever which includes stop devices and autothrust instinctive disconnect pushbutton switch
  - A graduated fixed sector
  - A reverse latching lever

•The throttle control lever is linked to a mechanical rod

The Throttle control handle comprises:
o a throttle control lever which incorporates stop devices, autothrust instinctive disconnect pushbutton switch
o a graduated fixed sector
o a reverse latching lever.

The throttle control lever is linked to a mechanical rod. This rod drives the input lever of the throttle control artificial feel unit.

• Range of Throttle control lever:
  - -20 deg.TLA (Reverser Full Throttle stop)
  - + 45 deg.TLA (Forward Full Throttle stop)

•An intermediate mechanical stop set to 0 deg. TLA

The throttle control lever moves over a range from -20 deg.TLA (Reverser Full Throttle stop) to +45 deg.TLA:
o -20 degrees TLA corresponds to Reverser Full Throttle stop
o +45 degrees TLA corresponds to Forward Full Throttle stop

An intermediate mechanical stop is set to 0 deg. TLA. This stop is overridden when the reverse latching lever is pulled up for selection of the reverse power. This stop is reset as soon as the throttle control lever is selected back to forward thrust area.

• In forward thrust area, there are two detent points:
  - MAX CLIMB detent point set at 25 deg.TLA
  - MAX CONTINUOUS/FLEX TAKE-OFF detent point set at 35 deg.TLA

•In the reverse thrust throttle range, there is one detent point:
  - -6 deg. TLA, this position agrees with the selection of the thrust reverser command and the reverse idle setting

•In the middle throttle range, the autothrust function can be active if engaged. This range agrees with the selection of MAX CLIMB or MAX CONTINUOUS thrust limit mode (in single engine operation)

•If autothrust not engaged, engine control is manual

•In the forward range, the autothrust function cannot be activated (except in Alpha floor condition). This range agrees with the selection of FLEX TAKE-OFF/MAX TAKE-OFF mode

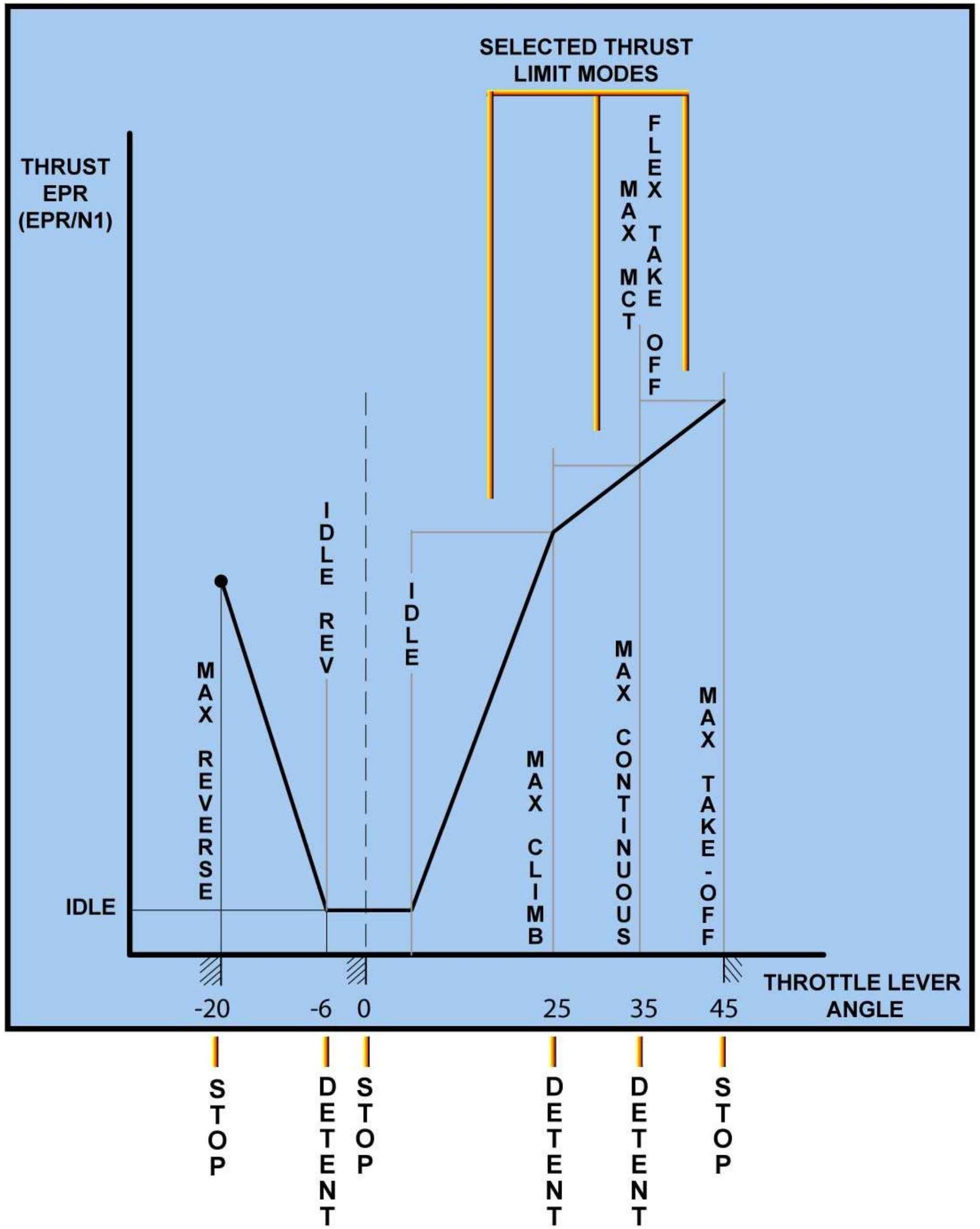
•From -20 deg.TLA to 0 deg.TLA, the autothrust function cannot be activated

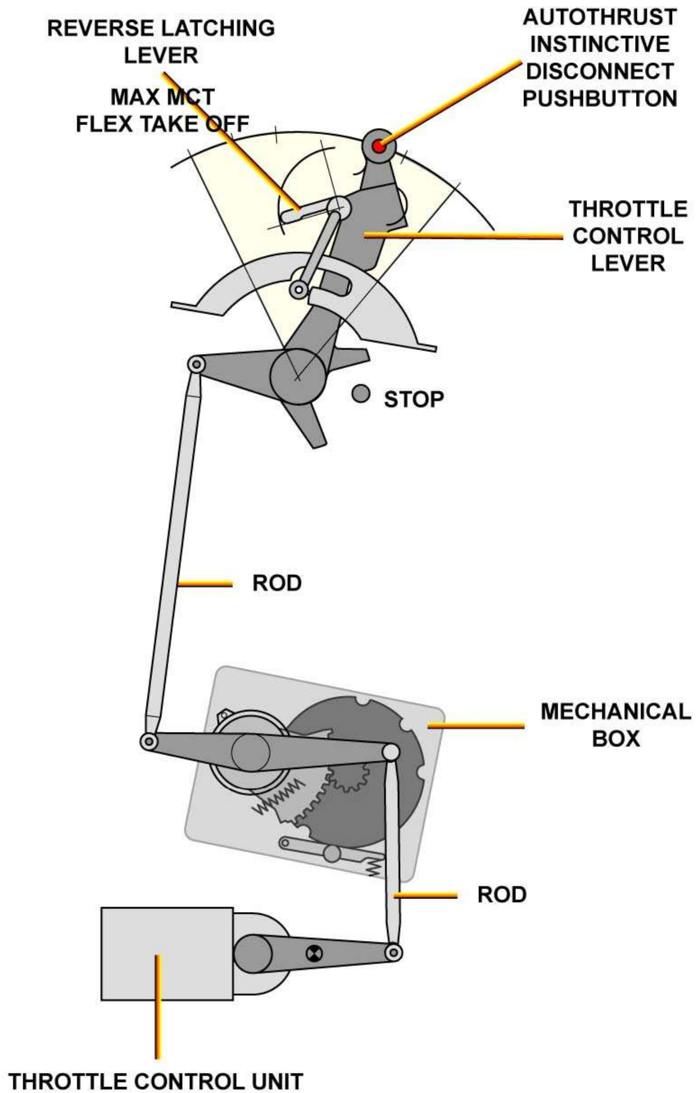
In the forward thrust area, there are two detent points, the MAX CLIMB detent point set to 25 deg.TLA and the MAX CONTINUOUS/FLEX TAKE-OFF detent point set to 35 deg.TLA.

In the reverse thrust throttle range, there is one detent point at - 6 deg.TLA. This position agrees with the selection of the thrust reverser command and the Reverse Idle setting.

In the middle throttle range (0 deg. To 35 deg.TLA), the autothrust function can be active if engaged. This range agrees with the selection of MAX CLIMB or MAX CONTINUOUS thrust limit mode (in single operation). If the autothrust is not engaged, the engine control is manual.

In the forward range (35 deg. To 45 deg.TLA), the autothrust function cannot be activated (except in alpha floor condition).This range agrees with the selection of FLEX TAKE-OFF/MAX TAKE-OFF Mode.


SELECTED THRUST LIMIT MODES
THRUST EPR (EPR/N1)
MAX MCT
FLEX TAKE OFF
IDLE REV
IDLE
MAX REVERSE
MAX CLIMB
MAX CONTINUOUS
MAX TAKE-OFF
IDLE
-20
-6
0
25
35
45
THROTTLE LEVER ANGLE
STOP
DETENT
STOP
DETENT
DETENT
STOP


REVERSE LATCHING LEVER
MAX MCT
FLEX TAKE OFF
AUTOTHRUST INSTINCTIVE DISCONNECT PUSHBUTTON
THROTTLE CONTROL LEVER
STOP
ROD
MECHANICAL BOX
ROD
THROTTLE CONTROL UNIT

THROTTLE CONTROL UNIT

• The throttle control unit comprises:

- An input lever
- Mechanical stops which limit the angular range
- 2 resolvers (one resolver per FADEC (ECU/EEC)
- 6 potentiometers installed three by three
- A device which drives the resolver and the potentiometer
- A pin device for rigging the resolver and potentiometers
- 1 switch whose signal is dedicated to the EIU
- 2 output electrical connectors

A mechanical rod transmits the throttle control lever movement. It connects the throttle artificial feel unit to the input lever of the throttle control unit. The throttle control unit comprises:

-An input lever
-Mechanical stops, which limit the angular range
-2 resolvers (one resolver per FADEC (ECU/EEC)
-6 potentiometers installed three by three
-A device, which drives the resolver and the potentiometer
-A pin device for rigging the resolver and potentiometers
-1 switch whose signal is dedicated to the EIU
-2 output electrical connectors

• The input lever drives two gear sectors
•Each sector drives itself a set of one resolver and three potentiometers.
•Relationship between throttle lever angle and throttle resolver angle (TRA): 1 deg.TLA=1.9 TRA (Linear)
•The accuracy of the throttle control unit is 0.5 deg.TRA
•The maximum discrepancy between the signals generated by two resolvers is 0.25 deg.TRA
•TLA resolver operates in two quadrants:

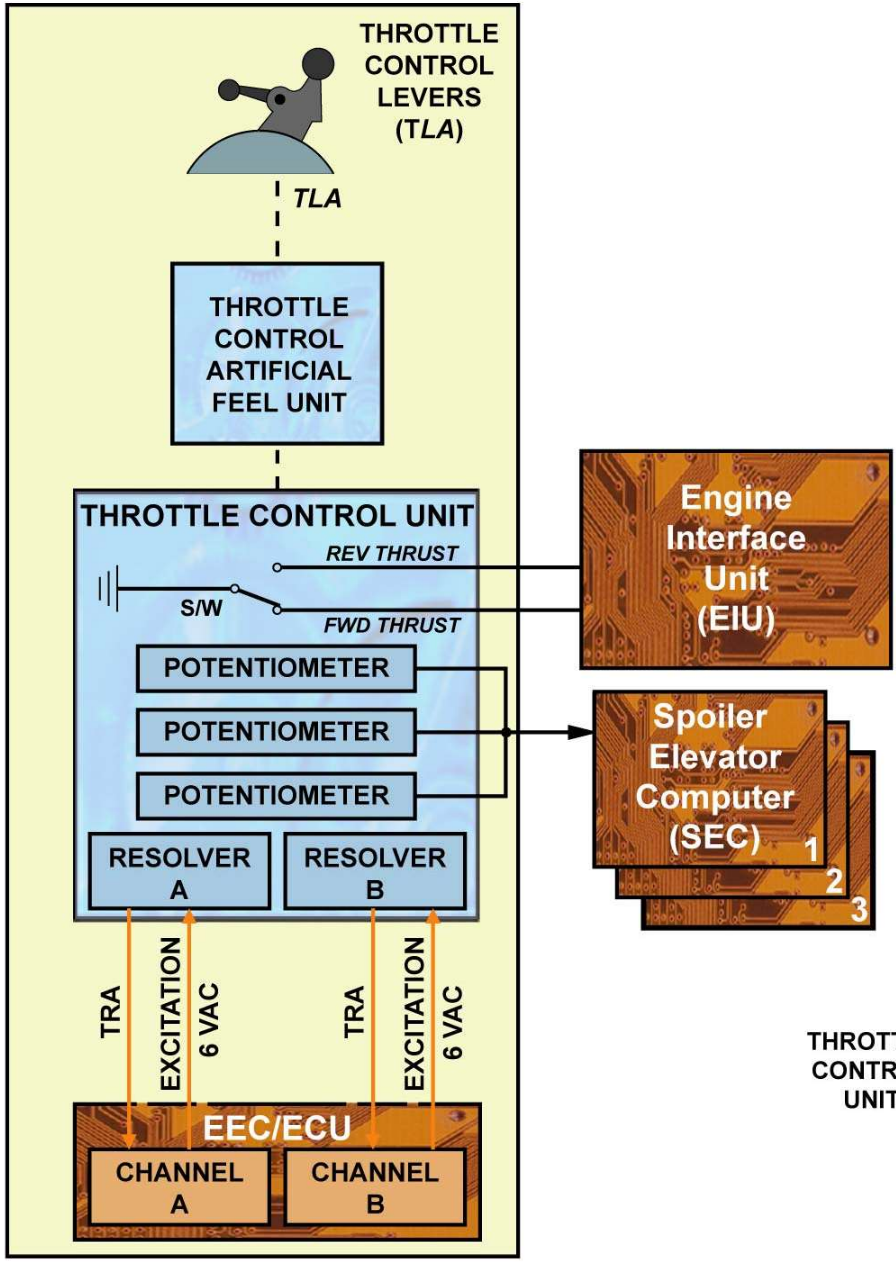
- 1 quadrant for positive angles
- 1 quadrant for negative angles

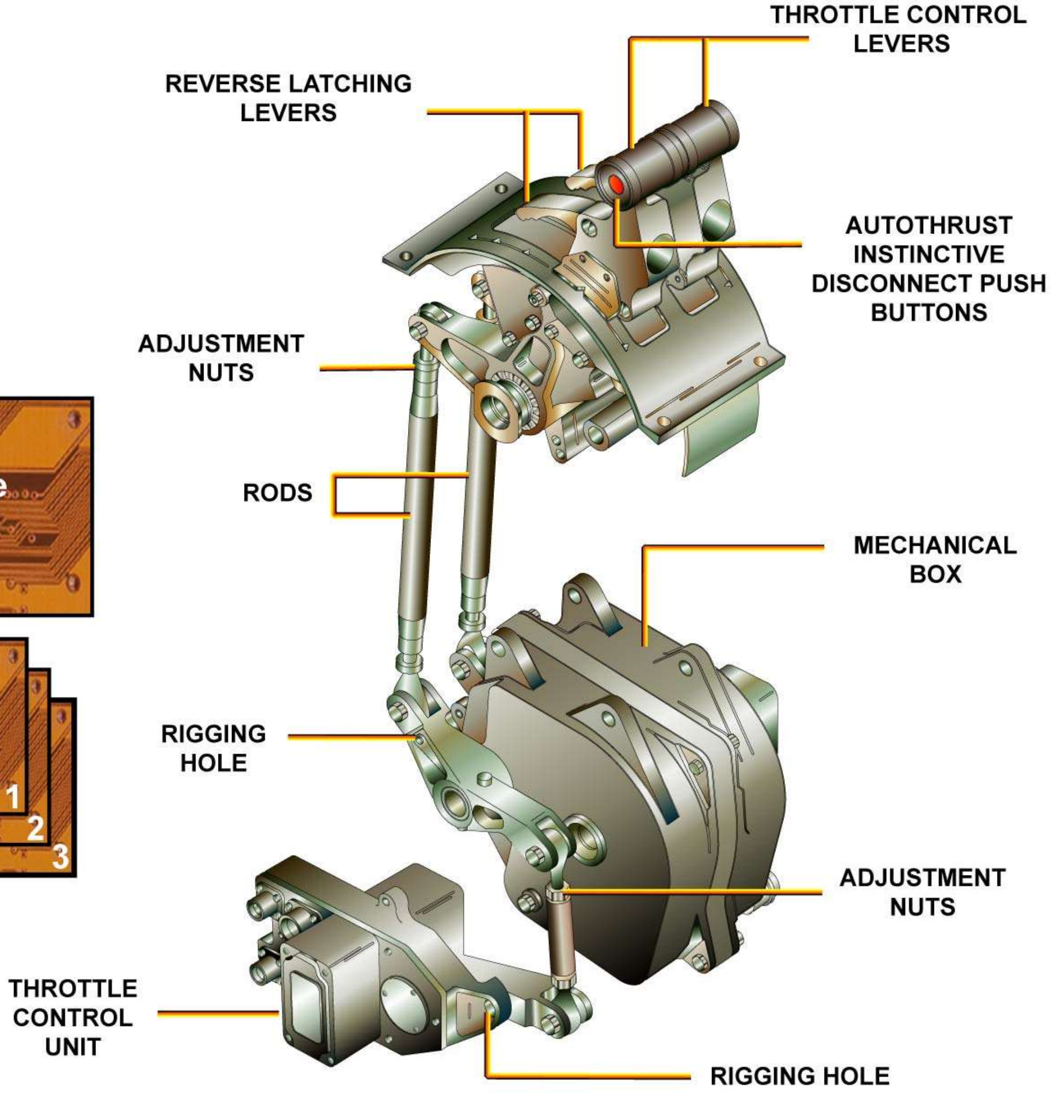
•Each resolver is dedicated to one FADEC channel (ECU / EEC) and receives its electrical excitation current (6 VAC) from the related FADEC channel (ECU / EEC)
The input lever drives two gear sectors assembled face to face. Each sector drives itself a set of one resolver and three potentiometers. The relationship between the throttle lever angle and throttle resolver angle (TRA) IS LINEAR AND 1 DEG.TLA = 1.9 TRA. The accuracy of the throttle control unit (error between the input lever position and the resolver angle) is 0.5 deg.TRA. The maximum discrepancy between the signals generated by two resolvers is 0.25 deg.TRA.
The TLA resolver operates in two quadrants. The first quadrant is used for positive angles and the second quadrant for negative angles. Each resolver is dedicated to one FADEC channel (ECU / EEC) and receives its electrical excitation current (6 VAC) from the related FADEC channel (ECU / EEC)

• The ECU takes into account a throttle resolver angle value:

- Less than - 47.5 deg.TRA or
- Greater than 98.8 deg.TRA as resolver position signal failure

•The ECU includes resolver fault accommodation logic. This logic allows engine operation after a failure or a complete loss of the throttle resolver position signal.
The ECU considers a throttle resolver angle value:
o less than -47.5 deg.TRA
or
o greater than 98.8 deg.TRA as resolver position signal failure.
The ECU includes a resolver fault accommodation logic. This logic allows engine operation after a failure or a complete loss of the throttle resolver position signal.


THROTTLE CONTROL LEVERS (TLA)
TLA
THROTTLE CONTROL ARTIFICIAL FEEL UNIT
THROTTLE CONTROL UNIT
REV THRUST
S/W
FWD THRUST
POTENTIOMETER
POTENTIOMETER
POTENTIOMETER
RESOLVER A
RESOLVER B
Engine Interface Unit (EIU)
Spoiler Elevator Computer (SEC)
1
2
3
TRA
EXCITATION 6 VAC
TRA
EXCITATION 6 VAC
EEC/ECU
CHANNEL A
CHANNEL B


THROTTLE CONTROL LEVERS
REVERSE LATCHING LEVERS
AUTOTHRUST INSTINCTIVE DISCONNECT PUSH BUTTONS
ADJUSTMENT NUTS
RODS
MECHANICAL BOX
RIGGING HOLE
ADJUSTMENT NUTS
THROTTLE CONTROL UNIT
RIGGING HOLE

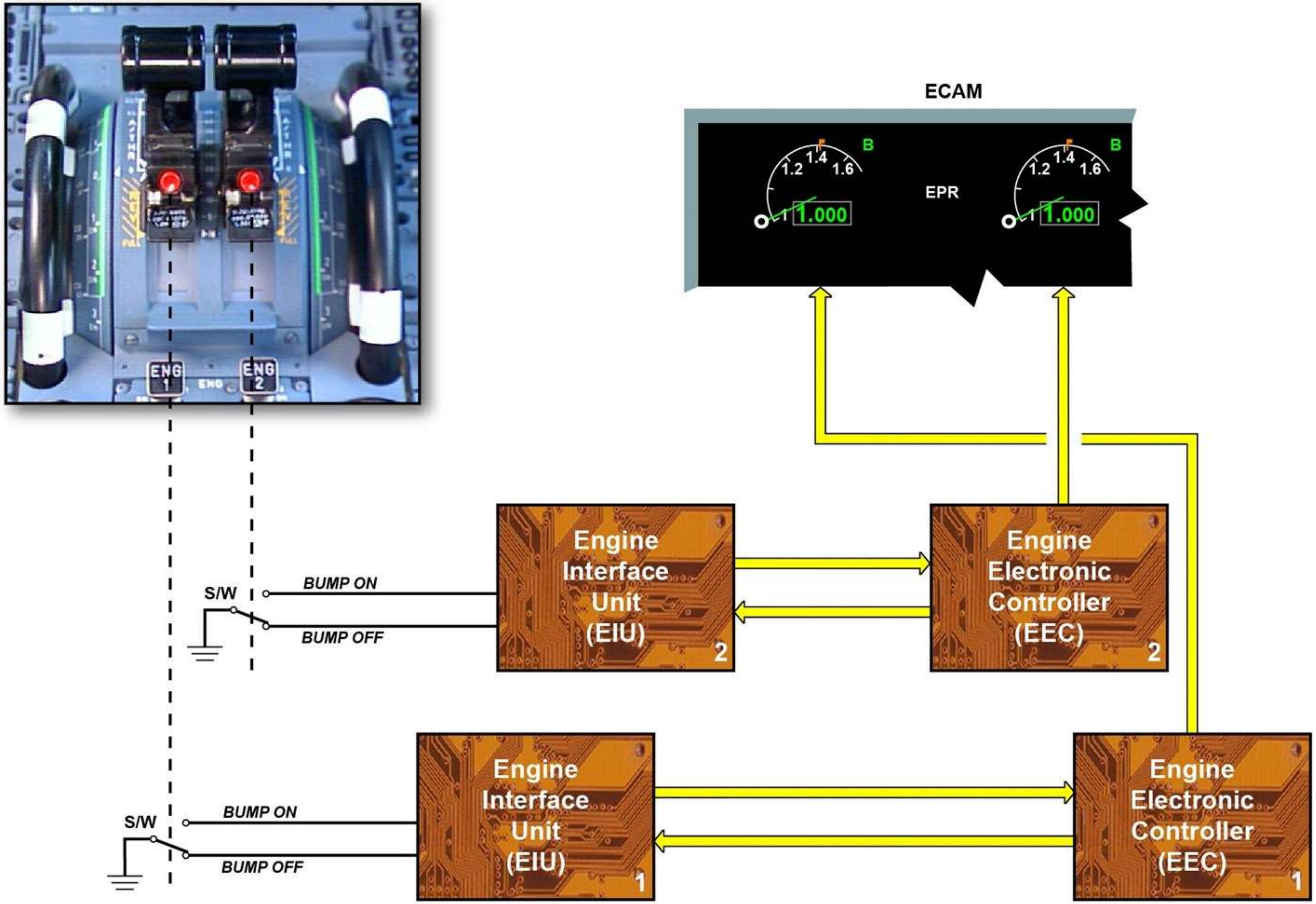
BUMP FUNCTION (PW1100G and IAE ENGINES ONLY)

- Request by pushbuttons on the throttle levers
- Signal to the EIU
- Thrust bump
    - For additional thrust capability during takeoff
    - With 2 engines or single engine operation

If an airline requests the bump function, this function is selected in the aircraft by guarded pushbutton switch with TLA at TOGA position (one on each throttle control lever). With this switch, a signal can be sent to the two FADEC units at the same time through the Engine Interface Unit (EIU).

Thrust bump can be used to obtain additional thrust capability during takeoff It can be used either with two engines or in single engine operation.

With the throttle levers at TOGA and the Bump P/B pushed, 'B' appears on the right side of the EPR/N1 dial on the EWD.


ECAM
EPR
1.2
1.4
1.6
B
1.000
ENG 1
ENG 2
S/W
BUMP ON
BUMP OFF
Engine Interface Unit (EIU) 2
Engine Electronic Controller (EEC) 2
Engine Interface Unit (EIU) 1
Engine Electronic Controller (EEC) 1

Engine Thrust Management Description and Operation

GENERAL

• Engine thrust can be set/
  - Manually with the throttle control lever
  - Automatically from the AFS

•Main thrust monitoring parameter is the N1

•Main thrust demand parameter is the FF

The engine thrust is controlled under the management of the Electronic Engine Controller (EEC).

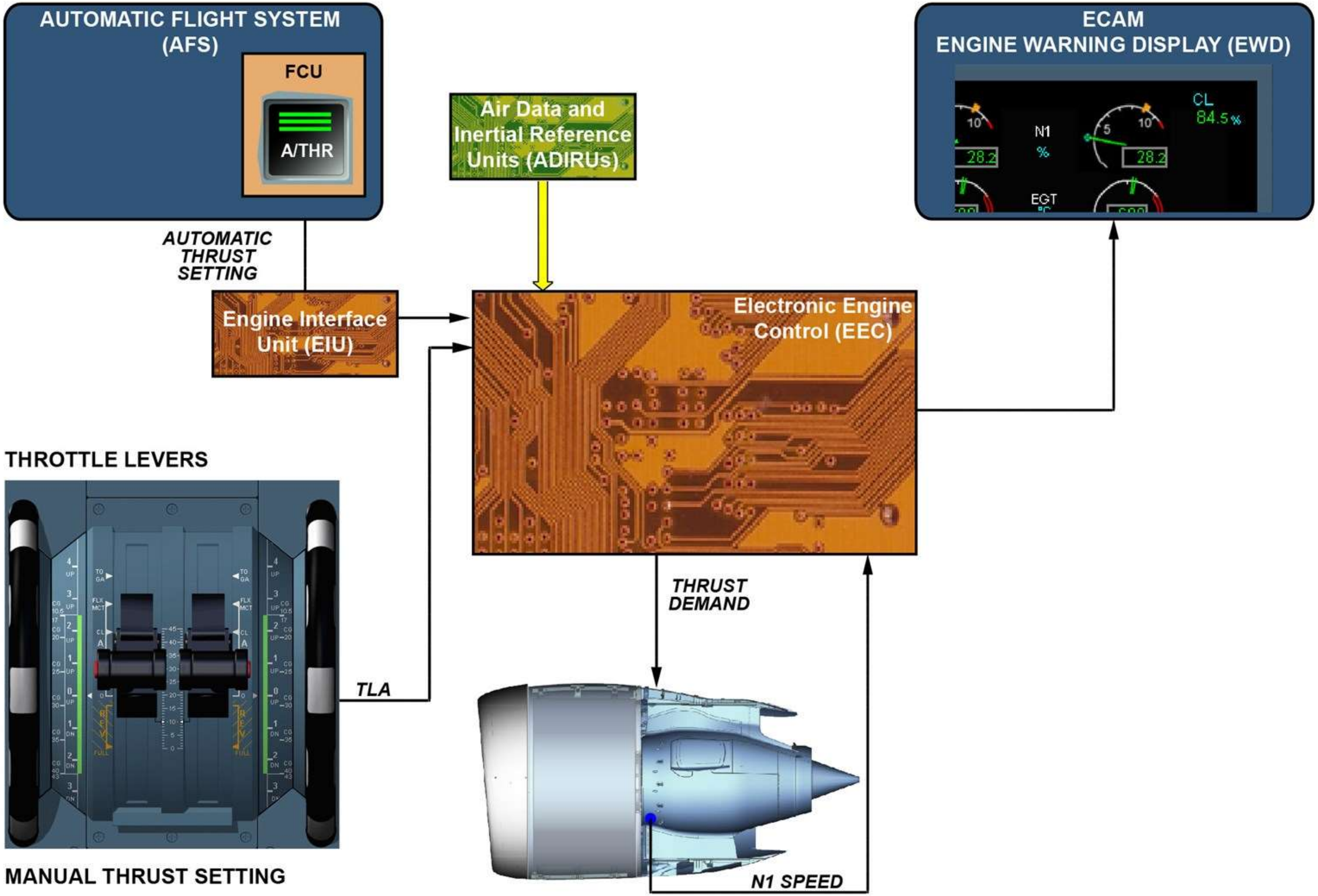
The engine thrust can be set:

- manually from the throttle control lever or,
- automatically from the Auto Flight System (AFS).

The engine thrust parameters are displayed on the ECAM.

The main thrust monitoring parameter is the N1 speed (LP shaft).

The main thrust demand parameter is the engine Fuel Flow (FF).


AUTOMATIC FLIGHT SYSTEM (AFS)
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
ECAM
ENGINE WARNING DISPLAY (EWD)
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
Electronic Engine Control (EEC)
THROTTLE LEVERS
TLA
THRUST DEMAND
N1 SPEED
MANUAL THRUST SETTING

THRUST LIMIT MODE

• Throttle levers are used as thrust limit mode selectors

•Throttle levers set between 2 detent points:

  - Upper detent will determine thrust limit mode

The throttle levers are used as thrust limit mode selectors.
Depending on the throttle lever position, a thrust limit mode is selected and appears on the upper ECAM display.
If the throttle levers are set between two detent points, the upper detent will determine the thrust limit mode.

• An additional Soft Go-Around (SGA) mode is available

An additional Soft Go-Around (SGA) mode is available.
It is automatically selected if during approach, the TOGA detent is set and the thrust levers are then moved back to the FLX/MCT detent.
Note:
- On the ground with the engines running, the displayed N1 rate limit corresponds to the TO/GA thrust limit whatever the thrust lever position is.
- On the ground with the engines running and if FLEX mode is selected, FLEX N1 is displayed whenever the thrust lever position is between IDLE and FLX/MCT.

IDLE levels:
- Minimum IDLE is the minimum speed that the engine can be operated at. Min idle command is calculated according to the flight phase and according to the minimum power level required to, at least, maintain bleed supply and aircraft services.
- Approach IDLE makes sure of fast acceleration of the engine if it becomes necessary during approach. It is set at a sufficiently high level for acceleration to go-around thrust in a specified time limit. This IDLE Mode will be selected by the FADEC upon EIU request.
- Reverse IDLE is the nominal idle power when throttle is in the reverse quadrant and above the low end of the REV idle.
- Elevated Reverse IDLE mode aims to increase idle power (reverse mode) during thrust reverser deployment in order to fasten transition from reverse idle to max reverse. This mode is only available for the first seconds of thrust reverser deployment and is higher than Reverse Idle.

N1 LIMIT

• N1 rating limit computed by EEC according to:

  - Thrust Lever Angle (TLA)
  - Air data parameters from ADIRUs

•Shown on the upper ECAM display

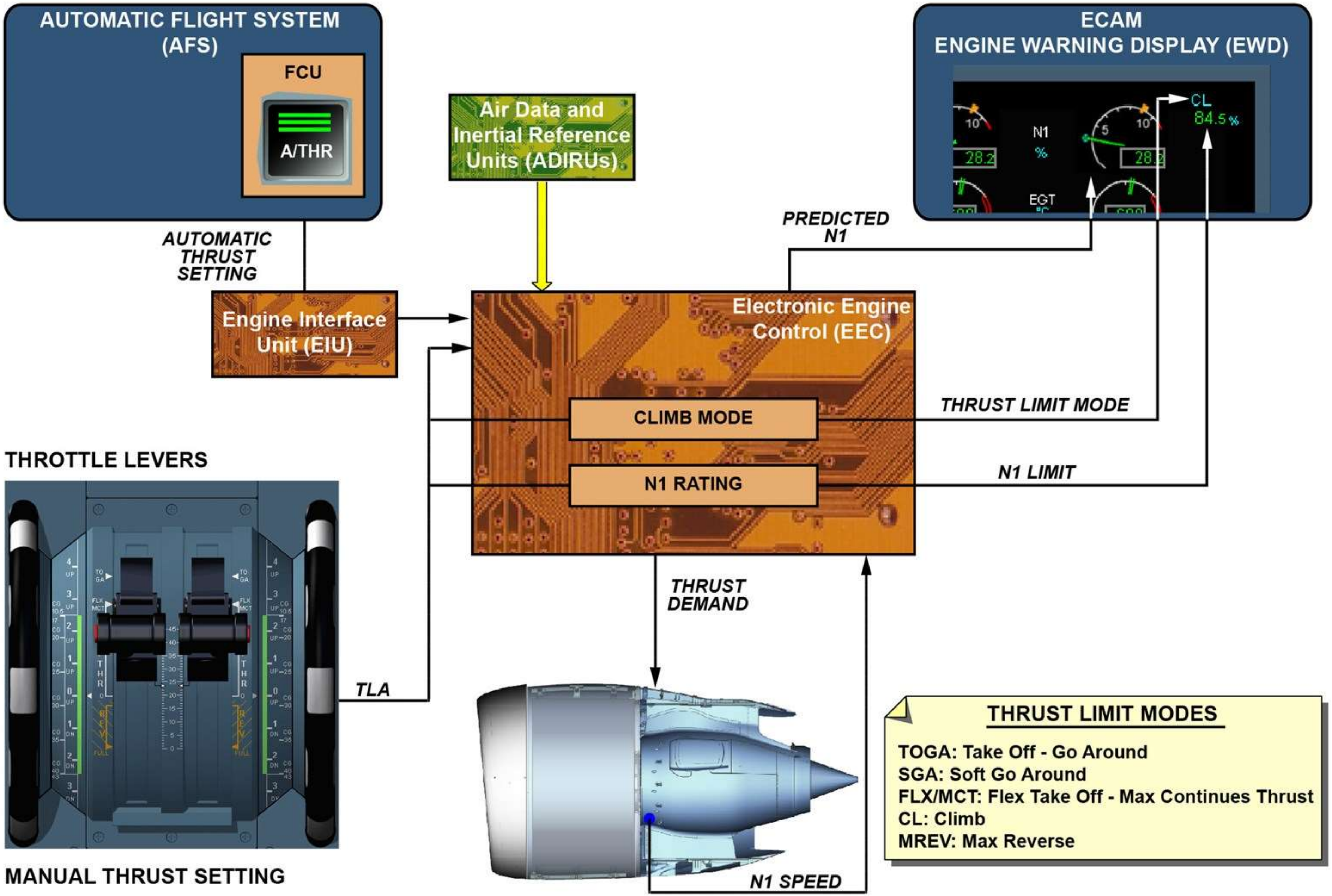
For each thrust limit mode selection, an N1 rating limit is computed by the EEC according to Thrust Lever Angle (TLA) and the air data parameters from the Air Data Inertial and Reference Units (ADIRUs). This indication is displayed in green on the upper ECAM display near the thrust limit mode indication.

PREDICTED N1

• Predicted N1 indicated by a blue circle

  - Corresponds to the TLA value

The predicted N1 is indicated by a blue circle on the N1 indicator and corresponds to the value determined by the TLA.


AUTOMATIC FLIGHT SYSTEM (AFS)
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
ECAM
ENGINE WARNING DISPLAY (EWD)
CL
84.5%
N1
%
EGT
28.2
28.2
PREDICTED N1
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
Electronic Engine Control (EEC)
CLIMB MODE
N1 RATING
THRUST LIMIT MODE
N1 LIMIT
THROTTLE LEVERS
TLA
THRUST DEMAND
N1 SPEED
MANUAL THRUST SETTING
THRUST LIMIT MODES
TOGA: Take Off - Go Around
SGA: Soft Go Around
FLX/MCT: Flex Take Off - Max Continues Thrust
CL: Climb
MREV: Max Reverse

ACTUAL N1

• Actual N1 = Actual value given by N1 speed sensor

•Displayed in green on the N1 indicator

The actual N1 is the actual value given by the N1 speed sensor and is used as a reference for the engine thrust control loop. This actual N1 is displayed in green on the N1 indicator.

N1 COMMAND

• Corresponds to:
  - N1 target (A/THR active)
  - N1 throttle (A/THR NOT active)

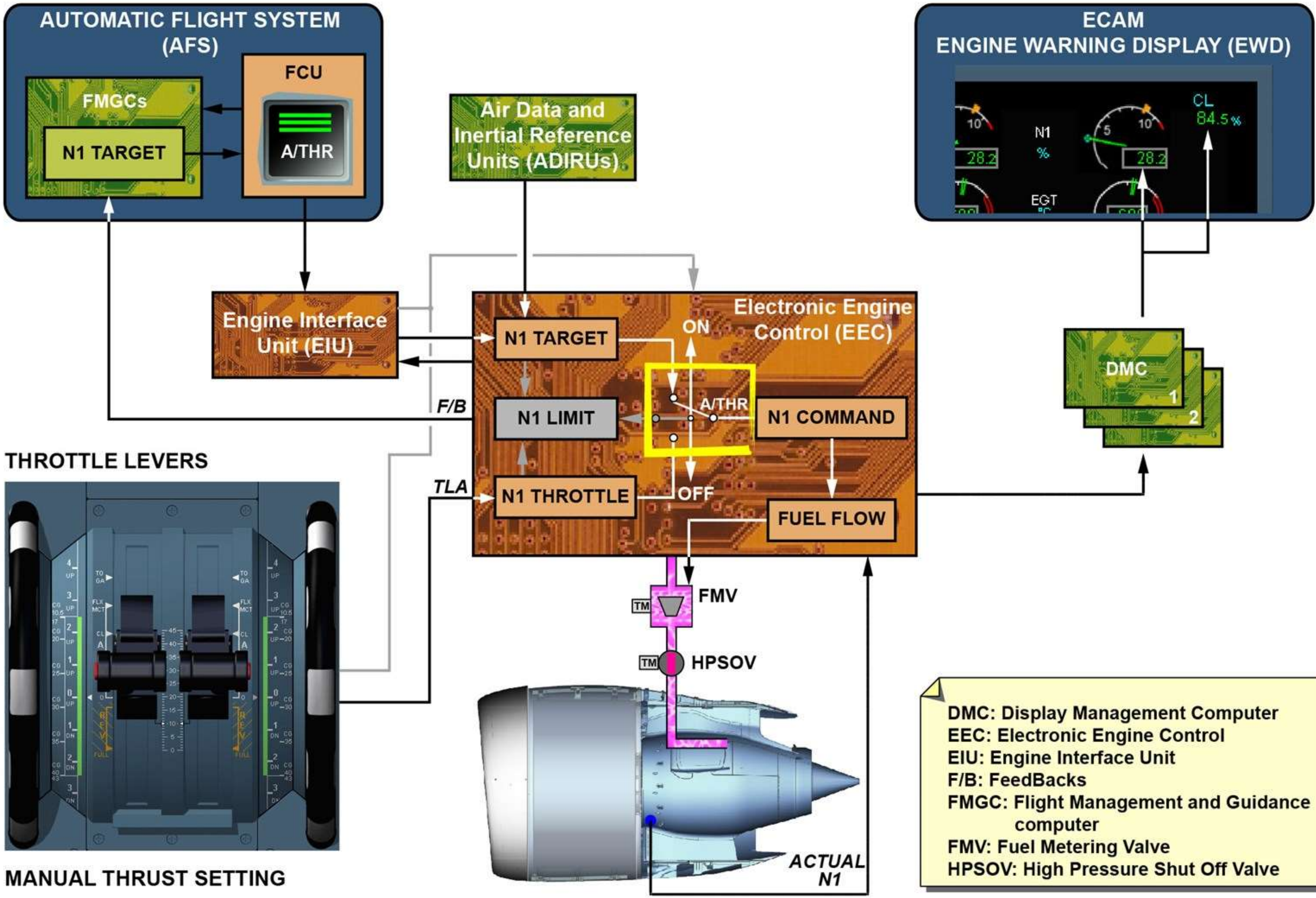
The N1 command, used to regulate the fuel flow, is:

N1 TARGET

• A/THR mode:
  - FMGCs compute N1 target according to AFS command, air data and ENG parameters

•Transient N1 (arc) = difference between N1 command and actual N1

In A/THR mode, the FMGCs compute an N1 target according to the AFS command, the air data and the engine parameters and send this demand to the EECs.



DMC: Display Management Computer
EEC: Electronic Engine Control
EIU: Engine Interface Unit
F/B: FeedBacks
FMGC: Flight Management and Guidance computer
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve

AUTOTHRUST CONTROL MODE

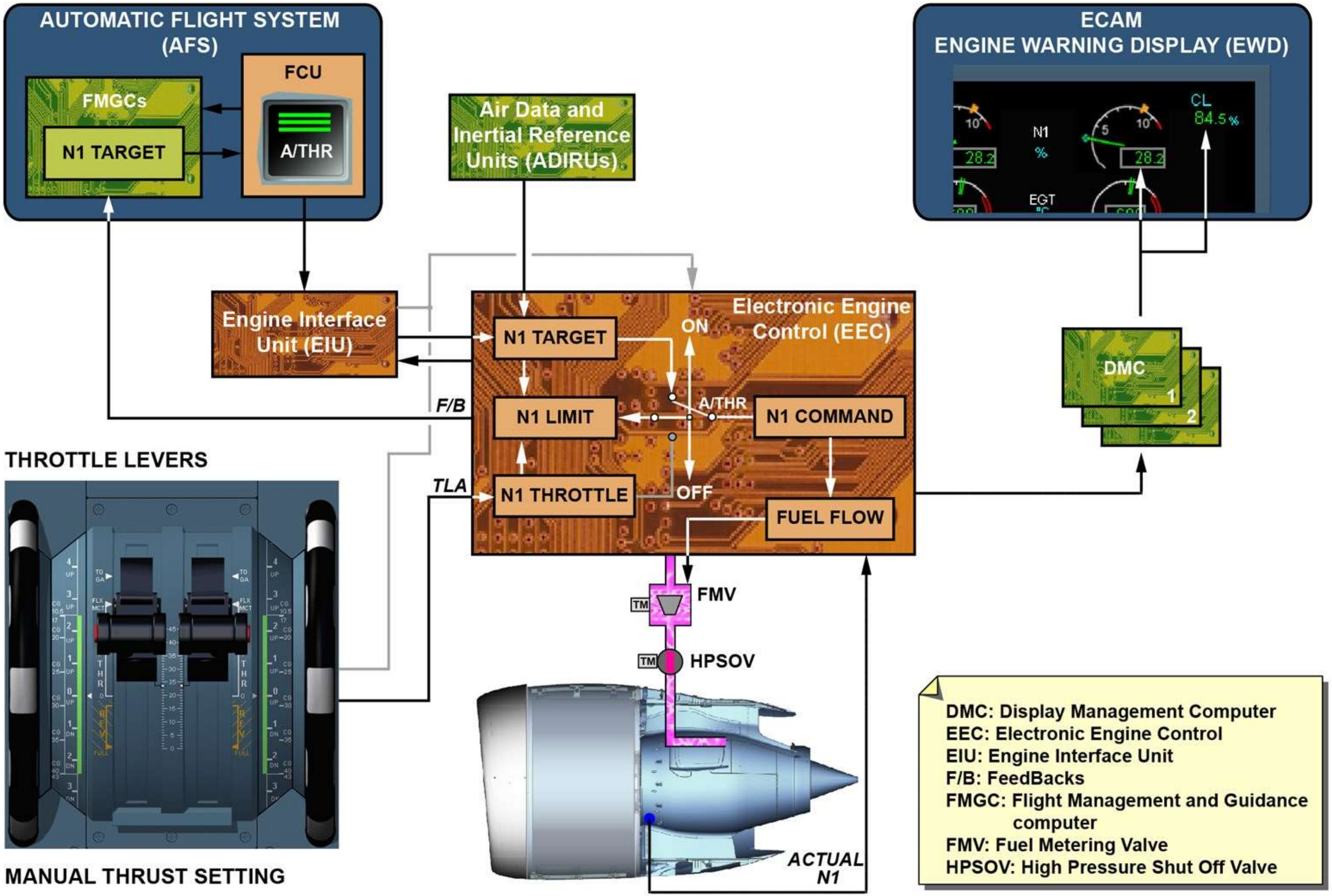
• A/THR engaged when:

- A/THR P/B pressed in
- or at take off power application

The A/THR function is engaged manually when the A/THR P/B is selected or automatically at take-off power application.

AUTOTHRUST ACTIVE

• After take-off and throttle levers set between IDLE and CL (including CL)
•N1 command is N1 target (from FMGC)
•Single engine operation => A/THR range extended to MCT
•N1 command limited by TLA when throttle levers are set between 2 detent points
When engaged, the A/THR function becomes active when the throttle levers are set to CLimb detent after take-off.
The N1 command is the FMGC N1 target.
The A/THR function is normally active when the throttle levers are set between IDLE and CLimb (including CLimb).
The A/THR active range is extended to MCT in the case of single engine operation.
When the throttle levers are set between two detent points, the N1 command is limited by the throttle lever position.
Note: In case of Alpha Floor detection, the A/THR function becomes active automatically and the N1 target is to TOGA.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
ECAM
ENGINE WARNING DISPLAY (EWD)
N1
%
EGT
CL
84.5 %
28.2
Engine Interface Unit (EIU)
Electronic Engine Control (EEC)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
F/B
TLA
DMC
1
2
THROTTLE LEVERS
MANUAL THRUST SETTING
FMV
TM
HPSOV
ACTUAL N1
DMC: Display Management Computer
EEC: Electronic Engine Control
EIU: Engine Interface Unit
F/B: FeedBacks
FMGC: Flight Management and Guidance computer
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve

AUTOTHRUST NOT ACTIVE

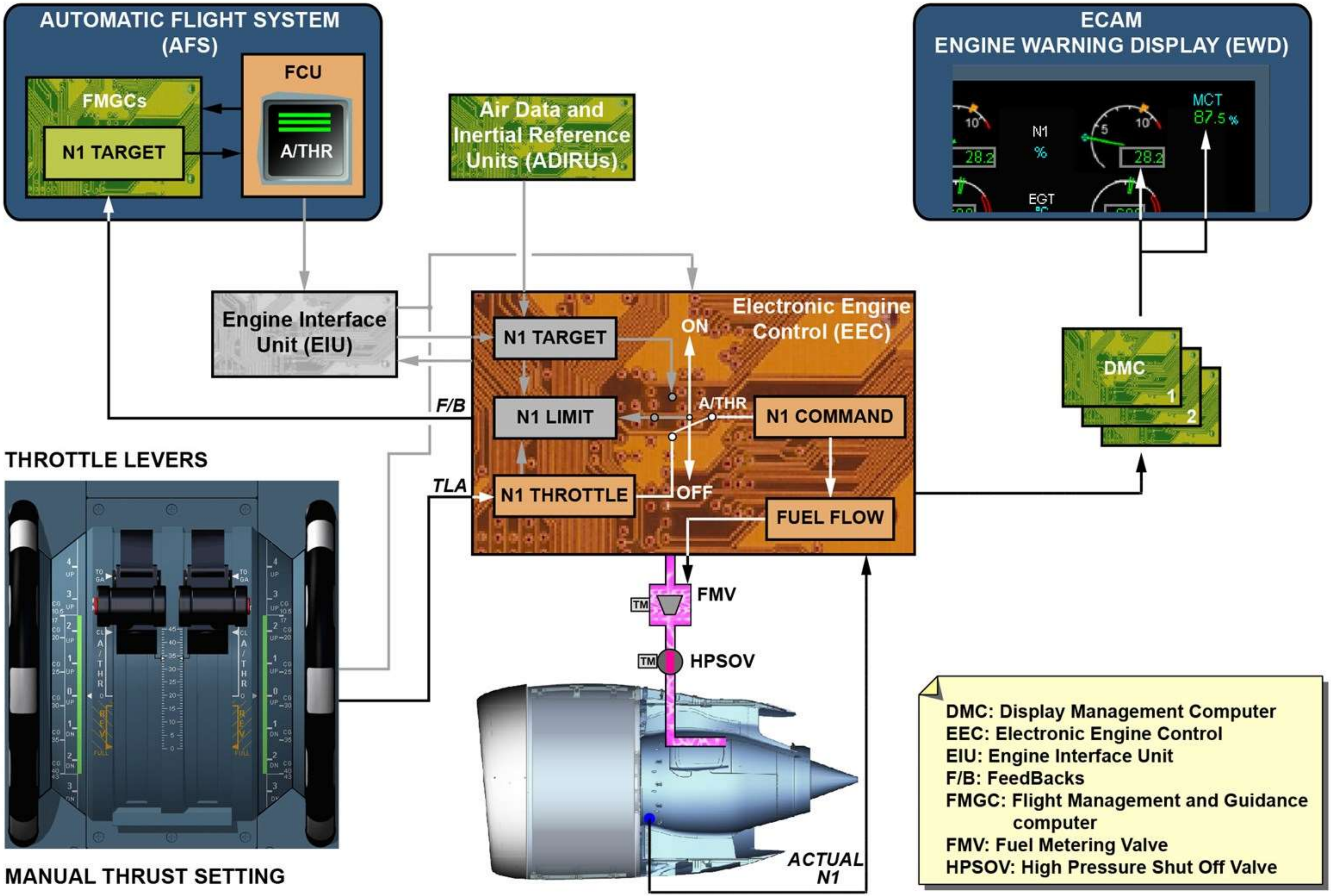
• A/THR inactive above Climb, with 2 engines running

•N1 command corresponds to N1 throttle (TLA)

When engaged, the A/THR function becomes inactive when the throttle levers are set above CLimb with both engines running.
In this case, the N1 command corresponds to the N1 throttle (TLA).

Note:

The A/THR function is inactive above MCT in case of single engine operation.
The A/THR function is disengaged when the throttle levers are set at IDLE stop.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
ECAM
ENGINE WARNING DISPLAY (EWD)
N1
%
EGT
MCT
87.5 %
28.2
28.2
Engine Interface Unit (EIU)
Electronic Engine Control (EEC)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
F/B
TLA
DMC
1
2
THROTTLE LEVERS
MANUAL THRUST SETTING
FMV
TM
HPSOV
TM
ACTUAL N1
DMC: Display Management Computer
EEC: Electronic Engine Control
EIU: Engine Interface Unit
F/B: FeedBacks
FMGC: Flight Management and Guidance computer
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve

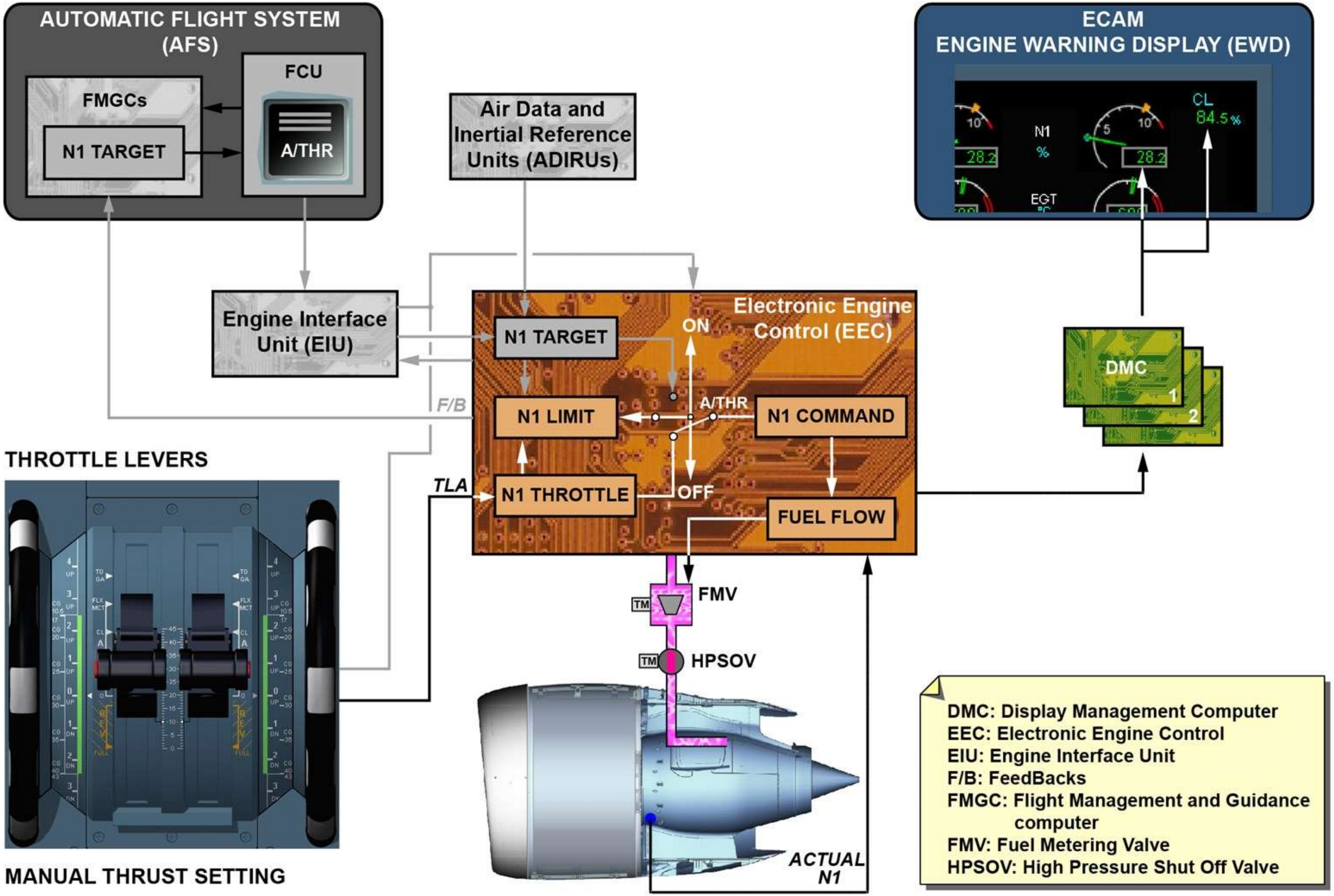
MANUAL CONTROL MODE

•Manual mode when:

- A/THR not engaged
- Or engaged and not active

•EEC processes N1 command signal according to N1 throttle (TLA)

The engines are in manual control mode when the A/THR function is not engaged, or engaged and not active (throttle levers not in the A/THR operating range and no Alpha Floor detected).



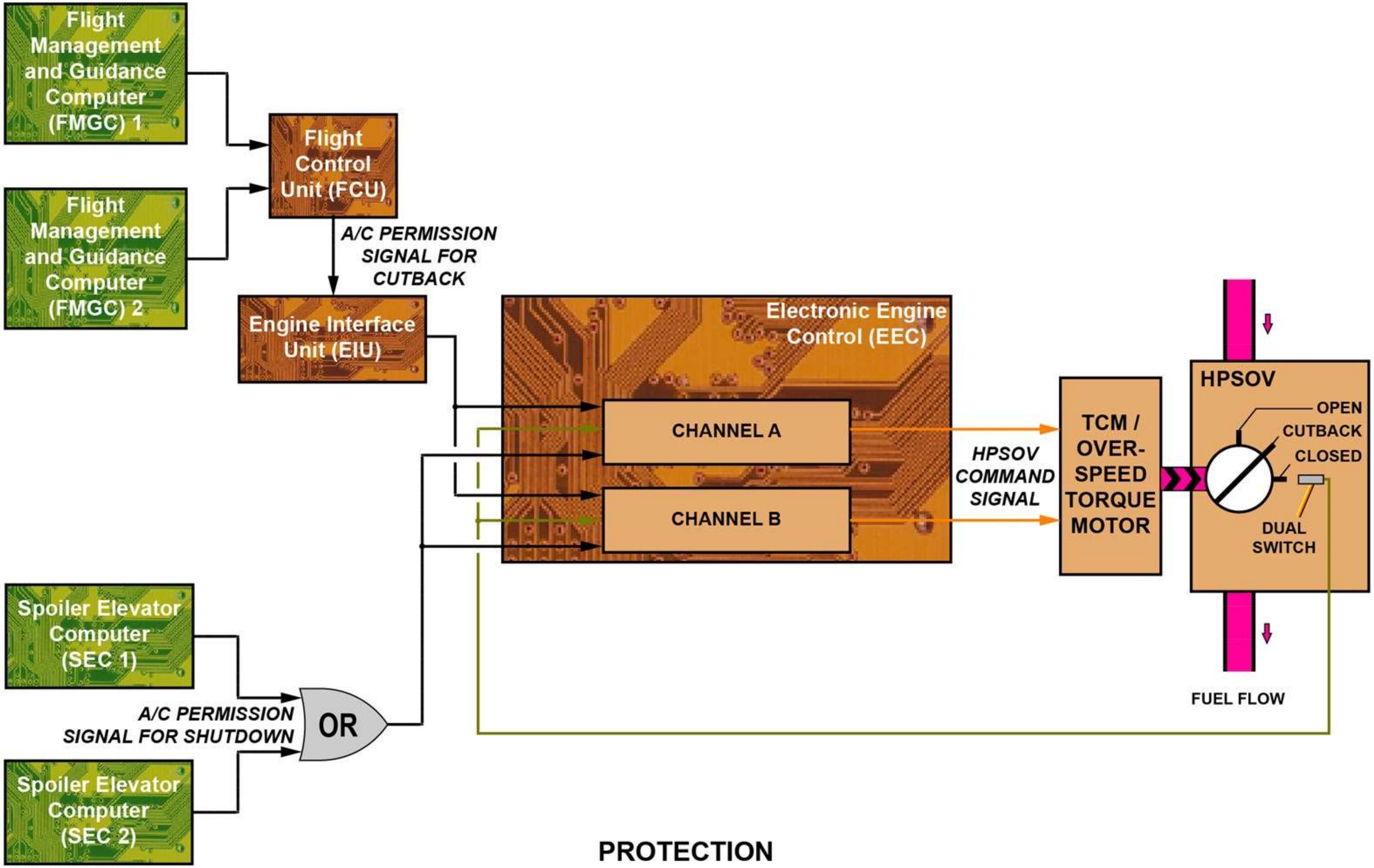
DMC: Display Management Computer
EEC: Electronic Engine Control
EIU: Engine Interface Unit
F/B: FeedBacks
FMGC: Flight Management and Guidance computer
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve

THRUST CONTROL MALFUNCTION

- FADEC protection function
- In flight: Cutback signal controls a fuel flow reduction
- On ground: Shutdown signal controls HPSOV to close position
- N1 or N2 overspeed or shaft shear detection also trigger a shutdown

The Thrust Control Malfunction (TCM) is a FADEC protection function against un-commanded and uncontrollable excessive power excursion in which the normal thrust control becomes inoperative.

Note: The FADEC logic uses TCM permission data from FMGCs to FCU to automatically reduce engine thrust during flare.


Flight Management and Guidance Computer (FMGC) 1
Flight Management and Guidance Computer (FMGC) 2
Flight Control Unit (FCU)
A/C PERMISSION SIGNAL FOR CUTBACK
Engine Interface Unit (EIU)
Electronic Engine Control (EEC)
CHANNEL A
CHANNEL B
HPSOV COMMAND SIGNAL
TCM / OVER-SPEED TORQUE MOTOR
HPSOV
OPEN
CUTBACK
CLOSED
DUAL SWITCH
FUEL FLOW
Spoiler Elevator Computer (SEC 1)
Spoiler Elevator Computer (SEC 2)
A/C PERMISSION SIGNAL FOR SHUTDOWN
OR

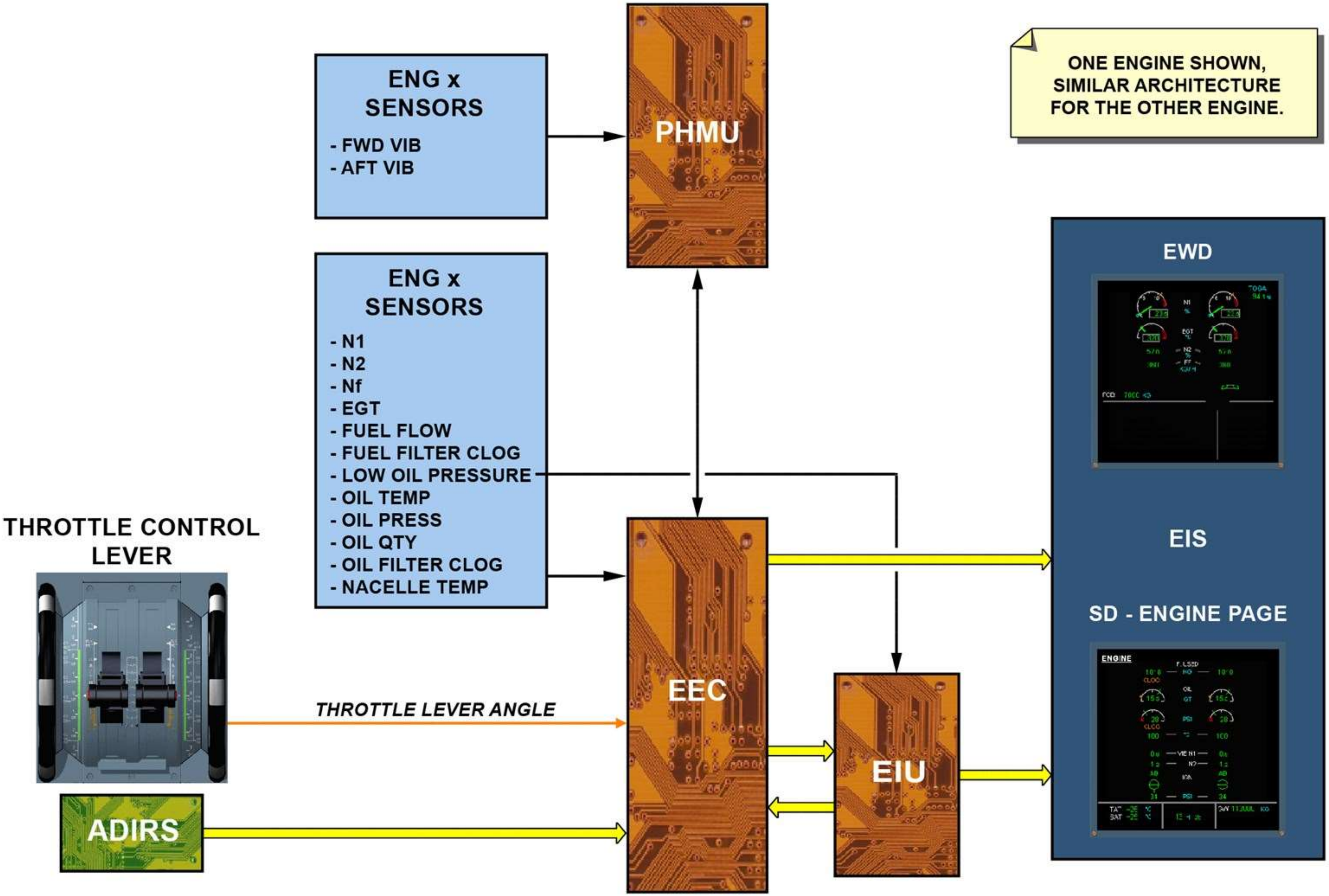
PROTECTION

Engine Monitoring Description and Operation

INDICATING

- EEC and PHMU monitor engine parameters
- Parameter sent to EIS & displayed on SD ENGINE Page
- Control and monitor engine:
    - In manual thrust control mode with Throttle Lever Angle position
    - In auto thrust control mode with EIU inputs

The engine indicating system has sensors that measure some engine parameters. These parameters are supplied to the Electronic Engine Control (EEC) and / or to the Prognostic and Health Monitoring Unit (PHMU) for computation and transmission. They are sent to the Electronic Instrument System (EIS) for display on the EWD and on the SD-ENGINE Page. In conjunction with inputs from the ADIRS, they are also used to control and monitor the engine with the Throttle Lever Angle (TLA) position in manual thrust control mode or with the Engine Interface Unit (EIU) inputs in auto thrust control mode.


ENG x SENSORS
- FWD VIB
- AFT VIB
PHMU
ONE ENGINE SHOWN, SIMILAR ARCHITECTURE FOR THE OTHER ENGINE.
ENG x SENSORS
- N1
- N2
- Nf
- EGT
- FUEL FLOW
- FUEL FILTER CLOG
- LOW OIL PRESSURE
- OIL TEMP
- OIL PRESS
- OIL QTY
- OIL FILTER CLOG
- NACELLE TEMP
EWD
EIS
SD - ENGINE PAGE
THROTTLE CONTROL LEVER
THROTTLE LEVER ANGLE
EEC
EIU
ADIRS

PRIMARY PARAMETERS

ROTATIONAL SPEED PARAMETERS DESCRIPTION

• N1 speed sensor is mounted on the CIC at 4 'o' clock position
•It senses LP rotor assembly speed
•Digital and needle indication on EWD

The N1 speed sensor is mounted on the rear of the Compressor Intermediate Case (CIC) at approximately 4 o'clock position. The N1 speed sensor detects the rotational speed of LP rotor assembly. The indication is shown in the ECAM EWD by a needle and a N1 digital indication display.

• N2 sensor is mounted on the RH side of Angle Gear Box (AGB)
•Detects HP rotor assembly speed
•Digital and needle indication on EWD

The N2 speed sensor is installed on the right hand side of the Angle Gear Box (AGB). The N2 speed sensor detects the rotational speed of the HP rotor assembly. The N2 rotational speed is indicated in the ECAM EWD by digits.
The digital display is shown on a grey background during engine start.

• Transmits signals to:
  - EEC for processing and monitoring
  - PHMU (via EEC) for vibrations computation

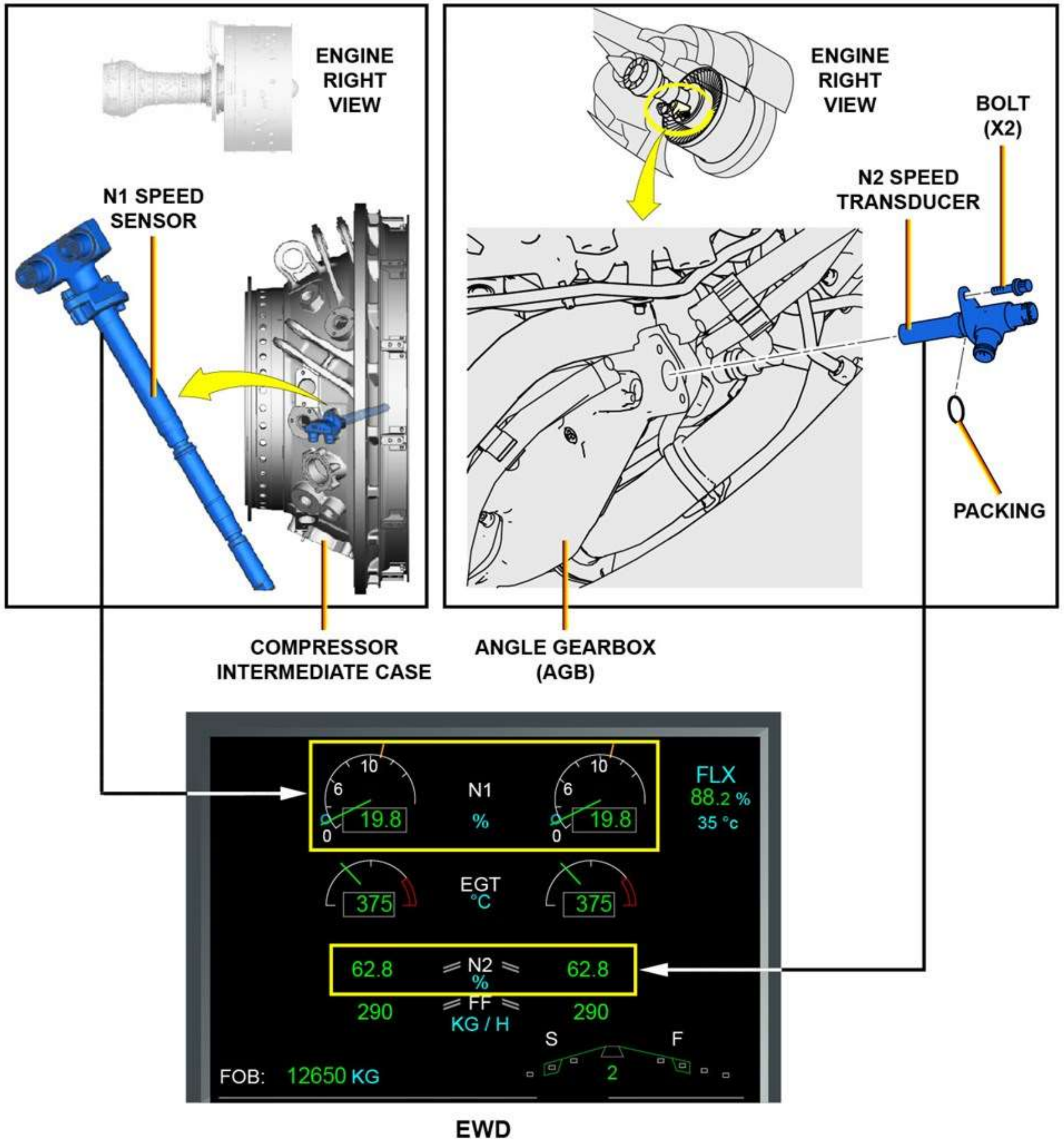
Both the N1 and N2 speed sensors are dual channel magnetic speed sensors and transmit the corresponding signals to the EEC for processing and monitoring and to the PHMU via the EEC for vibrations computation.
The N1 and N2 sensors are line replaceable units.

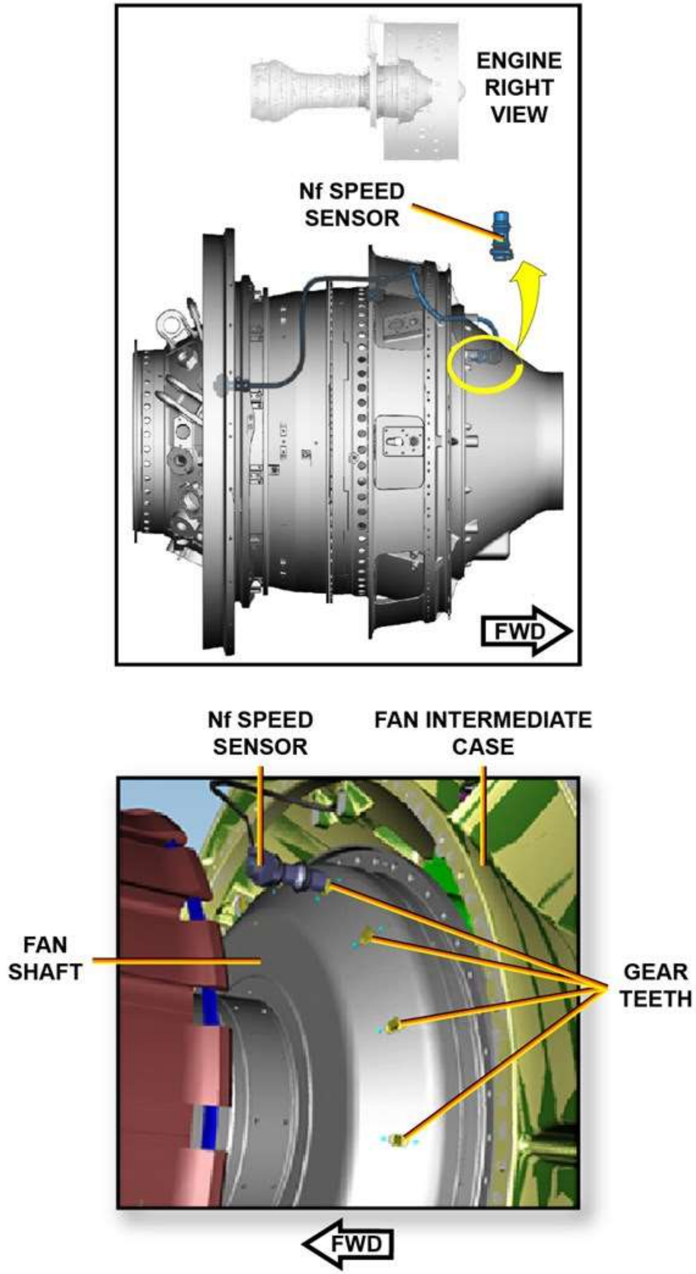
• The Fan speed (Nf) Sensor
  - Senses the fan rotor speed
  - Sends it to the EEC
  - No ECAM indication

•The Nf sensor data helps to detect de-coupling of the Fan Shaft from the LP shaft (sheared shaft)
  - By comparing the Fan Speed (Nf) to N1

•PHMU:
  - Uses the Fan Speed from EEC in conjunction with Fan Rotor vibration to monitor Fan Rotor vibration
  - Calculate trim balance solutions for maintenance purposes

The Fan Speed (Nf) sensor senses the fan rotor speed and sends it to the EEC. There is no indication of Nf on the ECAM.
The EEC uses the Fan Speed sensor to detect de-coupling of the Fan Shaft from the LP shaft (sheared shaft) by comparing the Nf to the N1. The PHMU uses the Fan Speed from the EEC in conjunction with Fan Rotor vibrations to monitor Fan Rotor vibration and calculate trim balance solution for maintenance purposes.
The Nf sensor is a Line Replaceable Unit (LRU).

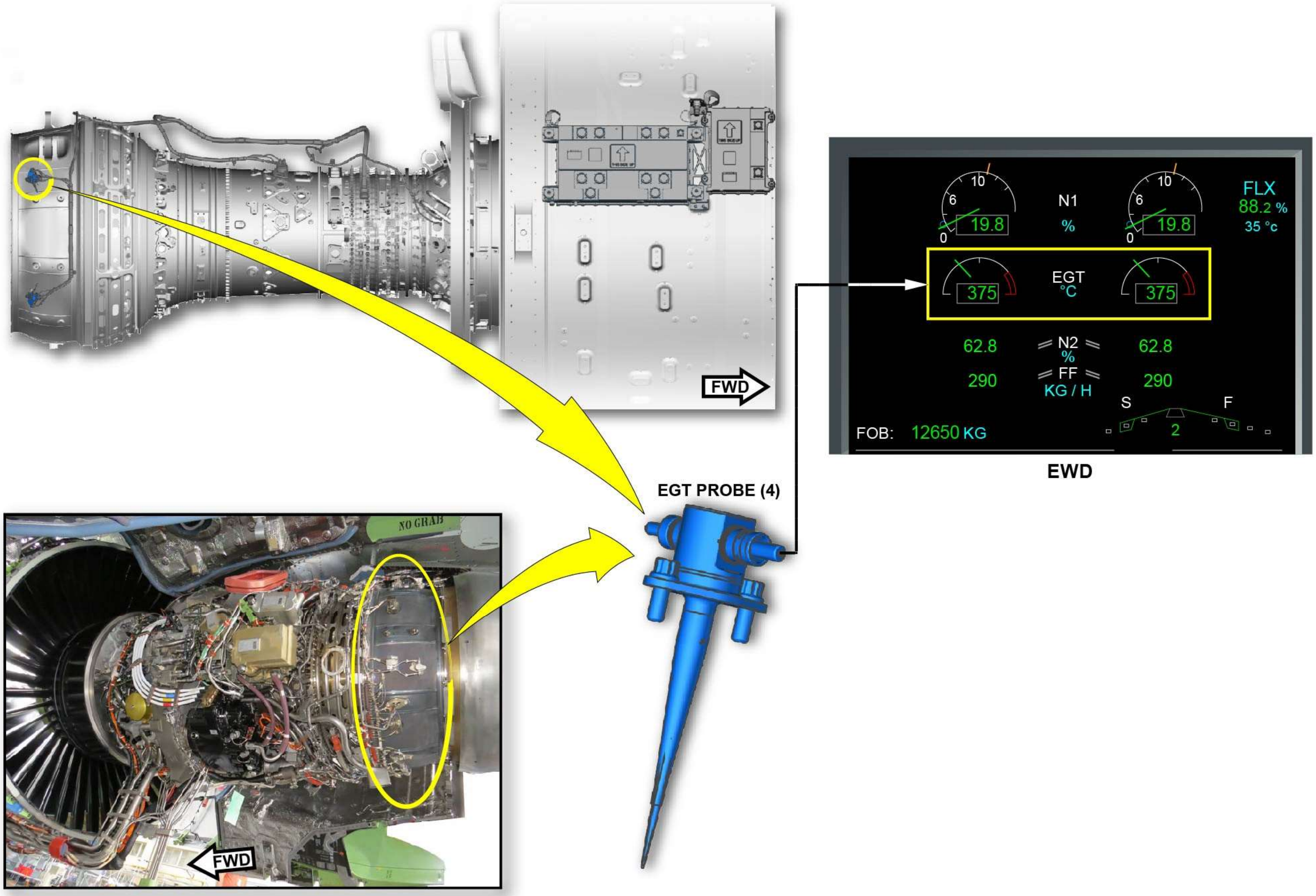

ENGINE RIGHT VIEW
N1 SPEED SENSOR
COMPRESSOR INTERMEDIATE CASE
ENGINE RIGHT VIEW
BOLT (X2)
N2 SPEED TRANSDUCER
PACKING
ANGLE GEARBOX (AGB)
N1
%
19.8
19.8
FLX
88.2 %
35 °c
EGT
°C
375
375
N2
%
62.8
62.8
FF
KG / H
290
290
S
F
2
FOB: 12650 KG
EWD


ENGINE RIGHT VIEW
Nf SPEED SENSOR
FWD
Nf SPEED SENSOR
FAN INTERMEDIATE CASE
FAN SHAFT
GEAR TEETH
FWD

EGT PARAMETERS

• EGT is sensed by 4 thermocouple (T5) probes located around the circumference of the Turbine Exhaust Case (TEC)
•Actual EGT digital and needle indication on EWD
•Single channel probe- 2 LH side averaged and sent to Channel A and 2 RH side averaged and sent to Channel B of EEC
•EGT thermocouples are LRU's

The engine EGT is sensed and averaged by four thermocouple probes (T5 probes) located around the circumference of the Turbine Exhaust Case (TEC). The actual engine EGT is displayed in the ECAM EWD by a needle and an EGT digital indication. Each probe is a single channel Chromel / Alumel thermocouple. The signals from the two T5 probes on the left side of the engine are electrically averaged and sent to Channel A of the EEC. The signal from the two T5 probes on the right side of the engine are electrically averaged and sent to channel B of the EEC.
The EGT thermocouples are LRUs.


FWD
NO GRAB
FWD
EGT PROBE (4)
10
6
0
19.8
N1
%
FLX
88.2 %
35 °c
EGT
°C
375
375
62.8
N2
%
62.8
290
FF
KG / H
290
S
F
2
FOB: 12650 KG
EWD

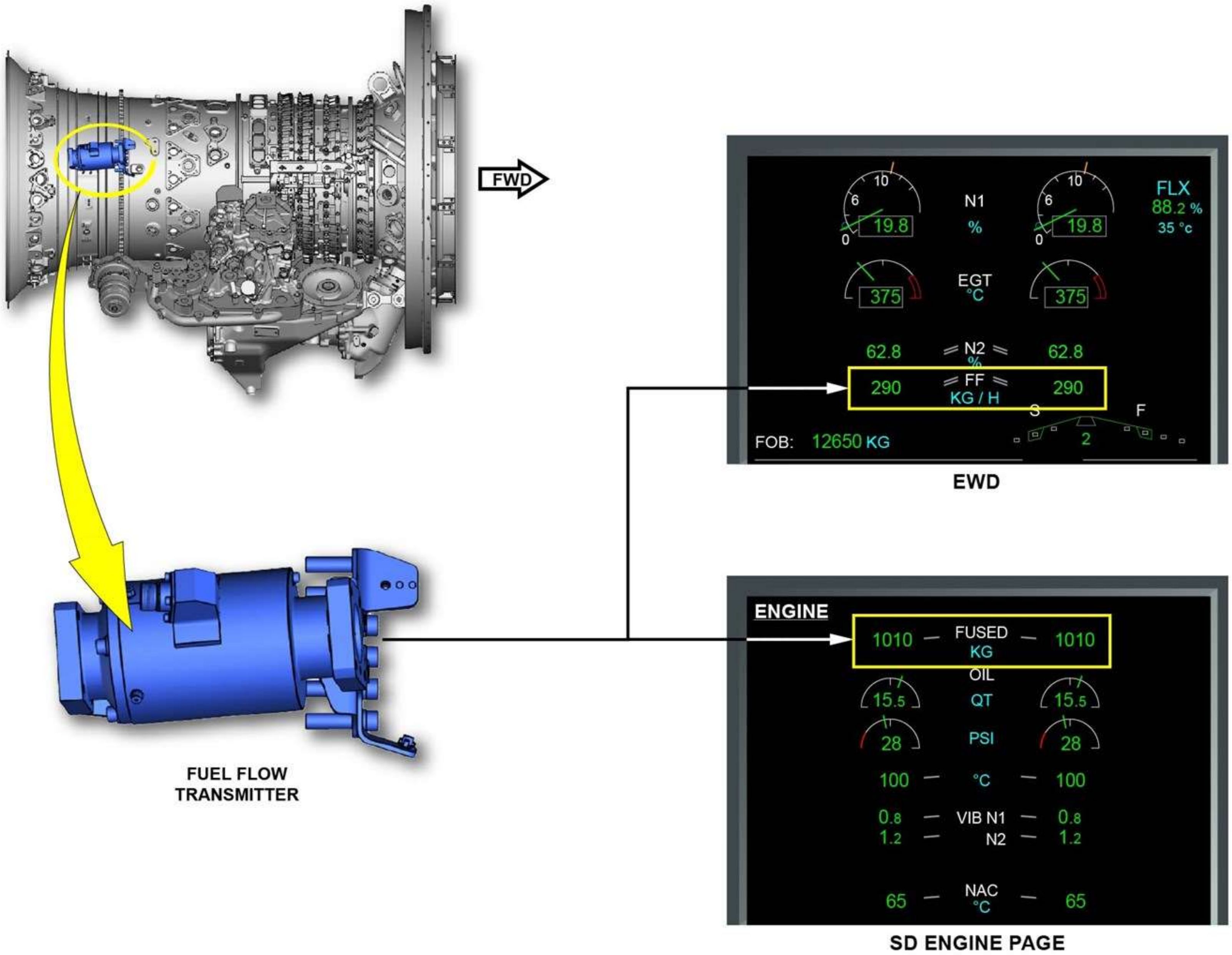
FUEL PARAMETERS DESCRIPTION

•FFM is mounted on the intermediate case RH side of the engine core
•FF & F.USED digital indication on ECAM EWD
•FFM is of magnetic drum and impeller type
•Fuel used:

- Computed from engine start to engine shutdown
- Reset to 0 at next engine start

•FFM is an LRU

The Fuel Flow Meter (FFM) is installed on the intermediate case right hand side of the engine core at approximately the 3 o'clock position. The fuel flow and the fuel used are displayed on the ECAM EWD by digital indications. The FFM is a magnetic drum and impeller type.
The fuel used value is computed by the EIS from the fuel flow value sent by the EEC. The fuel used for each engine is computed from the engine start to the engine shutdown. It is reset to 0 at the next engine start.
The FFM is an LRU.

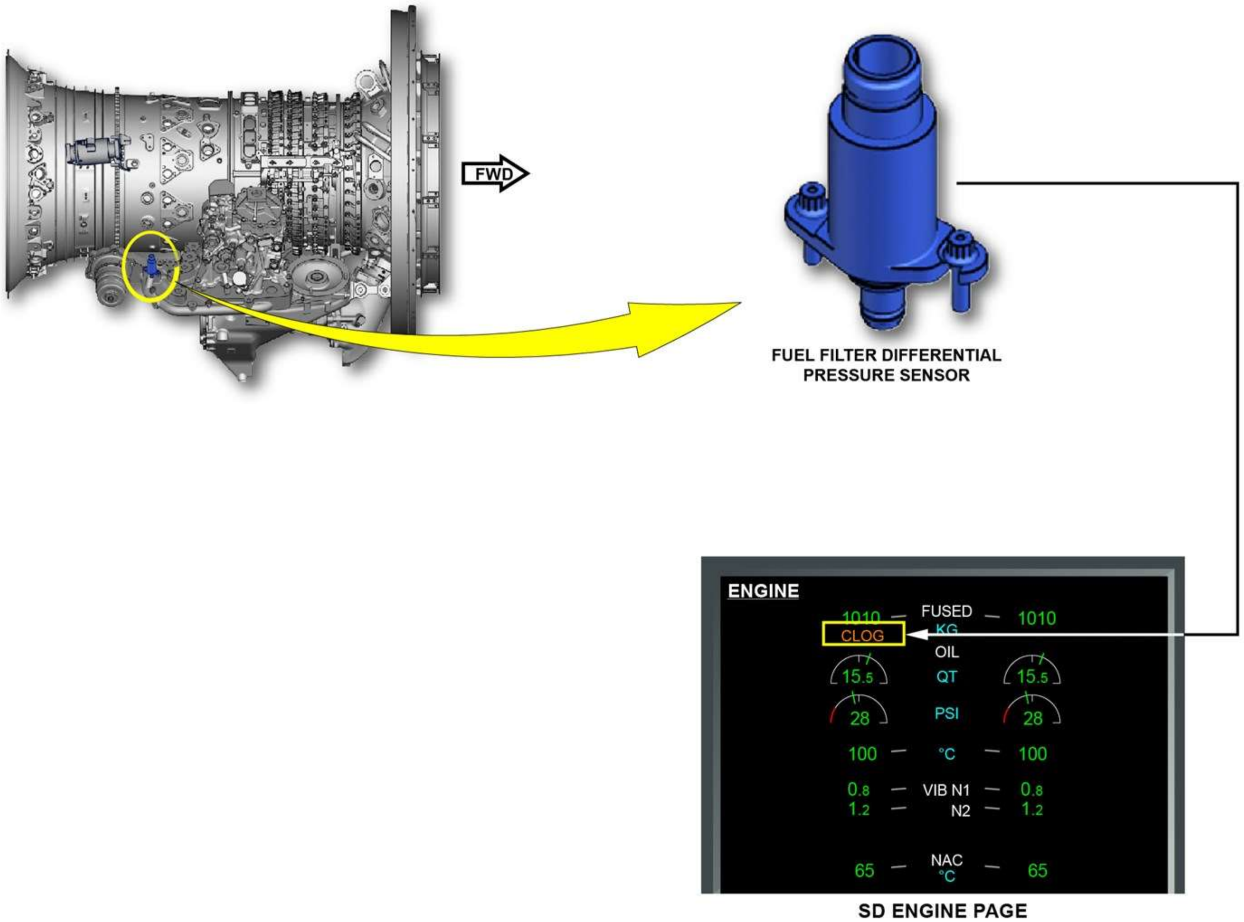

FWD
FUEL FLOW
TRANSMITTER
N1
%
10
6
0
19.8
FLX
88.2 %
35 °c
EGT
°C
375
62.8
N2
%
62.8
290
FF
KG / H
290
S
F
2
FOB: 12650 KG
EWD
ENGINE
1010
FUSED
KG
1010
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC
°C
65
SD ENGINE PAGE

FUEL PARAMETERS DESCRIPTION

•FFDP sensor bolted to fuel manifold
•EEC sends sensor signal to ECAM to generate clogging alerts:

- DEGRAD
- CLOG

The fuel filter differential pressure sensor is bolted to the fuel manifold which is attached to the Main Gearbox (MGB) at the 3 o'clock position. The sensor signal is transmitted by the EEC to the ECAM system to generate clogging alerts when the fuel differential pressure across this filter exceeds the thresholds. Two indications are available: DEGRAD or CLOG.



SECONDARY PARAMETERS
OIL PARAMETERS DESCRIPTION

• Oil Level sensor in oil tank
•OL sensor sends oil QTY analog signal to EEC
•Displayed on ECAM SD ENGINE page

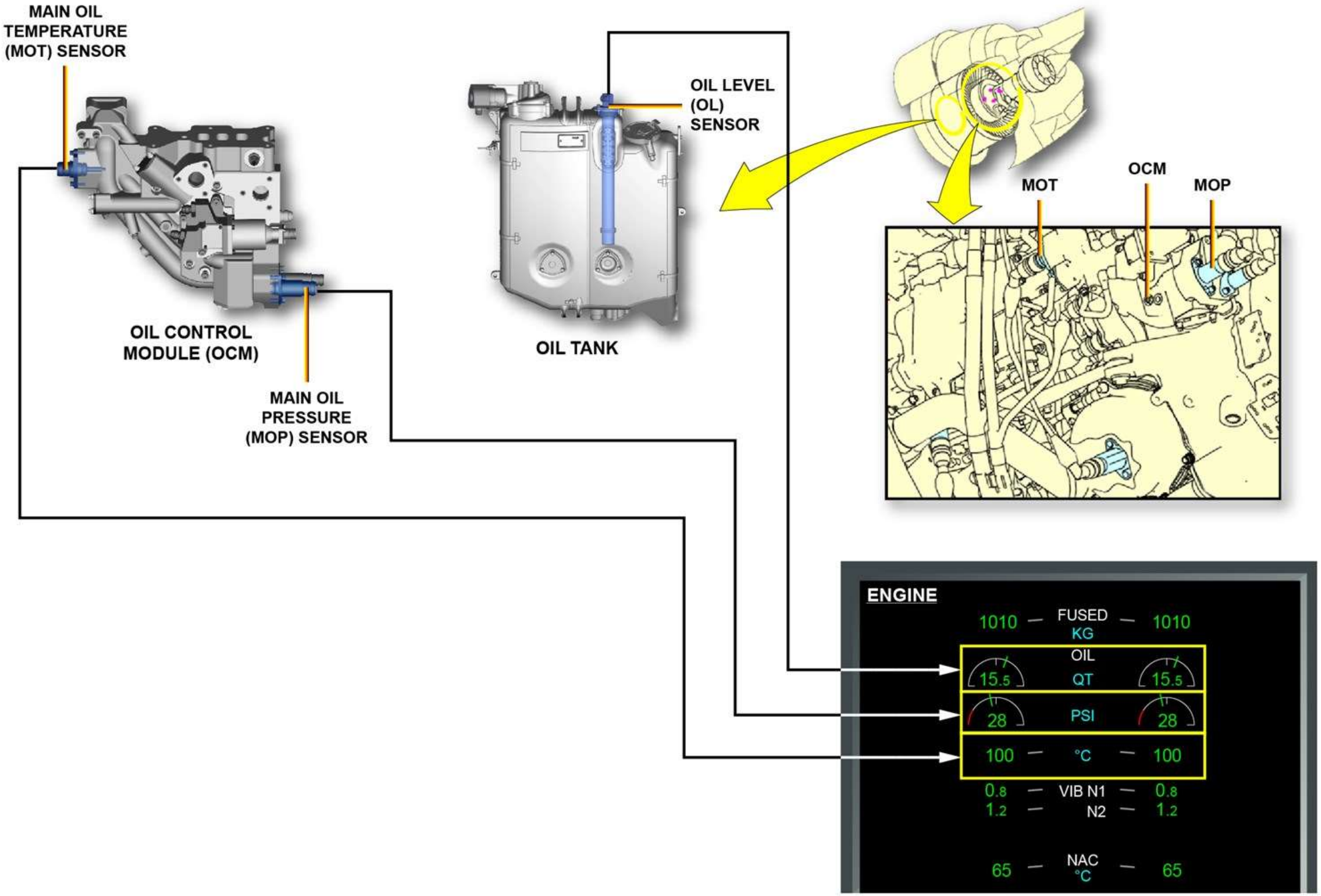
The Oil Level (OL) sensor is located in the oil tank. It sends the oil quantity analog signal to the EEC. The EEC sends the signal for display on ECAM SD ENGINE page.

• MOP sensor located on the LH side of engine on OCM, rear lower side on lubrication outlet line
•MOP sensor = dual channel
•Displayed on ECAM SD ENGINE page

The Main Oil Pressure (MOP) sensor is located on the left hand side of the engine on the Oil Control Module (OCM), rear lower side. It is a dual channel sensor which sends the signal to the EEC for monitoring. EEC sends the signal for display on ECAM SD ENGINE page.

• MOT = dual channel to measure temperature of scavenge oil returning to tank
•MOT sensor located on the front face of the OCM
•It monitors the return line oil temperature.

The Main Oil Temperature (MOT) sensor is a dual channel sensor and is used to measure the temperature of the scavenge oil returning to the tank. This data is monitored by the EEC and is displayed on the ECAM SD ENGINE page. The sensor is located on the front face of the OCM.



SD ENGINE PAGE

•Message in case of abnormal condition
In case of abnormal condition, sensors send signals to trigger messages on ECAM and / or CFDS.

• OFDP sensor installed on the LSOP adjacent to the Oil pressure filter
•Pressure sensor signal from EEC to ECAM to generate alerts:
- DEGRAD
- CLOG

An Oil Filter Differential Pressure (OFDP) sensor is installed adjacent to the oil pressure filter unit on the Lubrication and Scavenge Oil Pump (LSOP) unit. The pressure sensor signal is transmitted by the EEC to the ECAM system to generate the main oil filter clogging alerts when the oil differential pressure across this filter exceeds the thresholds. Two indications are available: DEGRAD or CLOG.

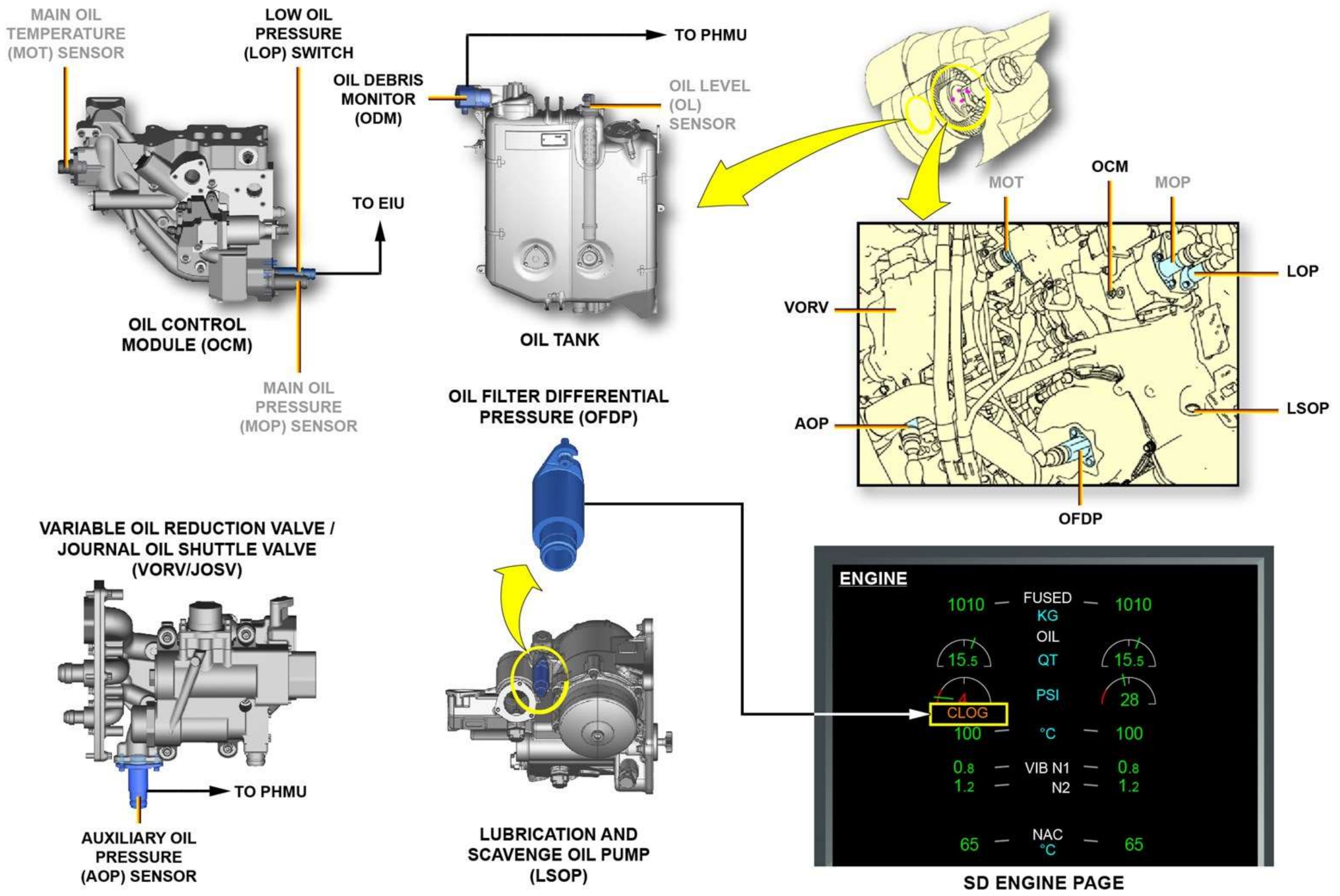
• AOP sensor:
- Located on the Left side of engine below VORV/JOSV
- Measures the oil pressure in the FDGS and detect any damage in the FDGS
- Sends signal to PHMU/EEC to detect FDG auxiliary oil supply malfunction

An Auxiliary Oil Pressure (AOP) sensor is located on the left side of the engine, below the Variable Oil Reduction Valve /Journal Oil Shuttle Valve (VORV/JOSV). It measures the pressure of oil delivered to the journal bearings in the Fan Drive Gear System (FDGS). It sends a signal to the PHMU/EEC, where it is used in conjunction with other oil parameters to detect a Fan Drive Gearbox (FDG) auxiliary oil supply malfunction.

• LOP switch:
- Signals EIU when oil pressure drops below threshold
- Is located on OCM

The Low Oil Pressure (LOP) switch signals the EIU when the oil pressure drops below a threshold. It is located on the left hand side of the engine on the Oil Control Module (OCM).

• ODM located on the top front side of the Oil tank
•Signals proportional to size and type of pollution particles to PHMU
•PHMU monitors debris (quantity & ferrous or non-ferrous debris)
•Data sent to EEC and ECAM + stored in DSU
The Oil Debris Monitoring (ODM) sensor is located on the top front side of the oil tank. It sends signals proportional to size and type of the pollution particles to the PHMU. The PHMU monitors the debris for quantity and identifies whether it is ferrous or non-ferrous debris. The data is transmitted to the EEC for analysis and to generate an ECAM message and trend monitoring accordingly. The data is also stored in the Data Storage Unit (DSU).


MAIN OIL TEMPERATURE (MOT) SENSOR
LOW OIL PRESSURE (LOP) SWITCH
OIL DEBRIS MONITOR (ODM)
TO PHMU
OIL LEVEL (OL) SENSOR
TO EIU
OIL CONTROL MODULE (OCM)
OIL TANK
MAIN OIL PRESSURE (MOP) SENSOR
OIL FILTER DIFFERENTIAL PRESSURE (OFDP)
MOT
OCM
MOP
LOP
VORV
AOP
LSOP
OFDP
VARIABLE OIL REDUCTION VALVE / JOURNAL OIL SHUTTLE VALVE (VORV/JOSV)
TO PHMU
AUXILIARY OIL PRESSURE (AOP) SENSOR
LUBRICATION AND SCAVENGE OIL PUMP (LSOP)
ENGINE
1010
FUSED
KG
1010
OIL
15.5
QT
15.5
PSI
28
CLOG
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC
°C
65
SD ENGINE PAGE

VIBRATION PARAMETERS DESCRIPTION

• 2 vibration sensors (Forward and Aft Vibration accelerometers)
•Information sent to EEC for display of parameters
•Used for display & fan trim balance

The vibration monitoring function within the PHMU uses the two vibration sensors to measure the Fan related vibrations (VIB N1) and the Core related vibrations (VIB N2), stores this information and sends it to the EEC. It is used for ECAM display in the ENGINE SD page. It's also used for the fan trim balance procedure.
The PHMU receives Nf, N1 and N2 data from EEC to capture and compute the appropriate vibration data.

• Forward Vibration Sensor
    - Single channel, piezoelectric accelerometer
    - Installed at 3 o'clock on the HP Compressor casing

The Forward Vibration Sensor is a single channel piezoelectric accelerometer, installed at 3 o'clock on the HP Compressor casing.

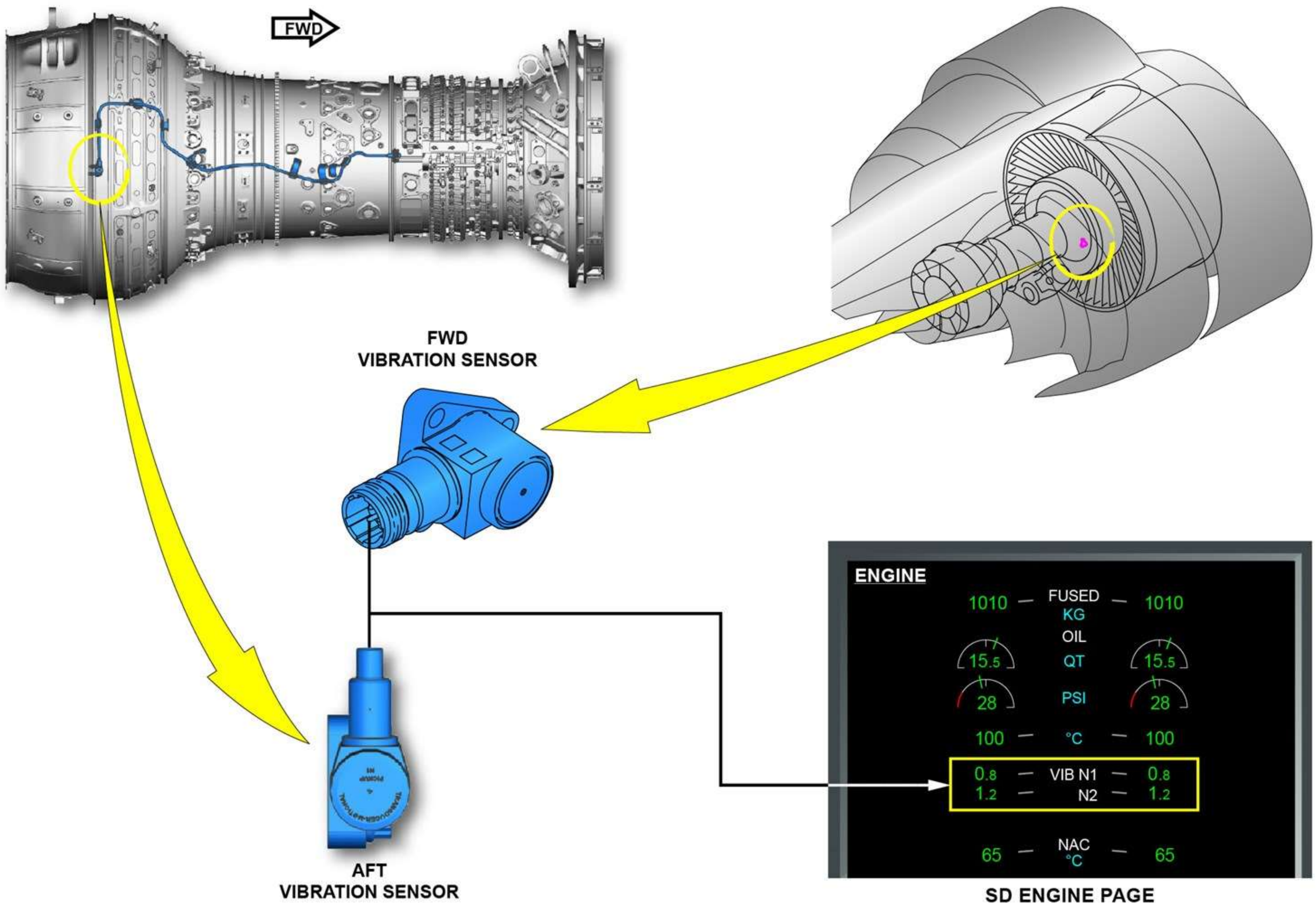
• The Aft Vibration Sensor
    - Single channel, piezoelectric accelerometer
    - Installed at 3 o'clock on the LP Turbine casing

The Aft Vibration Sensor is a single channel piezoelectric accelerometer, installed at 3 o'clock on the LP Turbine casing.

• In case of loss of one vibration sensor
    - PHMU processes using the other accelerometer data
    - May have a degraded signal

•Signal from one vibration sensor lost:
    - Vibration monitoring function still able to provide both vibration signals
    - Display fot affected sensor in degraded mode

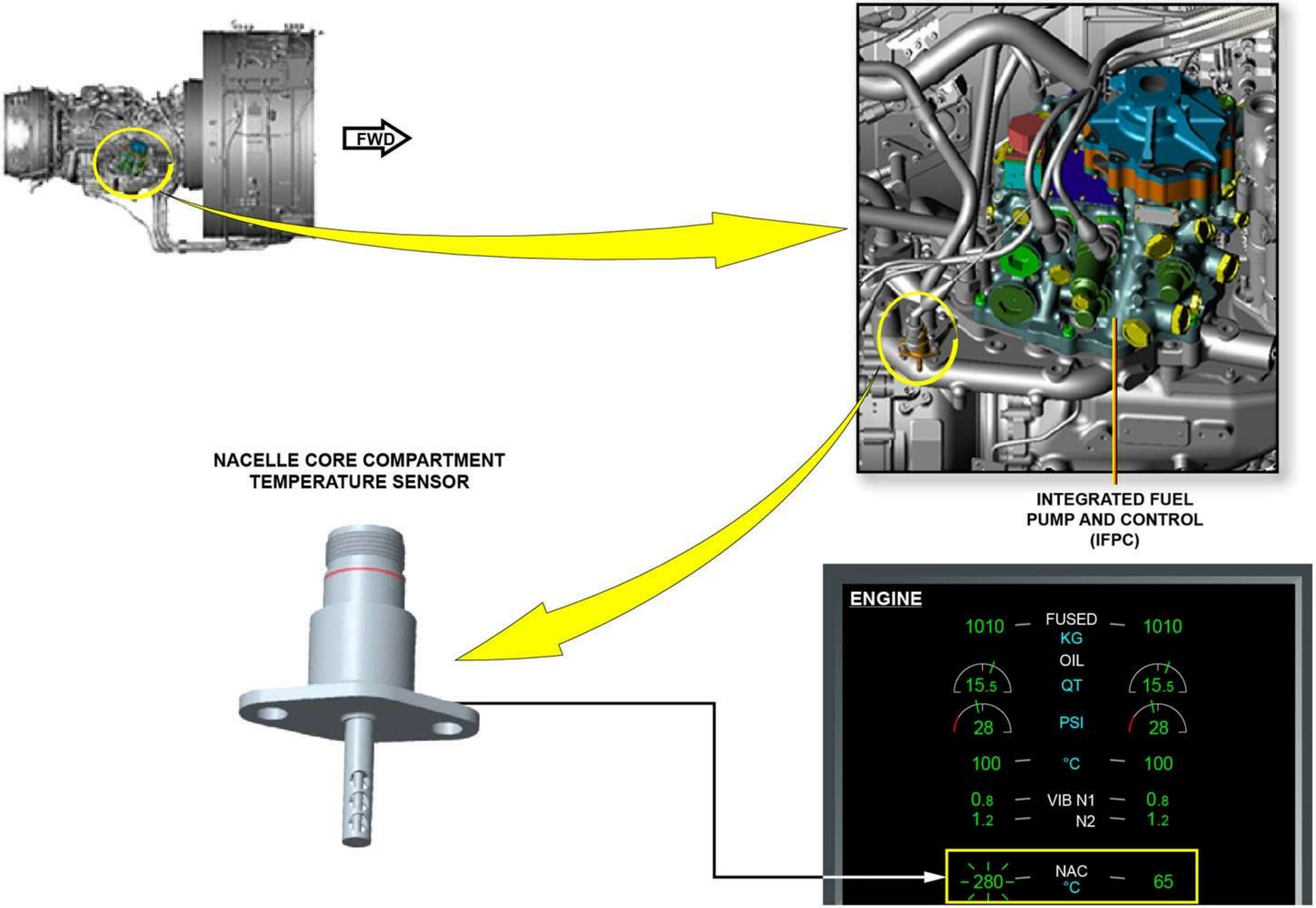
If the signal from one vibration sensor (either forward or aft vibration sensor) is lost during engine operation, the vibration monitoring function is still able to provide both vibration signals (N1 and N2) for cockpit display. However, the display for the affected sensor will be presented in degraded mode.


FWD
FWD
VIBRATION SENSOR
AFT
VIBRATION SENSOR
ENGINE
1010
FUSED
KG
1010
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC
°C
65
SD ENGINE PAGE

NACELLLE TEMPERATURE INDICATION

- Nacelle temperature monitored by a probe in core compartment
- Display on ECAM ENGINE SD
  - Shown green pulsing if temperature is above limit

The nacelle temperature is monitored by a temperature probe installed in the ventilated core compartment.
The nacelle temperature is displayed on the ECAM ENGINE SD. It is only shown green pulsing, when the temperature value is above the limit.



SD ENGINE PAGE

OTHER SENSORS FOR ENGINE CONTROL AND MONITORING

• Various sensors for EEC

Various sensors are used by the EEC for the engine control and monitoring.

• T2 sensor:

- Measures the air inlet temperature for rating, Mach number & bleed scheduling
- Located on the air inlet cowl at 1'o' clock position

The T2 sensor measures the air inlet temperature for engine rating, Mach number calculation and bleed scheduling. It is located in the air inlet cowl at 1 o'clock position.

• P 2.5/T 2.5 sensor measures air press downstream booster or HPC inlet

•Located on CIC at 1 o'clock

The P 2.5/T 2.5 sensor measures the air pressure and temperature downstream of the booster at the High Pressure Compressor (HPC) inlet. It is located on the Compressor Intermediate Case at 1 o'clock position.

• Burner Pressure (PB) sensor measures pressure related to combustion:

- Fuel scheduling
- Surge recovery
- Stall detection
- Idle modulation
- Continuous ignition logic

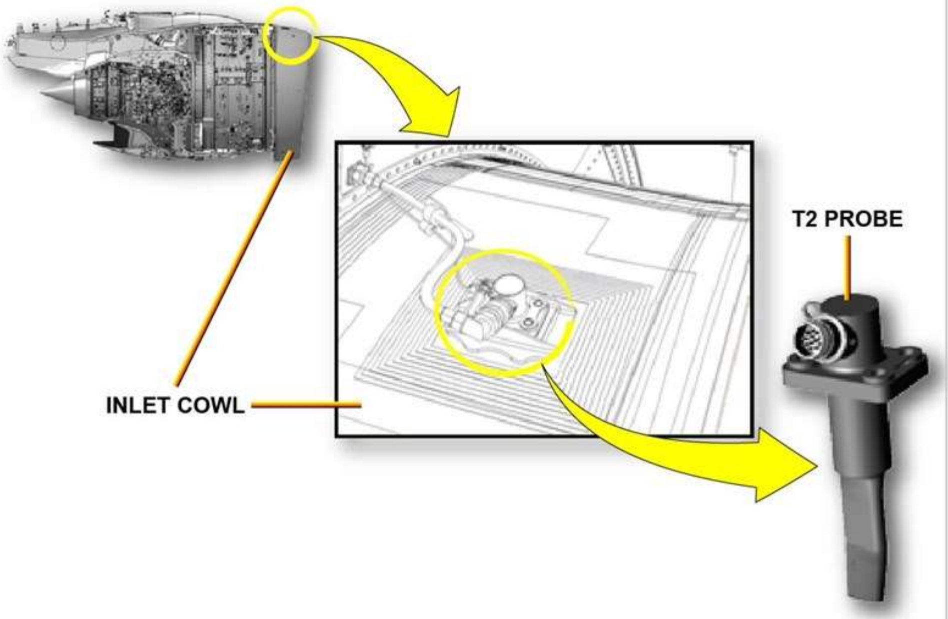
•Located in LH side HPC case at 11 o'clock

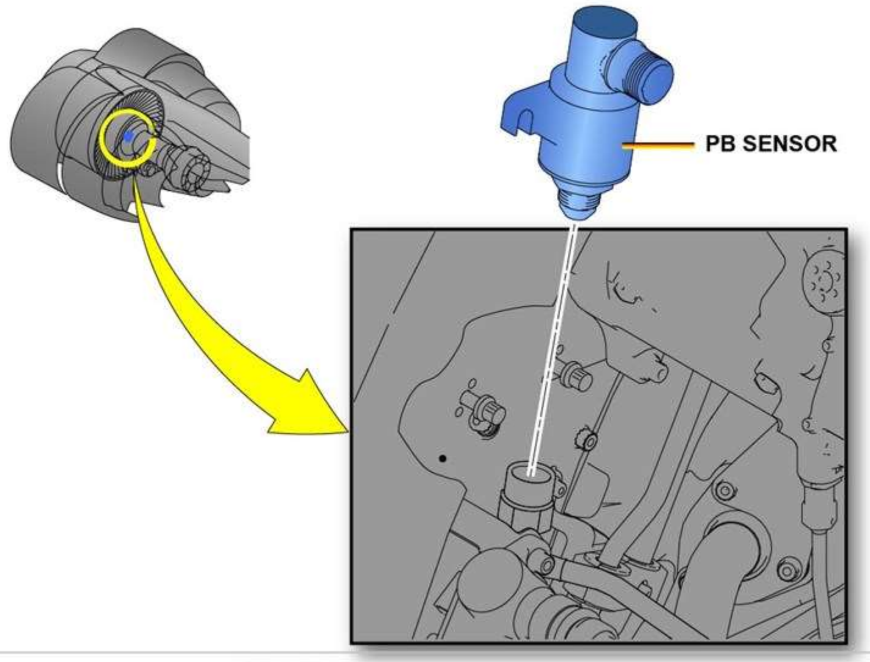
The Burner Pressure (PB) sensor measures the pressure related to the combustion for fuel scheduling, surge recovery, stall detection, idle modulation and continuous ignition logic. It is located in the LH side HP Compressor Case at 11 o'clock position.

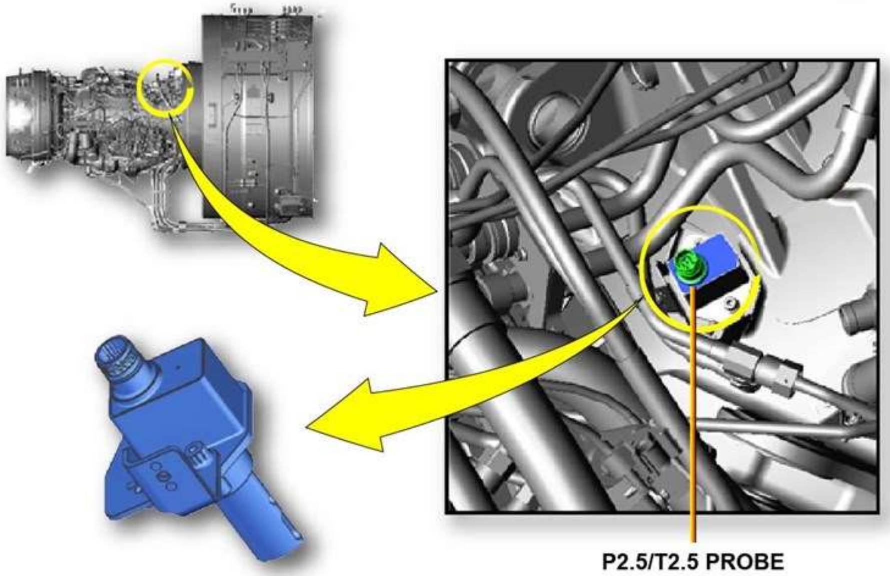
• T3 measures compressor discharge temp

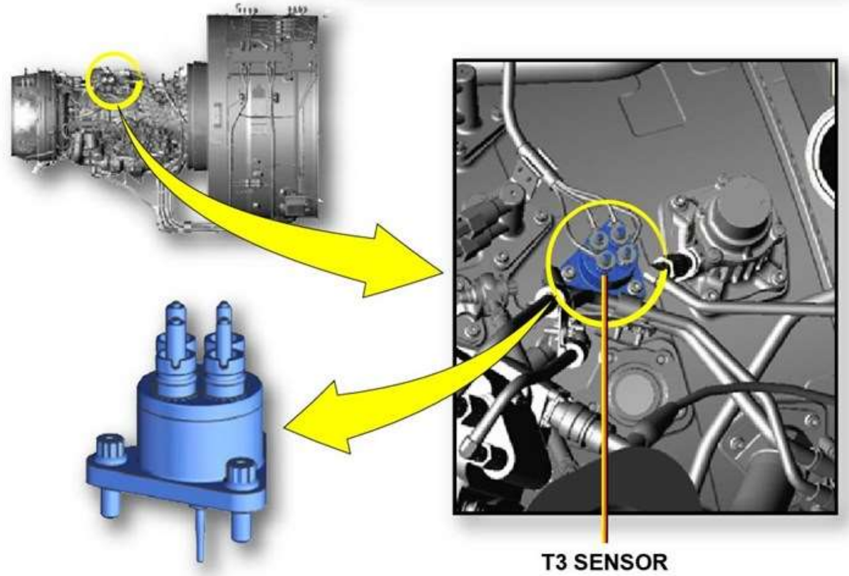
•Located on diffuser case

The T3 sensor measures the compressor discharge temperature for total temperature calculation. It is located on the diffuser case, forward of the fuel nozzles at 1 o'clock position.


T2 PROBE
INLET COWL


PB SENSOR


P2.5/T2.5 PROBE


T3 SENSOR

Thrust Reverser System Description and Operation

THRUST REVERSER SYSTEM LAYOUT

- Aerodynamic blockage type
  - Electrically controlled
  - Hydraulically operated
- Two translating sleeves, 10 blocker doors and cascade vanes

The thrust reverser system is of the aerodynamic blockage type.
For each engine, it consists of two translating sleeves, ten blocker doors and cascade vanes to redirect fan discharge airflow.

Pressurized by dedicated hydraulic power source:

- GREEN HYD for ENG 1
- YELLOW HYD for ENG 2

- Each system has:
  - HCU, ICV, DCV
  - 2 Worm drive actuators per side
  - Locking and monitoring devices

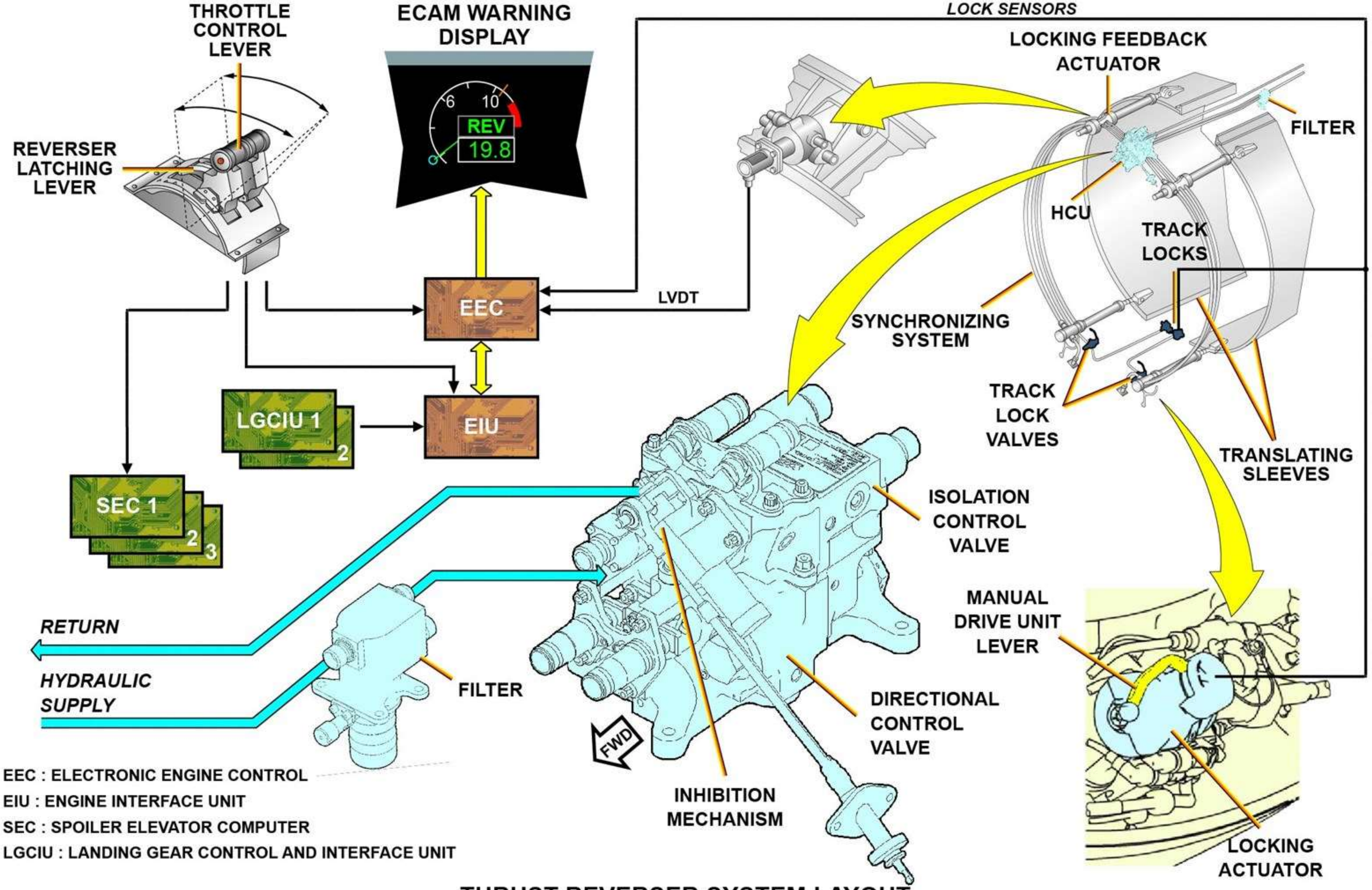
Each pair of actuators (per side) is connected by a synchro flex shaft inside of their deploy tube.
The DCV is connected to 3 lines per side (Deploy tube, stow line and return line).

Each system is pressurized by its dedicated hydraulic power source:
- the green hydraulic pressure for engine 1,
- and the yellow one for engine 2.

Each system is made of one Hydraulic Control Unit (HCU) including an Isolation Control Valve (ICV) and a Directional Control Valve (DCV), two worm drive actuators per side, locking and monitoring devices.

- Used on ground only
- 3 Lines of defense:
  - 1st= Primary lock in each actuator
  - 2nd=Primary lock on left upper actuator
  - 3rd=Tertiary lock at 6 o'clock

To avoid inadvertent deployment, the system operates under multiple and independent commands and it comprises several lines of defense: primary locks in each actuator and one tertiary lock at the bottom of each translating sleeve.



EEC : ELECTRONIC ENGINE CONTROL
EIU : ENGINE INTERFACE UNIT
SEC : SPOILER ELEVATOR COMPUTER
LGCIU : LANDING GEAR CONTROL AND INTERFACE UNIT

THRUST REVERSER SYSTEM LAYOUT

DEPLOY SEQUENCE

• Initial status

The EEC confirms the engine is running. The thrust reversers are stowed, locked and not inhibited.

In these conditions:

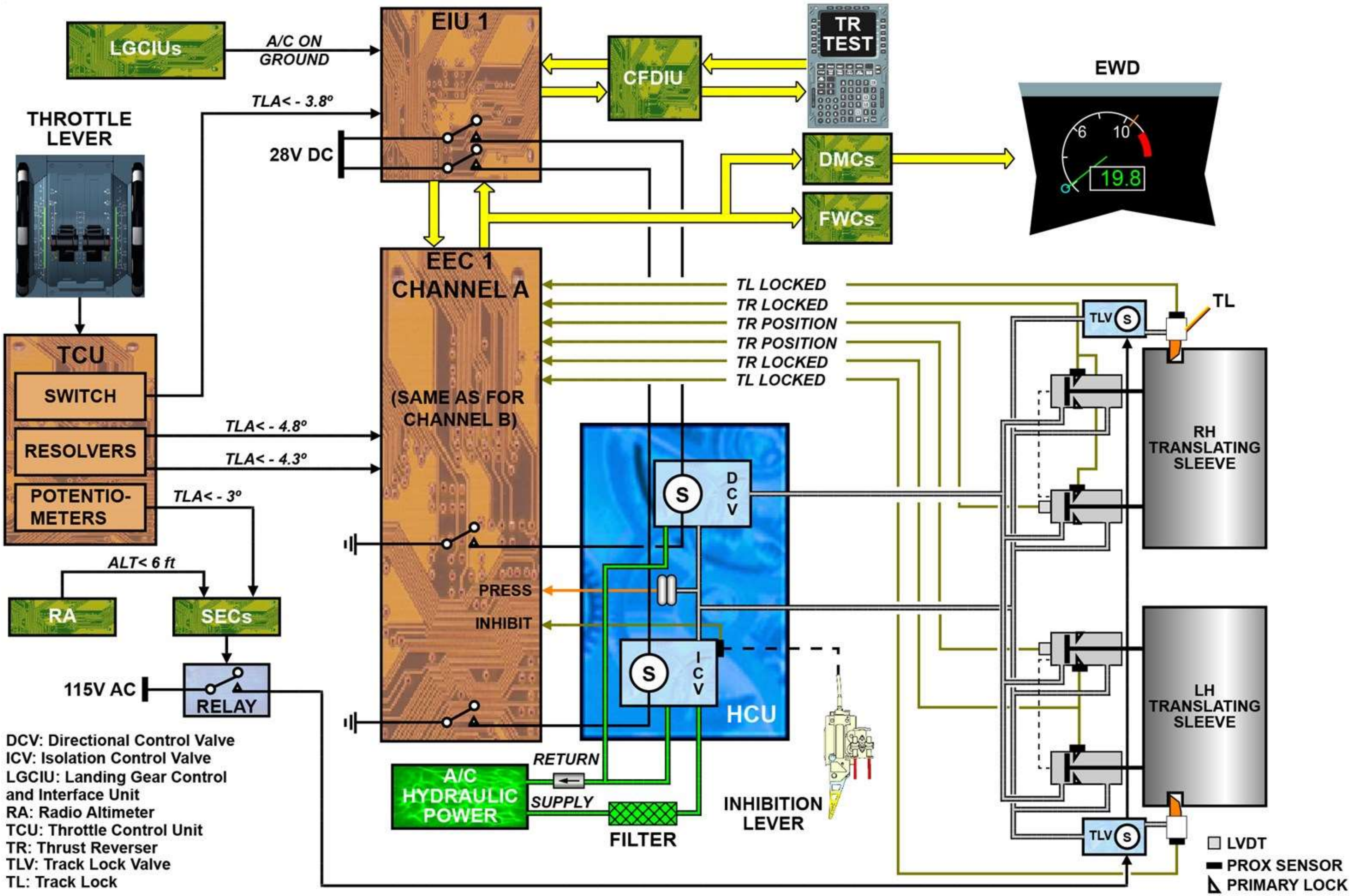
- the ICV, DCV, Track Lock Valves (TLV) are de-energized to prevent pressurization,
- the 6 proximity sensors indicate locked,
- the ICV pressure switch indicates a low pressure,
- both LVDTs indicate a stowed condition,
- the HCU inhibition lever proximity sensor indicates a non-inhibited condition.

To optimize the thrust reverser operation, the EEC operates in an active/active mode to avoid that any failure leads to not control the reverser deploying or stowing.

The ICV, DCV and TLV are spring loaded closed.

Engine running conditions are: N1, N2 and burner pressure above minimum values.

When the engine is not running, EEC should only command the thrust reverser during interactive mode.

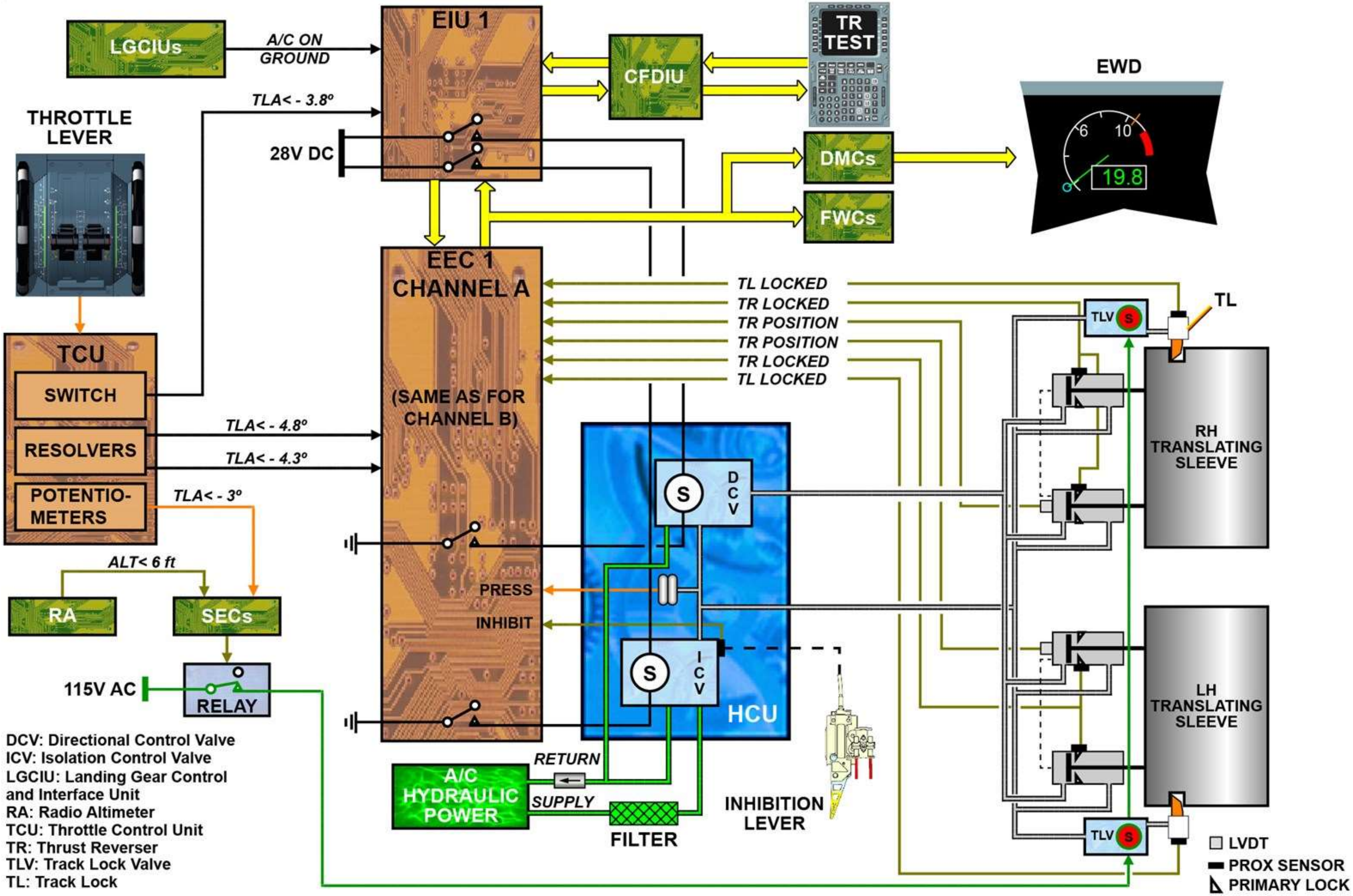

LGCIUs
A/C ON GROUND
EIU 1
CFDIU
TR TEST
EWD
6
10
19.8
TLA< - 3.8º
THROTTLE LEVER
28V DC
DMCs
FWCs
EEC 1 CHANNEL A
(SAME AS FOR CHANNEL B)
TL LOCKED
TR LOCKED
TR POSITION
TR POSITION
TR LOCKED
TL LOCKED
TL
TLV
S
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.8º
TLA< - 4.3º
TLA< - 3º
RH TRANSLATING SLEEVE
D C V
ALT< 6 ft
RA
SECs
PRESS
INHIBIT
I C V
115V AC
RELAY
HCU
LH TRANSLATING SLEEVE
RETURN
A/C HYDRAULIC POWER
SUPPLY
FILTER
INHIBITION LEVER
LVDT
PROX SENSOR
PRIMARY LOCK
DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

•Unlock�:

- TLA < -3� & Altitude < 6 ft: SECs power the TLV

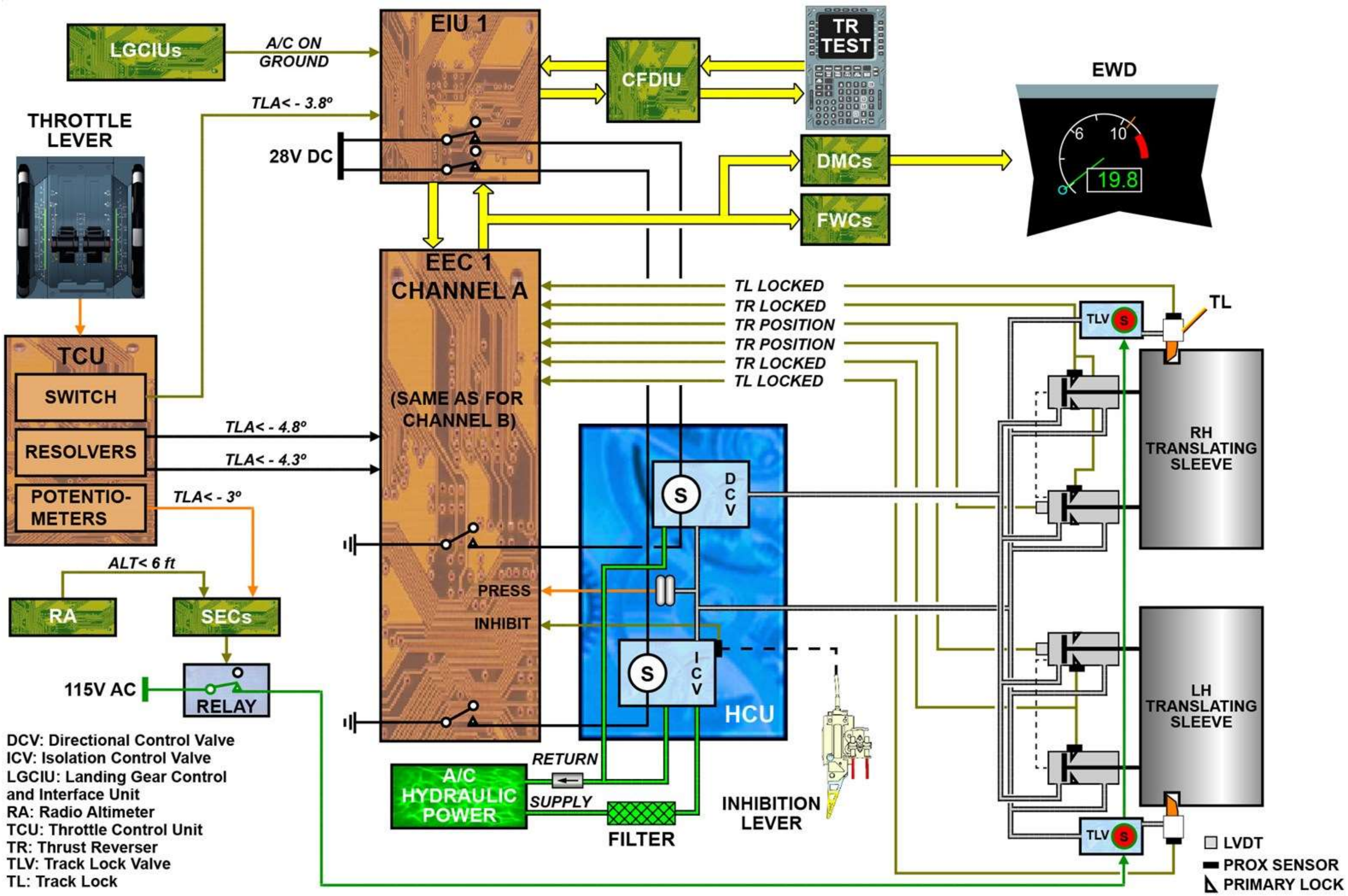
When the thrust-reverser lever is set to the deploy position, the following sequence occurs.

1.) As soon as the Spoiler Elevator Computers (SECs) receive the signal from the TCU potentiometers (Throttle Lever Angle (TLA) < -3�), and from the Radio Altimeter (RA) (altitude < 6 ft), they control the powering of the TLVs to open. In this position, the TLVs are ready to let the hydraulic pressure release the Track Lock (TL) when the ICV will be controlled open.

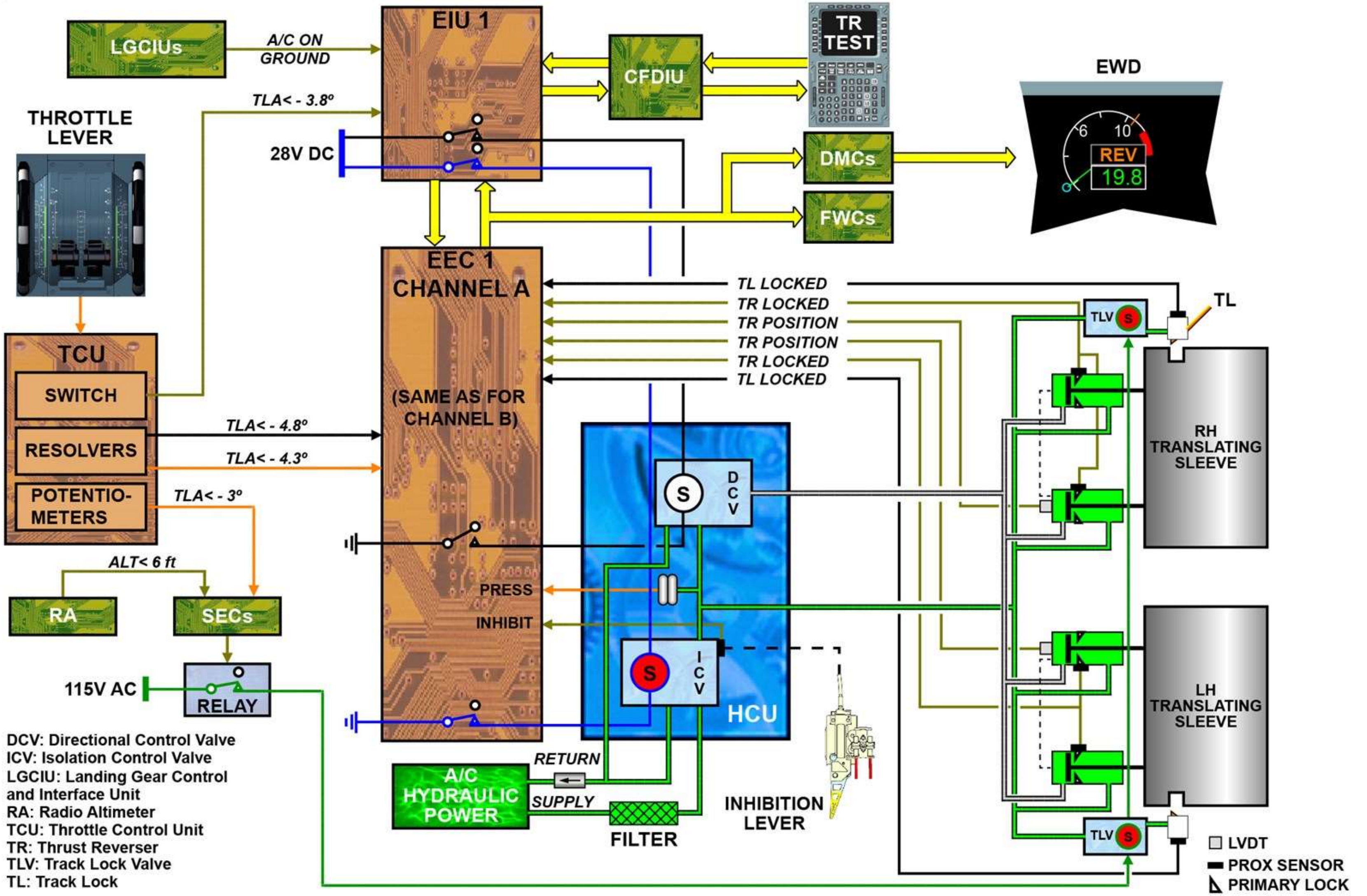


DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

•TLA < -3.8� & A/C on GND signal: inhibition relay energized to power the HCU
2.) When the Engine Interface Unit (EIU) receives the signals from the Throttle Control Unit (TCU) switch (TLA < -3.8�) and from the Landing Gear Control and Interface Units (LGCIUs) (aircraft on ground), it controls the closure of internal relays involved in the ICV and DCV powering.

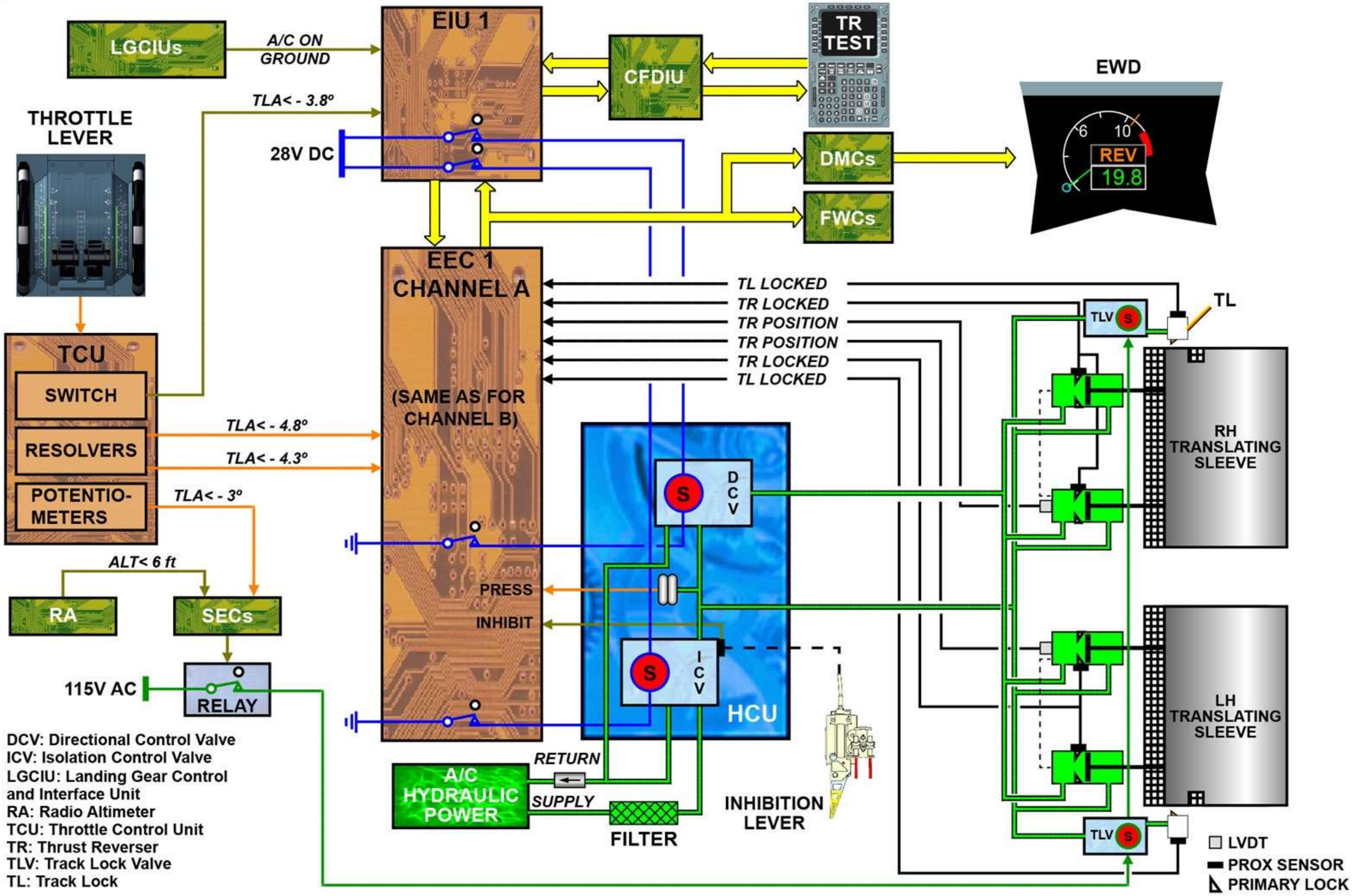


•TLA < -4.3: ICV powered to open, actuators overstowed and latches released
3.) When the Electronic Engine Control (EEC) receives the signals from the TCU resolvers (TLA < -4.3�), it closes an internal relay to power the ICV to open. The pressure is sent to the actuators rod chambers to perform an overstow and to the TLs to release the latches.

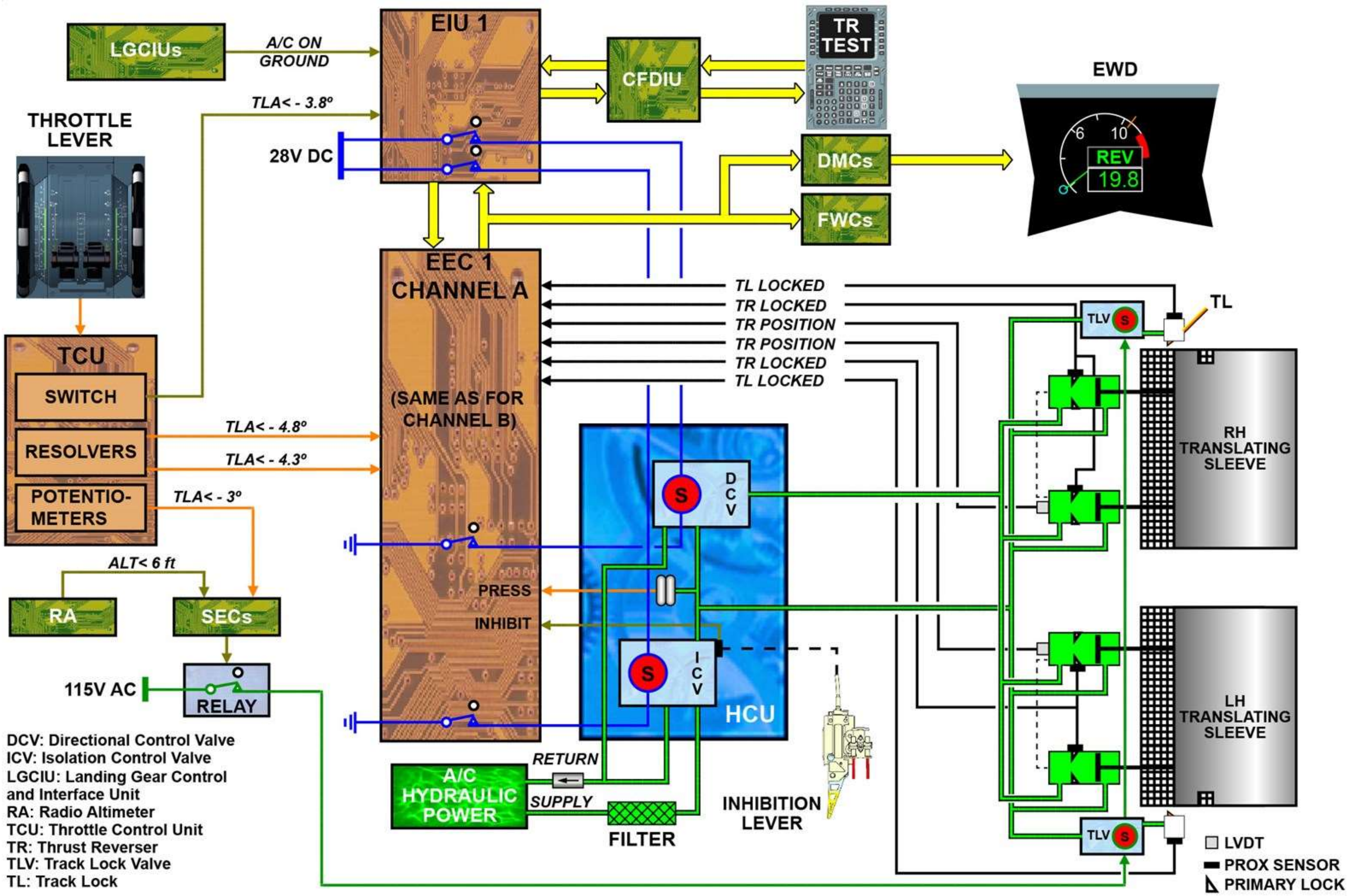


DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

•TLA < -4.8 & TLs confirmed unlocked: DCV powered to open, actuators internal primary locks released and translating sleeves deployed
4.) When the EEC receives the signals from the TCU resolvers (TLA < -4.8�) provided the TLs are confirmed unlocked, it closes an internal relay to power the DCV to open. The pressure is sent to the actuators jack heads to release the actuators internal primary locks and command the translating sleeves deployment.



•Max reverse thrust
5.) Above 85 % of travel, the EEC commands the engine to accelerate from reverse idle to max reverse thrust. Maximum allowable thrust is defined as a function of sleeve travel and TLA.
At 95% of travel, the actuators engage their integral snubbing devices, thus decreasing their extension speed before the full opening.
The TLV, ICV and DCV remain supplied to maintain the translating sleeves fully deployed by hydraulic pressure.



DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

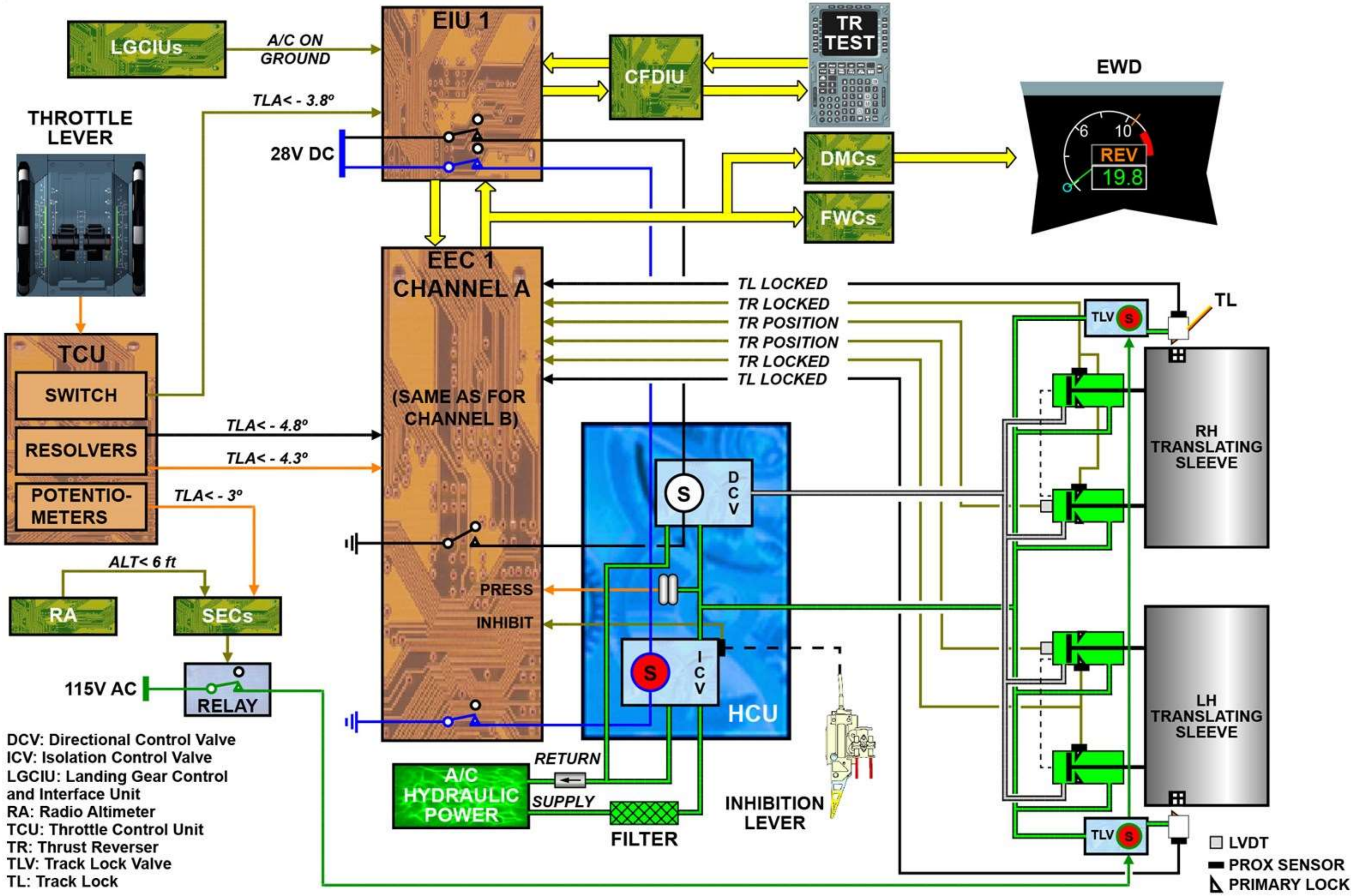
STOW SEQUENCE

• Thrust-reverser lever set to the stow position

- TLA > -4.8�: EEC de-energizes the DCV
- Translating sleeves stowed until internal primary locks re-engage

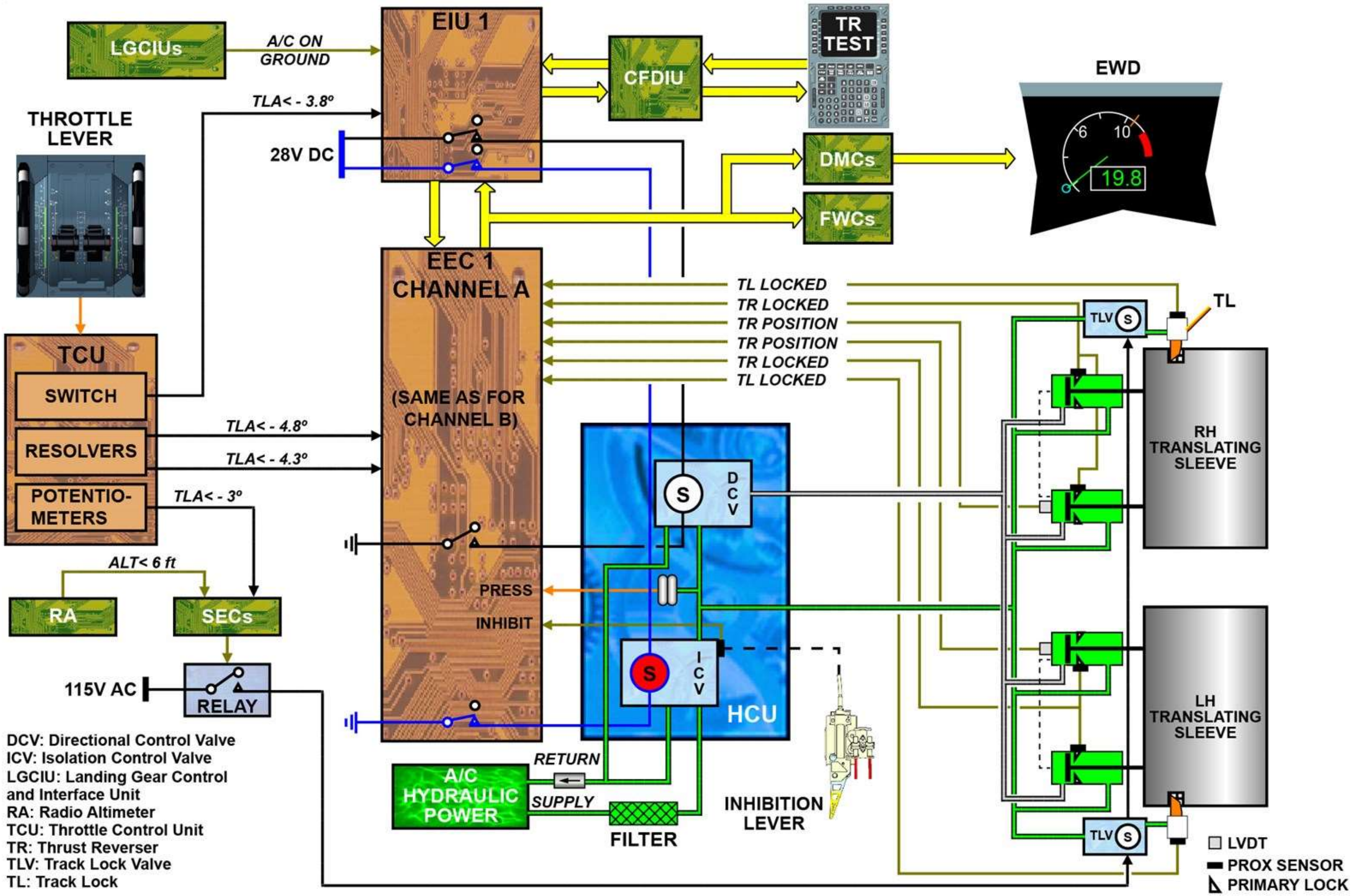
When the thrust-reverser lever is set to the stow position, the following sequence occurs.

1-When the EEC receives the signals from the TCU resolvers (TLA > -4.8�), it de-energizes the DCV. The pressure is sent only to the actuators rod chambers to stow the translating sleeves until the actuators internal primary locks are re-engaged.

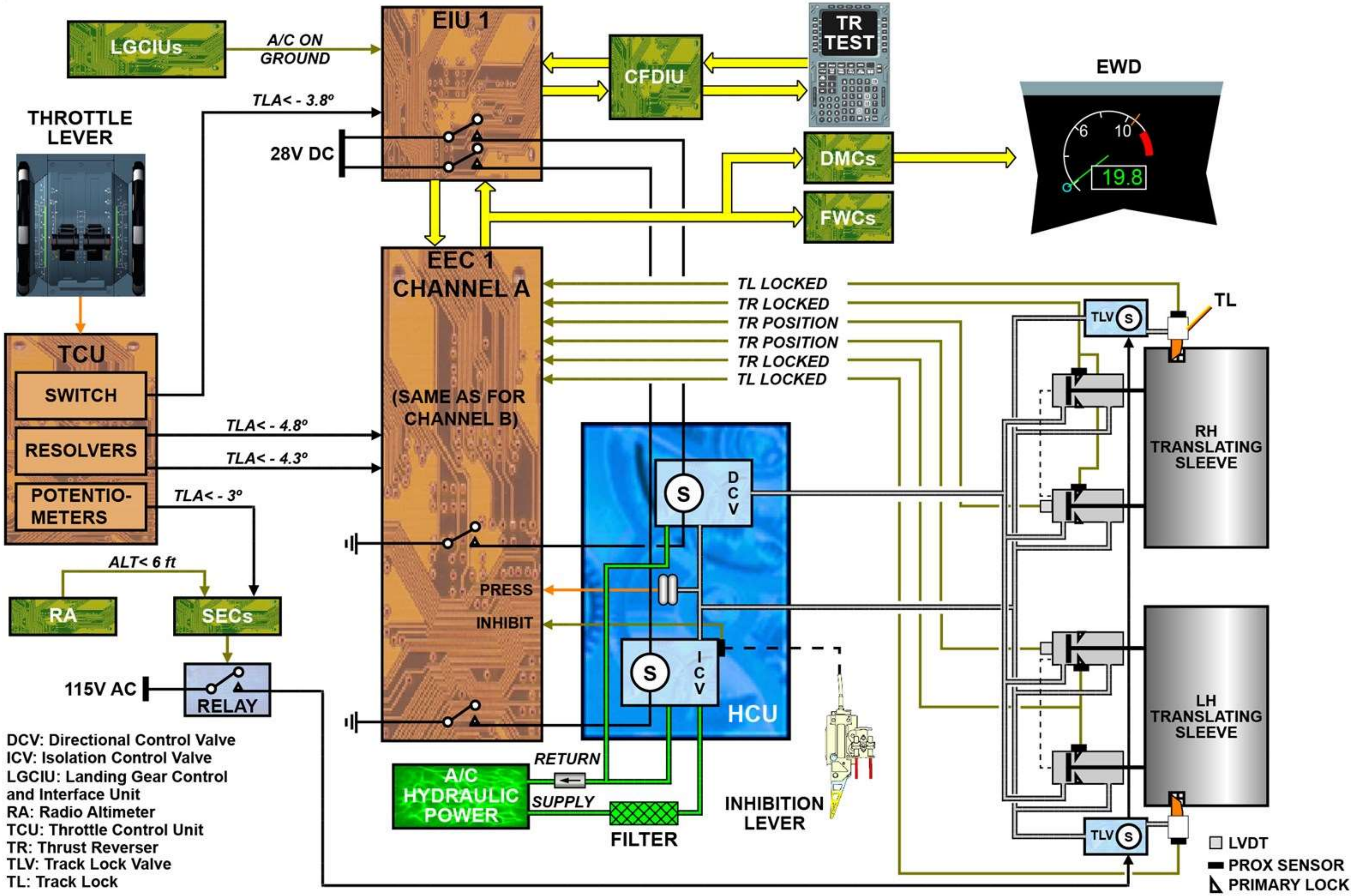


DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

•TLA > -4.8� + 15s: SECs de-energize the TLVs to re-engage the TLs
2-15 seconds after the SECs receive the signals from the TCU potentiometers (TLA > -2�), they de-energize the TLVs to re-engage the TLs.



•Stow sequence completed + 15s: EEC de-energizes the ICV
•EIU opens its internal relays to isolate ICV and DCV powering
3-15 seconds after the stow sequence is completed, the EEC de-energizes the ICV. Then the EIU opens its internal relays to isolate the ICV and DCV powering



DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

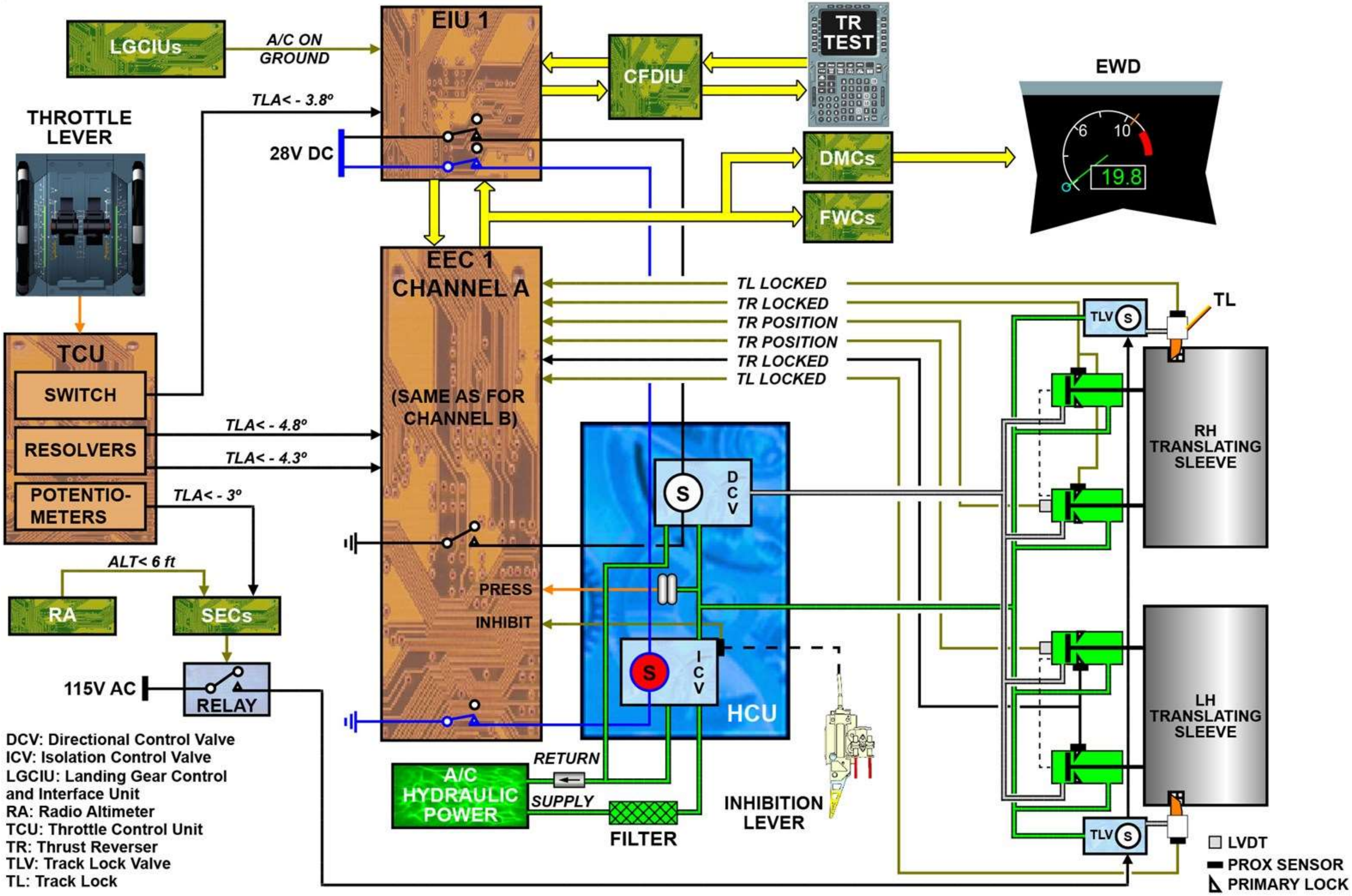
GROUND ASSISTED STOW SEQUENCE (GASS)

- Initiated by EEC if at least 1 primary lock is detected unlock:
  - After a normal stow sequence
  - After the engine start
- Initiated by energizing the ICV for 5s under certain conditions

The EEC shall initiate a thrust reverser GASS operation on ground only in order to lock the thrust reverser system in the following two cases:
- at least one primary lock is detected unlock after the normal stow sequence is completed (operational case),
- if at least one primary lock is detected unlock after the engine start (maintenance case).

The GASS shall be initiated by energizing the ICV for 5 seconds when all the following conditions are fulfilled:
- the aircraft is on ground,
- the throttle is in forward thrust region and less than CL position,
- no stow sequence is being commanded,
- within 15s after engine transition to idle following an engine start,
- one or two primary locks of any translating sleeve are seen unlocked,
- the sleeve positions (left and right) are less than 5% of travel,
- the thrust reverser is not inhibited,
- 28V DC power is available.

The GASS operation shall be limited to one cycle. This cycle shall be memorized and cleared after a master lever reset.



DCV: Directional Control Valve
ICV: Isolation Control Valve
LGCIU: Landing Gear Control and Interface Unit
RA: Radio Altimeter
TCU: Throttle Control Unit
TR: Thrust Reverser
TLV: Track Lock Valve
TL: Track Lock

Oil System Description and Operation

OIL SYSTEM LAYOUT

Comp loc ENG 1 LH

Lubrication unit module

•3 Non-regulated pressurized oil

•Lubricates bearings and accessories

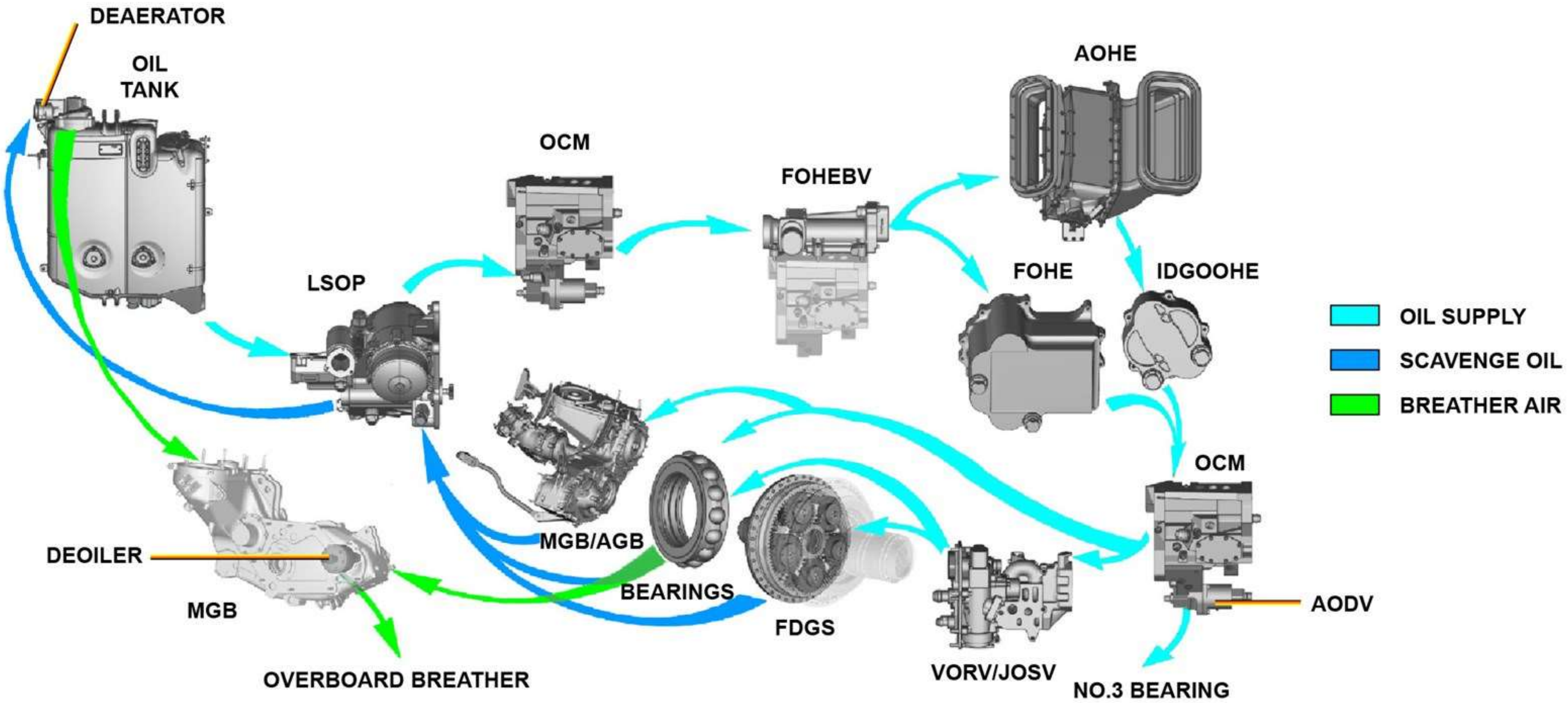
•Regulates the temperature

•Scavenges oil and vents de-oiled sealing air

The oil system:

- Lubricates the engine bearings, Angle Gearbox (AGB), Main Gearbox (MGB) and Fan Drive Gear System (FDGS) with filtered, non-pressure regulated oil,
- Regulates the temperature of the engine oil with the Air/Oil Heat Exchanger (AOHE), engine fuel with the Fuel/Oil Heat Exchanger (FOHE), Integrated Drive Generator (IDG) oil with IDG Oil/Oil Heat Exchanger (IDGOOHE),
- Scavenges the hot lubrication oil back to the tank,
- Vents overboard the excess of sealing air from the bearing compartments.

OIL SYSTEM LAYOUT

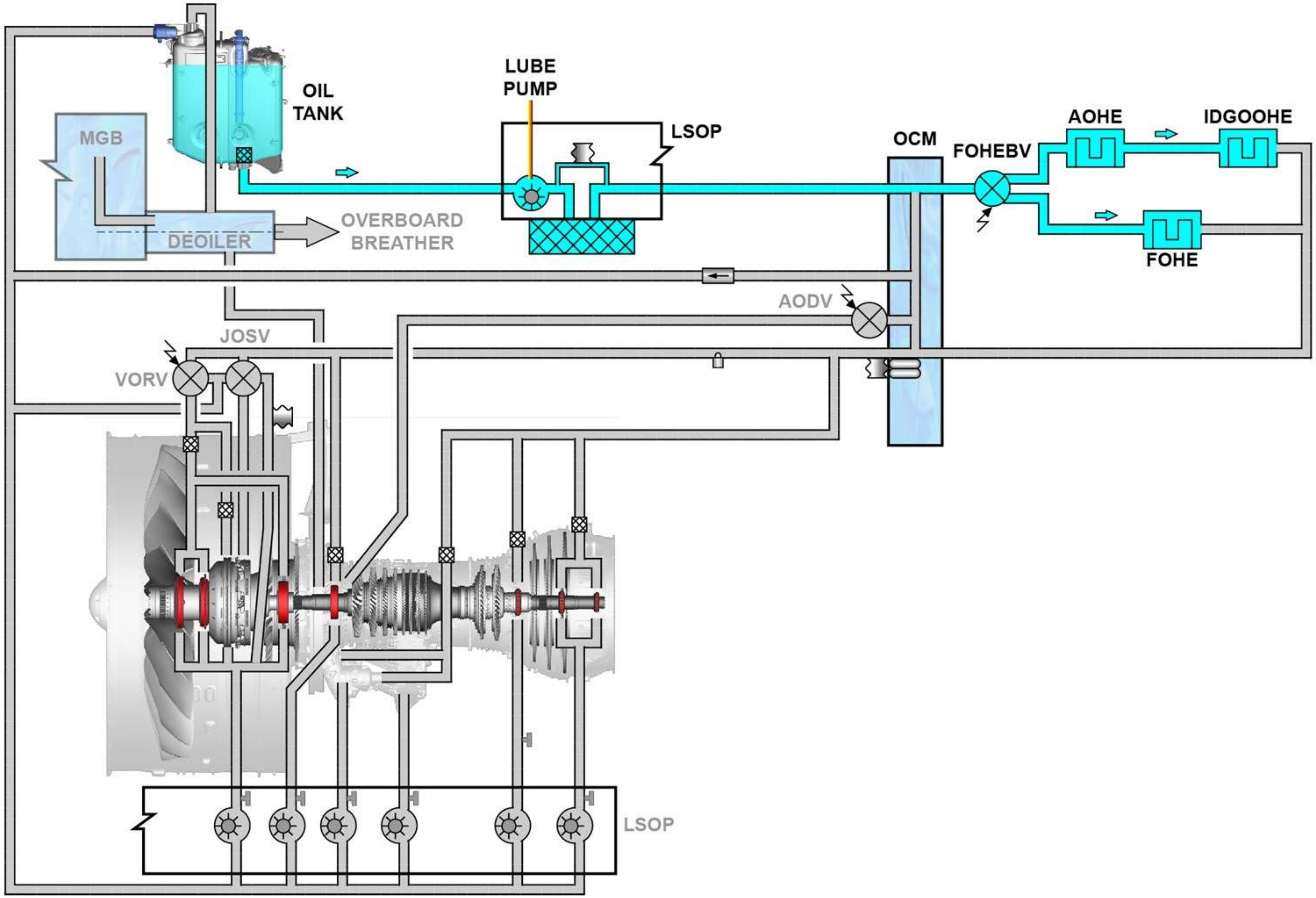


AGB: Angle Gearbox
AODV: Active Oil Damper Valve
AOHE: Air/Oil Heat Exchanger
FDGS: Fan Drive Gear System
FOHE: Fuel/Oil Heat Exchanger
FOHEBV: FOHE Bypass Valve
IDGOOHE: IDG Oil/Oil Heat Exchanger
JOSV: Journal Oil Shuttle Valve
LSOP: Lubrication and Scavenge Oil Pump
MGB: Main Gearbox
OCM: Oil Control Module
VORV: Variable Oil Reduction Valve

•Oil from tank to the lube pump included in the LSOP
•Pressurized oil through main oil filter to OCM
•Filtered oil to FOHEBV
- Oil flow modulated between AOHE and FOHE
- FOHEBV controlled by EEC

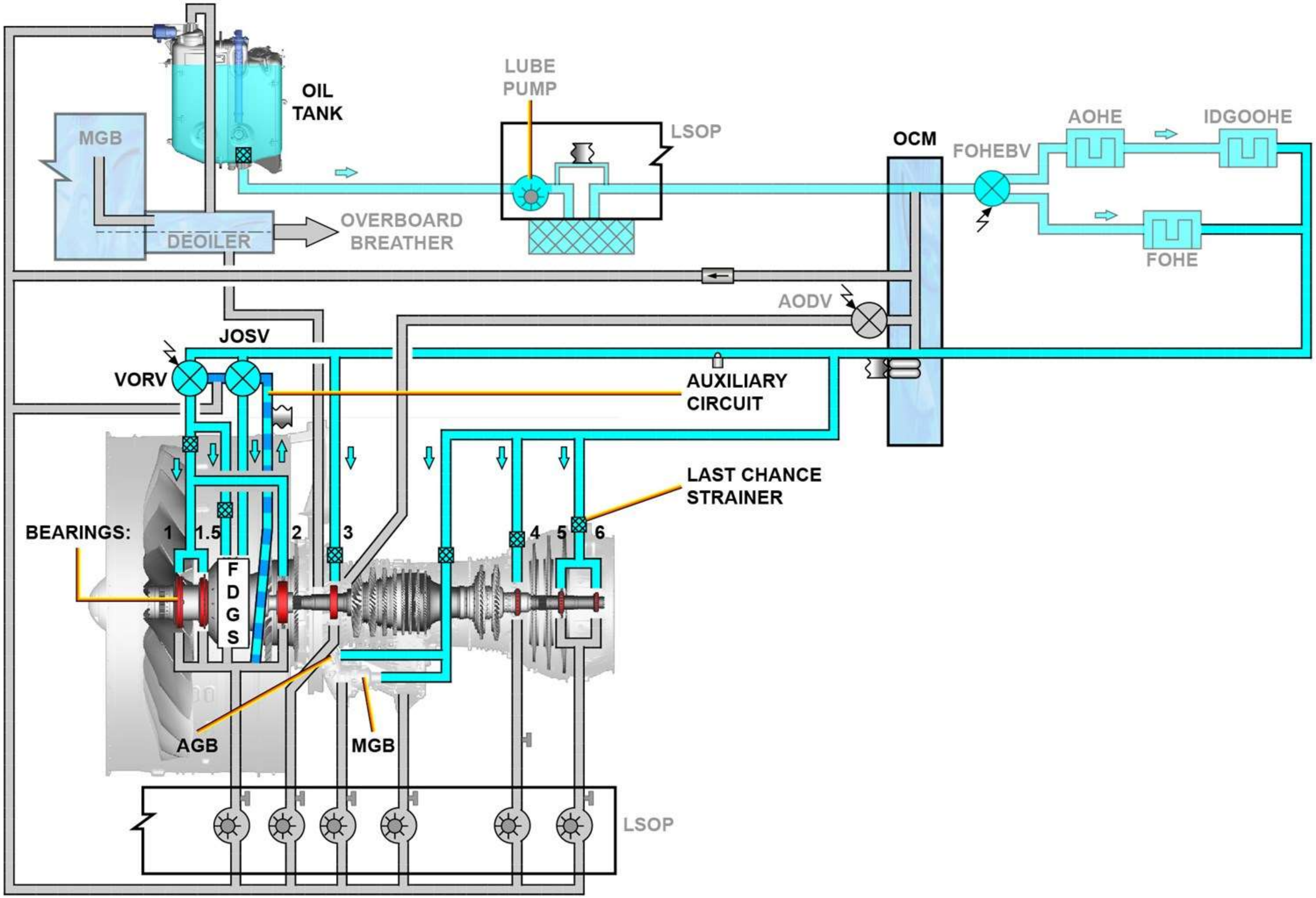
•Oil to AOHE also flows to IDGOOHE

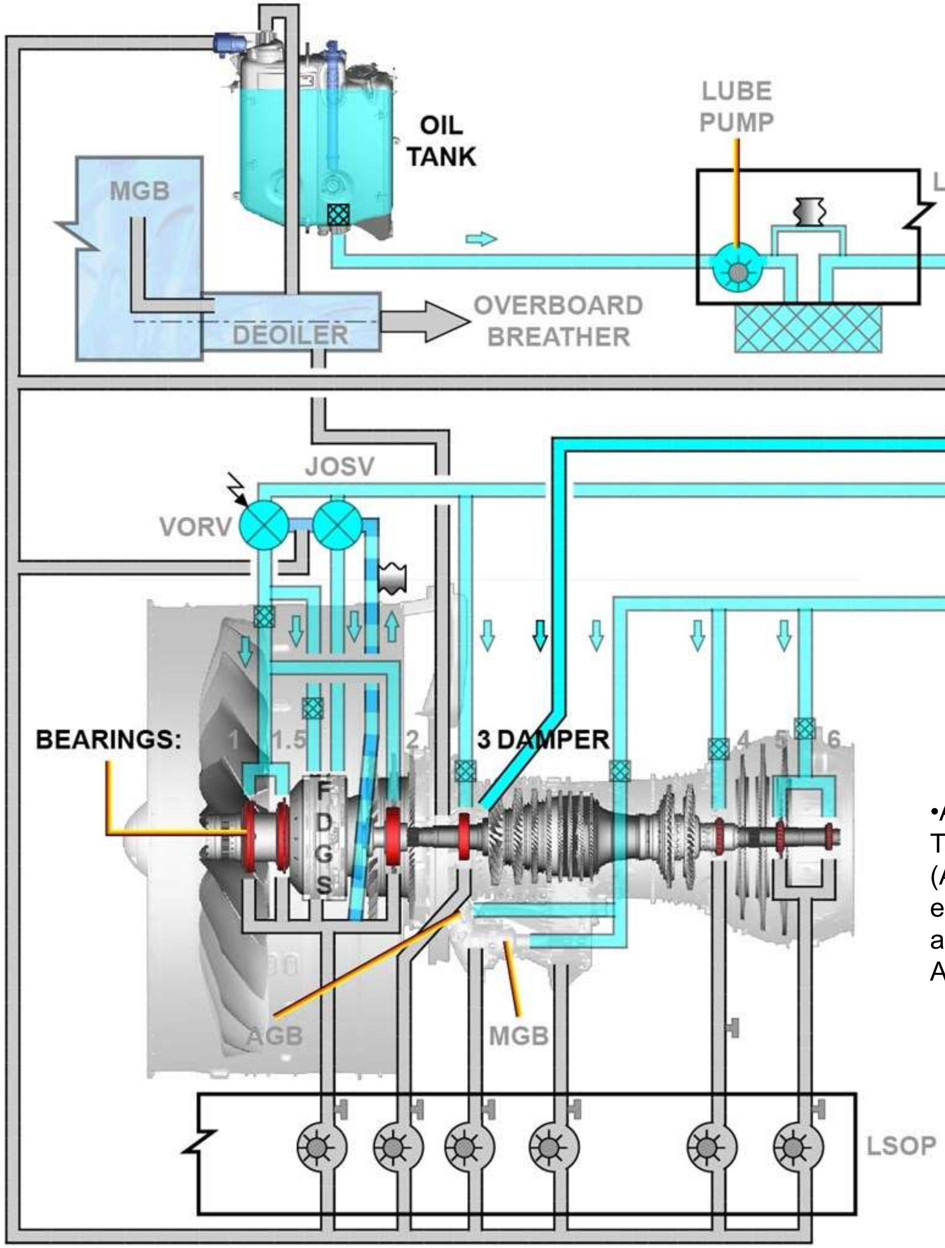
Oil flows from the pressurized oil tank to the lube pump in the Lubrication and Scavenge Oil Pump (LSOP).
The pressurized oil is directed to the main oil filter and to the Oil Control Module (OCM). The main part of the filtered oil flows to the Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV) which modulates the oil flow between the AOHE and the FOHE. The oil flow that is directed to the AOHE also flows through the IDGOOHE.
The FOHEBV is electrically controlled and monitored by the Electronic Engine Control (EEC) according to fuel temperature.
Pressurizing valve maintains 12 Psi in the tank to increase the inlet pressure to the pump to prevent pump cavitation.
The tank is fitted with a cap, a flapper valve, a sight glass and an oil level sensor. Its full level is 35 qts and max capacity is 39.5 qts.
Main oil filter is a dual element type (30 and 150 µm) with a primary oil filter bypass valve, a check valve to prevent oil leakage during filter service and a mechanically activated static anti−leak valve to prevent back−flow during shutdown.
There are three heat exchangers. All heat exchangers are of bypass type.
FOHEBV increases the oil flow to the FOHE when the fuel temperature is below a predetermined value.
FOHEBV failsafe position is maximum flow to the FOHE which is approximately 90% of the total oil flow.


OIL TANK
LUBE PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
MGB
DEOILER
OVERBOARD BREATHER
AODV
JOSV
VORV
LSOP

•Oil from heat exchangers sent to N�3, 4,5,6 bearings, AGB and MGB
•VORV controlled by EEC to bypass oil to the front bearings at low
•JOSV controlled by EEC to keep a continuous supply of oil to the fan drive journal bearings
Oil from the heat exchangers is sent via the OCM to the No. 3, 4, 5, 6 bearings and to the AGB and MGB.
Oil is also sent to the Variable Oil Reduction Valve (VORV) / Journal Oil Shuttle Valve (JOSV) which modulates the flow of oil to the No. 1, 1.5, 2 and Fan Drive Gear System (FDGS) based on engine power settings.
The VORV is electrically controlled and monitored by the EEC to bypass part of the oil flow to the front bearings at low power setting.

The JOSV is a mechanical device that keeps a continuous supply of oil to the fan drive journal bearings from the main oil supply in normal condition or from the auxiliary oil supply in windmill or zero or negative gravity conditions.
Nozzles in the main bearing compartments and gearboxes supply the oil to the different bearings, gears, seals, and accessory drive splines. Last chance strainers are provided at the entrance to the compartments to protect the oil nozzles from debris introduced to the oil system downstream of the main oil filter.
FOHEBV failsafe position is to FOHE.
VORV failsafe position is maximum flow to bearings, equivalent to high power setting.
The FDGS auxiliary oil supply actuated by the JOSV comprises a dedicated pump driven by the fan and an auxiliary reservoir.
Under normal conditions, the JOSV sends oil from the main oil pump to the journal bearings and scavenge oil from the bearings 1 and 1.5 support back to the return.
In windmill and zero or negative gravity conditions, scavenge oil from the bearings 1 and 1.5 support is sent back to the journal bearings.
The JOSV is monitored by a dedicated Auxiliary Oil Pressure sensor.


OIL
TANK
MGB
DEOILER
OVERBOARD
BREATHER
LUBE
PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
AODV
JOSV
VORV
AUXILIARY
CIRCUIT
LAST CHANCE
STRAINER
BEARINGS:
1
1.5
2
3
4
5
6
F
D
G
S
AGB
MGB
LSOP



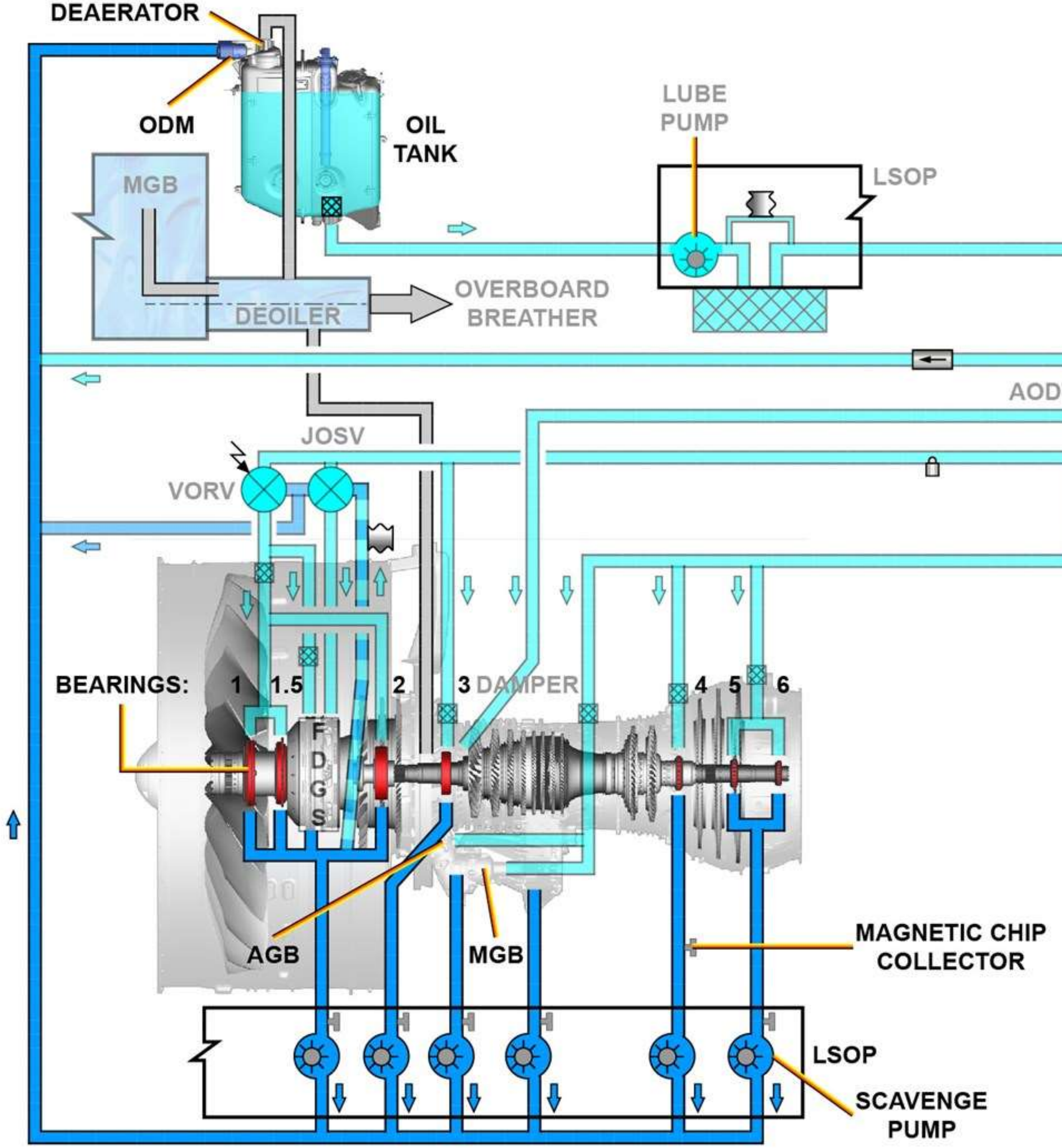
•AODV controlled by EEC to let oil flow to N�3 bearing damper at low power
The other part of the filtered oil is sent through the Active Oil Damper Valve (AODV) to the No. 3 bearing damper for N2 vibration control. The AODV is electrically controlled by the EEC to supply oil to the damper during starting and acceleration and shut it off at high power.
AODV failsafe position is open.

OIL SCAVENGE AND VENTING

•Six magnetic chip collectors
•ODM senses ferrous and non-ferrous particles and sends the information to the PHMU

The engine oil scavenge system is used to return the hot lubrication oil to the tank through the LSOP.
The LSOP has six scavenge pumps that are used to pull scavenge oil from the:
- No. 1, 1.5, 2 bearing and FDGS,
- No. 3 bearing compartment,
- No. 4 bearing compartment,
- No. 5 and 6 bearing compartment,
- MGB,
- AGB.

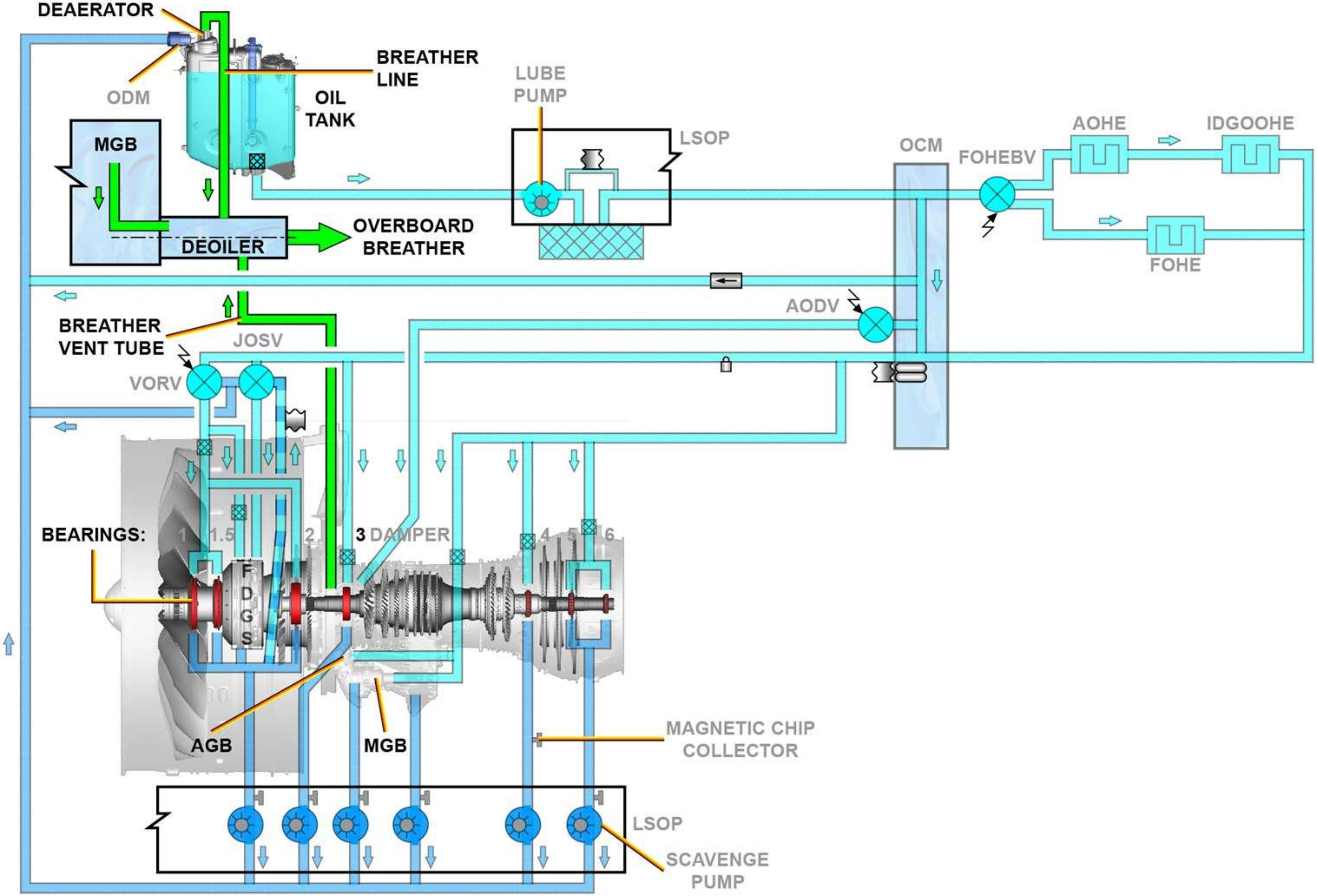
Six magnetic chip collectors, installed upstream of the scavenge pumps, catch ferrous metal particles.
The scavenge pumps send the scavenge oil to the oil tank through the Oil Debris Monitor (ODM) and the de-aerator.
The ODM senses the size and quantity of ferrous and non-ferrous particles in the scavenge oil system and the corresponding signal is processed by the Prognostic Health Monitoring Unit (PHMU).
The six chip collectors are bayonet-type plugs to be removed and examined at regular time intervals.
They are installed in housings with self-closing check valves to avoid oil leakage when removed.
Carbon particles that may be in the oil are not detected by the ODM since they have no significant effect on the magnetic field.


DEAERATOR
ODM
OIL
TANK
MGB
DEOILER
OVERBOARD
BREATHER
LUBE
PUMP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
AODV
JOSV
VORV
BEARINGS:
1
1.5
2
3
DAMPER
4
5
6
F
D
G
S
AGB
MGB
MAGNETIC CHIP
COLLECTOR
LSOP
SCAVENGE
PUMP

•One static de-aerator on the tank
  - Part of the air used to pressurize the oil tank
  - Excess of air sent to de-oiler

•One centrifugal de-oiler on the MGB
  - Receives the air/oil mist
  - Extracts air into the fan air stream through the overboard breather

The engine oil breather system is used to remove sealing air from the bearing compartments, separate the air from the oil, and vent it overboard.
In the tank, the de-aerator is a static component that separates the air that is mixed with the scavenged oil. Part of the air is used to pressurize the tank and the excess is sent to the centrifugal de-oiler.
The de-oiler is mechanically connected and driven by the MGB and receives the air/oil mist internally from the MGB, from the tank by the breather line and from the No. 3 bearing compartment by a dedicated breather vent tube. The extracted air is discharged through the overboard breather into the fan air stream.
The pressure in the tank is limited by a spring-loaded closed, mechanical poppet valve (cracking pressure = 12 Psi).
The static de-aerator is of swirl type.


DEAERATOR
BREATHER LINE
ODM
OIL TANK
LUBE PUMP
MGB
LSOP
OCM
AOHE
IDGOOHE
FOHEBV
DEOILER
OVERBOARD BREATHER
FOHE
AODV
BREATHER VENT TUBE
JOSV
VORV
BEARINGS:
1
1.5
2
3
DAMPER
4
5
6
F
D
G
S
AGB
MGB
MAGNETIC CHIP COLLECTOR
LSOP
SCAVENGE PUMP

OIL MONITORING AND INDICATING
•7 dedicated components: 2 fitted on the oil tank, 5 on the OCM, 1 on the VORV/JSOV
•2 status for clogging indication of the dual stage oil filter
The oil monitoring and indicating system comprises:
- Oil Level (OL) indicating,
- Oil Debris Monitoring (ODM),
- Main Oil Temperature (MOT) indicating,
- Main Oil Pressure (MOP) indicating,
- Low Oil Pressure (LOP) indicating,
- Oil Filter Differential Pressure (OFDP),
- Auxiliary Oil Pressure (AOP) indicating.

OIL LEVEL INDICATING
•OL sensor
  • Signal (proportional to oil level) is sent EEC channel B

The oil level sensor is installed on the top of the oil tank.
It is of the magnetic flow and reed switch type. The signal proportional to the oil level is sent to the EEC channel B.
OL displays between 0 (min necessary) and 17.7 qts (maximum quantity).
Tank quantity = display units + 20 qts.
Advisory at 1.2 qts displayed.

OIL DEBRIS MONITORING
•ODM sensor detects any type of pollution crossing its electromagnetic field
  • Signal processed by PHMU and sent to EEC Channel A
  • EEC compares the data to predefined values

The Oil Debris Monitoring (ODM) sensor is installed between the main oil scavenge line and the de-aerator in the oil tank.
It detects any type of pollution that crossed its electromagnetic field.
The signal corresponding to the ferrous and non-ferrous debris is processed by the PHMU. The PHMU calculates the number of particles in a given time period and sends it to the EEC channel A.
The EEC compares the data to predefined values and generates a maintenance signal.

MAIN OIL TEMPERATURE INDICATING
• Dual oil temperature sensor in OCM
  • Measures oil temperature

The dual oil temperature sensor is installed on the OCM.
It measures the oil temperature in the supply oil line and sends the signals to both EEC channels.
OIL LO TEMP below 47 �C.
OIL HI TEMP TBC.

MAIN OIL PRESSURE INDICATING
• Dual main oil pressure sensor in OCM
  • Measures pressure on the oil supply line

The dual main oil pressure sensor is installed on OCM.
It measures the pressure on the oil supply line and sends the signals to both EEC channels.
The low oil pressure limits are a function of N2 (between 0 and 12000 RPM, amber line at 64 Psi and red line at 54 Psi, above values increase).

LOW OIL PRESSURE INDICATING
•Low oil pressure switch in OCM
  • Detects low oil pressure condition on the oil supply line

The low oil pressure switch is installed on OCM.
It detects low oil pressure condition on the oil supply line and sends the signals to the Engine Interface Unit (EIU).
LOP switch closes when P < 60 Psi.

OIL FILTER DIFFERENTIAL PRESSURE

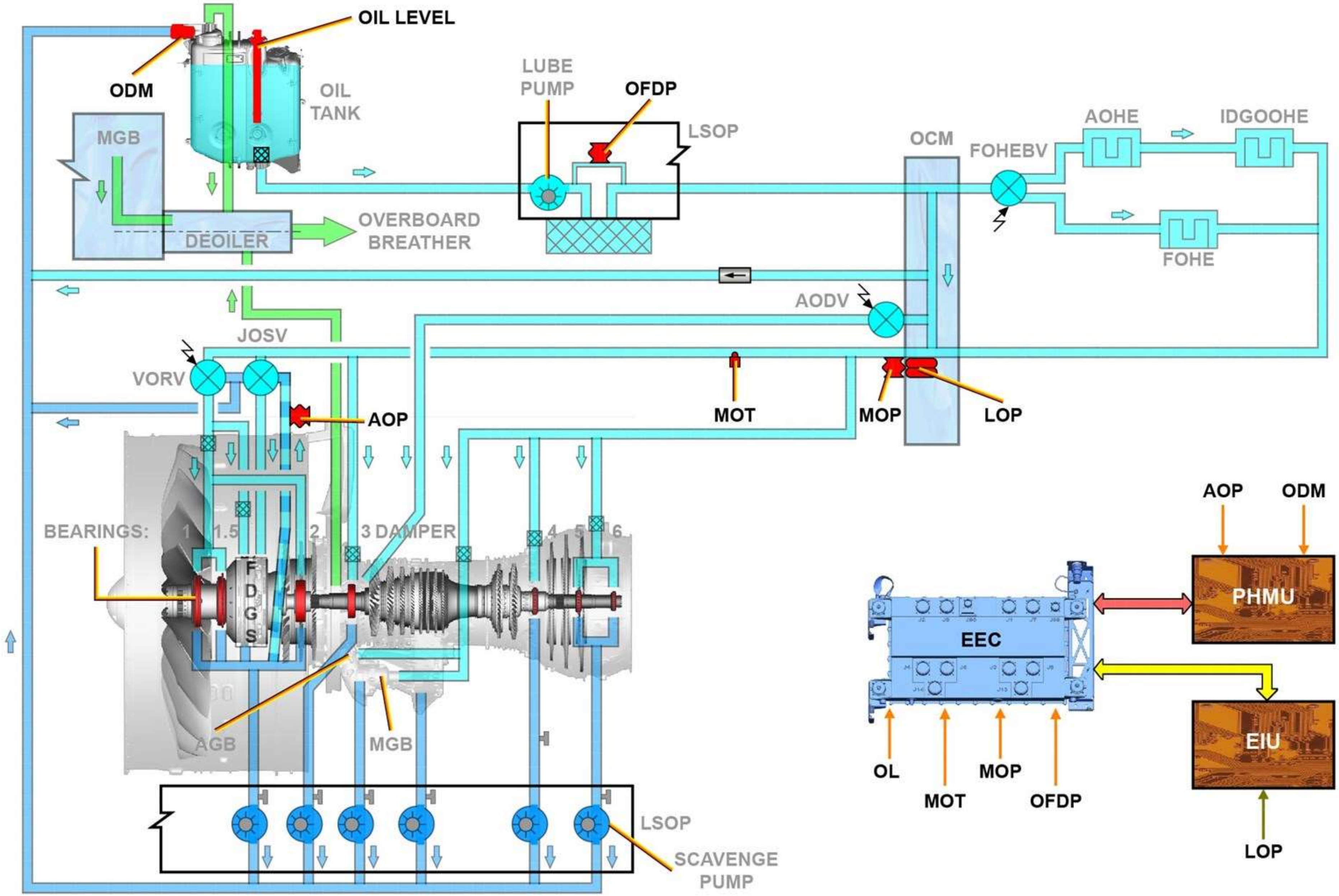
- Oil filter differential pressure sensor in OCM
  - If dP is more than expected: maintenance signal
  - If dP is too much: filter bypass valve opens and signal is generated

The oil filter differential pressure sensor is installed on the OCM, adjacent to the oil filter.
The differential pressure signal is sent to both EEC channels.
When the differential pressure across the filter is more than the specified limit, a maintenance signal is generated.
When the differential pressure across the primary oil filter element is too much, the filter bypass valve will open.
The pressurized oil then will go directly to the secondary filter and an oil filter bypass signal is also generated.
ENG x OIL FILTER DEGRAD when the engine oil filter is clogged (depending on N2, Oil temp and delta P, e.g.: 20000 rpm, 50 �C, delta P > 20 Psi).
ENG x OIL FILTER CLOG when the oil filter is in bypass (delta P > 55 Psi).

AUXILIARY OIL PRESSURE INDICATING

- Dual auxiliary oil pressure sensor on VORV / JOSV assembly
  - Measures the pressure of the auxiliary oil supply

The dual auxiliary oil pressure sensor is installed on the VORV / JOSV assembly.
It measures the pressure of the auxiliary oil supply for the journal bearings of the FDGS and sends it to both EEC channels to detect failures in the JOSV or the oil auxiliary pump.


OIL LEVEL
ODM
OIL TANK
MGB
DEOILER
OVERBOARD BREATHER
LUBE PUMP
OFDP
LSOP
OCM
FOHEBV
AOHE
IDGOOHE
FOHE
AODV
JOSV
VORV
AOP
MOT
MOP
LOP
BEARINGS: 1 1.5 2 3 DAMPER 4 5 6
FDGS
AGB
MGB
LSOP
SCAVENGE PUMP
AOP
ODM
PHMU
EEC
EIU
OL
MOT
MOP
OFDP
LOP

Opening And Closing of Engine Cowl Doors

OPENING OF THE ENGINE FAN COWL DOORS

• Safety precautions

Before working on the engine, safety precautions have to be taken.

WARNING:

KEEP PERSONNEL AND EQUIPMENT CLEAR OF THE FAN COWL DOORS WHEN THE HOLD OPEN RODS ARE NOT LOCKED. THE COWL DOORS CAN CLOSE QUICKLY AND INJURY TO PERSONS OR DAMAGE TO EQUIPMENT CAN OCCUR.

DO NOT ATTEMPT TO OPEN THE FAN COWL DOORS IF THE WIND SPEED IS HIGHER THAN 96 KM/H (60 MPH).

BE CAREFUL IF YOU OPEN A FAN COWL DOOR WHEN THE WIND SPEED IS 40 KM/H (25 MPH) OR MORE. IF THE WIND MOVES THE FAN COWL DOOR, INJURY TO PERSONS AND/OR DAMAGE TO THE ENGINE CAN OCCUR.

• Ensure that:

- ENG MODE rotary selector is in NORM position
- Minimum 5 minutes elapsed before moving ENG MASTER 1(2) lever from OFF position
- WARNING NOTICE(S) is(are) in position on ENG MODE rotary selector switch and ENG MASTER lever
- ON legend on FADEC GND PWR 1(2) P/B is off
- WARNING NOTICE(S) is (are) in position not to energize FADEC 1(2)

In the cockpit, make sure that the ENG MODE rotary selector is in the NORM position.

Make sure that the ENG MASTER 1(2) lever was in the OFF position not less than five minutes before you do this procedure.

Put WARNING NOTICE(S) in position to tell persons not to operate the ENG MODE rotary selector and the ENG MASTER 1(2) lever.

On the ENG section of maintenance panel 50VU, make sure that the ON legend of the FADEC GND PWR 1(2) pushbutton switch is off.

Put WARNING NOTICE(S) in position to tell persons not to energize FADEC 1(2).

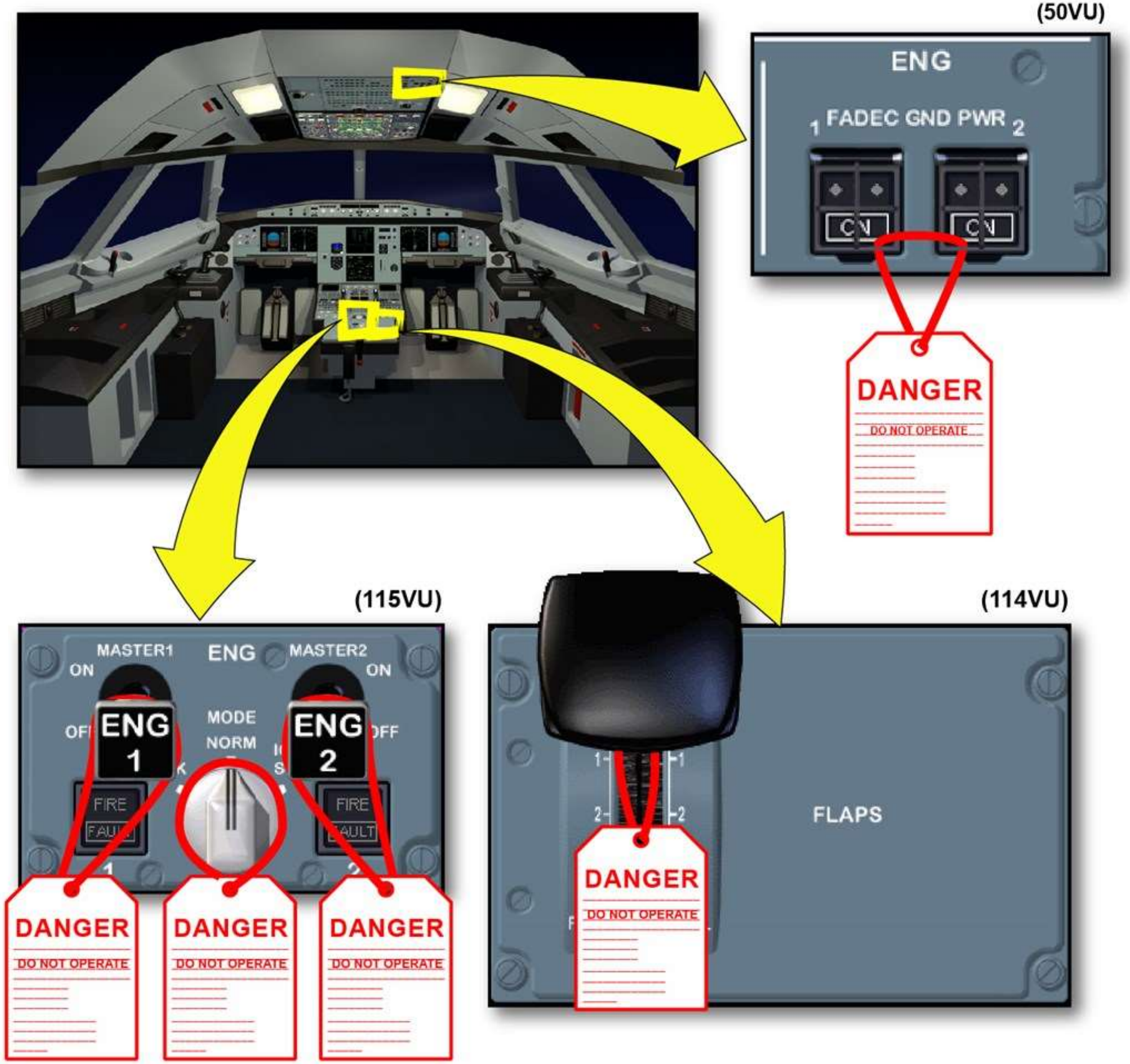
• Ensure that:

- Slats are retracted
- WARNING NOTICE(S) is (are) in position not to move the slat control lever

Make sure that the slats are retracted.

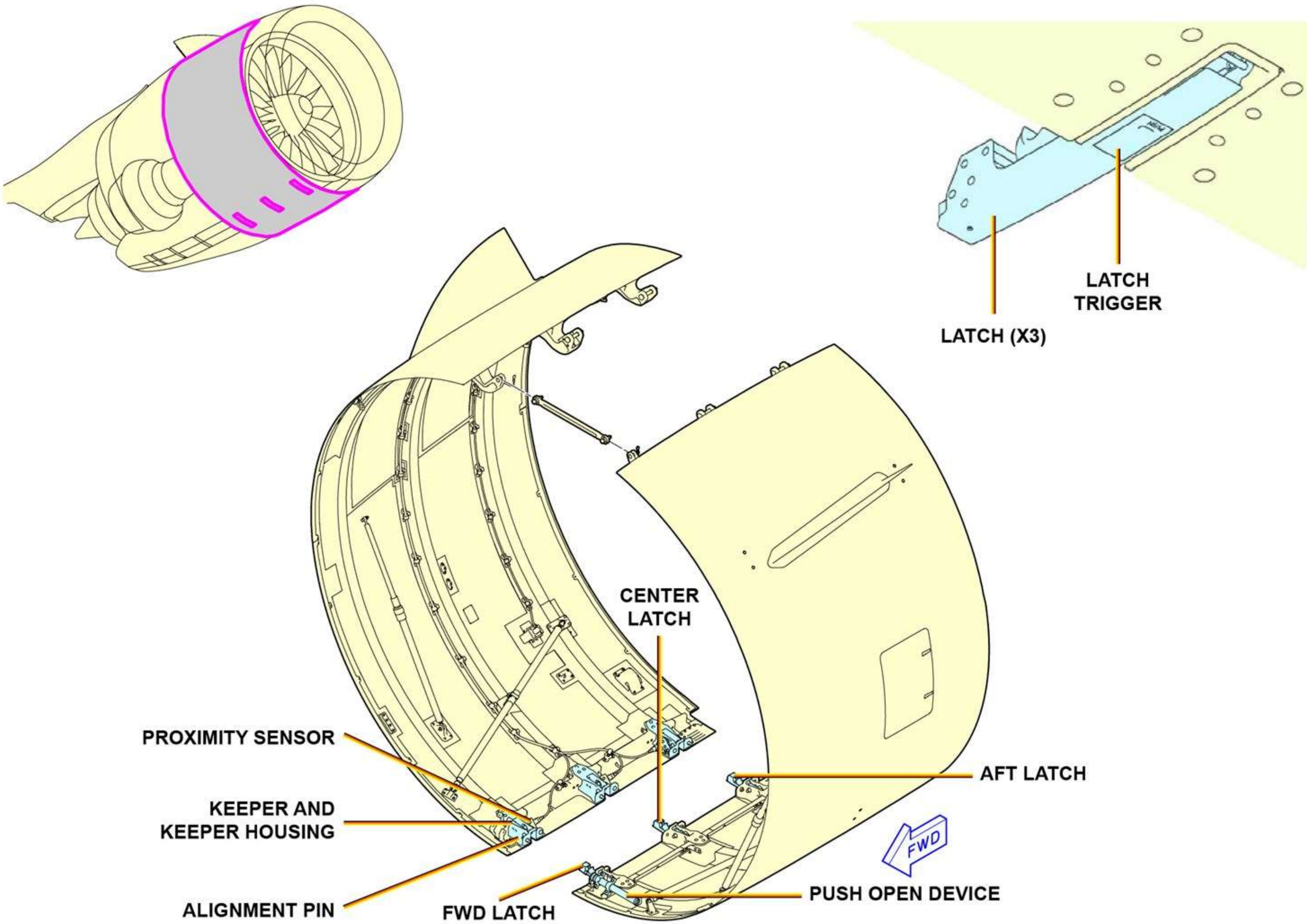
Put WARNING NOTICE(S) in the cockpit to tell persons not to move the slat control lever.

CAUTION: DO NOT OPEN THE FAN COWL IF THE WING LEADING EDGE SLATS ARE EXTENDED. DAMAGE TO THE FAN COWL, WING LEADING EDGE SLATS AND WING CAN OCCUR.



FAN COWL INSTRUCTIONS MARKING

•Unlock and pull down the 3 latches from rear to front
•Pull the handle
On the engine, unlock and open the three latches:
Push the fan cowl door latch triggers to release the AFT latch, CENTER latch and the FWD latch on the bottom of the left fan cowl door.
Pull down in sequence each handle (first the AFT then the CENTER then the FWD) to open the three latches.
Move the latches away from the three latch keepers.
NOTE: The push-open devices on the outboard fan cowl doors will push the doors apart after you release the last latch from the latch keeper.
Pull the handle to release the right fan cowl from the inlet cowl.

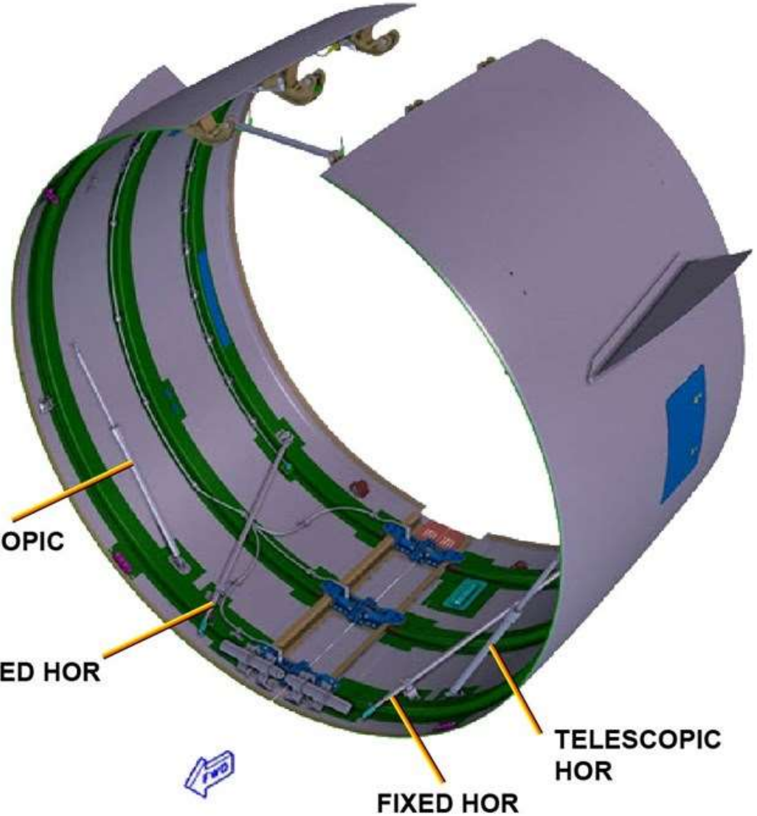

LATCH TRIGGER
LATCH (X3)
CENTER LATCH
PROXIMITY SENSOR
KEEPER AND KEEPER HOUSING
ALIGNMENT PIN
FWD LATCH
AFT LATCH
PUSH OPEN DEVICE
FWD

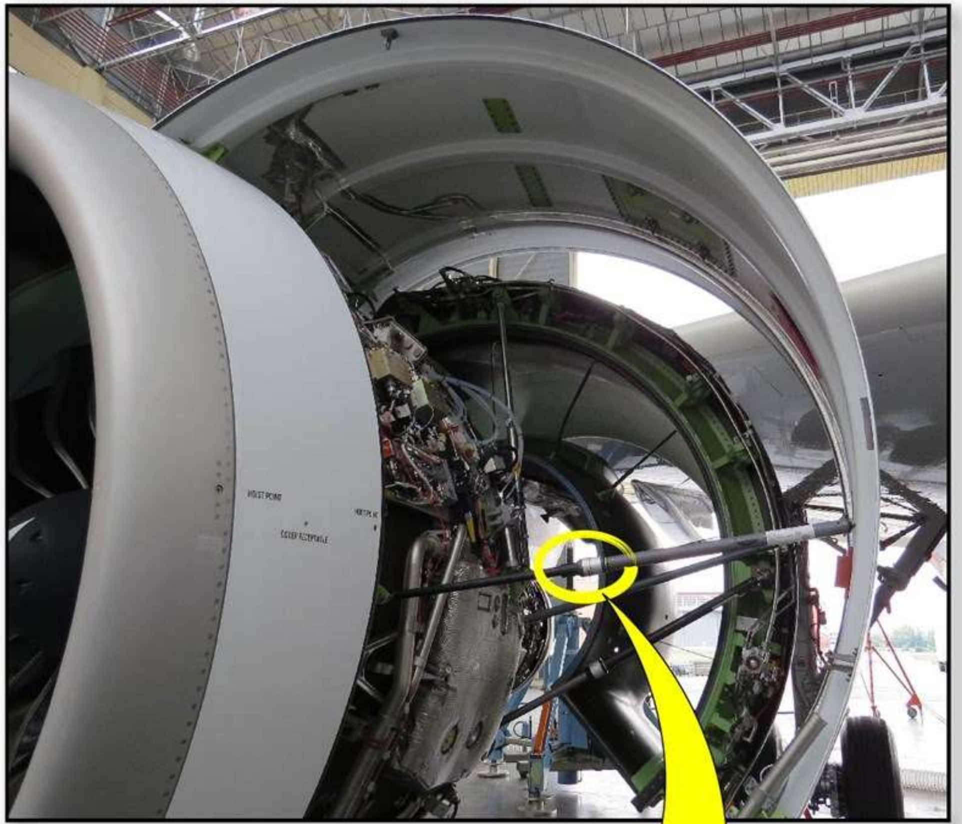
•Manually open the doors
•Connect HORs
•Lower doors
•Make an entry in the Logbook

Manually lift and hold the left fan cowl door at the lower edge.
Lift the left fan cowl door until the telescoping Hold Open Rod (HOR) correctly engages and locks into position (green band visible).
Make sure that the telescoping HOR is at the correct length.
Remove, lock and attach the fixed HOR to the bracket on the engine.
Slowly lower the left fan cowl door until the fixed HOR and the telescoping HOR hold the weight of the door.

CAUTION:
- DO NOT LEAVE THIS JOB AFTER UNLATCHING THE FAN COWLS. IF YOU ARE CALLED AWAY PRIOR TO OPEN ONE COWL DOOR, THEN EITHER OPEN ONE COWL DOOR OR RE-LATCH THE LATCHES BEFORE WALKING AWAY FROM THIS ENGINE.
- BE CAREFUL IF YOU LIFT THE FAN COWL DOOR MORE THAN 52 DEGREES FROM THE VERTICAL. DAMAGE TO THE FAN COWL DOOR OR PYLON CAN OCCUR.
- WHEN YOU OPEN OR CLOSE THE FAN COWL DOOR, BE CAREFUL NOT TO PUSH THE DOOR FORWARD OR AFT. IF YOU DO THIS, THE DOOR CAN HIT COMPONENTS AND CAUSE DAMAGE TO THEM OR PREVENT CORRECT ENGAGEMENT OF THE AXIAL LOCATORS.

If required, repeat this procedure for the other fan cowl door.
Make an entry in the logbook.





LOCKED HOLD OPEN ROD (HOR)

OPENING OF THE ENGINE THRUST REVERSER COWL DOORS

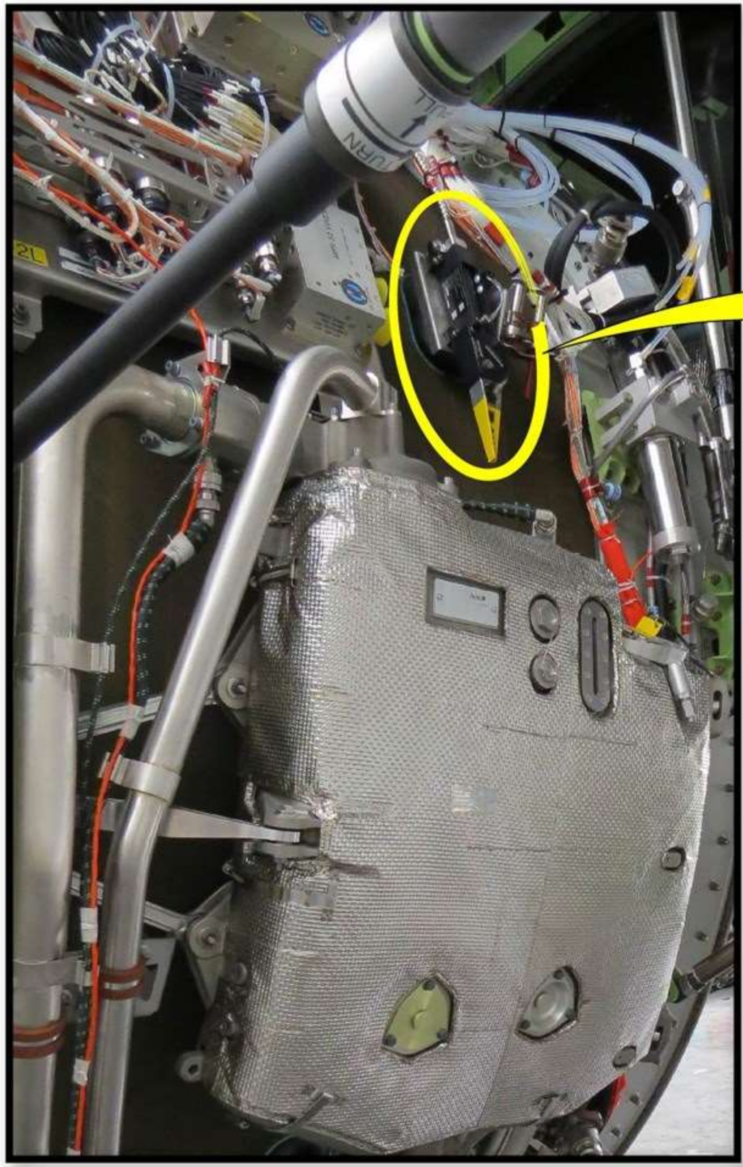
• Make thrust reverser unserviceable

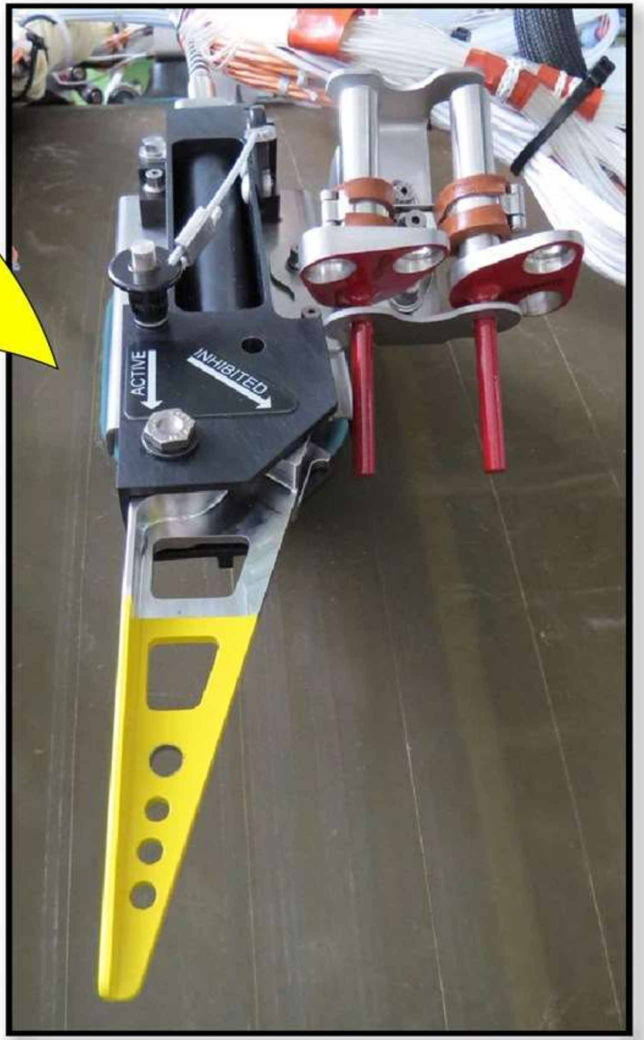
Do the deactivation of the thrust reverser system for maintenance as per the AMM.

WARNING: DO NOT KEEP OPEN A THRUST REVERSER DOOR WHEN THE WIND SPEED IS 83.5 KM/H (51.6 MPH) OR MORE. IF THE WIND MOVES THE THRUST REVERSER DOOR, INJURY TO PERSONS AND/OR DAMAGE TO EQUIPMENT CAN OCCUR.

BE CAREFUL IF YOU OPEN OR CLOSE A THRUST REVERSER DOOR WHEN THE WIND SPEED IS 37 KM/H (23 MPH) OR MORE. IF THE WIND MOVES THE THRUST REVERSER DOOR, INJURY TO PERSONS AND/OR DAMAGE TO EQUIPMENT CAN OCCUR.

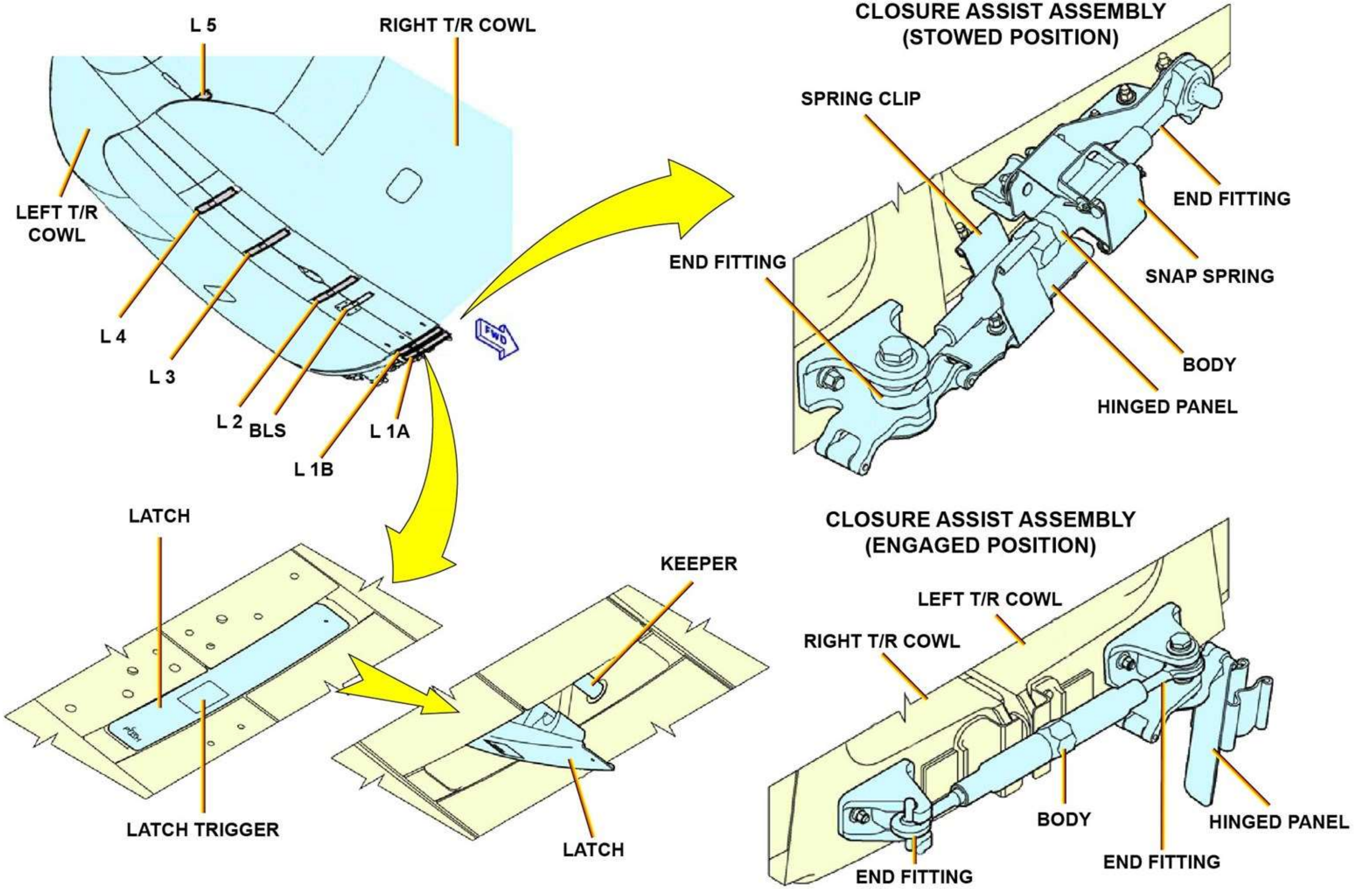
NOTE: Do not open the left and right thrust-reverser cowl-doors at the same time. Thrust-reverser cowl-doors must be opened one after the other.



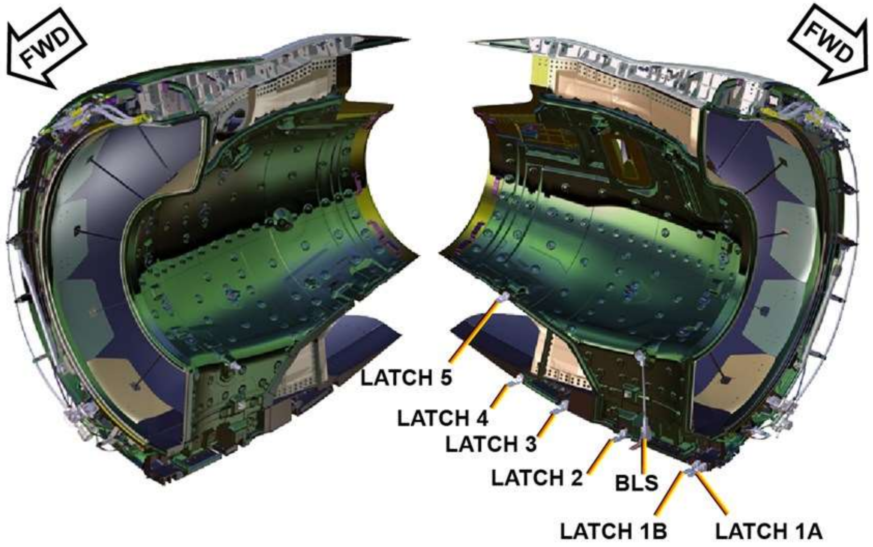


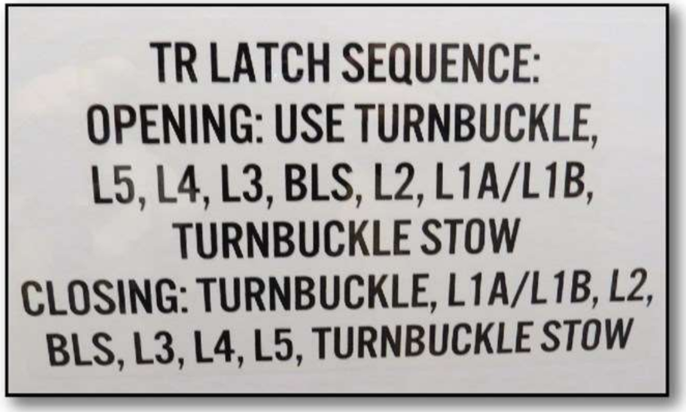
THRUST REVERSER INHIBITION LEVER

•Engage the closure assist assembly if necessary
If necessary, engage the closure assist assembly.
NOTE: The closure assist assembly only helps to open or close the L1A and L1B latches. It is not necessary to use the closure assist assembly if you can open and close these latches without it.

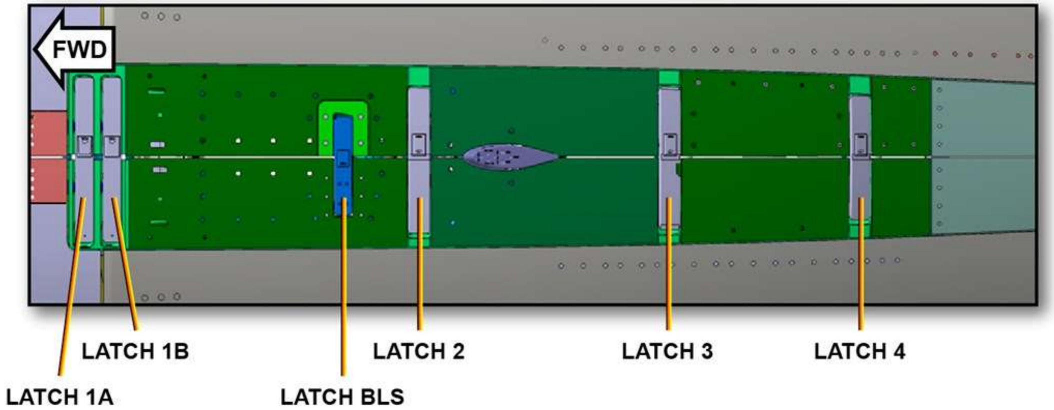


•Release the latches in sequence: L5, L4, L3, BLS, L2, L1A and L1B
On the Thrust Reverser Cowl, push the latch trigger to release and open the latches in sequence: L5, L4, L3, Bifurcation Latching System (BLS), L2, L1A and L1B





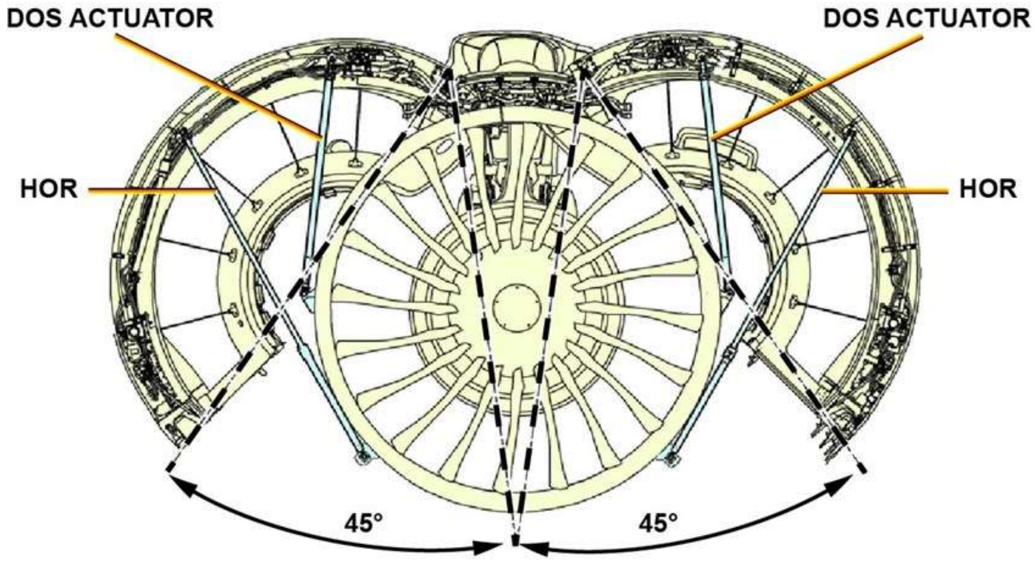
THRUST REVERSER LATCHES

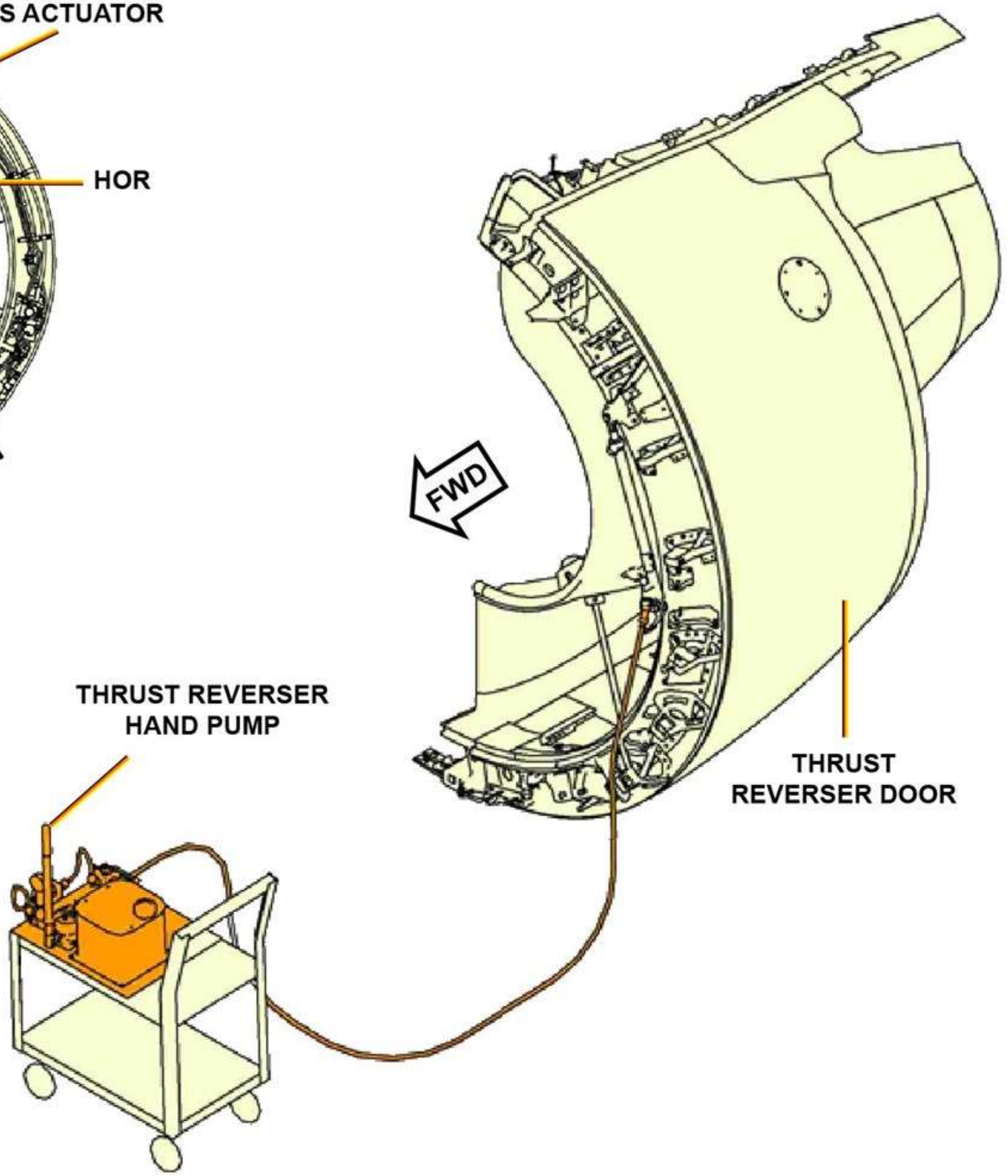


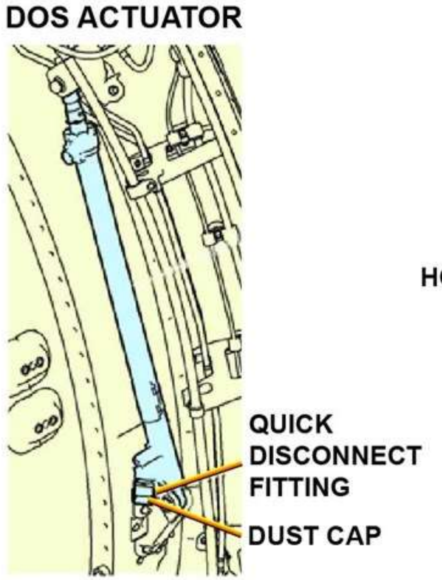
- Connect hand pump
- Open door to 45 degrees position
- Manually release pressure from DOS actuator

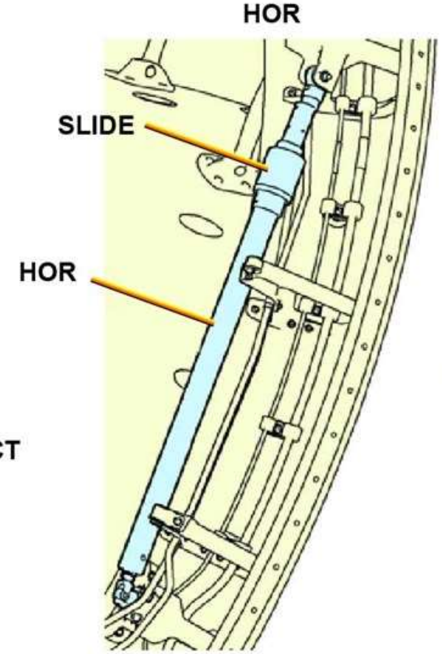
Connect the hand pump flexible hose to the quick disconnect fitting of the Door Opening System (DOS) actuator and operate it until the DOS actuator opens the left thrust reverser door to 45 degrees.
Manually release the pressure from the DOS actuator.

NOTE: The DOS actuator will retract until the compressive lock in the actuator engages.
WARNING: DO NOT MOVE BETWEEN THE ENGINE AND THE OPEN THRUST REVERSER DOOR UNTIL THE COMPRESSIVE LOCK IN THE DOS ACTUATOR IS ENGAGED. THE THRUST REVERSER DOOR IS HEAVY. IT WILL CLOSE QUICKLY IF THE DOS ACTUATOR FAILS. THIS CAN CAUSE INJURIES TO PERSONNEL AND DAMAGE TO EQUIPMENT.

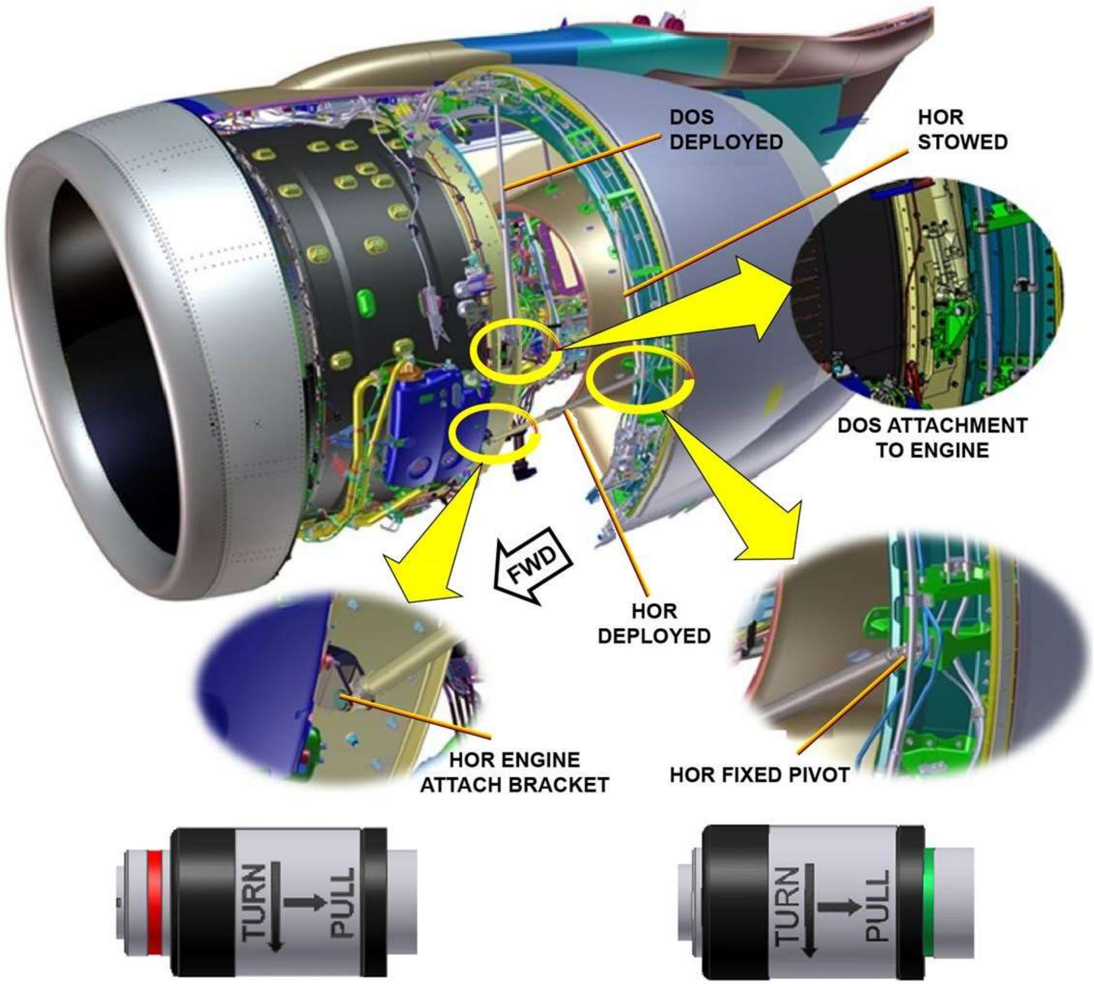

DOS ACTUATOR
DOS ACTUATOR
HOR
HOR
45°
45°


FWD
THRUST REVERSER DOOR
THRUST REVERSER HAND PUMP


DOS ACTUATOR
QUICK DISCONNECT FITTING
DUST CAP


HOR
SLIDE
HOR

•Release and extend the HOR
•Attach and secure HORs to each bracket
•Open the relief valve on the hand pump
Release and extend the hold open rod.
Adjust it as necessary and attach it to the HOR support bracket on the fan case. Make sure it is locked (green band visible).
If necessary, repeat the sequence to open the right Thrust Reverser Cowl.



CLOSING OF THE ENGINE THRUST REVERSER COWL DOORS

• Pay attention of the warnings and cautions

Pay attention of the warnings and cautions mentioned for Fan and Thrust Reverser cowls opening.
Make sure that you did the deactivation of the thrust reverser system for maintenance.
NOTE: Do not close the thrust-reverser cowl-doors at the same time. Thrust-reverser cowl-doors must be closed one after the other.

•Explanation of the method to close T/R cowl doors:

- Connect the hand pump
- Operate hand pump to pressurize the actuator
- Remove HORs

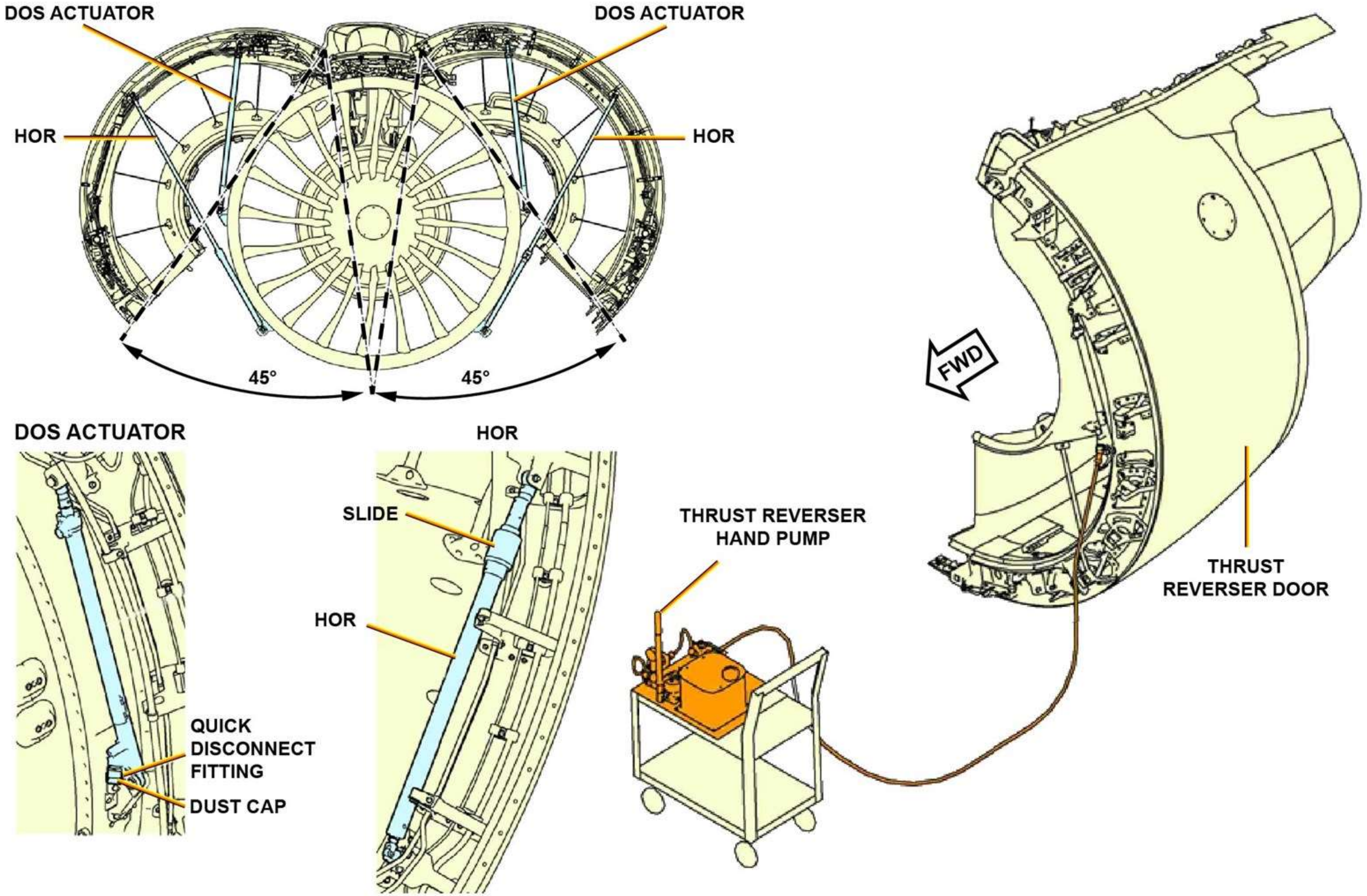
Connect the hand pump flexible hose to the quick disconnect fitting of the DOS actuator and operate it until the DOS actuator opens the left thrust reverser door to be able to release the HOR from its support bracket on the fan case.
Adjust the length of the HOR as necessary and attach it to the HOR stow bracket on the left thrust reverser door.

• Explanation of the method to close T/R cowl doors (Cont'd):

- Open the relief valve to allow the door to close
- Release pressure from DOS actuator to close the pressure relief valve
- Push up the latches

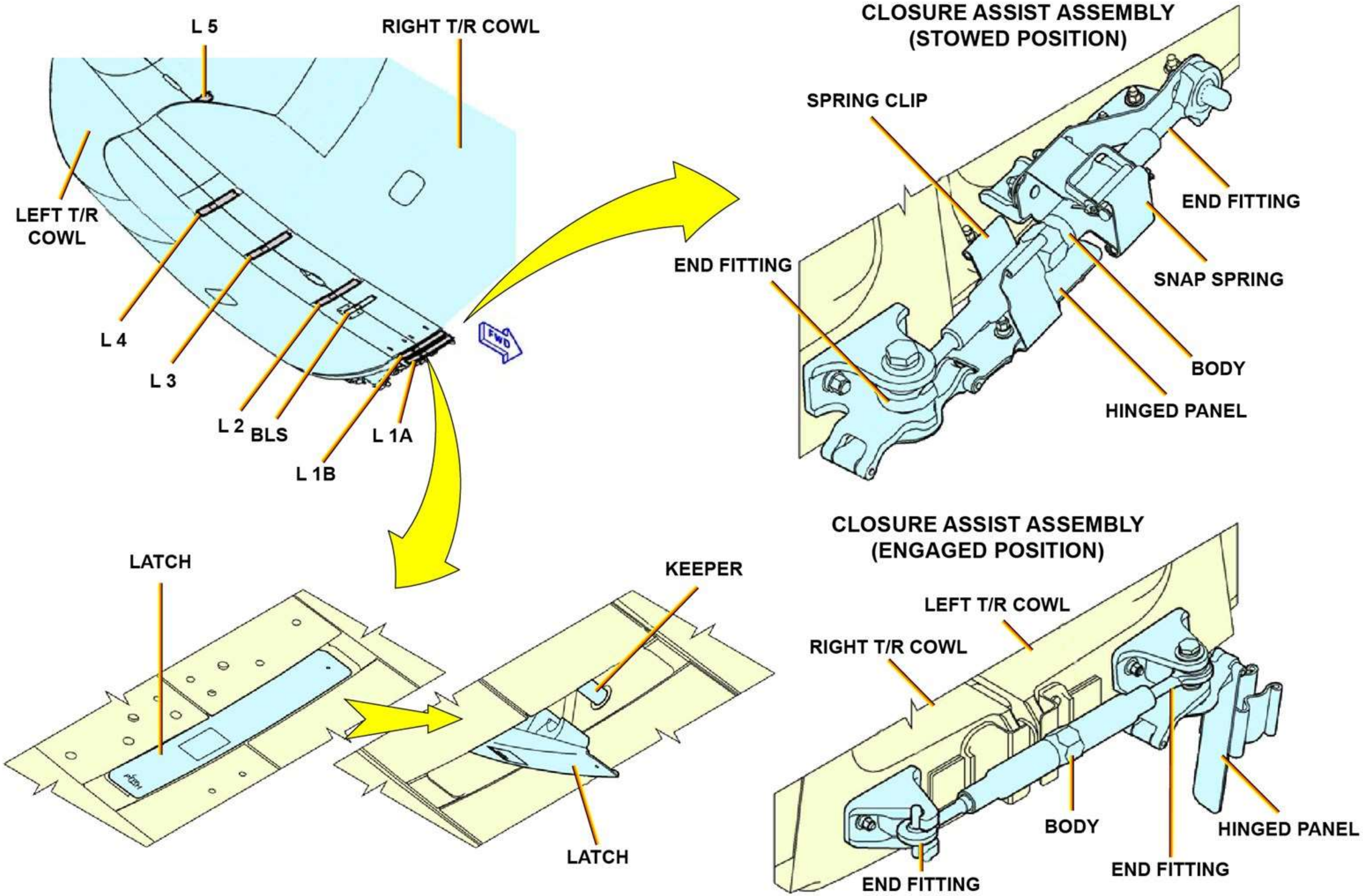
Operate the hand pump until the DOS actuator is fully extended, the compressive lock in the actuator disengages, and the pressure relief valve in the actuator is open. Manually release the pressure from the DOS actuator to close the pressure relief valve.

NOTE: The DOS actuator will retract at a constant speed until the thrust reverser door closes.
Disconnect the hand pump flexible hose.
Repeat the same sequence to close the right thrust reverser door.


DOS ACTUATOR
DOS ACTUATOR
HOR
HOR
45°
45°
FWD
DOS ACTUATOR
QUICK DISCONNECT FITTING
DUST CAP
HOR
SLIDE
HOR
THRUST REVERSER HAND PUMP
THRUST REVERSER DOOR

•Engage the closure assist assembly if necessary: Move it out of stow bracket
•Adjust length to attach it to the closure assist hook
•Engage it in the closure assist hook.
•Turn the body with a WRENCH to pull the 2 T/R doors together
•Stow the closure assist assembly in its storage position
•Engage L1A and L1B latches.
If necessary, engage the closure assist assembly:
- Move it out of the stow bracket.
- Adjust the length until the end fitting can be attached to the closure assist hook on the right thrust reverser door.
- Engage it in the closure assist hook.
- Turn the body of the closure assist assembly with a WRENCH to pull the two thrust reverser doors together until you can engage the L1A and L1B latches at the bottom of the doors.
- Stow the closure assist assembly in its storage position.
When you engage the L1A and L1B latches, if the force you measure is not between 17.8 daN (40 lbf) and 22.2 daN (50 lbf), adjust the thrust reverser doors.

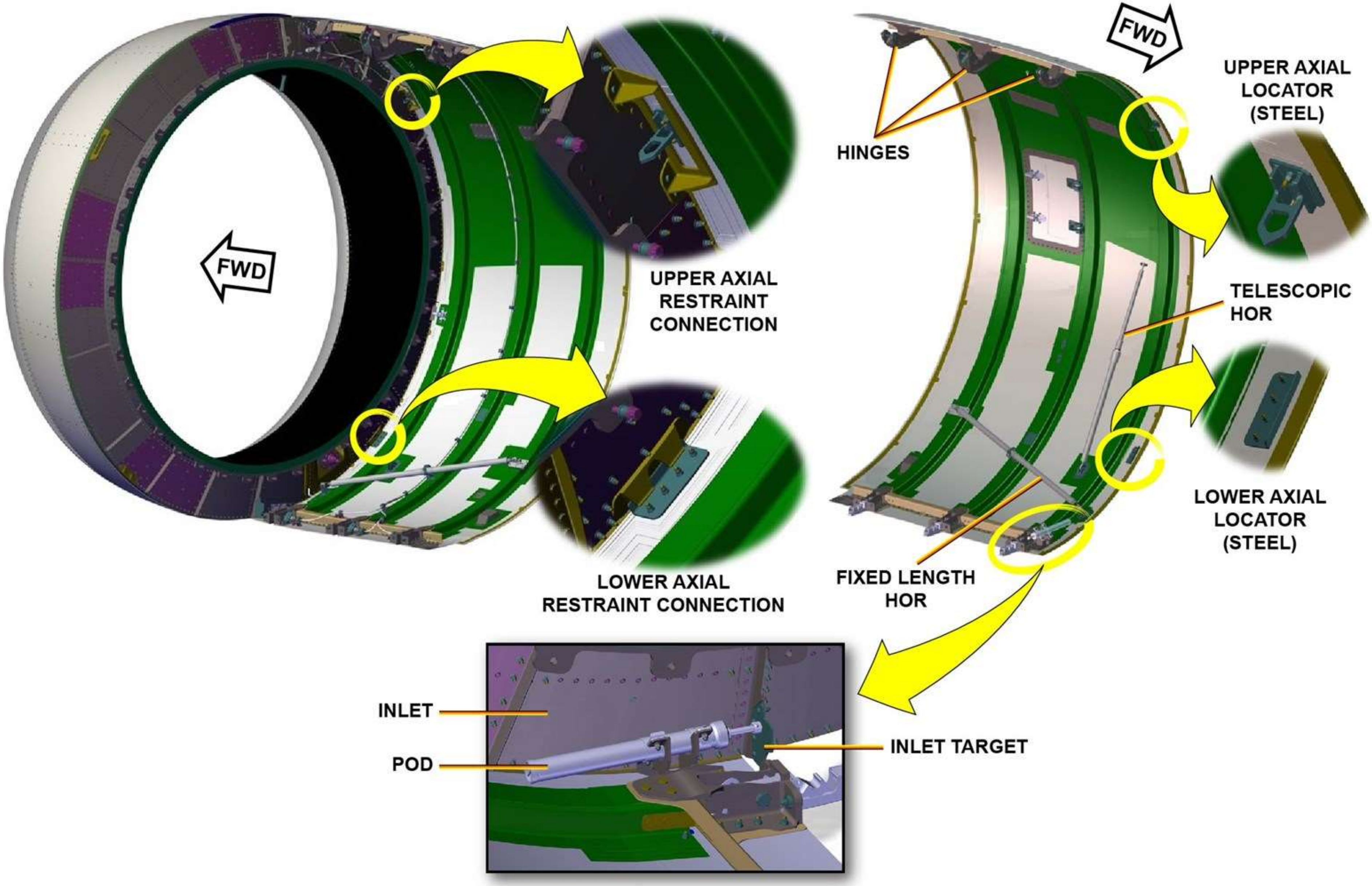
• Close remaining T/R door latches: L1A, L1B, 2, BLS, 3, 4 and 5
•Make sure that the work area is clean and clear of tool(s)
•Make thrust reverser serviceable
Close the remaining thrust reverser door latches in the sequence that follows: L1A, L1B, 2, BLS, 3, 4 and 5.
If the force you measure is not between 17.8 daN (40 lbf) and 22.2 daN (50 lbf), adjust the thrust reverser doors.
Make sure that the work area is clean and clear of tool(s) and other items.
Reactivate the T/R.


L 5
RIGHT T/R COWL
LEFT T/R COWL
L 4
L 3
L 2
BLS
L 1B
L 1A
FWD
CLOSURE ASSIST ASSEMBLY (STOWED POSITION)
SPRING CLIP
END FITTING
END FITTING
SNAP SPRING
BODY
HINGED PANEL
LATCH
KEEPER
LATCH
CLOSURE ASSIST ASSEMBLY (ENGAGED POSITION)
LEFT T/R COWL
RIGHT T/R COWL
BODY
HINGED PANEL
END FITTING
END FITTING

CLOSING OF THE ENGINE FAN COWL DOORS

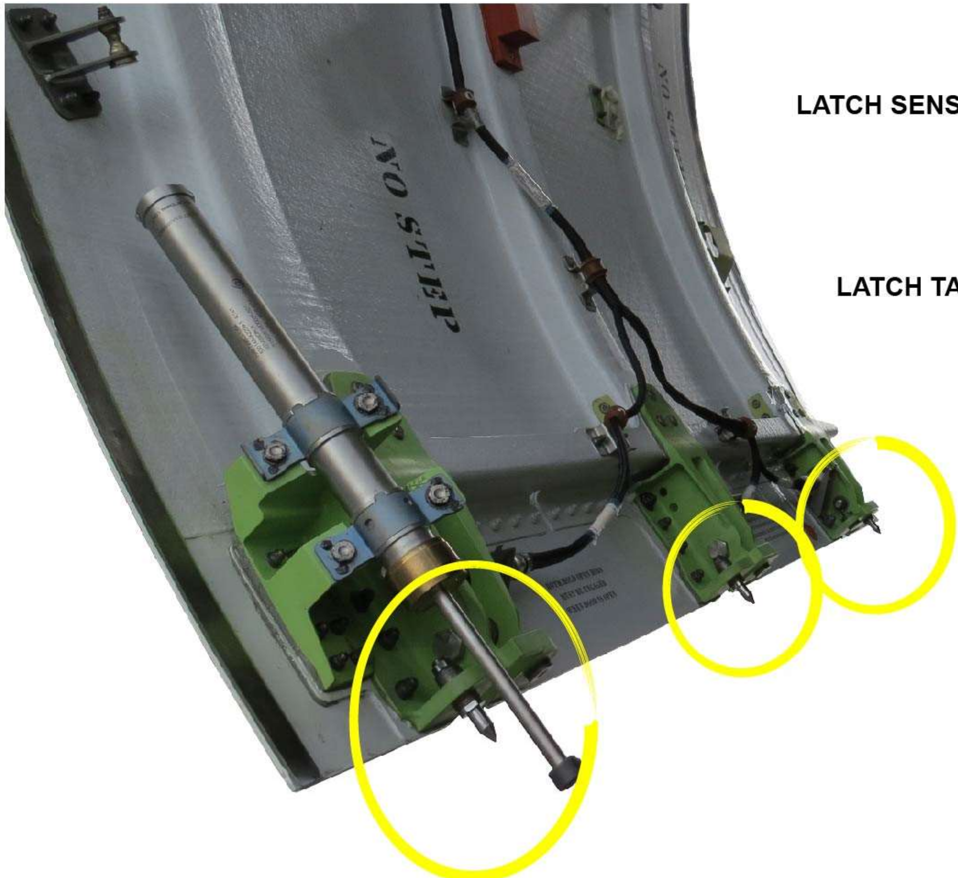
• Manually lift and hold the left fan cowl door
•Disengage then lock the HORs
•Manually lift the left fan cowl door
•Turn the collar and pull it up
Manually lift and hold the left fan cowl door at the lower edge so that the weight is not on the HOR and telescoping HOR.
Disconnect the fixed HOR from the engine bracket and attach it to the stow bracket on the left fan cowl door.
Manually lift the left fan cowl door until the telescoping HOR extends sufficiently so that you can turn the release collar.
Turn the collar and pull it up to unlock the telescoping HOR.
NOTE: When the telescoping HOR is unlocked, you will no longer see a green band adjacent to the release collar. You will see a red band adjacent to the release collar.

• Slowly lower the left fan cowl door
•Push the right fan cowl door against the inlet cowl
•Close latches front to rear
Slowly lower the left fan cowl door until it is on the bottom. Perform the same steps to lower the right fan cowl door.
Push the right fan cowl door until it is against the inlet cowl.
Make sure that the axial locators on the right fan cowl door engage the locator clips on the inlet cowl.
Make sure that the latch engages with the inlet cowl.



PUSH OPEN DEVICE (POD)

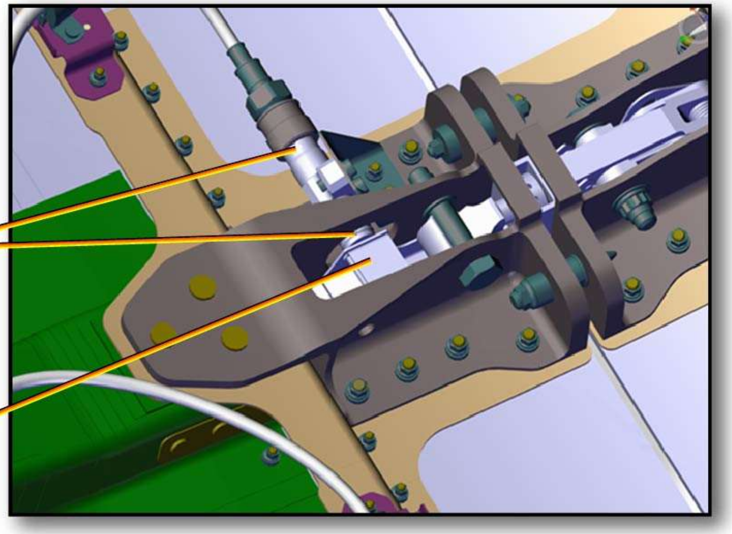
•Push left fan cowl door against the right one
•Make sure that the alignment pins enter in dedicated holes
•Make sure that the axial locators engage the locator clips
Push the left fan cowl door against the right fan cowl door.
Make sure that the alignment pins go into the holes adjacent to the FWD, CENTER and AFT latches.
Make sure that the axial locators on the left fan cowl door engage the locator clips on the inlet cowl.
NOTE: The push-open devices on the outboard fan cowl doors will push the doors as you close them.



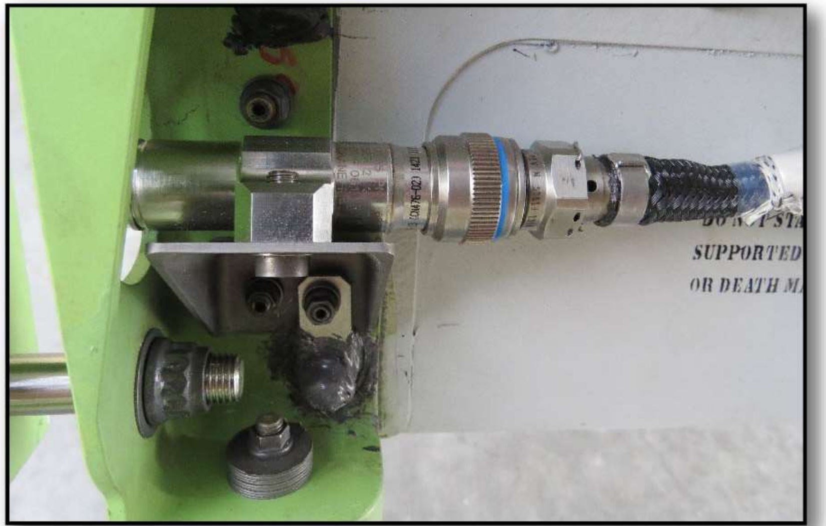
ALIGNMENT PINS

LATCH SENSOR

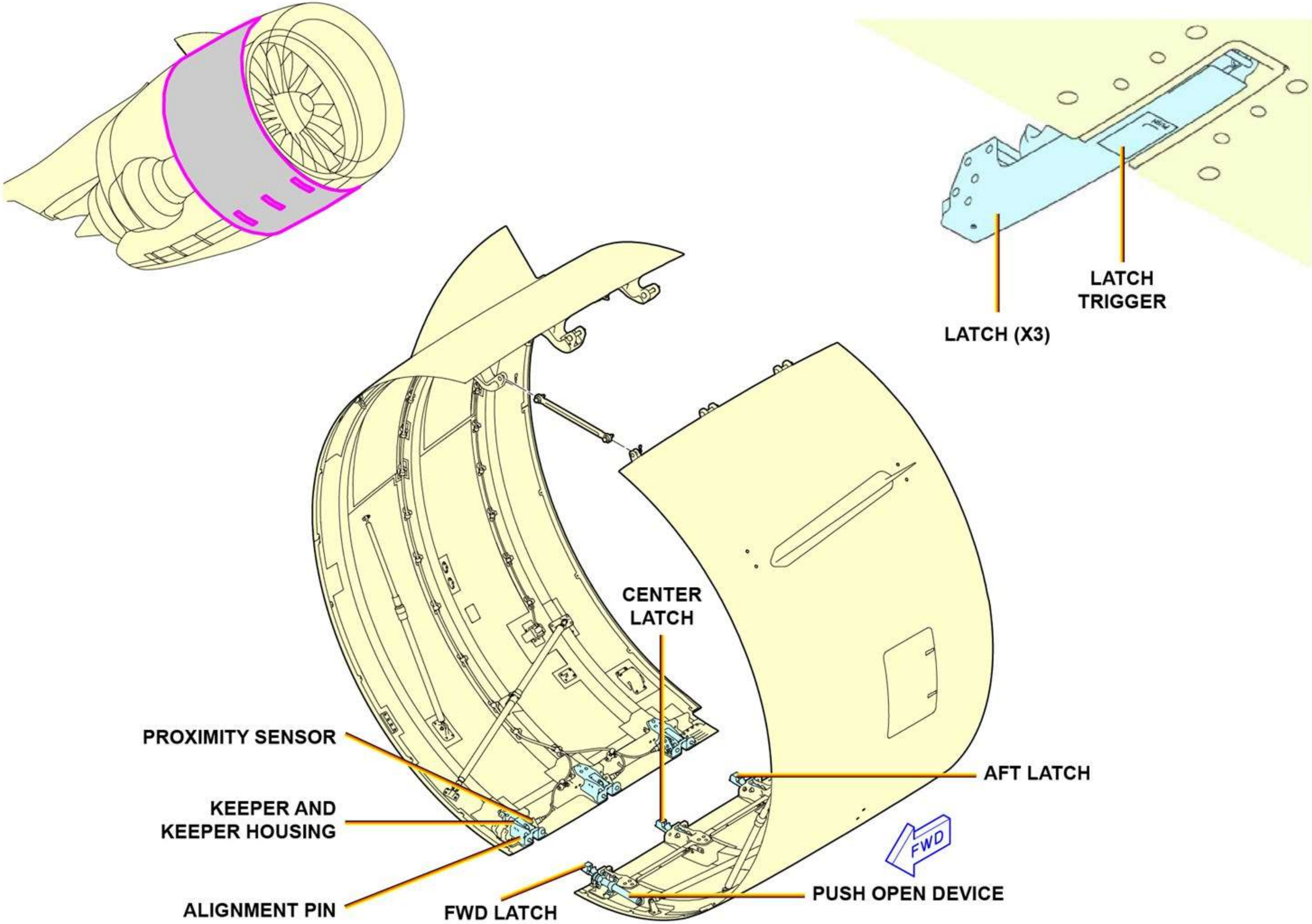
LATCH TARGET



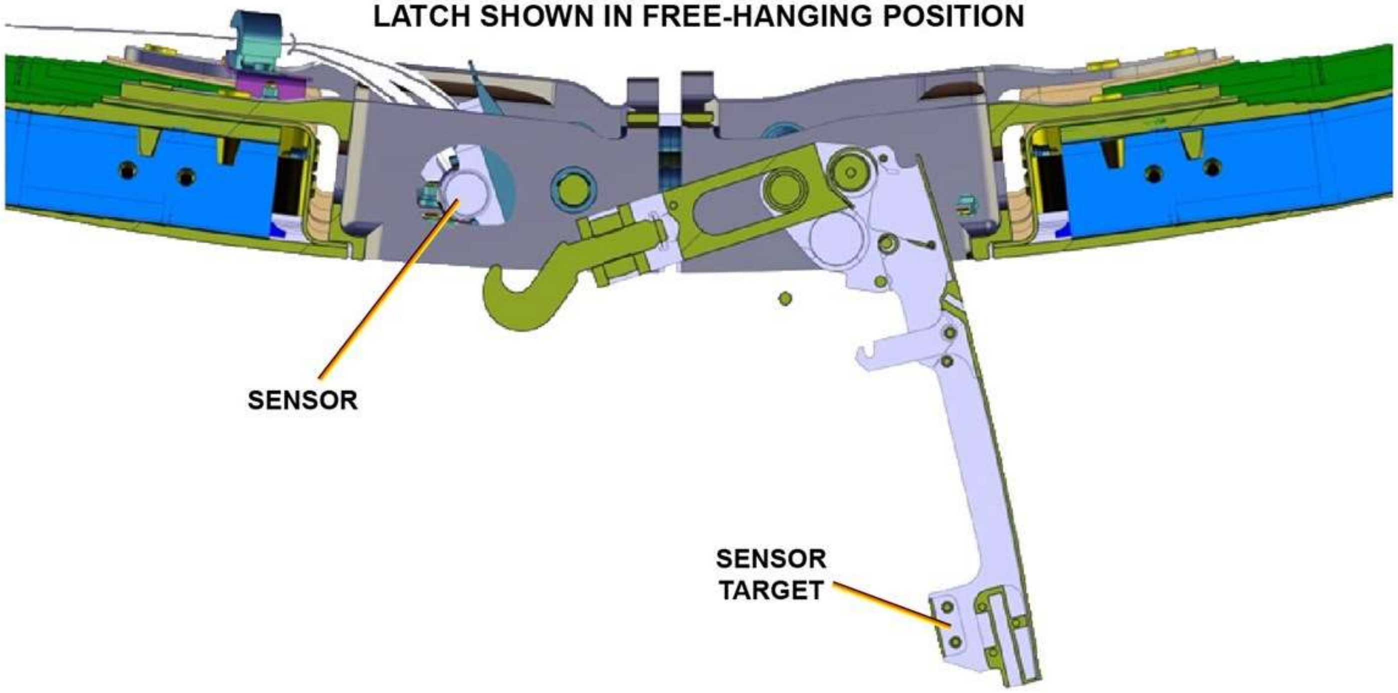
PROXIMITY SENSOR

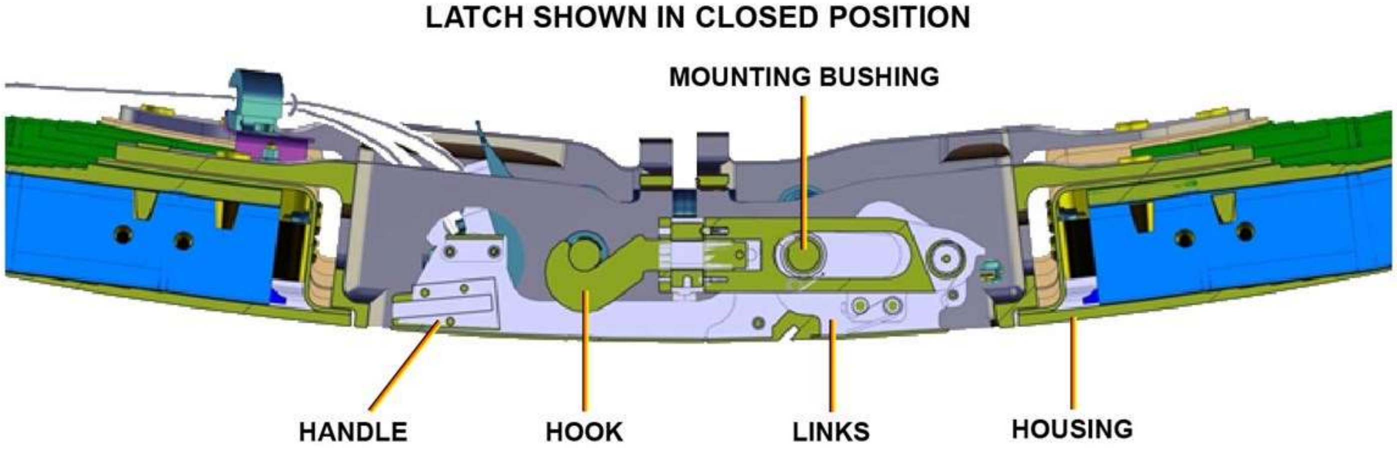


•Engage the hook on the FWD latch
•Close the FWD latch
•Engage the hook on the CENTER
•Close the CENTER latch
•Engage the hook on the AFT
•Close the AFT latch
Once the side latch on the right fan cowl door is latched and flush with the cowl, engage the hook on the FWD latch with the related latch keeper.
Close the FWD latch until it is flush with the door surface and locked into position.
Engage the hook on the CENTER latch with the related latch keeper.
Close the CENTER latch until it is flush with the door surface and locked into position.
Engage the hook on the AFT latch with the related latch keeper.
Close the AFT latch until it is flush with the door surface and locked into position.


LATCH TRIGGER
LATCH (X3)
CENTER LATCH
PROXIMITY SENSOR
KEEPER AND KEEPER HOUSING
ALIGNMENT PIN
FWD LATCH
AFT LATCH
PUSH OPEN DEVICE
FWD

•Proximity sensors detect improper latching
Make sure that the force to close each latch is between 11.57 daN (26 lbf) and 16.01 daN (36 lbf). If not, adjust the fan cowl latches.
Make sure that the distance between the left and right fan cowl doors is between 4.32 mm (0.170 in.) and 6.35 mm (0.25 in.). If not adjust the fan cowl latches.
The proximity sensors installed on each latch detect improper latching and trigger an ECAM indication


LATCH SHOWN IN FREE-HANGING POSITION
SENSOR
SENSOR
TARGET


LATCH SHOWN IN CLOSED POSITION
MOUNTING BUSHING
HANDLE
HOOK
LINKS
HOUSING

Thrust Reverser Handling

THRUST REVERSER DEACTIVATION AND LOCKOUT

• Inhibit cable handle assembly accessible through the oil tank access door

•For ground maintenance:

- Inhibition lever to inhibited position

Thrust reverser deactivation for ground maintenance:
- Apply the applicable safety precautions.

Engine cockpit controls isolated and secured
- Open the oil tank access-door on the left fan cowl door.
- Turn the lever on the inhibit cable handle assembly to the inhibited position and secure it with the lockout pin.

The lever will move the inhibition cable to control the HCU/ICU internal inhibit mechanism. This will lead to activate two inhibition switches (when FADEC GND PWR is set to ON, ENG X REV INHIBITED warning is displayed).
The lever is spring loaded to the active position whereas the HCU/ICU stable position is inhibited if the cable is broken.

• For flight:

- Inhibition lever to inhibited position
- 2 lockout pins secured in the latch beam

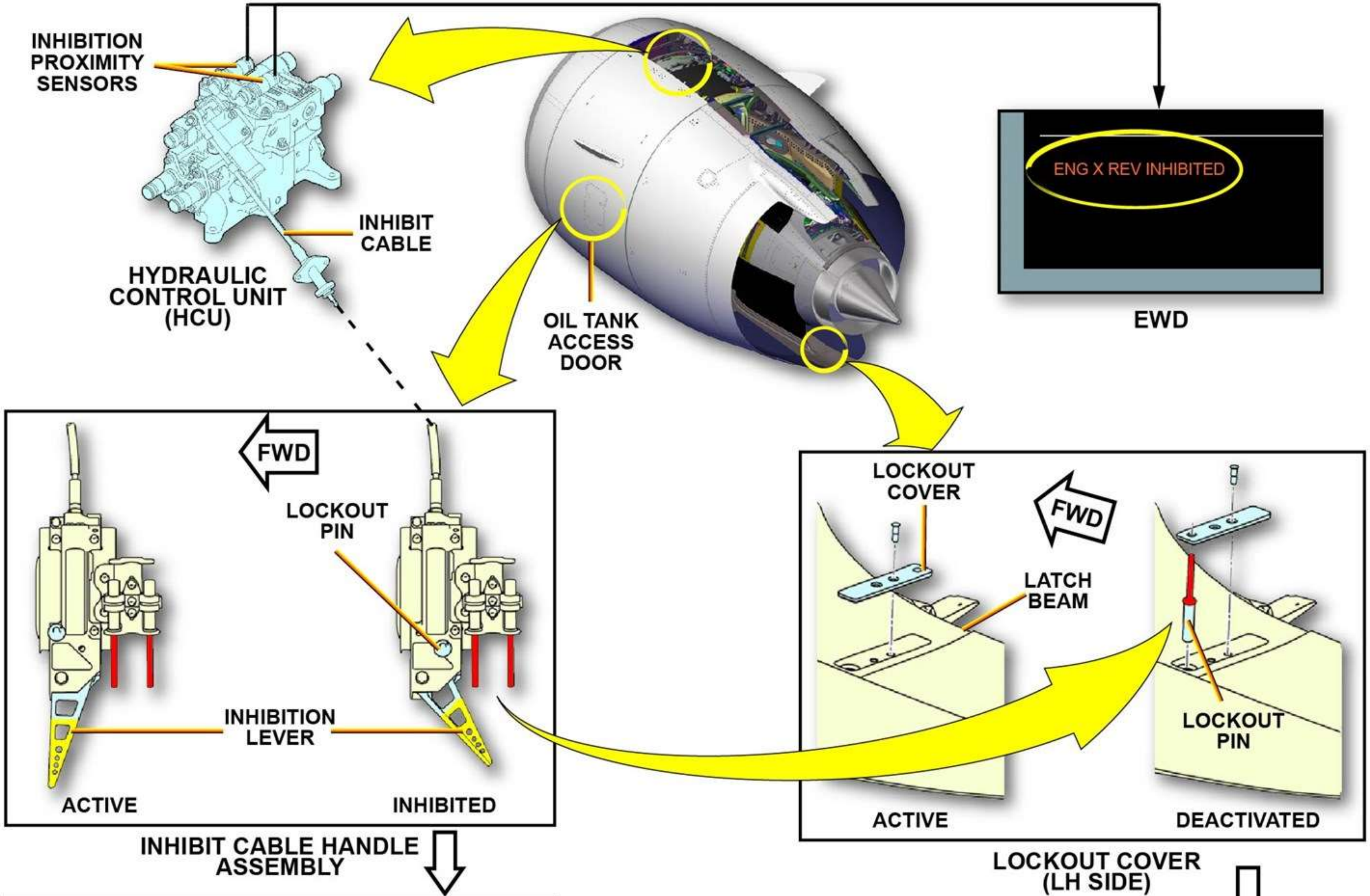
Thrust reverser deactivation for flight:
- Apply the applicable safety precautions.

Engine cockpit controls isolated and secured.
- Do the Thrust Reverser deactivation for ground maintenance.
- Install the translating sleeve lockout pins in the latch beam.

Remove the lockout pins from the stowage bracket, remove the lockout covers, insert the lockout pins, install the lockout covers to let each pin to protrude through the dedicated cover hole.

- Check for the Thrust Reverser deactivation warning on the EWD.

With FADEC GND PWR ON, ENG X REV INHIBITED warning displayed with no associated warnings (REVERSER UNLOCKED or REV PRESSURIZED).
- Make the corresponding entry in the logbook and put a warning notice in the cockpit.



	INHIBIT CABLE HANDLE ASSEMBLY	LOCKOUT COVER (LH SIDE)
DEACTIVATION FOR GROUND MAINTENANCE	X	
DEACTIVATION FOR FLIGHT	X	X (ON BOTH SIDES)

MANUAL OPERATION OF THE THRUST REVERSER TRANSLATING SLEEVES

• Deactivate the upper and lower TRAS actuators
•Deactivate the TRAS track lock
•Deactivate the MDU and turn clockwise to extend

Manual extention of the thrust reverser translating sleeves:
- Apply the applicable safety precautions.

Engine cockpit controls isolated and secured and thrust reverser halves closed.
- Open the fan cowl doors.
- Do the deactivation of the thrust reverser system for maintenance.
- Do the deactivation of the Thrust Reverser Actuation System (TRAS) locking feedback actuator for the applicable thrust reverser half.
- Do the deactivation of the TRAS locking actuator for the applicable thrust reverser half.

Remove the lockout pin, rotate the manual lock drive to the unlocked position, and install the lockout pin.
- Do the deactivation of the TRAS track lock for the applicable thrust reverser half.

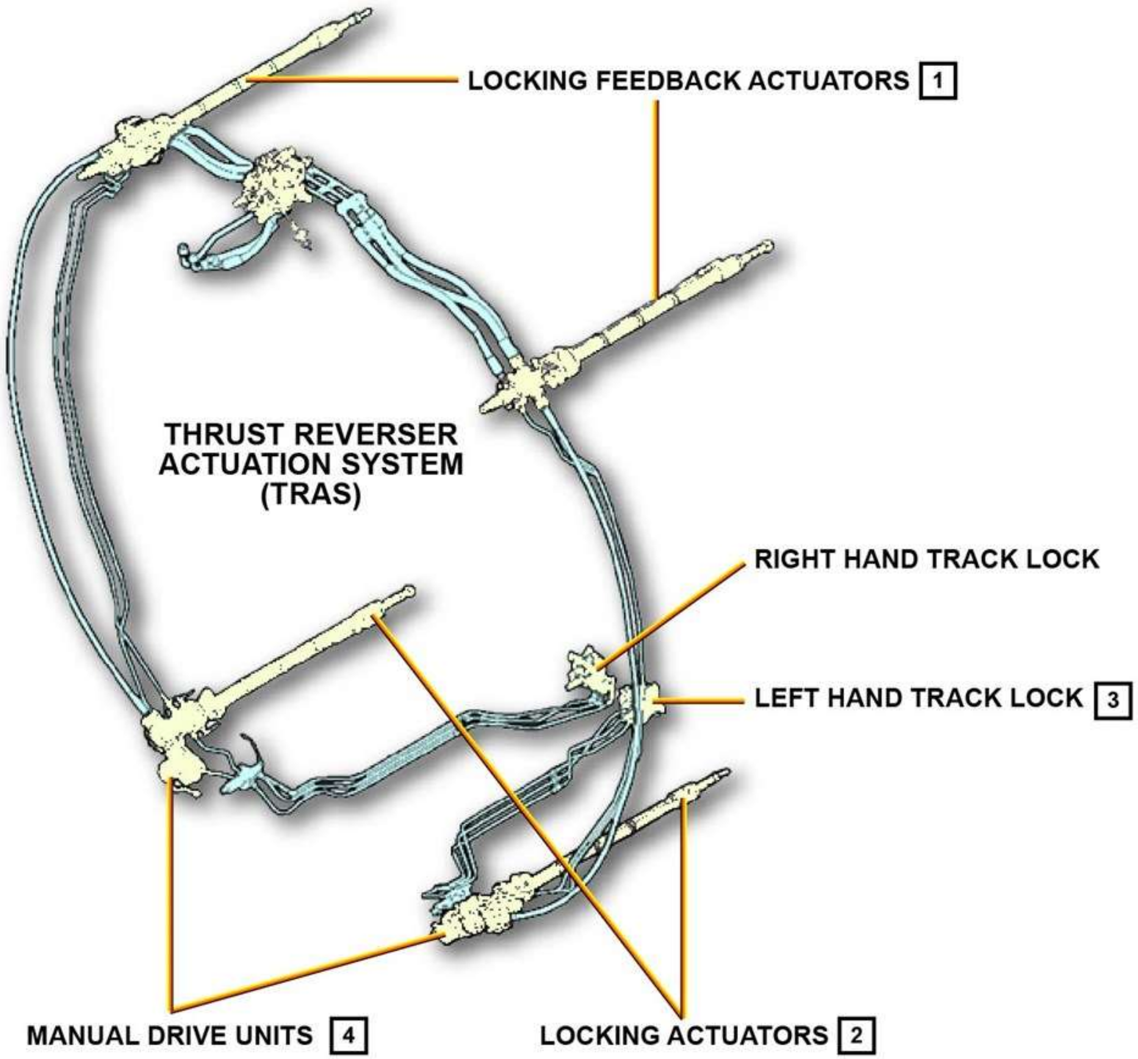
Remove the track lock cover, remove the lockout pin, rotate the lockout lever to the unlocked position, install the lockout pin, install the track lock cover with the pin on the top.
- Manually extend the applicable translating sleeve by unlocking the Manual Drive Unit (MDU) and turning it with a square drive tool.

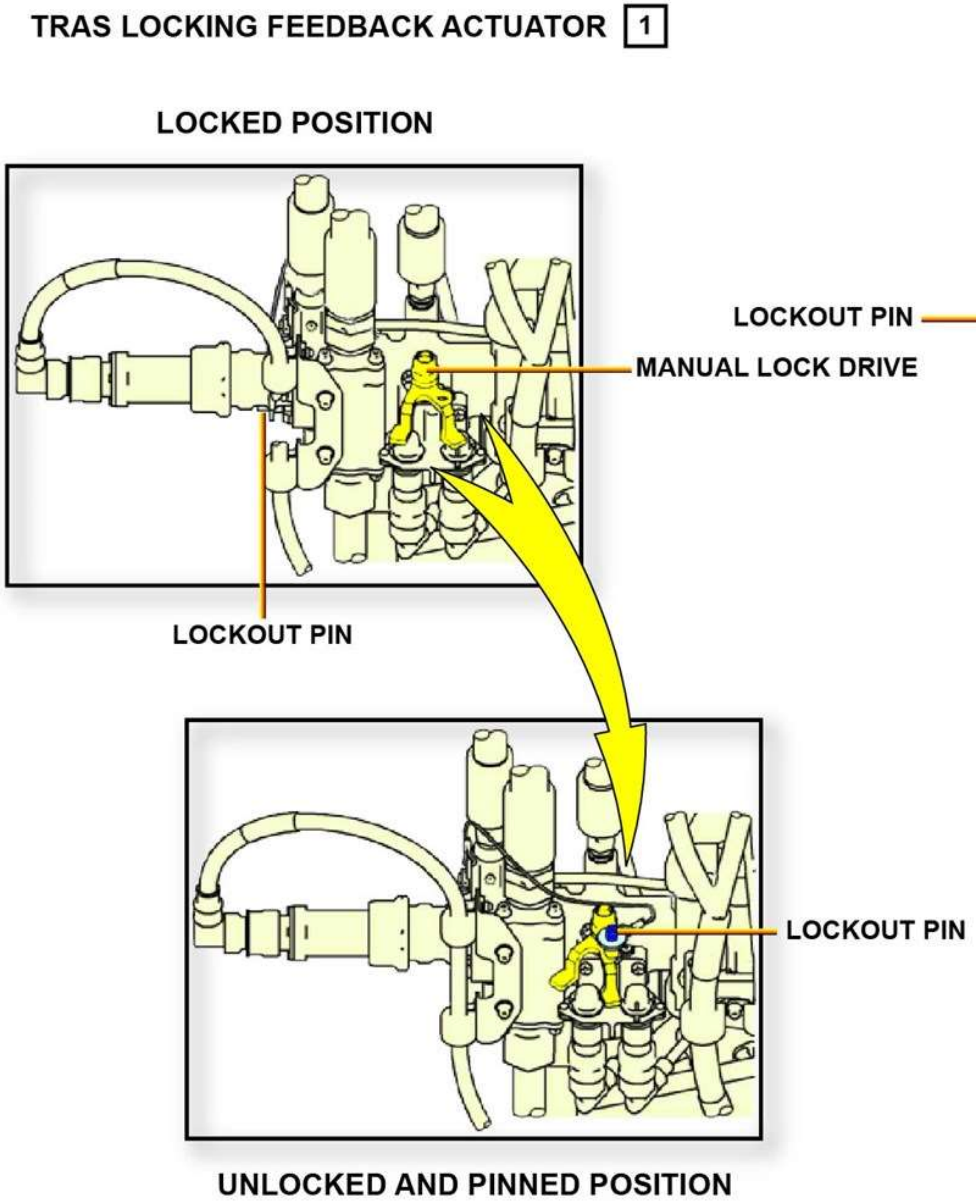
Turn the manual drive unit lever to the unlocked position, engage the square drive tool, and turn clockwise the RH MDU (counter-clockwise for the LH MDU) socket to extend the translating sleeve.

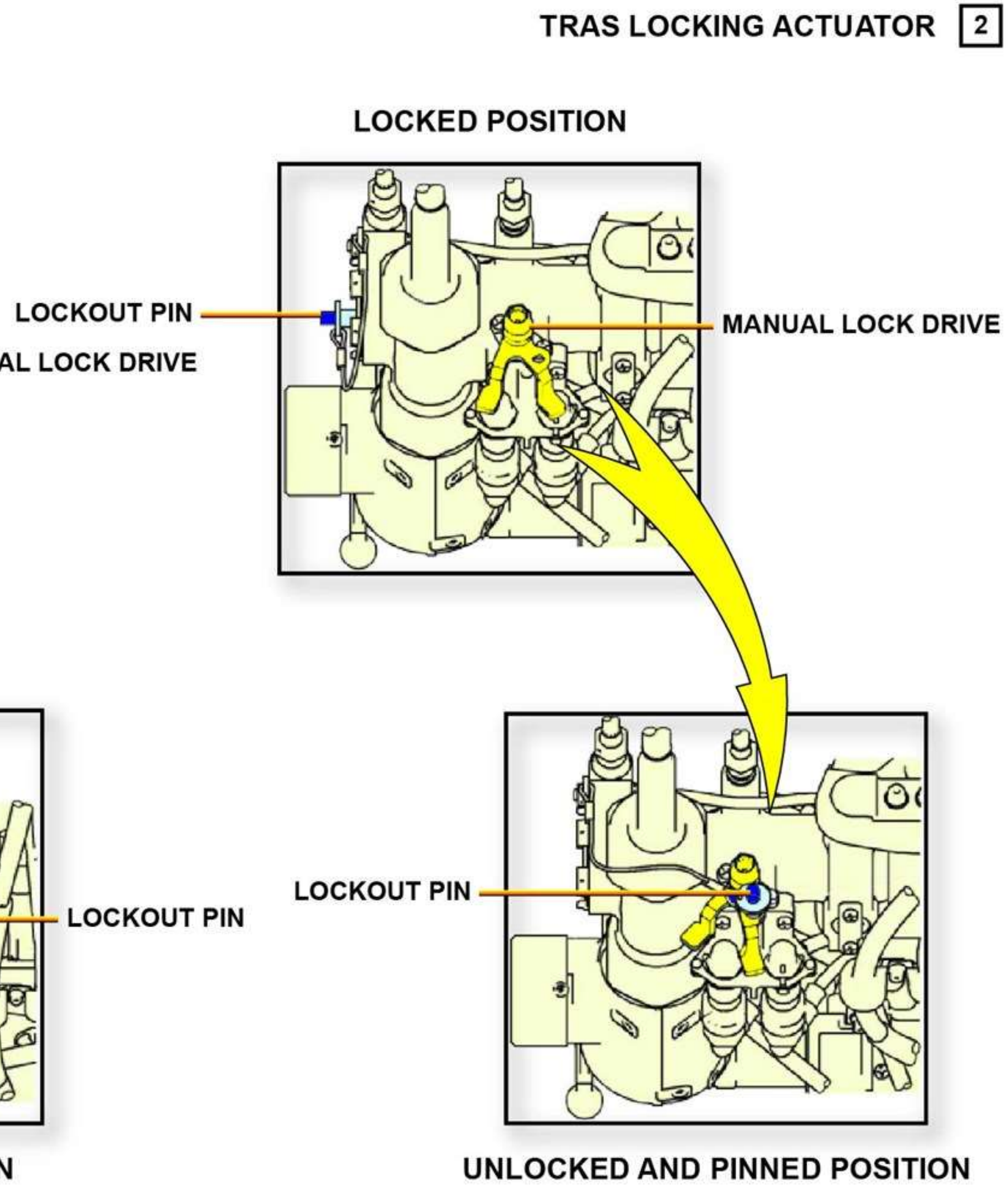
• Step in opposite order
•Operational test with MCDU

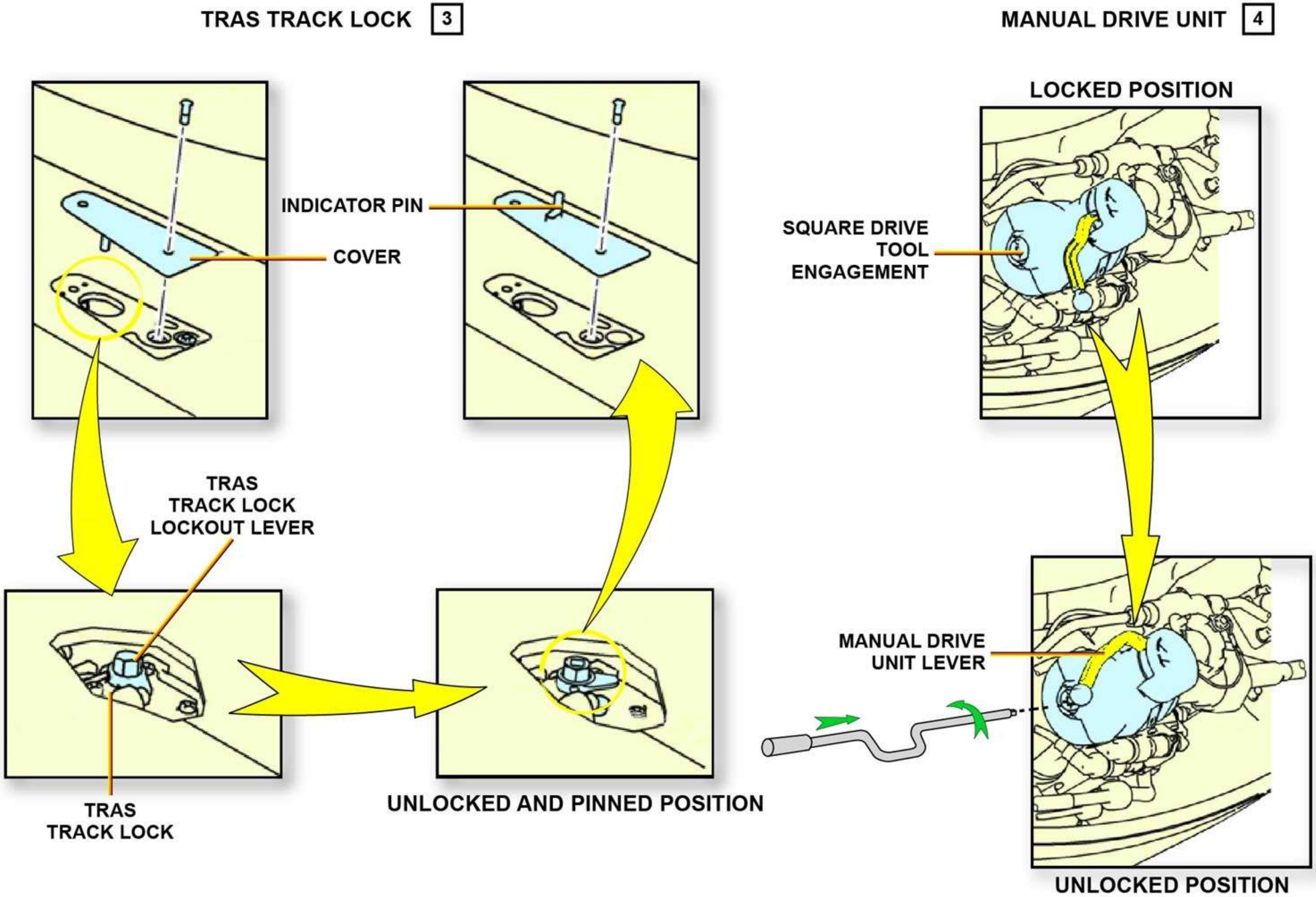
Manual retraction of the thrust reverser translating sleeves:
- Perform the steps in the opposite order.
- Do the operational test of the thrust reverser with the MCDU.

TRANSLATING SLEEVES MANUAL EXTENSION




TRAS LOCKING FEEDBACK ACTUATOR 1
LOCKED POSITION
MANUAL LOCK DRIVE
LOCKOUT PIN
LOCKOUT PIN
UNLOCKED AND PINNED POSITION


TRAS LOCKING ACTUATOR 2
LOCKED POSITION
LOCKOUT PIN
MANUAL LOCK DRIVE
LOCKOUT PIN
UNLOCKED AND PINNED POSITION


TRAS TRACK LOCK 3
MANUAL DRIVE UNIT 4
LOCKED POSITION
INDICATOR PIN
COVER
SQUARE DRIVE TOOL ENGAGEMENT
TRAS TRACK LOCK LOCKOUT LEVER
MANUAL DRIVE UNIT LEVER
TRAS TRACK LOCK
UNLOCKED AND PINNED POSITION
UNLOCKED POSITION

Power Plant System Line Maintenance (PW1100G)

ENGINE OIL SERVICING

Comp loc ENG 1 LH
OIL Tank Fill Cap
START Air Valve
FAN Cowl
Drain Mast
T/R Cowl Inhib Level

- Wait 5 minutes after engine shut down before servicing
- Sight gage on oil tank
- Filler cap Unlocking / Locking

Caution: The engine should be shut down for at least 5 minutes prior to oil servicing. This allows the residual pressure in the oil tank to decrease. If you open the filler cap when there is pressure in the tank the hot oil can spray out and burn you.

Note: If possible, the engine oil should be checked and serviced within 15 to 120 minutes after engine shutdown.

Note: If the engine has been shutdown for more than 2 hours, then follow the procedure in the AMM.

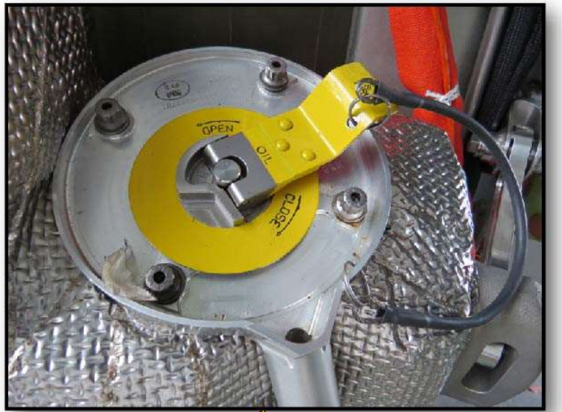
Procedure:

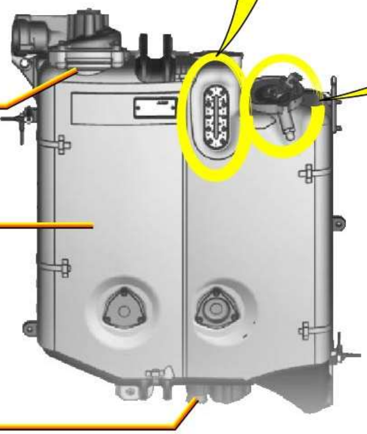
- open engine oil service door on left fan cowl,
- check oil level on the sight gage on the oil tank,
- raise filler cap handle to vertical (unlocked position),
- turn the oil filler cap counterclockwise and lift to remove,
- add approved oil as necessary up to the FULL mark on the sight gage,
- install oil filler cap - make sure to LOCK the cap.

PW1100G OIL TANK ACCESS DOOR

OIL LEVEL
SIGHT GLASS

FILLER NECK
ASSEMBLY





OIL TANK ASSEMBLY

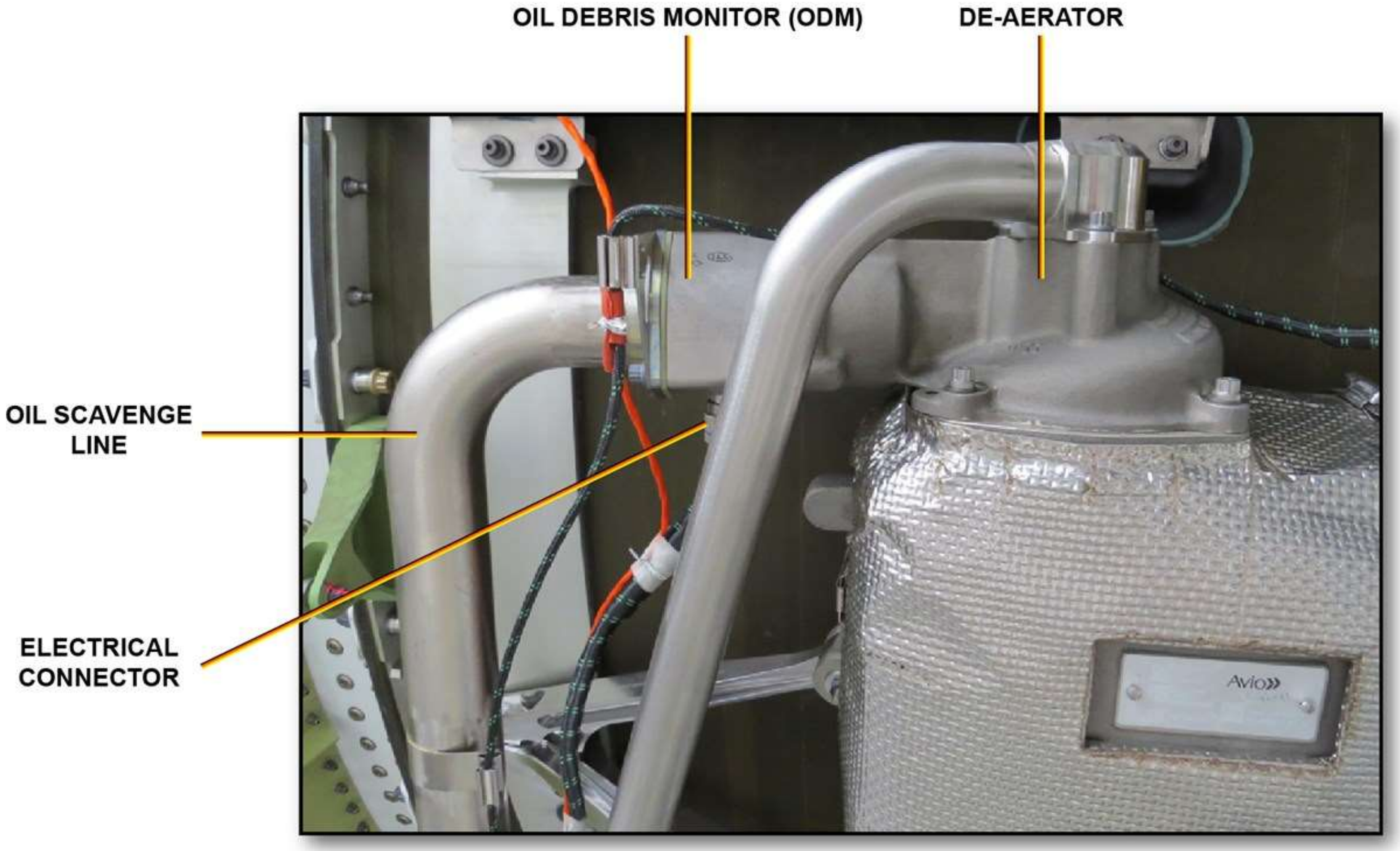
OIL TANK CAPACITY:
39,6 quarts (37,4 liters)
FULL LEVEL:
34,9 quarts (33,1 liters)

AVOID FLUID SPILLAGE
USE APPROPRIATE STORAGE EQUIPMENT
FOR CHEMICAL PRODUCTS

OIL DEBRIS MONITOR (ODM)

- 4 ODM is used to sense size & quantity of ferrous and non-ferrous metal
- In-line sensor
- Installed between the main oil scavenge line & the de-aerator in the oil tank assembly
- When ODM detects metallic debris:
  - ODM signals the PHMU which processes to the EEC
  - EIU generates maintenance message
- ODM is an LRU

An Oil Debris Monitor (ODM) is used to sense the size and quantity of ferrous and non-ferrous metal in the scavenge oil system.
It is an in-line sensor installed between the main oil scavenge line and the de-aerator in the oil tank assembly.
When the ODM detects metallic debris in the engine lubrication system, it signals the Prognostics and Health Management Unit (PHMU) which processes to the Engine Electronic Controller (EEC); then the Engine Interface Unit (EIU) generates appropriate maintenance message.
The ODM is a Line Replaceable Unit (LRU).


OIL DEBRIS MONITOR (ODM)
DE-AERATOR
OIL SCAVENGE LINE
ELECTRICAL CONNECTOR
Avio

CHIP COLLECTORS

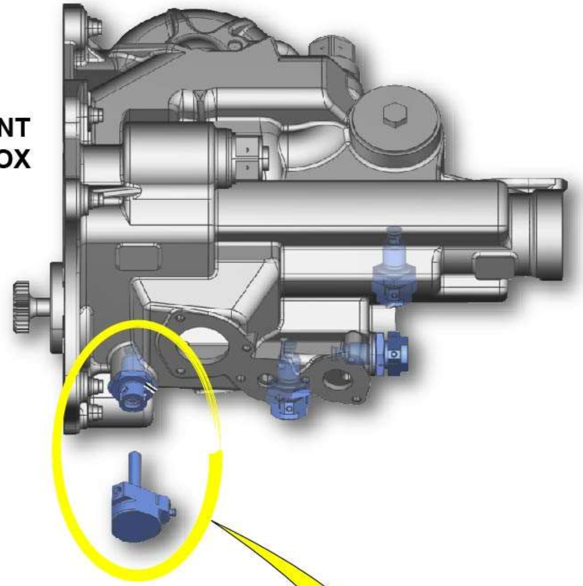
•6 magnetic chip collectors
•Catch ferrous metal particles in scavenge and supply oil
•Located:

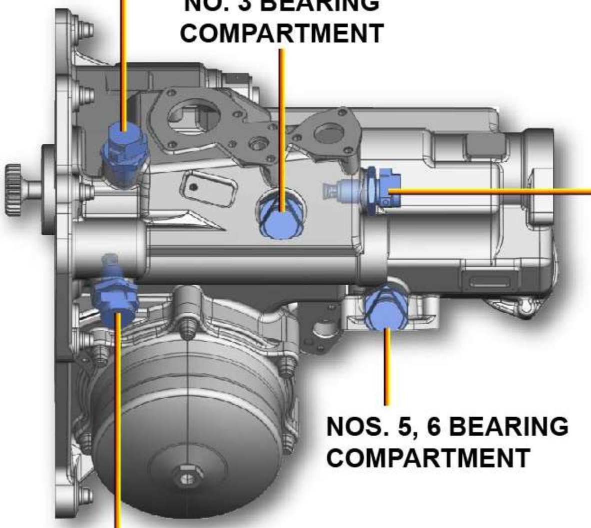
- On the lubrication and scavenge oil pump
- At 6 6 o'clock position

•Bayonet-type plugs, they are LRUs

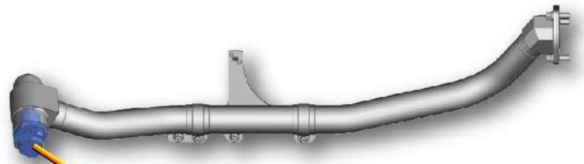
The engine oil scavenge system has six magnetic chip collectors which catch ferrous metal particles that might exist in the scavenge and supply oil:
The No. 4 bearing magnetic chip collector is located in the No. 4 bearing oil scavenge line.
The Angle Gearbox (AGB), Main Gearbox (MGB), No. 1, 1.5 and 2 Bearing and Fan Drive Gear System (FDGS), No. 3 bearing, and No. 5 and 6 bearing magnetic chip collectors are located on the lubrication and scavenge oil pump, at the 6 o'clock position.
The six chip collectors are bayonet-type plugs, they are LRUs.

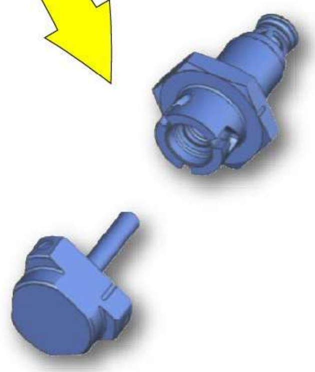
LUBRICATION AND SCAVENGE OIL PUMP WITH CHIP COLLECTORS





BOTTOM VIEW





MAGNETIC CHIP COLLECTOR

MEL / DEACTIVATION
START VALVE MANUAL OPERATION

•Start valve manual operation

- Access hole at 3 O'clock on RH thrust reverser inner-fixed-structure
- Establish communications with the cockpit
- Use 3/8" square drive extension to move start valve

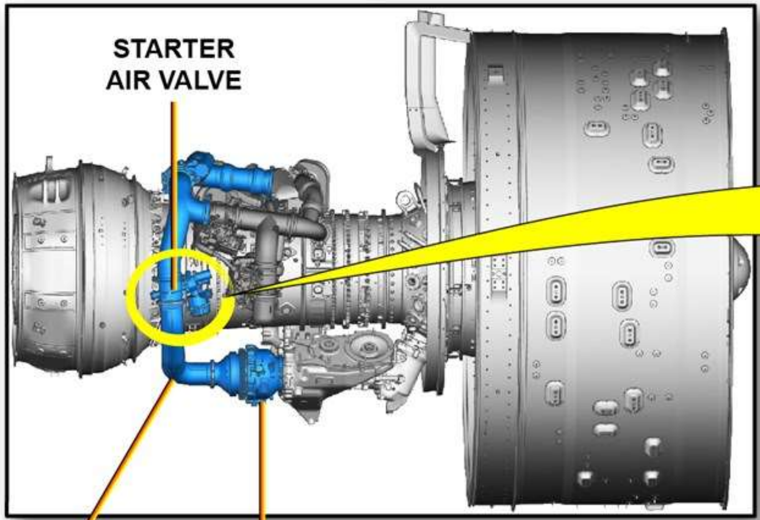
•SAV closes when the shaft is released

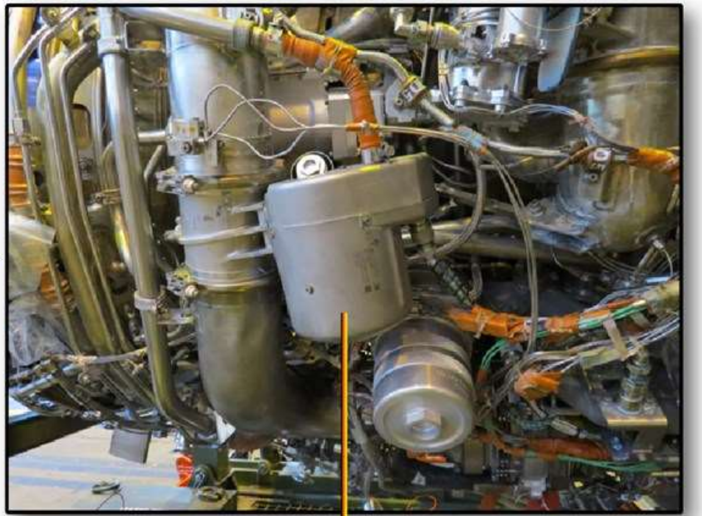
In case of an electrical failure of the Start Air Valve (SAV), the SAV can be operated manually to start the engine.
The aircraft may be dispatched per MEL with the valve INOP closed.

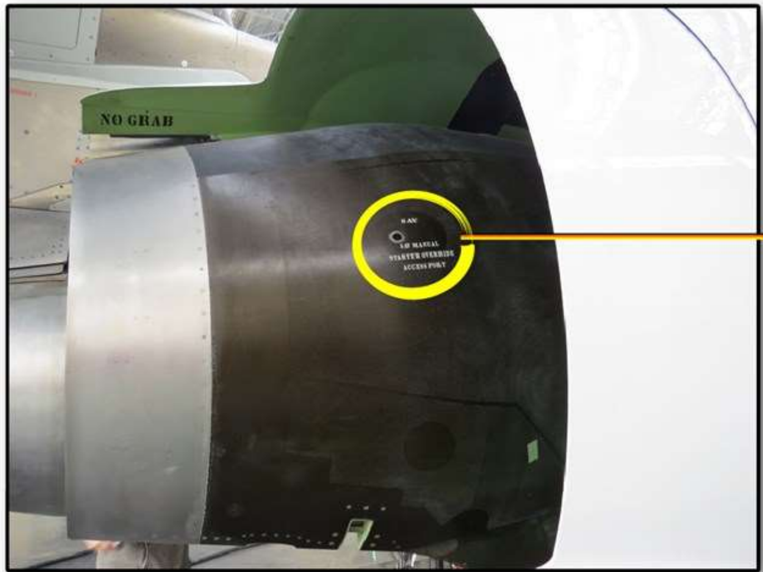
- First establish the communications with the cockpit (Interphone jack on engine inlet cowl),
- then on command from the cockpit, insert a 3/8" square drive extension into the manual wrench socket located on the RH thrust reverser inner-fixed-structure at 3 O'clock.
- turn the valve shaft, this opens the butterfly valve.

WARNING: STAY AWAY FROM THE DANGER AREAS AT THE FRONT AND THE SIDES OF THE ENGINE DURING OPERATION. THE SUCTION IS SUFFICIENT AT THE AIR INTAKE COWL TO PULL A PERSON INTO (IN PART OR FULLY) THE ENGINE. THIS CAN KILL A PERSON OR CAUSE A BAD INJURY.

The valve will close when the shaft is released. The SAV is an LRU.


STARTER AIR VALVE
STARTER AIR DUCT
AIR TURBUNE STARTER
PW1100G


STARTER AIR VALVE

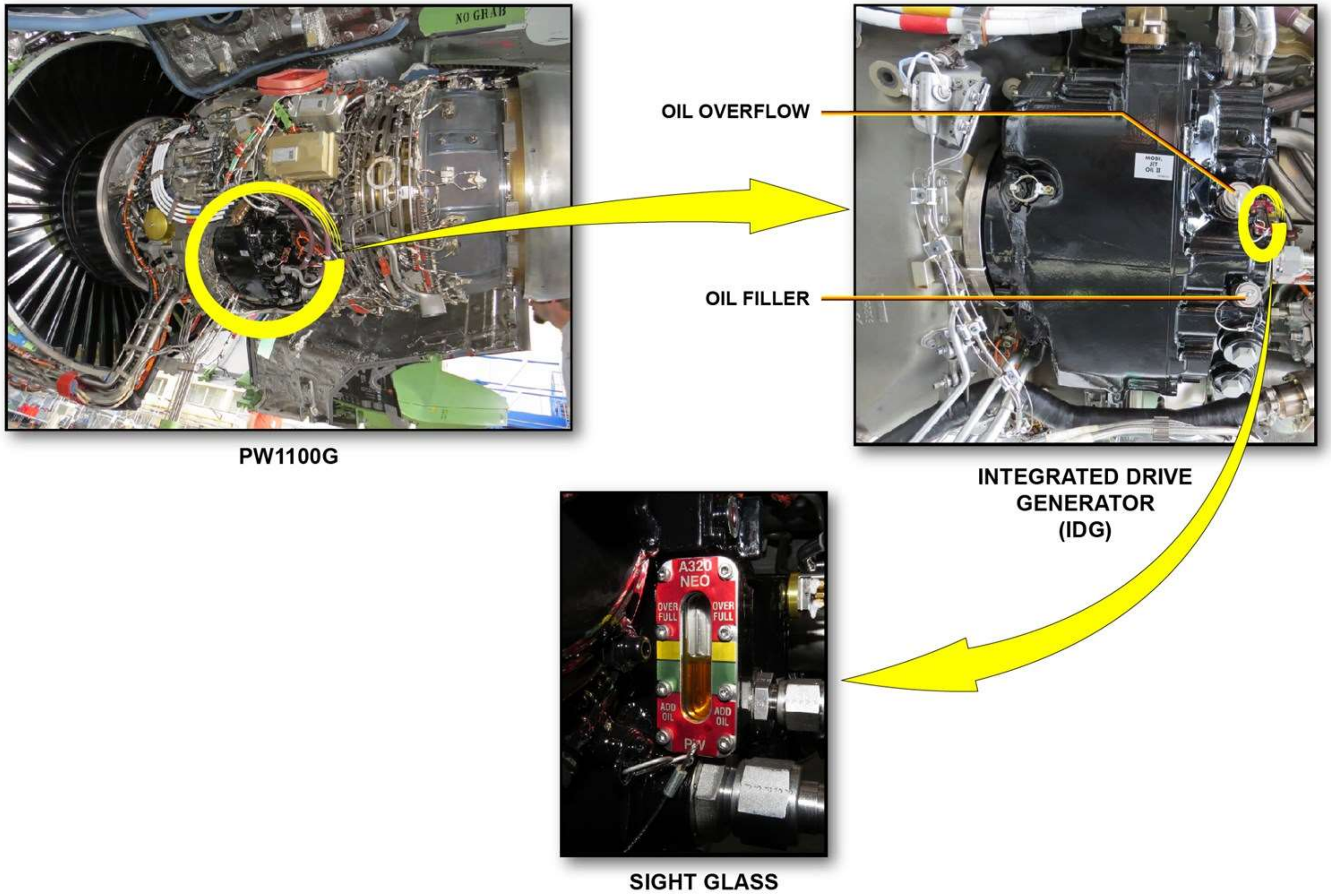

NO GRAB
STARTER VALVE ACCESS PORT


MANUAL OVERRIDE

MAINTENANCE TIPS

•For IDG servicing the left thrust reverser cowl-door has to be opened
•The IDG has two new additional sensors

For IDG servicing the left thrust reverser cowl-door has to be opened as the IDG installation change to core mounted area.
The IDG has two new additional sensors (oil level sensor and oil filter DPI) providing warnings IDG OIL LVL, IDG FILTER CLOG, which permit to increase the periodic inspection interval.



•Obey to Cautions and Warnings

Follow the General Warnings and Cautions, related Safety Data and Standard Precautions for Maintenance Procedures.

PW1100G

END