A350
TECHNICAL TRAINING MANUAL
MAINTENANCE COURSE - T1+T2 - RR Trent XWB
Standard Practices-Engine

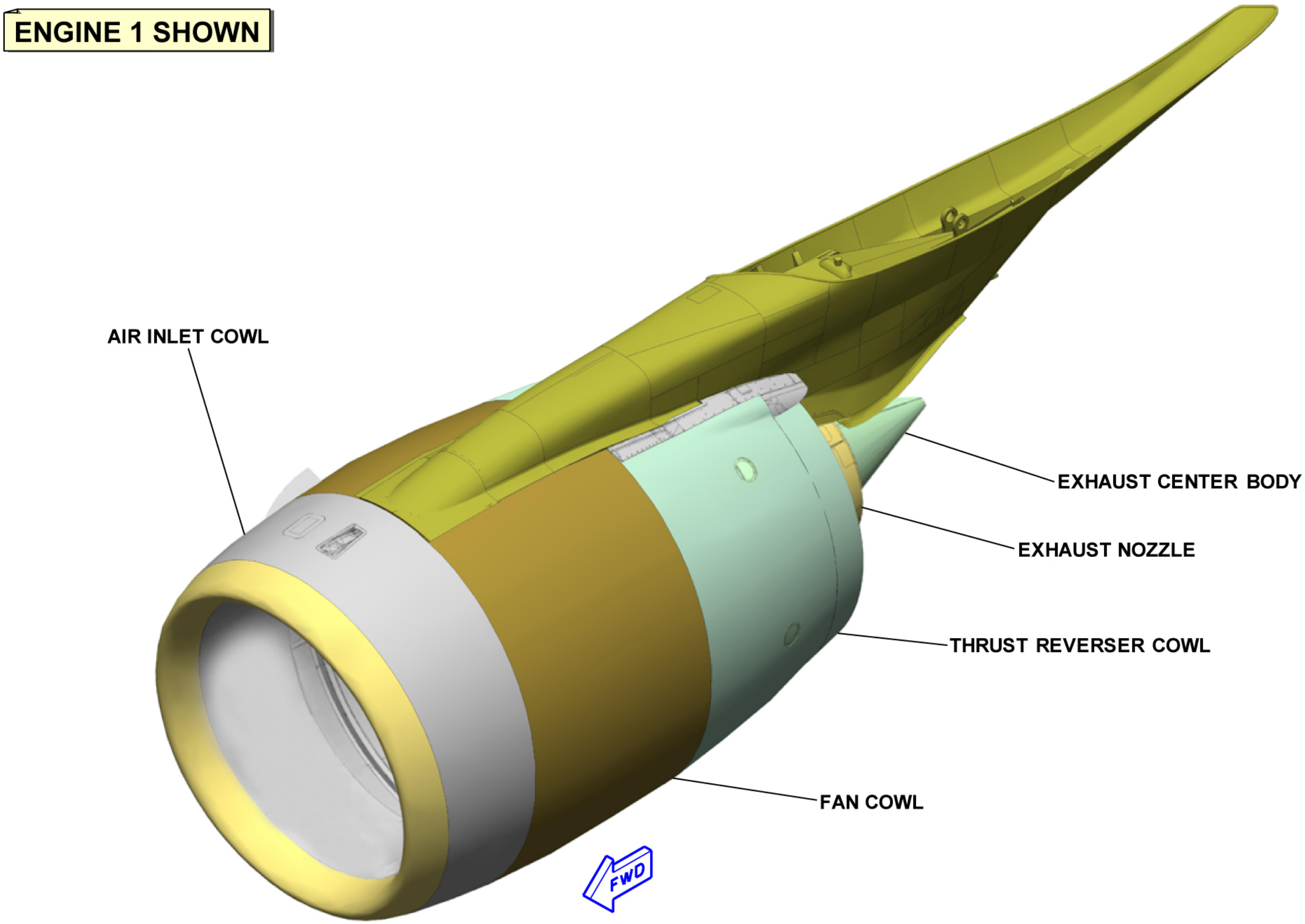
STANDARD PRACTICES-ENGINE

V1813401 - V01T0M0

NACELLE DESCRIPTION (2/3)

General Presentation

The nacelle is the aerodynamic structure around the engine.
It is made of:
- An air inlet cowl
- Two fan cowls - one on each side of the engine
- Two Thrust Reverser (T/R) cowls - one on each side of the engine
- An exhaust assembly consisting of an exhaust nozzle and an exhaust center body.



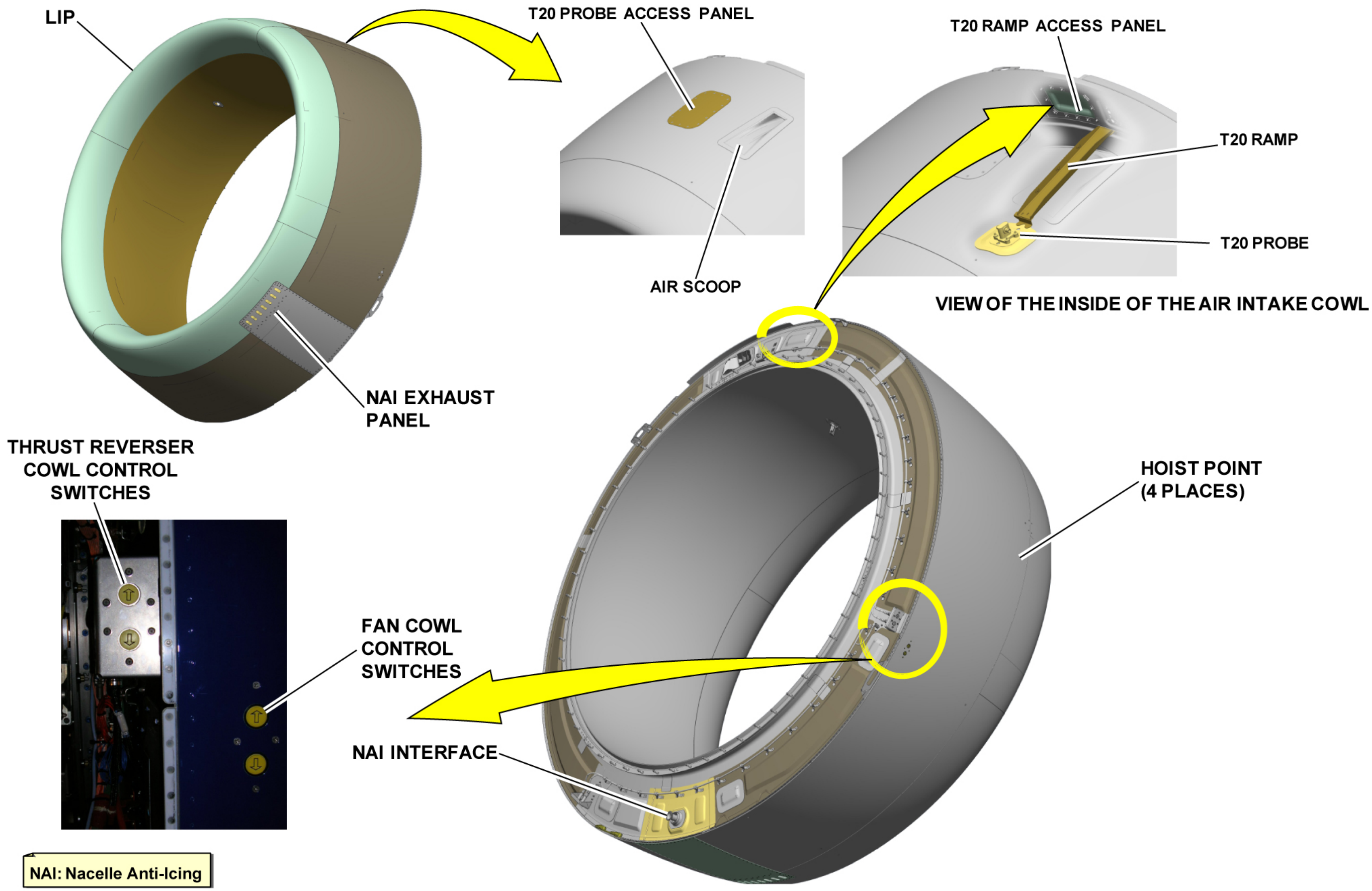
GENERAL PRESENTATION

V1813401 - V01T0M0 - VM70D2NACEL3001

NACELLE DESCRIPTION (2/3)

Air Inlet Cowl Description

The air inlet cowl gives smooth air flow to the engine and around the nacelle outer surfaces.
On the bulkhead a pipe connection lets an interface with the nacelle anti-ice system.
On its outer bottom face, the air inlet cowl has an exhaust panel for the discharge of nacelle anti-ice air, used to prevent the ice build-up on the lip.
On the top outer surface a panel lets access to the T20 probe. One more access panel at the top of the bulkhead lets access to the T20 ramp, on which the electrical harness is attached.
An air scoop gives cooling to the area around the fan case.
On each side of the air intake, the maintenance crew can reach the Power Door Opening System (PDOS) switches to open the fan and the T/R cowls.
The hoist points are available for handling.



AIR INLET COWL DESCRIPTION

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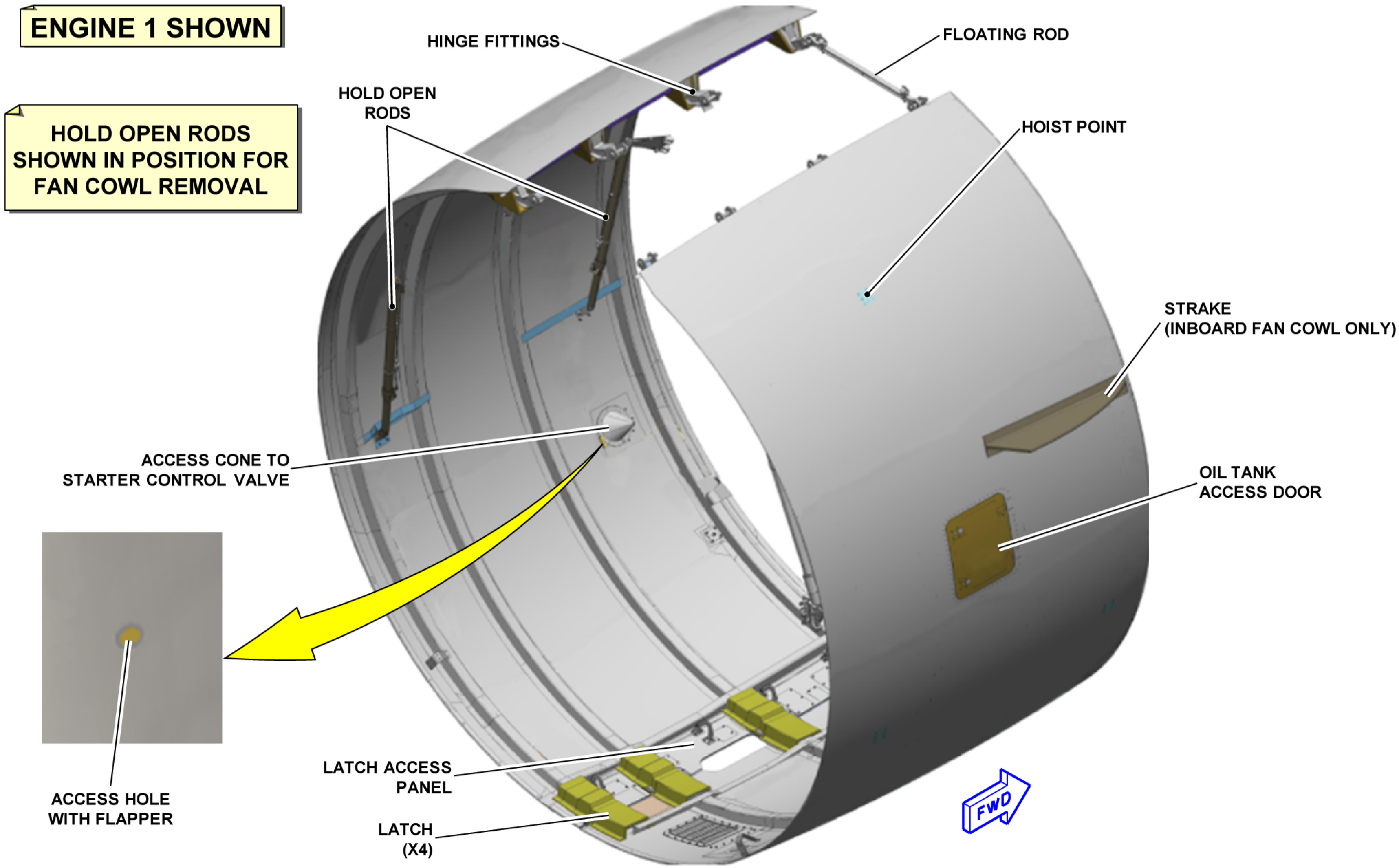
NACELLE DESCRIPTION (2/3)

Fan Cowls Description

The fan cowls give protection to the fan case.
The fan cowls are hinged at their top end by hinge fittings. A floating road connects the forward hinge fittings together.
The fan cowls are attached at their bottom by latches (quantity 4). A latch access panel gives access to the latches.
Each cowl has two Hold Open Rods (HORs) to keep the cowls open and locked during maintenance.
The left fan cowl has an access hole with a flapper on its outer surface and an access cone on its inner surface. This gives access to the starter control valve during manual operation.
The right fan cowl has an oil-tank access door. The inboard fan cowl has a strake, for better airflow around the wing leading edge.
The hoist points allow handling of the cowl during removal/installation.



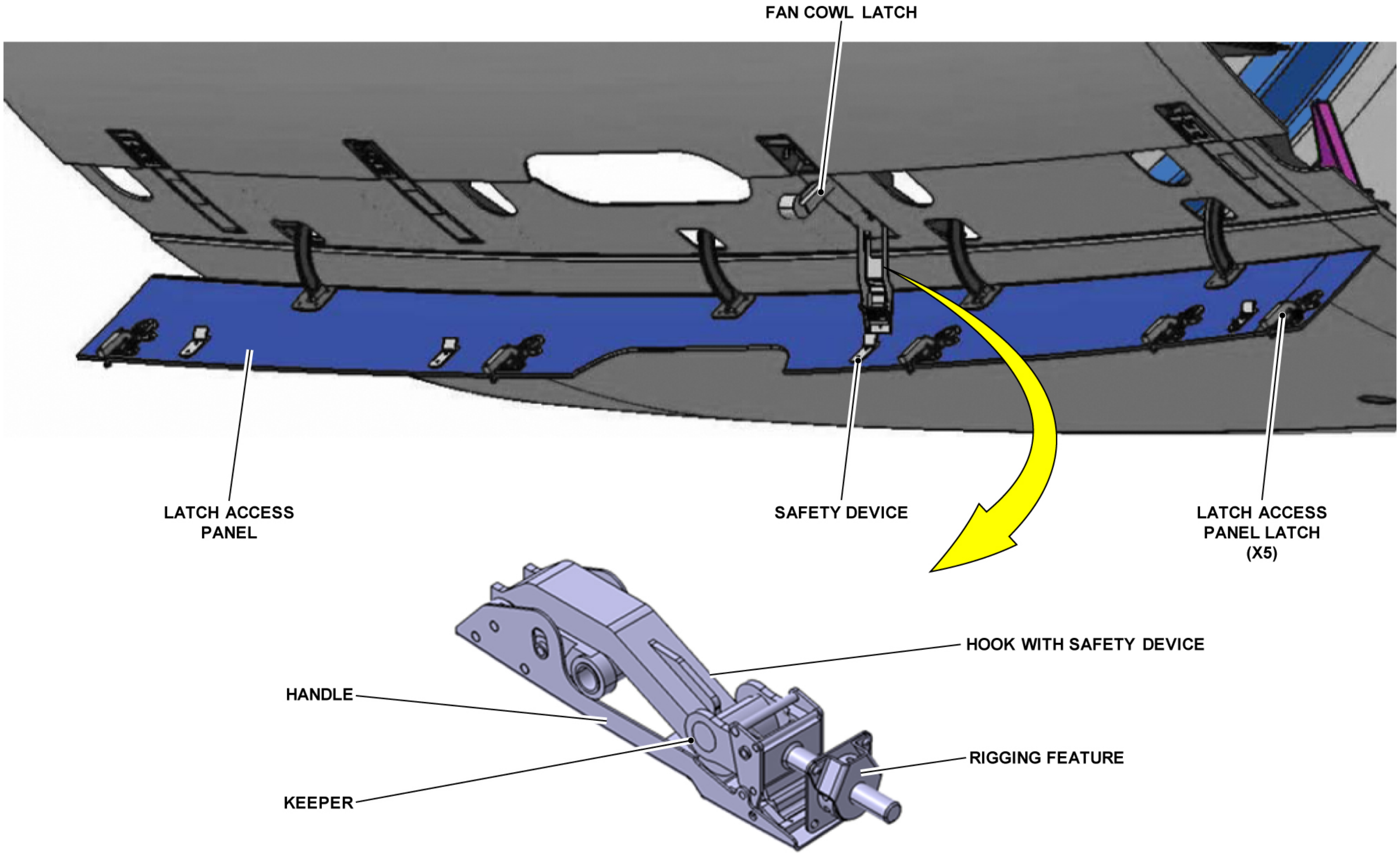
FAN COWLS DESCRIPTION

NACELLE DESCRIPTION (2/3)

Fan Cowls Description (continued)

Fan Cowls Latch Access Panel and Latches Description

The latch access panel gives access to the latches during opening of the fan cowls. The latch access panel is held closed by latches (quantity 5).
The latch access panel has safety devices, which prevent closure of the latch access panel if one (or several) fan cowl latch is open.
The fan cowl latches are typical hook latches.
If the hook is not engaged in the keeper, a safety mechanism prevents locking the latch.
All the latches include rigging features.



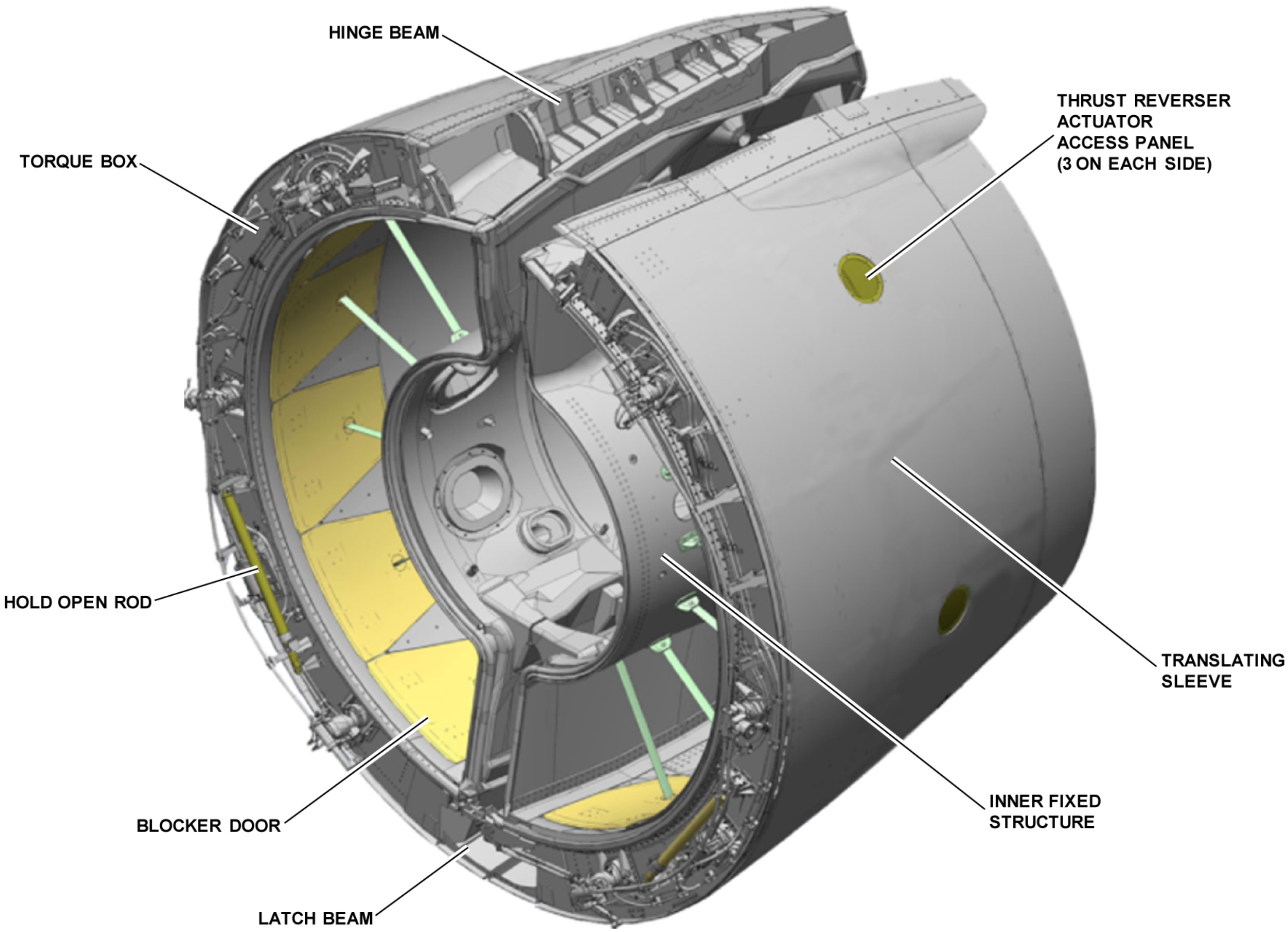
FAN COWLS DESCRIPTION - FAN COWLS LATCH ACCESS PANEL AND LATCHES DESCRIPTION

NACELLE DESCRIPTION (2/3)

Thrust Reverser Cowl Description

The T/R assembly encloses the engine core with an aerodynamic flow path and gives a fan exhaust duct. The T/R assembly is used to cause an aerodynamic brake during the landing.
The T/R is made of two similar halves, also known as "C-ducts" due to their shape.
Each T/R half includes:
- A torque box: A solid half-circumferential structure supporting most of the T/R components.
- A hinge beam: Hinges connect the T/R half to the engine pylon.
- A latch beam: Latches close and lock the halves together and give access to the engine core component during maintenance.
- An inner fixed structure: Encloses the engine core and makes the inner contour of the fan exhaust.
- A translating sleeve with blocker doors allows diverting the fan exhaust radially to cause an aerodynamic brake.

The T/R actuators access panels on the outer surface of the translating sleeve allow access to the actuators attachments to the translating sleeve.
Each T/R half can be open for maintenance and held open with a HOR.



THRUST REVERSER COWL DESCRIPTION

NACELLE DESCRIPTION (2/3)

Thrust Reverser Cowl Description (continued)

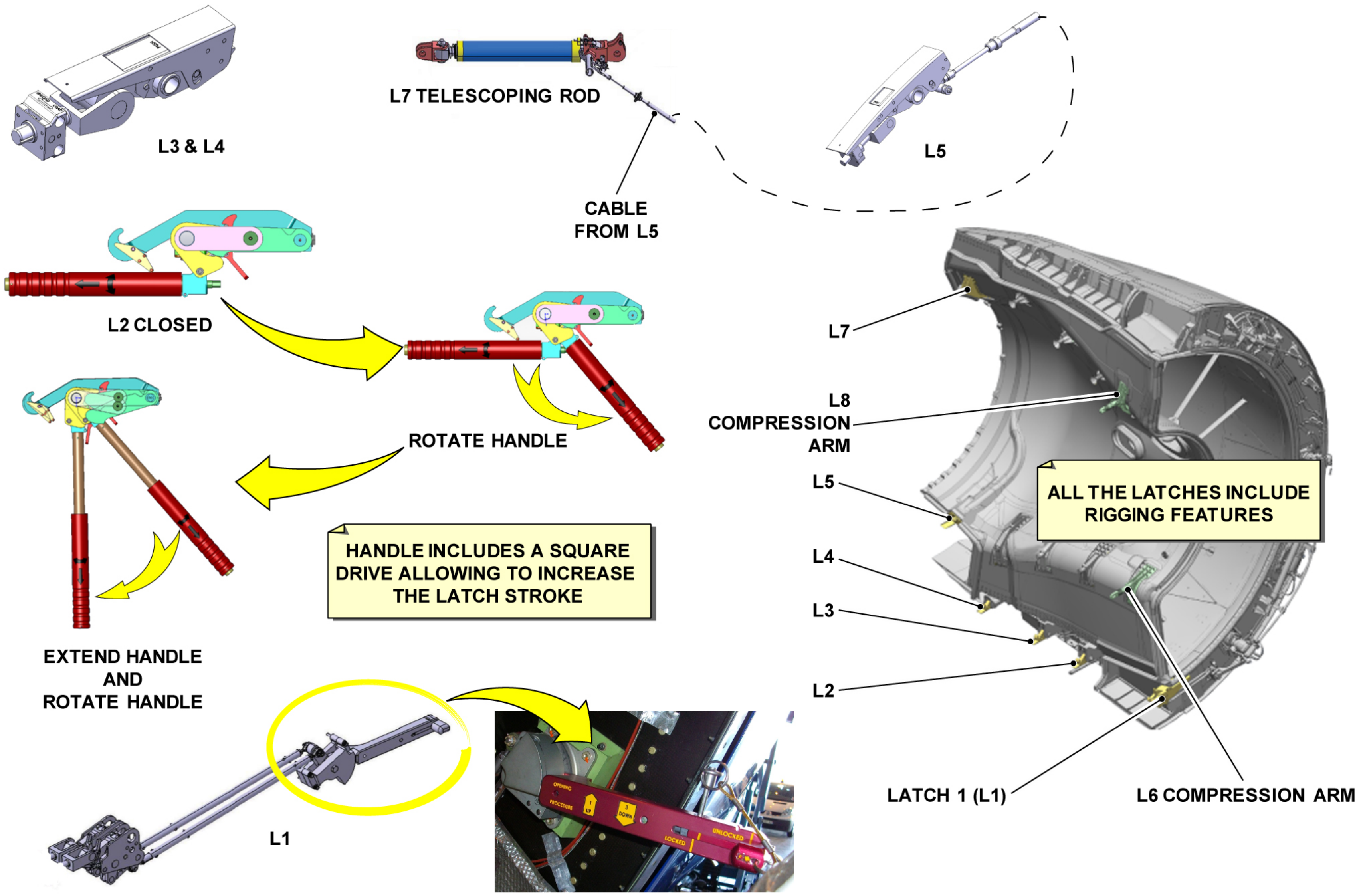
Thrust Reverser Cowl Latches and Latch Access PanelsDescription

Left T/R cowl:
The left T/R cowl has these latching features:
- Latch 1 (L1): It is a dual hook latch controlled by a handle. If the latch is not properly closed, the handle interferes with the fan cowl, which cannot be closed.
- L2: It is also known as a "take-up latch". L2 is a long stroke latch. The latch stroke can be increased or decreased by inserting and turning a square drive in the extendable handle. It is used to move the two T/R halves together during the closure. Thus it let the closure of the other latches.
- L3 and L4: Conventional hook latches.
- L5: It is a conventional hook latch. It also unlatches the remote latch L7 with a cable.
- L6 and L8 compression arms: These arms come in contact with the remote latches on the right T/R cowl.
- L7 telescoping rod: The rod is connected to the two T/R cowls at the top of the inner fixed structure aft part. A cable actuated by L5 allows to engage an internal mechanism that locks the rod in its retracted position.

All the latches include rigging features.
Right T/R cowl:
The right T/R cowl has these latching features:
- L6 and L8 remote latches: The compression arms connected to the left T/R cowl come in contact with the remote latches. When the remote latch is in locked position a pin locks the compression arms.
- L6 and L8 release handle: The handle is installed on the hinge beam. It controls the position of the latch pins with cables.

All the latches include rigging features.

T/R cowl latch access panel:
The right T/R cowl latch beam has 2 latch access panels.
In the open position, the latch access panel gives access to L2, L3, L4 latches and L6/L8 release handle.
Each latch access panel has a pressure relief door to protect the T/R cowl integrity, if there is an overpressure between the cowl and the engine.
Safety devices prevent closure of the latch access panel if the latches are not correctly closed.



THRUST REVERSER COWL DESCRIPTION - THRUST REVERSER COWL LATCHES AND LATCH ACCESS PANELSDESCRIPTION

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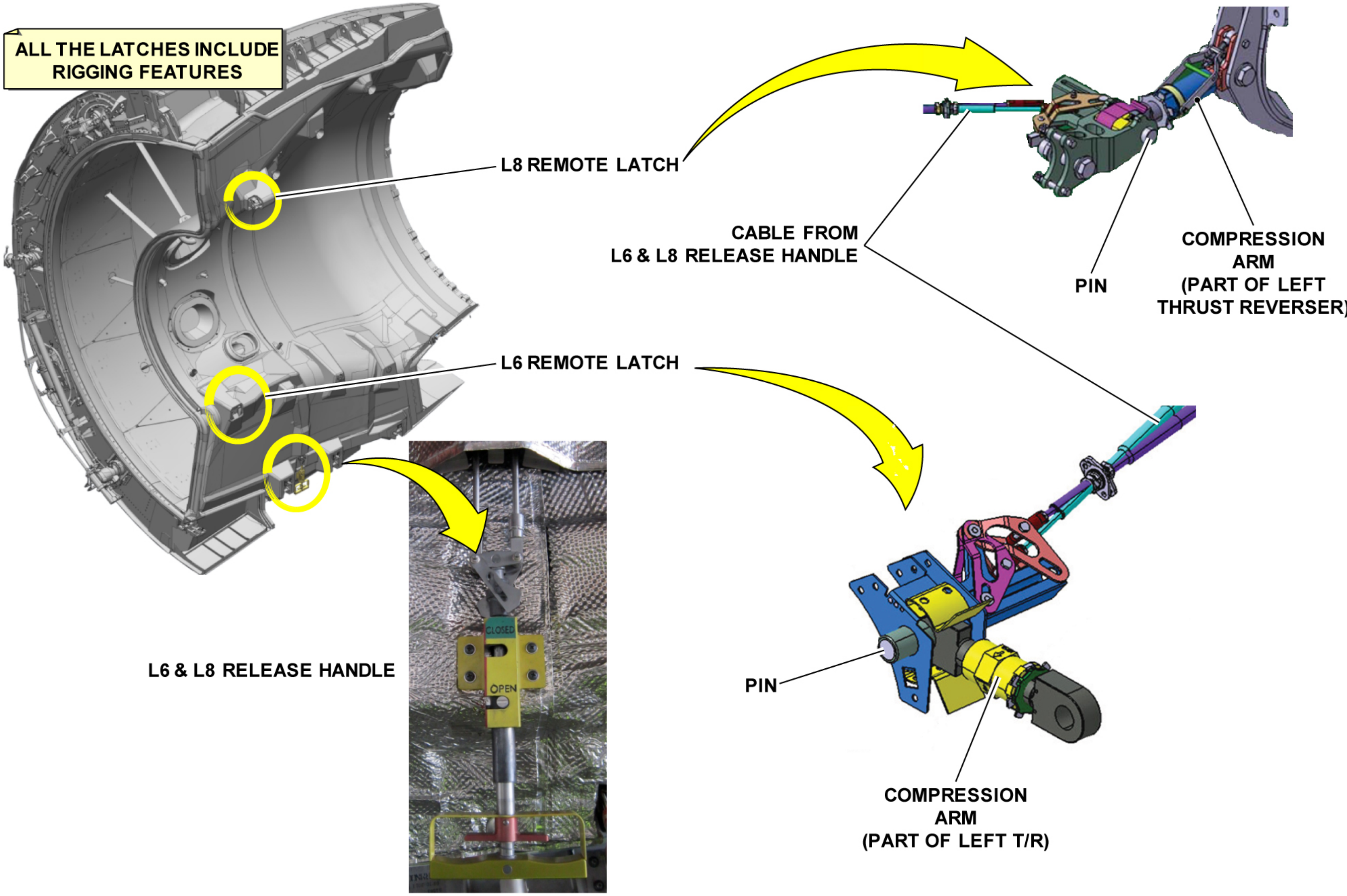

THRUST REVERSER COWL DESCRIPTION - THRUST REVERSER COWL LATCHES AND LATCH ACCESS PANELSDESCRIPTION

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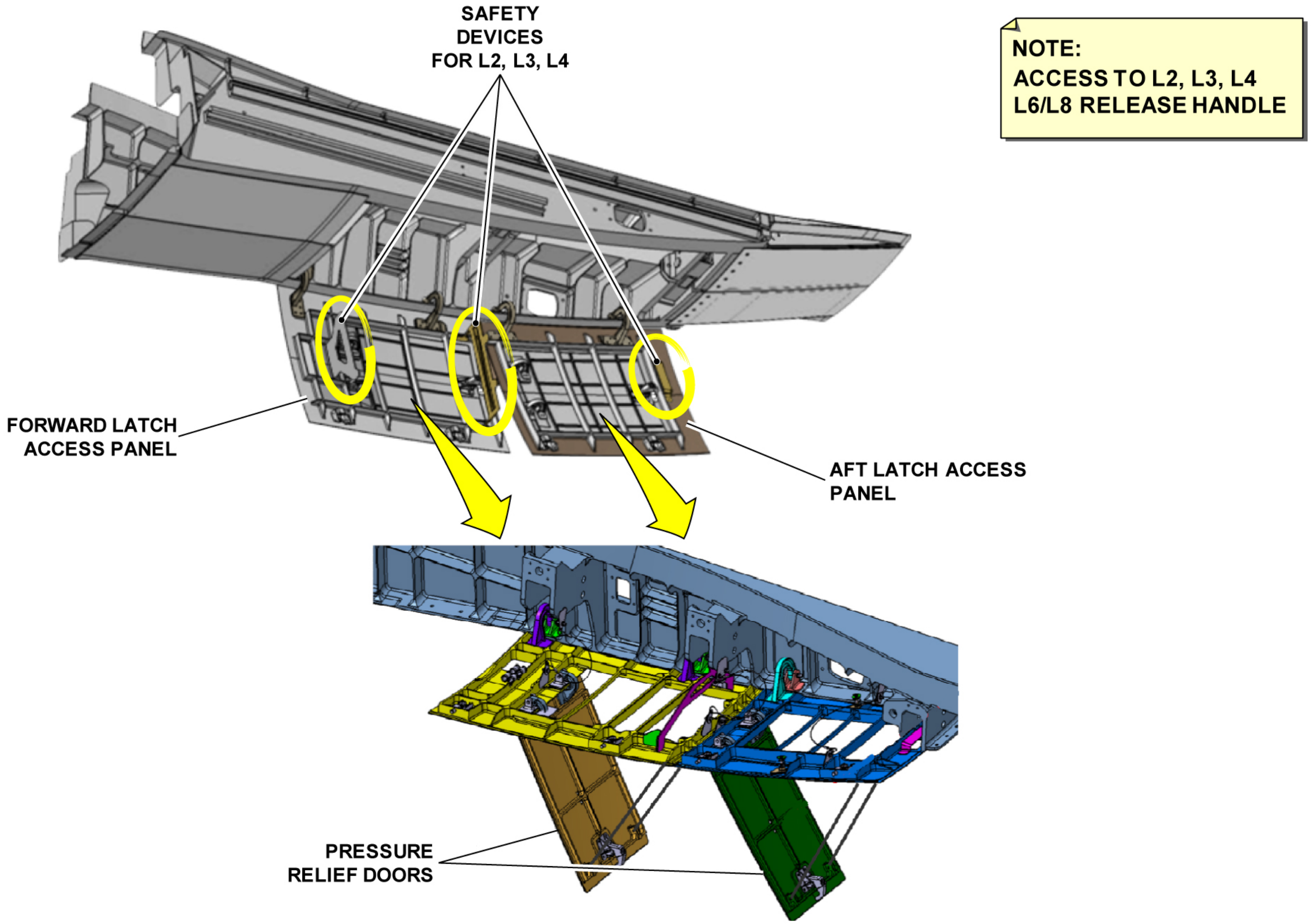

THRUST REVERSER COWL DESCRIPTION - THRUST REVERSER COWL LATCHES AND LATCH ACCESS PANELSDESCRIPTION

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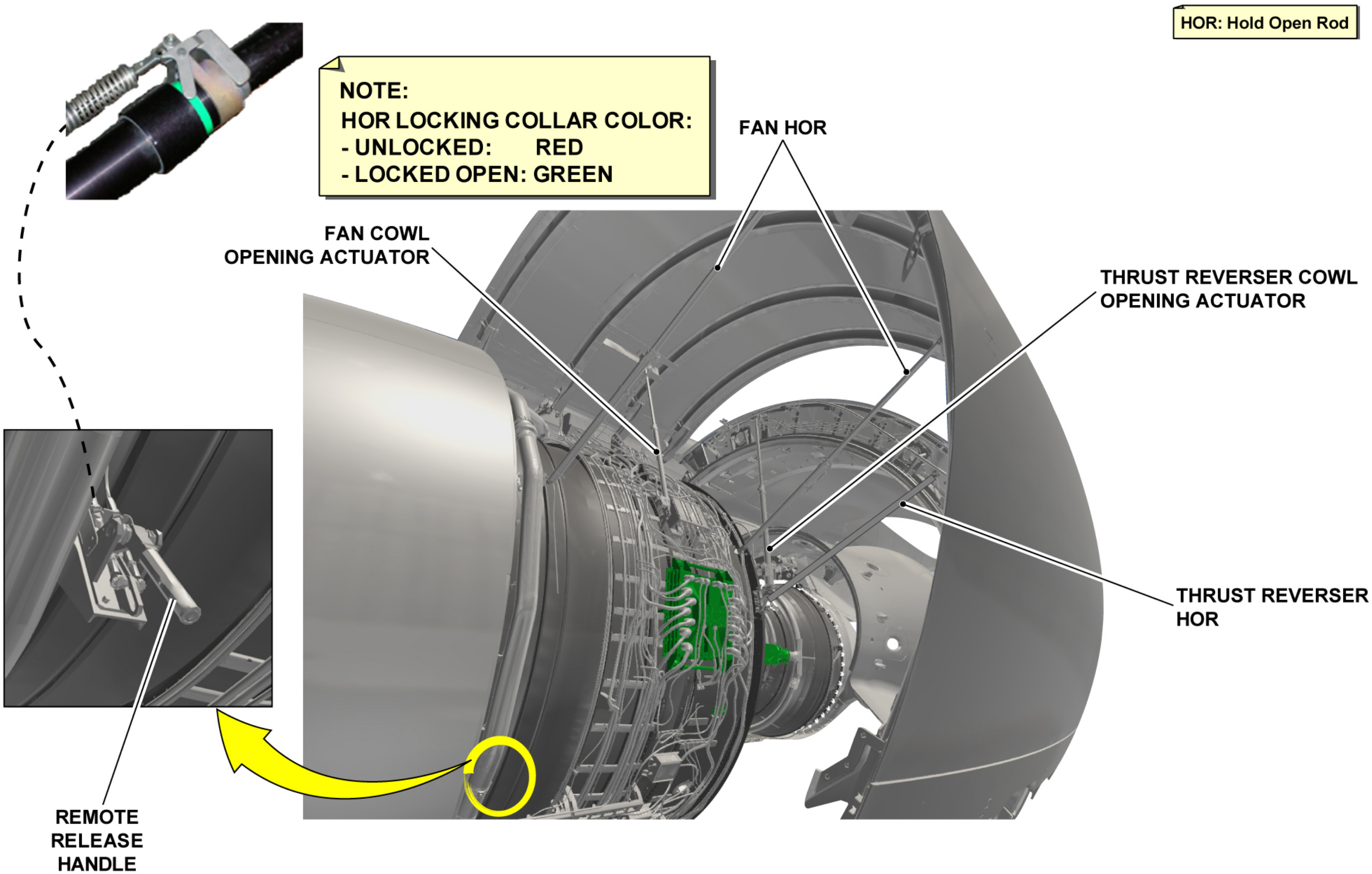
NACELLE DESCRIPTION (2/3)

Fan Cowls and T/R Cowls Hold Open Rod Description

Two HORs permit to keep the fan cowls open during maintenance. The HORs are permanently attached between the fan case and the fan cowl.
To open the fan cowls, there is one fan cowl opening actuator per fan cowl.
One HOR is used for the T/R cowl. It is normally secured on the T/R cowl torque box. When the T/R cowl has to be held open, the HOR is manually attached to the fan case. To open the T/R cowls, there is one T/R opening actuator per T/R cowl.
Each HOR is a telescoping rod with a locking system.
The HORs can lock in one of the two positions: fully or not fully open positions.
The HORs lock automatically, when they reach one of these two locking positions.
For the fan cowl, a remote release handle installed on the air inlet flange allows to unlock the locks before closing the fan cowl.
For the T/R cowl, the HORs locks are manually released by hand.
For all the HORs, a locking collar shows the state of the locking system:
- Unlocked: Red
- Locked: Green.



FAN COWLS AND T/R COWLS HOLD OPEN ROD DESCRIPTION

NACELLE DESCRIPTION (2/3)

Power Door Opening System (PDOS) Description

PDOS is a system which helps in opening and closing of the fan and T/R cowls easily. The primary components of the PDOS (for each engine) are:
- A power pack made of a reservoir, an electrical pump, a solenoid valves module and a logic module
- A set of two fan opening actuators
- A set of two T/R opening actuators
- Fan and T/R cowl control switches
- A fan cowl proximity switch.

When a control switch is pushed and held, the logic module in the power pack sends a discrete signal to a Conversion Module (CM) (used in the fire protection system). The CM sends the command signal to the Engine Interface Function (EIF). The EIF sends instructions to the Electrical Power Distribution System (EPDS) to supply electrical power to the power pack electrical-pump and solenoid valves. The pump is energized and pressurizes fluid supplied by the reservoir. The logic module also sends a control signal to the solenoid valve module. Depending on the switch pushed, the related solenoid valve supplies pressurized fluid to its fan or T/R opening actuator.

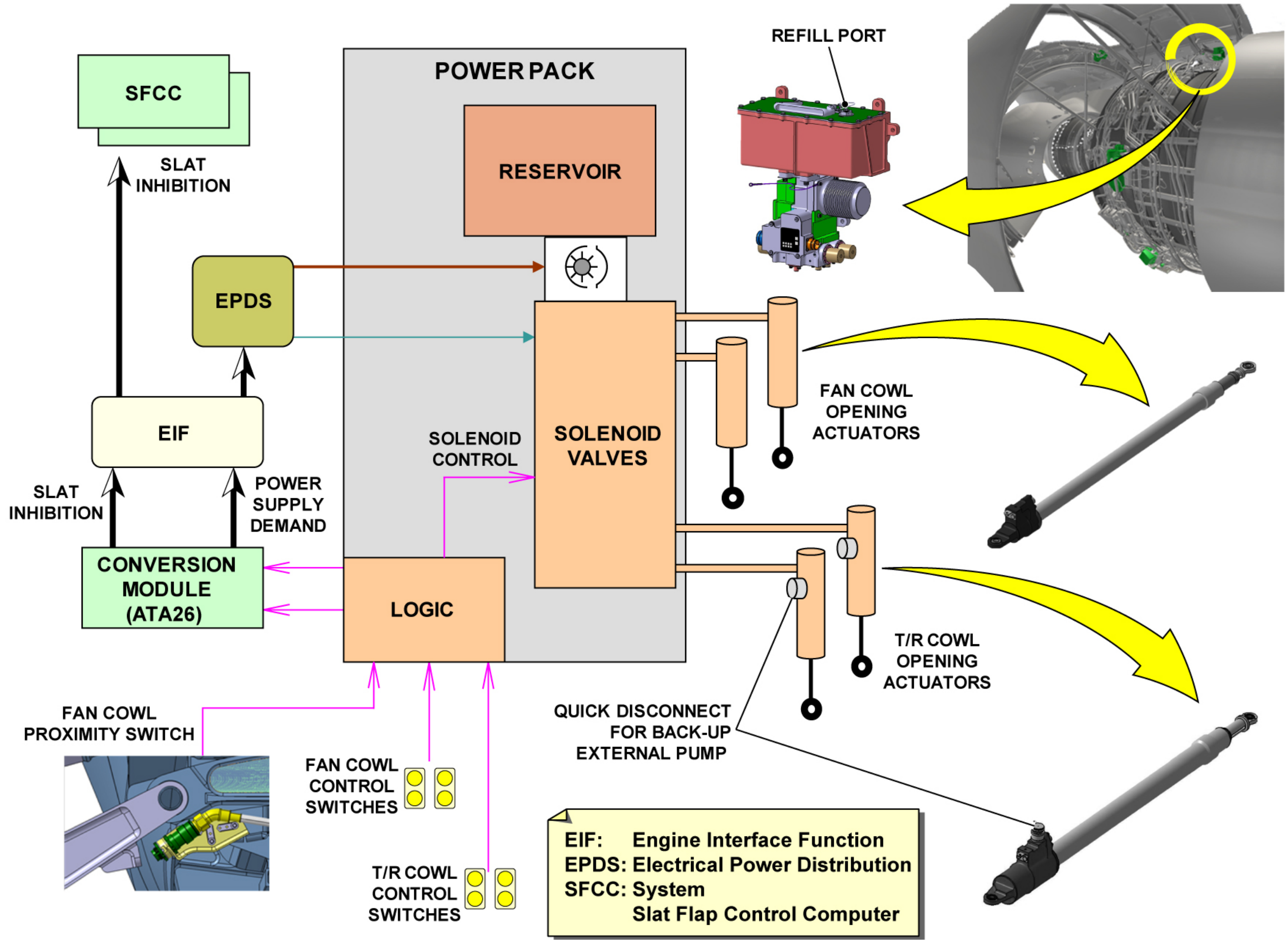
The PDOS has a protection against collision between the fan cowl and the inner slat:

When the inner fan cowl is open more than a predetermined angle, the fan cowl proximity switch sends a signal to the power-pack logic module. The logic module sends an inhibition signal to the Slat Flap Control Computer (SFCC), through the CM and the EIF. The slats cannot extend.

If the PDOS is unserviceable, the fan cowls can be pushed manually to the open position. A quick disconnect fitted to each T/R opening actuator lets connection of an external pump, allowing opening of the T/R cowl.

The power pack is installed on top of the fan case (it is accessible through a panel on the pylon or by opening the fan cowl).

For servicing, a refill port is installed at the top of the power pack reservoir. It is possible to get access to the refill port by the removal of a panel on the pylon.



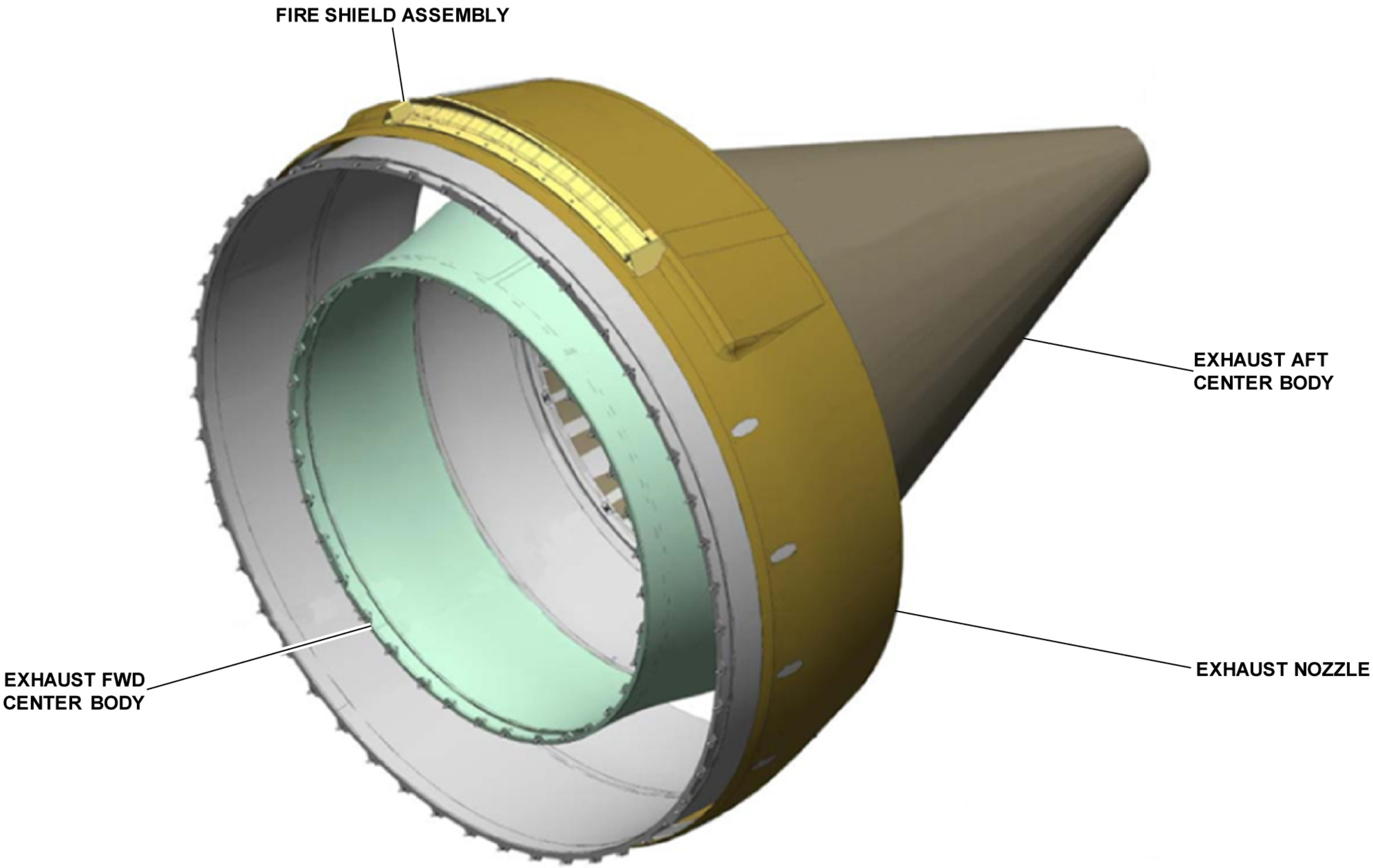
POWER DOOR OPENING SYSTEM (PDOS) DESCRIPTION

NACELLE DESCRIPTION (2/3)

Exhaust Assembly Description

The exhaust assembly is made of:
- The exhaust center body
- The exhaust nozzle.

The exhaust center body is a two piece assembly. The forward center body is attached to the turbine inner contour. The aft center body is attached to the forward center body.
The exhaust nozzle is attached to the turbine outer contour. It includes a fire shield assembly which gives protection to the aft pylon from fire damage.

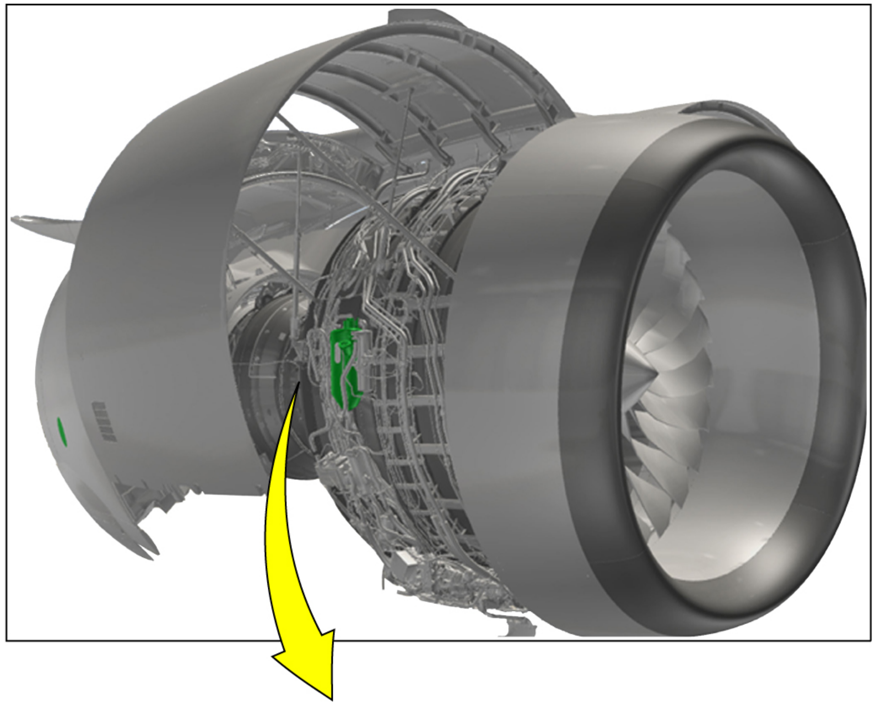


EXHAUST ASSEMBLY DESCRIPTION

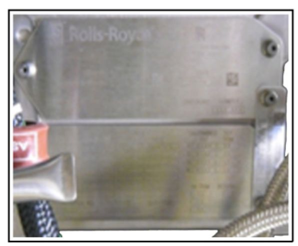
ENGINE DESCRIPTION (2/3)

Overview

The Rolls-Royce Trent XWB is a high bypass (9:1), triple spool turbofan engine.
The engine data slip-plate is located on the right side of the fan case and includes data about the engine (Serial Number (S/N), thrust rating, etc).
The engine maximum take off thrust is:
- 84,200 lbs for the Rolls-Royce TRENT XWB 84K.



ENGINE DATA PLATE



TAKE OFF THRUST :
A350-900:84,200 LBS (TRENT XWB 84K)

OVERVIEW

ENGINE DESCRIPTION (2/3)

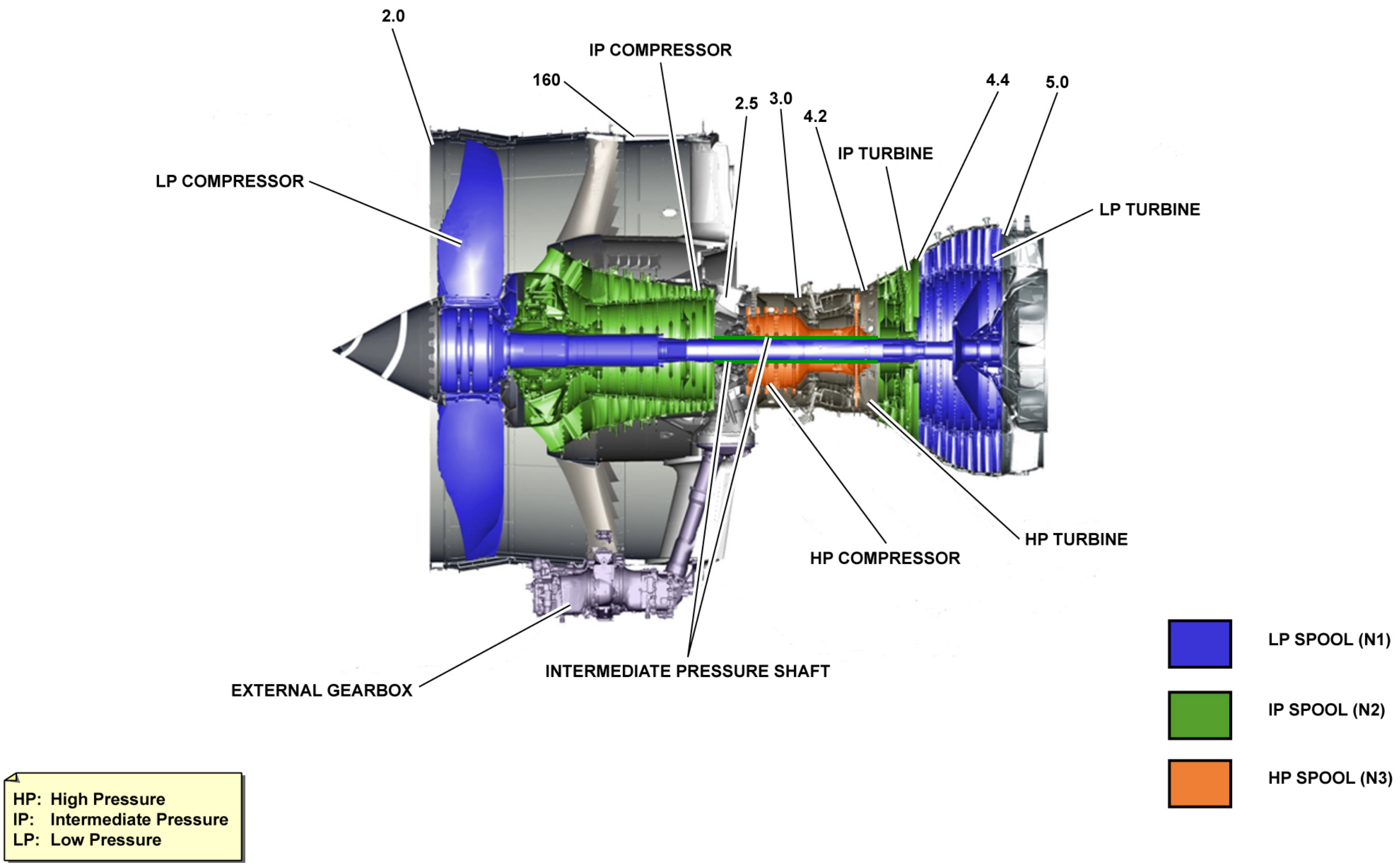
Construction Features

Gaspath Configuration

The engine has three rotating assemblies: The LP, IP and HP systems. Each system has a compressor driven by a turbine through a shaft. The shafts are concentric and can rotate freely from each other. A combustion chamber located between the High Pressure Compressor (HPC) and the High Pressure Turbine (HPT) mixes the compressed air supplied by the compressors with fuel, burns this mixture and releases it into the turbines with a higher energy. This lets the turbines drive their related compressor and cause thrust. Note that the HP system drives the external gearbox fitted on the fan case.

Gaspath Stations

The main aerodynamic stations are:
- 2.0 - Low Pressure Compressor (LPC) inlet
- 160 - LPC exit
- 2.5 - HPC inlet
- 3.0 - HPC exit
- 4.2 - IP turbine inlet
- 4.4 - Low Pressure Turbine (LPT) inlet
- 5.0 - LPT exit.



CONSTRUCTION FEATURES - GASPATH CONFIGURATION & GASPATH STATIONS

V1813401 - V01T0M0 - VM70D1ENGIN3001

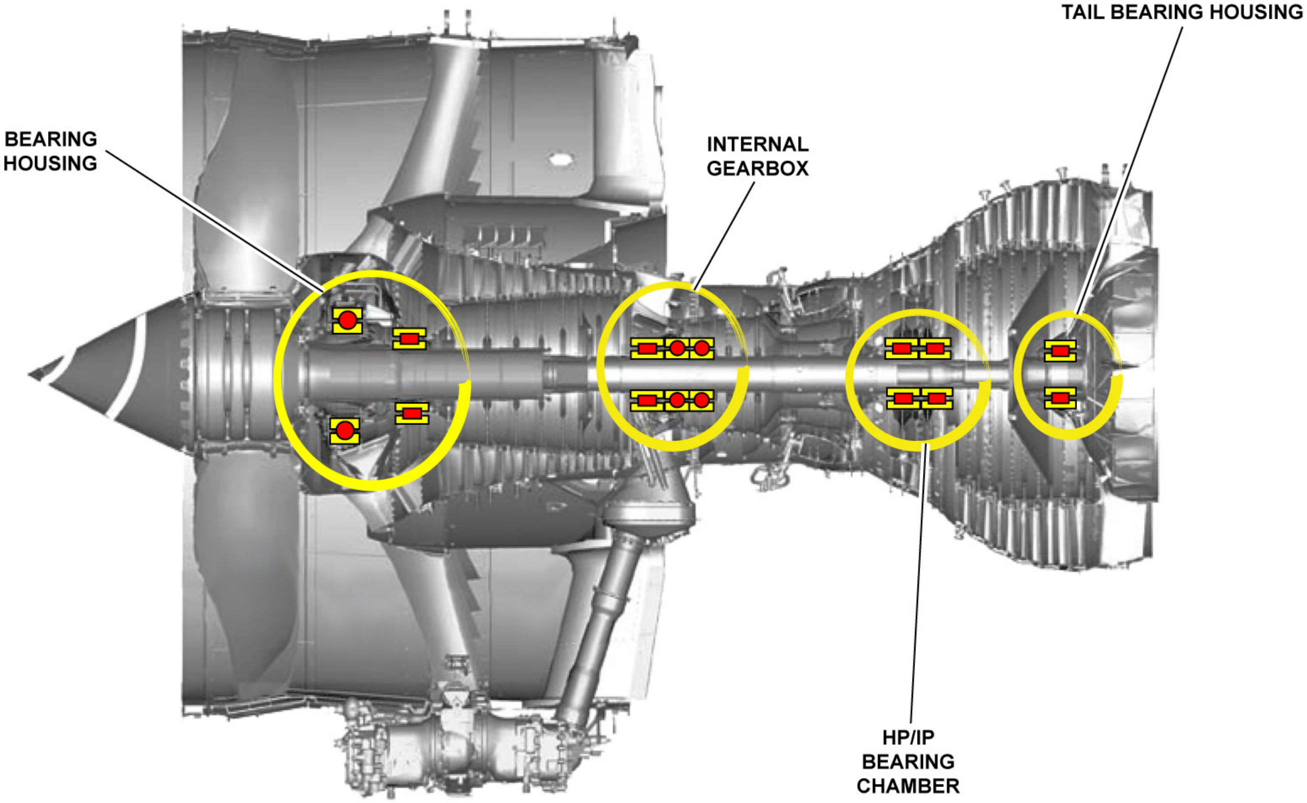
ENGINE DESCRIPTION (2/3)

Construction Features (continued)

Engine Bearing Housings

The Rolls-Royce Trent XWB has main bearings located in four main areas:
- Front bearing housing
- Internal gearbox
- HP/IP bearing chamber
- Tail bearing housing.

Each of these areas receives oil for lubrication, cooling and cleaning.
The main bearings are of two different types:
- Ball bearings (also referred to as location bearings) transmit radial and axial loads. They transmit thrust and locate the shafts.
- Roller bearings transmit radial loads only. They hold the shafts and let their rotation.



CONSTRUCTION FEATURES - ENGINE BEARING HOUSINGS

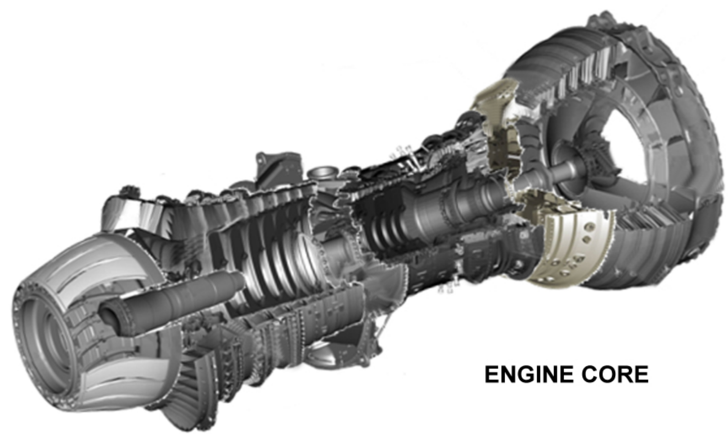
ENGINE DESCRIPTION (2/3)

Construction Features (continued)

Splitting Concept

The Trent XWB has the engine core, the fan case (with the external gearbox), the fan blades and the spinner. The engine core and the fan case can be separated for easier transportation.


FAN BLADES AND SPINNER



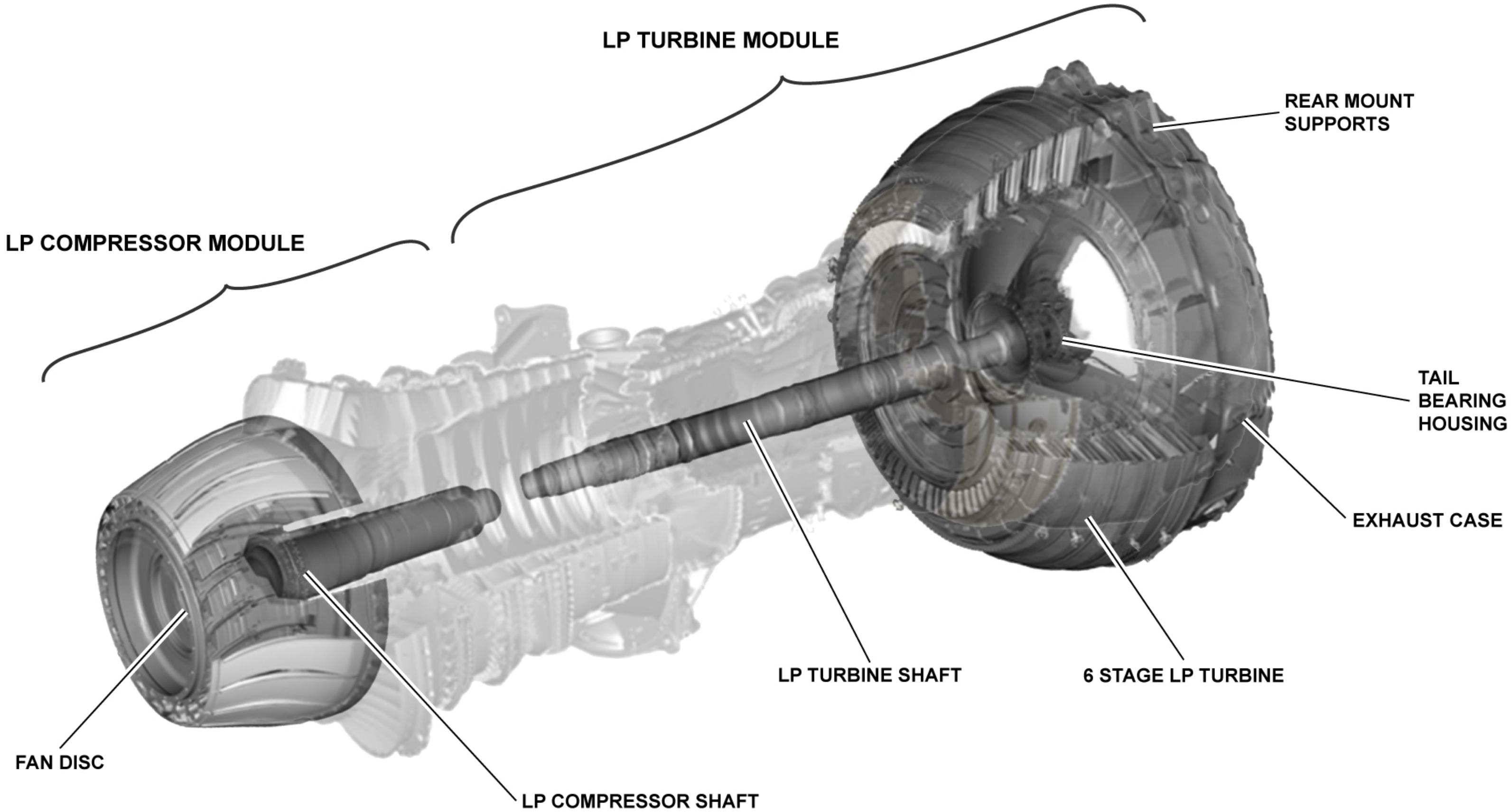
CONSTRUCTION FEATURES - SPLITTING CONCEPT

ENGINE DESCRIPTION (2/3)

Engine Core Description

LP Compressor and LP Turbine Modules

The LPC module has a fan disc and the LPC shaft.
The fan disc has dovetail slots (22) in which the fan blades are installed (refer to the fan blades paragraph).
The LPT module includes the LPT, the LPT shaft and the exhaust case.
The LPT is a six-stage (vanes and blades) axial turbine.
The exhaust case is attached to the aft of the LPT case and include the tail bearing housing and the rear engine mount supports.



ENGINE CORE DESCRIPTION - LP COMPRESSOR AND LP TURBINE MODULES

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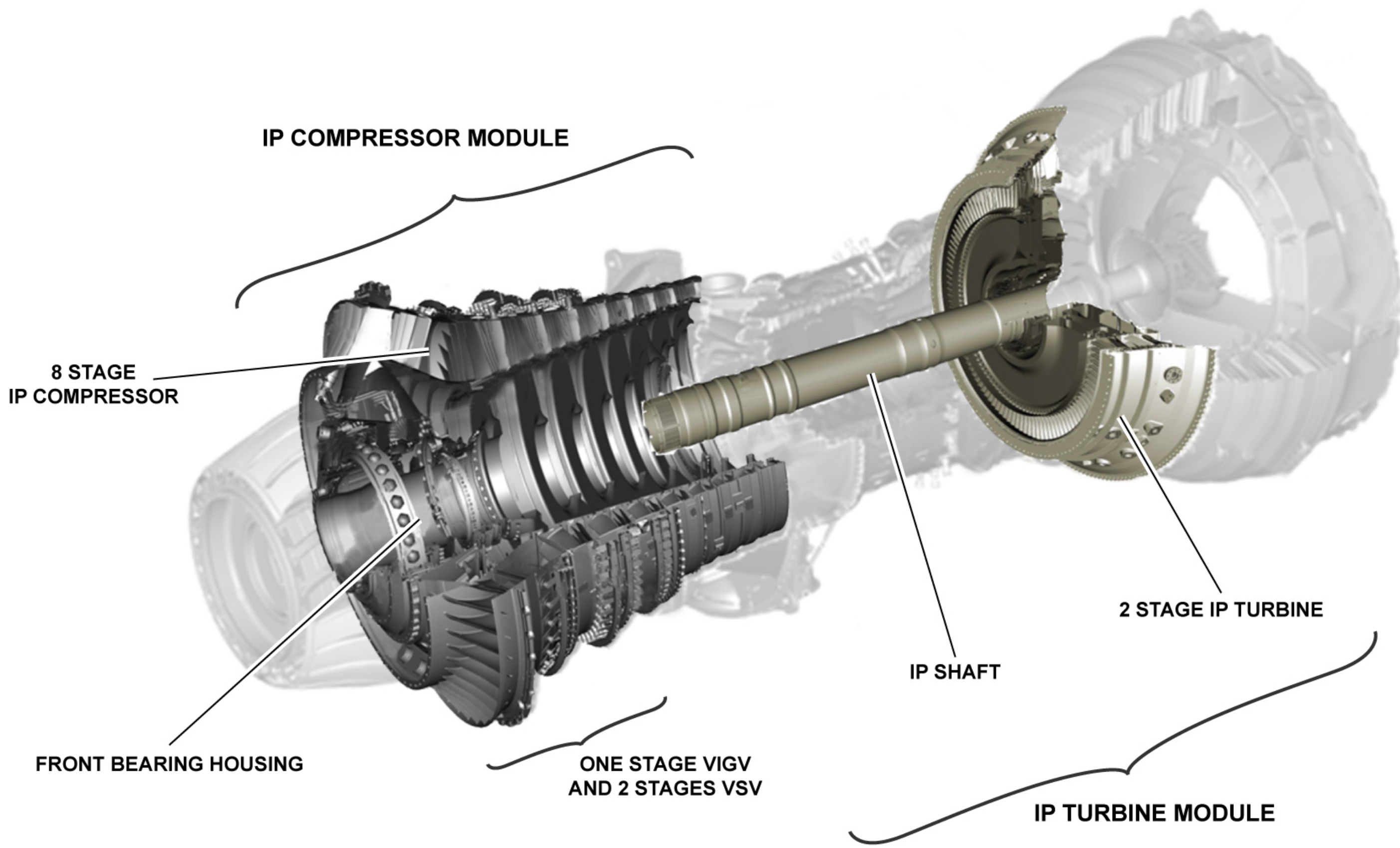
ENGINE DESCRIPTION (2/3)

Engine Core Description (continued)

IP Compressor and IP Turbine Modules

The IP compressor module is an eight-stage axial compressor including:
- The front bearing housing
- One stage of VIGVs and two stages of VSVs installed on the case.

The IP turbine module includes:
- A two stage axial turbine
- An IP turbine shaft.



VIGV: Variable Inlet Guide Vane
VSV: Variable Stator Vane

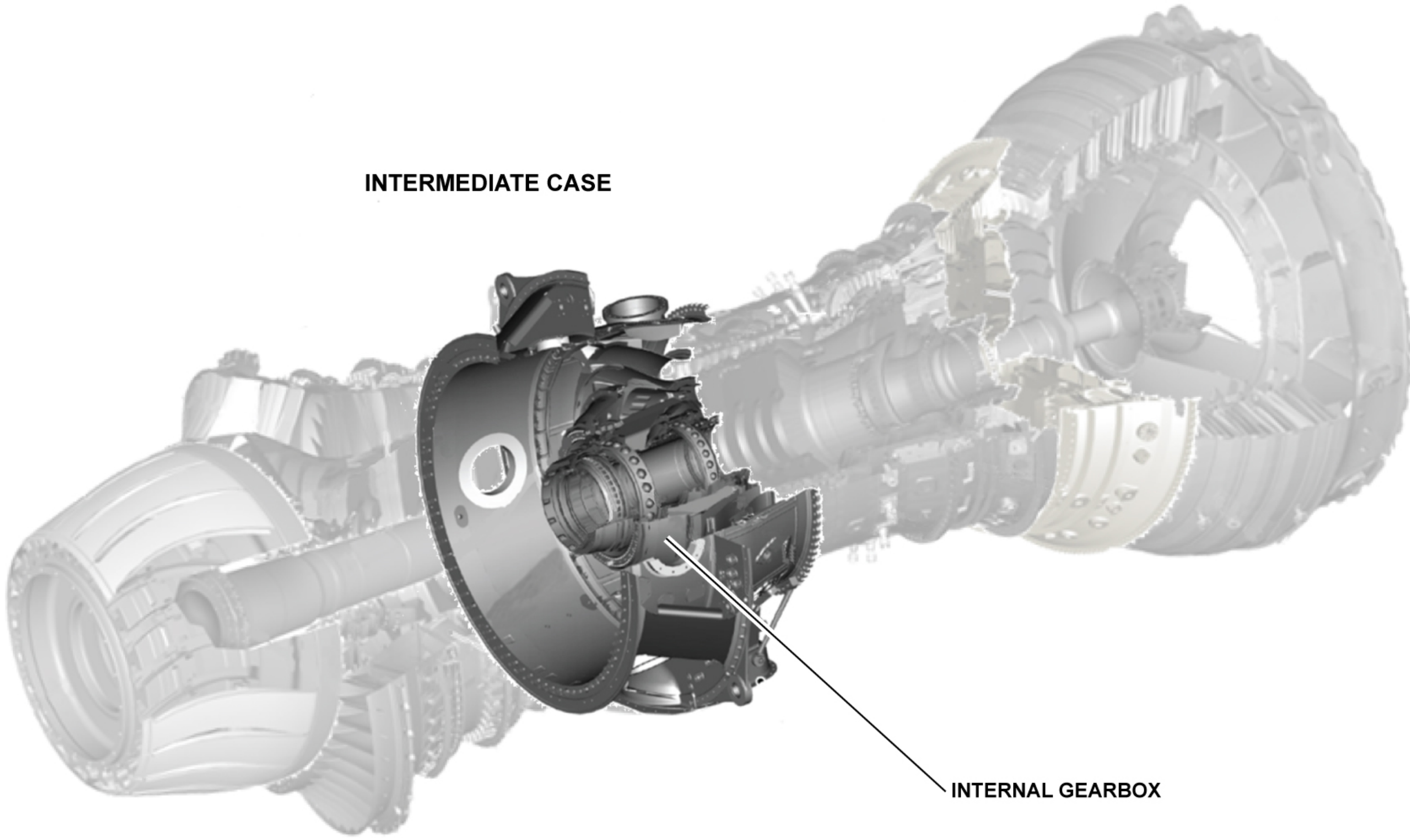
ENGINE CORE DESCRIPTION - IP COMPRESSOR AND IP TURBINE MODULES

ENGINE DESCRIPTION (2/3)

Engine Core Description (continued)

Intermediate Case

The intermediate case is an interface between the IP compressor and the HP system. It includes the internal gearbox.



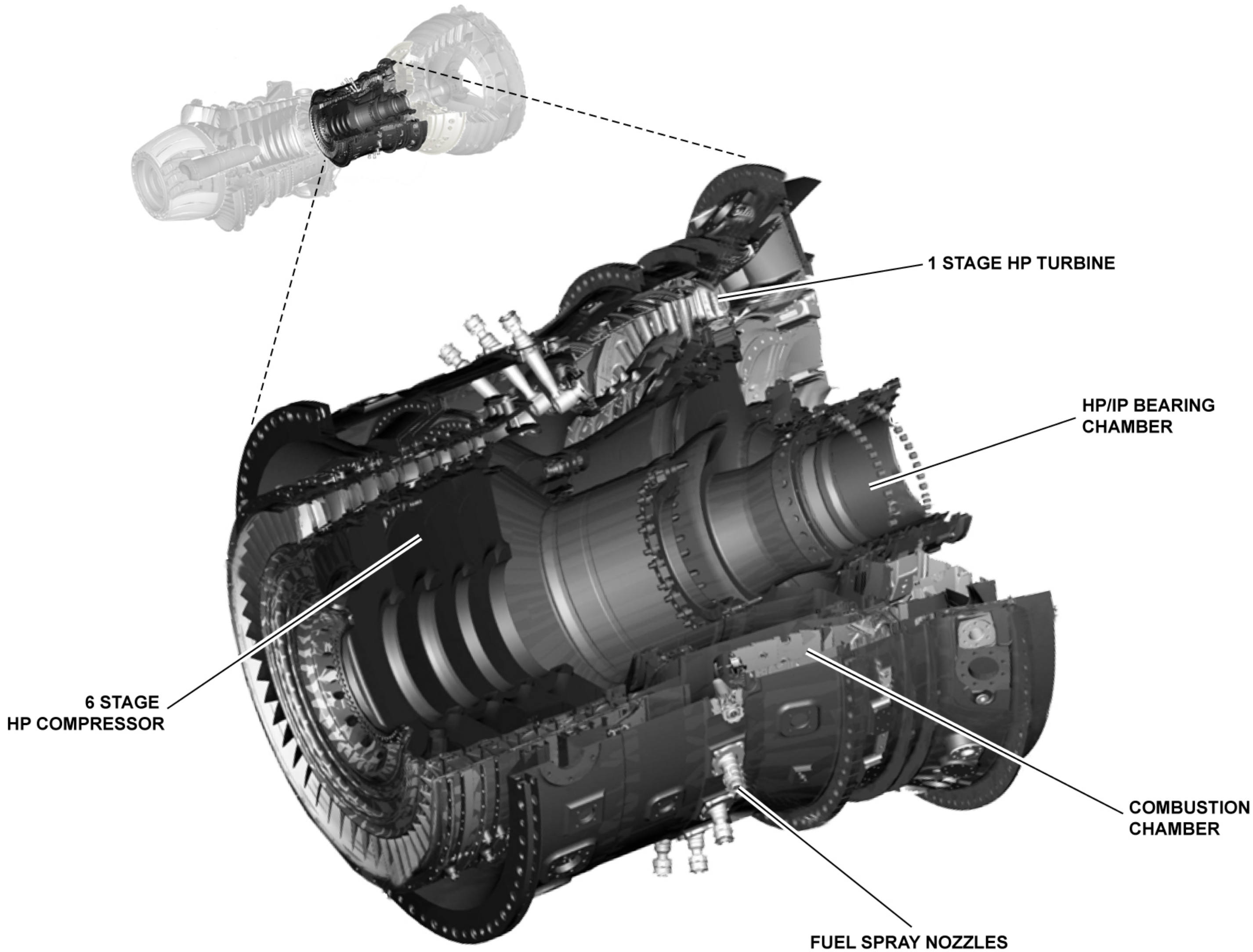
ENGINE CORE DESCRIPTION - INTERMEDIATE CASE

ENGINE DESCRIPTION (2/3)

Engine Core Description (continued)

HP System

The HP system has three major assemblies:
- A six stage axial compressor
- An annular combustion chamber with fuel spray nozzles (20) supplying the fuel and two igniters (not shown)
- A single-stage axial turbine. The HP/IP bearing chamber is attached aft of the HPT.



ENGINE CORE DESCRIPTION - HP SYSTEM

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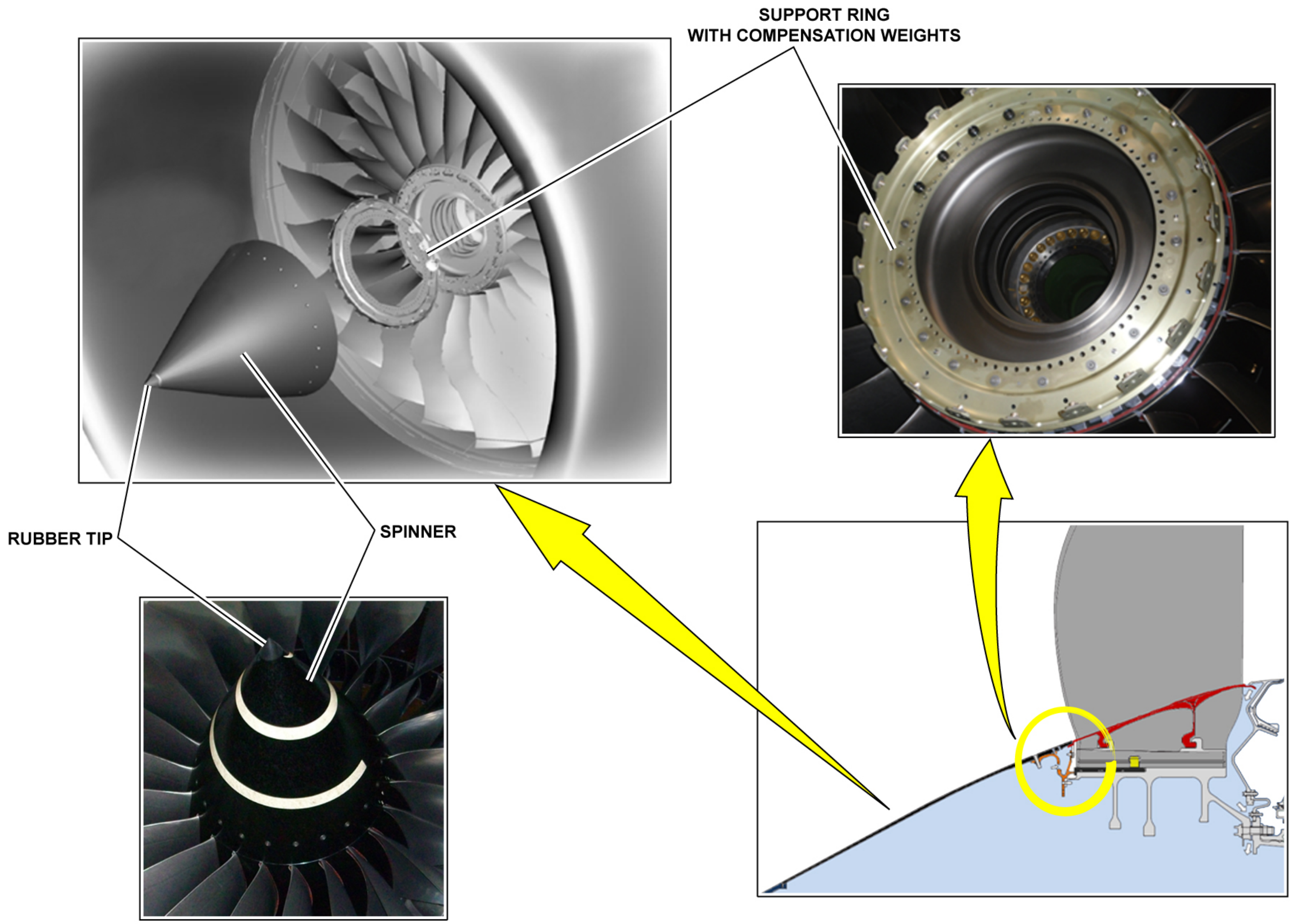
ENGINE DESCRIPTION (2/3)

Fan Assembly Description

Spinner

The spinner is a one piece composite conical part, which is installed at the front of the fan disc to give a smooth aerodynamic shape in the air intake.
To prevent ice accretion on the spinner, a rubber tip vibrates during engine running.
The spinner is bolted to the spinner support ring, which is bolted to the fan disc. The support ring has a flange where the compensation weights are installed.



FAN ASSEMBLY DESCRIPTION - SPINNER

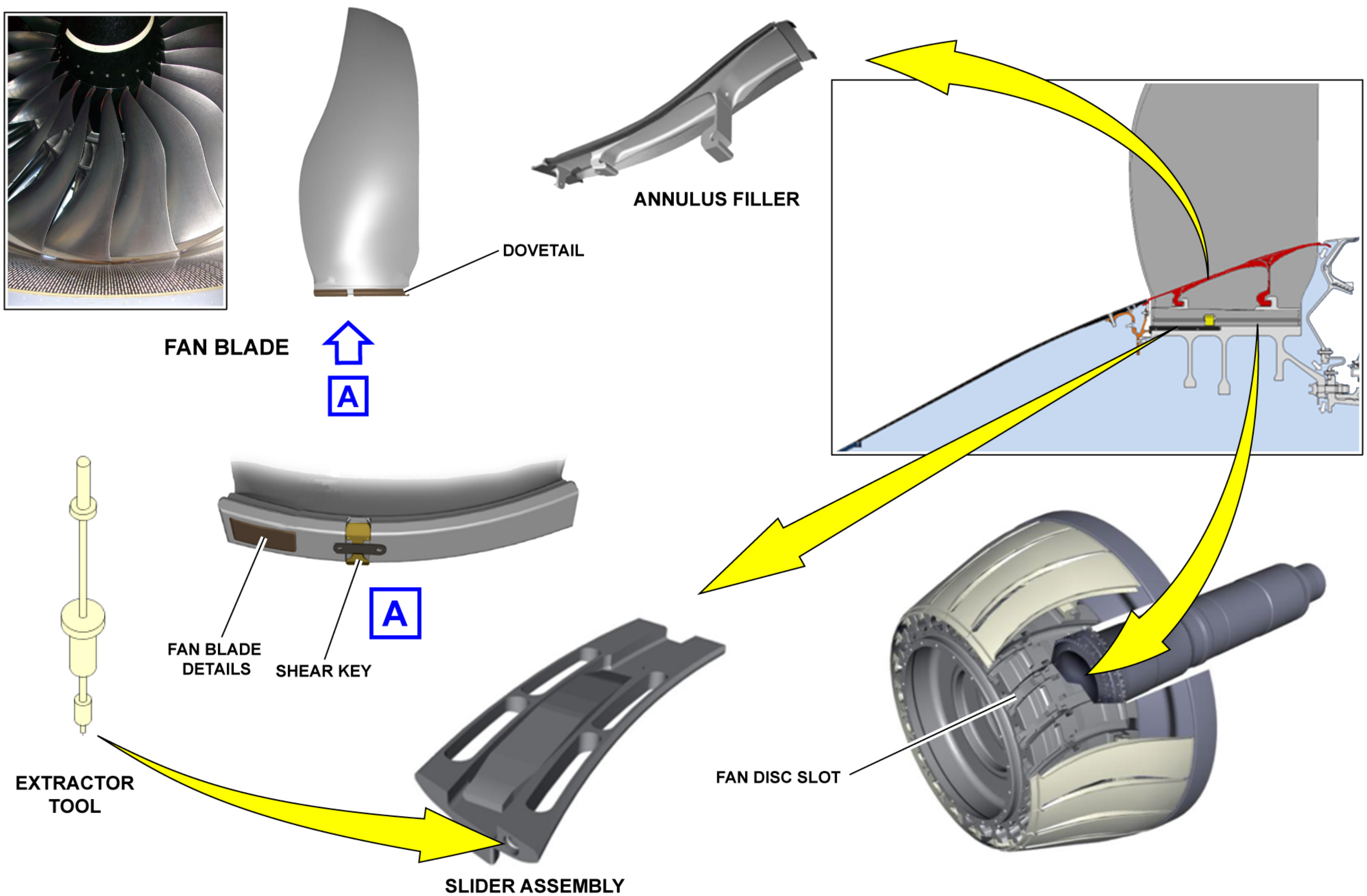
V1813401 - V01T0M0 - VM70D1ENGIN3001

ENGINE DESCRIPTION (2/3)

Fan Assembly Description (continued)

Fan Blades

Titanium fan blades (22) are installed on the fan disc. Each blade locates into the disc by a curved dovetail.
To keep the fan blade in axial position, there is a shear key on the blade dovetail, which goes into a recess located in the fan disc slot.
To keep the blade in the radial position, there is a slider assembly between the fan disc slot and the bottom of the blade dovetail.
The fan blade details (S/N, moment weight...) are viewed at the bottom of its dovetail.
To remove the slider assembly, an extractor tool is used.
Aluminum annulus fillers are installed between the blades to give a smooth aerodynamic contour.



FAN ASSEMBLY DESCRIPTION - FAN BLADES

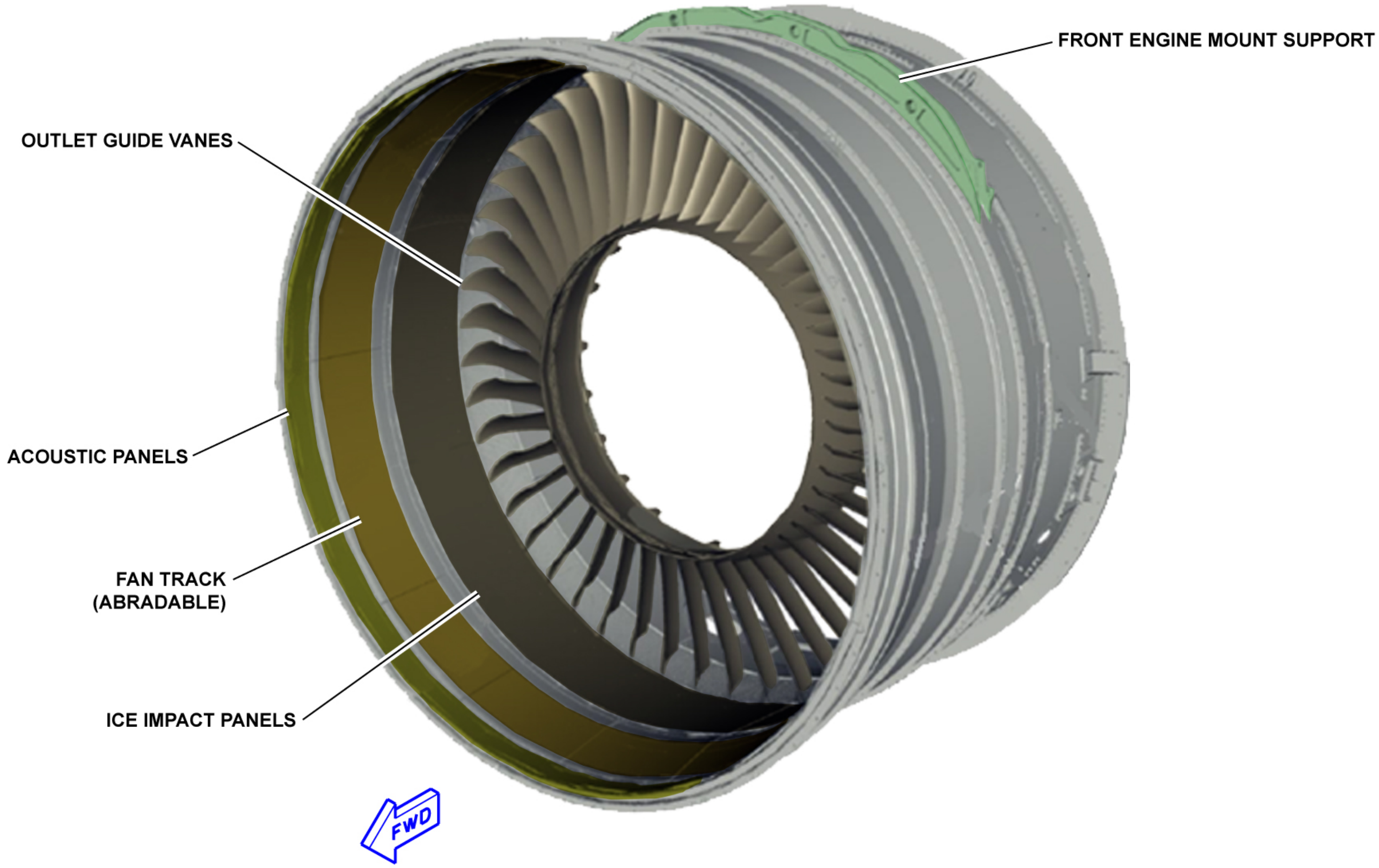
V1813401 - V01T0M0 - VM70D1ENGIN3001

ENGINE DESCRIPTION (2/3)

Fan Assembly Description (continued)

Fan Case

The fan case is bolted to the engine-core front end. Separation of the fan case from the engine core is possible for transportation. The fan case is the support for the external gearbox and the front engine mount. The forward part can contain a blade separation (titanium ring). Acoustic panels, fan track (with abradable) and ice impact panels are installed on the inner side. The rear part of the fan case is a ring (composite) which supports the A-frames (see fairings topic). An assembly of OGVs (titanium) forms an interface with the engine core.



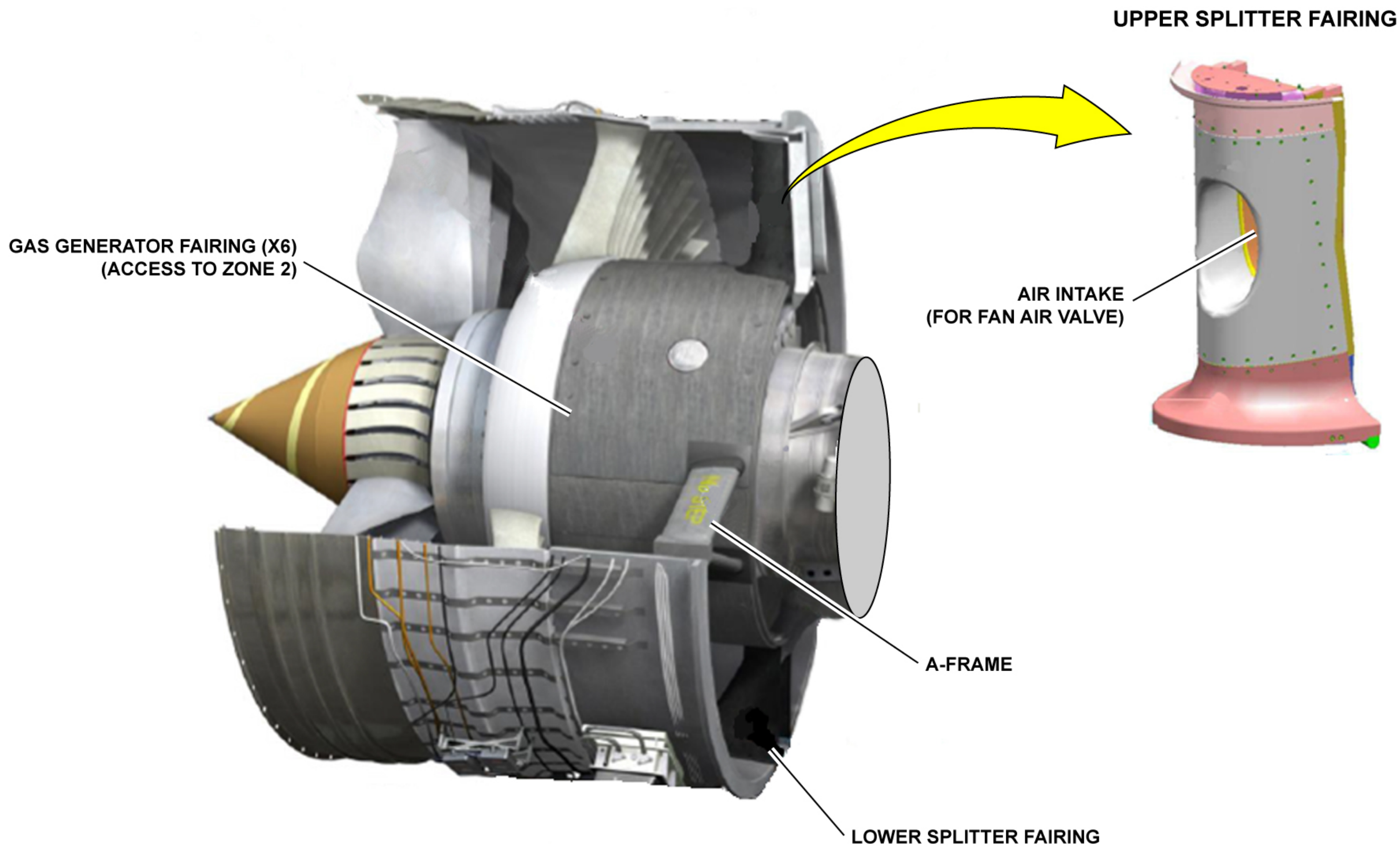
FAN ASSEMBLY DESCRIPTION - FAN CASE

ENGINE DESCRIPTION (2/3)

Fan Assembly Description (continued)

Fairings

To give a smooth inner aerodynamic contour for the fan airflow, a total of six gas generator fairings (one upper, one center and one lower on each side) are installed around the forward part of the IP compressor. Removal of the gas generator fairings is possible to get access to specific engine components.
Upper and lower splitter fairings give an aerodynamic contour around the upper and lower service struts and divide the fan airflow in the two C-ducts. The upper splitter fairing has an air intake which is used by the engine bleed air system heat exchanger (Precooler).
Two A-frames (one on each side) give the interface between the rear fan case and the engine core.



FAN ASSEMBLY DESCRIPTION - FAIRINGS

ENGINE DESCRIPTION (2/3)

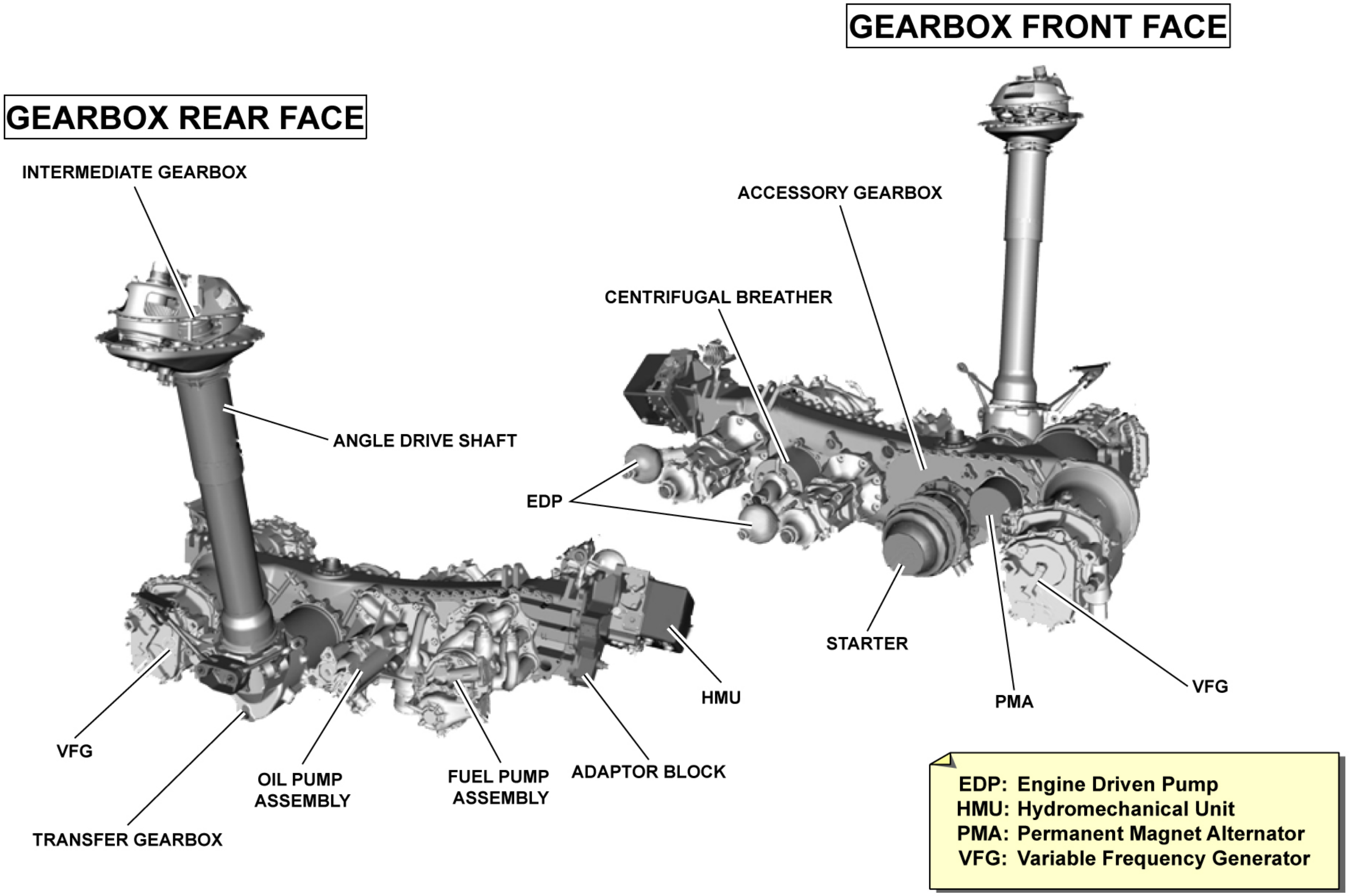
Gearbox Description

The gearbox module converts mechanical power from the HPC rotor to the accessory units. It also turns the rotor during starting.
The gearbox module is divided into four primary assemblies:
- The intermediate gearbox (step aside gearbox) connected at the bottom of the intermediate case
- The angle drive shaft
- The transfer gearbox
- The accessory gearbox.

The components mounted on the accessory-gearbox front face are:
- One VFG
- PMA
- Starter
- Two hydraulic EDPs
- Centrifugal breather.

The components mounted on the accessory gearbox-rear face are:
- One VFG
- Oil pump assembly
- Fuel pump assembly.

The HMU is on the adaptor block on the right side of the external gearbox.



GEARBOX DESCRIPTION

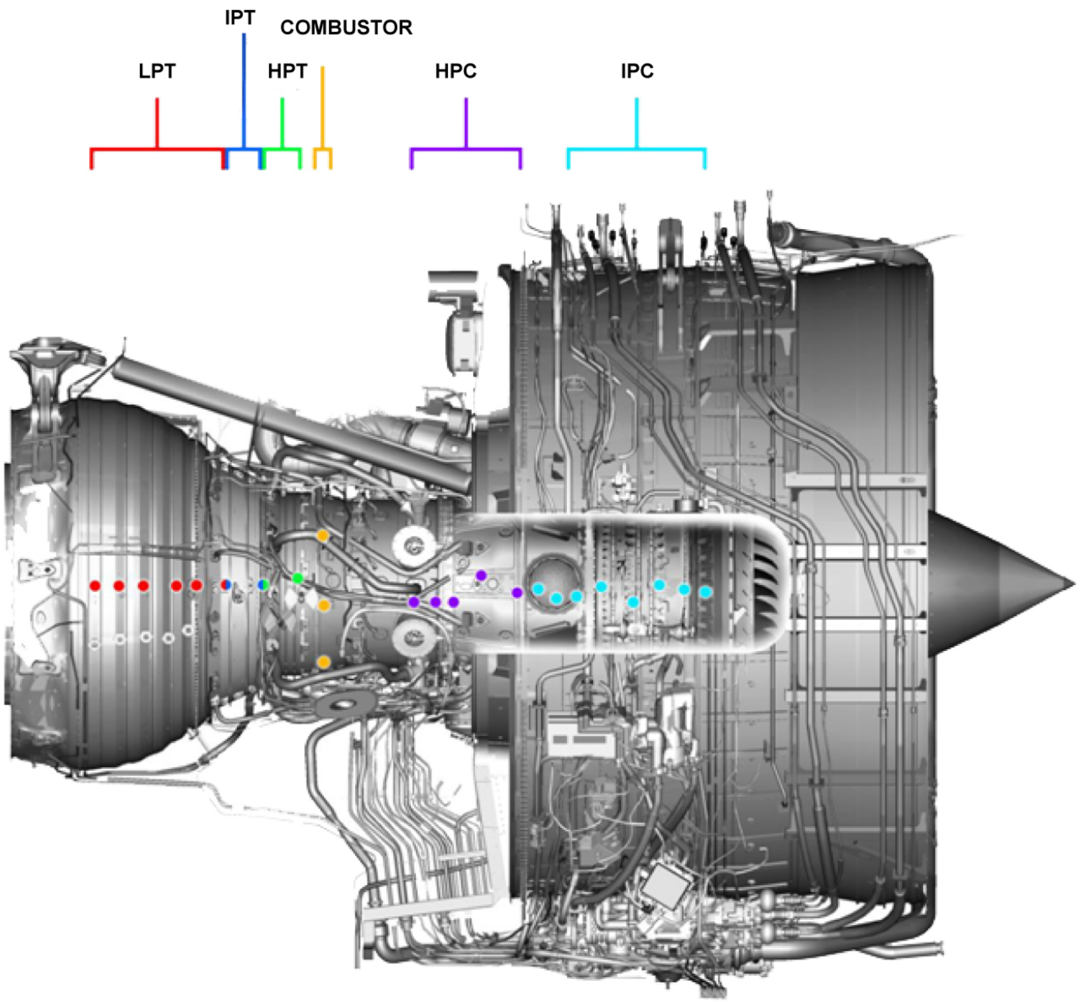
V1813401 - V01T0M0 - VM70D1ENGIN3001

ENGINE DESCRIPTION (2/3)

Borescope Description

Ports and Plugs

The borescope ports let the internal inspection of the gaspath with borescope equipment.
The compressor and turbine borescope access-ports are along the length of the right side of the engine.
The combustion chamber borescope access ports are positioned around the circumference of the combustion outer case.
There are different types of borescope plugs based on their location.
Some are removed by using an extraction tool.



BORESCOPE PLUGS

HPC: High Pressure Compressor
HPT: High Pressure Turbine
IPT: Intermediate Pressure Turbine
LPT: Low Pressure Turbine
IPC: Intermediate Pressure Compressor

BORESCOPE DESCRIPTION - PORTS AND PLUGS

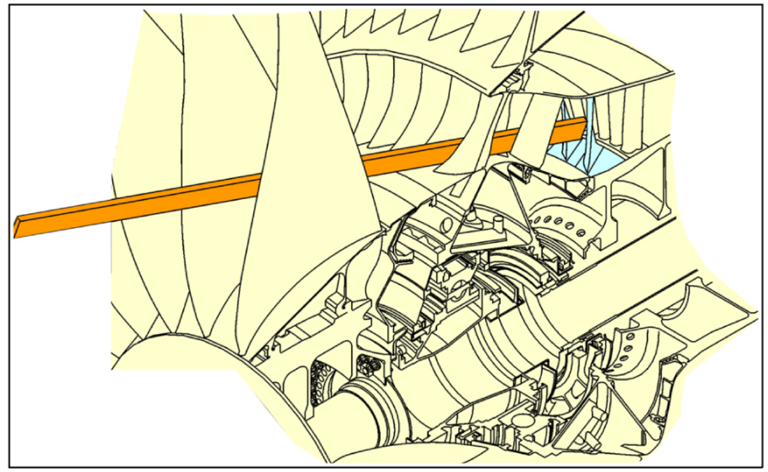
V1813401 - V01T0M0 - VM70D1ENGIN3001

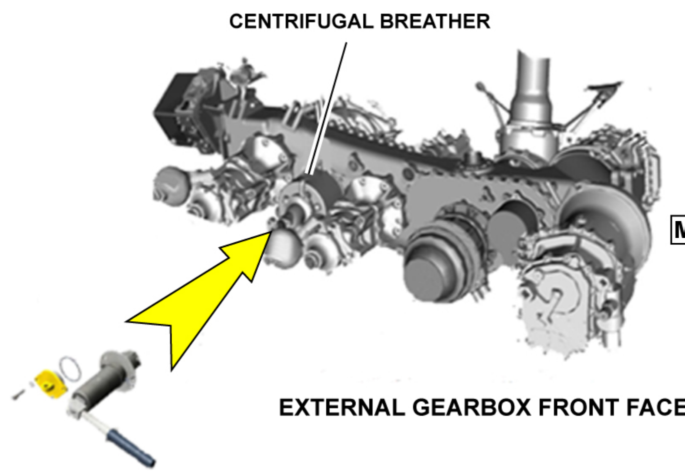
ENGINE DESCRIPTION (2/3)

Borescope Description (continued)

Manual Crank

The LP system can be manually rotated by turning the fan by hand.
The IP system can be manually turned using a dedicated tool to get access to the IP compressor first stage blades through the LPC fan blades.
The HP system can be manually cranked by installing a dedicated turning tool at the end of the centrifugal breather after removing its access plate.





HP: High Pressure
IP: Intermediate Pressure
LP: Low Pressure

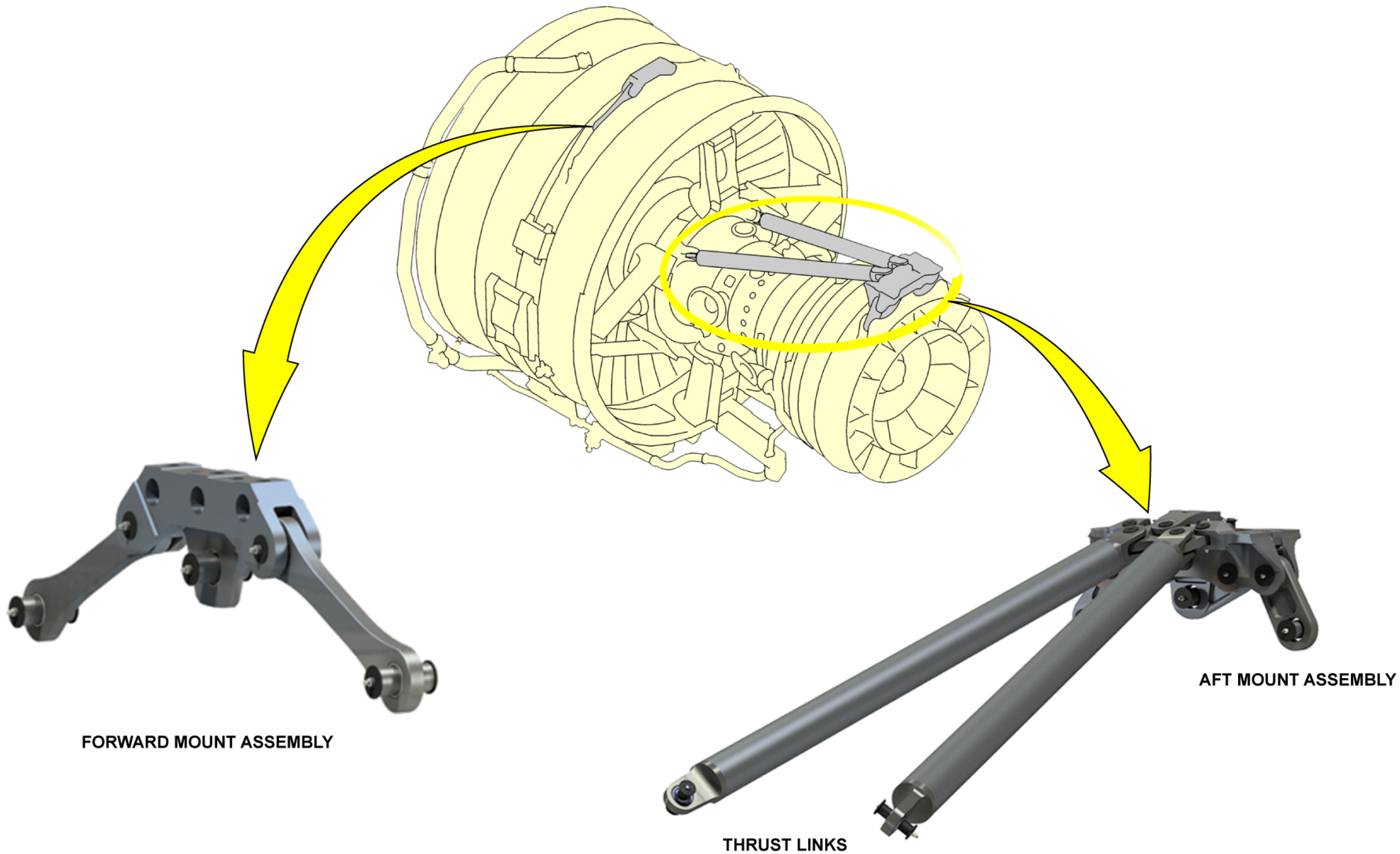
BORESCOPE DESCRIPTION - MANUAL CRANK

ENGINE DESCRIPTION (2/3)

Engine Mounts and Thrust Links Description

Three mount assemblies transmit the engine loads to the pylon primary structure.
- The forward mount assembly transmits the vertical and side loads. It attaches the top of the LPC case to the forward end of the pylon.
- The aft mount assembly transmits the vertical, side and torque loads. It attaches the top of the LPT exhaust case to the lower part of the pylon.
- The thrust mount assembly transmits the thrust of the engine to the pylon. It attaches each side of the intermediate case to the aft mount.

For an engine removal/installation the mount assemblies stay installed on the engine. They are part of the Quick Engine Change (QEC).



ENGINE MOUNTS AND THRUST LINKS DESCRIPTION

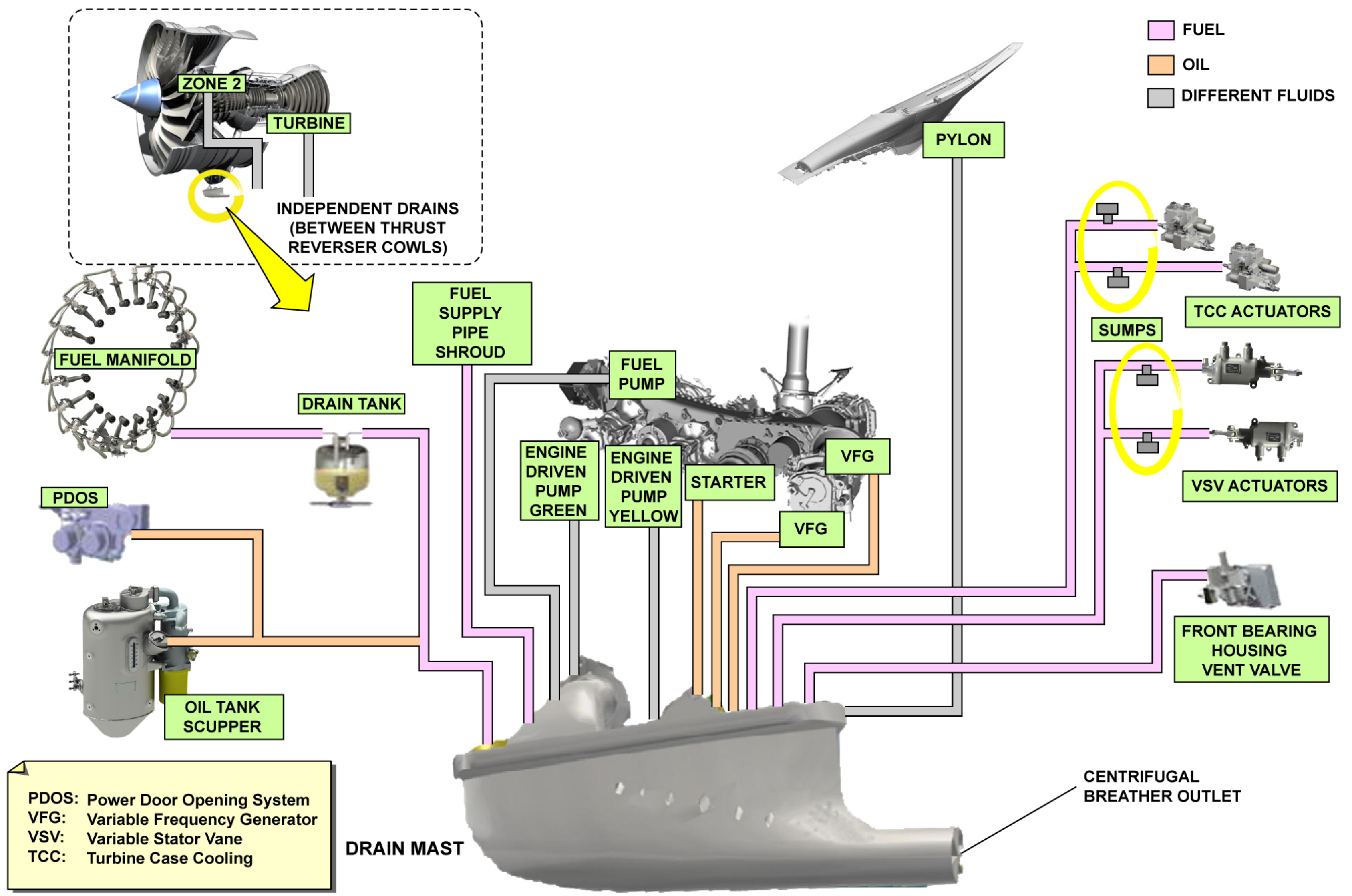
ENGINE DESCRIPTION (2/3)

Drain System Description

The power plant drains system can be divided into two types of drains:
- Drain mast
- Independent drain lines.

The drain mast drains different types of fluid:
- Fuel (fuel-supply pipe shroud, fuel pump, VSVAs, IP turbine and HPT Clearance Control (TCC) actuators, front bearing-housing vent-valve, drain tank)
- Oil (oil-tank filler scupper, air starter, VFGs, PDOS, EDPs, fuel pump)
- Hydraulic (green hydraulic pump, yellow hydraulic pump)
- Fluid coming from the pylon.

For easy troubleshooting, the drain lines are separated and identified.
Some lines (TCC actuators, VSVA) are grouped together and sumps equipped with screw plugs let identification of the leaking unit.
Air from the centrifugal breather is sent through a dedicated outlet.
Fluids from the Zone 2 or from the turbine case (wet start) are drained by two independent lines located at the split line between the Thrust Reverser (T/R) cowlings.



DRAIN SYSTEM DESCRIPTION

ENGINE AND NACELLE MAINTENANCE (3)

MORTORQ® Spiral Drive System

The MORTORQ® spiral drive-system gives better contact between the screw and the driver for higher torque capability and less damage to the screw.
The screw also has a low profile head.
This type of screws is used in different areas of the engine.

MORTORQ® SPIRAL DRIVE SCREW
- MORE TORQUE
- LESS DAMAGE

MORTORQ® SPIRAL DRIVE SYSTEM

ENGINE AND NACELLE MAINTENANCE (3)

Lockwireless Boroscope Plugs

Some of the Trent XWB boroscope-ports are attached with lockwireless boroscope plugs.
Lockwireless boroscope plugs lets:
- Self-lock during installation
- The use of standard tools for removal and installation.

LOCKWIRELESS BORESCOPE PLUGS

-SELF-LOCK DURING INSTALLATION
-STANDARD TOOL

LOCKWIRELESS BOROSCOPE PLUGS

ENGINE AND NACELLE MAINTENANCE (3)

Tooling for Engine Removal/Installation/Splitting

Engine Stands

For the Trent XWB two types of stand can be used:
- The whole engine stand, which lets transportation of the full engine
- The split engine stand, which lets splitting and transportation of the fan case assembly and the engine core.

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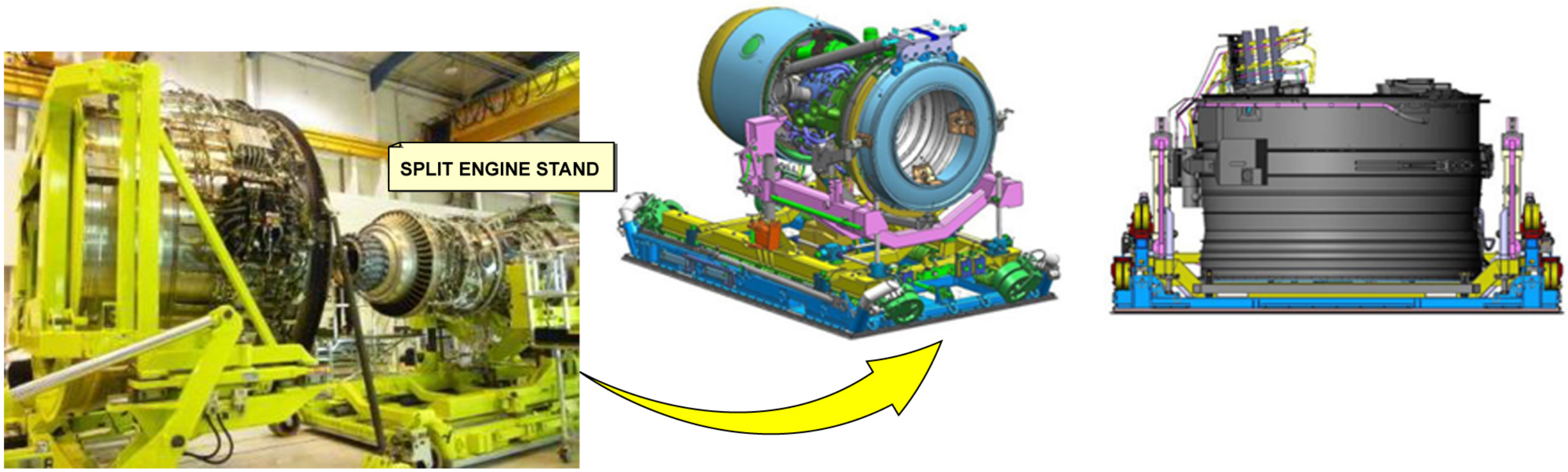


TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - ENGINE STANDS

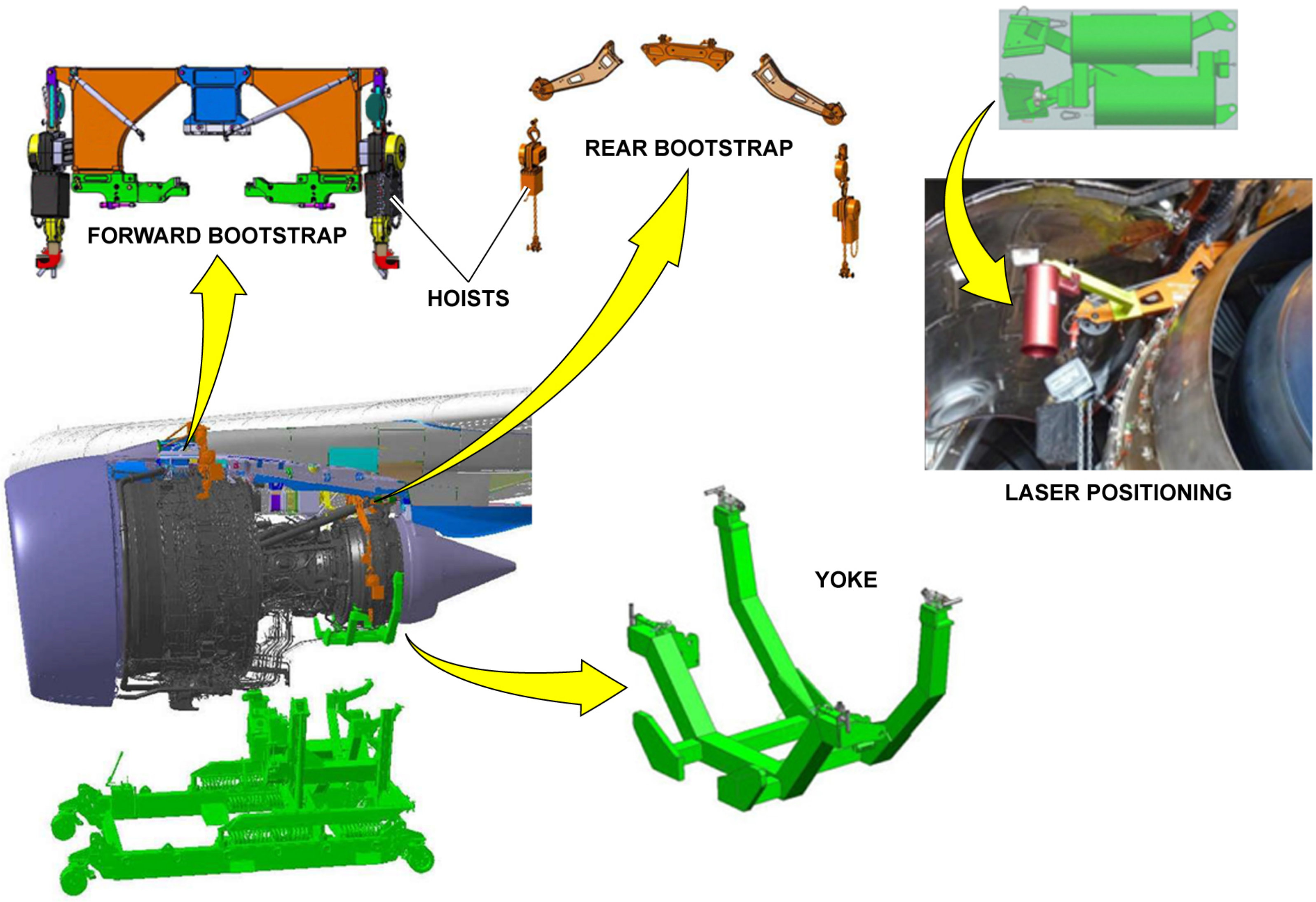
V1813401 - V01T0M0 - VM70M1MAINT3001

ENGINE AND NACELLE MAINTENANCE (3)

Tooling for Engine Removal/Installation/Splitting (continued)

Bootstrap Assemblies and Yoke

The bootstrap assemblies are used to lift or drop the engine between the engine stand and the pylon.
On the previous program, the engine is lifted with a cradle connected to the two bootstraps.
On the Trent XWB, the engine is lifted without a cradle: this is referred as direct lift.
The forward bootstrap hoists are connected to the fan case.
The rear bootstrap hoists are connected to a yoke installed around the engine turbine.
A laser positioning kit is installed on the rear bootstrap. It helps the operator to set the engine stand correctly.



TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - BOOTSTRAP ASSEMBLIES AND YOKE

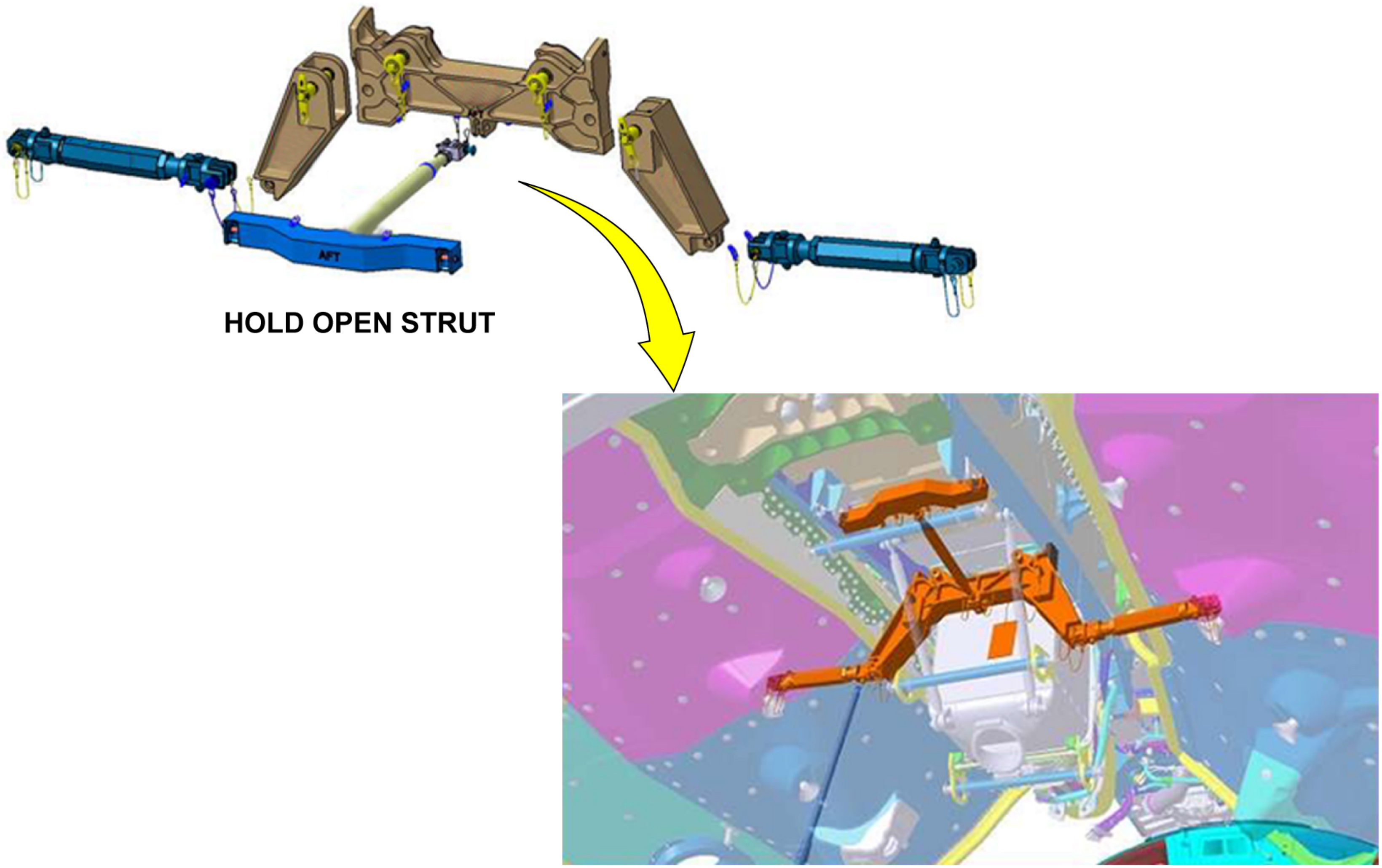
V1813401 - V01T0M0 - VM70M1MAINT3001

ENGINE AND NACELLE MAINTENANCE (3)

Tooling for Engine Removal/Installation/Splitting (continued)

Hold Open Strut

The hold open strut is a tool used to hold the Thrust Reverser (T/R) cowls open and locked in a fully open position during the removal and installation of the engine.



TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - HOLD OPEN STRUT

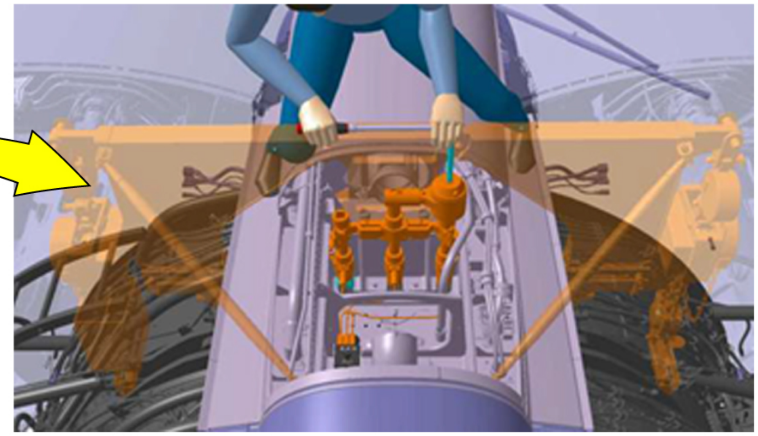
V1813401 - V01T0M0 - VM70M1MAINT3001

ENGINE AND NACELLE MAINTENANCE (3)

Tooling for Engine Removal/Installation/Splitting (continued)

Torque Equipment

Specific tools are used to torque the bolts maintaining the engine to the pylon.
A torque multiplier is used on the forward mount.
A rear engine mount torque assembly is used on the rear mount.

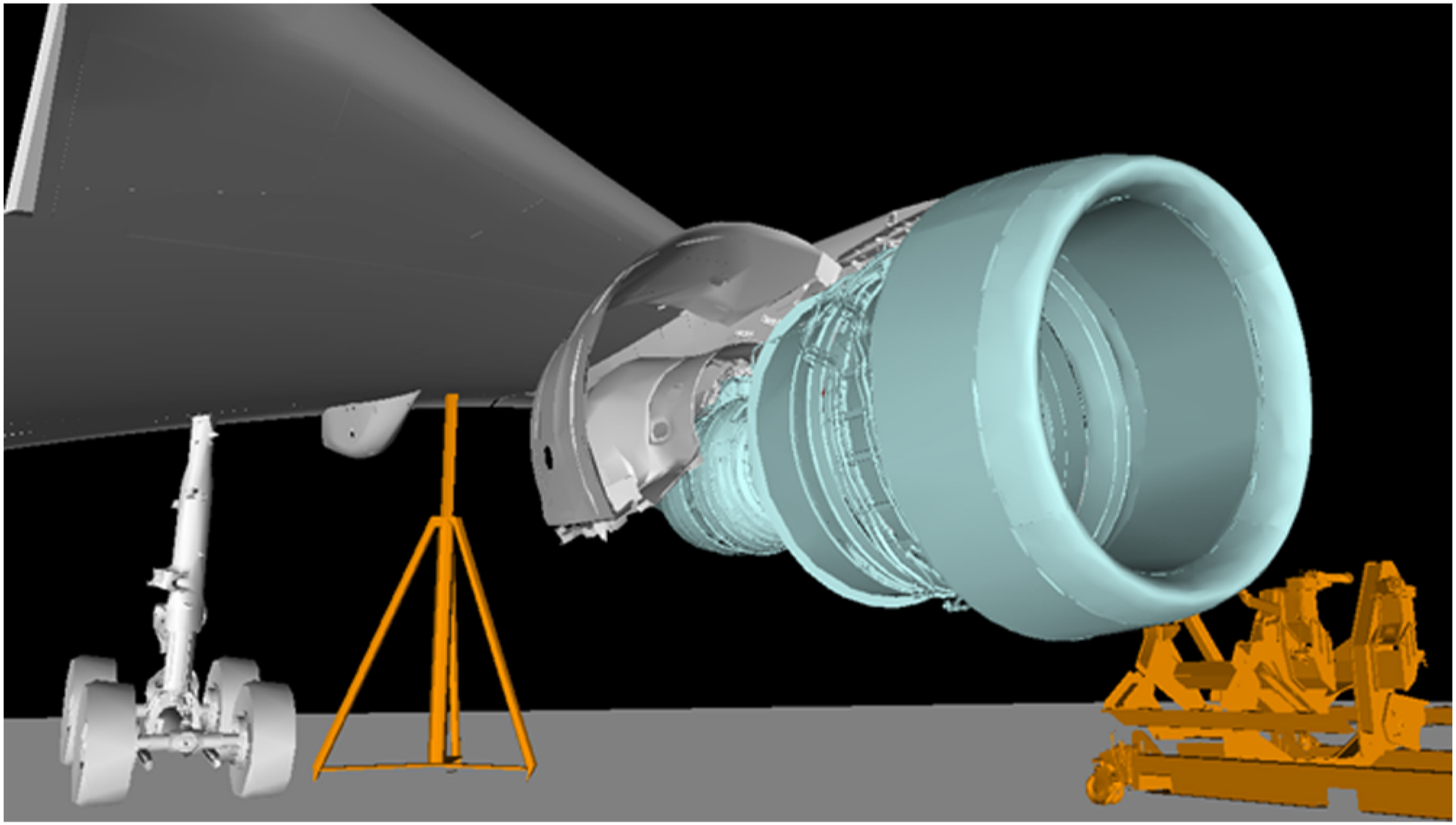


TORQUE MULTIPLIER

REAR MOUNT TORQUE ASSEMBLY

TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - TORQUE EQUIPMENT

BOOTSTRAP AND TORQUE EQUIPMENTS ANIMATION



TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - TORQUE EQUIPMENT

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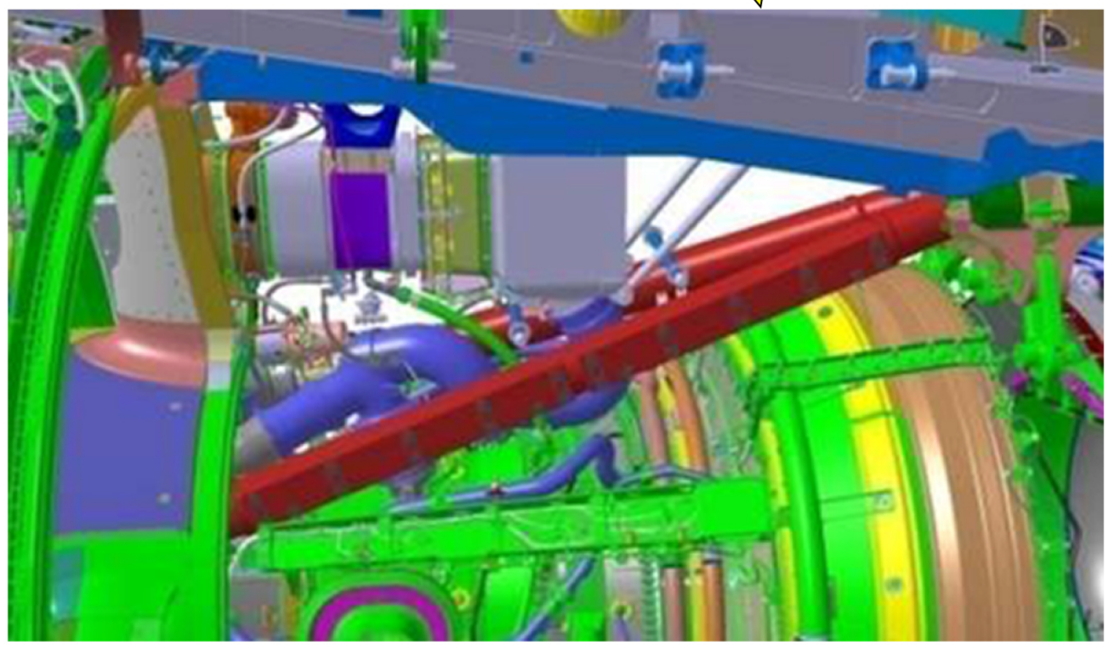
ENGINE AND NACELLE MAINTENANCE (3)

Tooling for Engine Removal/Installation/Splitting (continued)

Thrust Links Protections

Thrust links protections are installed around the thrust links during removal and installation of the engine.

THRUST LINKS PROTECTION



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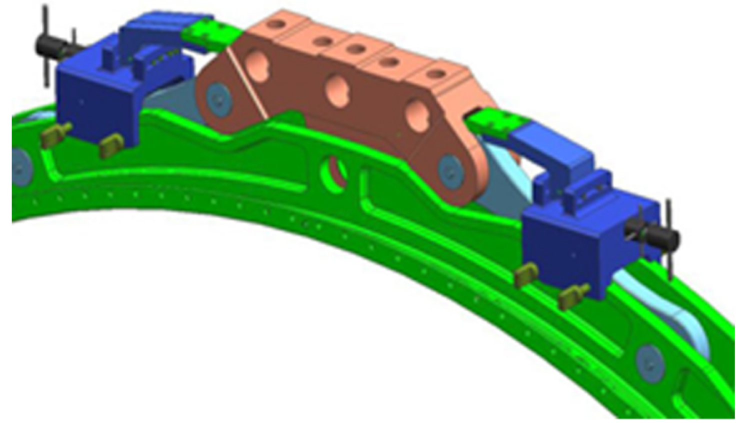
TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - THRUST LINKS PROTECTIONS

ENGINE AND NACELLE MAINTENANCE (3)

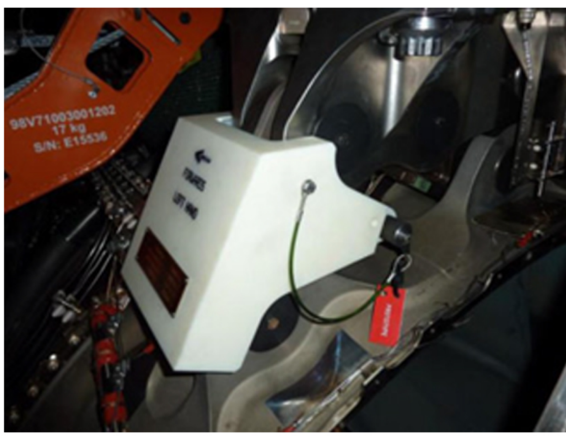
Tooling for Engine Removal/Installation/Splitting (continued)

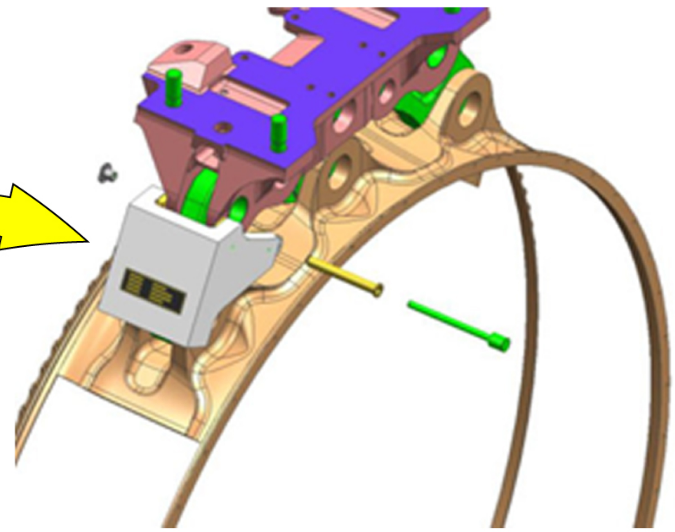
Mount Support Tools

The mount support tools limit the movement of the mounts during transportation.



FORWARD MOUNT SUPPORT TOOLS





REAR MOUNT SUPPORT TOOLS

TOOLING FOR ENGINE REMOVAL/INSTALLATION/SPLITTING - MOUNT SUPPORT TOOLS

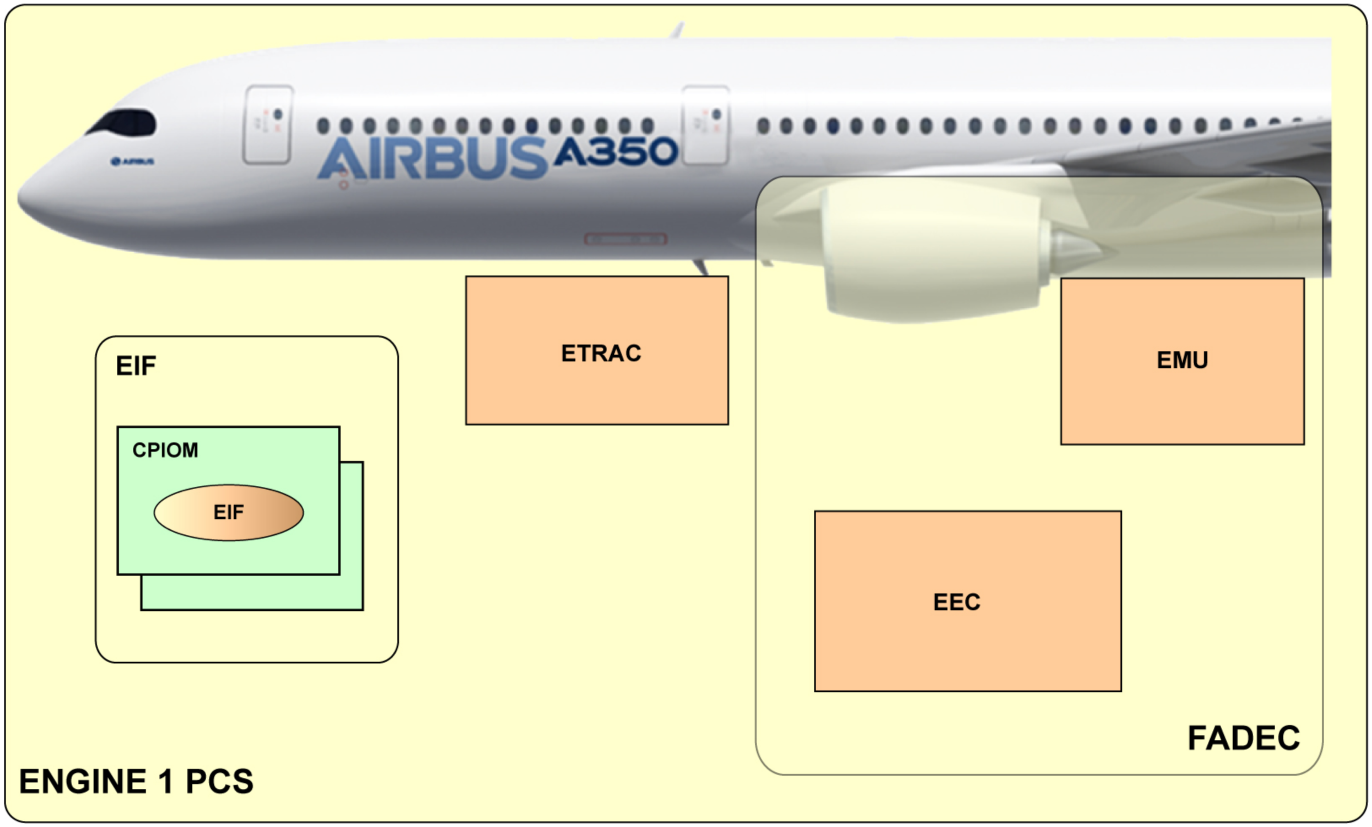
V1813401 - V01T0M0 - VM70M1MAINT3001

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

Propulsion Control System (PCS) General Presentation

The PCS controls and monitors the engine.
For each engine the PCS has these components:
- One Engine Electronic Controller (EEC), on the engine
- One Engine Monitoring Unit (EMU), on the engine
- One Engine Interface Function (EIF) with two EIF applications hosted in two different Core Processing Input/Output Modules (CPIOMs)
- One Engine Thrust Reverser Actuation Controller (ETRAC), on the airframe.

The Full Authority Digital Engine Control (FADEC) system is a part of the PCS and primarily consists of the EEC and the EMU.



NOTE:
ENGINE 1 PCS IS SHOWN.
ENGINE 2 PCS IS SIMILAR.

CPIOM:	**Core Processing Input/Output Module**
EEC:	**Engine Electronic Controller**
EIF:	**Engine Interface Function**
EMU:	**Engine Monitoring Unit**
ETRAC:	**Electronic Thrust Reverser Actuation Controller**
FADEC:	**Full Authority Digital Engine Control**
PCS:	**Propulsion Control System**

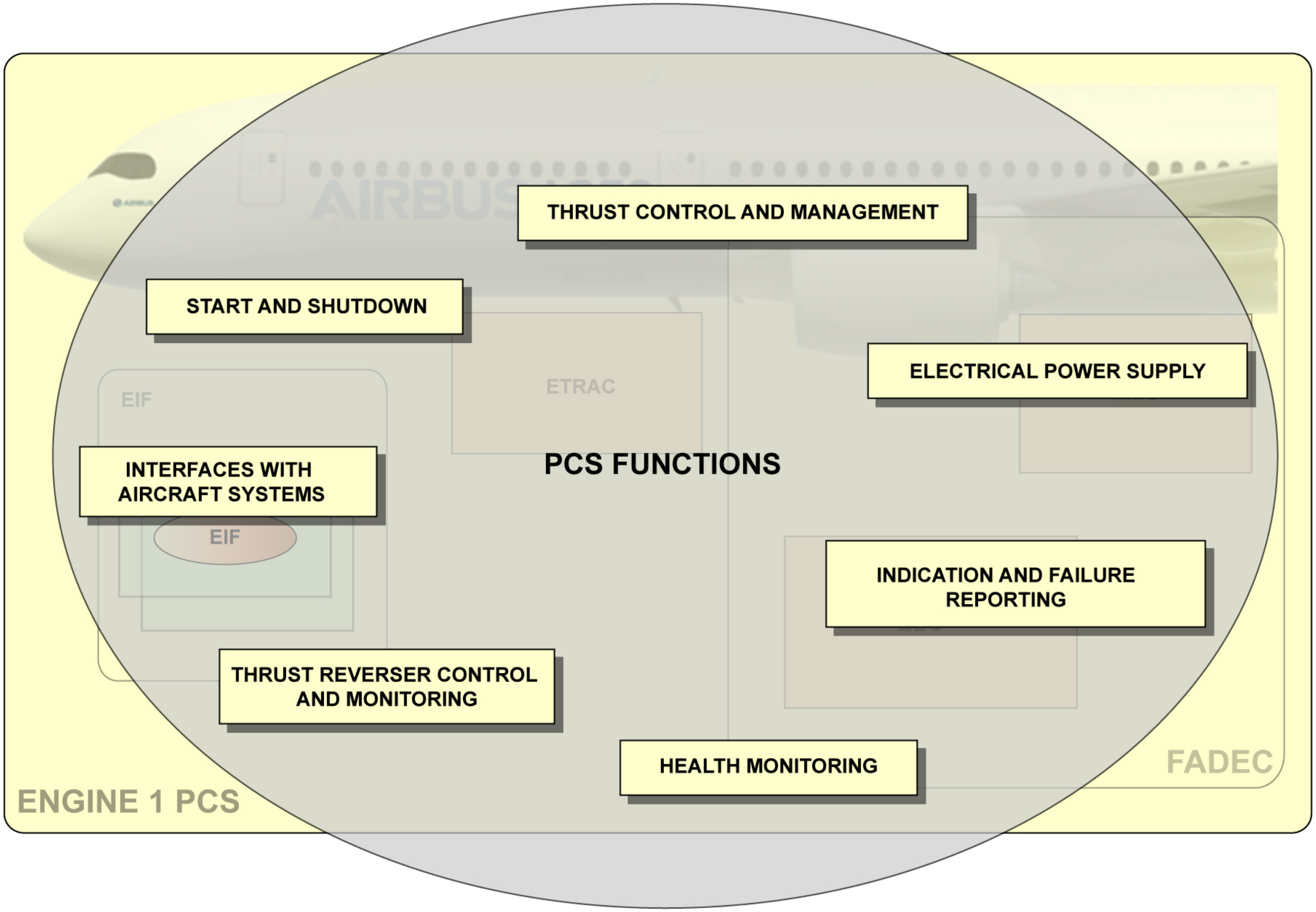
PROPULSION CONTROL SYSTEM (PCS) GENERAL PRESENTATION

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description

PCS Functions

The PCS manages:
- The engine start and shutdown
- The thrust control and management
- The electrical power supply to the system
- The engine indicating and failure reporting
- The generation of data for monitoring of engine health
- The Thrust Reverser (T/R) control and monitoring
- The interface between the engine and the aircraft systems.



PCS FUNCTION/DESCRIPTION - PCS FUNCTIONS

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description (continued)

EIF and EEC Functions

The EEC and the EIF are the heart of PCS. They work together as a team and share the engine primary functions:
- Start and shutdown: The EIF receives cockpit selection and sends data to the EEC for engine starting and shutdown
- Thrust control and management: The EIF sends the throttle-lever position signals and the air data to the EEC. With these data the EEC controls and manages the thrust
- Electrical power supply: The EIF controls the supply of electrical power to the system (with EEC, ETRAC and EMU) from the aircraft electrical system
- T/R control and monitoring: The EIF and the EEC are involved in the T/R control and monitoring system
- Engine indication and warning: The EEC supplies most of the indications to the cockpit display system
- Interface with the aircraft systems: The EIF is the primary interface between the EEC and the aircraft systems. The EIF receives, selects and consolidates numerous aircraft data and sends them to the EEC. The EIF also consolidates engine data and sends them to the different aircraft systems.

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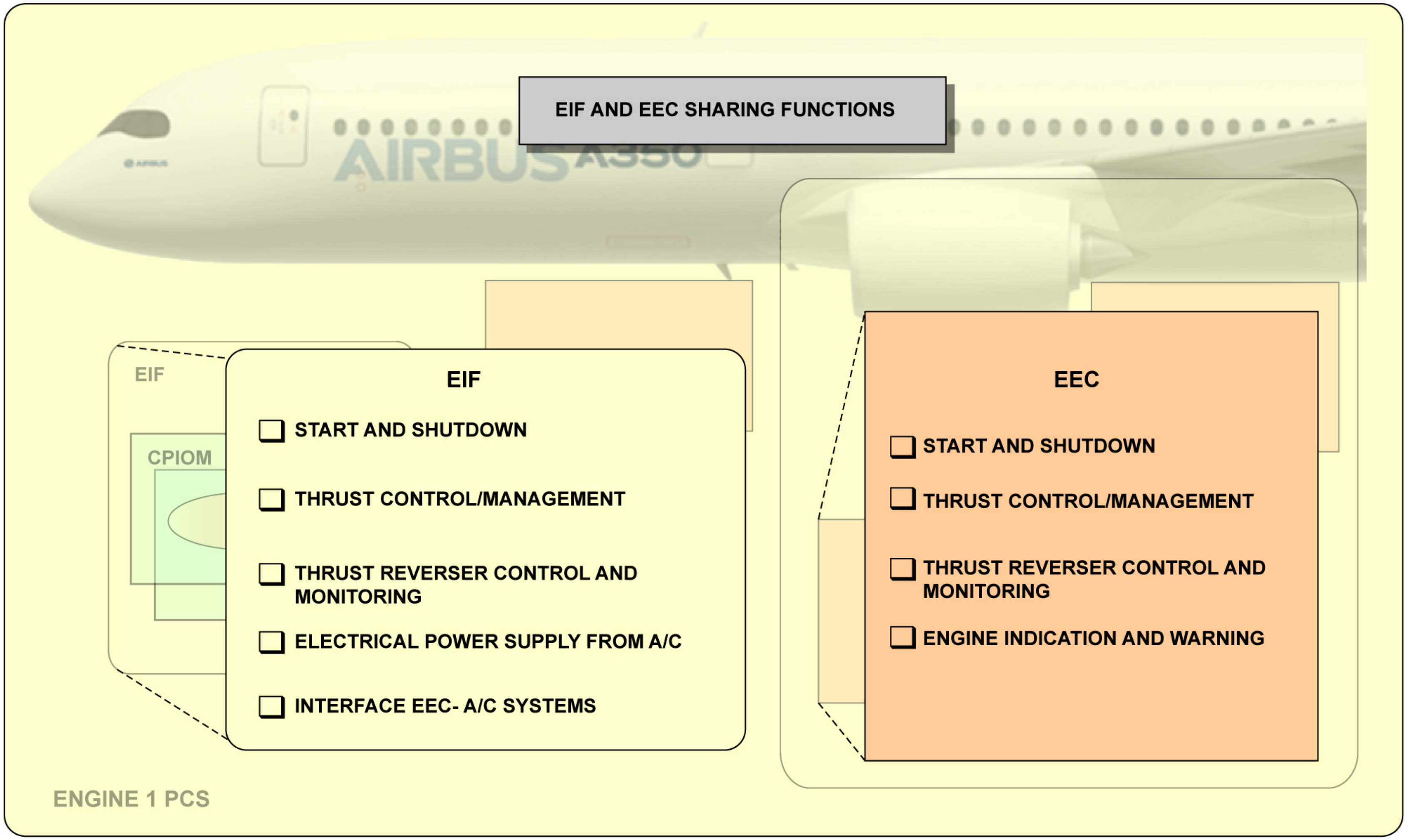

PCS FUNCTION/DESCRIPTION - EIF AND EEC FUNCTIONS

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description (continued)

ETRAC and EMU Functions

The ETRAC is the central computer in the T/R control system.
The functions of EMU are health monitoring, vibration computation and fan trim balance. It has no control on the engine operation.

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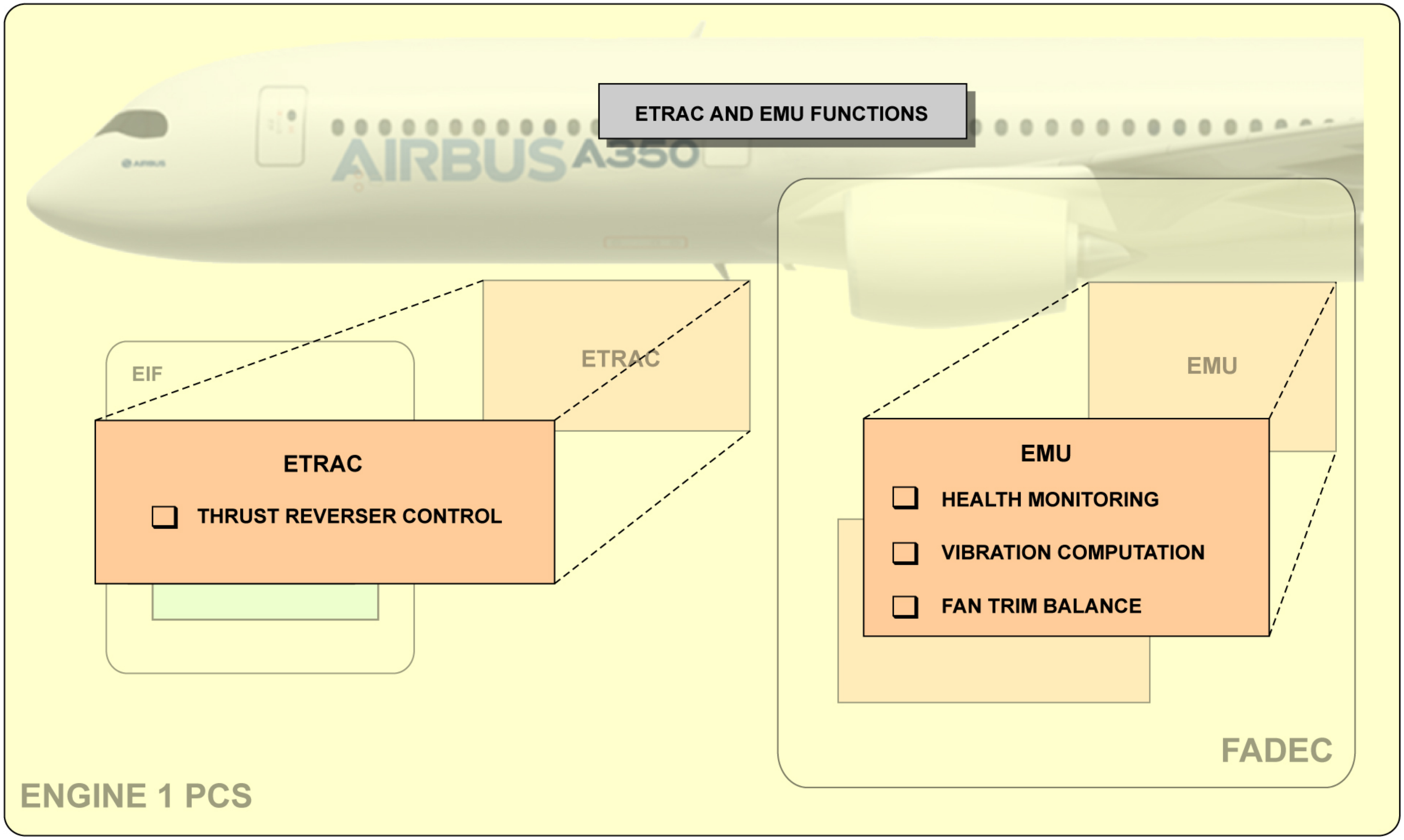


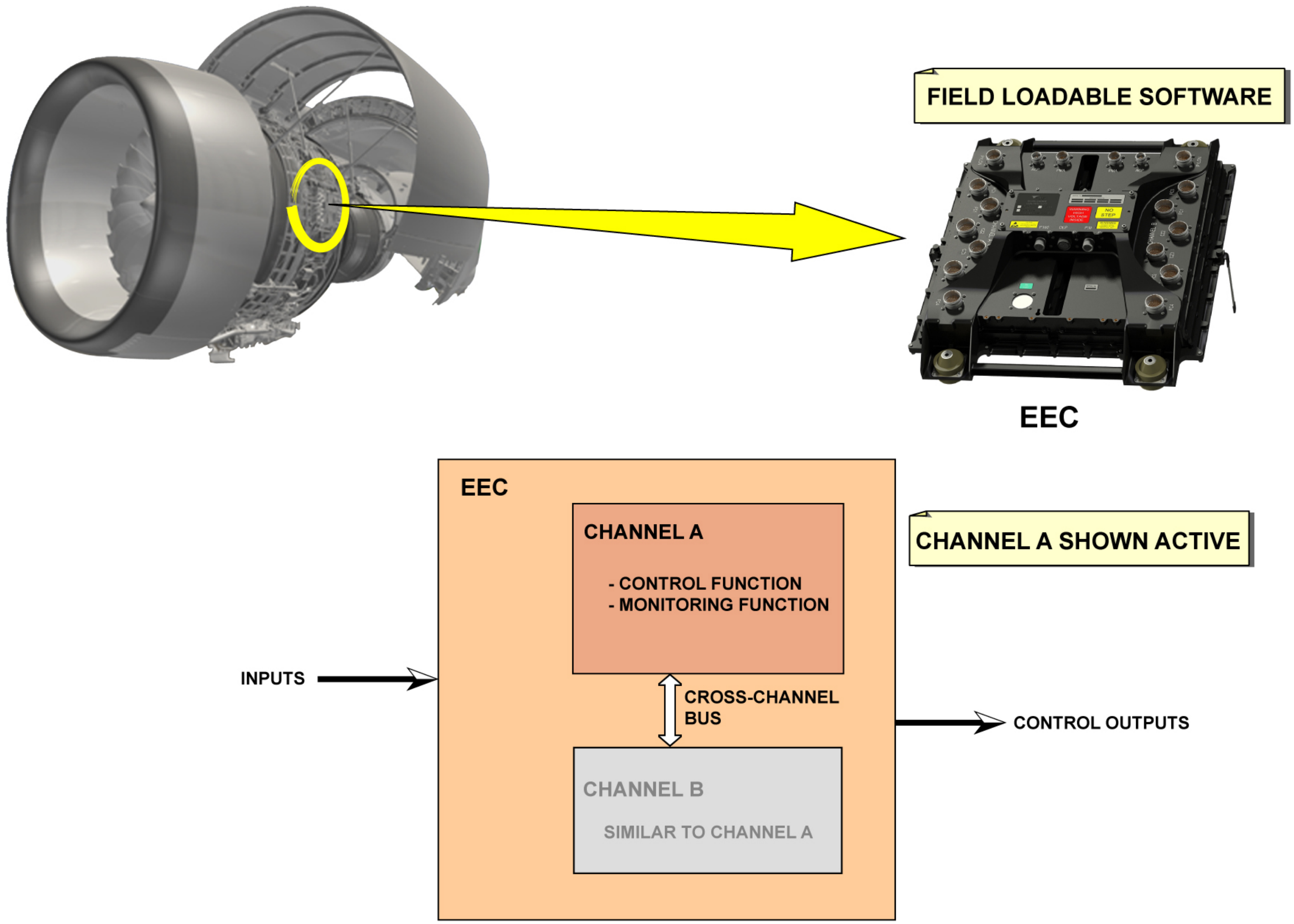
PCS FUNCTION/DESCRIPTION - ETRAC AND EMU FUNCTIONS

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description (continued)

EEC Description

The EEC is a dual channel computer installed on the fan case (left hand side). Only one channel (channel A or channel B) is in control at a time, the other one is in stand-by mode and will operate, if there is a major failure in the control channel. Without failure, there is an automatic change-over at each start. A cross-channel digital bus gives a mean of exchange between the channels. The EEC includes field loadable software.
Each channel control function sends control outputs to the engine systems. A monitoring function in each channel shuts the engine down, if there is a major failure.



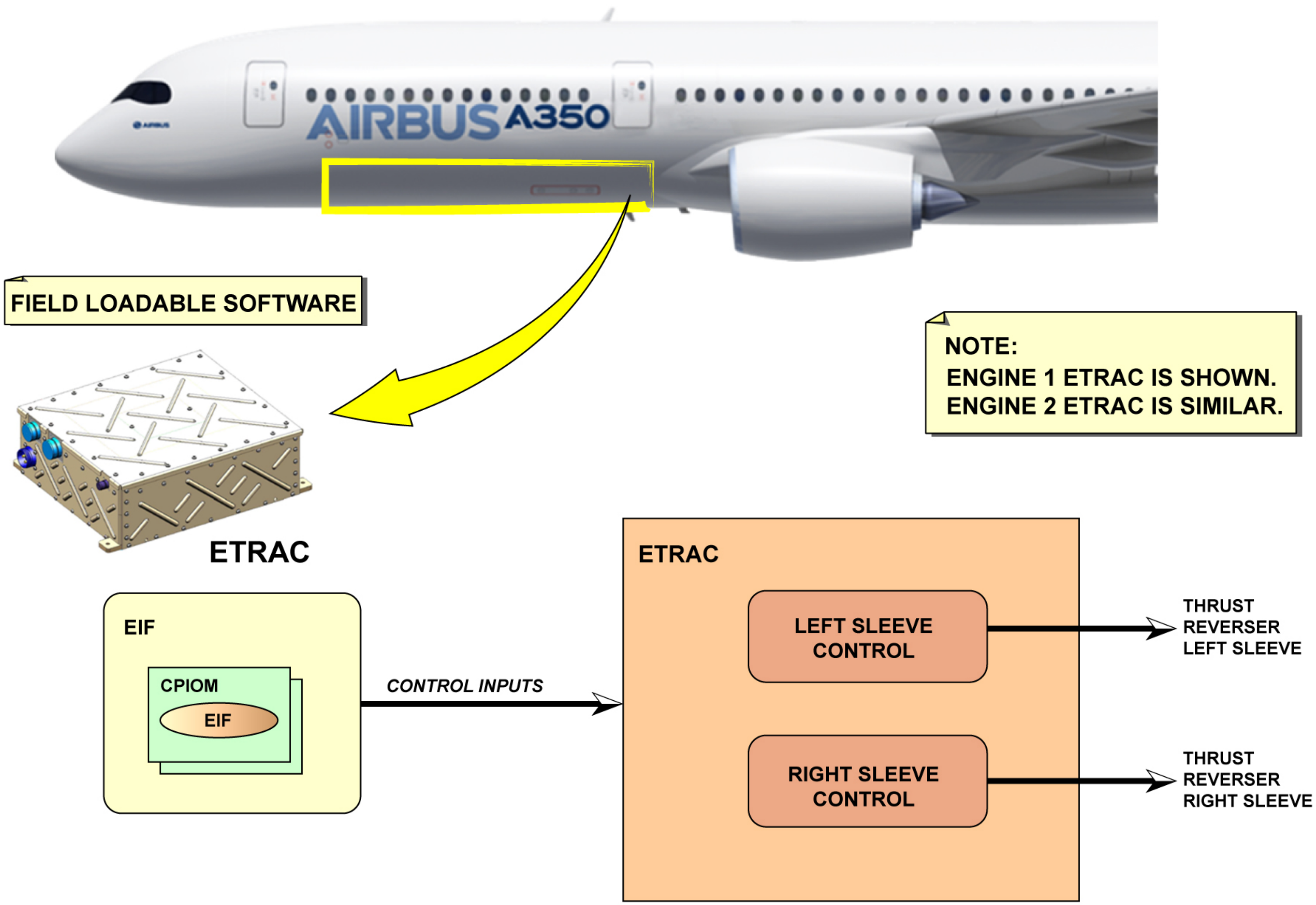
PCS FUNCTION/DESCRIPTION - EEC DESCRIPTION

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description (continued)

ETRAC Description

The ETRAC is a computer installed in the aft part of the forward cargo compartment. There is one ETRAC per engine. Each engine T/R includes two translating sleeves: left and right. The ETRAC independently controls the left and the right translating sleeves. The command signals (stow or deploy) come from the related EIF. The ETRAC includes field loadable software.



PCS FUNCTION/DESCRIPTION - ETRAC DESCRIPTION

V1813401 - V01T0M0 - VM70D4PCSAR3001

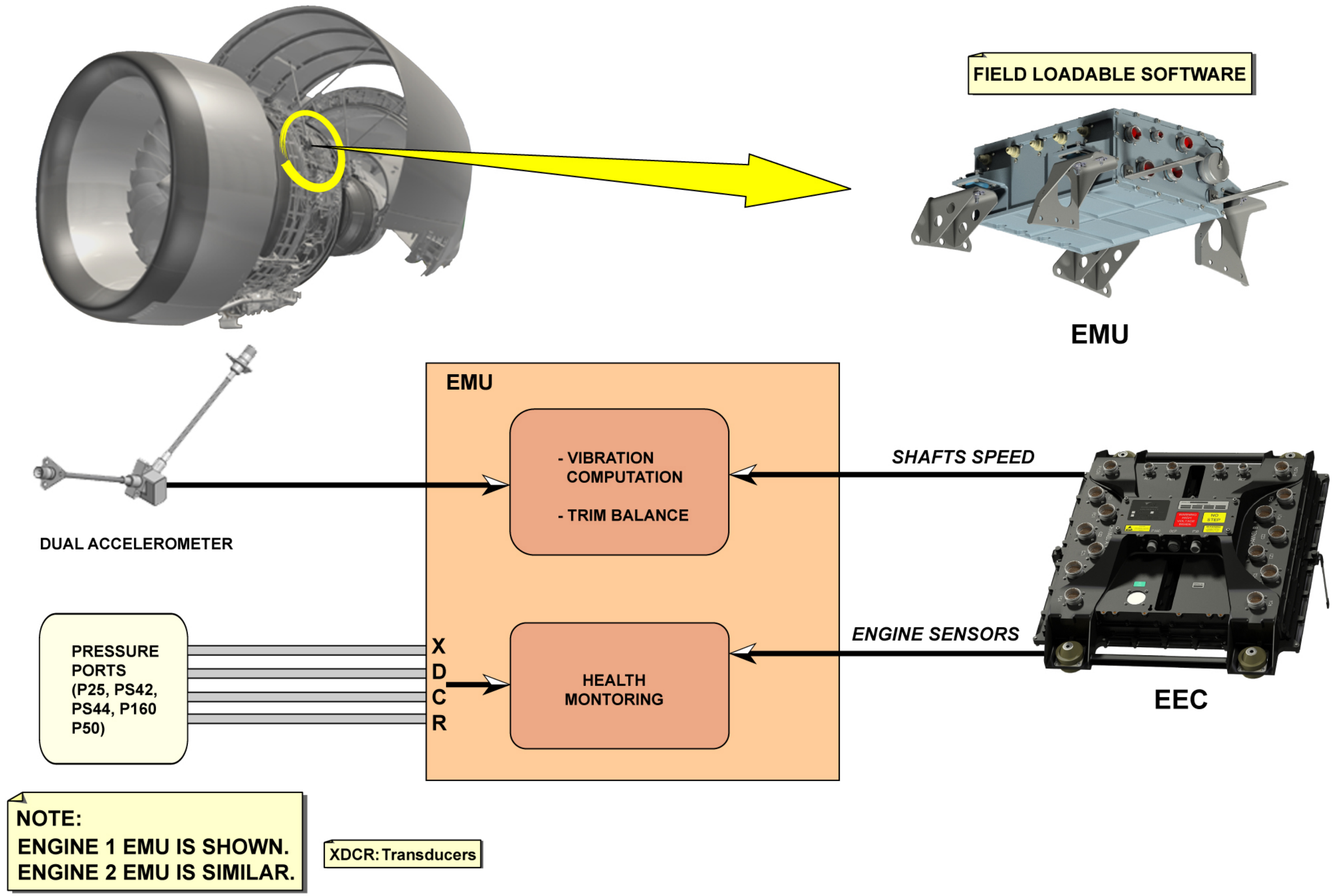
PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Function/Description (continued)

EMU Description

The EMU is a computer installed on the engine fan case (left hand side). The EMU includes field loadable software and does:

- Vibration computation and trim balance calculation. The EMU uses amplified signals from a dual accelerometer and shaft speed inputs sent by the EEC
- Engine Health Monitoring (EHM) by collecting pressure data (P25, Ps42, Ps44, Ps160, P50) from dedicated pressure ports and engine data inputs from the EEC sensors. This function is designed to give diagnostic information.



PCS FUNCTION/DESCRIPTION - EMU DESCRIPTION

V1813401 - V01T0M0 - VM70D4PCSAR3001

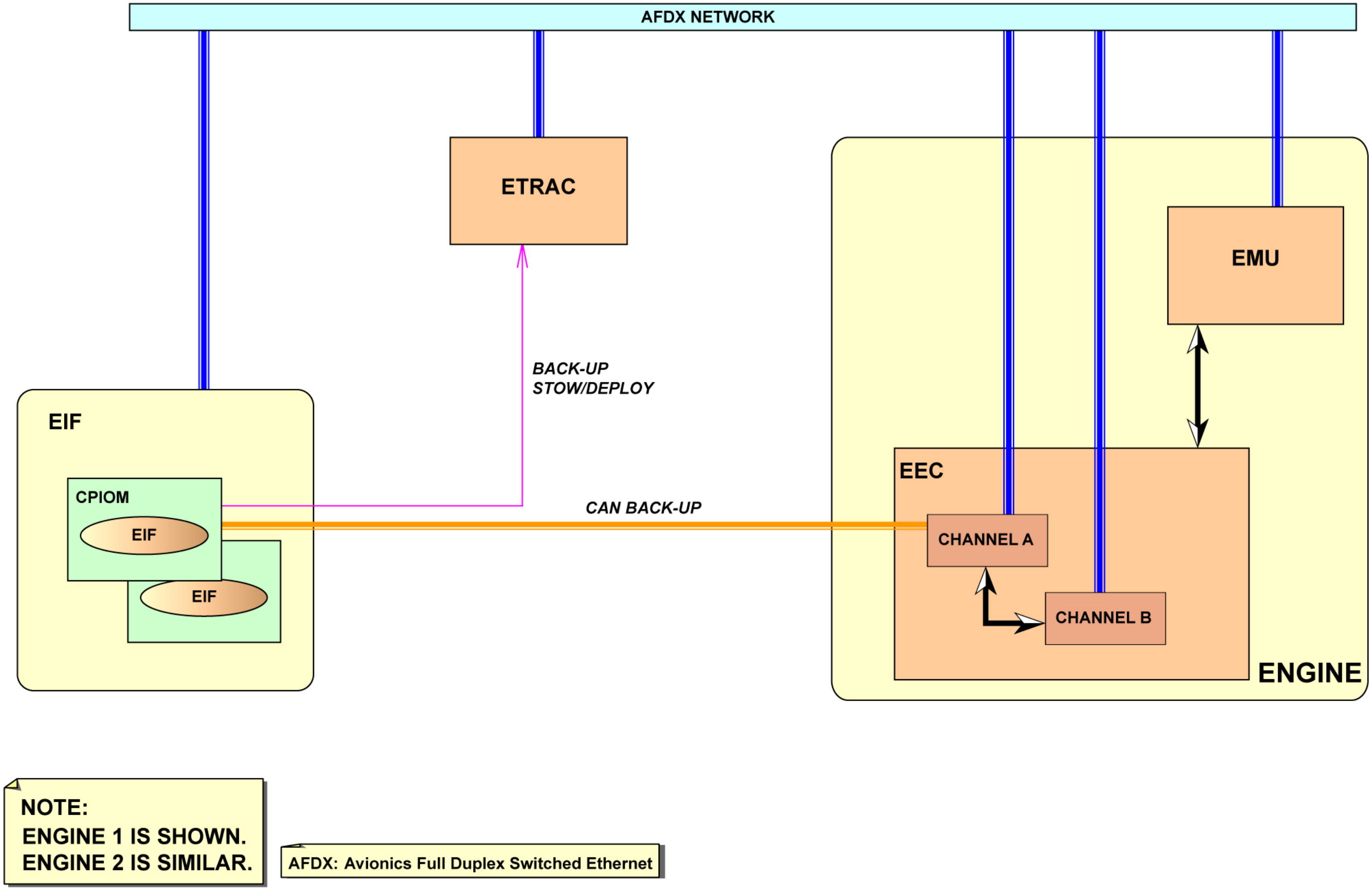
PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Interfaces

Interfaces within the PCS

The Avionics Full Duplex Switched Ethernet (AFDX) network is the primary source of communication within the PCS. The primary streams of data exchange are:

- EIF and EEC channels communicate through the AFDX network to do their related functions. A back-up Controller Area Network (CAN) bus connects one of the 2 EIF applications to one EEC channel (Channel A). It is used in case of an AFDX network failure
- EIF sends stow/deploy signals to the ETRAC through the AFDX network. One of the EIF applications supplies back-up discrete signals to the ETRAC
- The EMU and the EEC communicate through a dedicated non-AFDX digital bus. The EMU then gives vibration data and engine health information to the AFDX network.



PCS INTERFACES - INTERFACES WITHIN THE PCS

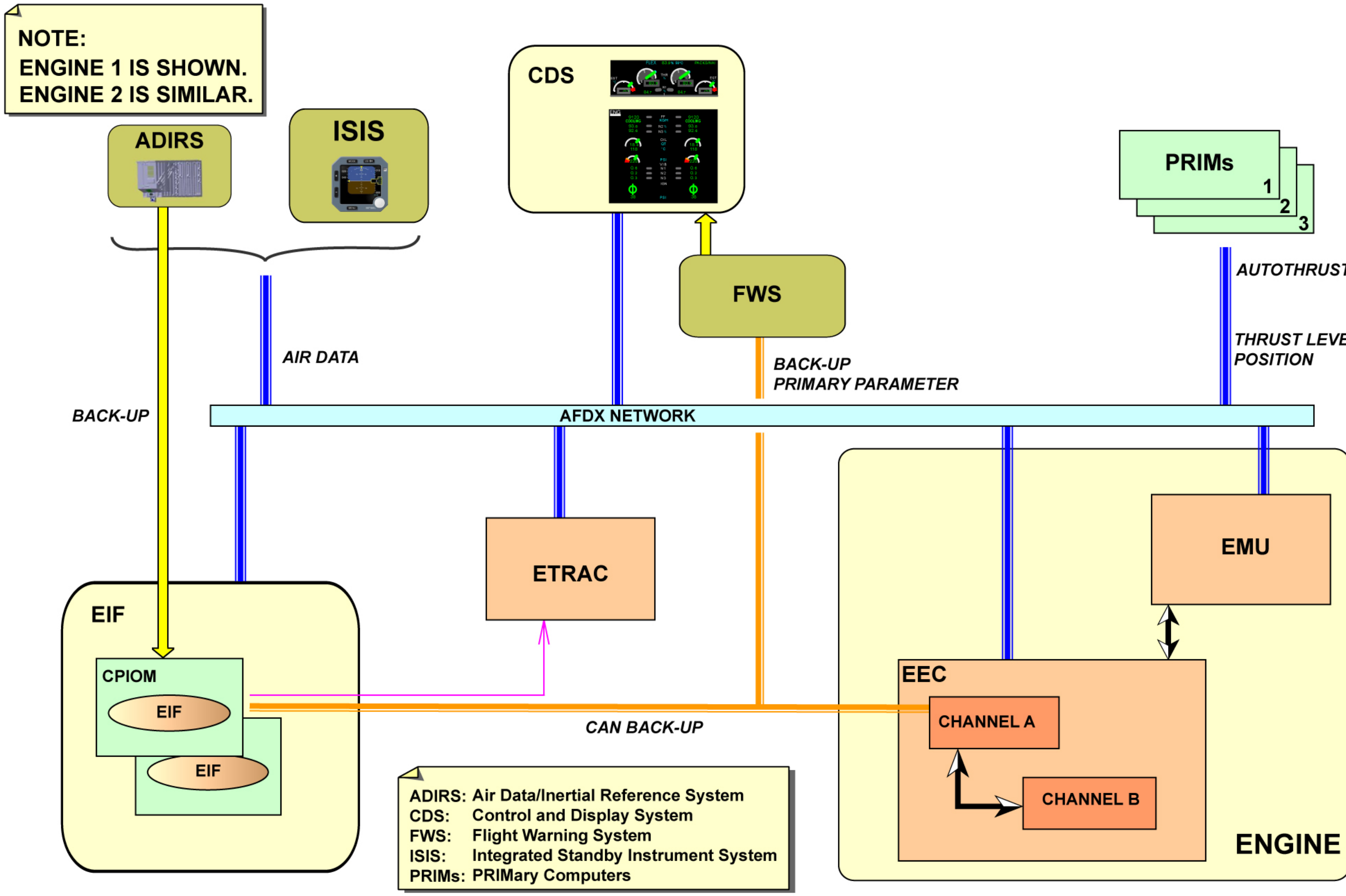
PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Interfaces (continued)

Interfaces with Aircraft Systems

PCS communication with aircraft systems is primarily done through the AFDX network.
The AFDX network is normally used as follows:
- The EIF receives air data from the Air Data/Inertial Reference System (ADIRS) and the Integrated Standby Instrument System (ISIS).
- The EEC sends most of engine parameters to the Control and Display System (CDS). The EIF sends T/R position to the CDS. The EMU gives vibration data.
- The PRIMary Computers (PRIMs) communicate with the PCS for the Autothrust (A/THR) function and the thrust lever position.

For redundancy purpose a back-up communication system is used for critical data:
- An ARINC bus gives air data information directly to one application of the EIF.
- The back-up CAN bus-interconnecting the EEC with the EIF is also used to send the primary engine parameters (Thrust, N1 and Exhaust Gas Temperature (EGT)) to the CDS through the Flight Warning System (FWS).



PCS INTERFACES - INTERFACES WITH AIRCRAFT SYSTEMS

V1813401 - V01T0M0 - VM70D4PCSAR3001

PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

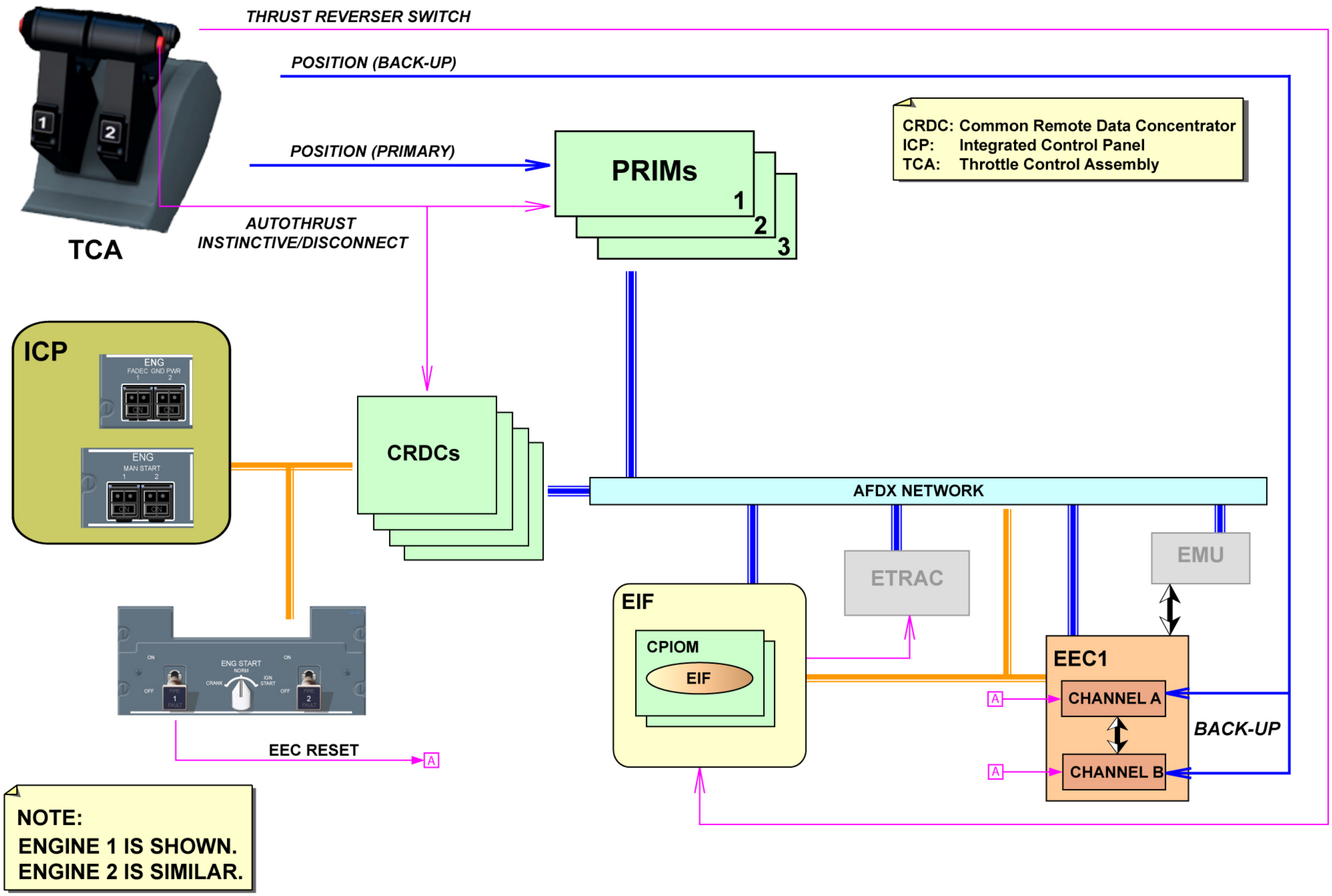
PCS Interfaces (continued)

Interfaces with Cockpit Controls

The Throttle Control Assembly (TCA) sends different signals to the PCS (EEC/EIF):
- The primary source of throttle position is sent through analog signals to the PRIMs. The signals are converted to a digital format and then sent to the PCS through the AFDX network
- The back-up source of throttle position gives analog signals to both EEC channels
- The T/R switch sends a discrete signal to the EIF used in the T/R control
- The A/THR instinctive disconnect switch sends discrete signals to the EEC through the Common Remote Data Concentrator (CRDC)/AFDX network and is also hard-wired to the PRIMs.

The FADEC GND PWR and MAN START switches send digital signals to PCS through the AFDX network. The engine start selector interfaces with the PCS through the AFDX network.

The engine master switch sends its position:
- Digitally to the AFDX network
- By hard-wired discrete to both EEC channels for reset function.



PCS INTERFACES - INTERFACES WITH COCKPIT CONTROLS

V1813401 - V01T0M0 - VM70D4PCSAR3001

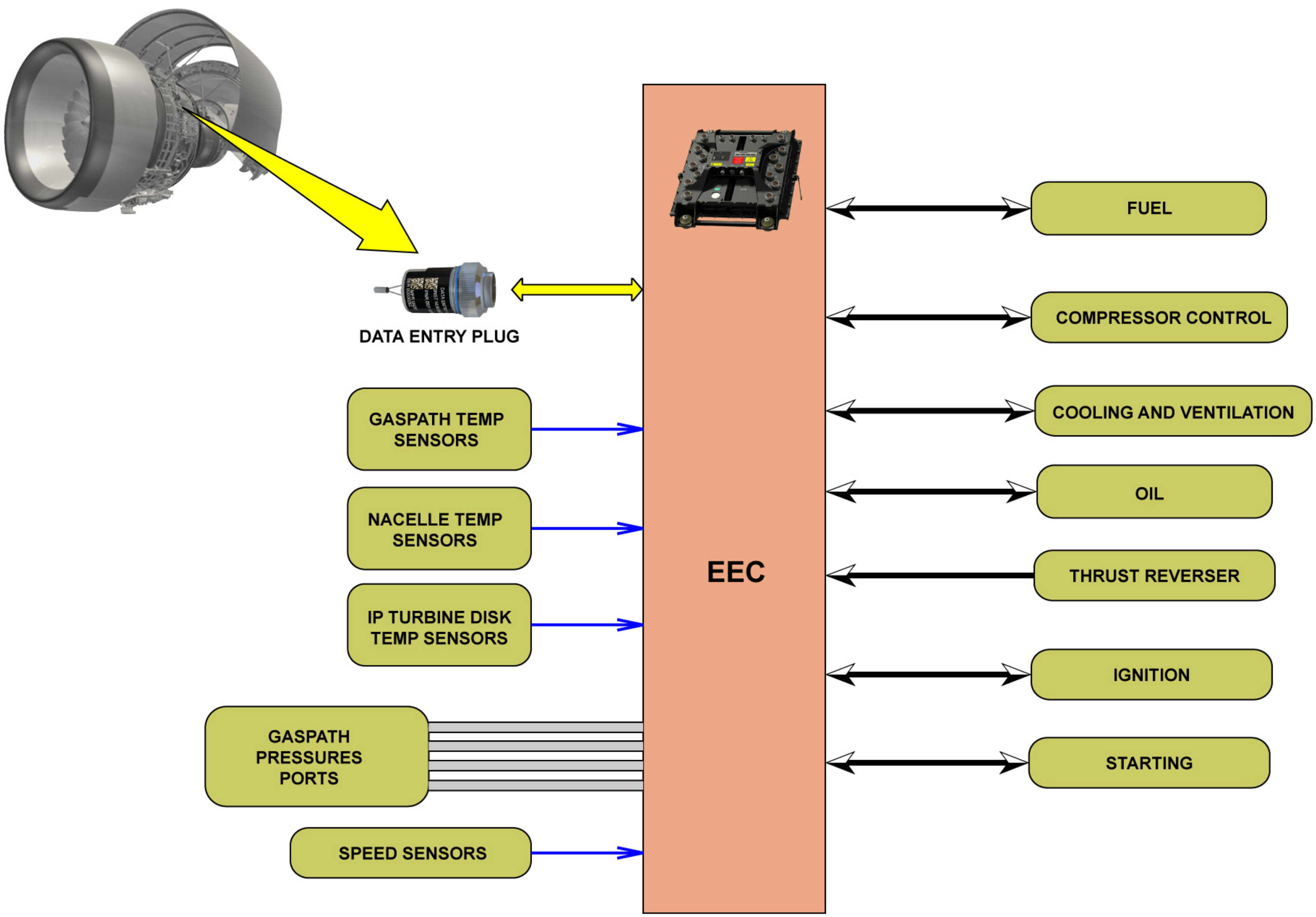
PCS ARCHITECTURE AND INTERFACES DESCRIPTION (2/3)

PCS Interfaces (continued)

Interfaces between the EEC and the Engine

To control the engine, the EEC receives these inputs:
- Digital inputs from the Data Entry Plug (DEP): The DEP is a memory device that supplies the engine's unique data (engine standard, engine serial number, engine ratings selection, N1 trim and Turbine Gas Temperature (TGT) trim) to the EEC. The DEP is connected to the EEC and is attached to the engine fan case by a lanyard
- Analog signal from gaspath temperature sensors (T20, T25, T30, T50, and EGT)
- Analog signal from nacelle temperature sensors (Zone1, 2 and 3)
- Analog signals from the IP turbine disk temperature thermocouples
- Gaspath pressure pick-ups (P0, P25, P30, P160)
- Shaft speed from speed sensors.

The EEC interfaces with these engine sub-systems:
- Fuel
- Compressor control
- Cooling and ventilation
- Oil
- T/R
- Ignition
- Starting.

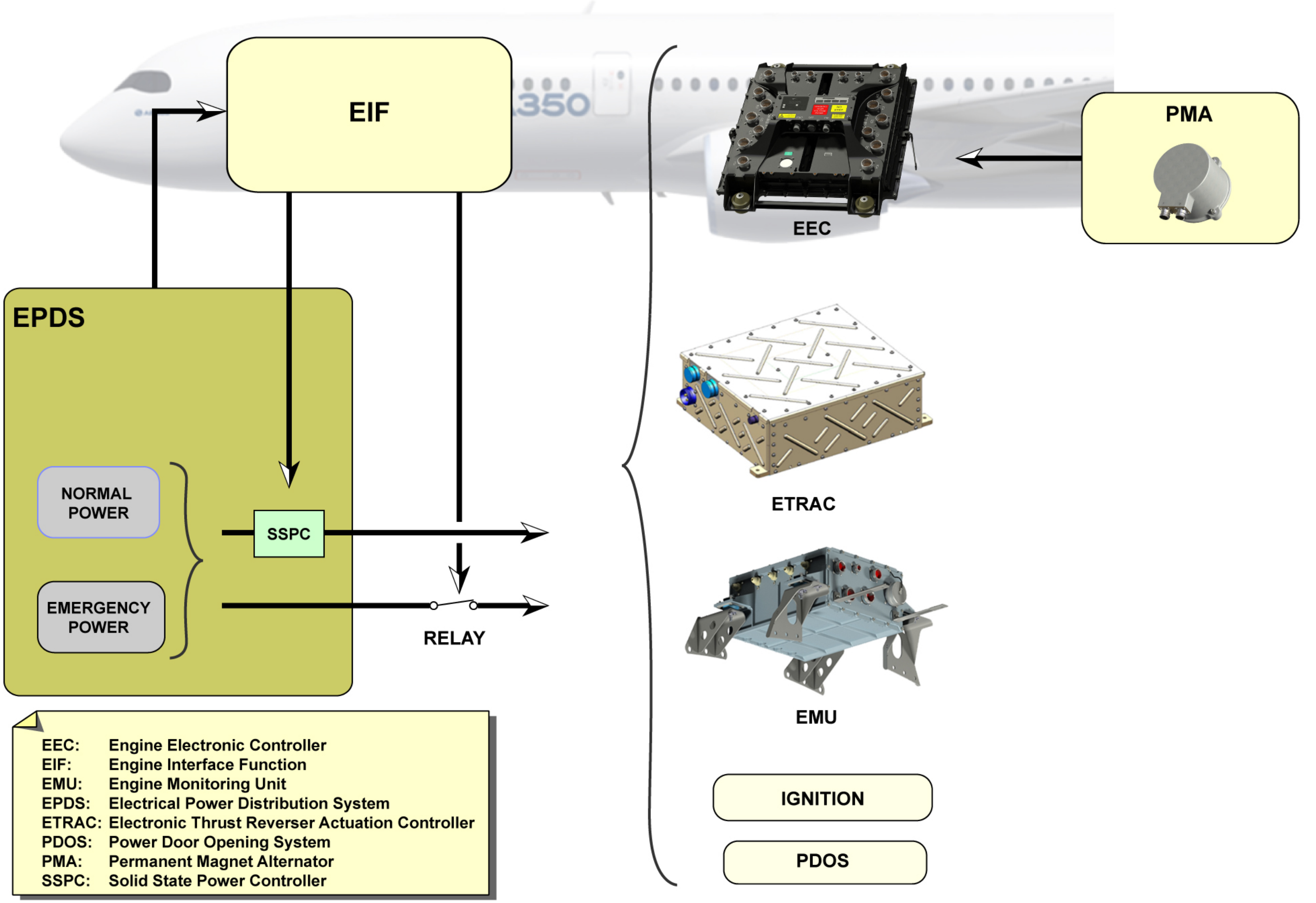


PCS INTERFACES - INTERFACES BETWEEN THE EEC AND THE ENGINE

PCS POWER SUPPLY DESCRIPTION (2/3)

General Presentation

The Propulsion Control System (PCS) gets electrical power as follows:
- The Electrical Power Distribution System (EPDS) supplies power to the Engine Interface Function (EIF)
- The EIF controls the distribution of normal and emergency power through Solid State Power Controllers (SSPCs) and relays to these equipments:
- Engine Electronic Controller (EEC)
- Electronic Thrust Reverser Actuation Controller (ETRAC)
- Engine Monitoring Unit (EMU)
- Ignition system
- Power Door Opening System (PDOS).
- A dedicated alternator referred as Permanent Magnet Alternator (PMA) powers the EEC while the engine operates above a set speed.



GENERAL PRESENTATION

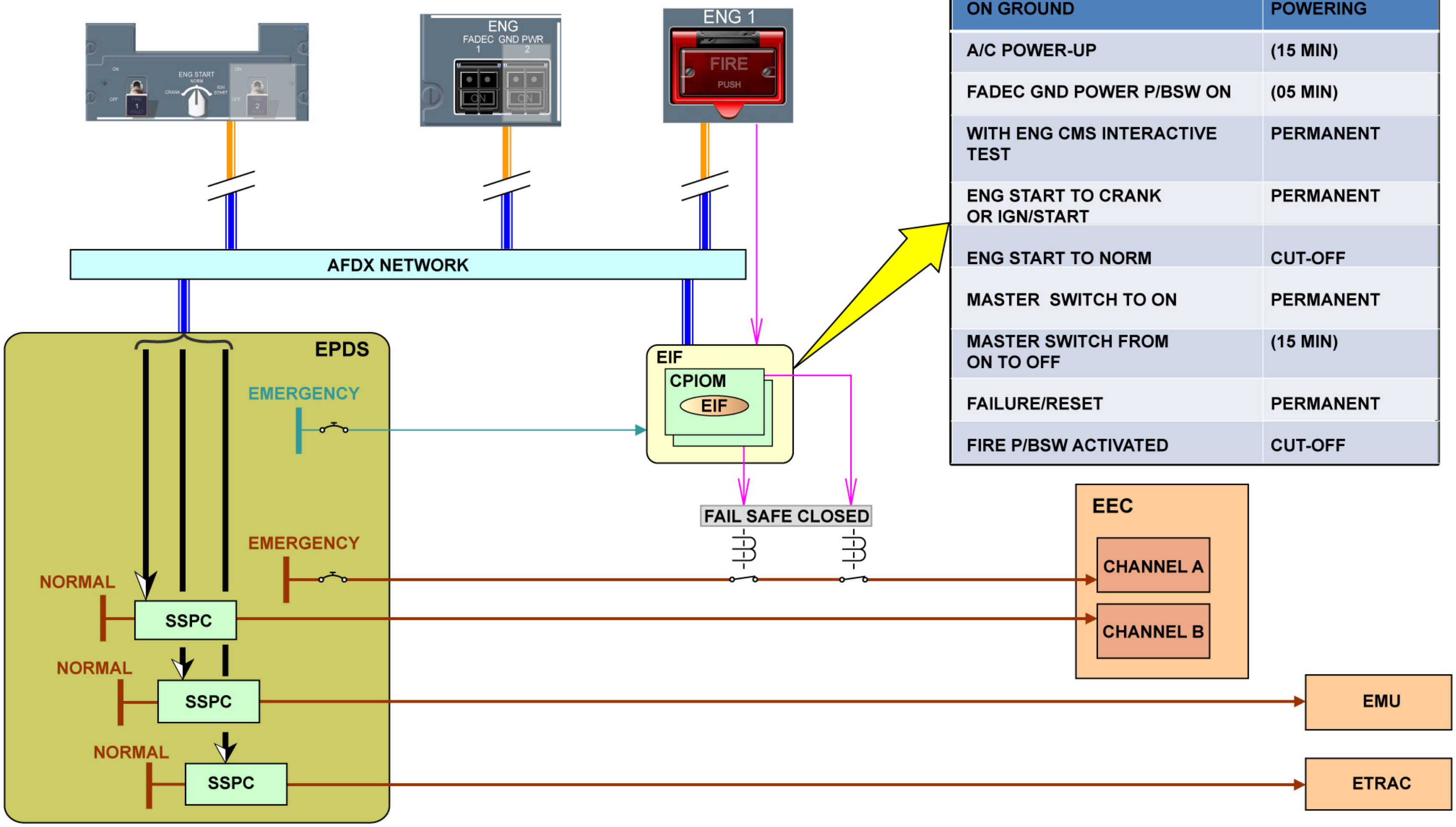
V1813401 - V01T0M0 - VM70D5PCSPO3001

PCS POWER SUPPLY DESCRIPTION (2/3)

Aircraft Electrical Power to PCS

The Core Processing Input/Output Modules (CPIOMs) supporting the EIFs applications are powered by a DC emergency bus.
The EEC receives power from two 115VAC buses.
The channel A of the EEC is supplied by a 115VAC emergency bus whereas the channel B receives power from a 115VAC normal bus.
The EMU and the ETRAC are powered from 115VAC normal buses.
In flight EIF, EMU and ETRAC are powered by the aircraft electrical network.
On ground, the EIF stays powered as long as the aircraft is powered. The EIF receives cockpit control signals through the Avionics Full Duplex Switched Ethernet (AFDX) network and applies the following ground power/de-power logic for the EEC, EMU and ETRAC:
- At aircraft power-up the electrical power is available for a period of time (15mins).
- The Full Authority Digital Engine Control (FADEC) ground-power switch supplies power for some time (5mins) or permanently during engine Central Maintenance System (CMS) interactive test.
- The engine start selector selects permanent power when placed in CRANK or IGN START positions. When it is moved to NORM position power is cut-off immediately.
- The master switch in the ON position gives permanent power.
- When the master switch is moved from ON to OFF, the power continue to be available for a period of time (15mins).
- If an EIF fails (or is in a reset mode), the relays and SSPCs will be in a fail-safe closed position and the power supply will be permanent.

Finally in flight or on ground, the activation of the fire pushbutton always leads power cut-off immediately to the EEC, the EMU and the ETRAC.



ON GROUND	POWERING
A/C POWER-UP	(15 MIN)
FADEC GND POWER P/BSW ON	(05 MIN)
WITH ENG CMS INTERACTIVE TEST	PERMANENT
ENG START TO CRANK OR IGN/START	PERMANENT
ENG START TO NORM	CUT-OFF
MASTER SWITCH TO ON	PERMANENT
MASTER SWITCH FROM ON TO OFF	(15 MIN)
FAILURE/RESET	PERMANENT
FIRE P/BSW ACTIVATED	CUT-OFF

AFDX: Avionics Full Duplex Switched Ethernet
CMS: Central Maintenance System
CPIOM: Core Processing Input/Output Module
FADEC: Full Authority Digital Engine Control

AIRCRAFT ELECTRICAL POWER TO PCS

V1813401 - V01T0M0 - VM70D5PCSPO3001

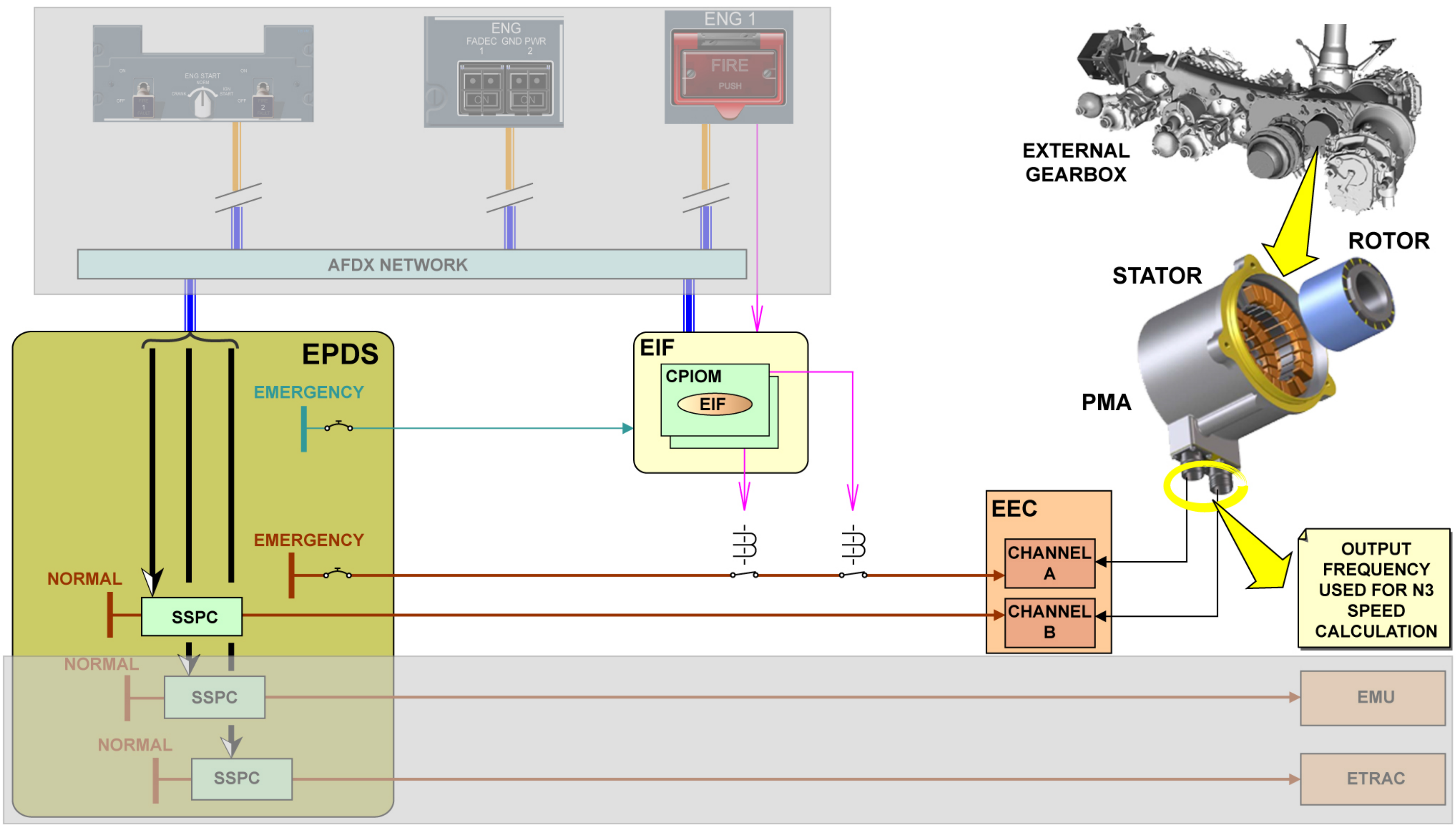
PCS POWER SUPPLY DESCRIPTION (2/3)

PMA Power to EEC

The EEC can choose between 2 sources of electrical power. When the engine speed is below a N3 percentage threshold (6%), the EEC will use power from the aircraft electrical network.
When the engine speed is above this threshold, the PMA will supply the electrical power necessary for the EEC.
In this case the EEC gives priority to the PMA power supply over the aircraft electrical network.
If a PMA failure occurs, the EEC automatically selects the aircraft electrical network.
The PMA has these two primary parts:
- A permanent magnet rotor driven by the engine external gearbox
- A separate stator housing.

The PMA supplies 2 independent (three-phase) AC electrical power outputs for each EEC channel.

NOTE: Frequency of these power outputs depends on the engine N3 speed. Therefore each EEC channel calculates N3 speed by sensing this frequency.



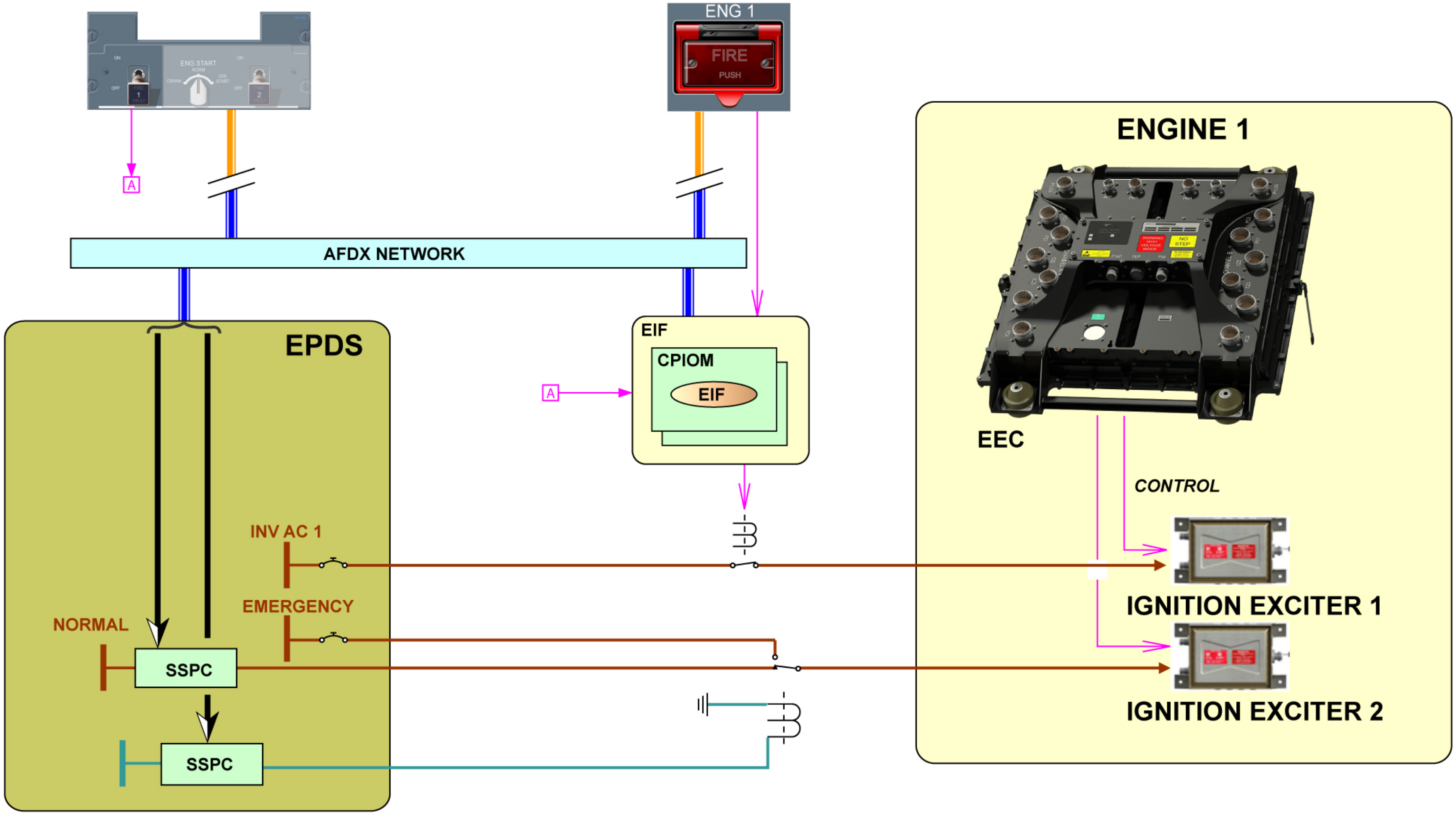
PMA POWER TO EEC

PCS POWER SUPPLY DESCRIPTION (2/3)

Aircraft Power to Ignition System

The dual ignition system receives electrical power from the Electrical Power Distribution System (EPDS).
Ignition exciter 1 is supplied by the static inverter bus through a relay controlled by the EIF through hard-wired discrete signals.
Ignition exciter 2 is usually supplied by a 115VAC normal bus. The EIF controls the distribution with a SSPC through the AFDX network. If the normal bus is not available, the electrical power will switch to the emergency bus. The EIF is in control of this back-up operation by operating a 28VDC SSPC and a dedicated relay.
To power or de-power the ignition systems, the EIF calculates a command based on master switch and fire switch positions. The ignition systems are de-powered, if one of these conditions is true:
- The master switch is OFF
- The fire switch is operated.

The AFDX network is used to transfer these data between the cockpit and the EIF. But, redundant hard-wired discretes connect the master switch and the fire push-button to the EIFs.
The EIF controls the power distribution of the two ignition systems. But, the EEC is in charge for the ignition systems selection and activation.
(Refer to the ignition chapter for detailed information)



AIRCRAFT POWER TO IGNITION SYSTEM

V1813401 - V01T0M0 - VM70D5PCSPO3001

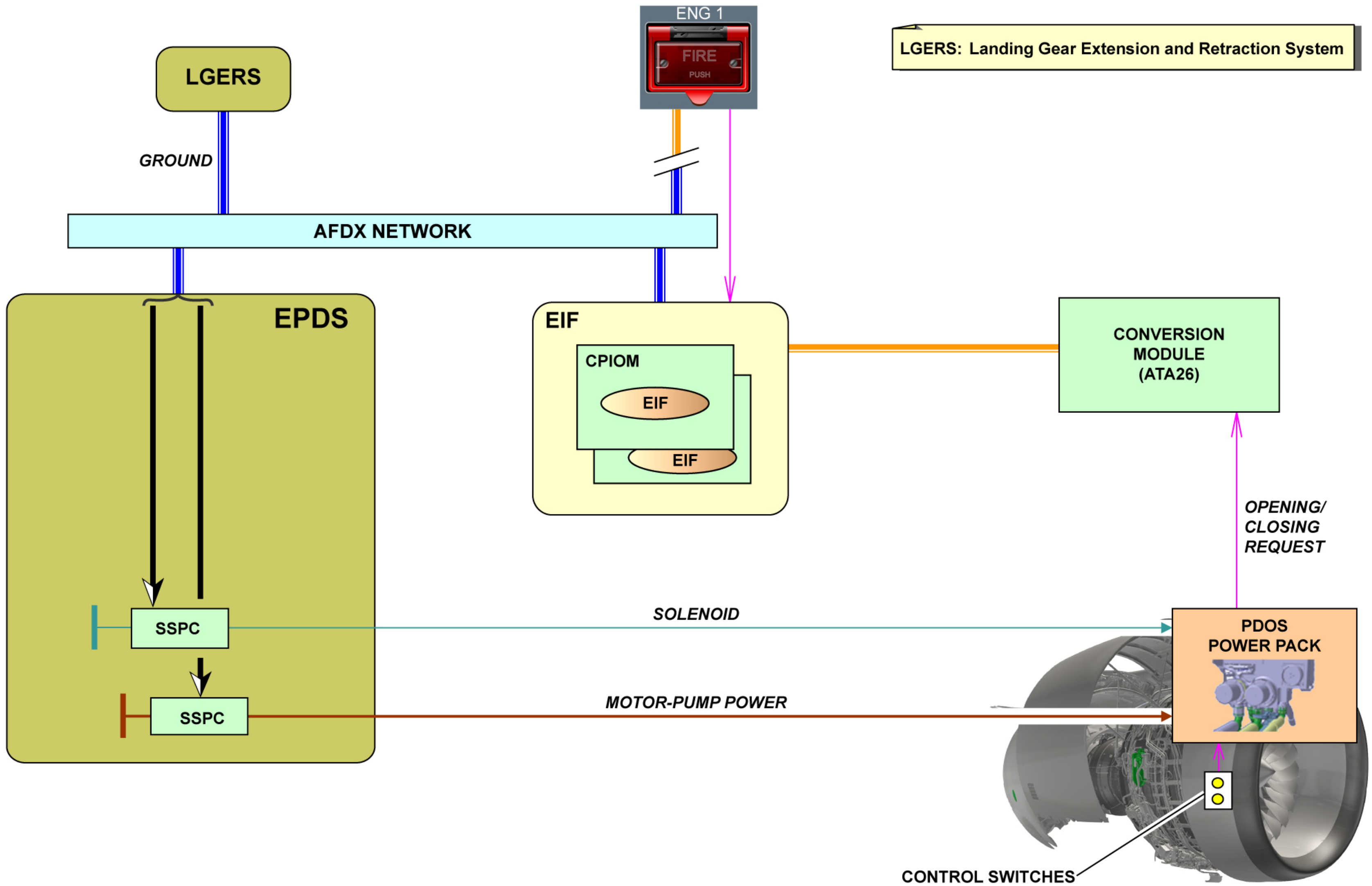
PCS POWER SUPPLY DESCRIPTION (2/3)

Aircraft Power to PDOS System

The PDOS is electrically powered by the EPDS.
On ground only, opening/closing requests from PDOS control switches are sent to the EIF through a conversion module (ATA26). The EIF controls the power distribution to the PDOS control solenoids through SSPC. Only when an opening signal is sent, the EIF distributes 115VAC to the motor-pump through a dedicated SSPC.
Action on the fire pushbutton will stop distribution of electrical power to the PDOS.

NOTE: Refer to nacelle description module for detailed description of the PDOS.

V1813401 - V01T0M0 - VM70D5PCSPO3001



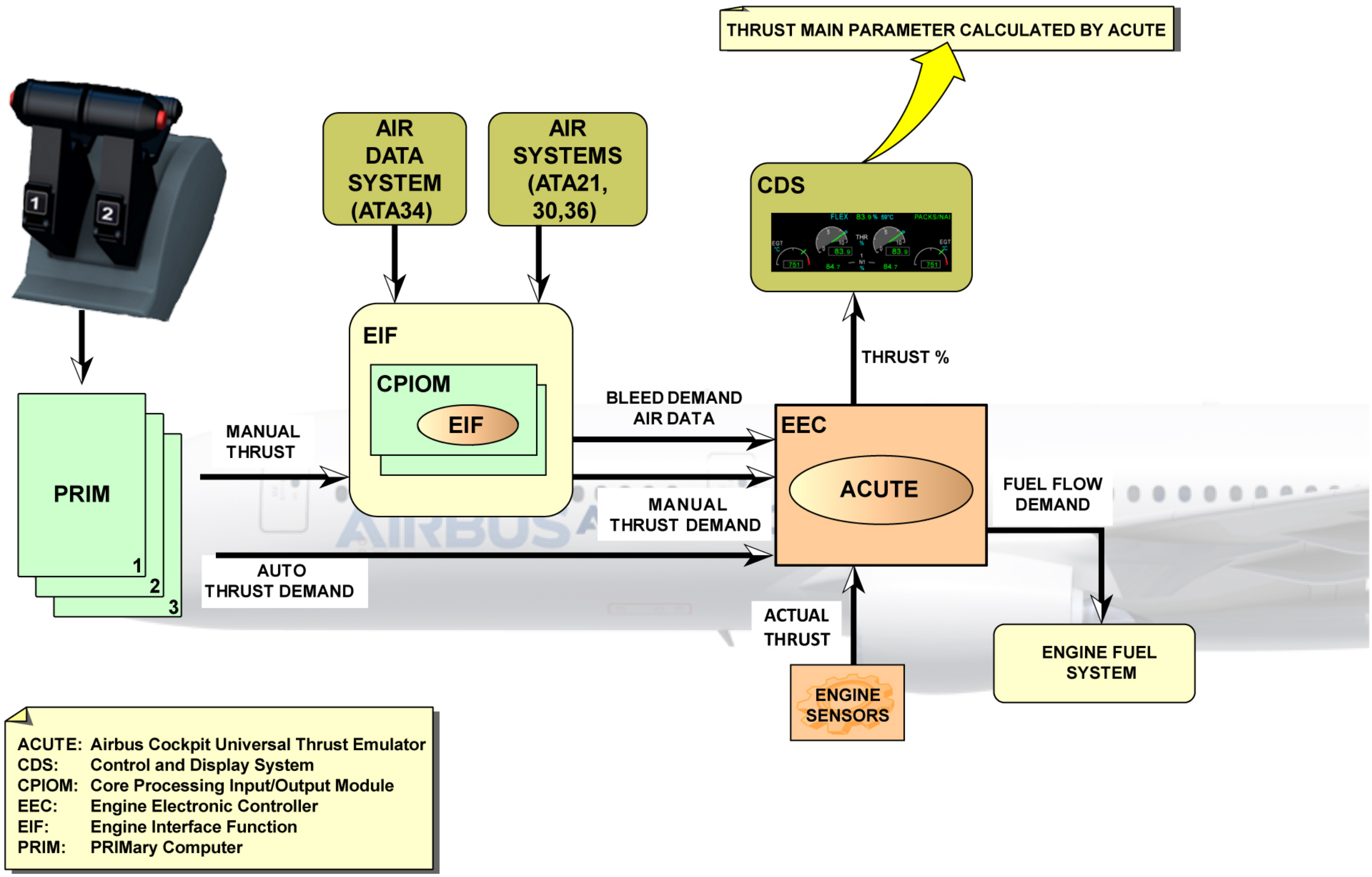
AIRCRAFT POWER TO PDOS SYSTEM

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Thrust Control General Description

To control the thrust the EEC uses:
- The throttle control levers positions
- The Automatic Flight System (AFS) demands from PRIMary Computers (PRIMs) (Autothrust (A/THR))
- The air data from air data system
- The bleed demand from air systems.

Manual thrust is controlled by action on the thrust control lever. The PRIMs receive thrust-lever position signals and send them to the Engine Interface Function (EIF). The EIF then proceeds to a signal selection and gives the resultant signal to the EEC. This is a manual thrust demand.
The PRIM's calculate A/THR demand and send it directly to the EEC.
The EEC compares the thrust demand with the actual thrust (based on the engine sensors) and calculates a fuel flow demand depending on the air data and the bleed demand. Related output control signals are transmitted to the engine fuel system. The EEC continuously monitors different engine parameters to give automatic protection.
The EEC sends a thrust parameter to the Control and Display System (CDS). The thrust indication shows the actual percentage of thrust available and is calculated by ACUTE function.



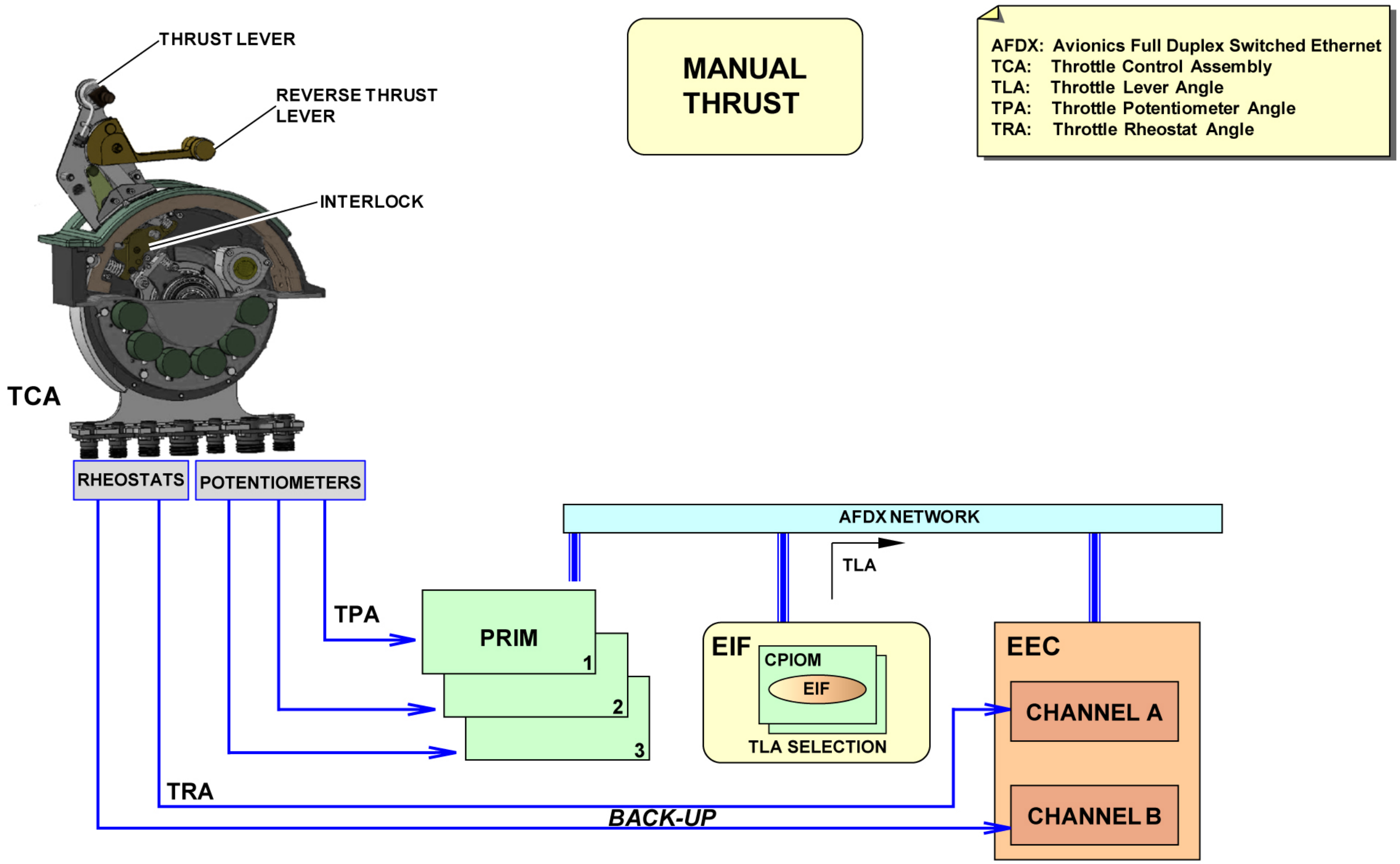
THRUST CONTROL GENERAL DESCRIPTION

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Manual Thrust Description

The manual thrust is controlled from the TCA. The TCA includes the following components for each engine:
- A thrust lever controls forward thrust
- A reverse thrust lever (hinged to the thrust lever) controls the reverse thrust
- An interlock preventing application of forward thrust and reverse thrust at the same time
- A set of sensors converting rotational movements into electrical signals.

Any movement of the lever is transmitted to PRIMs by a set of throttle potentiometer angle sensors (2 per PRIM). The PRIMs convert the signals to Avionics Full Duplex Switched Ethernet (AFDX) signals and send them to EIF. The EIF performs a selection of these signals, referred to as the TLA selection. The EIF then sends the resultant selected TLA to the EEC.
The throttle rheostat angle sensors are hard-wired to the EEC (1 per channel) to give a back-up thrust lever position.



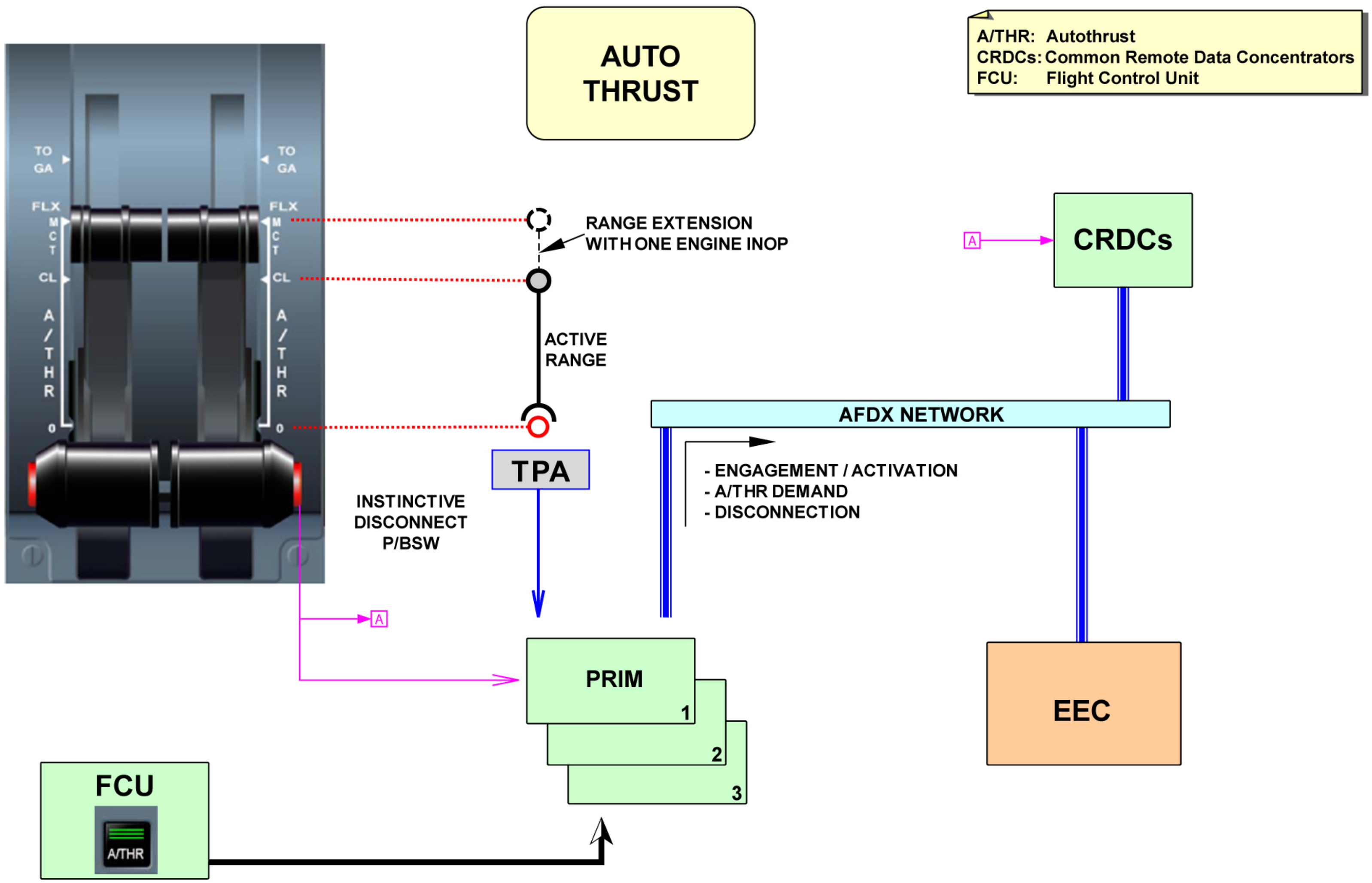
MANUAL THRUST DESCRIPTION

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Auto Thrust Description

The PRIMs send A/THR engagement and activation orders to the EEC. The activation depends on the throttle lever position. The active range is between idle (0) and climb (CL) detents. The range extends to Maximum Continuous Thrust (MCT) with one engine inoperative. The EEC validates the engagement and activation with an internal logic.
When the A/THR is active, the EEC follows the A/THR command sent by the PRIMs.
The A/THR disconnection is done:
- By action on the instinctive disconnect pushbutton. The PRIMs send a disengagement order to the EEC through the AFDX network
- By action on the A/THR pushbutton on the Flight Control Unit (FCU) through the PRIMs
- By selecting idle or reverse thrust
- Automatically in case of a failure (PRIM, EEC, etc.).

A hard-wire connects the instinctive disconnect pushbutton to some CRDCs to send a back-up disconnection order directly to the EEC.

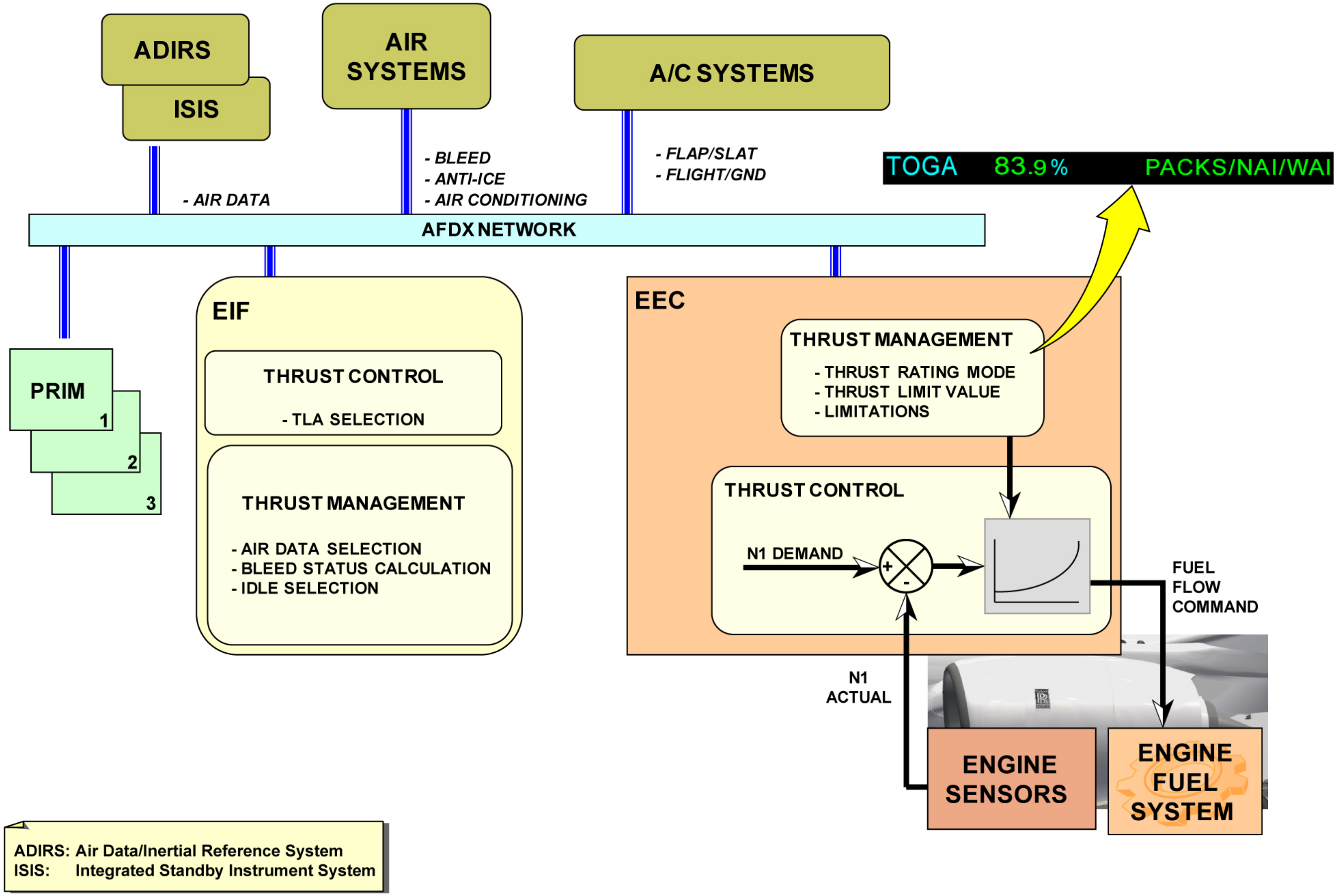


AUTO THRUST DESCRIPTION

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Thrust Control and Management Description

In manual thrust mode, the EIF send the selected TLA to the EEC. This is a manual thrust demand. In A/THR mode, the PRIMs send the A/THR demand directly to the EEC.
The EEC uses N1 as the control parameter. Thus, the manual or A/THR demand is converted in a N1 demand. The EEC compares the N1 demand with the N1 actual and converts the result into a fuel flow command sent to the engine fuel system (refer to the Engine Fuel System chapter for a complete description of the EEC/engine fuel system interfaces).
The thrust management function calculates the thrust rating mode and the thrust limit value and applies limitations to the thrust. The thrust management function is shared by the EIF and the EEC as follows:
The EIF does:
- Air data selection: The EIF receives air data from the Air Data/Inertial Reference System (ADIRS) and the Integrated Standby Instrument System (ISIS). After a complex voting process the EIF transmits the most reliable data to the EEC.
- Bleed status calculation: The EIF receives bleed, anti-ice and air conditioning data from the air systems and sends a bleed status to the EEC.
- Idle selection: Depending on the aircraft configuration (flap/slat position, flight/ground) and flight phase, the EIF selects a related idle and send a request to the EEC.
Based on these signals, the EEC does these functions:
- The EEC selects a thrust rating mode for each throttle lever detent (i.e. 0, CL, MCT/FLEX, TO/GA). The thrust rating mode also depends on parameters sent by the PRIMs (FlexT/O,...)
- The EEC calculates a thrust limit value (shown as a percentage) related to the selected thrust rating mode. For this calculation the EEC uses voted air data. The thrust limit value corresponds to the maximum thrust available at the corresponding thrust rating mode
- The EEC also applies limitations to the thrust depending on the bleed status and the idle selection.
The thrust rating mode, thrust limit value and bleed usage can be seen on the Engine Display (ED) page.



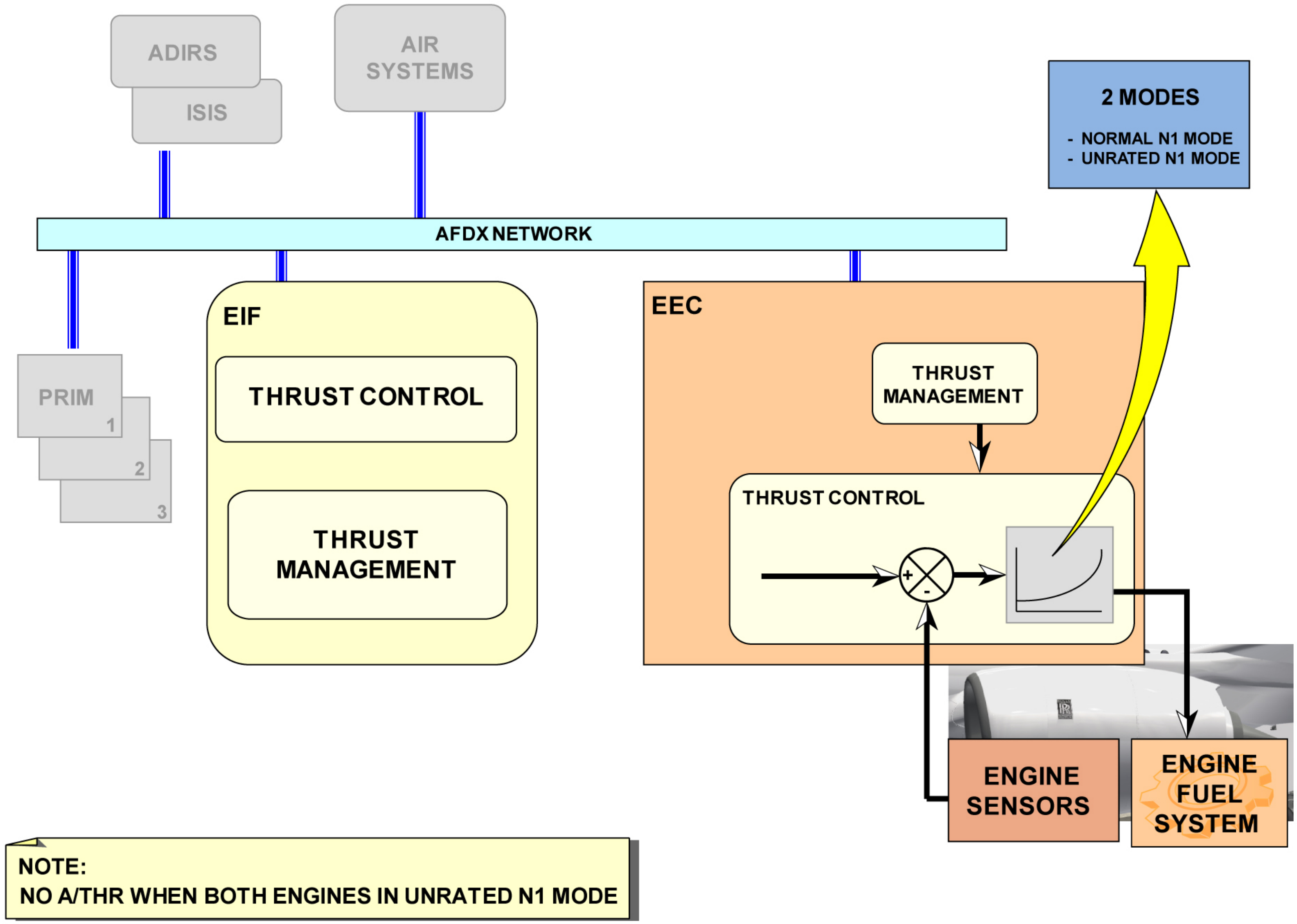
THRUST CONTROL AND MANAGEMENT DESCRIPTION

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Modes

The EEC can select these two modes of operations:
- Normal N1 mode: This is the normal mode used to control the thrust when all the air data are available
- Unrated N1 mode (also known as degraded mode): The EEC automatically reverts to this mode, if one of the voted air data parameter is not valid. In this mode the EEC set the thrust based on TLA and altitude only.

If both the engines operate in degraded mode, the A/THR disconnects automatically.

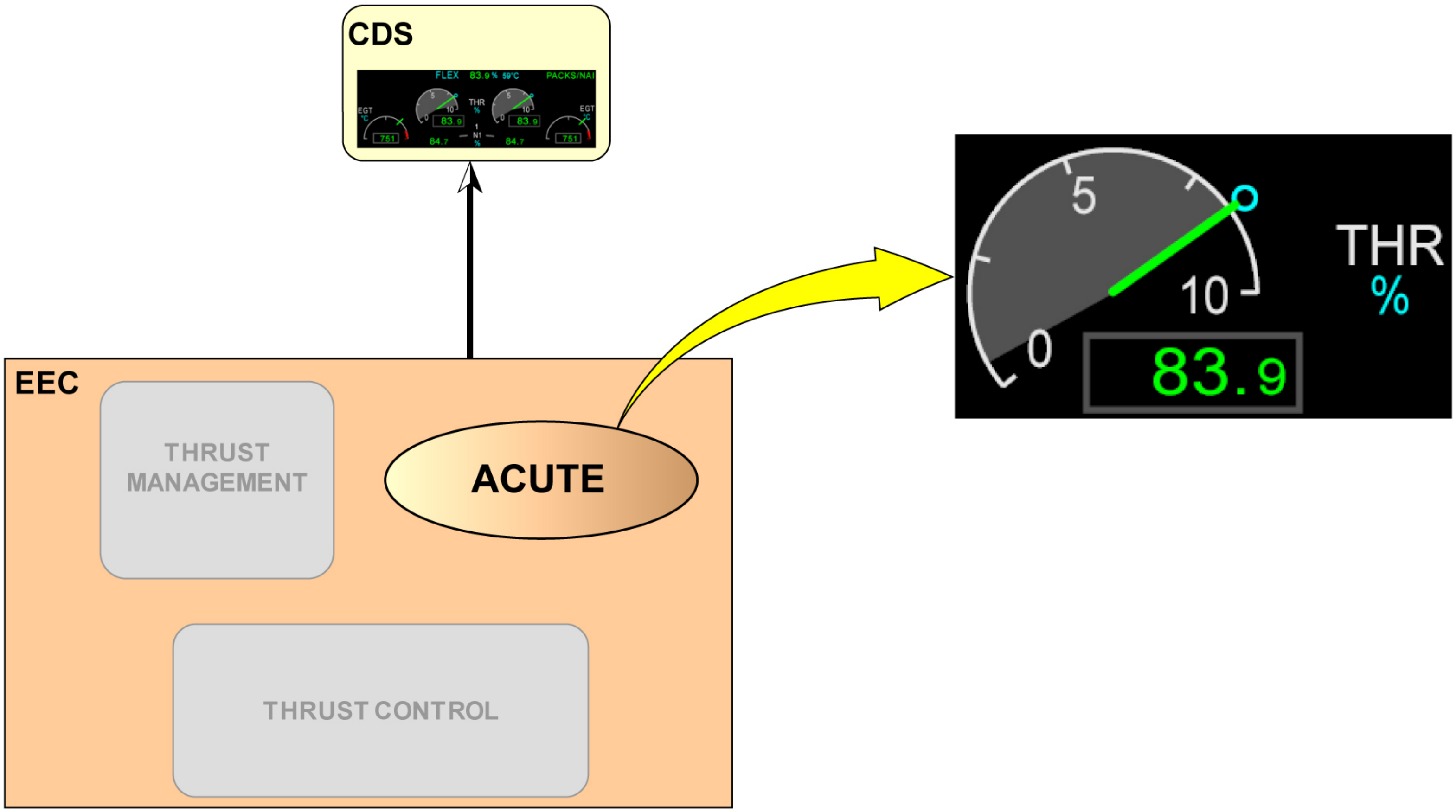

ADIRS
ISIS
AIR SYSTEMS
2 MODES
- NORMAL N1 MODE
- UNRATED N1 MODE
AFDX NETWORK
PRIM
1
2
3
EIF
THRUST CONTROL
THRUST MANAGEMENT
EEC
THRUST MANAGEMENT
THRUST CONTROL
+
-
ENGINE SENSORS
ENGINE FUEL SYSTEM
NOTE:
NO A/THR WHEN BOTH ENGINES IN UNRATED N1 MODE

MODES

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Airbus Cockpit Universal Thrust Emulator (ACUTE)

The Thrust (THR) parameter is one of the primary parameters on the ED page. It is continuously displayed together with Exhaust Gas Temperature (EGT) (derived from Turbine Gas Temperature (TGT)) and N1.
THR is calculated by the ACUTE, a function residing in the EEC.
THR represents a percentage of available thrust. It is computed from N1 and other data.



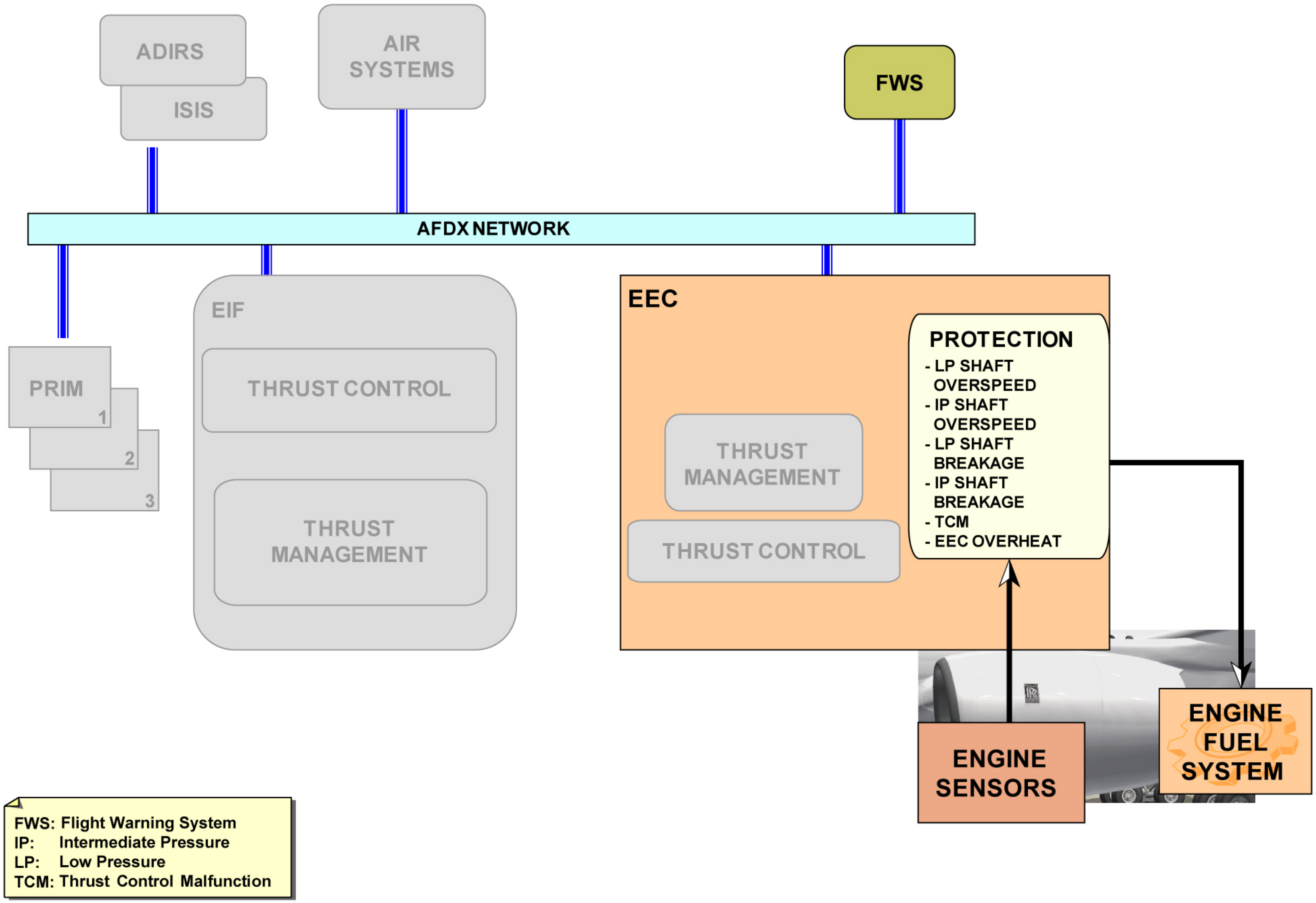
AIRBUS COCKPIT UNIVERSAL THRUST EMULATOR (ACUTE)

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Protections

The EEC gives these protections:
- Overspeed protection, if there is a Low Pressure (LP) or IP shaft excessive speed
- LPT shaft breakage, if there is an LP shaft rupture
- IP turbine shaft breakage if there is an IP shaft rupture
- TCM, if there is too much thrust
- EEC overheat protection.

Depending on the situation, the EEC can:
- Generate a message for the Flight Warning System (FWS) to display a warning in the flight deck
- Limit or reduce the thrust
- Automatically stop the engine.



PROTECTIONS

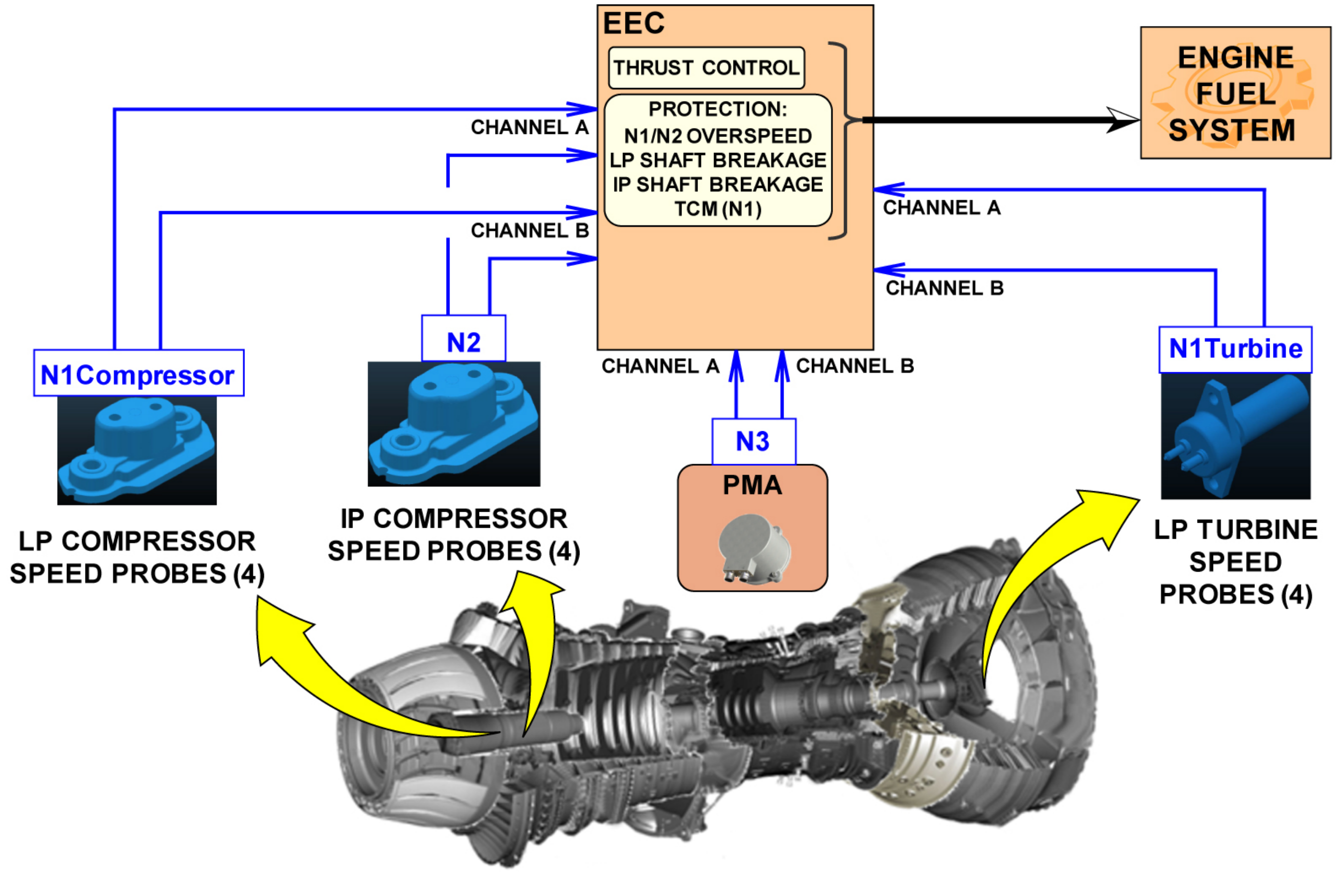
V1813401 - V01T0M0 - VM70D6THRCO3001

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Sensors Description and Associated Functions

Speed Sensing

The N1 shaft speed is monitored by a set of LPC speed probes (4 probes located in the front bearing housing) and a set of LPT speed probes (4 probes located in the tail bearing housing). The N2 shaft speed is monitored by a set of IP compressor speed probes (4 probes located in the front bearing housing).
The N1 and N2 transducers are installed around the phonic wheels and supply signals with a frequency proportional to shaft speed. Each set of speed probes sends signals to both the EEC channels.
The N3 shaft speed is measured by converting the PMA output frequency.
These signals are used for:
- Thrust control: The EEC uses N1 in the thrust control loop.
- Protection:
- N1/N2 overspeed: The EEC will automatically stop the engine, if there is an N1 or N2 severe overspeed condition.
- LP shaft breakage: The EEC will automatically stop the engine, if there is an LP shaft breakage. For this function the EEC compares the speed of the N1 compressor with the speed of the N1 turbine.
- IP shaft breakage: The EEC will automatically stop the engine, if there is an IP shaft breakage. For this function the EEC detects a rapid deceleration of N2.
- TCM: The EEC detects excessive thrust and protects the engine by limiting or reducing the thrust in flight or by stopping the engine on the ground. The EEC uses N1 for this function.



PMA: Permanent Magnet Alternator

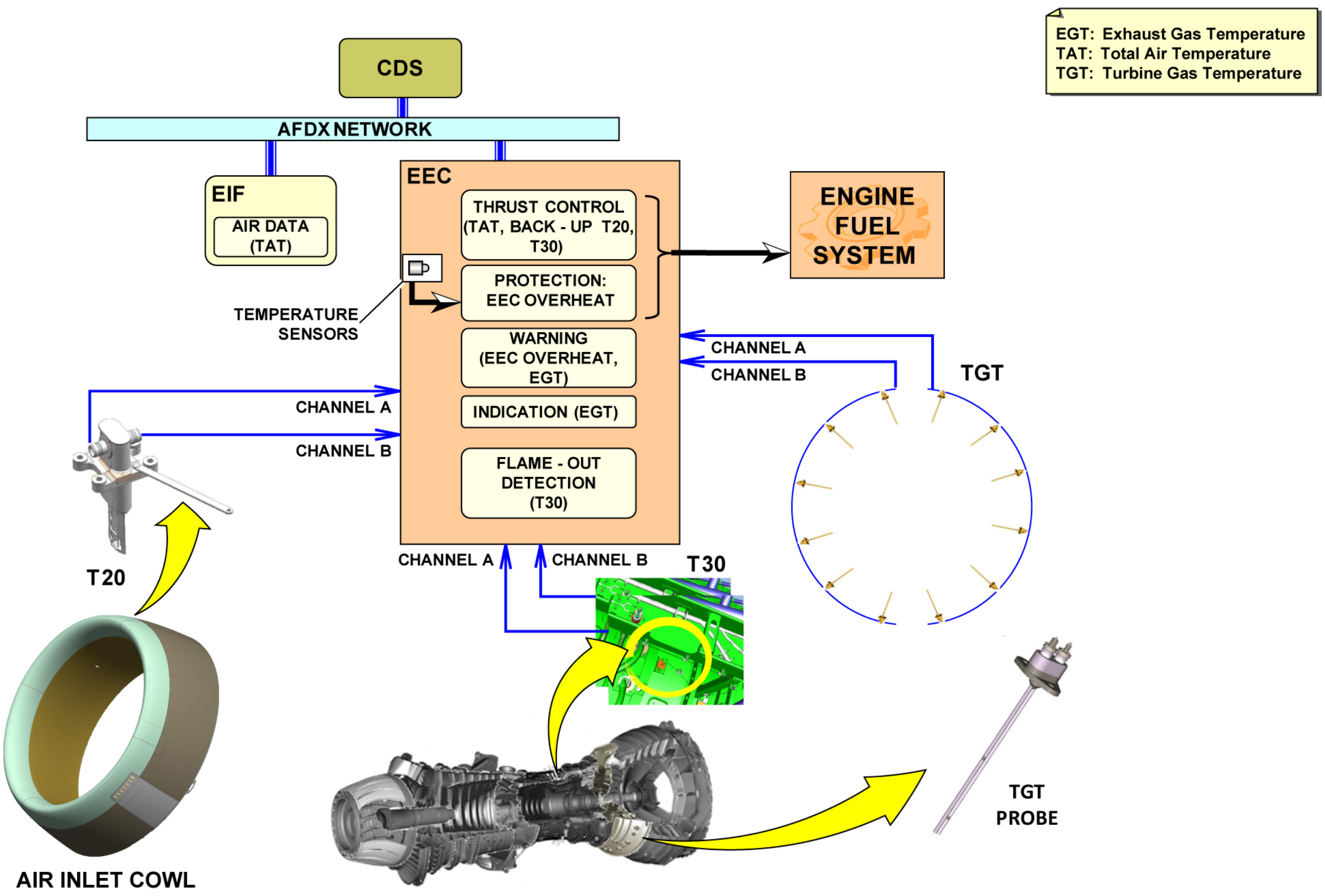
SENSORS DESCRIPTION AND ASSOCIATED FUNCTIONS - SPEED SENSING

THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

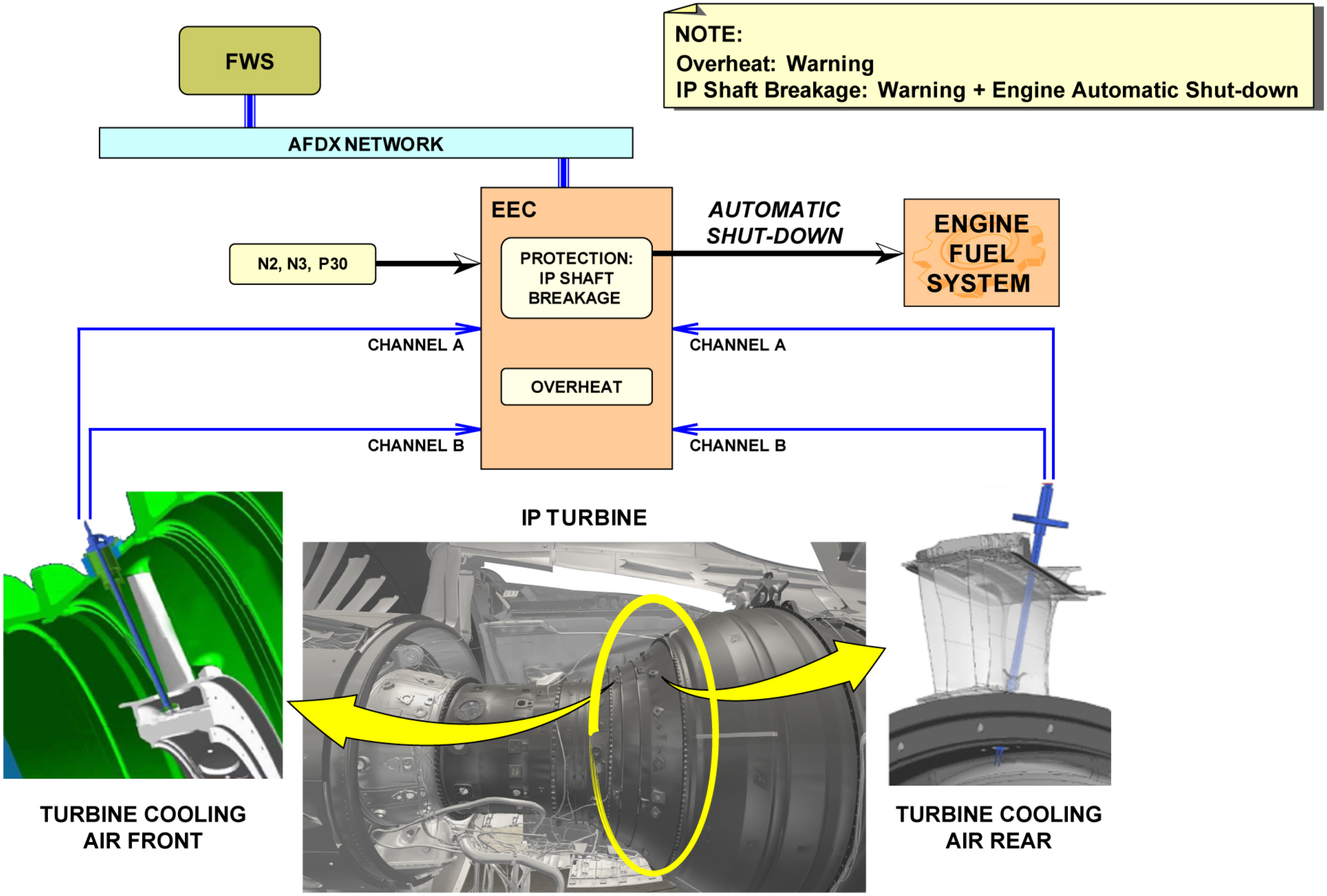
Sensors Description and Associated Functions (continued)

Temperature Sensing

The T20 dual thermocouple supplies engine intake air-temperature to the two EEC channels. If the EEC does not receive the selected Total Air Temperature (TAT) from EIF, it uses T20 as a back-up for thrust control.
The two T30 thermocouples supply High Pressure Compressor (HPC) outlet pressure to the two EEC channels. The EEC uses these data for thrust control and flame-out detection (refer to Ignition System chapter).
Some temperature sensors are installed inside the EEC. If an EEC overheat occurs, a warning is triggered. A severe overheat leads to an automatic engine shutdown under certain conditions.
Two groups of thermocouples (quantity 12 total), one on each side of the LPT case, sends TGT signals to the EEC (one group per channel).
The EEC converts TGT into EGT for indication (primary engine parameter) and warning (EGT exceedance) purposes.
The two IP turbine disks receive cooling air.
The turbine cooling-air front and rear dual thermocouples sense the cooling air temperature and send signals to the two EEC channels.
The EEC combines the turbine-cooling air front and the turbine-cooling air rear with N2, N3 and P30 in a logic that finds an IP turbine overspeed. In such a condition, the IP shaft-breakage protection automatically stops the engine.



SENSORS DESCRIPTION AND ASSOCIATED FUNCTIONS - TEMPERATURE SENSING



SENSORS DESCRIPTION AND ASSOCIATED FUNCTIONS - TEMPERATURE SENSING

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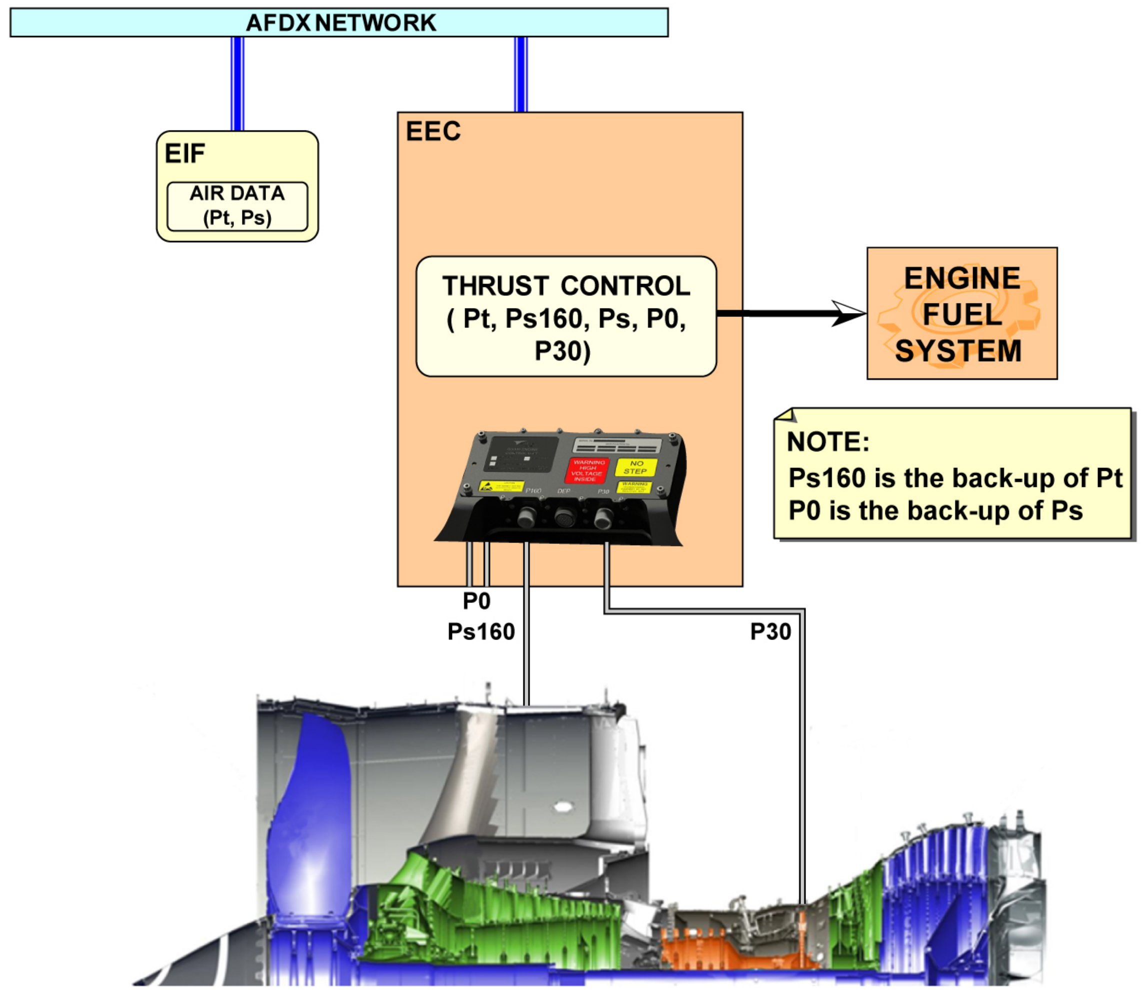
THRUST CONTROL AND ENGINE PROTECTION DESCRIPTION (2/3)

Sensors Description and Associated Functions (continued)

Pressure Sensing

The EEC has pneumatic connections for Ps160 and P30 sensing lines. The EEC converts Ps160 in P20. The EEC uses P20 as a back-up Pt in the thrust control function, if total pressure from the EIF is unavailable.
The EEC uses P30 in the thrust control function. P30 is also essential in the stall and surge detection.
The EEC casing has two pressure ports from which P0 is sensed. The EEC uses P0 as a back-up static pressure (Ps) in the thrust control, if static pressure from EIF is unavailable.



SENSORS DESCRIPTION AND ASSOCIATED FUNCTIONS - PRESSURE SENSING

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

General Presentation

The engine receives fuel from the aircraft fuel tank through the Low Pressure Shut-Off Valve (LPSOV) controlled by the engine master switch.
Fuel pressure increases in the first stage of the fuel pump to positively supply the engine fuel system. Fuel then goes into the Fuel Oil Heat Exchanger (FOHE), where its temperature increases (at the same time the oil temperature decreases).
The Low Pressure (LP) fuel filter removes unwanted particles.
Much of the fuel that comes out of the fuel filter goes back to the second stage of the fuel pump where its pressure increases more. A part of the fuel that comes out of the fuel filter is used to operate the front bearing housing vent-valve (see Oil System Description for more details).
From the fuel pump, fuel is pushed into the Hydro Mechanical Unit (HMU) at high pressure.
The HMU supplies the fuel, depending on the fuel-flow demand signal from the Engine Electronic Controller (EEC).
Fuel not used is sent back to the fuel pump for re-use.
The HMU also sends pressurized fuel to operate the engine air-system valves and actuators.
The metered fuel flows to the fuel manifold and nozzles and is burned into the combustion chamber.
During shutdown the master switch controls the closure of the LPSOV and the High Pressure Shut-Off Valve (HPSOV).
Any fuel remaining in the manifold downstream of the HPSOV drains into the drain tank and is re-used during the next start.
The EEC automatically stops the engine or decreases the fuel flow in some conditions (overspeed, Thrust Control Malfunction (TCM), etc.).

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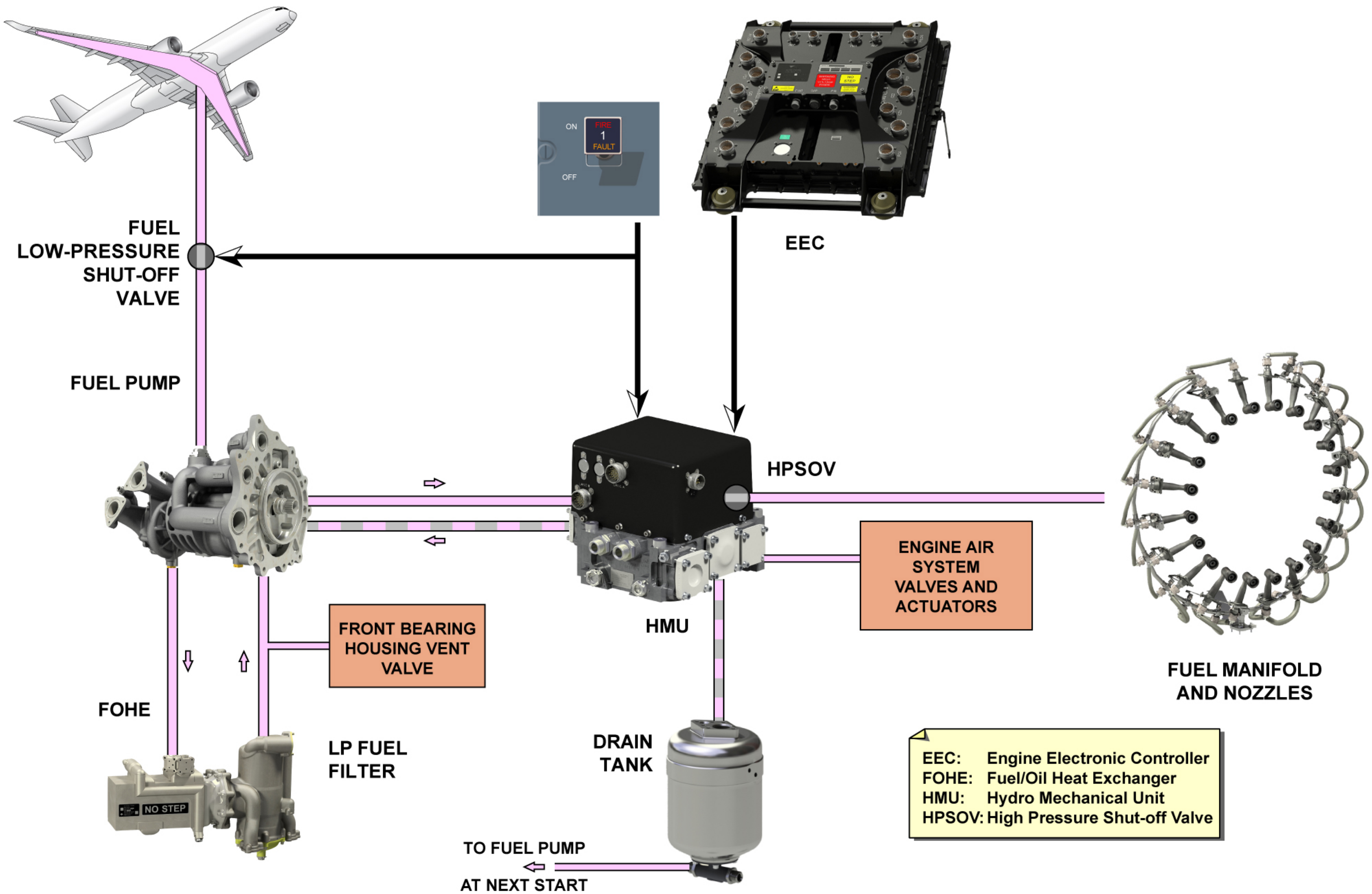


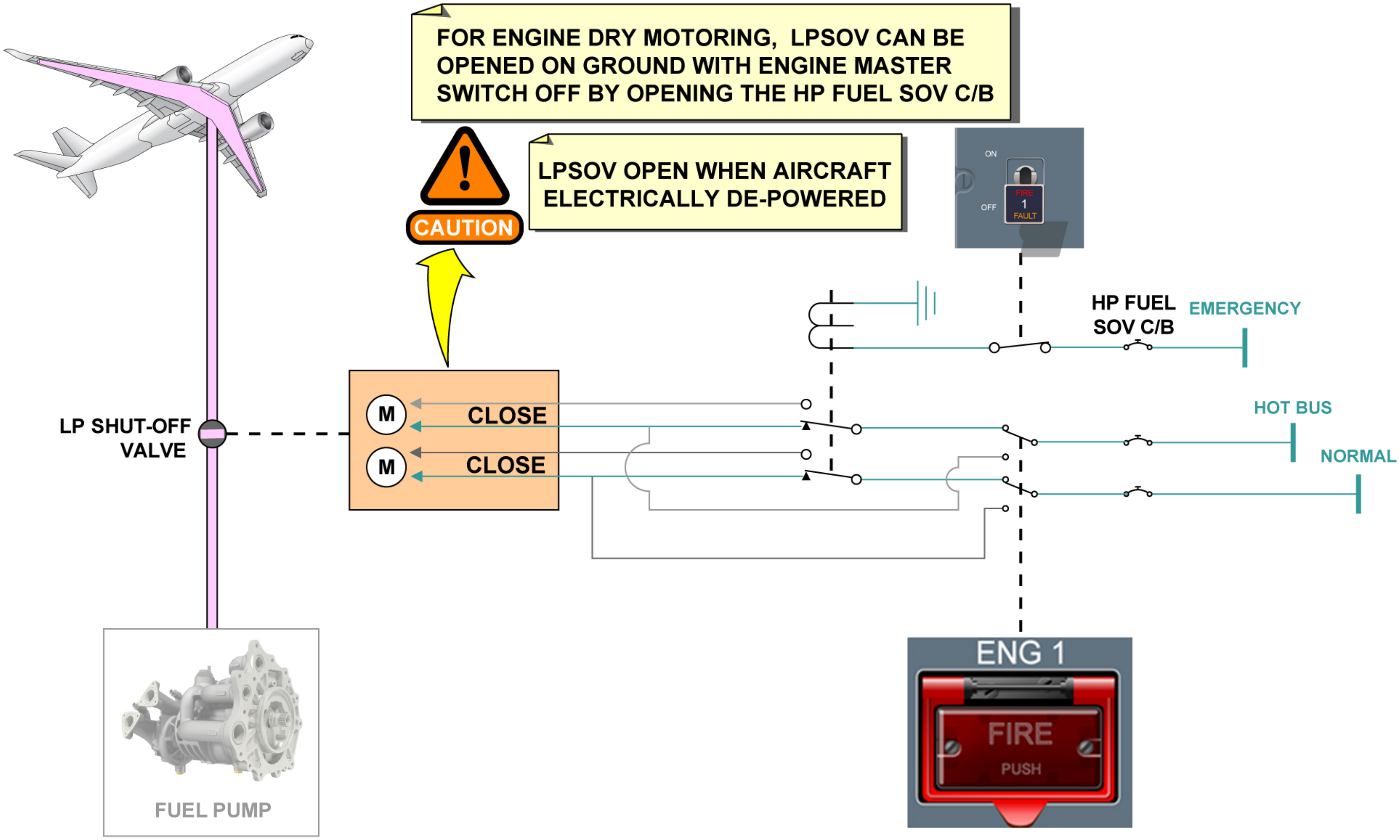
GENERAL PRESENTATION

V1813401 - V01T0M0 - VM70D7FUEL03001

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Low-Pressure Shut-Off Valve Description

The LPSOV allows the fuel to be supplied or isolated from the aircraft fuel system to the engine fuel system (refer to the Engine Feed System Description chapter).
When the master switch is ON, the LPSOV is open. When the master switch is OFF, the LPSOV is closed.
CAUTION: WHEN THE AIRCRAFT IS ELECTRICALLY DE-POWERED, THE LPSOV GOES TO ITS OPEN FAIL-SAFE POSITION, WHATEVER THE POSITION OF THE ENGINE MASTER SWITCH.
If there is a fire, the engine fire-switch circuit bypasses the relay and controls the LPSOV to close.
For engine dry motoring, the LPSOV can be opened on ground with engine master switch OFF by opening the High Pressure (HP) fuel Shut-Off Valve (SOV) C/B.



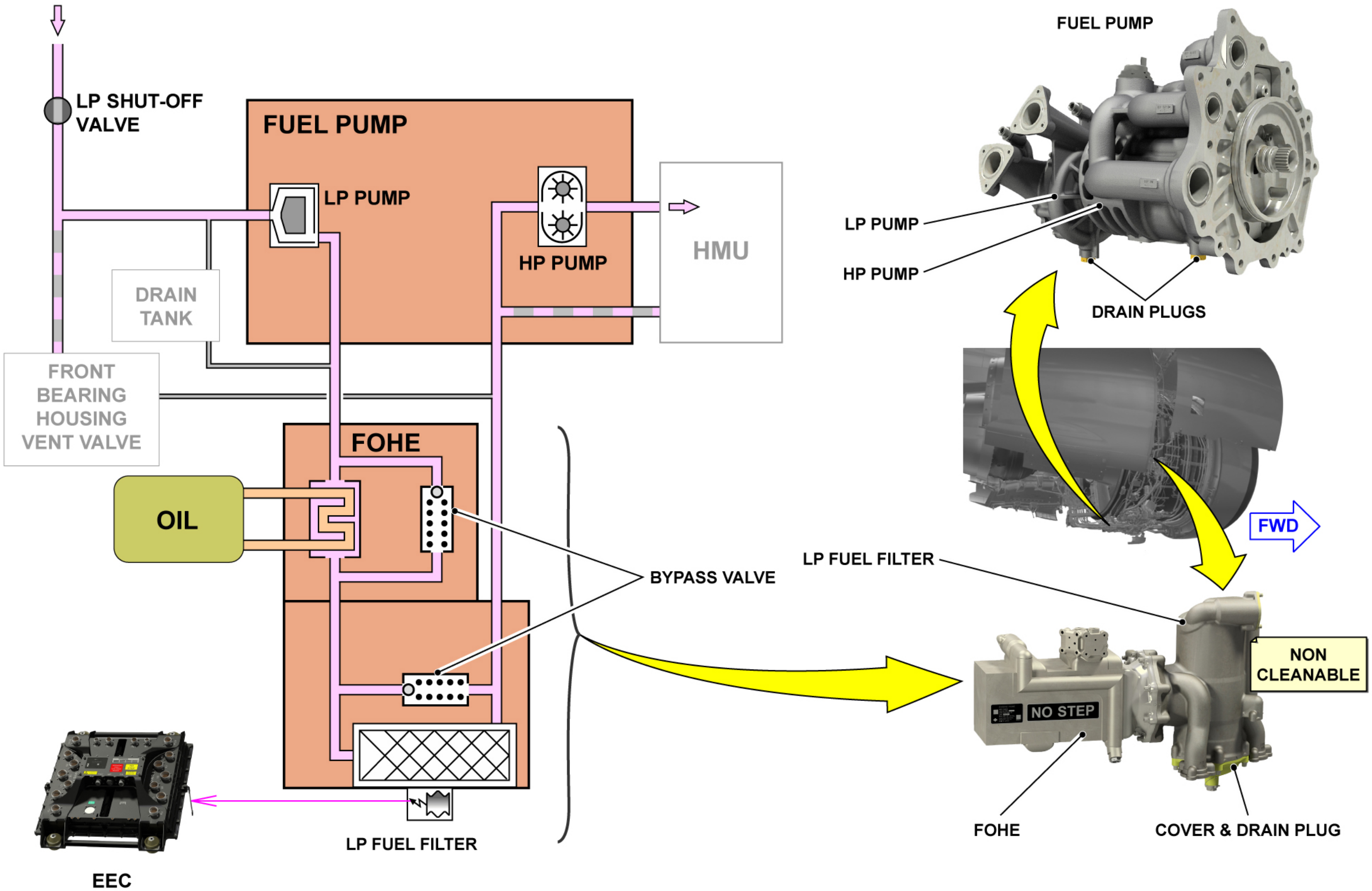
LOW-PRESSURE SHUT-OFF VALVE DESCRIPTION

V1813401 - V01T0M0 - VM70D7FUEL03001

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Fuel Pump, Fuel Oil Heat Exchanger and LP Fuel Filter Description

From the LPSOV the fuel goes to the fuel pump.
The fuel pump is installed on and driven by the external gearbox.
The first stage of the fuel pump is a LP (centrifugal) pump. The fuel pressure increases to a value depending on the engine speed.
From the first stage of the fuel pump, the fuel enters the FOHE.
The FOHE is located on the fan case (right hand side).
A bypass valve allows continuous fuel supply, if there is a blockage.
The LP fuel filter removes debris and particles from the fuel to prevent contamination and blockage in the HMU.
The LP fuel-filter differential-pressure transducer monitors the filter condition. The EEC sends a message to the Control and Display System (CDS) when there is an impending filter blockage. A bypass valve prevents fuel blockage.
The fuel filter housing has a cover and a drain plug to replace the non-cleanable filter element.
Much of the fuel is highly pressurized by the second stage of the fuel pump.
The drain plugs are at the bottom of the fuel pump to do maintenance.



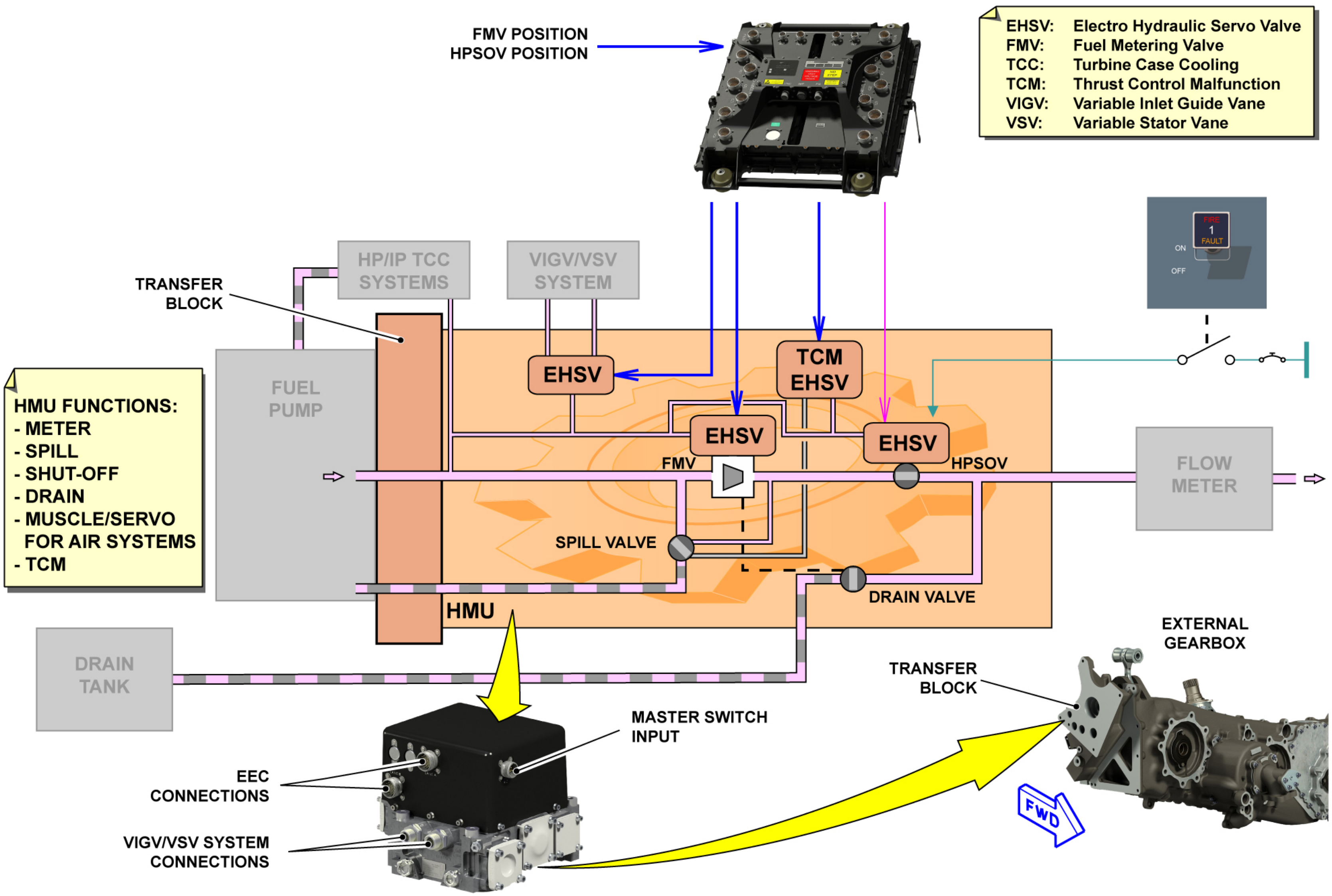
FUEL PUMP, FUEL OIL HEAT EXCHANGER AND LP FUEL FILTER DESCRIPTION

V1813401 - V01T0M0 - VM70D7FUEL03001

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Hydro Mechanical Unit Description

The fuel from the fuel pump goes through a transfer block. The transfer block is attached to the right end of the external gearbox. It lets the routing of fuel between the fuel pump and the HMU (reduction in the number of pipes).
The HMU is attached to the transfer block. Internal valves and Electro Hydraulic Servo Valve (EHSV) does these functions:
- The Fuel Metering Valve (FMV) and related EHSV meters the fuel sent to the combustion chamber with EEC control.
- The spill valve is a modulating valve. It keeps a constant pressure drop across the FMV. It sends unused fuel back to the fuel pump.
- The HPSOV is an On/Off valve operated by an EHSV. The EEC opens the HPSOV during start. The master switch closes the valve during shutdown by hardwired electrical supply. Finally, the EEC can close the valve for overspeed protection or for TCM on the ground. This leads to an automatic shutdown. The EEC monitors the HPSOV position.
- The drain valve is mechanically connected to the FMV and moves to the opposite position. During engine operation it is closed. During shutdown it opens and fuel downstream of the HPSOV is sent to the drain tank.
- A part of the fuel entering the HMU is used as a servo fuel by the Variable Inlet Guide Vane (VIGV)/Variable Stator Vane (VSV) EHSV and as muscle fuel by the HP/Intermediate Pressure (IP) Turbine Clearance Control (TCC) system.
- The TCM EHSV lets the EEC to do the TCM accommodation in flight. The TCM EHSV drives the spill valve to a more open position for fuel flow reduction resulting in thrust reduction.

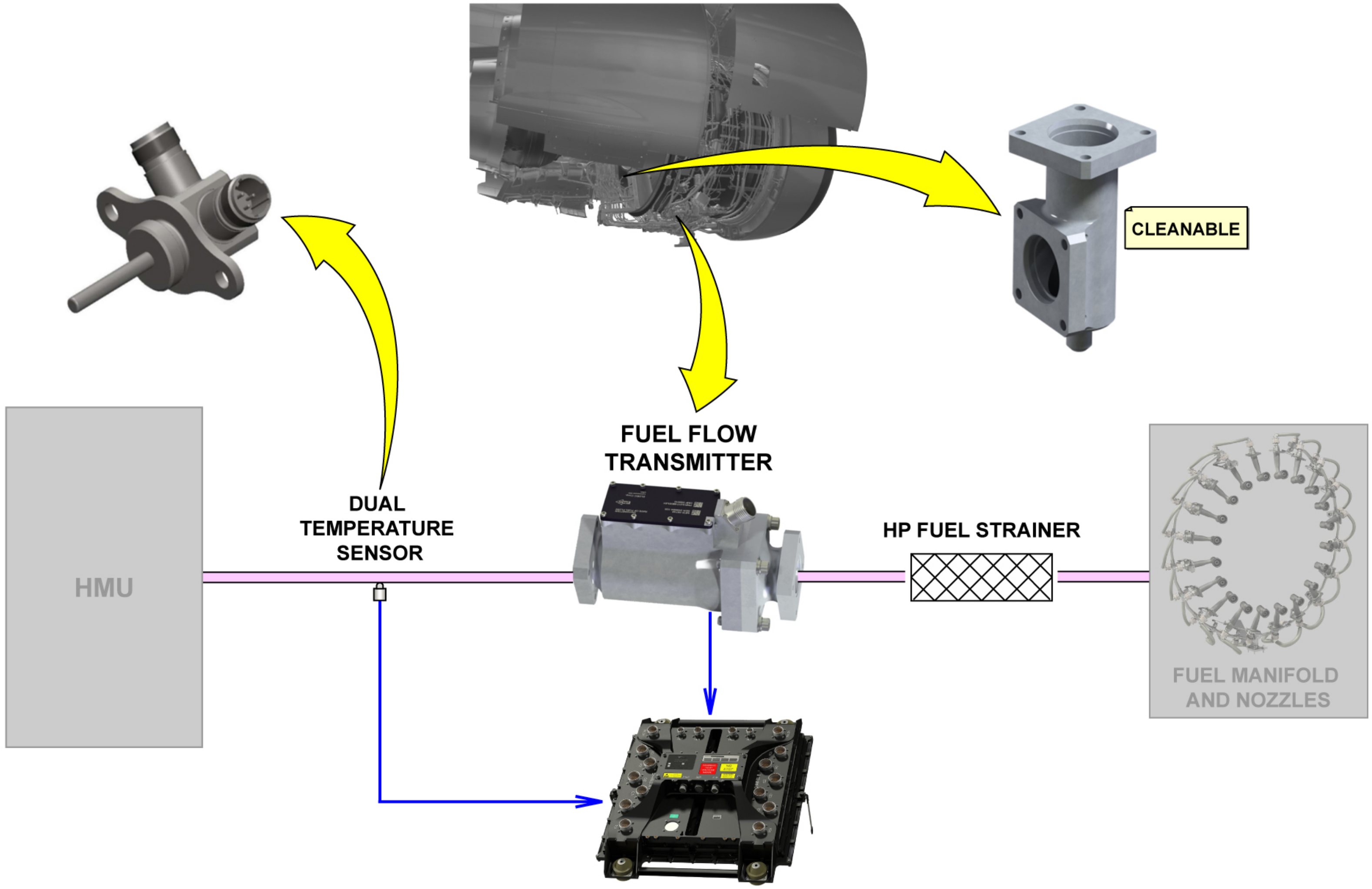


HYDRO MECHANICAL UNIT DESCRIPTION

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Fuel Flow/Temperature Monitoring and HP Filter Description

Metered fuel temperature is monitored by a dual temperature sensor. The signals are sent to the EEC for monitoring and temperature control purpose (refer to Oil System Description chapter).
The fuel flow transmitter is installed downstream of the temperature sensor. It sends actual fuel flow information to the EEC for indication purpose.
The dual temperature sensor and the flow-meter are located on the fuel supply tube downstream of the HMU.
The fuel supply tube goes into the engine core zone. The fuel is filtered by a cleanable metallic HP fuel-strainer. This is the last filtration for the fuel.



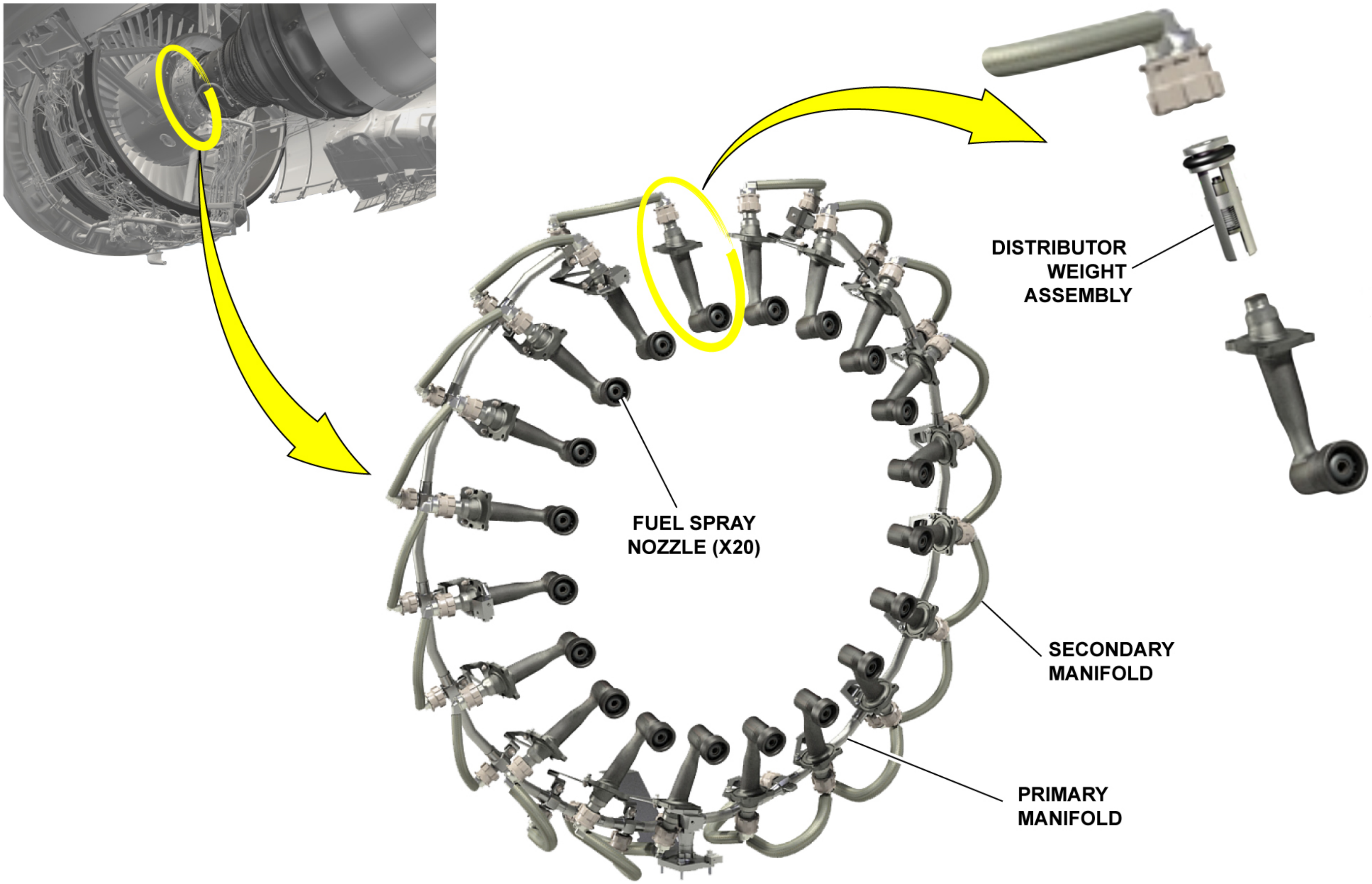
FUEL FLOW/TEMPERATURE MONITORING AND HP FILTER DESCRIPTION

V1813401 - V01T0M0 - VM70D7FUEL03001

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Manifold and Nozzles Description

Metered fuel from the HP fuel strainer enters into the primary manifold at the bottom. The primary manifold is an annular tube divided in two halves: One half on the left side and one on the right side around the combustion chamber.
The primary manifold supplies fuel to the secondary manifolds (quantity 20).
The secondary manifolds are flexible tubes connecting the primary manifold to the fuel spray nozzles.
The fuel spray nozzles (quantity 20) are equally spaced around the combustion chamber. The nozzle head supplies a correct mixing and spraying of the air/fuel mixture into the combustion chamber (inner and outer swirl vanes).
A distributor weight assembly is installed in the nozzle inlet. At low fuel flow condition, pressure at the bottom of the primary nozzle is higher than at the top. The distributor weight assembly is more open at the top than at the bottom to re-equalize the pressure.



MANIFOLD AND NOZZLES DESCRIPTION

V1813401 - V01T0M0 - VM70D7FUEL03001

ENGINE FUEL SYSTEM DESCRIPTION (2/3)

Drain Tank Description

The drain tank installed on the fan case (right side) is used to collect fuel remaining in the fuel manifold after an engine shutdown or a start failure. This is to minimize the build-up of carbon in the fuel nozzles.
During the shutdown, the FMV drives the drain valve to open. Fuel remaining between the HPSOV and the fuel nozzles is drained into the drain tank. Because the fuel pump does not give pressure in the ejector pump, the non-return valve is closed and the drained fuel stays in the drain tank.
During the next start, the FMV drives the drain valve to close. The fuel pump produces muscle pressure in the ejector pump, creating suction in the drain tank. The non-return valve opens and fuel in the drain tank returns to the pump inlet and is re-used by the HMU. When the drain tank is empty, the float valve closes to prevent air ingestion in the system.
Note: After a number of subsequent failed starts, the drain tank becomes full and fuel overflows to the engine drain mast.

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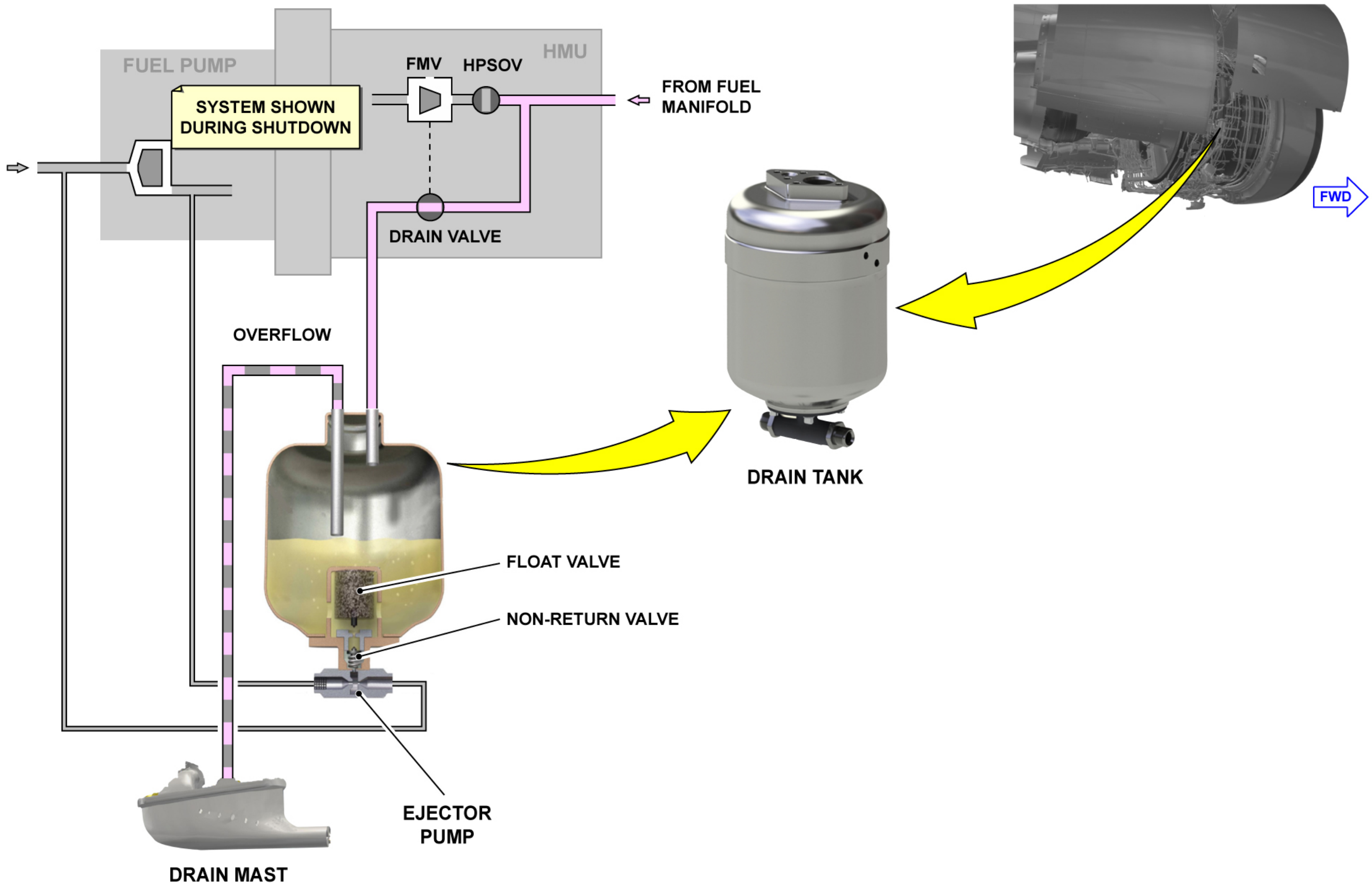


V1813401 - V01T0M0 - VM70D7FUEL03001

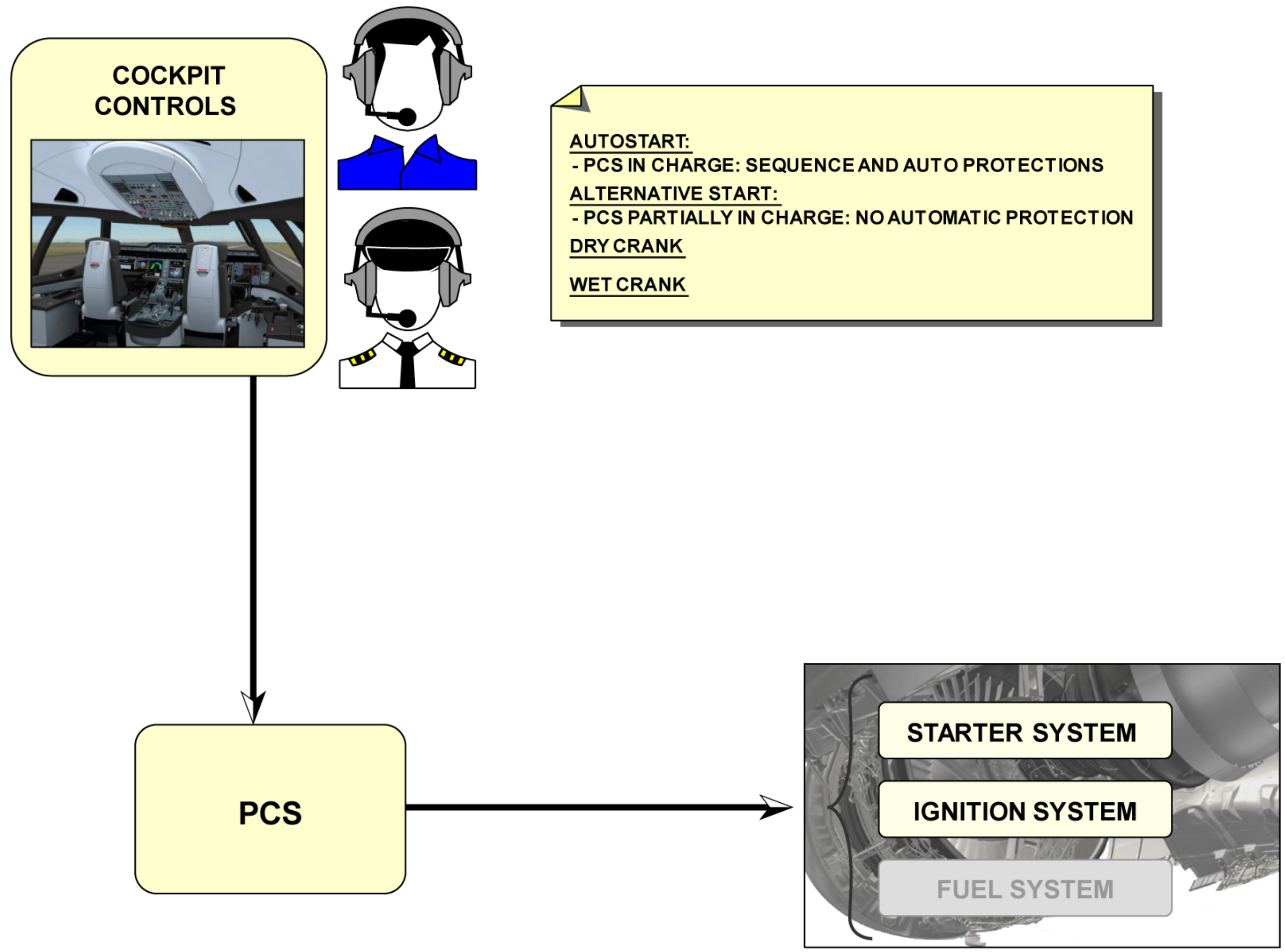
DRAIN TANK DESCRIPTION

ENGINE STARTING AND IGNITION SYSTEM DESCRIPTION (2/3)

General Presentation

The starting and ignition system lets the maintenance crew or the flight crew start or crank the engine.
Actions on the cockpit controls are sent to the Propulsion Control System (PCS). The PCS controls the starting, ignition and fuel systems accordingly.
The system lets the engine start in all operating conditions. The crew can select an automatic start or a manual start:
- For an automatic start, the PCS is in charge of the starting sequence and gives automatic protections. If there is a problem, the PCS aborts the start.
- For the alternative (MAN) start, the PCS is partially in charge of the sequence and there are no automatic protections.

On the ground, the maintenance crew can also use the starting system to crank the engine. During a dry crank the engine is motored with no fuel being injected. But, during a wet crank the fuel system supplies the fuel.



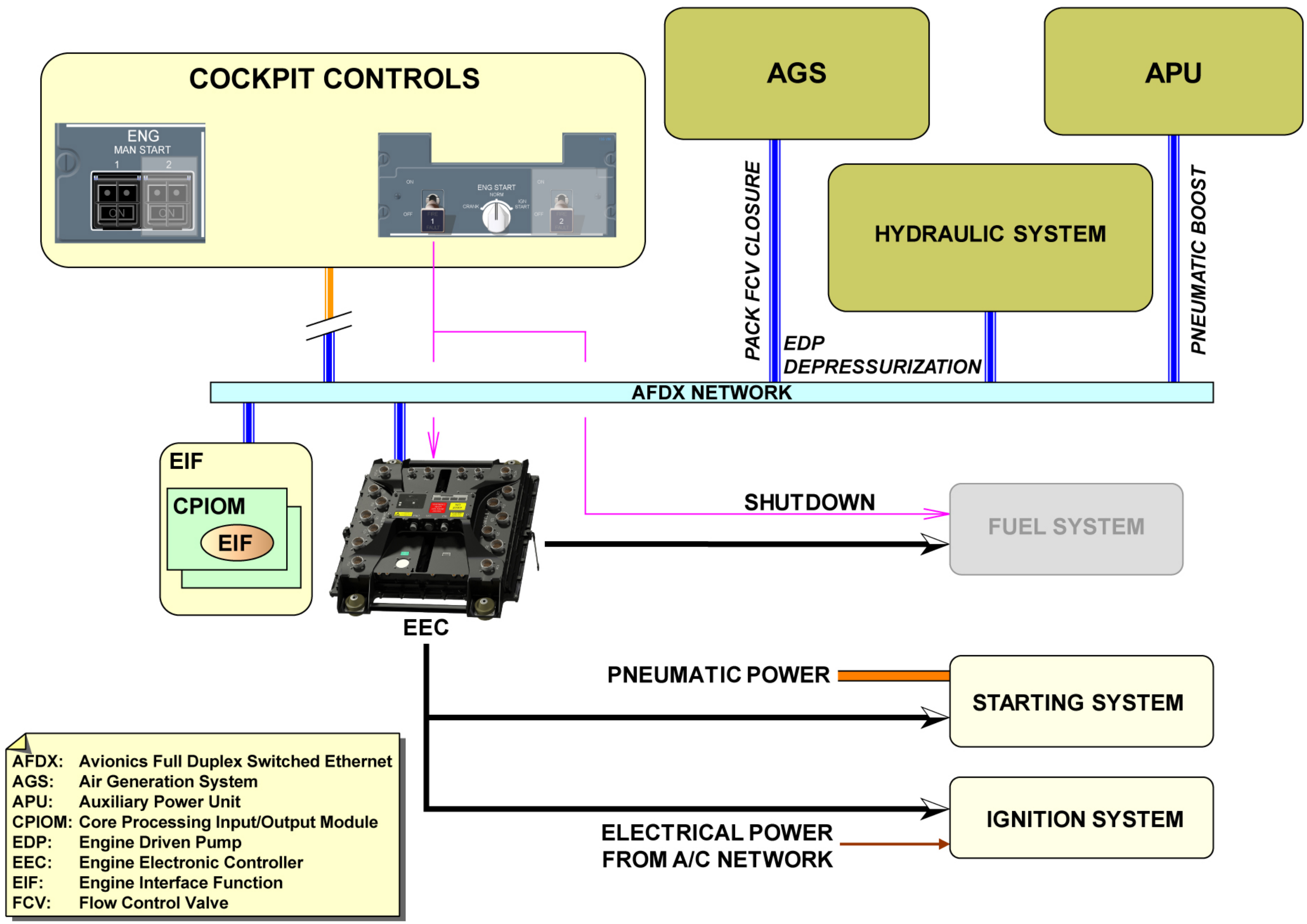
PCS: Propulsion Control System

GENERAL PRESENTATION

ENGINE STARTING AND IGNITION SYSTEM DESCRIPTION (2/3)

Starting and Ignition System Main Interfaces

The cockpit controls involved in the starting and ignition system are the manual start switch, the Engine Master Switch (EMS) and the engine start selector.
During usual operation, these cockpit controls send digital signals on the Avionics Full Duplex Switched Ethernet (AFDX) network. The Engine Interface Function (EIF) receives these selections and calculates a related command signal (auto start, manual start etc.).
This command signal is sent to the Electronic Engine Control (EEC) through the AFDX network. The EEC controls the starting, the ignition and the engine fuel systems as per this signal.
The starter uses air from the pneumatic system to crank the engine.
The ignition system uses electrical power from the aircraft electrical network.
For safety, a discrete between the EMS and the engine fuel system lets the engine shutdown. One more discrete from the EMS lets the EEC reset.
During the start sequence the command signal sent by the EIF is also used by these systems:
- The Air Generation System(AGS) closes the pack Flow Control Valve (FCV), which lets a correct flow of pneumatic air supplied to the starter system
- The Auxiliary Power Unit (APU) boosts its pneumatic air flow delivery
- The hydraulic system depressurizes the Engine Driven Pumps (EDPs) to decrease the load on the external gearbox.



STARTING AND IGNITION SYSTEM MAIN INTERFACES

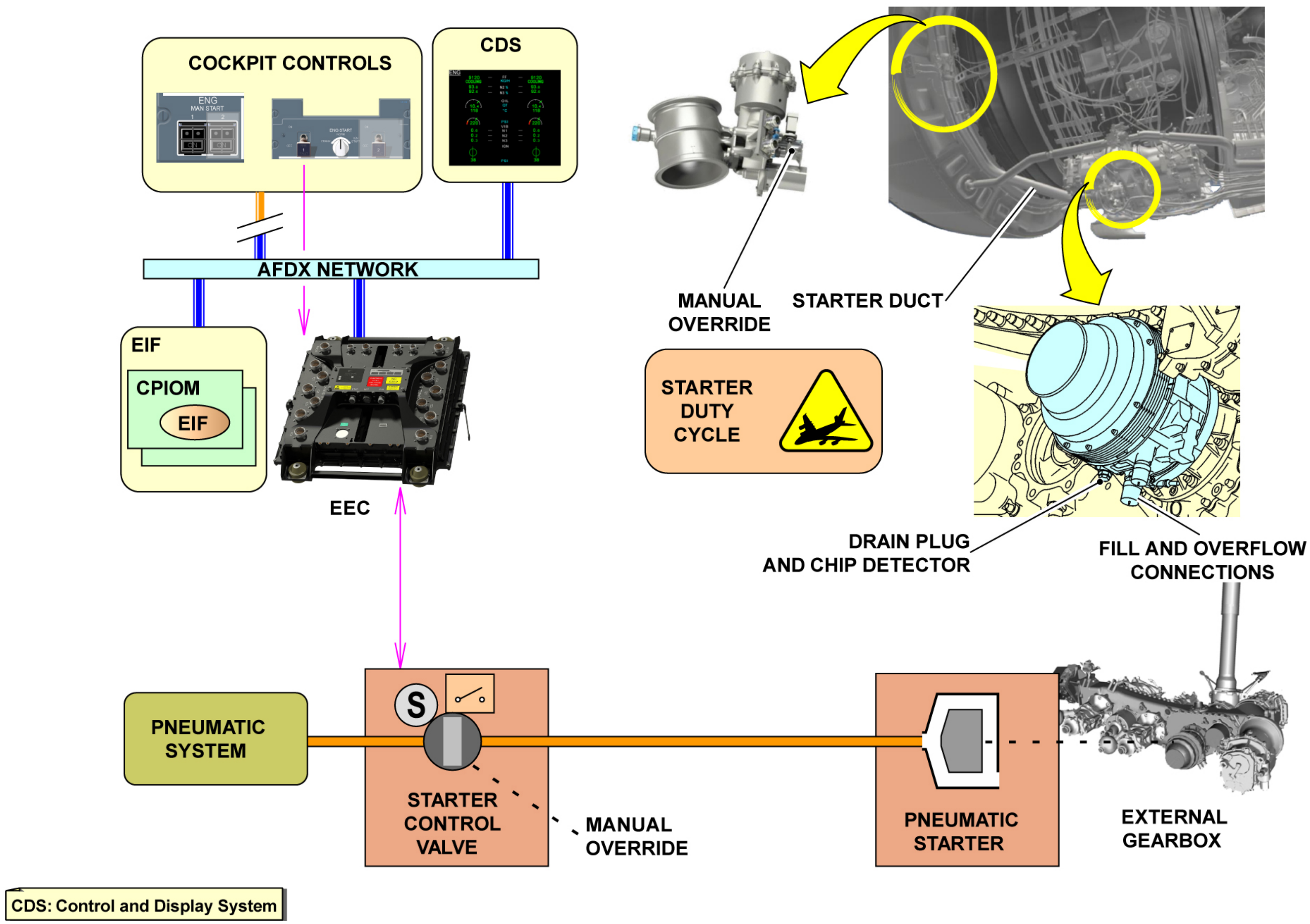
V1813401 - V01T0M0 - VM70DBIGNST3001

ENGINE STARTING AND IGNITION SYSTEM DESCRIPTION (2/3)

Starting System Description

The starting system function is to change pneumatic power into a rotational torque to crank the engine. The primary components are:
- A starter control valve
- A pneumatic starter
- A starter duct.

The starter control valve installed on the fan case is electrically controlled and operates pneumatically. The EEC controls the starter control valve to open or close, if there is a command signal from the EIF (or directly from the EMS in back-up). The EEC receives a position feedback signal from the starter control valve for control and indication in the cockpit (engine page).
A manual override device lets a ground operator open the valve manually (using a standard tool with an extension through a dedicated hole in the fan cowling).
The pneumatic starter installed on the external gearbox is made of a turbine receiving pneumatic power from the starter control valve. An internal clutch disconnects the starter control valve from the gearbox above a predetermined engine speed.
The pneumatic starter has its oil system. For maintenance, fill and overflow connections and a drain plug are installed. A chip detector lets recognition of excessive wear.
The starter duct connects the starter components together and the pneumatic system (pylon area).
Caution: Respect the starter duty cycle.



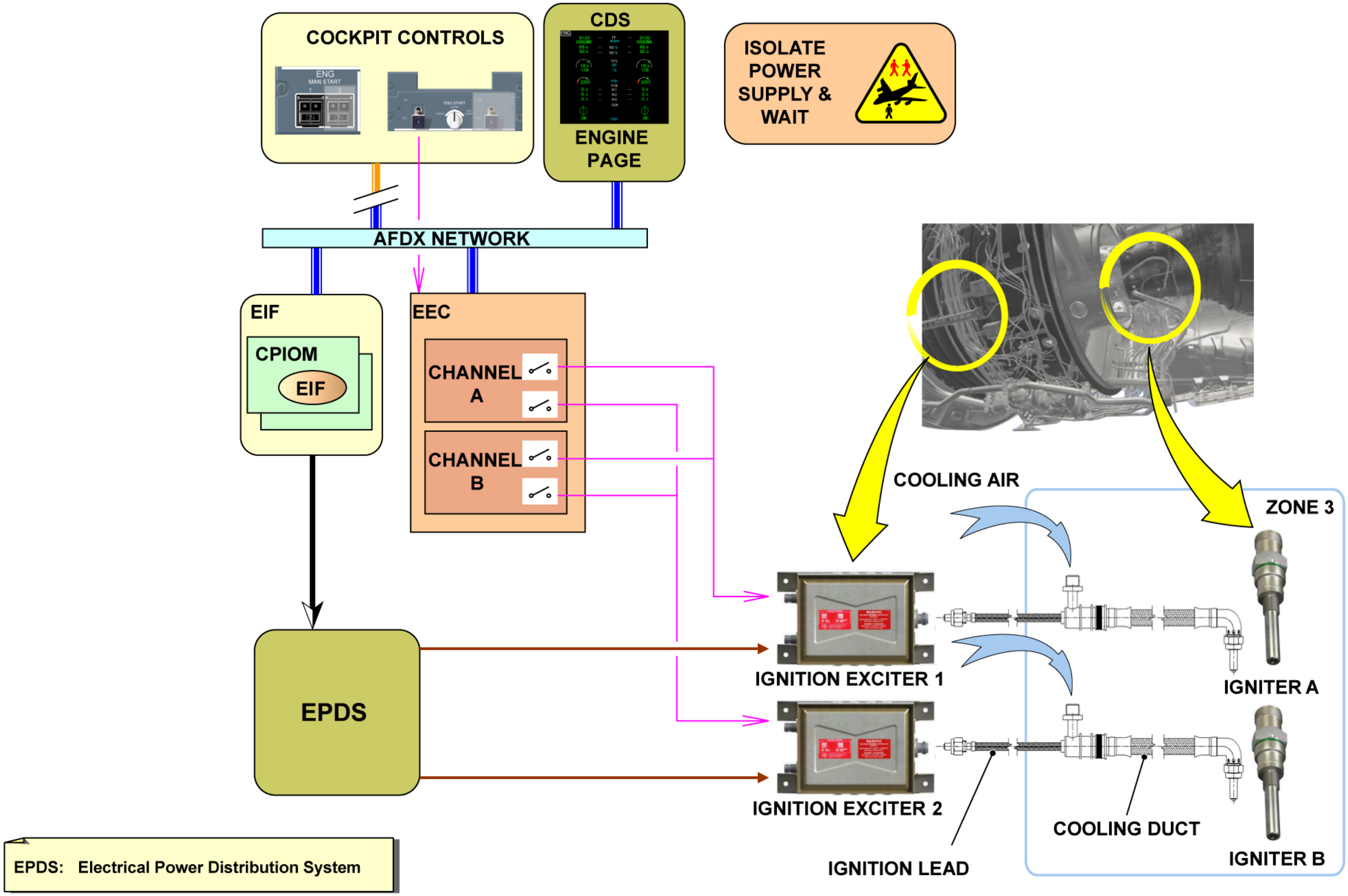
STARTING SYSTEM DESCRIPTION

ENGINE STARTING AND IGNITION SYSTEM DESCRIPTION (2/3)

Ignition System Description

The ignition system function is to ignite the air/fuel mixture in the combustion chamber during the start. It also prevents an engine flame-out in bad weather conditions.
The ignition system has two redundant and independent systems. Each system is made of an ignition exciter, an ignition lead and an Igniter.
The ignition exciters installed on the fan case (left side) receive electrical power supply from the aircraft electrical network (115 VAC supplied by Electrical Power Distribution System (EPDS) with EIF control).
They change this power to high energy pulses (transformer and condenser are used), when they receive a command signal from the EEC.
The switching configuration in the EEC lets any EEC channel to control one or both ignition systems.
During the first autostart on the ground, only one igniter is used. In other conditions, the two igniters are used.
The EEC gives automatic continuous ignition, if there is flame-out or rain/hail ingestion.
The EEC also gives data to the Control and Display System (CDS) on the system operation.
The ignition leads make the interface between the ignition exciters and the igniters. In Zone 3 most of the leads are protected against overheat by a cooling shroud (or duct) receiving cooling air (from the Intermediate Pressure Turbine Case Cooling (IPTCC) cooling duct).
The igniters are installed on the engine core around the combustion chamber (one on each side). They receive high energy pulses from the Ignition exciter and release powerful sparks in the combustion chamber.
Note: Strictly follow the approved maintenance procedures when working on the ignition system. Dangerous electrical discharges can occur. Before working on the ignition system, isolate power supply and wait for a sufficient time.

V1813401 - V01T0M0 - VM70DBIGNST3001



IGNITION SYSTEM DESCRIPTION

ENGINE SYSTEMS CONTROL AND INDICATING (2/3)

Engine Systems - General (2)

The following engine controls are located on the overhead panel:
- The EIM 1&2 RESET switches,
- The ENGine FADEC GND PWR P/B switches,
- The ENGine FIRE P/B switches,
- The ENG MANual START P/B switches

The Autothrust (A/THR) P/B is located on the glareshield.
The following controls are located on the pedestal:
- The ENG START selector,
- The ENG MASTER Levers (MASTER Lever OFF direct to LP & HP Fuel SOV and for EEC reset signal).
- The THRUST Levers with the instinctive disconnect P/Bs,
- The REVERSER Levers,

The primary engine parameters are displayed on the EWD.
The secondary engine parameters are displayed on the SD ENG page.

FADEC Powering and Depowering (2)

When A/C is on ground, each FADEC system is automatically de-powered 15 min after:
- A/C power-up,
- Engine Shutdown.

When pressing the FADEC GND PWR P/B SW to ON, the FADEC parameters come up on the EWD and the amber "XX" are replaced by the main parameters. If the FADEC GND PWR P/B SW remains ON, the related FADEC remains powered for 10 min, except if OMS is in interactive mode. In this case the FADEC remains powered during this interactive mode.
Also by setting the ENG START selector switch to the CRANK or IGN START position with engines not running the FADEC is immediately powered.
The corresponding indication is clearly displayed on the EWD and the amber "XX" are replaced by the main parameters. On ENG SD page, the secondary parameters are clearly displayed.
If the EIM 1(2) reset switch is pulled for maintenance purpose, the related FADEC is immediately powered (fail-safe). When the reset switch is pushed back to normal position, the related FADEC remains powered for 15 min.
When releasing out the ENG1(2) FIRE P/B, the related FADEC is immediately depowered. In addition the related engine is isolated from the following systems:
- Hydraulic system, by closure of the fire shut-off valves,
- Bleed system, by closure of the HPV and MPV,
- Fuel system, by closure of the fuel LP valve.

Note: WITH ENG FIRE P/B RELEASED OUT, THE ENGINE FIRE EXTINGUISHERS ARE ARMED. DO NOT PRESS THE AGENT P/BSWs OTHERWISE THE FIRE EXTINGUISHERS WILL BE DISCHARGED.

Engine Parameters Display (2)

The Airbus Cockpit Universal Thrust Emulator (ACUTE) converts the engine control parameter into a common thrust parameter (THR) which is indicated on EWD. The main thrust parameter (THR) is calculated from the FAN speed parameter (N1).
Among the main parameters displayed on the EWD, you have the Thrust Rating mode indication (CLB, MCT or FLEX, TOGA) and a corresponding thrust limit value
The LP rotor speed (N1) and EGT indications are also displayed on EWD.
The ENGINE SD page can be manually called by the selection of the ENG key on the ECAM Control Panel (ECP) located on the pedestal.
The engine secondary parameters, which are shown on the ENGINE SD page, are the following:
- IP rotor speed (N2),
- HP rotor speed (N3),

- Fuel Flow (FF),
- Engine oil quantity (OIL QTY),
- Engine oil temperature (OIL TEMP),
- Engine oil pressure (OIL PRESS),
- Engine rotor vibration levels (VIB N1, N2, N3).

During Engine Start or Crank sequence, the bleed pressure PSI, Start Valves positions and ignition indications (during start sequence only) appear.

Engine Fuel System Contamination (2)

When the engine fuel filter is detected as clogged by the related differential pressure switch, the "ENG1(2) FUEL SYS CONTAMINATION" warning is triggered on ECAM.
CAUTION: You must not operate the engine if the fuel system is contaminated
Contaminated fuel can bypass the filter and cause damage to the engine.
Replace the LP fuel filter before you operate the engine again.

Engine Dry Crank (3)

There are two engine cranking methods:
- Dry Crank
- Wet Crank.

For cranking an engine, the ENG START rotary selector is selected to CRANK position followed by switching of:
- Associated MAN START P/B to ON, for a Dry crank only.
- Associated MAN START P/B to ON and associated ENG MASTER Lever to ON, for a Wet crank.

Note: For a Wet crank, fuel supply should be limited to the minimum and should be followed by a Dry crank to remove fuel from combustion chamber.
Summary of Engine Dry Crank procedure:
- PACK 1 & 2 Pushbuttons...OFF
- ENG START Selector...CRANK

ECAM ENG page appears.
Check all indications are normal and all parameters for logical indication.
Air pressure above 30 psi.
- Ground Clearance...OBTAIN

Announce Motor Engine 1(2)
- ENG MAN START 1(2)..ON
- Start Chrono.
- On ECAM ENG page:

Check Start valve in line
N3 increases
Oil pressure increases within 30 seconds
N1 and N2 rotation
When dry motoring completed:
- ENG MAN START 1(2)...OFF
- Stop Chrono, and note starter operating time.
- On ECAM check:

Start valve cross line
N3 decreases
- ENG START Selector...NORM

Engine Dry motoring completed.

Engine Wet Crank (3)

Summary of Engine Wet Crank (Motoring) procedure:
- FUEL Pumps...ON
- PACK 1 & 2 Pushbuttons...OFF
- ENG START Selector...CRANK

ECAM ENG page appears.
Check all indications are normal and all parameters for logical indication.
Make sure EGT is less than 150 deg.C
Air pressure above 30 psi.
- Ground Clearance...OBTAIN

Announce Motor Engine 1(2) .
- ENG MAN START P/B 1(2)..ON
- Start Chrono.

- On ECAM ENG page:
Check Start valve in line
N3 increases
Oil pressure increases within 30 seconds
N1 and N2 rotation
When N3 > 20%
- ENG MASTER Lever 1(2,3,4)..ON
- On ECAM, check:
Oil pressure
Fuel Flow
After 10 seconds max of fuel vaporizing
- ENG MASTER Lever 1(2)..OFF
Observe dry motoring.
After 20 seconds minimum
- ENG MAN START P/B 1(2)..OFF
- Stop Chrono, and Note starter operating time.
- On ECAM check:
Start valve cross line
N3 decreases
- ENG START Selector..NORM
- FUEL Pumps...OFF
Engine Wet motoring completed.

Engine Thrust Control (3)

Two thrust control modes are used to obtain the required thrust, the manual and automatic mode.
In manual mode, the PCS receives a command signal from the Thrust Lever through the PRIM to compute the Thrust.
In autothrust mode, when the Auto THRust function is activated, the PRIMs computes the Thrust by taking into account:
- the Thrust Target demand from AFS and,
- the Throttle Lever Angle, for Thrust Limitation and to display the thrust limit mode

The Thrust Levers can be individually moved (manually only) and are used to adjust the aircraft forward thrust. The thrust levers can be moved to 4 different detents points: 0 (IDLE), CL for Climb, FLX/MCT for Flexible takeoff thrust and TOGA for Takeoff and Go-Around.
The movement of the Thrust Levers is indicated by a cyan circle on the EWD THR dial indicator. The thrust rating mode corresponding to the lever position/detent is also displayed on the upper part of the EWD.
CLB Thrust rating mode is displayed by default when engines are not running with thrust levers set below CL detent. As soon as first engine is started the CLB mode is automatically replaced by TOGA mode (or FLX mode if a flex temp has been inserted).
Two A/THR instinctive disconnect P/Bs (red) are located on the Thrust Levers. They input the PRIMs in order to disconnect the A/THR function as soon as one of them is pressed. Then the PRIMs send disconnection order to the EEC.
A back-up disconnection command is sent to some CRDC, then to the EEC.
An A/THR P/B is located on the Flight Control Unit (FCU) section of the glareshield. When it is pressed, three green lines on this P/B SW are illuminated and the A/THR white text is displayed on PFD-Flight Mode Announciator (FMA). The green lines go off when any instinctive disconnect P/B is pressed or when the A/THR P/B is pressed again.
The Reverser levers are used to control the deployment and stowing of the thrust reversers and to adjust the reverse thrust. The reverser levers move between two detents: IDLE and full reverse thrust.
A Reverse gray sector appears on the THR dial indicator to indicate the current reverse thrust range. A needle indicates the current reverse thrust and a blue circle the position of the reverser lever.
An associated REV indication appears onto the indicator.
REV 1 (2) indication:
- REV title turns green on the THR dial indicator, when the associated Thrust Reverser system is confirmed fully deployed.

Engine Automatic Start (3)

After the preliminary cockpit preparation has been done, the engine start can be initiated.
In normal start procedure, you start engine in automatic mode.
To start the engine in normal procedure:
- Turn the ENG START selector on "IGNition START" position, the ECAM ENG page appears,
- Observe PACKS valves auto closure when ENG START rotary selector leaves NORM position.
- Check if all indications are normal and all parameters for logical indications.
Before starting, make sure that the EGT is less than 150 ºC (302 ºF).
At beginning of auto start sequence, if the EGT is more than 150 ºC (302 ºF), the FADEC will automatically do an abort and a dry motor until the EGT decreases to less than 150 ºC (302 ºF).
- Ask the ground clearance to start the engine.
WARNING: Obey the safety precautions for engine ground operation. Make sure of use of safety entry corridors to go near an engine that is in operation at low idle (forward thrust only).
- If you obtain this clearance, announce the start engine,
- Check the air pressure is above 30 psi on the ECAM,
- Set the ENG MASTER lever to ON,
- On the ECAM, check that the start valve is in line and the start valve air pressure is upper 30 psi. The N3 and the oil pressure increase,
- When N3 is equal to 25%, the active igniter (A or B) is indicated and the fuel flows.
The light up is automatically initiated by the FADEC.
- Start the chrono and check the EGT increases within 30 seconds,
- At N3 above 30%, N1 increases and the oil pressure is green,
- Continue to monitor EGT. The EGT limit for a ground start is 700 ºC.
- At N3 above 50%, the start valve is cross line and the igniter indication disappears,
- AVAIL indication appears inside dedicated THR indicator, to indicate a successful engine start.
- When the engine is at idle, check parameters for logical indication.
- PACKS valves reopen when engine start sequence completed.
After Engine Start(s), return ENG START rotary selector to NORM.

Engine Manual Start (3)

After the preliminary cockpit preparation has been done, the engine start can be initiated.
To start the engine in Manual mode:
- Turn the ENG START selector on "IGNition START" position, the ECAM ENG page appears,
- Observe PACKS valves auto closure when ENG START rotary selector leaves NORM position.
- Check if all indications are normal and all parameters for logical indications,
You must not start the engine if the EGT is more than 150 ºC (302 ºF). If you do so, the EGT will exceed its limit during the engine start. You can dry motor the engine to decrease the EGT.
MAKE SURE THAT THE EGT IS LESS THAN 150 ºC (302 ºF).
CAUTION: There is no automatic protection while performing an engine start in manual mode.
- Ask the ground clearance to start the engine.
WARNING: Obey the safety precautions for engine ground operation. Make sure of use of safety entry corridors to go near an engine that is in operation at low Idle (forward thrust only).
- Check the air pressure is above 30 psi on the ECAM,
- On overhead panel, select ENG MAN START P/B to ON,
The start valve opens and the N3 rate increases.
- At maximum motoring speed (or 25% N3 minimum) set the ENG MASTER lever ON. The ignition (IGN A and B), and fuel flow (FF) indications come automatically into view on the ENGINE page.
- Start the chronometer and check EGT increases within 30 seconds,
Be careful and observe all the engine parameters, there is no automatic abort during the engine manual start. Be sure that EGT increases normally. EGT Ground start limit is 700 ºC.

In case of High EGT, abort engine immediately by selecting ENG MASTER Lever to OFF.
- At 50% N3, the start air valve closes automatically, even if MAN START P/B is still ON (no effect), and the ignition stops.
- AVAIL indication appears inside dedicated THR indicator, to indicate a successful engine start.
- When the engine is at idle, check parameters for logical indication.
- PACKS valves reopen when engine start sequence completed.
After Engine Start, deselect the MAN START P/B SW and return ENG START rotary selector to NORM.

Start Fault: Starter Control Valve Failed Closed (3)

If a start valve failure is detected during an engine automatic start, the following occurs:
- a single chime sounds,
- the MASTER CAUTion lights come on,
- the ENG 1(2) START VLV FAULT (NOT OPEN) or (NOT CLOSED) message is displayed on E/WD,
- with associated subtitle VLV STUCK CLOSED or START VLV NOT CLOSED,
- the FAULT light on MASTER lever, comes on (during automatic start only).
If the engine start valve fails to open, the engine start sequence can be done using the manual override device of the start valve.

Start Fault: Hot Start (3)

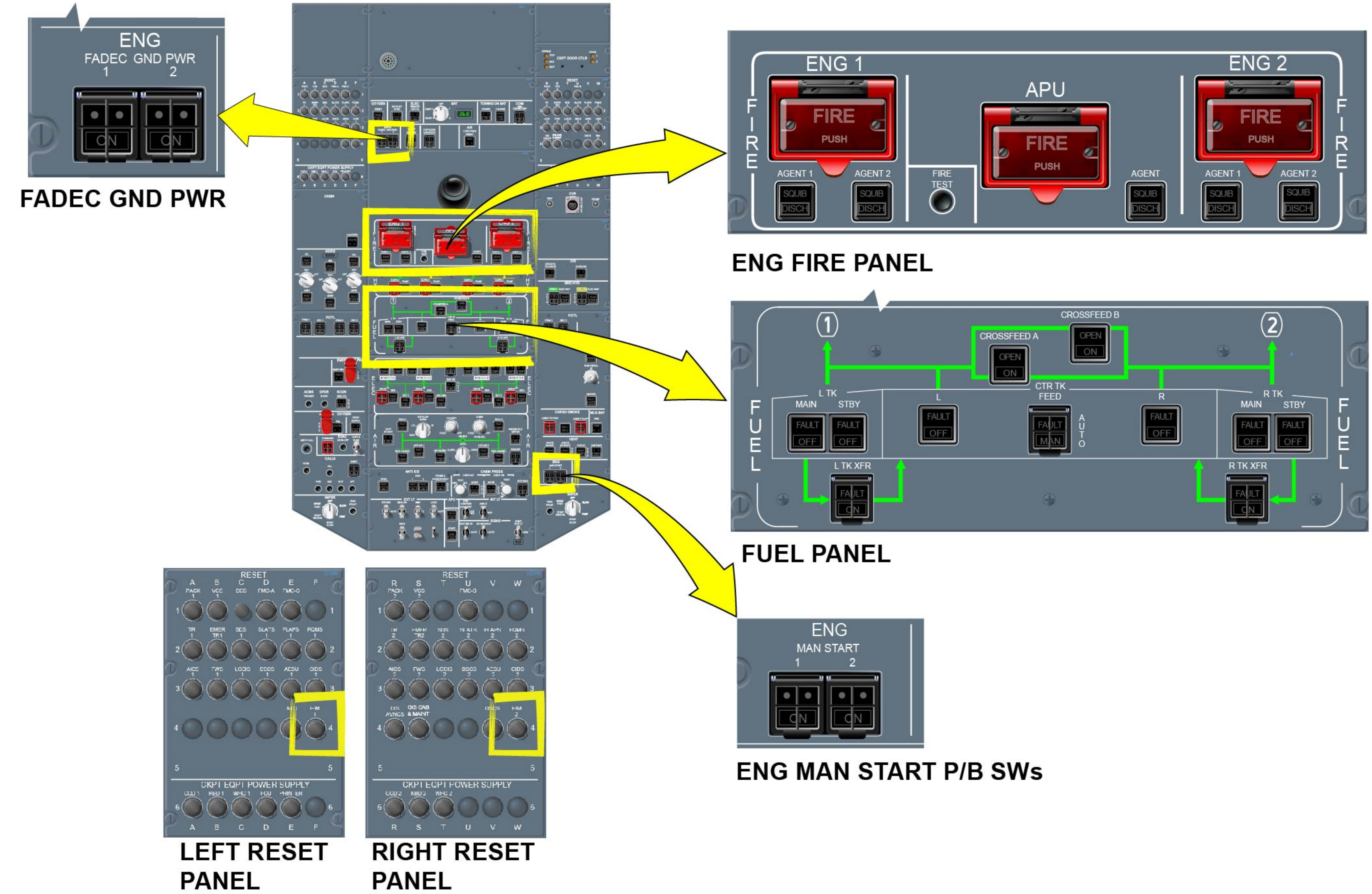
- ENG START FAULT, EGT OVERLIMIT warning message on EWD: the EGT has reached the maximum allowed EGT during start.
When the fault occurs on ground during an engine automatic start, the EEC proceeds to a start abort sequence including a dry cranking in order to decrease EGT below 150°C.
. NEW START IN PROGRESS message appears, on EWD.
. The SAV (Starter Air Valve), FUEL and IGNITERS are commanded off,
. As soon as N3 decreases below 10% (pneumatic starter re-engagement speed), the EEC commands the starter valve to open and performs a dry crank until the EGT decreases down to 150°C.
. A second start attempt is automatically initiated with both igniters A and B. If the fault is still present, a third attempt is performed. If the fault remains, the start sequence is definitively aborted after a dry crank sequence (until EGT below150°C).

Start Fault: No Light Up (3)

A failure of one ignition exciter or igniter plug during start sequence is identified by the ENG START FAULT - NO LIGHT UP warning, with associated subtitle IGN A(B) FAULT.
As a consequence the EGT does not rise, which is recognized by the EEC. During an automatic start, the sequence is automatically aborted by the EEC that will perform a dry cranking before to initiate a second start attempt with both igniters A&B supplied.
If the fault persists, a third attempt is performed. If fault remains, the start sequence is definitively aborted.

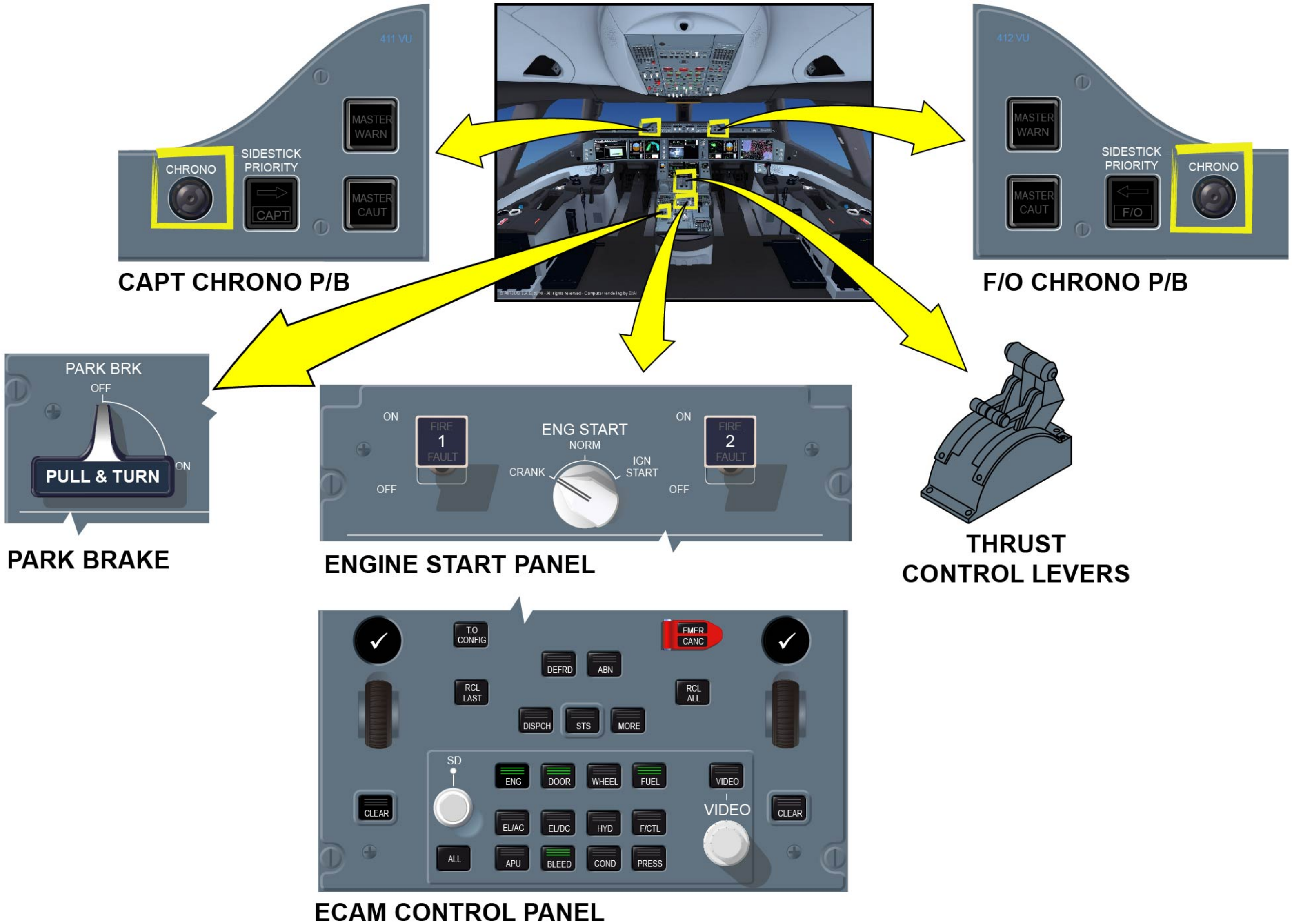
Turbine Overheat (3)

The engine turbine overheat is detected by two dual thermocouples, one at the front and one at the rear of the IP turbine disk.
When overheat is detected, the red ENG TURBINE OVHT warning is triggered on the EWD. The MASTER WARNING lights flash and the Continuous Repetitive Chime sounds.
In case of TURBINE OVHT warning occurring on ground, an immediate engine shutdown is required to prevent any damage on the IP turbine.

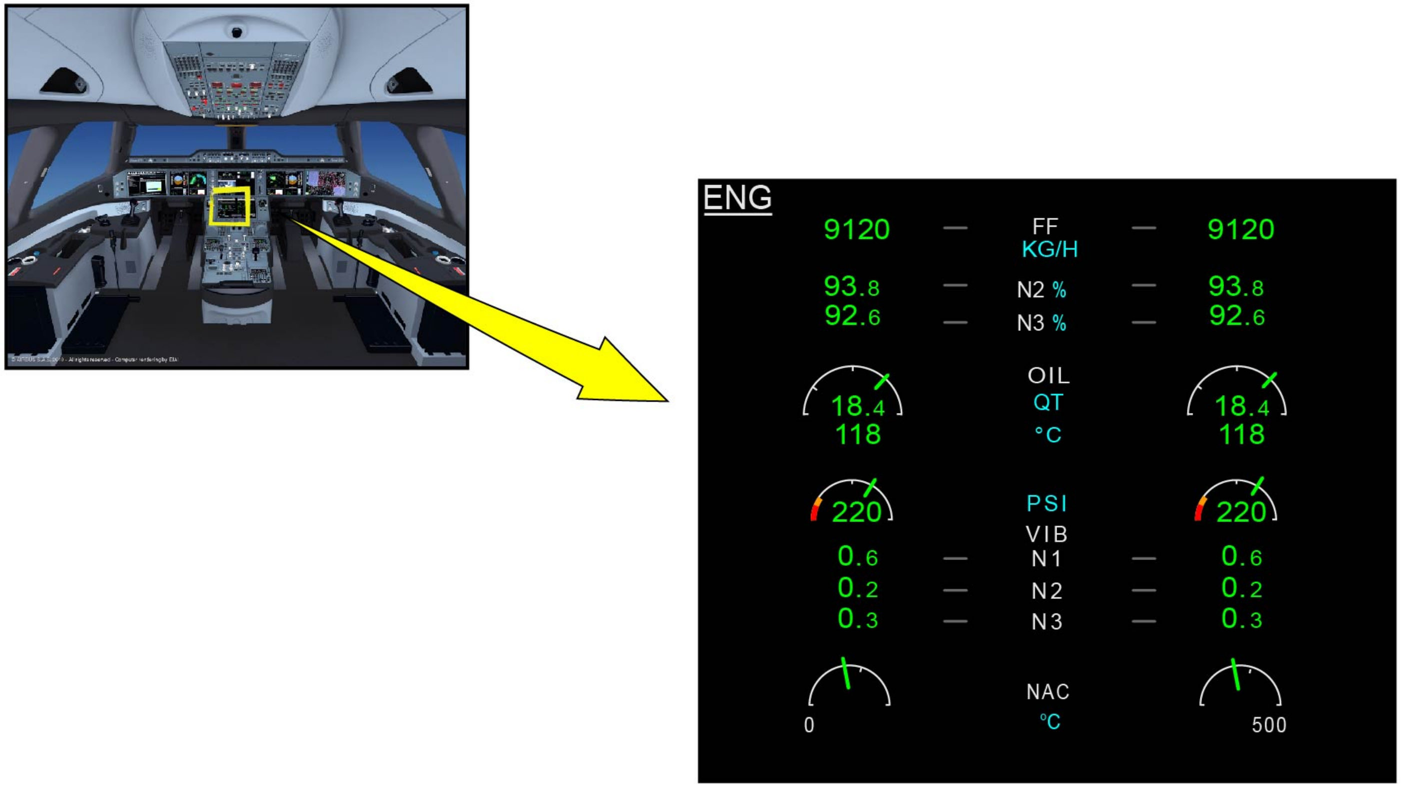


ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)

V1813401 - V01T0M0 - VM70I1000003001



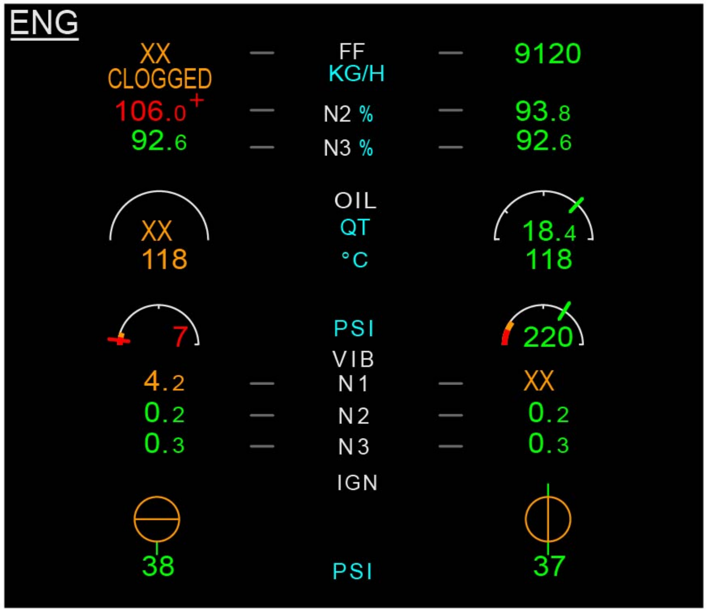
ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)



ENG SD PAGE

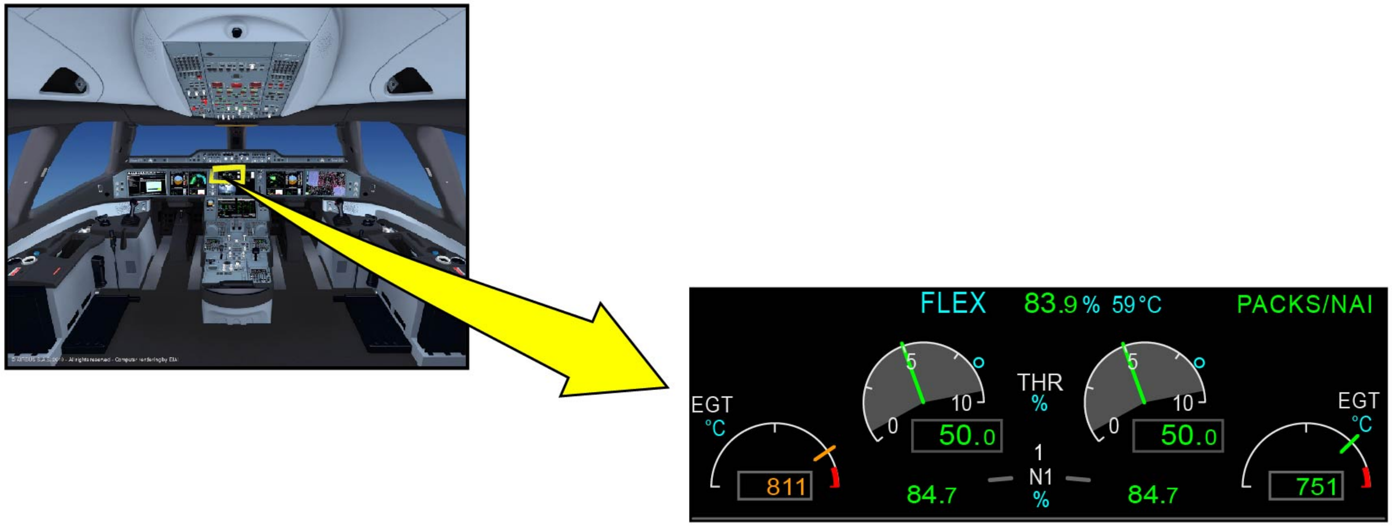
ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)

THIS SD SHOWS SEVERAL AVAILABLE INDICATIONS BUT NOT A SYSTEM CONFIGURATION.



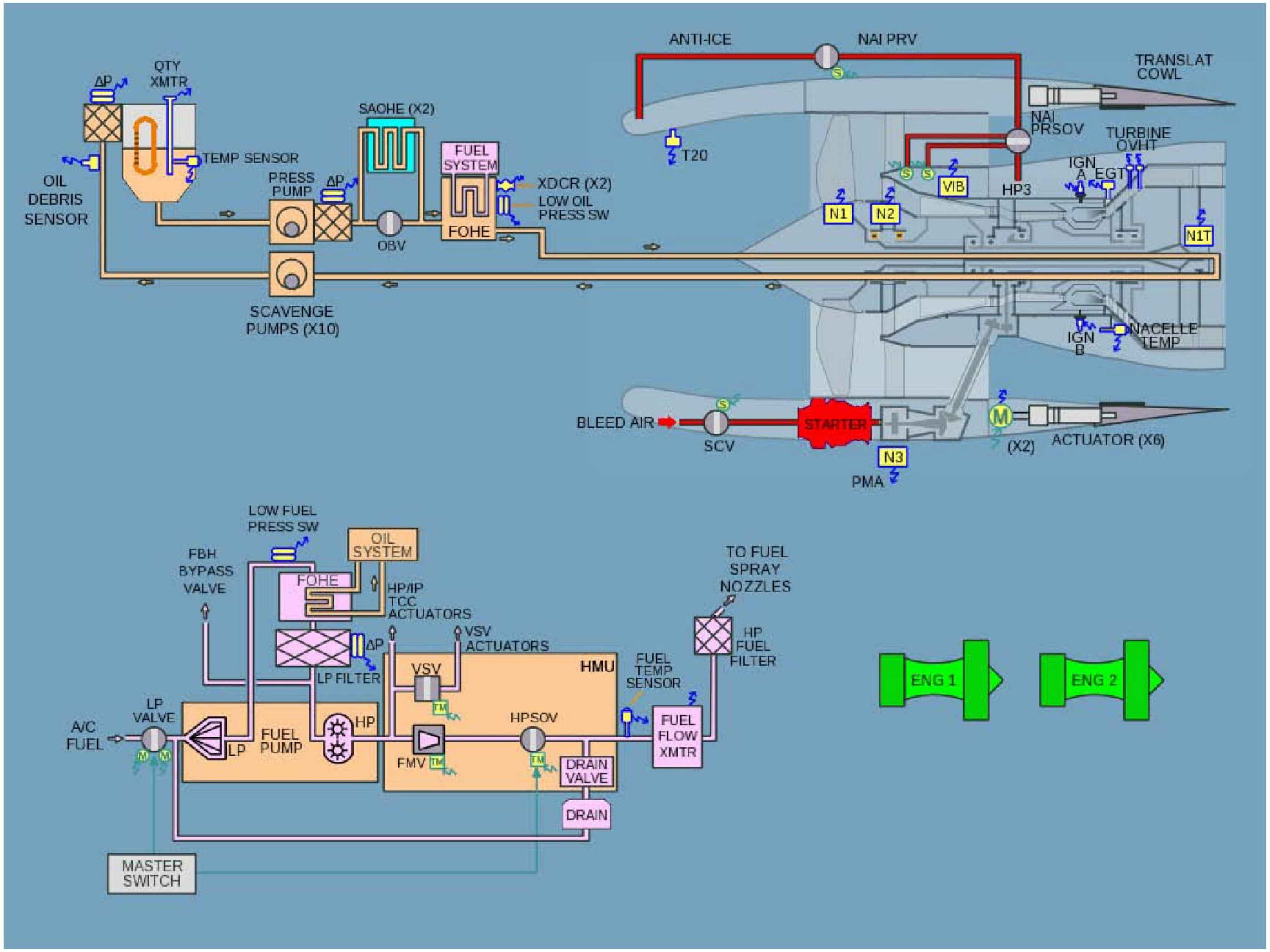
ABNORMAL ENGINE SD PAGE

ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)



ABNORMAL ED PAGE (TURB OVERHEAT)

ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)



ENGINE SYSTEMS - GENERAL (2) ... TURBINE OVERHEAT (3)

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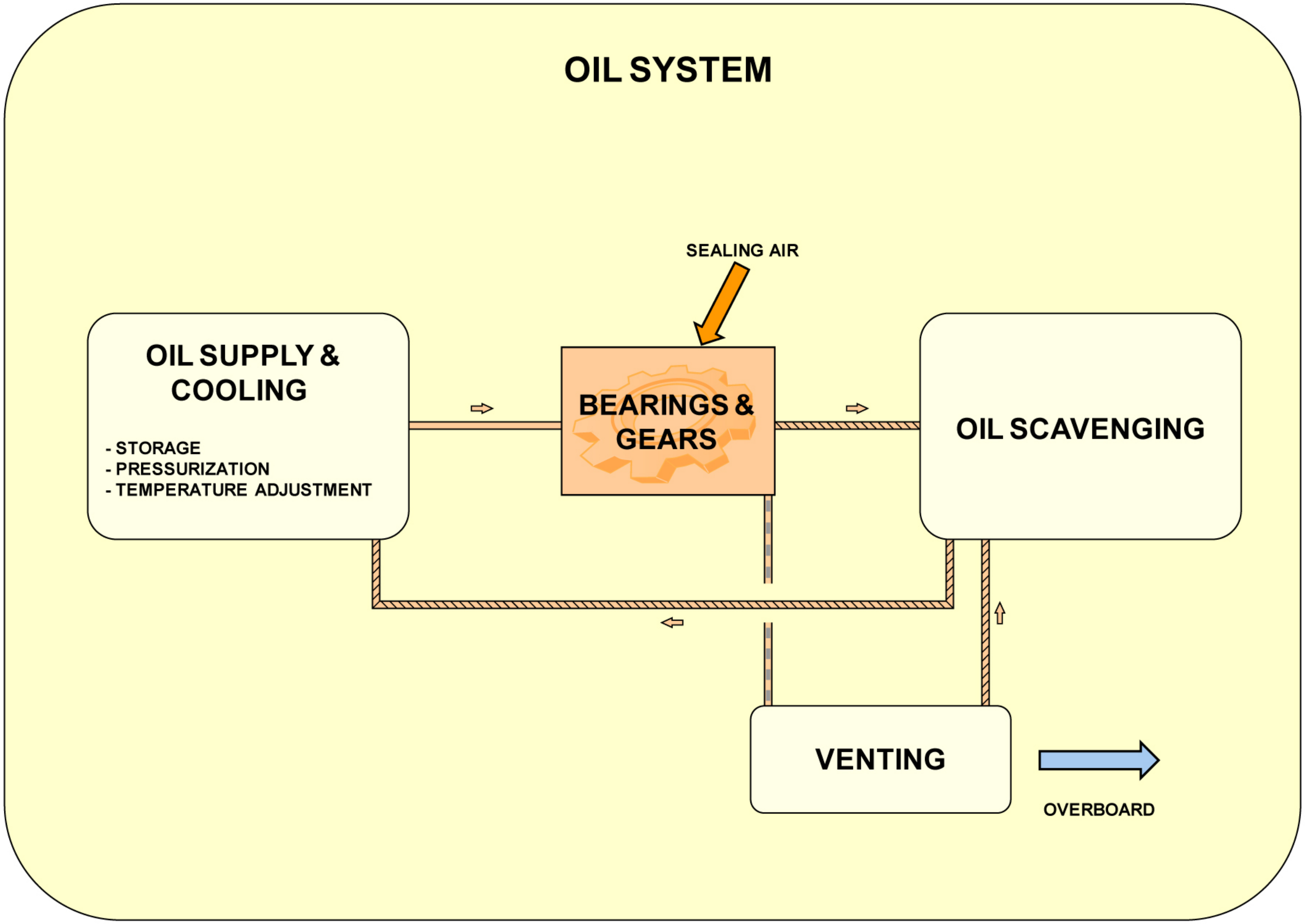
OIL SYSTEM DESCRIPTION (2/3)

General Presentation

The functions of the oil system are:
- Oil feeding and cooling: Oil is stored, pressurized and temperature controlled before it is distributed to the bearings and gears chambers. Most of these chambers are sealed with air from the engine compressors.
- Oil scavenging: Oil is scavenged from the chambers and sent back for storage.
- Venting: The venting system receives air and oil mix directly from the chambers. Oil is removed from this mix and scavenged by the oil scavenging system. The extracted air is then discharged overboard.



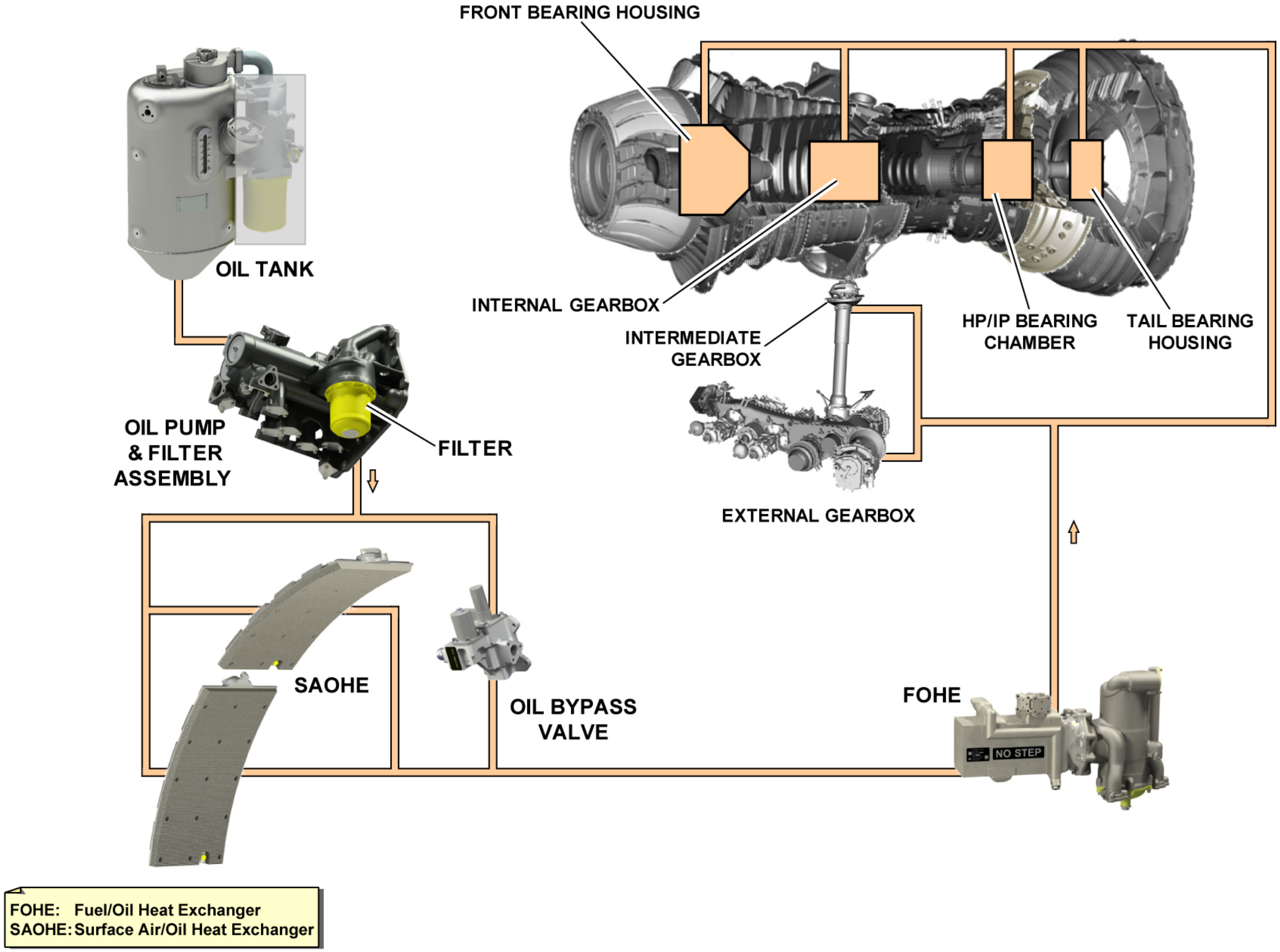
GENERAL PRESENTATION

OIL SYSTEM DESCRIPTION (2/3)

Oil Supply and Cooling

The engine oil from the oil tank goes into the oil pump and filter assembly.
Oil is filtered and sent to the cooling system.
The oil cooling system has two subsystems:
- Two Surface Air Oil Heat Exchangers (SAOHEs) decrease the excessive oil temperature with fan air. When the oil temperature is within a normal range, the oil bypass valve bypasses the SAOHEs
- A Fuel Oil Heat Exchanger (FOHE) supplies heat exchange between fuel and oil.

The oil is then distributed to the engine bearings (located in the front bearing housing, internal gearbox, High Pressure (HP) / Intermediate Pressure (IP) bearing chamber and the Tail Bearing Housing (TBH)).
The oil is also sent to the external and the intermediate gearboxes.



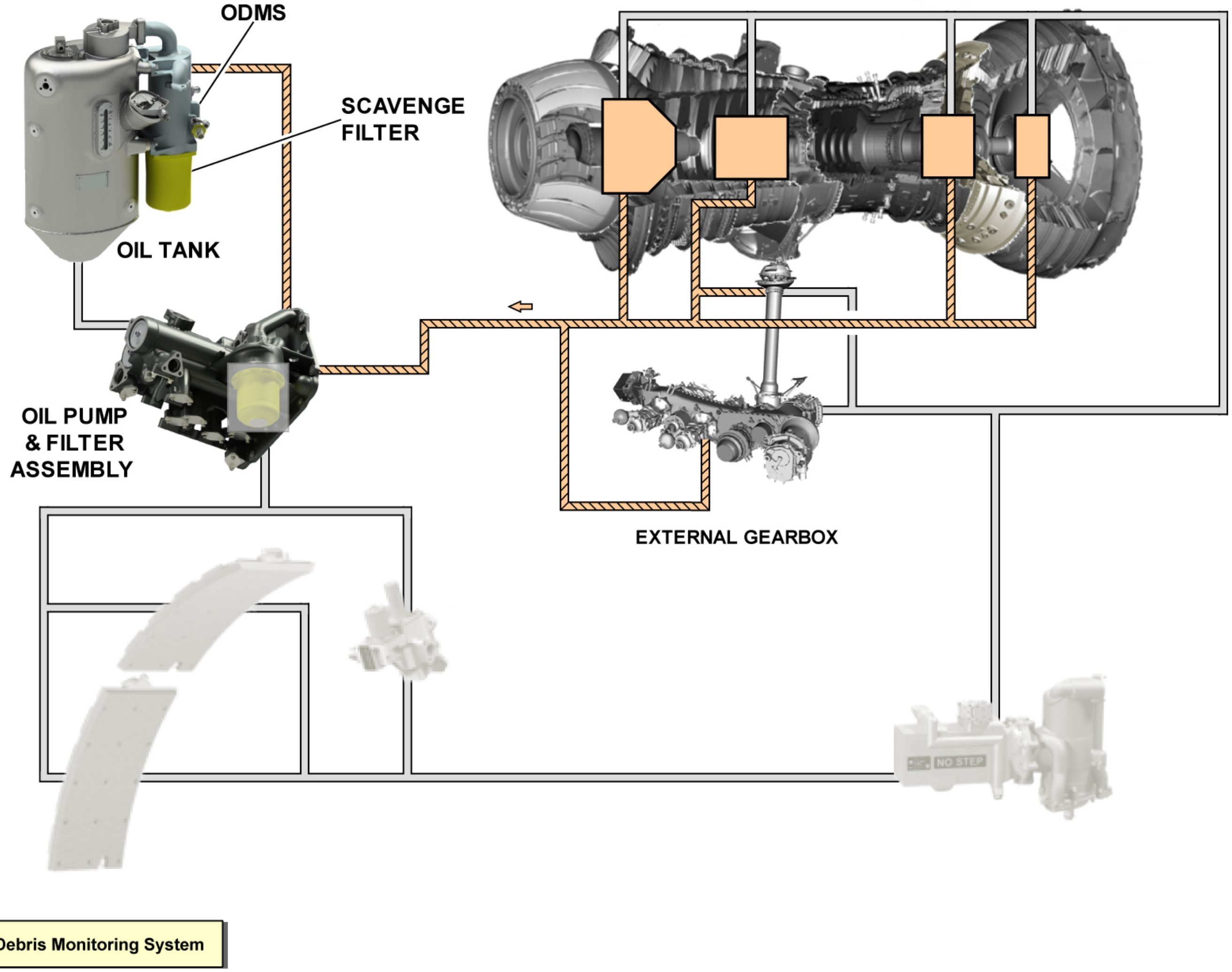
V1813401 - V01T0M0 - VM70D8OILDE3001

OIL SUPPLY AND COOLING

OIL SYSTEM DESCRIPTION (2/3)

Oil Scavenge

From the bearing chambers/housings and the gearbox, oil is pumped by the oil pump and filter assembly and sent back to the oil tank.
Before oil goes into the oil tank, scavenged oil flows through an Oil Debris Monitoring System (ODMS), which lets detection of metallic debris, if there is too much wear. Oil is then filtered through a scavenge filter.



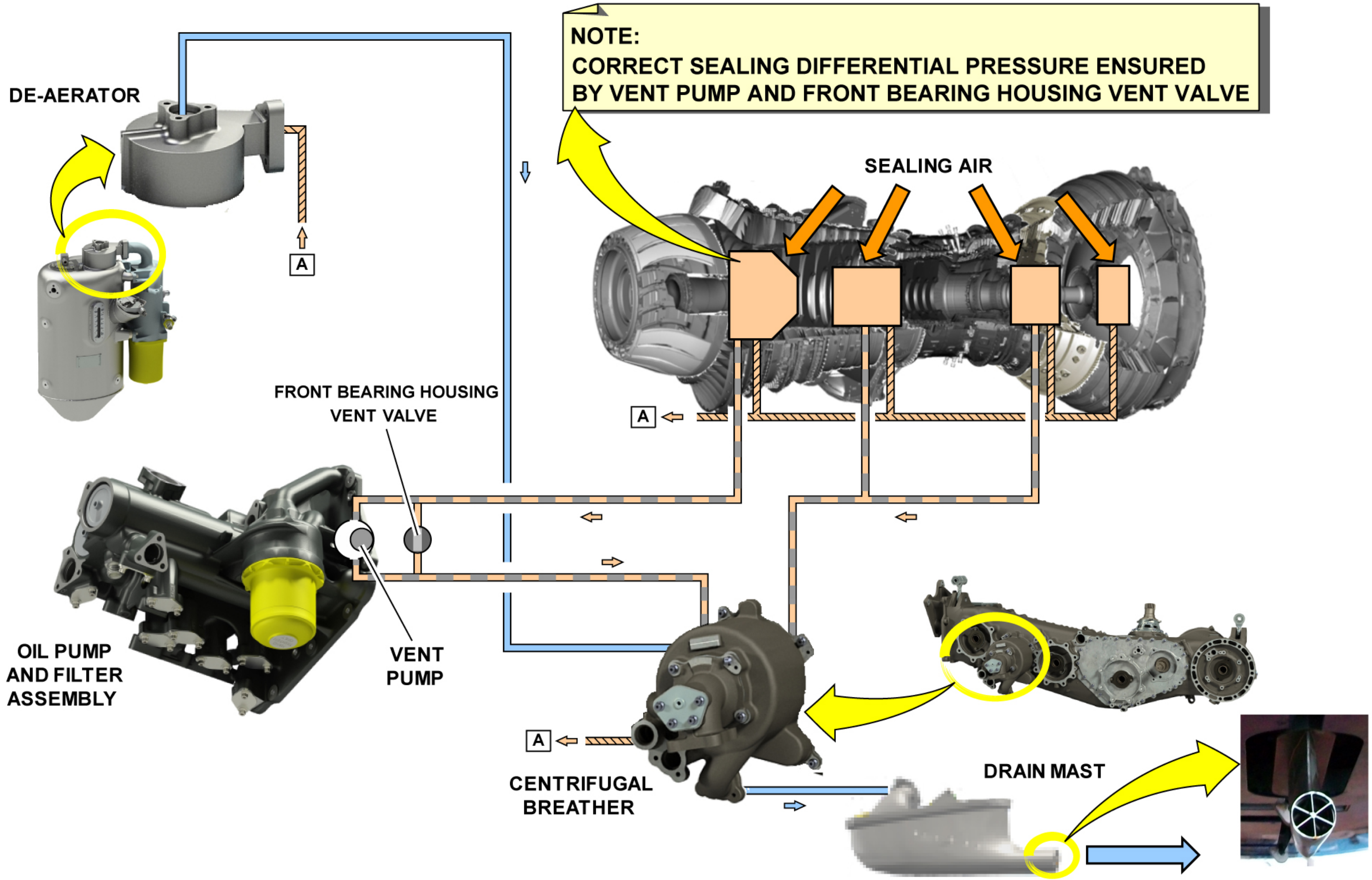
OIL SCAVENGE

OIL SYSTEM DESCRIPTION (2/3)

Venting

The bearing chambers are sealed by air from different engine compressor stages. Some of this air goes into the chambers and mixes with the oil. Scavenged oil containing air enters the oil tank through a de-aerator. Oil falls into the tank, but air is sent to the venting system.
The centrifugal breather, installed on the external gearbox, is the primary component of the venting system and has these functions:
- It receives air from the oil tank de-aerator
- It receives air/oil mix from the bearing chambers/housings
- It removes oil contained in the air and sends de-oiled air overboard through the drain mast
- Remaining oil is then scavenged by the oil pump & filter assembly.

The front bearing housing sealing needs pressure regulation:
At low power, the centrifugal breather causes too low suction in the front bearing housing. To prevent possible oil mist in the engine bleed and then into the air conditioning system, a dedicated vent pump (located in the oil pump and filter assembly) causes more suction.
At a high-power condition, suction from the centrifugal breather is sufficient. A front bearing-housing vent-valve opens to bypass the vent pump.



VENTING

V1813401 - V01T0M0 - VM70D8OILDE3001

OIL SYSTEM DESCRIPTION (2/3)

Components Description

Oil Tank

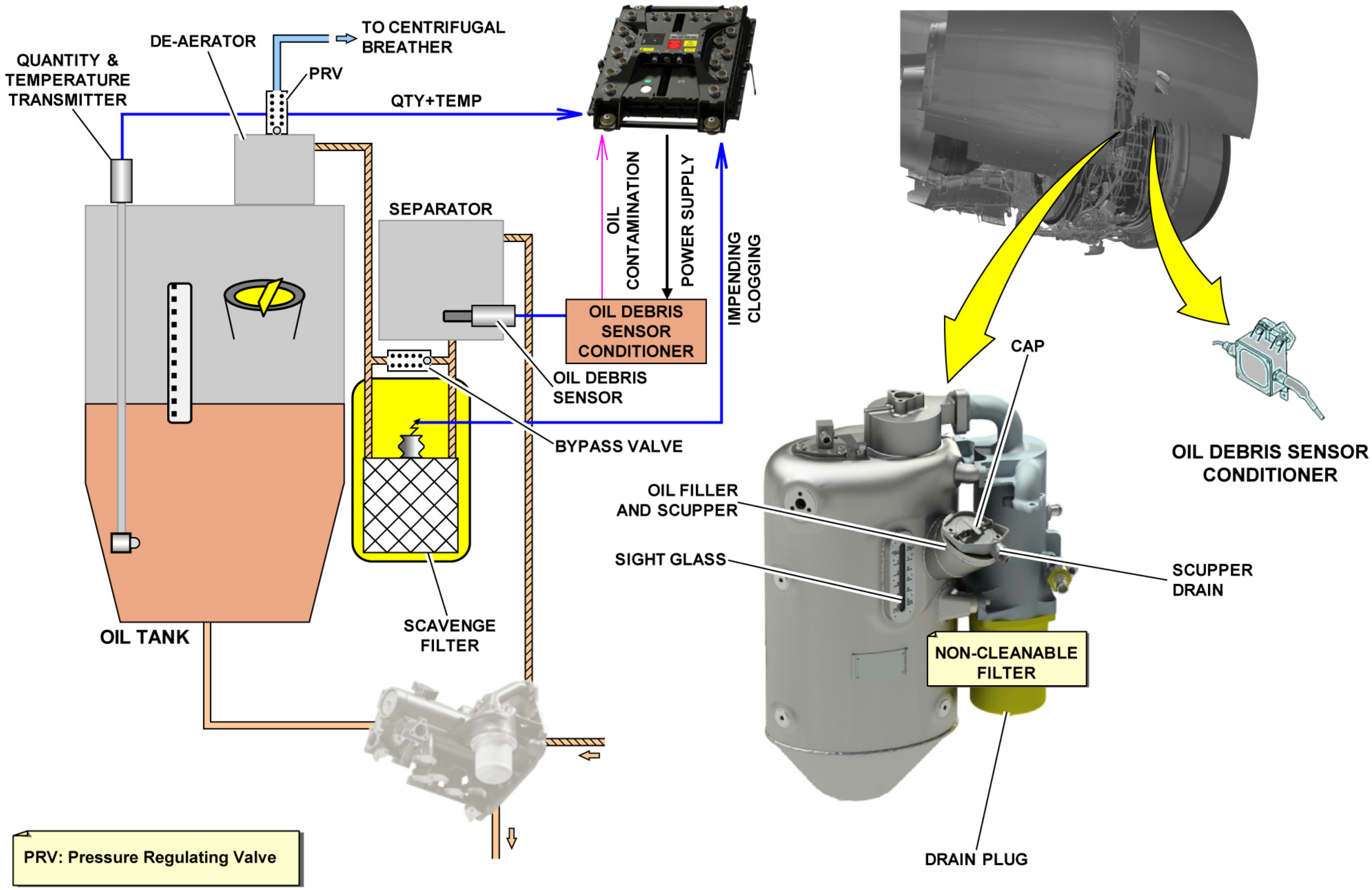
The oil tank is installed on the fan case (right side). It has these major parts:
- The main tank
- The ODMS
- The scavenge filter
- The de-aerator.

A feed line supplies oil to the oil pump and filter assembly. A combined quantity and a temperature sensor transmits quantity and temperature signals to the Engine Electronic Controller (EEC). A sight glass and a filler/scupper assembly allow oil servicing. The scupper drains to the engine drain mast.

The scavenged oil goes into the ODMS separator. Debris are then separated from the oil and collected by the oil debris sensor. The oil-debris sensor conditioner is electrically energized by the EEC. This conditioner sends a signal to the EEC for each debri detected by the oil debris sensor. If contamination is more than a pre-determined limit, the EEC sends a message to the Flight Warning System (FWS) for generation of a dispatch message.

The scavenged oil is filtered by a non-cleanable scavenge filter. The EEC monitors an impending clogging condition with a differential pressure transducer. If the filter is fully clogged, a bypass valve lets a continuous flow of scavenged oil.

A Pressure Regulating Valve (PRV) on the de-aerator makes sure that the oil tank is pressurized during operation.



COMPONENTS DESCRIPTION - OIL TANK

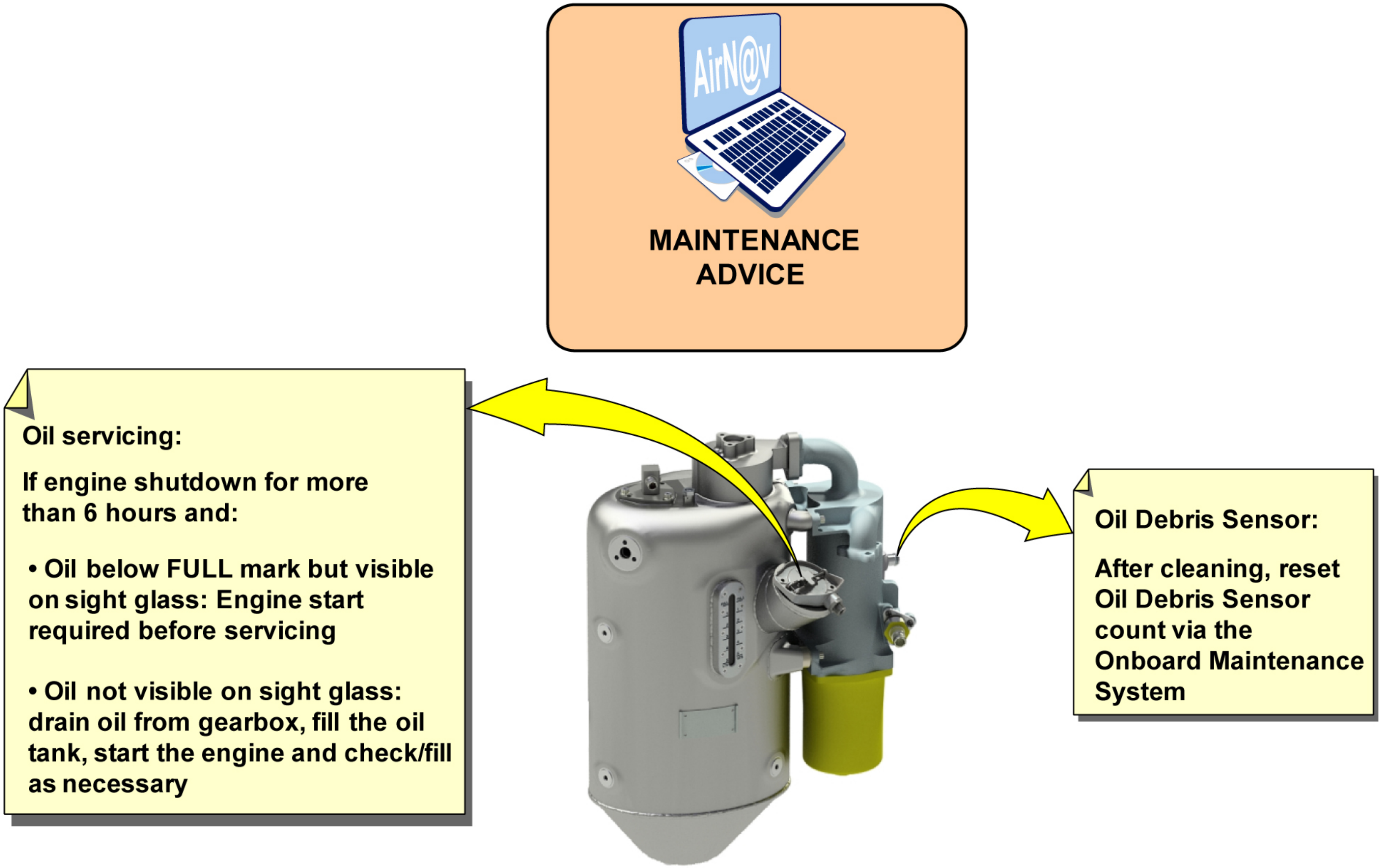
OIL SYSTEM DESCRIPTION (2/3)

Components Description (continued)

Oil Maintenance Advices

Before you do the engine oil servicing, make sure that you consider the following statement:
Perform the oil servicing within 6 hours after the engine shutdown.
If the engine has been stopped for more than 6 hours, oil may have migrated into the external gearbox by gravity.
In this case, to prevent over servicing follow these rules:
- The oil level is below the FULL mark and oil is visible in the sight glass: Run the engine at idle for 5 minutes and then check/fill the engine with oil as necessary.
- The oil is not visible in the sight glass: Drain the accessory gearbox, fill the engine with oil, run the engine for 5 minutes and check/fill the engine with oil as necessary again.

After the cleaning procedure of the oil debris sensor, make sure that you reset the debris count by performing the related interactive test through the Onboard Maintenance System (OMS).



V1813401 - V01T0M0 - VM70D8OILDE3001

COMPONENTS DESCRIPTION - OIL MAINTENANCE ADVICES

OIL SYSTEM DESCRIPTION (2/3)

Components Description (continued)

Oil Pump and Filter Assembly and Front Bearing Housing Vent Valve

The oil pump and filter assembly is installed on and driven by the gearbox (aft face).

Its primary components are:

- A pressure pump
- A pressure filter
- A set of scavenge pumps (quantity 9)
- A vent pump.

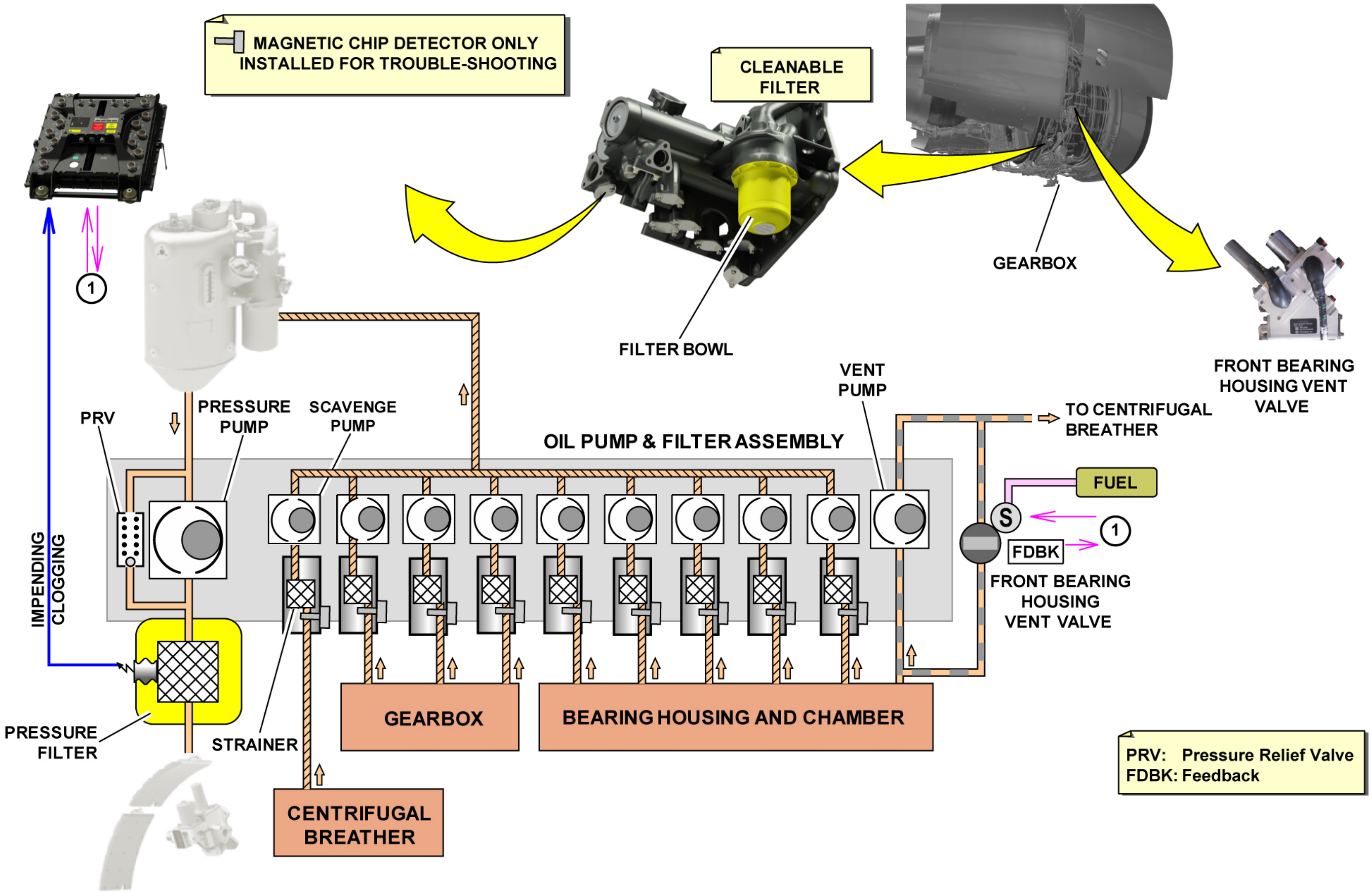
The oil from the tank is pressurized by the pressure pump. A pressure relief valve gives protection to the oil system against excessive pressure (for example during a cold start).

The pressure filter cleans the oil sent to the system. The EEC monitors the filter for impending clogging by a differential pressure transducer.

The oil from the bearing housing/chambers, gearbox and centrifugal breather is scavenged by the scavenge pumps. Each pump inlet has a strainer and a housing for installation of a magnetic chip detector (troubleshooting if there is an oil contamination).

The vent pump lets correct sealing differential pressure around the front bearing housing seals at low engine power.

The front bearing-housing vent valve is installed on the fan case (right side). It is a two-position (open/close) valve controlled and monitored by the EEC and operated by fuel muscle pressure. It closes at low power and opens at high power.



COMPONENTS DESCRIPTION - OIL PUMP AND FILTER ASSEMBLY AND FRONT BEARING HOUSING VENT VALVE

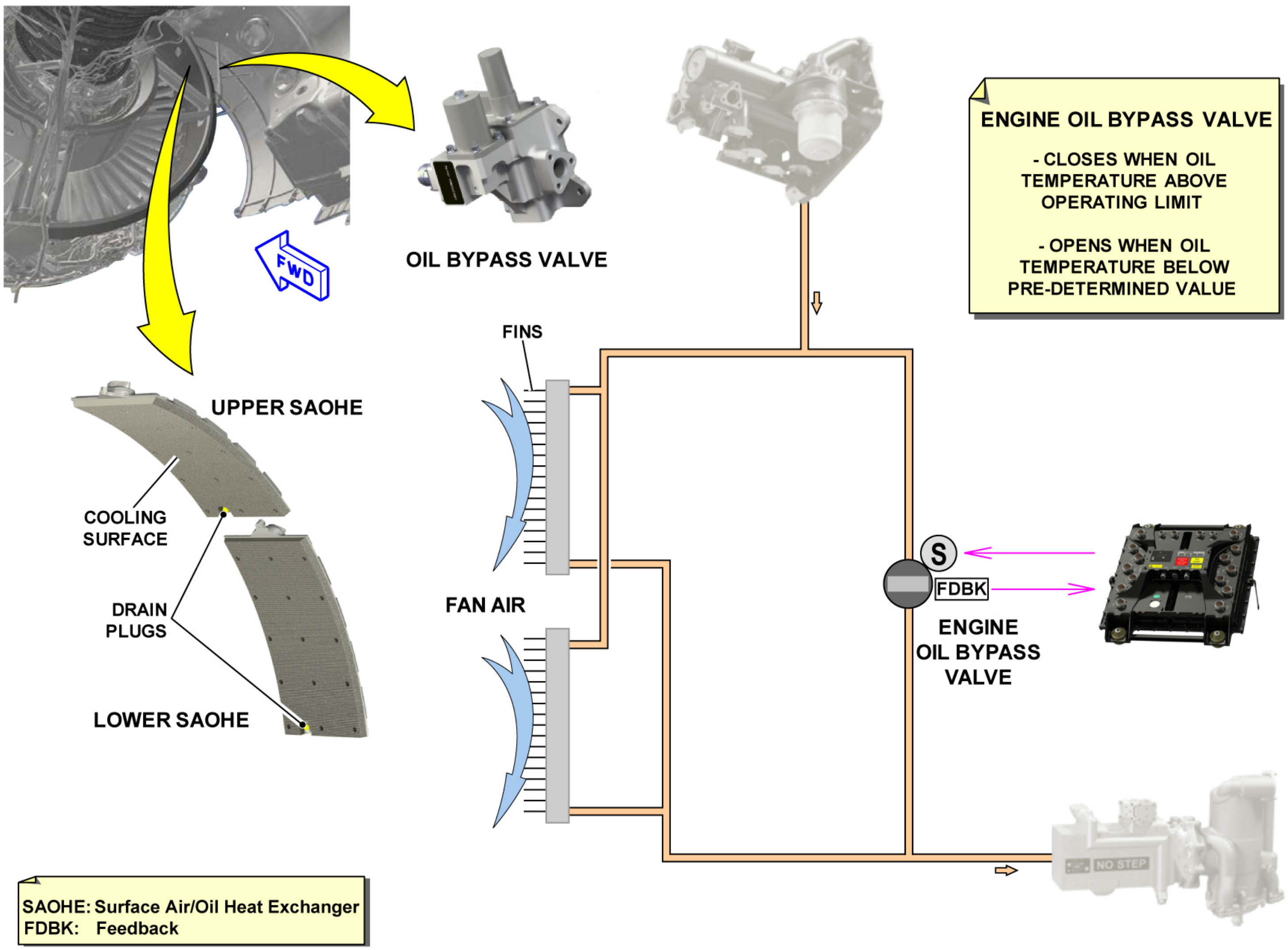
V1813401 - V01T0M0 - VM70D8OILDE3001

OIL SYSTEM DESCRIPTION (2/3)

Components Description (continued)

Surface Air/Oil Heat Exchanger (SAOHE) and Engine Oil Bypass Valve

The oil from the pressure pump is kept in a pre-determined temperature range by the SAOHEs and the engine-oil bypass valve, if the cooling with the FOHE is not sufficient.
Two equivalent SAOHEs (upper and lower) are installed on the rear fan-case internal face (right side at the top). Their cooling surface is made of fins, dissipating heat into the fan airflow. A drain plug is available for maintenance.
The engine-oil bypass valve is installed on the fan case (right side). It is a two position valve electrically controlled by the EEC and operated by oil muscle pressure. The EEC monitors the valve position. The valve is open when the oil temperature is below a pre-determined value and closed when the oil temperature is higher.



V1813401 - V01T0M0 - VM70D8OILDE3001

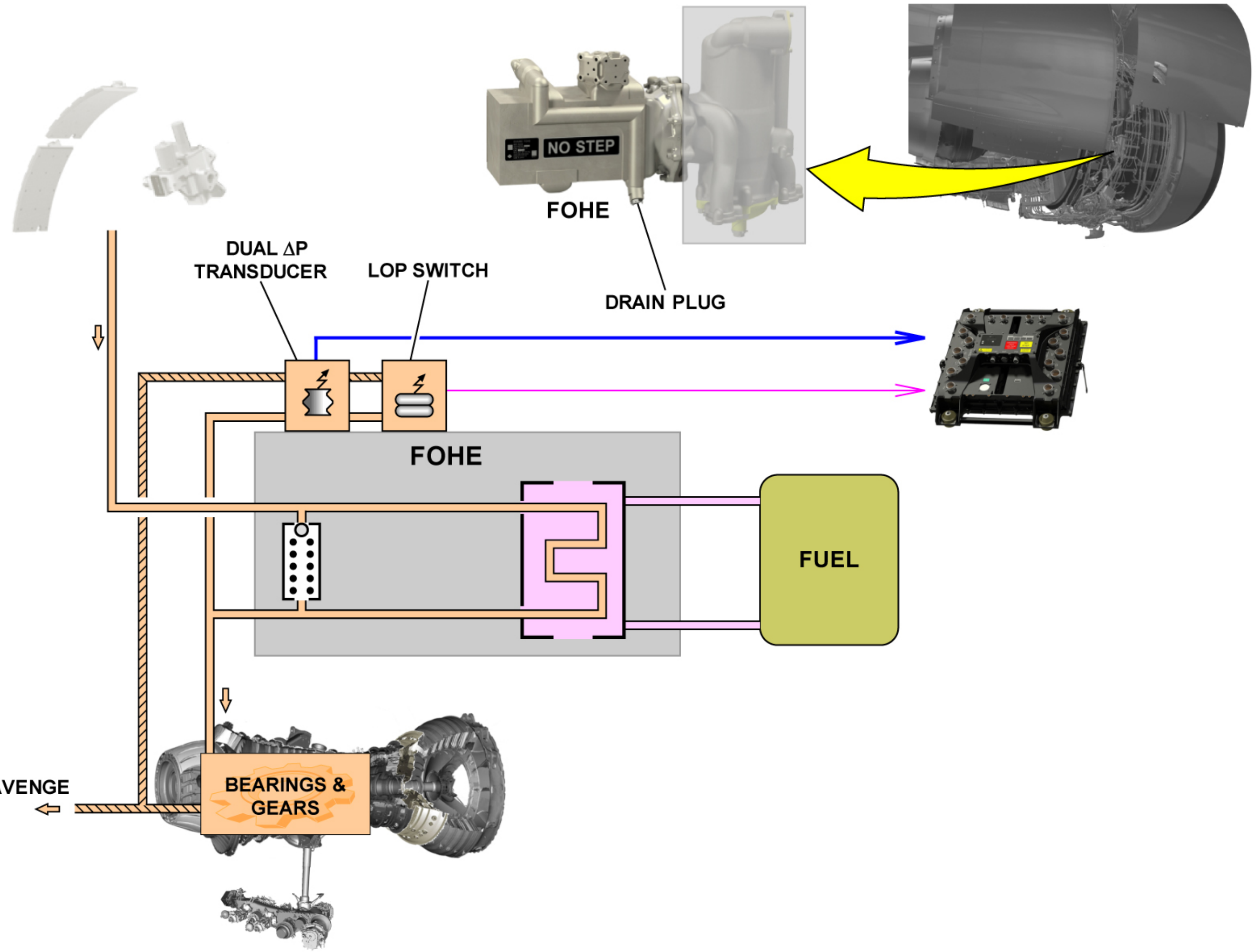
COMPONENTS DESCRIPTION - SURFACE AIR/OIL HEAT EXCHANGER (SAOHE) AND ENGINE OIL BYPASS VALVE

OIL SYSTEM DESCRIPTION (2/3)

Components Description (continued)

Fuel/Oil Heat Exchanger (FOHE)

The primary oil cooler is the FOHE. It receives oil from the SAOHE or the oil bypass valve, lets heat exchange between the oil and the fuel (fuel heats up and oil cools down) and releases cooled oil to the bearings and gears.
The FOHE is installed on the fan case (right side). It is by-passable if a clogging condition occurs. A drain plug is used during removal of the unit.
A dual oil differential pressure transducer and a Low Oil Pressure (LOP) switch installed on the FOHE give the EEC with oil differential pressure signal for cockpit indication (Control and Display System (CDS)) and differential low oil pressure signal for cockpit warning (FWS).



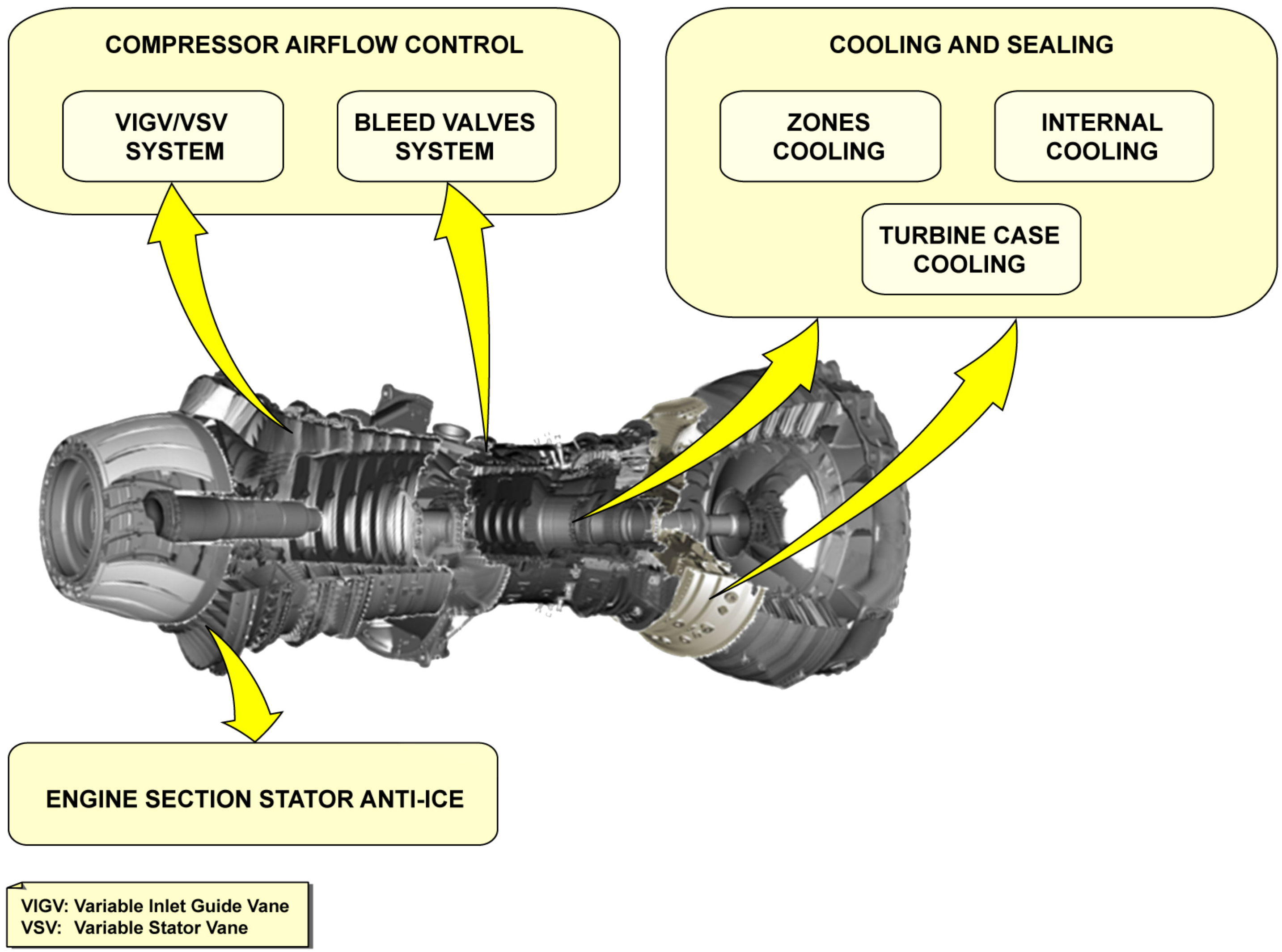
LOP: Low Oil Pressure

COMPONENTS DESCRIPTION - FUEL/OIL HEAT EXCHANGER (FOHE)

ENGINE AIR SYSTEM DESCRIPTION (2/3)

General Overview

The engine air system has these functions:
- Compressor airflow control: The Variable Inlet Guide Vane (VIGV) / Variable Stator Vane (VSV) system and the bleed valves system together control the airflow that goes into the engine core compressors. This is for better performance and surge/stall protection.
- Cooling and sealing: Air from different areas of the engine is used for zones cooling, internal cooling and Turbine Case Cooling (TCC). Air for internal cooling is also used to keep the bearing chambers/housings sealed.
- Engine Section Stator (ESS) anti-ice: To prevent ice build-up and compressor damage, there is a hot air supply to the ESS (nozzle guide vanes at the entrance of the Intermediate Pressure (IP) compressor).



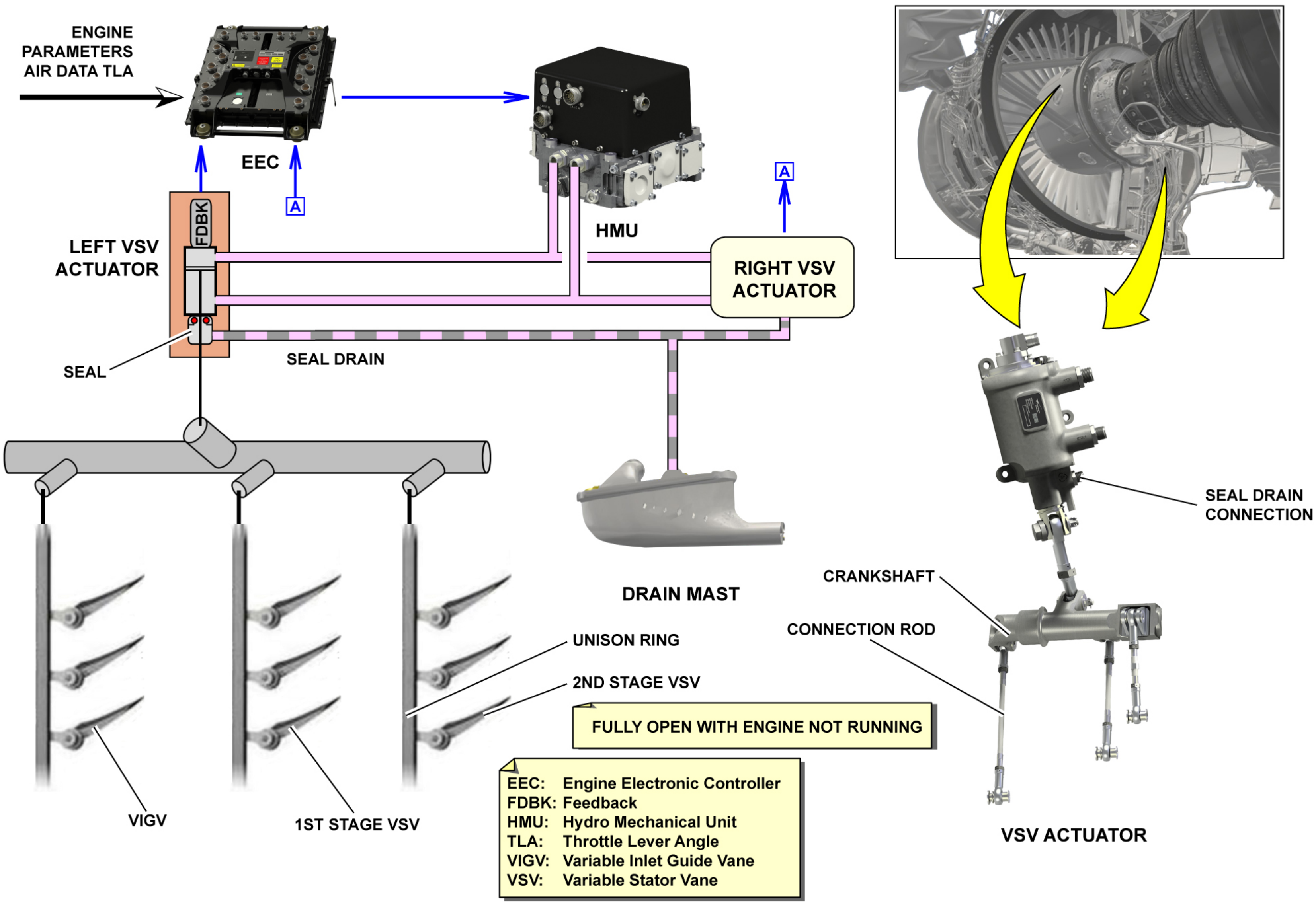
GENERAL OVERVIEW

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Compressor Control Description

Variable Inlet Guide Vane/Variable Stator Vane (VIGV/VSV) System

The VIGV/VSV system controls airflow through the IP and High Pressure (HP) compressors to optimize performance and prevent the surge/stall at all operating conditions.
The VIGVs and the first 2 stages of VSVs are connected to unison rings. The unison rings turn around the IP compressor case to change the vanes angle. When the vanes are driven to a more open position, the airflow increases. A more closed position decreases the airflow.
The unison rings are connected to two Variable Stator Vane Actuators (VSVAs) through connection rod and crankshafts.
The VSVAs and mechanisms are installed on each side of the IP compressor. The gas generator fairing must be removed to access the VSV system components.
The VSVAs are operated by the Hydro Mechanical Unit (HMU) with fuel servo pressure.
The Engine Electronic Controller (EEC) sends commands to the HMU (depending on engine parameters, thrust lever position and external ambient conditions). Usually, the vanes are driven to open at high power and to close at low power. The vanes are fully open when the engine is not running.
Each VSVA has:
- A feedback transmitter which sends the actuator position to the EEC
- A seal drain connected to the drain mast, which sends fuel leakage overboard.



V1813401 - V01T0M0 - VM70D9AIRDE3001

COMPRESSOR CONTROL DESCRIPTION - VARIABLE INLET GUIDE VANE/VARIABLE STATOR VANE (VIGV/VSV) SYSTEM

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Compressor Control Description (continued)

Bleed Valves System

The bleed valve system prevents the surge/stall at all operating conditions.
The system has: Three IP8, three HP3 bleed valves and a left bleed valve controller.
The bleed valves are open/close pneumatic valves installed around the related compressor. In the open position, they discharge a part of the compressor airflow into the fan airflow to prevent the surge or stall.
The bleed valves are controlled and actuated by the left bleed valve controller. This unit is an assembly of six solenoid valves (one per bleed valve). It uses High Pressure Compressor (HPC) air as muscle pressure to control the bleed valves in the open or close position. It is located behind the gas generator fairing.
Each bleed valve is spring-loaded open when the engine is not running. When the engine is running (and depending on engine parameters and air data), the EEC controls the bleed valves open or close.
Note: Each bleed valve has a seal which interfaces with the fairing or cowling. The seals make sure that fan air cannot go into the area between the fairings/cowlings and the engine core.

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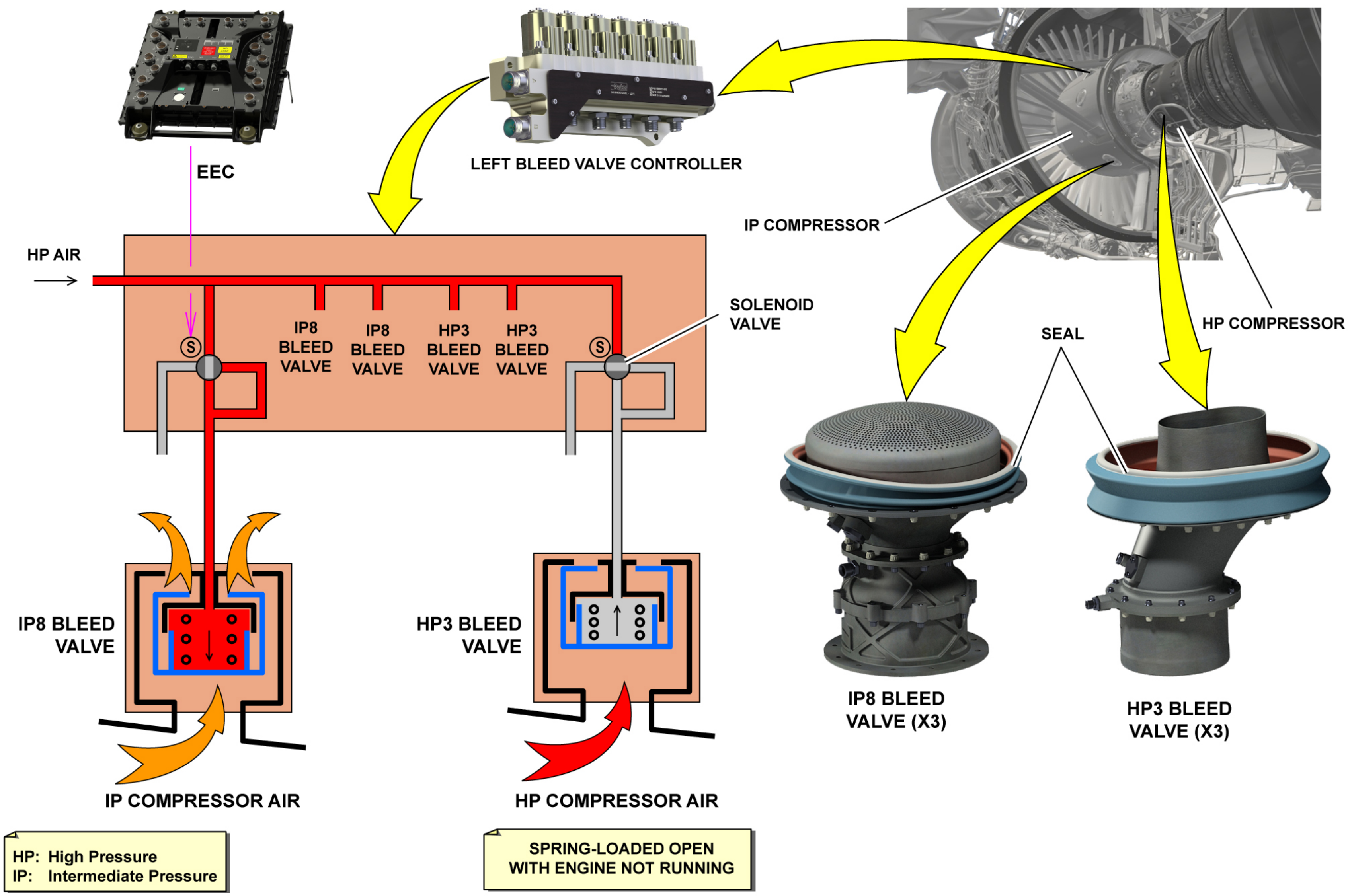


COMPRESSOR CONTROL DESCRIPTION - BLEED VALVES SYSTEM

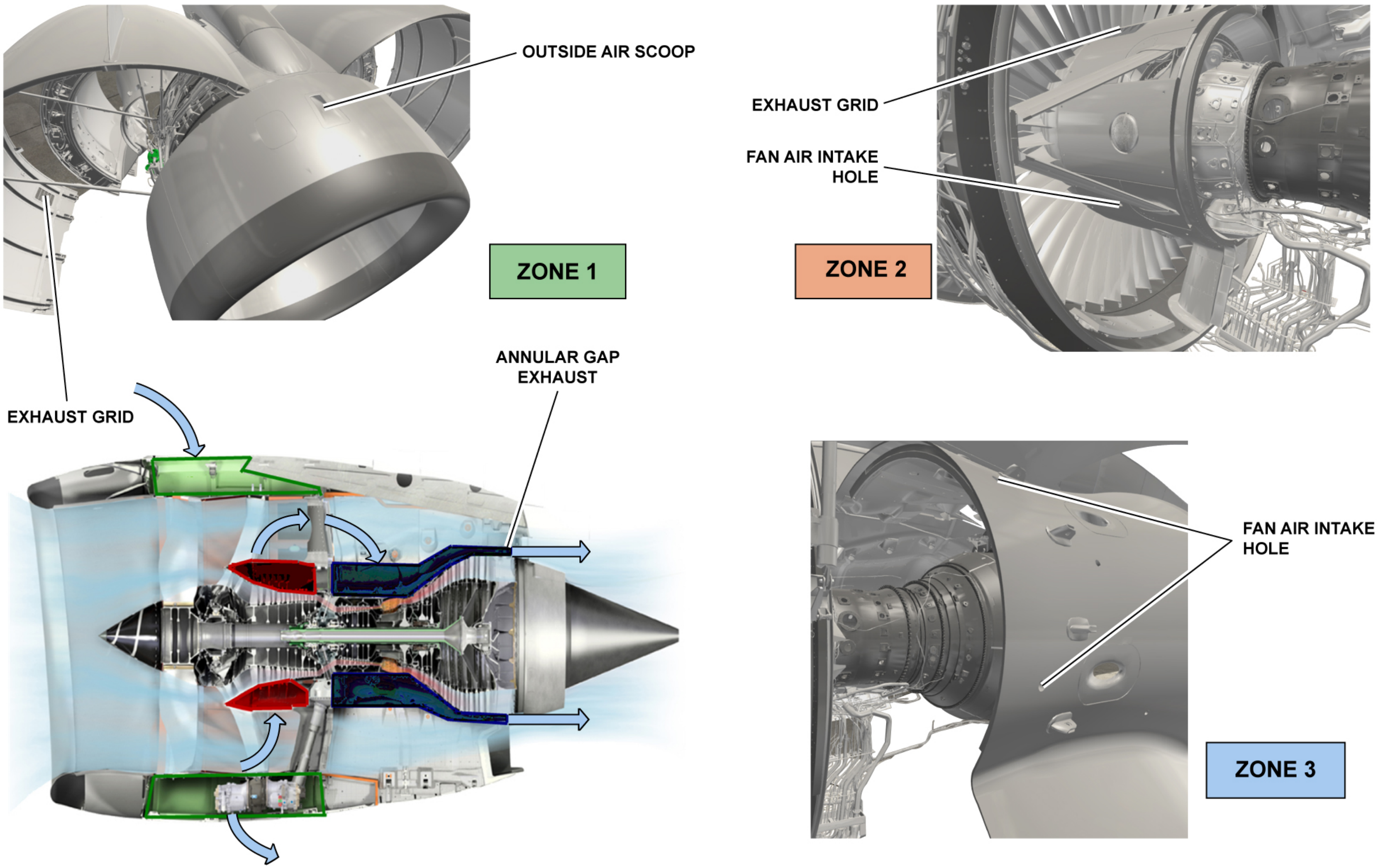
V1813401 - V01T0M0 - VM70D9AIRDE3001

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Cooling and Sealing System Description

Zone Cooling

There are three different cooling zones. They represent fire containment zones and are separated by structural bulkhead and seals.
Zone 1 is the area between the fan case and the fan cowls.
A scoop at the top of the inlet cowl supplies outside air cooling airflow by ram air effect. Air is then discharged overboard through an exhaust grid on the fan cowl.
Zone 2 is the area between the IP compressor case and the gas generator fairings.
When the engine is running, fan air goes into the zone through intake holes and is released back into the fan airflow through exhaust grids.
Zone 3 is the area between the engine core and the Thrust Reverser (T/R) cowls inner fixed structure.
When the engine is running, fan air goes into the zone through dedicated intake holes and is discharged overboard through the annular gap between the T/R cowl and the exhaust nozzle.



COOLING AND SEALING SYSTEM DESCRIPTION - ZONE COOLING

V1813401 - V01T0M0 - VM70D9AIRDE3001

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Cooling and Sealing System Description (continued)

Zone Temperature Monitoring

The EEC monitors temperature of each cooled zone.
A dual temperature sensor on the fan case senses Zone 1 temperature. The EEC uses this signal to detect a duct burst (starter or anti-ice ducts). If the temperature is more, the EEC sends a message to the anti-ice protection system and overheat detection system through the Engine Interface Function (EIF) for bleed isolation. The EEC also sends a direct message to the Flight Warning System (FWS) for warning generation.
A dual temperature sensor in Zone 2 is used to sense a possible leak from the air ducts or components (IP8 bleed valve,...). In such a situation, the EEC sends a signal to the FWS for warning generation.
The EEC monitors the Zone 3 dual temperature-sensor to show the nacelle temperature and detect a possible leak from air components or an overheat condition. It sends signals to the FWS for warning generation and to the Control and Display System (CDS) for nacelle temperature indication.

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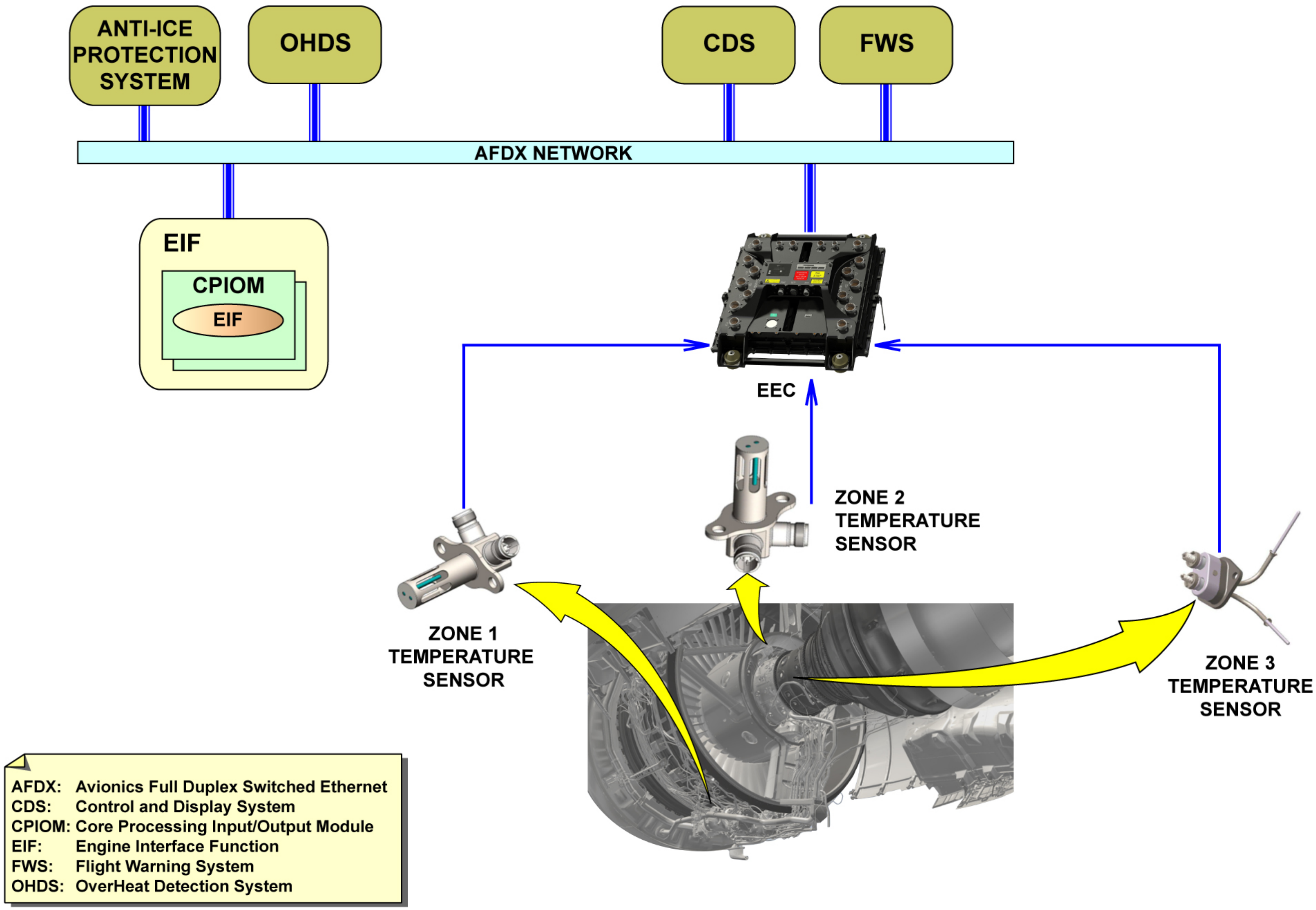


V1813401 - V01T0M0 - VM70D9AIRDE3001

COOLING AND SEALING SYSTEM DESCRIPTION - ZONE TEMPERATURE MONITORING

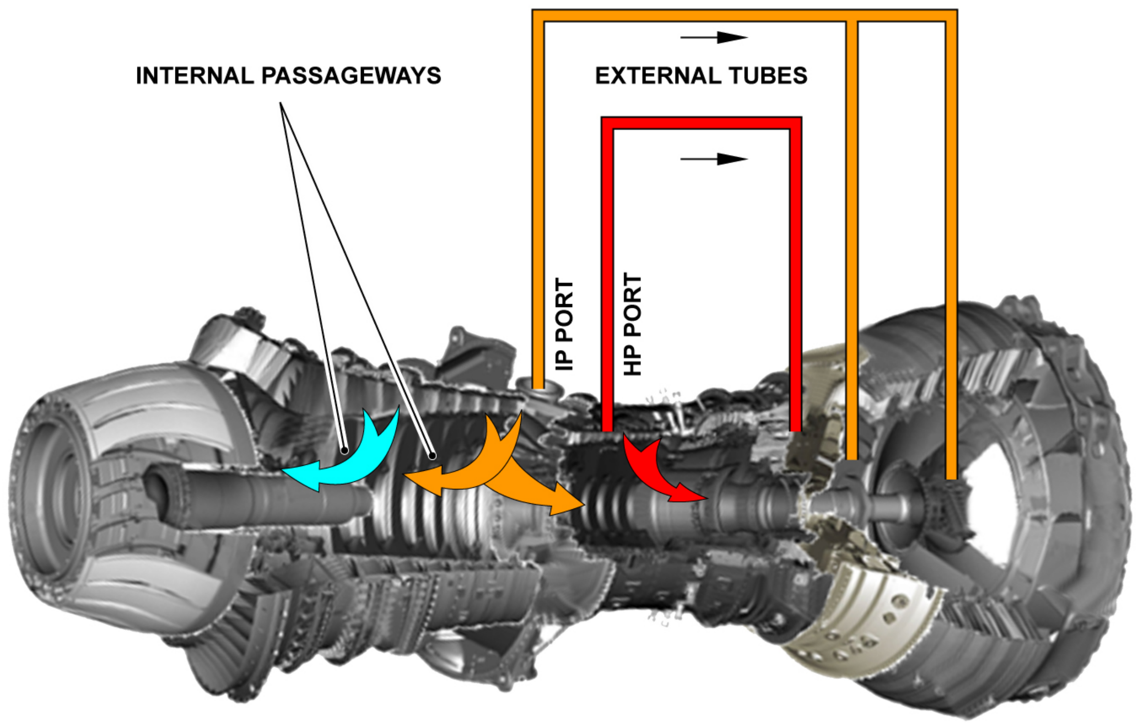
ENGINE AIR SYSTEM DESCRIPTION (2/3)

Cooling and Sealing System Description (continued)

Internal Cooling System

An internal cooling system decreases the temperature of the different areas of the engine. It also seals and pressurizes the bearing chambers and housings.
Air from different IP and HP compressor stage is supplied to different areas through internal passageways and external tubes.

V1813401 - V01T0M0 - VM70D9AIRDE3001



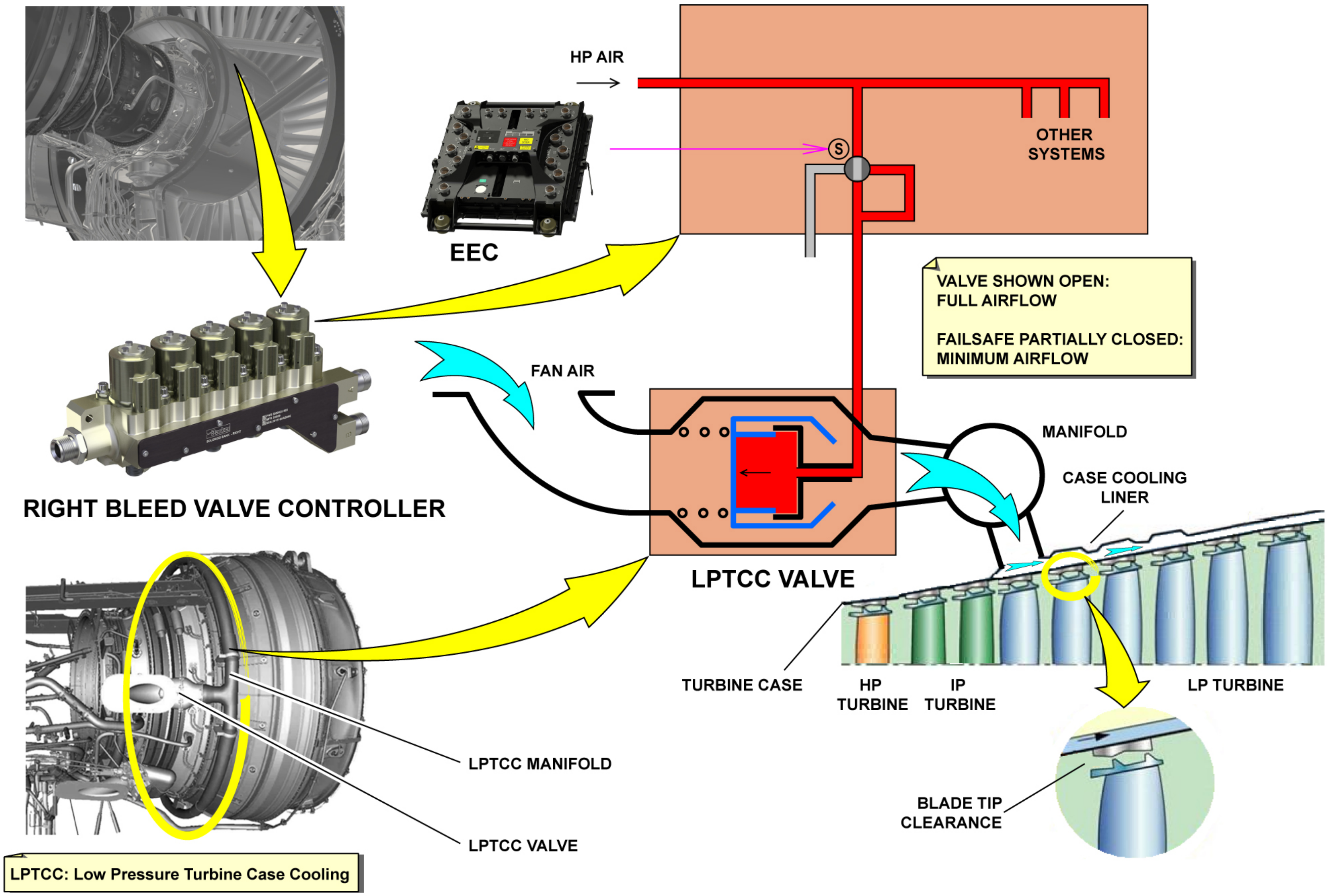
COOLING AND SEALING SYSTEM DESCRIPTION - INTERNAL COOLING SYSTEM

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Cooling and Sealing System Description (continued)

Low Pressure Turbine Case Cooling (LPTCC) System Description

The TCC system supplies cooling air around the turbine cases to control the turbine-blade tip clearance for a better fuel consumption efficiency.
The Low Pressure Turbine Case Cooling (LPTCC) system has an LPTCC valve and the right bleed valve controller.
The LPTCC valve installed on the turbine case is a pneumatic valve, spring-loaded partially closed and controlled by the right bleed valve controller.
The right bleed valve controller installed under the generator gas fairing has solenoids controlled by the EEC and receives HP air from an engine compressor pick-up.
When the aircraft is in cruise, the EEC controls the valve to open. Fan air is sent to a manifold and then inside a case cooling liner. The case expansion is minimized and thus decreases the blade tip clearance.
In the other condition, the LPTCC valve is partially closed and it lets a minimum airflow.



COOLING AND SEALING SYSTEM DESCRIPTION - LOW PRESSURE TURBINE CASE COOLING (LPTCC) SYSTEM DESCRIPTION

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Cooling and Sealing System Description (continued)

Intermediate Pressure Turbine Case Cooling (IPTCC) and High Pressure Turbine Case (HPTCC) Cooling Systems Description

The IPTCC and HPTCC systems are almost the same.
Each system has an actuator, a control cable, a valve, a manifold and spray bars.
The IPTCC and HPTCC actuators installed on the fan case are operated by fuel muscle pressure and electrically controlled by the EEC.
Each actuator has an Electro Hydraulic Servo Valve (EHSV) controlled by the EEC, a position transmitter to give feedback signal to the EEC and a seal drain connected to the engine drain mast.
Each actuator moves its related valve using a TCC control cable.
The IPTCC and HPTCC valves are mechanical valves (spring-loaded closed) installed on the turbine case. They attach to their TCC control cable with a turnbuckle for rigging purpose.
The EEC modulates the IPTCC and HPTCC valves position (depending on flight phases) to let more or less fan air to enter into related manifolds. Thus, fan air is discharged around the turbine cases through spray bars.

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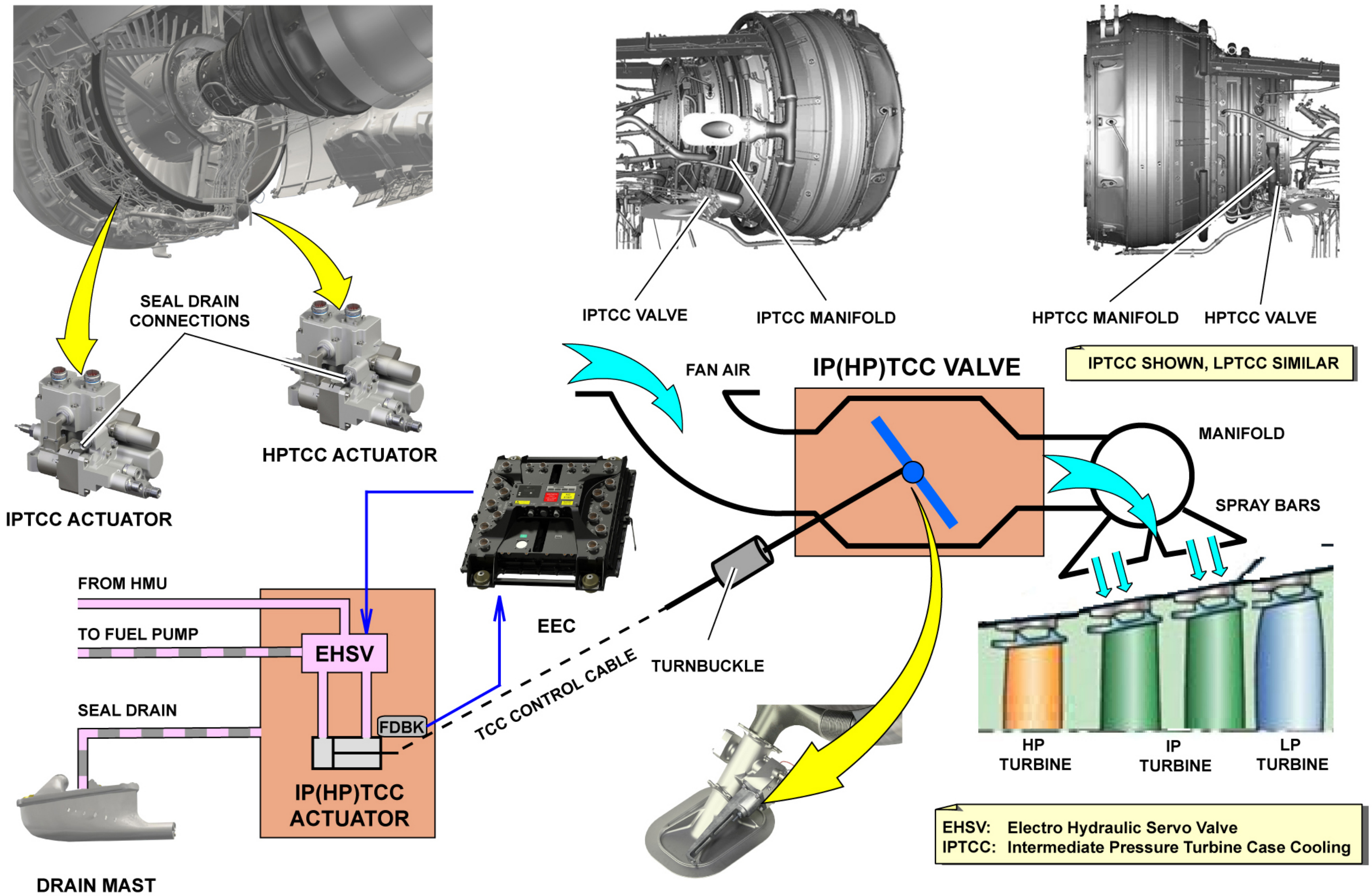


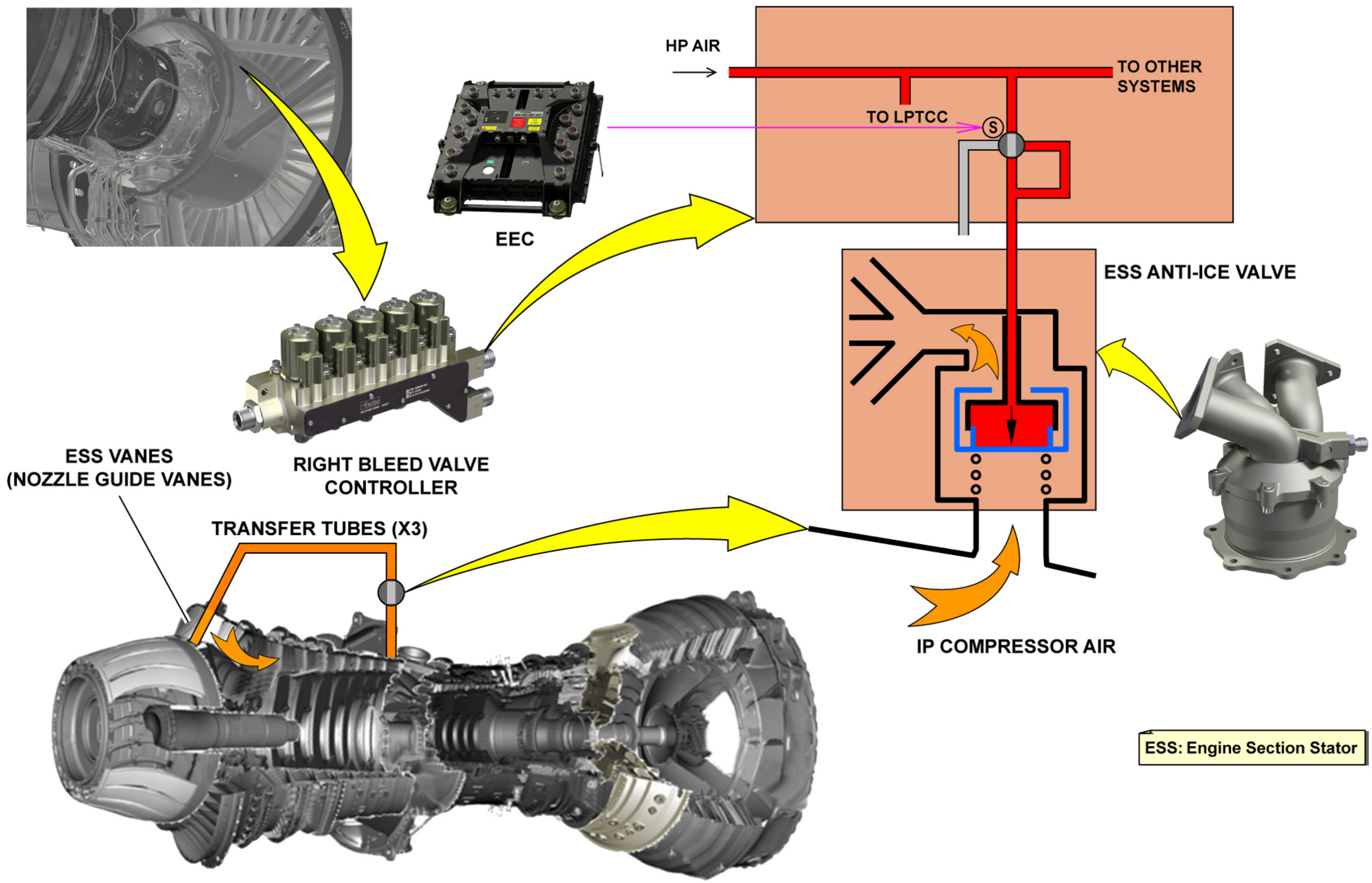
V1813401 - V01T0M0 - VM70D9AIRDE3001

COOLING AND SEALING SYSTEM DESCRIPTION - INTERMEDIATE PRESSURE TURBINE CASE COOLING (IPTCC) AND HIGH PRESSURE TURBINE CASE (HPTCC) COOLING SYSTEMS DESCRIPTION

ENGINE AIR SYSTEM DESCRIPTION (2/3)

Engine Stator Section (ESS) Anti-ice System Description

The engine core is protected from ice build-up by supplying IP compressor air into the IP compressor Nozzle Guide Vane (NGV), also known as ESS.
The ESS anti-ice valve installed on the IP compressor is a pneumatic valve (spring-loaded closed) controlled by the right bleed valve controller. The EEC commands the right bleed valve controller to open the ESS anti-ice valve when there is a risk of ice formation (depending on air data and engine core temperature). The IP compressor air is delivered to transfer tubes (quantity 3), discharged in the ESS vanes and then into the compressor airflow through slots on the vanes trailing edge.



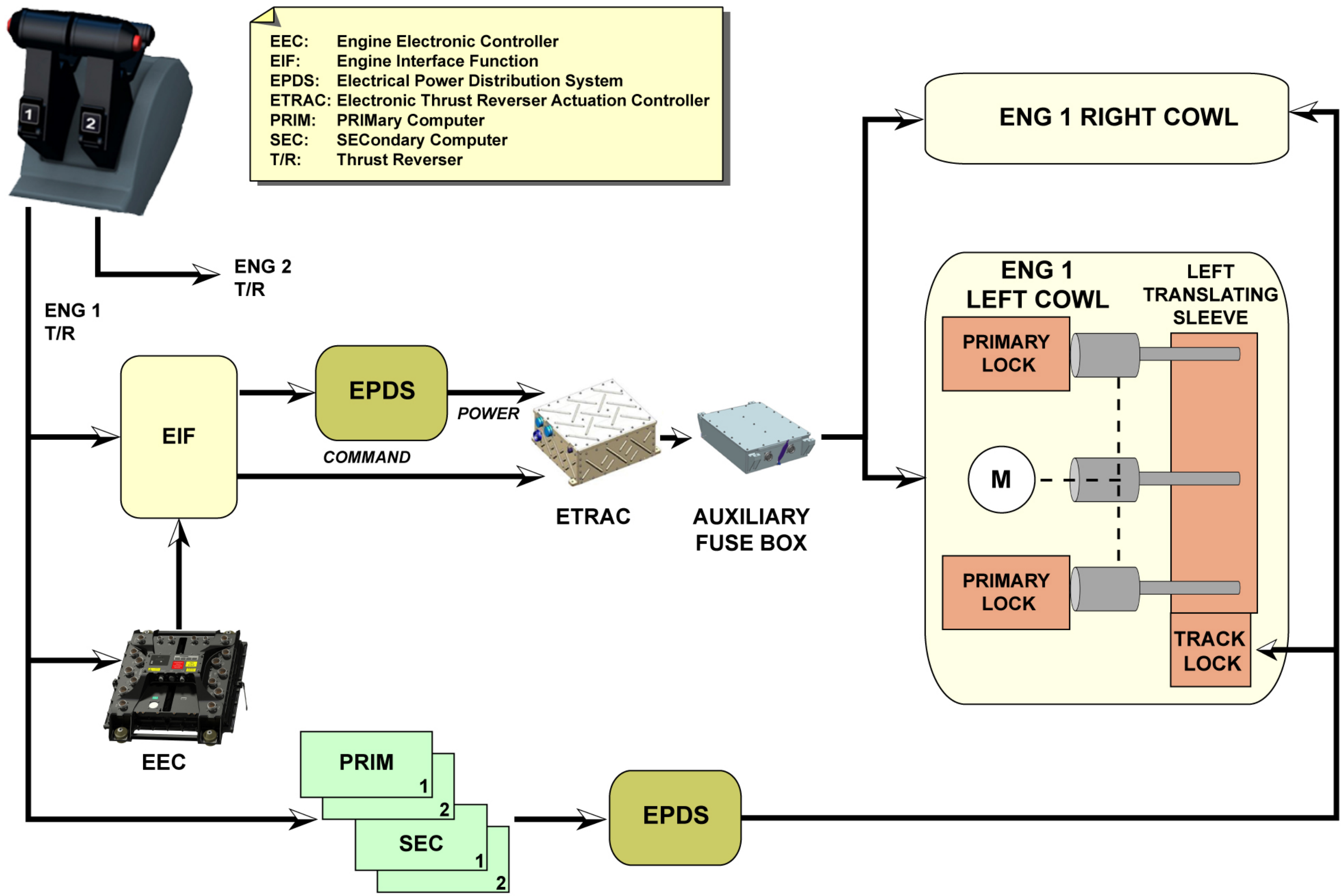
ENGINE STATOR SECTION (ESS) ANTI-ICE SYSTEM DESCRIPTION

V1813401 - V01T0M0 - VM70D9AIRDE3001

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

General Description

The Rolls-Royce Trent XWB Thrust Reversers (T/Rs) are electrically controlled and operated.
The left and right T/R cowl of each engine has a translating sleeve. When deployed, the translating sleeves divert the fan airflow to cause an air brake.
Each translating sleeve is moved by three mechanical actuators connected to an electrical motor.
In the stowed position, the translating sleeve is locked by two primary locks and a track lock.
The electrical motor and the primary locks are powered and controlled by the Electrical Thrust Reverser Actuation Controller (ETRAC) through an auxiliary fuse box. There is one ETRAC and one auxiliary fuse box per engine.
An action on the T/R lever transmits signals to the Engine Interface Function (EIF), the Engine Electronic Controller (EEC) and the Primary (PRIM) / Secondary (SEC) computers.
The EIF uses its dedicated signal and the signal from the EEC to control the electrical power and send stow/deploy command signals to the ETRAC.
If a signal is missing or one of the EIF applications is not operative, redundancy in the control path permits to keep control of the T/R system.
For safety reason, a locking system independent from the engine systems, make sure that the T/R cannot deploy inadvertently.
This system has:
- The PRIM or SEC computers, controlling the system
- The Electrical Power Distribution System (EPDS) to supply electrical power
- An electrical lock, known as track lock.



GENERAL DESCRIPTION

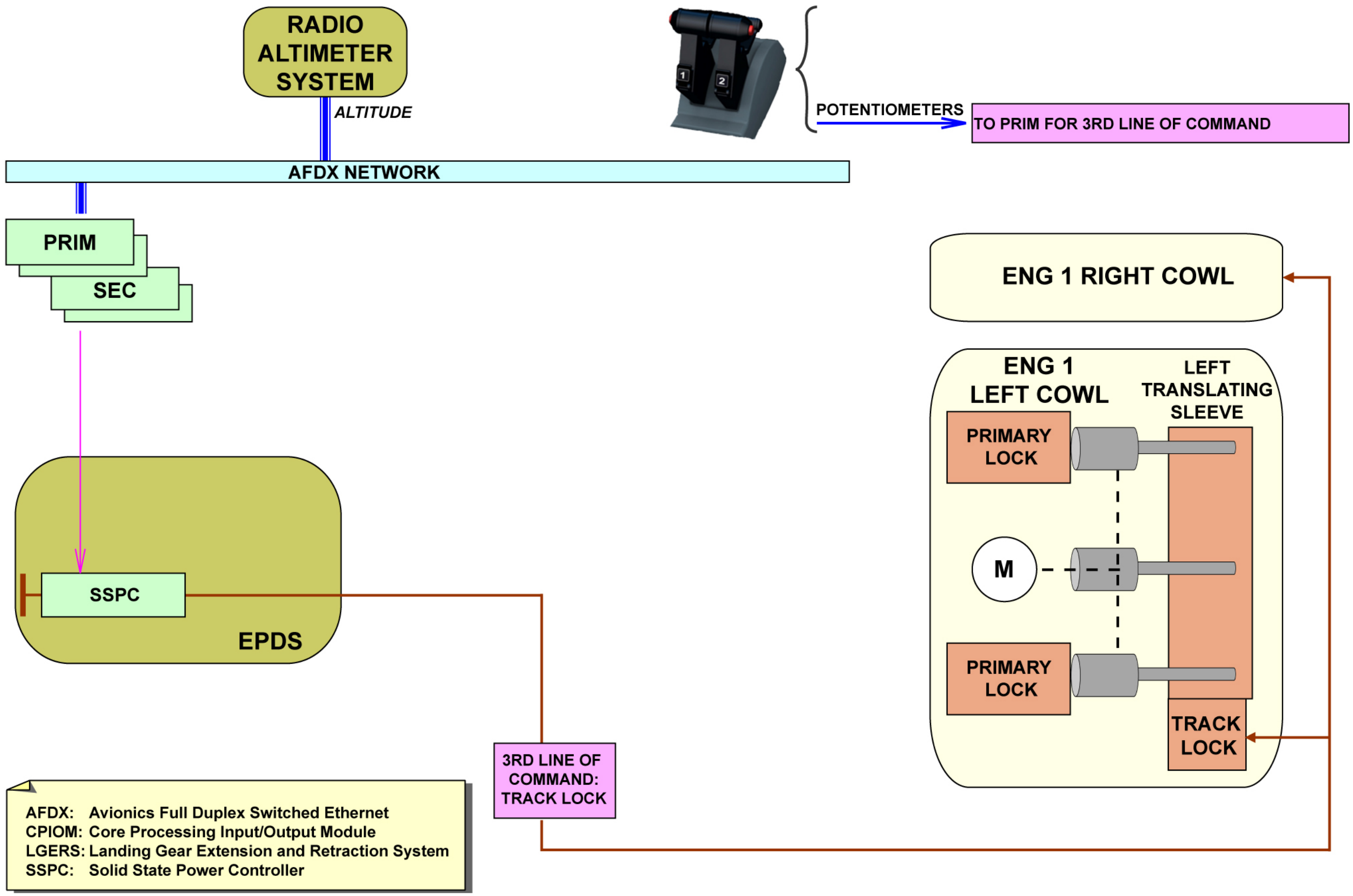
THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Control Path and Lines of Command

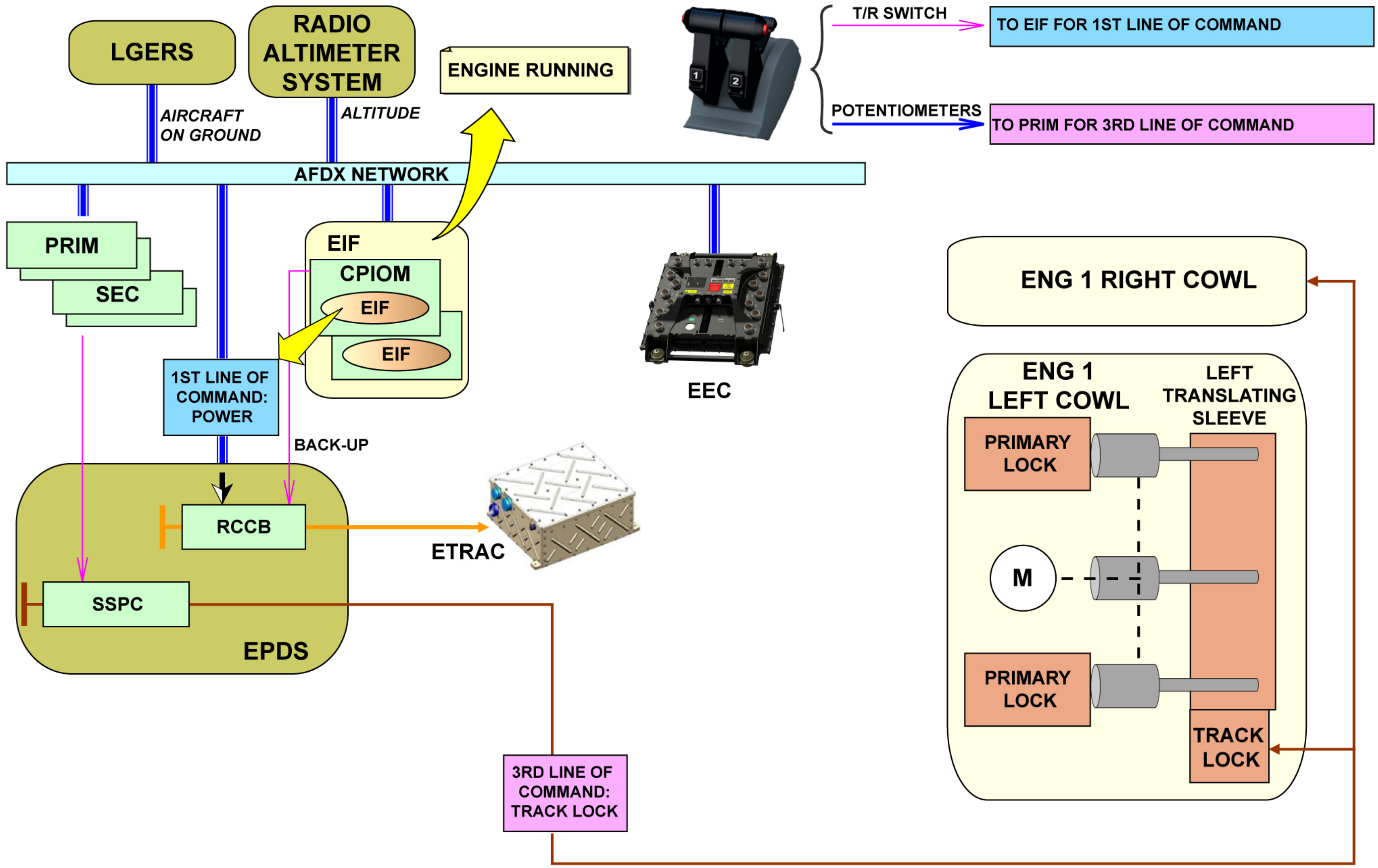
The T/R control system has three lines of command:
- The third line of command controls the independent locking system. This line is fully independent from the Propulsion Control System (PCS). The PRIM computers receive the T/R lever position (potentiometers) and a signal from the radio-altimeter system (RA below 6 ft) to send a discrete signal to the EPDS to release the track lock. If the PRIM computers are not operative, two SEC computers will take over.
- The first line of command supplies a (230VAC) source of electrical power to the ETRAC. The ETRAC uses this power to control the electrical motor and to unlock the primary locks.

A dedicated switch (T/R switch) sends a T/R lever position signal (discrete) to EIF applications. If the aircraft is on ground (Landing Gear Extension and Retraction System (LGERS)) and the engine is running, one of the two applications sends a digital command through the Avionics Full Duplex Switched Ethernet (AFDX) network to the EPDS to supply electrical power (230VAC) through a dedicated Remote Control Circuit Breaker (RCCB).
A discrete signal is used, if the AFDX is not available.
If the application fails, the other application will take over.
- The second line of command gives stow or deploy command to the ETRAC. The ETRAC uses the electrical power to control the electrical motor and to unlock the primary locks, through an auxiliary fuse box. The auxiliary fuse box is installed below the ETRAC and gives protection to the ETRAS system against electrical failure.

Dedicated position transmitters (rheostats) send T/R lever position signal (analog) to the EEC. The EEC digitalizes this signal and sends it to EIF applications. With the A/C on ground and engine running, and depending on the T/R lever position, the EIF application (not used for the first line of command) sends stow / deploy commands to the ETRAC through the AFDX network. If this application is not operative, the other application will take over. A discrete signal is used as a back-up if there is an AFDX network failure.
For safety reason, a ground safety switch (under the belly fairing) is used during operational test of the T/R with the engine not running. There is one switch per engine.

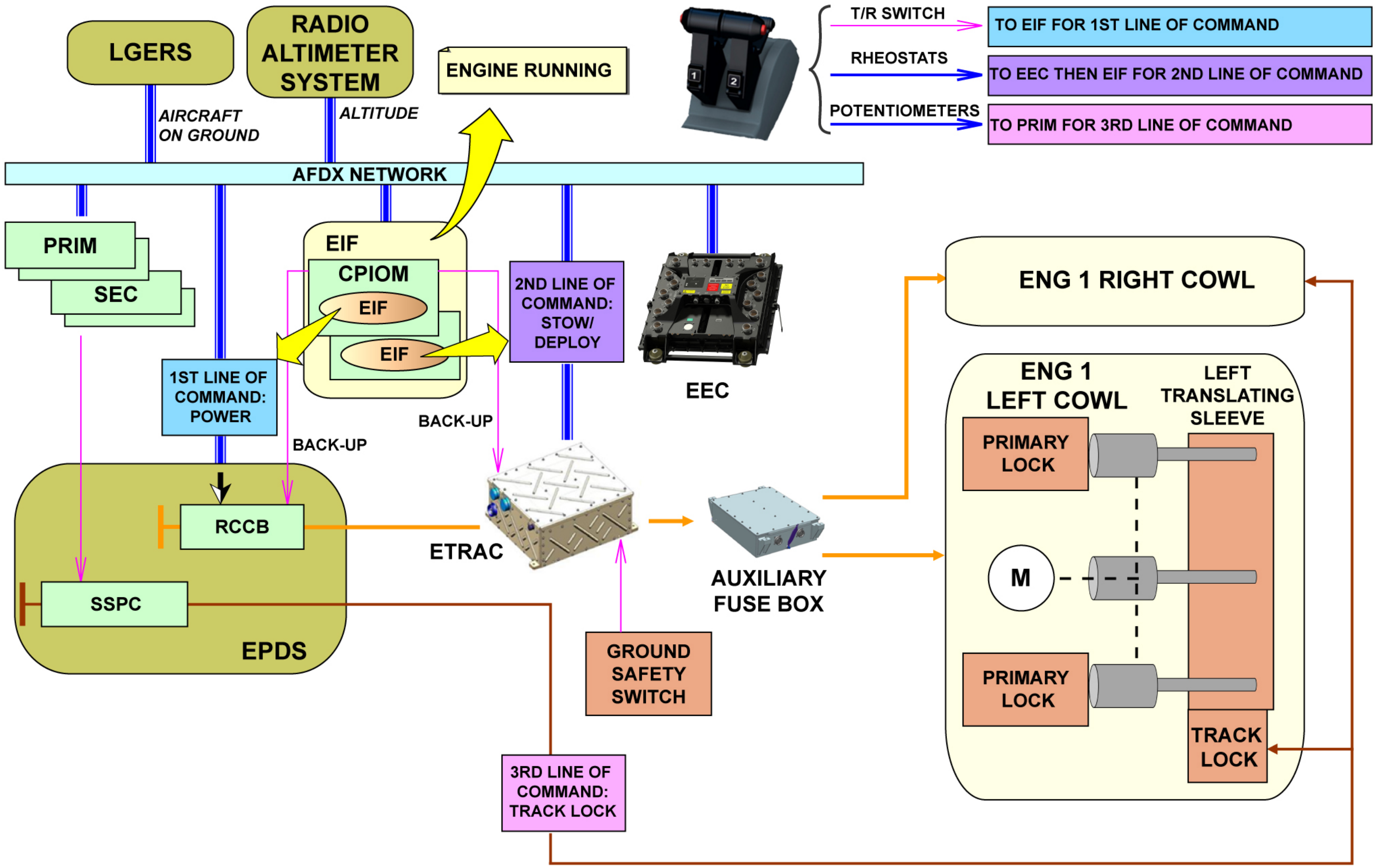


CONTROL PATH AND LINES OF COMMAND



CONTROL PATH AND LINES OF COMMAND

V1813401 - V01T0M0 - VM70DATHREV3001



CONTROL PATH AND LINES OF COMMAND

V1813401 - V01T0M0 - VM70DATHREV3001

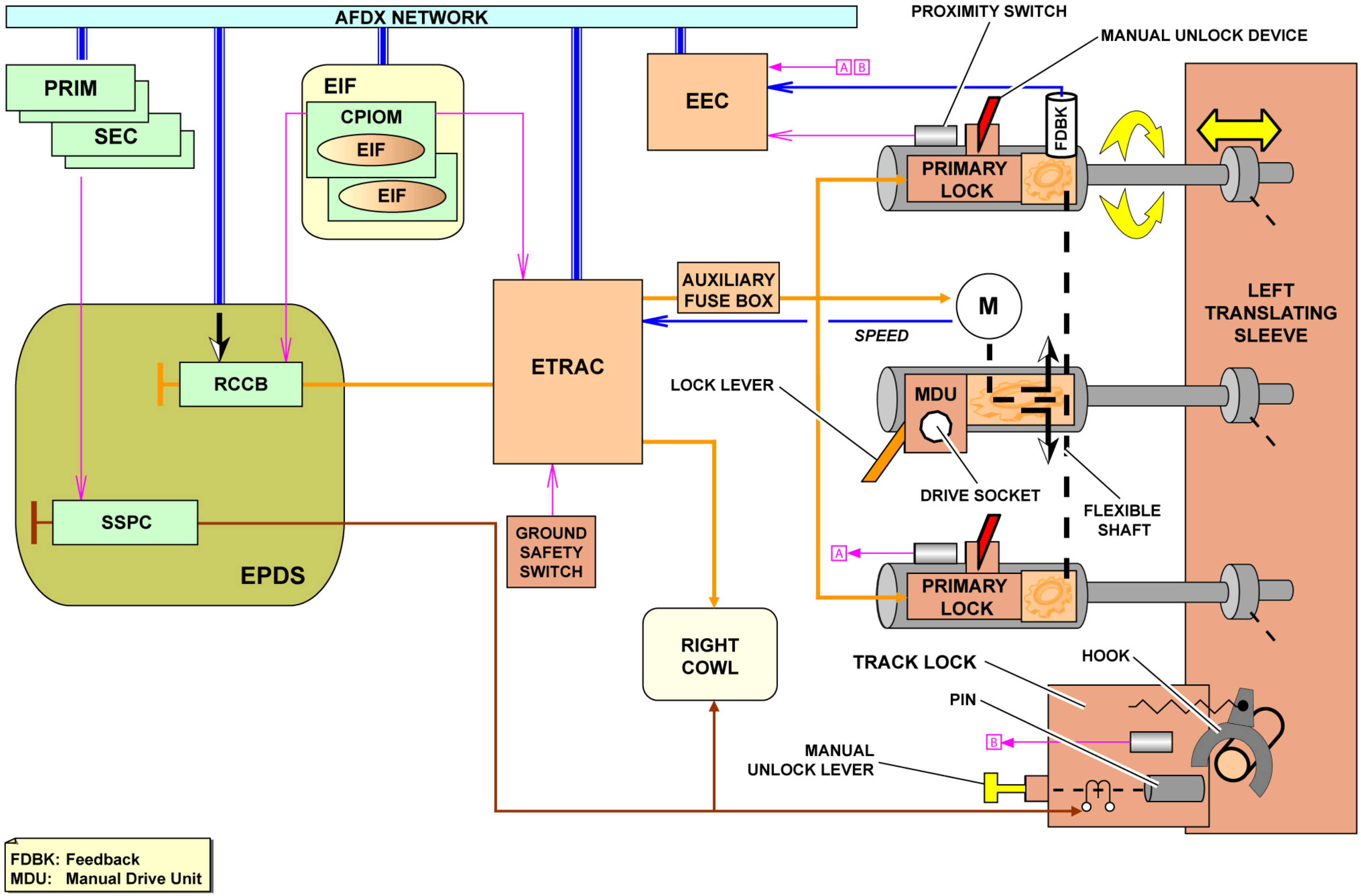
THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Electro-Mechanical System Description and Operation

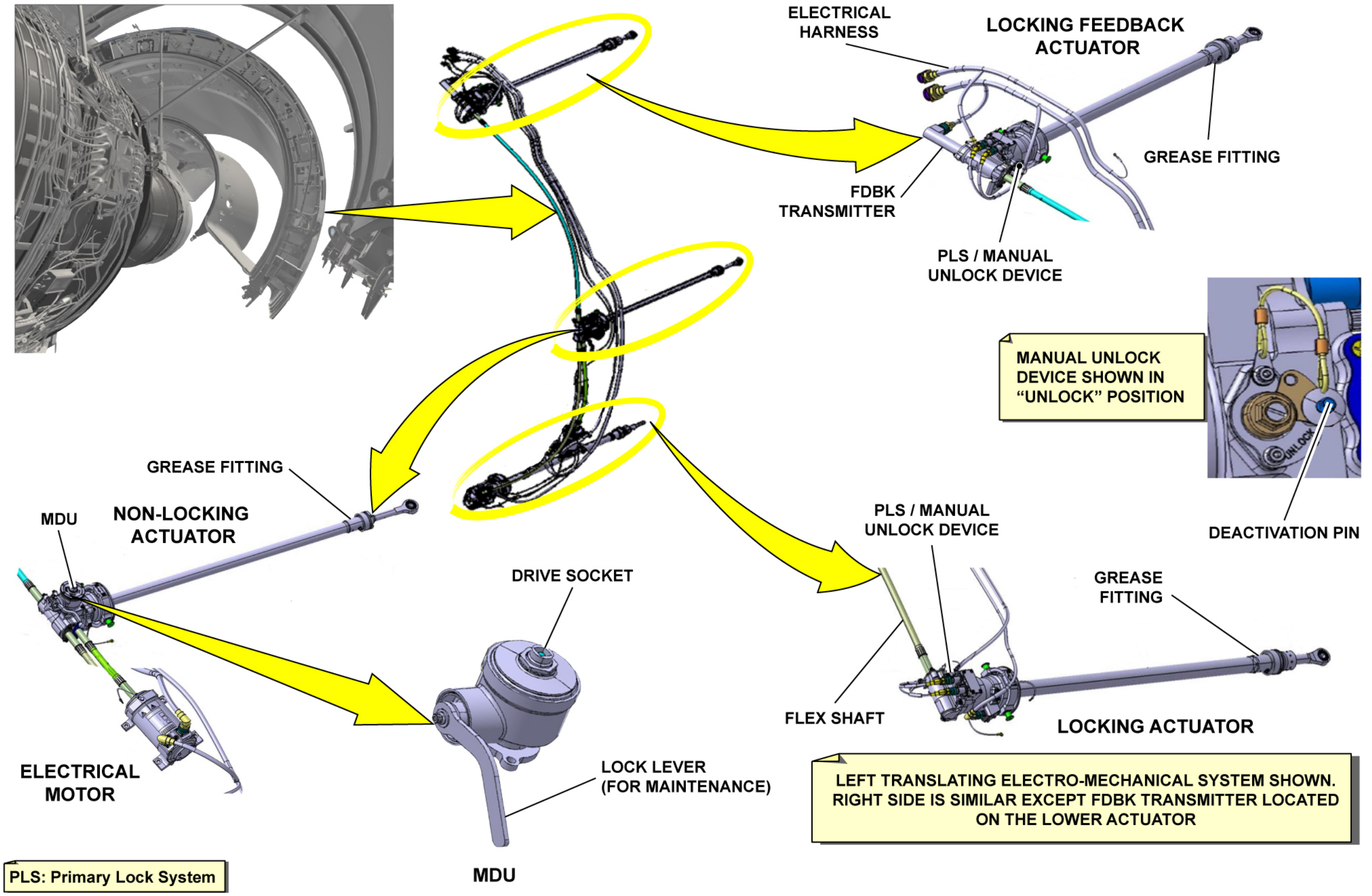
For each translating sleeve the electro-mechanical system has:
- One electrical motor
- Three ball-screw mechanical actuators converting rotational movement of the electrical motor into a translating movement
- The upper and lower actuators include a primary lock with a manual unlock device and a proximity switch. A position transmitter is installed on one actuator.
- The center actuator includes a Manual Drive Unit (MDU) and a lock lever.
- Flexible shafts connecting the electrical motor and the actuators together
- One track lock including:
- A hook (spring-loaded open)
- A solenoid moving a locking pin. The locking pin locks the hook in the locked position when the solenoid is not energized
- A proximity switch
- A manual unlock lever.

Deploy operation:
When the crew selects T/R, the PRIM (or SEC in back-up) commands the EPDS to energize the track lock solenoids (until the T/R is almost fully deployed). The hooks open with the spring action. The track locks are now unlocked.
The ETRAC, on reception of deploy command from the EIF, supplies electrical power to the primary locks which unlock the upper and lower actuators.
The ETRAC also controls the electrical motors in the deploy direction.
Each electrical motor drives its on-side center actuator by a flex shaft.
The center actuator drives the upper and lower actuators by flex shafts.
When the T/R is fully deployed, the ETRAC removes electrical power to the electrical motors and to the primary locks which mechanically remain in the unlocked status.
Stow operation:
When the crew de-select the T/R, the ETRAC receives stow signal from the EIF.
The ETRAC distribute electrical power to the electrical motors in the stow direction.
The electrical motors drive the actuators to the stowed position.
When the translating cowls reach their stowed position, the primary and track locks are mechanically moved to their locked position and remain mechanically locked until the next deployment.
The EPDS with a command from the EIF, stops supplying electrical power.
System monitoring:
The EEC continuously receives translating sleeves position through the position transmitters installed on one of the upper or lower actuator.
The EEC gives this information to the ETRAC for control-loop and to the EIF for monitoring and indicating.
The EEC receives status of all the primary and track locks. The EEC transmits this data to the EIF for monitoring and warning.
The ETRAC monitors the electrical motor operation (speed and overheat).
Maintenance features:
Manual unlock devices on the upper and lower actuators and manual unlock lever on the track lock allows manual unlock of each translating sleeve individually. By inserting a standard tool in the MDU drive socket, the maintenance crew can then stow or deploy the translating sleeve.
During maintenance on the engine, manual lock of the T/R cowl is possible with the lock lever installed on the center actuator.
This lock lever is automatically reset when the fan cowl is closed.
Most of the components are installed on the T/R cowl torque box.
The upper and lower actuators include a manual unlock device. Standard tool is used to move the device in "unlock" position. A deactivation pin secures the device.
The center actuator and the electrical motor are located in the center. The center actuator includes the MDU and the lock lever.

An electrical harness supplies electrical power and controls signals to the system.
Three flex shafts lets the electrical motor drive its three actuators simultaneously.
For the left translating cowl the feedback transmitter is located on the top actuator.
For the right translating cowl, the electro-mechanical system is almost the same as the left translating cowl apart from the feedback transmitter actuator, located on the lower actuator.
All the actuators include a fitting located at the rod end, for greasing.



ELECTRO-MECHANICAL SYSTEM DESCRIPTION AND OPERATION



ELECTRO-MECHANICAL SYSTEM DESCRIPTION AND OPERATION

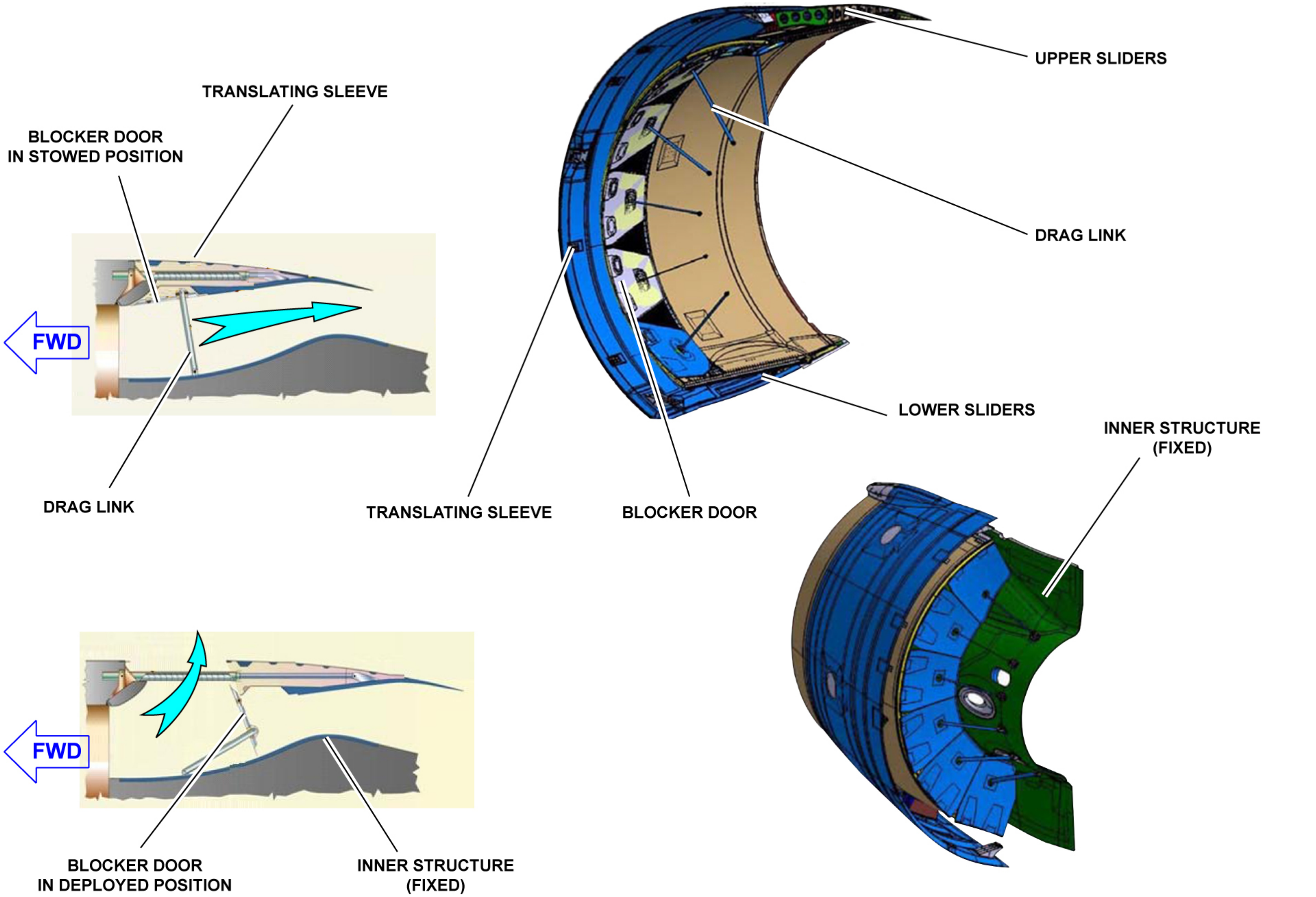
V1813401 - V01T0M0 - VM70DATHREV3001

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Translating Structure Description

Each T/R cowl has a translating structure made of:
- A translating sleeve sliding with the upper and lower sliders
- A set of (quantity 6) blocker doors hinged to the translating sleeve at their front end
- A set of (quantity 6) drag links hinged to the blocker doors at one end and hinged to the inner fixed structure of the T/R cowl at the other end.

When the translating sleeve is stowed, the blocker doors are flush with the inner surface of the cowl.
When the translating sleeve moves rearward, the drag links pull the blocker doors. The blocker doors block the fan airflow, which is released overboard through the cascade boxes, creating an air braking effect.

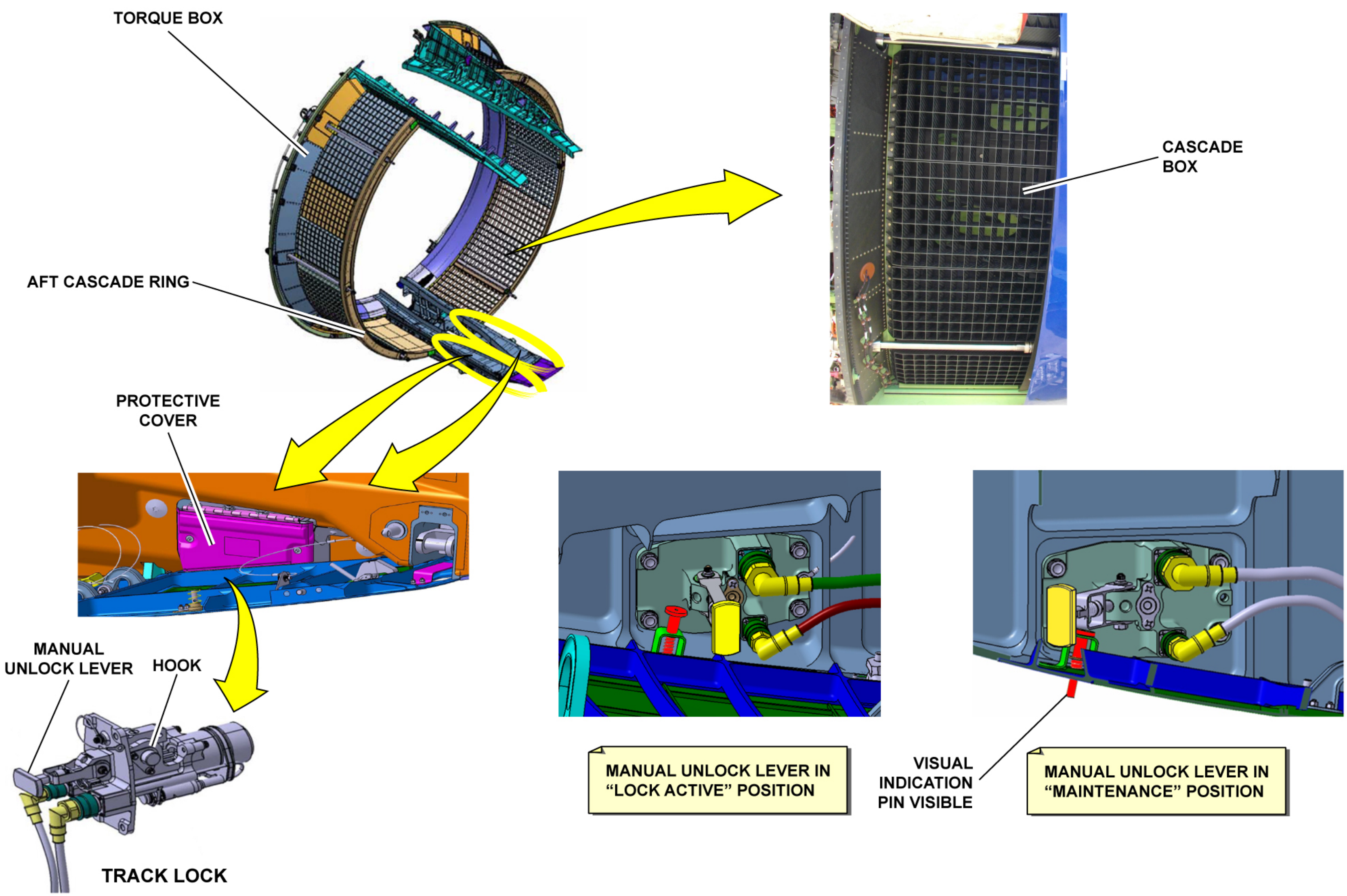


TRANSLATING STRUCTURE DESCRIPTION

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Cascade Boxes and Track Lock Description

The cascade boxes installed between the torque box and the aft cascade ring divert the fan airflow in forward or side direction when the translating sleeve is deployed. There are different types of cascade boxes which are not interchangeable.
The track lock installed on each latch beam includes a hook and a manual unlock lever.
A protective cover must be open to access the unlock lever.
The lever is manually moved from the "lock active" position to the "maintenance" position.
In the "maintenance" position, the lever pushes on a visual indication pin, when the latch access panel is closed. The indication pin protrudes outside the latch access panel, giving indication that the track lock has been left in the "maintenance" position.

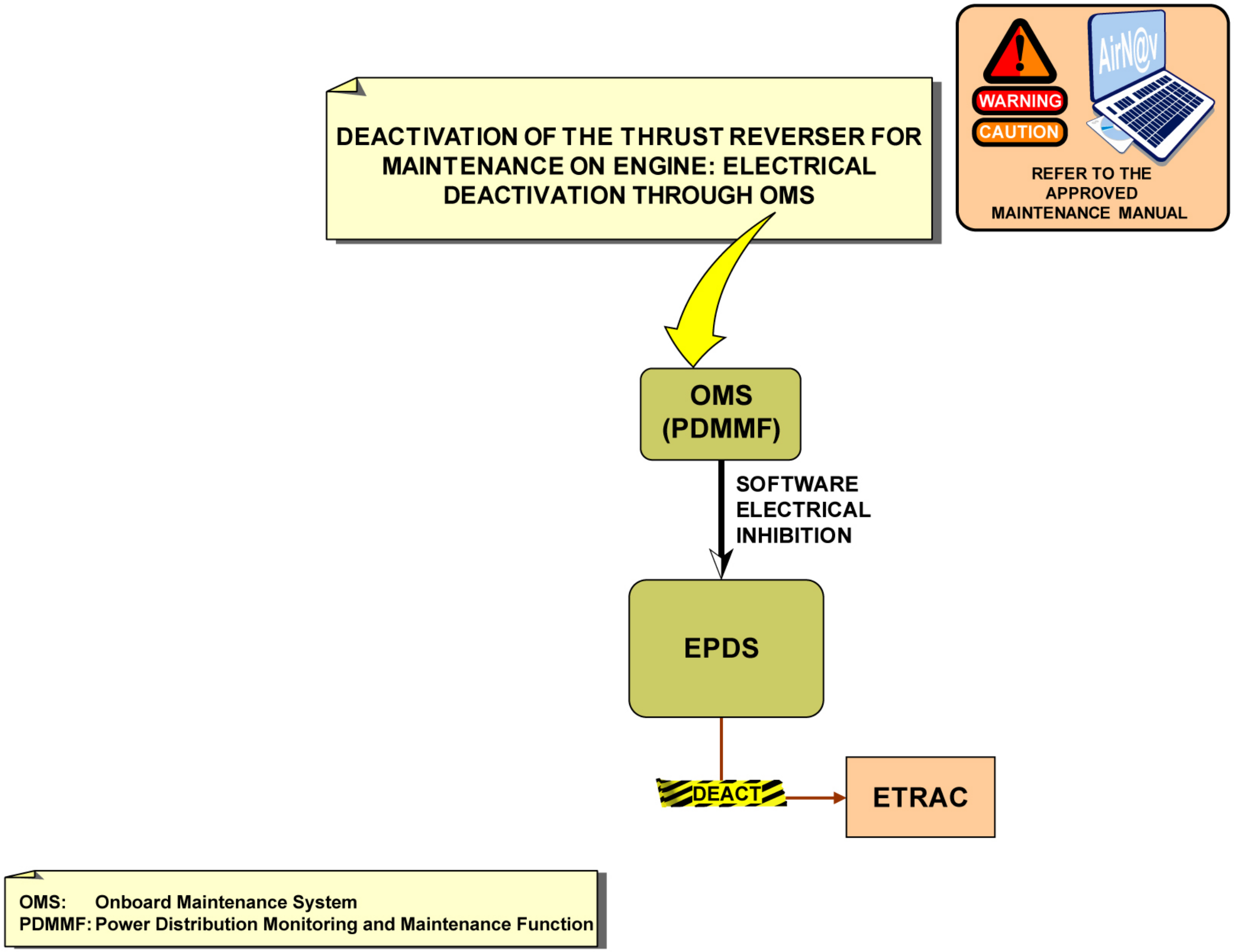


CASCADE BOXES AND TRACK LOCK DESCRIPTION

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Deactivation for Maintenance

Deactivation of the T/R for maintenance is done as listed:
- Electrical deactivation: An electrical deactivation trough the Onboard Maintenance System (OMS) Power Distribution Monitoring and Maintenance Function (PDMMF) commands the EPDS to inhibit the electrical power sent to the ETRAC. This step is sufficient, if the maintenance is done on the engine and not on the T/R system.

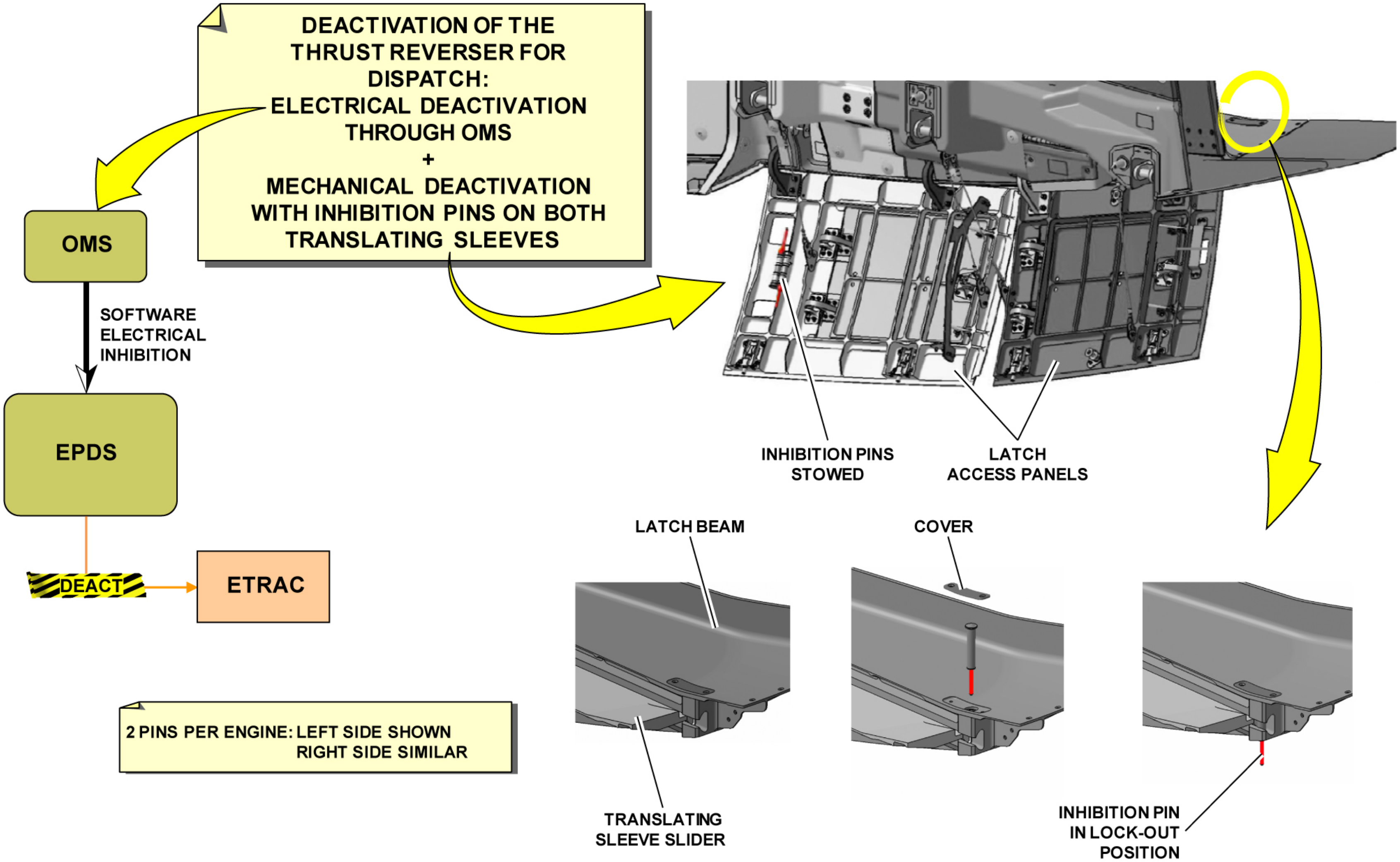


DEACTIVATION FOR MAINTENANCE

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Deactivation for Dispatch

Deactivation of the T/R for flight dispatch is done in two main steps:
- Electrical deactivation: An electrical deactivation through the OMS (PDMMF) commands the EPDS to inhibit the electrical power sent to the ETRAC.
- Mechanical deactivation: Stowed inside the latch access panel, the inhibition pins are installed on the aft end of the latch beams. In this position each pin blocks the lower translating sleeve slider in the stowed position and it is visible outside through the cowling.

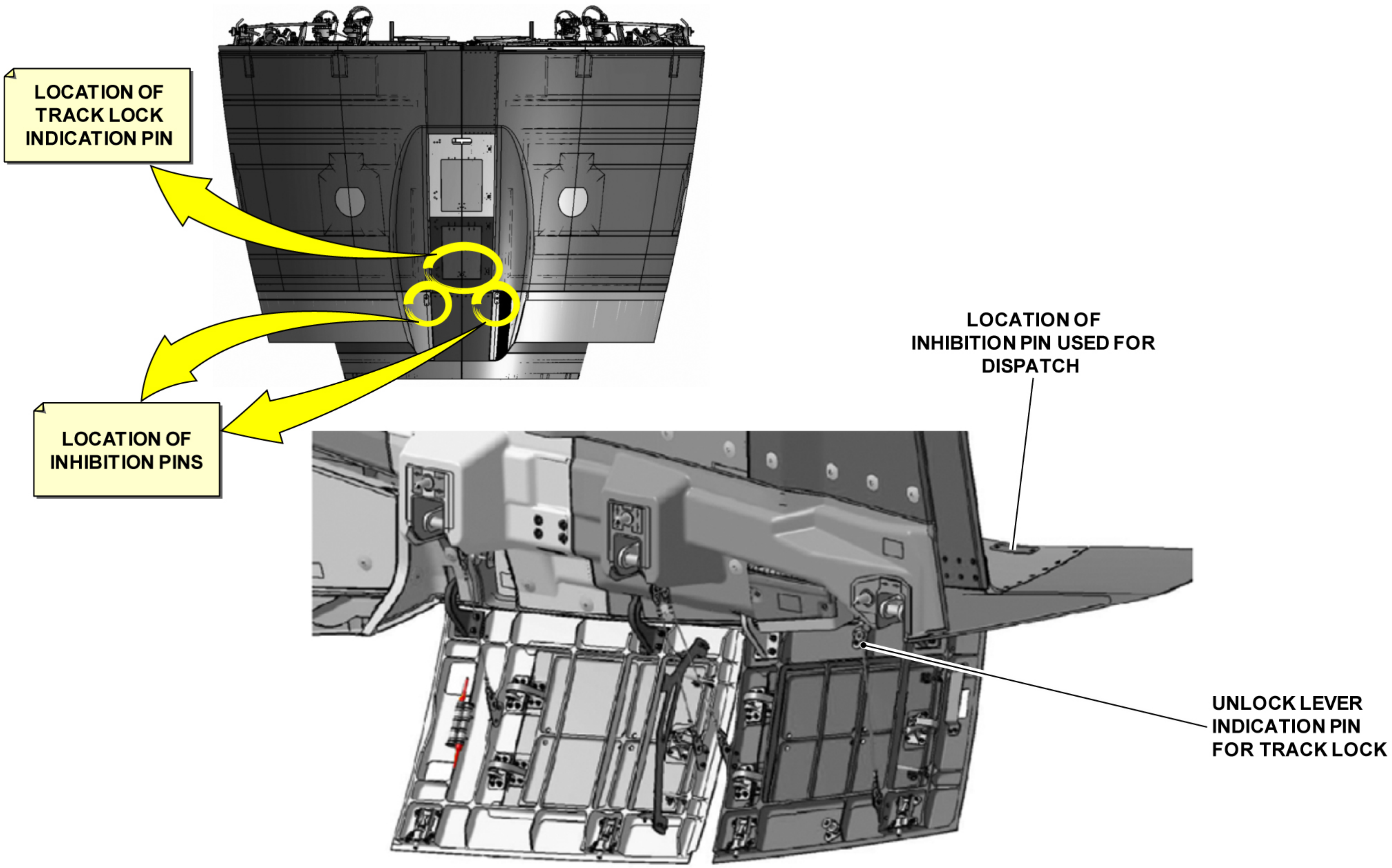


DEACTIVATION FOR DISPATCH

THRUST REVERSER SYSTEM DESCRIPTION (2/3)

Maintenance Tip

Maintenance tip:
The unlock lever indication pin showing that the track lock is in maintenance position (unlocked) is installed on the T/R latch beam aft access panel. The inhibition pins installed during the deactivation for dispatch are located just outside the aft access panel.
Make sure that the correct pin is identified.



MAINTENANCE TIP

ENGINE OIL AND THRUST REVERSER SYSTEM CONTROL AND INDICATING (2/3)

Oil Low Press (3)

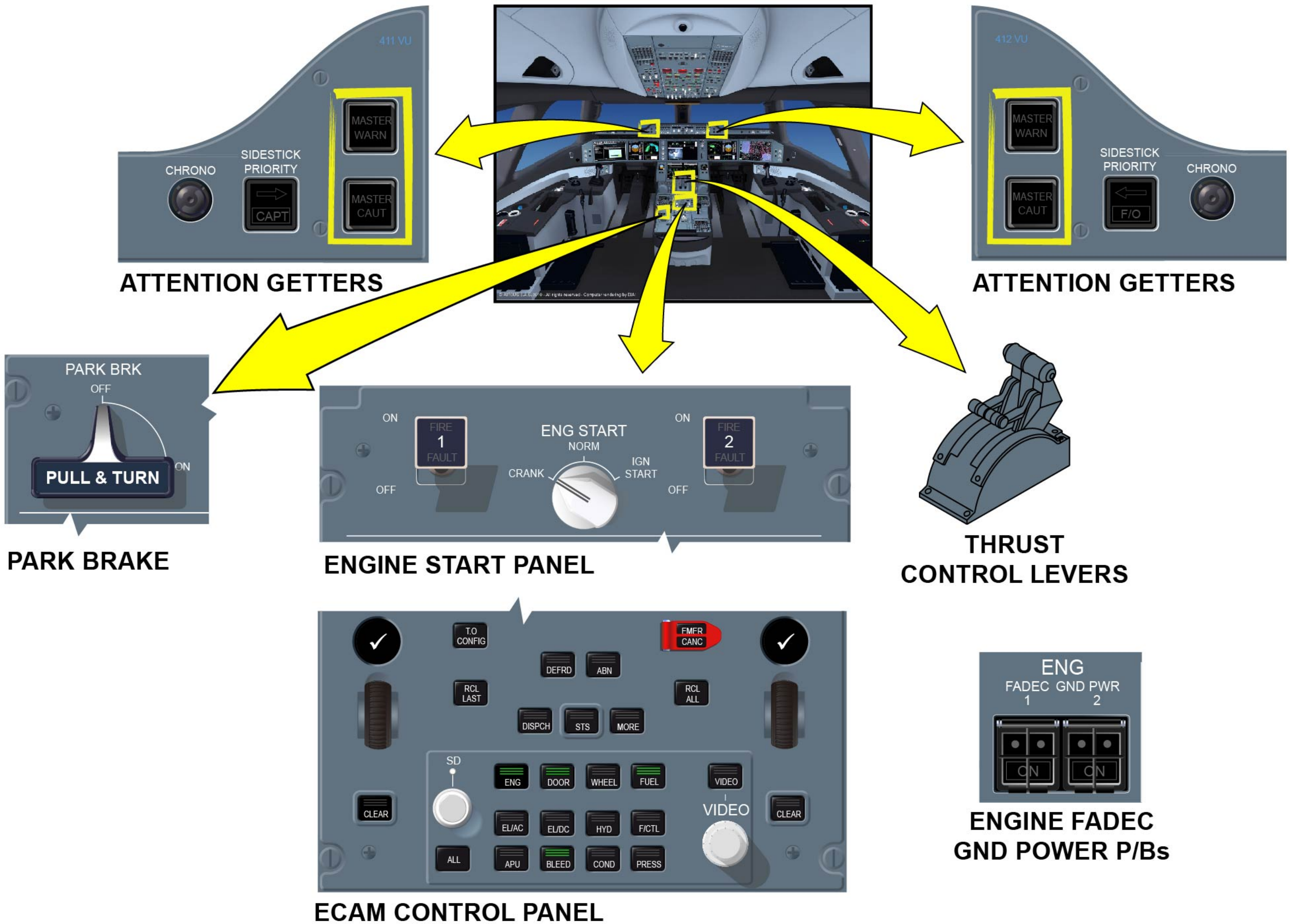
In case the engine oil pressure decreases during engine operation, its green indication changes to amber color and becomes red if it drops below 25 PSI.
The red ENG OIL PRESS LO warning is triggered on the EWD, the MASTER WARNING lights flash, the Continuous Repetitive Chime (CRC) sounds and the ENGINE SD page is automatically displayed.
The low oil pressure is detected by a LP switch, whereas the oil pressure indication is given by two oil pressure transmitters.
If the Oil pressure reduces below red line limit (25PSI):
- Reduce Thrust lever to Idle,
- Shut down the engine to avoid damage.

Thrust Reverser Inhibited (2)

A thrust reverser inhibition is performed on ground, for dispatch purpose. To inhibit a thrust reverser, through the OMS, an interactive test allows deactivating electrically the thrust reverser system. When the inhibition has been performed, the amber message "ENG REVERSER INHIBITED" in displayed on the EWD.

Thrust Reverser Unlocked (3)

Reverse thrust is only available when Aircraft is on ground, engine running and reverser lever selected.
The Thrust Reverser levers are used to control the deployment and the stowing of the thrust reversers, and to adjust the reverse thrust.
Each Thrust Reverser lever can be moved individually from IDLE REV detent to MAX REV detent, when the associated Thrust Lever is in the FWD IDLE detent.
Note: When operating Engine Reversers with A/C Static on ground, it is strongly recommended to keep the Thrust Reverser Levers at IDLE REV detent only.
When the thrust reverser is fully deployed, the REV green indication is displayed on the N1 dial on EWD.
The REV amber indication is displayed when the Reverse Thrust is selected and the thrust reverser is in transit, or when the reverser is unlocked.
If a Thrust Reverser is detected unlocked, the ENG REV UNLOCKED message is displayed on EWD.
When pushing the Thrust Lever to FWD IDLE position, the thrust is automatically limited to idle by the FADEC.
If an engine Thrust Reverser is detected unlocked, the aircraft dispatch is allowed under the condition that the faulty thrust reverser system is locked and deactivated.



OIL LOW PRESS (3) ... THRUST REVERSER UNLOCKED (3)

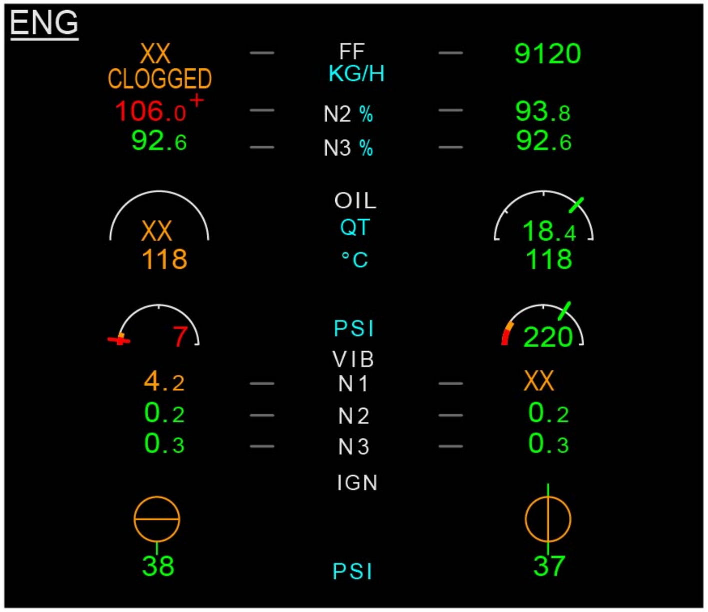
V1813401 - V01T0M0 - VM70I3000003001

ENGINE DISPLAY (ED)

V1813401 - V01T0M0 - VM70I3000003001

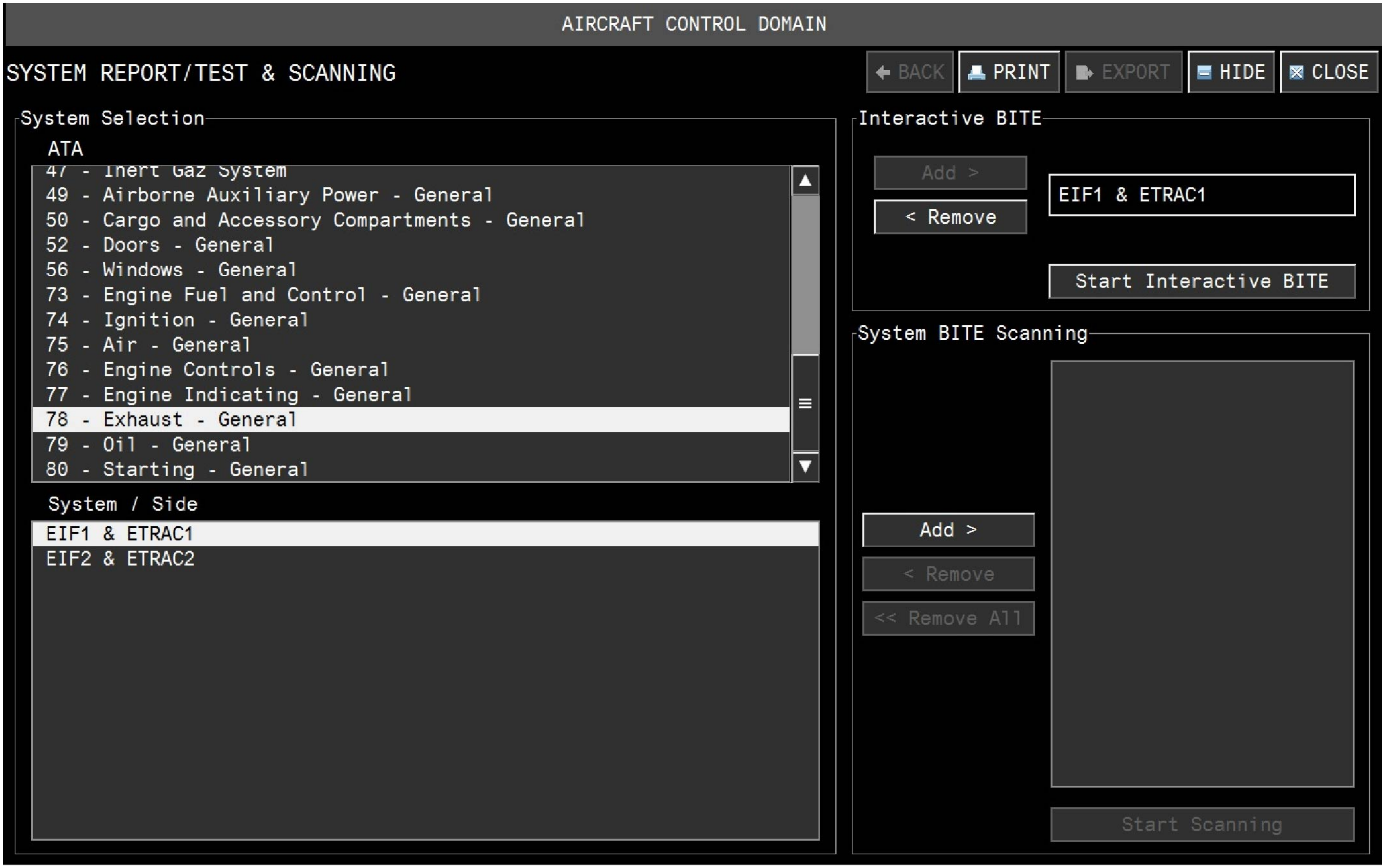
OIL LOW PRESS (3) ... THRUST REVERSER UNLOCKED (3)

THIS SD SHOWS SEVERAL AVAILABLE INDICATIONS BUT NOT A SYSTEM CONFIGURATION.



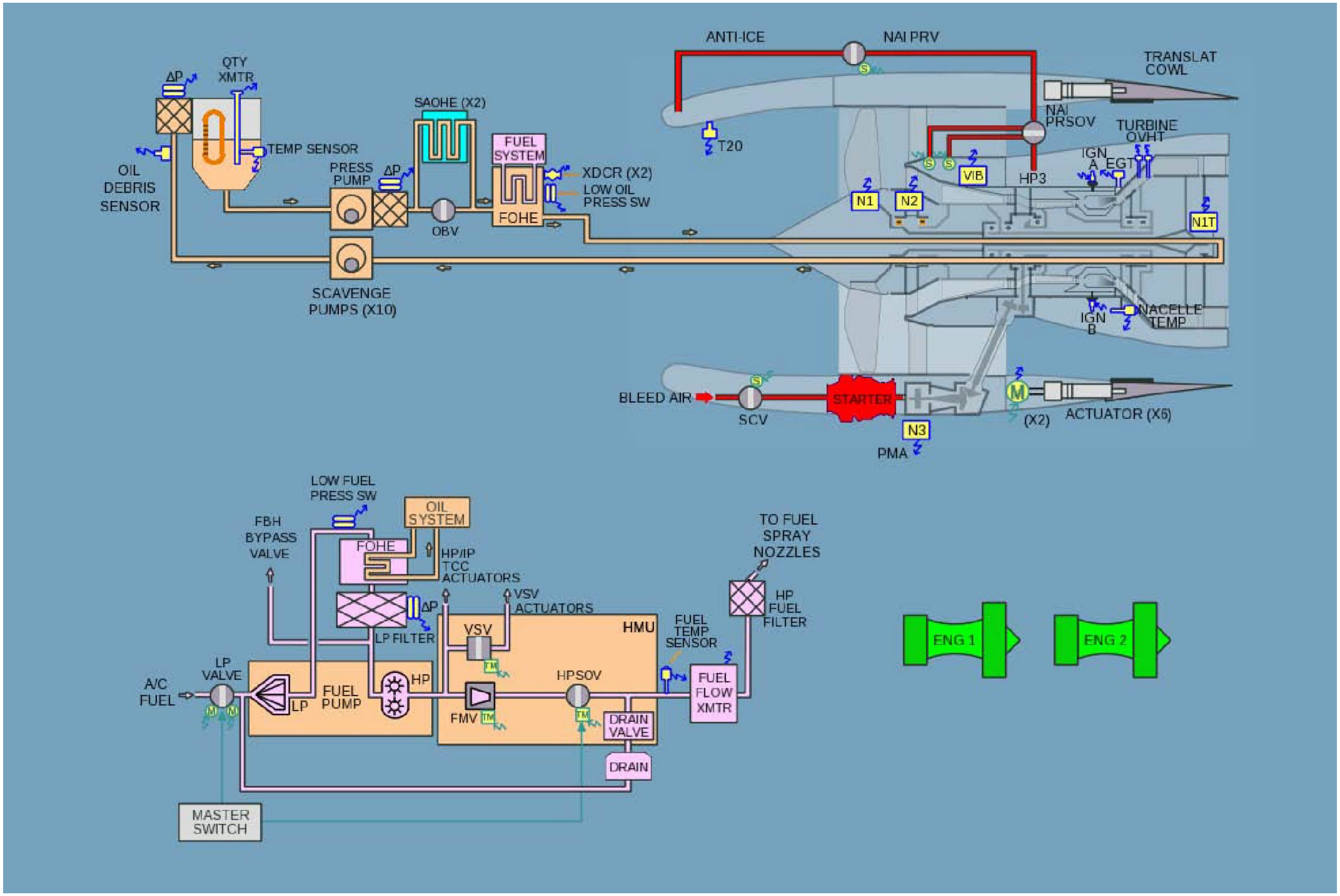
ABNORMAL ENGINE SD PAGE

OIL LOW PRESS (3) ... THRUST REVERSER UNLOCKED (3)



OIL LOW PRESS (3) ... THRUST REVERSER UNLOCKED (3)

V1813401 - V01T0M0 - VM70I3000003001



OIL LOW PRESS (3) ... THRUST REVERSER UNLOCKED (3)

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