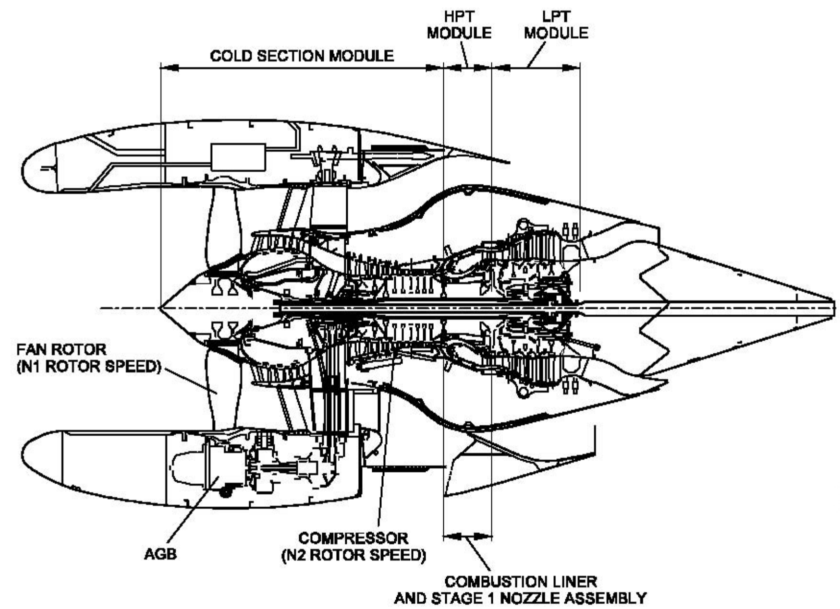
Engines

- The EMB-190 is equipped with two GE CF34-10E6 turbofan engines. Each engine is housed in an aerodynamic nacelle suspended by a pylon installed under the wing.
- The engine produces maximum power from 17,100 lbs up to 18,500 lbs on the reserve mode (RSV) at ISA condition.
- The engine is a high-bypass, two-spool, axial-flow, turbofan engine. It can be divided into the following modules: the cold section, the accessory gear box, the combustion liner and stage 1 nozzle assembly, the high-pressure turbine and the low-pressure turbine.



CF34-10E ENGINE

- The engine basic characteristics are: A single-stage low-pressure fan that is driven by a four-stage low-pressure turbine. This spool represents the N1 speed indication on the cockpit.
- A 9-stage, axial-flow compressor with variable geometry Inlet Guide Vanes and stator stages driven by a two stage high pressure turbine. This spool represents the N2 speed indication on the EICAS.

- A dual-channel **F**ull **A**uthority **D**igital **E**lectronic **C**ontrol (FADEC) provides flexible engine operation, reduced pilot workload, and the highest level of reliability, safety and maintainability.
- The accessory gearbox provides mounting pads for the electric alternator, IDG, and the hydraulic pump.
- 5 thermocouples mounted in the inlet stream of the low pressure turbine sense the gas temperature and send their signals to the FADEC.
- The signals are used for ITT indication, hot start logic and flame out detection. Engine fuel flow is measured within the fuel control unit that also sends a signal to the FADEC and to the EICAS for indication.
- The engine fuel system has two sub-systems: a fuel control system, and a fuel distribution system, which provides the engine with scheduled fuel for combustion.
- The engine fuel control system is composed of a two channel **F**ull **A**uthority **D**igital **E**lectronic **C**ontrol (FADEC), a **F**uel **M**etering **U**nit (FMU), a **P**ermanent **M**agnet **A**lternator (PMA), engine sensors, **V**ariable **G**eometry (VG) actuators, and an **O**perability **B**leed **V**alve (OBV). The components of the fuel distribution system include the fuel pump, fuel filter, fuel manifold, and 18 fuel injectors.
- Fuel supplied by the airplane fuel tanks flows to the engine fuel pumps. Upon exiting the tanks, the fuel flows through the low-pressure pump and then divides into two paths. One flows through the high-pressure fuel pump and returns to the fuel tank as ***motive flow***.
- The second flows through the ***fuel/oil heat exchanger*** to the high-pressure fuel pump. The flow leaves the pump and passes through the fuel filter. Once filtered, the fuel flows to the FMU.
- From there the fuel is returned back to the fuel pump to increase the fuel pressure before it enters the FMU. The FMU meters the fuel by means of FADEC inputs, and sends this fuel by way of the fuel manifold to the 18 fuel injectors mounted in the combustor frame.

- The fuel control system is managed by a two-channel **F**ull **A**uthority **D**igital **E**lectronic **C**ontrol (FADEC). The FADEC controls the engine fuel requirements in response to thrust command inputs from the aircraft.
- The FADEC software provides thrust management based on aircraft and air data inputs. These inputs are used to calculate appropriate reference N1 for any given thrust lever position.
- FADEC is powered from the Aircraft DC Electrical System until approximately 50% N2 when it then receives its power from the **P**ermanent **M**agnet **A**lternator (PMA).
- Some of the N1 references are modified by discrete inputs like **A**utomatic **T**akeoff **T**hrust **C**ontrol **S**ystem (ATTCS), thrust reverser position, Weight On Wheels, and bleed discrete inputs.
- In addition to setting the correct N1 for a given TLA position, the FADEC schedules limit fuel to protect the engine speeds, temperature and **C**ompressor **D**ischarge **P**ressure (CDP) limits.
- The engine fuel indicating system is monitored by engine-mounted sensors that provide their information to the EICAS. The indicating system consists of a fuel filter by-pass switch, a fuel low-pressure switch, and a fuel flow-measuring device.
- The purpose of the engine oil system is to provide lubrication and cooling to the turbine engine main shaft bearings and the accessory gear box bearings.
- The engine lubrication system contains the following main components:
    - An oil reservoir, which is an integral part of the accessory gearbox
    - The lube and scavenge pump

- The Oil Filtration Module, which includes a filter by-pass valve
- Fuel/oil heat exchanger which cools the oil and heats the fuel.

- The engine oil system can be monitored on the EICAS and MFD status page. The EICAS indicates the engine oil pressure and the oil temperature. The engine oil pressure readout is displayed in pounds per square inch for each engine.

- Indication is green in normal operation, amber when operating in the cautionary range and red when operating limits are exceeded. The engine oil temperature readout is in degrees Celsius for each engine.

Indication is green in normal operation and amber when operating in the cautionary range. Engine oil level status is displayed on the MFD status page in quarts.

- Each engine has its own scale with pointer and a numerical display. The left scale corresponds to engine 1 and the right scale is for engine 2. The scale is divided into two segments. The bottom segment is the amber region and an upper segment, which is displayed in white, is the normal region.

- The engine ignition system provides the electrical spark required for initiation of engine combustion of the fuel/air mixture during start, engine auto-relight, and when the ignition selector knobs are selected to OVRD position. The system also performs engine flameout detection and automatic relight logic. The ignition system for each engine consists of two ignition exciters, two ignition leads and two igniters.

- Engine ignition is controlled by the FADEC and integrated aircraft systems that automatically initiate ignition in response to engine core speed developed by the starter air system. Only one igniter is energized for ground starts so that latent faults can be detected. Two igniters are energized for air starts, flameouts, loss of ARINC busses, a missed light-off or if continuous ignition is requested by the pilot.
- Selection of the ignition system can be performed manually from the Engine Control Panel by selecting the ignition selector knob to the Off, Auto or OVRD position.
- When ignition is selected to the auto position, the FADEC automatically controls the ignition system, depending on engine requirements. When ignition is selected to the OVRD position, the FADEC continuously activates both exciters when the engine is running.
- The FADEC will deactivate the ignition system under the following conditions: Upon engine shutdown or when the pilot sets the Ignition Selector Knob to OFF during dry motoring on ground. ***In flight the FADEC disregards the OFF position.*** After each engine start the FADEC swaps igniters.
- The FADEC activates both igniters whenever a flameout is detected in flight or on ground. When this occurs, a ***FAIL*** indication is displayed in the center of the N1 dial. A ***WML*** icon is displayed beside the respective N2, indicating that the engine auto-relight attempt is in progress. The ignition remains ON (annotated by the IGN A/B just above the WML icon) for 5 seconds after the flameout detection has been cleared.
- If the engine relight does not occur within 30 seconds when the N2 rotation is below idle, moving the START/STOP selector knob to the STOP position will terminate the auto relight
- The engine starting system is designed to provide sufficient rotor speed to initiate combustion light-off, and to obtain self-sustaining engine propulsion. The starting system includes an **A**ir **T**urbine **S**tarter (ATS), a **S**tarter **C**ontrol **V**alve (SCV), portions of the bleed air system and starting control panel. Engine starting is a combined aircraft and FADEC operation.

- The FADEC controls fuel flow, the starter command and the ignition command, while the aircraft controls the starter control valve and the **E**ngine-**D**riven **P**ump (EDP) of the hydraulic system, and also switches power to the ignition exciters as commanded by the FADEC. The aircraft also manages the bleed system interface during starts.
- By selecting the start/stop selector knob on the engine control panel momentarily to the start position, pressurized air is directed to the air turbine starter, which rotates the engine rotor via the accessory gearbox.
- The FADEC automatically commands the ignition and fuel flow “ON”. The FADEC schedules the fuel flow to accelerate the engine to Idle, de-energizes the Starter Control Valve at approximately 50% N2, and turns the ignition off when the engine reaches idle. The isolation valve is automatically controlled only if the X-Bleed switch is selected in the “pushed in” (auto) position.
- With the Engine at Idle, remember the 2-4-6 rule:
  - N1 Approx **26% - 27%**
  - ITT Approx **460° - 520°** (depending on OAT)
  - N2 Approx **62% - 65%**
  - Fuel Flow Approx 550#/hr
  - Oil Press >25psi
- Also once the engine is at idle the ITT red pointer will jump from the start limit of 740° to 947°.
- For windmill start, the engine rotors are rotated by the aircraft forward airspeed, providing windmill rotation. The start is commanded through the start/stop selector knob, and the FADEC then automatically commands ignition and fuel. Ignition will be turned off when idle speed is reached.
- The hydraulic Engine Driven Pump is unloaded by energizing the Engine Driven Pump solenoid during engine windmill starts in order to reduce drag on the core rotor.

- An assisted start sequence is carried out as follows:
    - The ignition switch is placed in auto position.
    - The bleed air system is then configured so that air at the Starter Control Valve is available.
    - The start/stop selector knob is momentarily selected to START, so that the MAU senses the START switch closure and sends the START switch signal to the FADEC.
    - The Starter Control Valve opens. The FADEC commands the ignition on at approximately 7% N2, and the fuel metering valve to open at approximately 20% N2.
    - The FADEC will schedule the fuel flow to accelerate the engine to idle and will de-energize the Starter Control Valve at approximately 50% N2.
    - Ignition will be turned off when the engine reaches idle.
- An inflight assisted start is identical to a ground start, but the FADEC will open the metering valve if N2 has not reached 20% after 15 seconds.
- A windmill start is performed according to the following sequence:
    - The ignition switch is set to auto.
    - The start/stop selector knob is momentarily set to start.
    - The switch position is sensed by the MAU, which sends the START switch signal to the FADEC.
    - Since no pneumatic pressure is available, the Starter Control Valve does not open.
    - The FADEC recognizes that the Starter Control Valve remains closed after the open demand and automatically commands ignition and fuel flow at 7.2% N2 or after 15 seconds if 7.2% N2 is not yet reached.

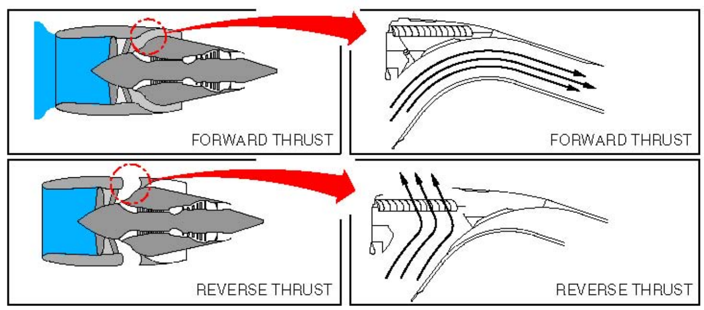
- The FADEC will schedule fuel flow to accelerate the engine and turn off ignition as idle speed is reached.

- The FADEC start protection logic provides automatic ***Hot, Hung and No light-off start protection*** with the aircraft weight on wheels. Hot and hung starts are not protected in the air by the FADEC.

- The hot start protection will terminate the start when ITT rises above ***740°C*** during a ground start, by closing the fuel metering valve and shutting off ignition. The FADEC will not de-energize the starter driver in this case to allow immediate engine cooling by motoring. To terminate motoring, the start/stop selector knob has to be moved to STOP.

- The thrust reverser assembly is located directly aft of and is clamped to the aft fan case. It forms a duct for fan exhaust air when the left and right assemblies are latched in place.

- Each thrust reverser half consists of a fixed structure that supports the transcowl, houses the cascades, and contains the thrust reverser actuation system.



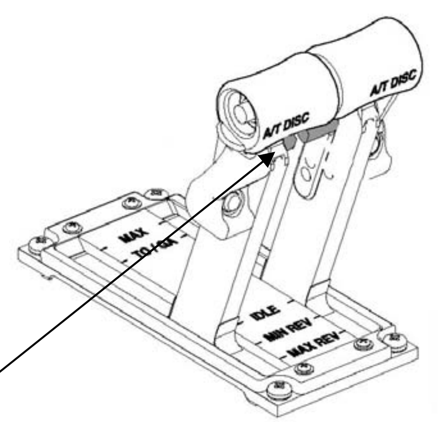
- In the forward thrust configuration, the transcowl is in the forward, stowed position covering the cascades. In the reverse thrust configuration, the transcowl is in the aft, deployed position blocking the fan duct and exposing the cascades.

- The assemblies have a translating cowl that moves aft when commanded by the thrust lever, resulting in a re-direction of the fan air-stream during reverse thrust operation.

- Each thrust reverser half is operated by two hydraulic actuators pressurized by the aircraft hydraulic system (#1 Engine Reverser powered by Hyd System 1 and the #2 Engine is powered by Hyd System 2).

- The actuators extend when reverse is selected, and drive the transcowl aft along tracks on the upper and lower beams of the thrust reverser fixed structure. Appropriate interlocks and position sensors, which indicate the position of the transcowl to the flight crew, are incorporated in the system.

- The thrust reverser is controlled from the cockpit through a thrust reverser control, integrated into the Thrust Control Quadrant.
- This allows the thrust reverser to be deployed or stowed by hydraulic actuators mounted in the thrust reverser.
- The FADEC receives various inputs such as Weight On Wheels, wheel speed, and Thrust Lever Angle from the aircraft systems, and activates the system logic when all signals are correct for reverse thrust.



- Once the thrust lever is retarded into the reverse range of the quadrant, the cowl lock and Direction Control Unit are energized, which enables the thrust reverser to be deployed.
- The thrust reverse deployment occurs only if the airplane is on ground and the respective engine is running. Moving the thrust lever to Idle enables the lifting of the Thrust Reverse Trigger.
- Moving the thrust lever to the reverse position commands the thrust reverse deployment. During normal operation the FADEC will limit the thrust to idle until the thrust reversers for both engines are fully deployed, thereby minimizing the possibility of un-commanded asymmetric thrust.
- If the engine is inoperative the thrust reverse trigger is not released, so the respective thrust lever cannot be moved to reverse position, however, full reverse thrust remains available on the operative engine.

The thrust reverser is ***not*** designed to operate in flight and Un-commanded thrust reverser deployment limits engine thrust to flight idle.

- The engine thrust control is provided by the thrust management system within the FADEC, and controls the engine in response to thrust command inputs from the aircraft.
- The aircraft provides 28 VDC from the essential bus to each FADEC channel for system power when the engine is not running or when performing a FADEC controlled engine start with an engine speed below 50 % N2. 28 VDC from the DC Essential Bus is supplied for T2 sensor anti-icing, and 115V/400 Hz power to each ignition exciter.
- Selection between the aircraft 28 VDC from the essential bus and the PMA power is performed automatically by the FADEC when the engine speed is greater than 50 % N2.
- The engine monitoring function is also performed by the FADEC by monitoring inputs from various sources and by performing tests for failures and over limit conditions.
- The FADEC supplies ARINC 429 outputs of engine parameters and status to other aircraft avionics, and supplies information to aid in detection, reporting and storing of faults, engine dispatch level and exceedance information, and data for trend data records.

- The FADEC will perform diagnostics on its input data to determine if any failures exist. If a failure exists, and if the failure is one that the pilot should be aware of, a message or indication will be displayed.

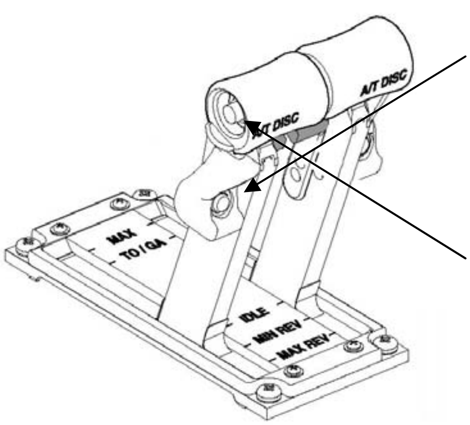
The Thrust Control Quadrant (TCQ) is located on the aircraft cockpit center console and combines two lever assemblies, one for each engine, which may be operated independently, in unison or in autothrottle mode.

The full travel of the thrust levers is 85.0°, divided into five settings which provides RVDT's output signal corresponding to:

MAX reverse at 0.5° TLA, MIN reverse at 12.0° TLA, IDLE at 22.0° TLA, TO/GA at 75.0° TLA and MAX power at 85.0° TLA.

These five settings are also identified and illuminated on both sides of the thrust control quadrant.

- The Thrust Control Quadrant case is provided with two soft detents (grooves), one at TO/GA (75.0°) and the other at MIN REV (12.0°).
- The MAX REV position is achieved by pulling the thrust lever against a spring. Positive adjustable stops are provided at the MAX and MAX REV positions to limit the movement of the thrust levers. Thrust levers are capable of unrestricted forward movement from IDLE to MAX power.
- Two electrical idle stop solenoids, one for each thrust lever, are installed on the thrust control quadrant at the 22.0° TLA position.
- These solenoids provide protection against thrust lever command below idle in flight. Power to these solenoids is provided by the SPDA, and allows selection of reverse thrust immediately after touchdown and during ground operations.
- Position indication is provided by two micro switches (one for each solenoid), which sense the Idle Lock shafts and trigger messages on the EICAS whenever the solenoids become unlocked during flight or locked on ground.



The TO/GA switches are mounted on each thrust lever to enable the pilot to manually generate a Take-Off/Go-Around signal.

They are momentary push button, single pole single throw. The A/T disc switches on each thrust lever enables the pilot to manually switch off the autothrottle system.

- The autothrottle servo drive with associated control electronics is provided for each lever. The servo drive features a motor and gear head combination to provide required force to operate each lever.

- The **A**UTOMATIC **T**AKEOFF **T**HRUST **C**ONTROL **S**YSTEM (ATTCS), controlled by the FADEC, automatically provides engine thrust reserve (RSV) in the event of an engine failure during takeoff, go-around phase or windshear warning detection.

- The T/O Dataset Menu page on the MCDU provides ATTCS mode setting. The ATTCS status (ON/OFF) may be selected via MCDU on the Takeoff Data Set page.

- However, if no selection is made before takeoff the system assumes status ***ON by default.*** The ATTCS is armed (Green "ATTCS" above N1 gages) when:

  - Either thrust lever is in TO/GA position during takeoff
  - ATTCS is selected "ON" on the Takeoff Data Set page
  - During a go-around.

- The ATTCS is activated manually whenever the system is armed and either TLA is advanced above TOGA position.

- If ATTCS is activated, the green "ATTCS" indication disappears and the cyan thrust mode will be displayed with an additional "RSV" indication.

- When the flight crew shuts down an engine, an "OFF" icon will appear in the ITT gage. If an engine should fail, a "FAIL" icon will appear.

- ATTCS will become active when:
  - There is a 15% difference in N1
  - Engine failure during Takeoff

- Engine failure during Go-Around

- The following thrust ratings are available on the CF34-10E Engine:
    - TO-1, TO-1 RSV
    - TO-2, TO-2 RSV
    - TO-3, TO-3 RSV
    - G/A, G/A RSV

    (TO-1 through G/A: 5 Minute Limit!)

    - Climb
    - Cruise
    - MCT

- There are Four (4) Idle Thrust Ratings controlled by the FADEC:
    - GRD Idle
    - FLT Idle – WOW and Approach Idle Not Selected
    - Approach Idle – WOW, Approach Mode Set, Flaps >10°, Gear Down and <15,000ft
    - Final Approach Idle - < 1,200ft, Approach Configuration (considers Anti-Ice off regardless of system status)

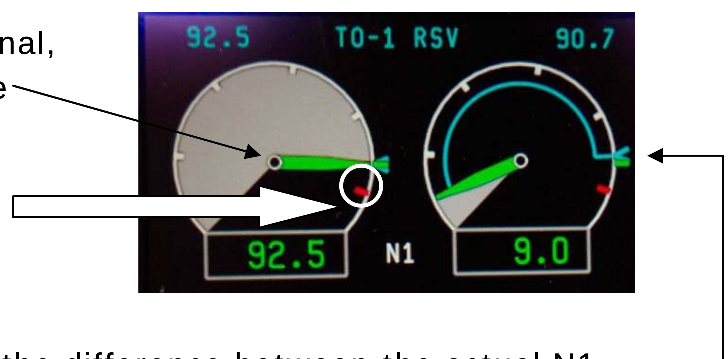
- Flexible takeoff is a ***reduced takeoff thrust*** setting based on assumed temperature. The FADEC determines flexible takeoff rates for any of the two possible takeoff modes, reducing the takeoff thrust based on assumed temperature set on the Takeoff Data Set page. The indication FLEX TO-1, FLEX TO-2 or FLEX TO-3 will be displayed on the EICAS for the respective flexible takeoff thrust.

- The flex takeoff reduction is limited to climb thrust.

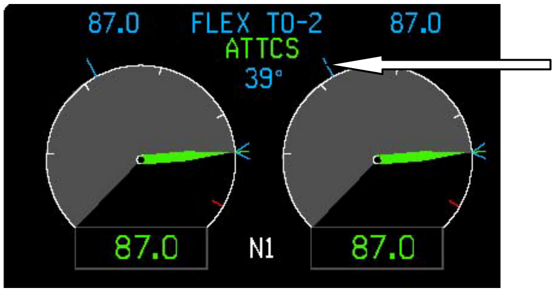
- The **T**hrust **M**anagement **S**ystem (TMS) is configured in a dual redundant architecture, designed for increased system availability.

- Only one channel of the Thrust Management System, as well as only a single thrust rating selection (TRS), one **E**lectronic **T**hrust **T**rim system (ETTS) and one **A**uto**T**hrottle (AT) are operating at any given time.
- The pilot can select the priority autothrottle channel as well as thrust rating selection and electronic thrust trim system channels via the MCDU.
- The **T**HRUST **R**ATING **S**ELECTION (TRS) determines the appropriate thrust rating upper limit based on the phase of flight when in auto mode or based on pilot selection when in manual mode.
- The selected thrust rating in either auto (thrust rating selection determined) or manual (pilot selected) rating mode is displayed on the EICAS display for pilot reference and is used by the autothrottle, when engaged, so as not to exceed the determined thrust rating upper limit.
- The auto rating or one of the manual ratings is selected on the MCDU on the thrust rating select page. The selected thrust rating/mode, of either AUTO, GA, CON, CLB, or CRZ is indicated in green on the MCDU.
- The TAKE-OFF DATASET (TDS) works within the thrust rating selection system to allow the pilot to change the default Take-off thrust rating, in order to accommodate for the different takeoff conditions and prolong engine life while making efficient use of fuel. The three possible take-off Datasets are TO-1, TO-2 or TO-3. These selections are made on the MCDU on the Take-off Dataset menu page.
- The emergency shutdown subsystem provides a way of controlling the flow of fluids and air to and from the engine during emergency procedures.
- In an emergency situation, the pilot can stop the engine immediately by pulling the ***fire handle***. This action stops the fuel flow to the engine and also stops the flow of the hydraulic fluids and pneumatic air from the engine to the aircraft systems (IDG GCU is also opened due to the wind down of the engine).

- Pulling the related fire handle will stop the engine in an emergency situation. The fuel shutoff valve will close which stops the fuel supply to the engine.
- The hydraulic system shutoff will also close, isolating the engine side of the hydraulic system from the airframe hydraulic system.
- The handle also generates a signal which is sent via the MAU to the Air Management System, which closes the high pressure shutoff valve and the engine bleed valve. This isolates the engine air system from the airframe systems.
- The N1 is a primary engine instrument and is displayed to the crew as a dial, pointer, and digital readout for each engine.
- The N1 Digital Readout is a numerical display of the fan rotor speed, displayed as a percentage of total rpm for each engine. The N1 Digital Readout is displayed whenever N1 information is valid. The N1 Dial provides a graphical representation of the current N1.
- The N1 for each engine is indicated by a rotating analog pointer. The dials display pie-shaped shading in the area between the 0% position of the scale to the current pointer position. There are two arc segments that make up the N1 dial.
- Segment 1 (0% to N1 Redline) represents the normal range of N1, and segment 2 (Redline and all positions higher) is the red range of N1.
- In the event of a loss of N1 signal, N1 pointer is removed from the display.
- The redline is the exceedance threshold and represents the maximum allowable N1 value.



- The N1 Reference Arc displays the difference between the actual N1 values and the requested N1 value applied by the thrust lever position.



- The N1 Wing Anti Ice (WAI) bug is displayed on the outside of the N1 Dial.
- The N1 Wing Anti Ice bug indicates the minimum N1 value when the wing anti ice is on and the aircraft is on the final approach phase.
- The Thrust Rating Annunciation is displayed as text in the center above the N1 dials. Selected Thrust Rating is provided by the Thrust Rating Selector (TRS) and is based on phase of flight.
- A Flex Takeoff is used to reduce the engine thrust, to account for favorable takeoff conditions. An N1 Rating bug is displayed at the corresponding N1 value on the dial.
- Takeoff Thrust Ratings are selected via the MCDU on the Takeoff Dataset Menu page.
- The Flex Temperature limits thrust to a value less than the active takeoff rating if the Flex Takeoff option is selected on and a flex temperature is set to a value greater than the take off temperature (pilot inputs).
- Flex Temperature is displayed between the N1 Dials, below the "ATTCS" Status Annunciation.
- Flex Temperature is selected via the MCDU on the Takeoff Dataset Menu page.
- The Max Thrust is the maximum allowable N1 value that can be selected moving thrust levers to the Max position.
- Max Thrust is displayed for each engine as a Green tickmark on the N1 Dial. The maximum N1 value will always be lower than the N1 redline.

- When ATTCS is enabled or armed, it is annunciated with the label “ATTCS” in green above the N1 dials. If ATTCS is active in case of an engine failure, the ATTCS annunciation is removed from display and “TO-1 RSV”, "TO-2 RSV”, “TO-3 RSV” or “GA RSV” are shown.

		CF34-10E6A1		CF34-10E6	
Ratings		Thrust (lbf)		Thrust (lbf)	
Thrust Mode	ATTCS	All Engine Oper.	One Engine Inop.	All Engine Oper.	One Engine Inop.
T/O-1	ON	-	-	17100	18500
	OFF	18500	18500	17100	17100
T/O-2	ON	17100	18500	15450	16650
	OFF	17100	17100	15450	15450
T/O-3	ON	15450	16650	-	-
	OFF	15450	15450	-	-
GA	ON	17100	18500	17100	18500
CON	-	16255	16255	16255	16255
CLB-1	-	15950	-	15950	-
CLB-2	-	14020	-	14020	-
CRZ	-	13830	-	13830	-

- When an engine is shutdown by crew action, the Engine Shutdown Annunciation ***OFF*** is displayed in the center of the N1 Dial for the affected engine.

- When an engine flames out or is shutdown without crew action, the Engine Shutdown Annunciation ***FAIL*** is displayed in the center of the N1 Dial for the affected engine and a Caution CAS Message is displayed.

- The Thrust Reverser Annunciations are displayed under the N1 Dials whenever the thrust reverser is not stowed. This is shown with the annunciation ***REV*** in green. An amber ***REV*** annunciation if the Thrust Reverser is transitioning from one state to another (stowed to/from deployed). The annunciation is displayed in red inverse video in case of an inadvertent deployment in the air and a CAS message will be displayed.

- The ITT is a primary engine instrument and is displayed to the crew as a dial, pointer, and digital readout for each engine. The ITT Readout is a numerical display of the ITT for each engine, displayed in degrees Celsius.

- The ITT Dial provides a graphical representation of the current ITT.

- ITT for each engine is indicated by a rotating analog Pointer. The dials display pie-shaped shading in the area between the beginning of the scale to the current pointer position.

- The ITT Redline represents the maximum ITT for the certified thrust rating modes. The lengths of the arc segments on the ITT Dial and the location of the redline tickmark vary depending on the redline data provided by the FADEC.
- The ITT amber line is the limit that corresponds to the maximum continuous ITT limit. The ITT amber line is displayed on the EICAS only in-flight after the end of the takeoff phase.
- The Engine Fire Annunciation indicates detection of an engine fire condition for the engine and is displayed as an icon on the ITT gage.
- The Igniter Annunciations indicate the various states of the igniters for each engine. The label A and/or B or OFF annunciations are displayed under the IGN label.
- The possible annunciations are:
  - IGN A indicates igniter A has been commanded on
  - IGN B indicates igniter B has been commanded on
  - IGN A B indicates igniter A and B have been commanded on
  - IGN OFF indicates igniter locked off
- The N2 is displayed as a digital readout for both engines. If the N2 value is invalid or outside of the displayable range, the N2 digital readout is replaced with three dashes.
- For each engine, the ***WML*** annunciation is displayed when condition of an engine flameout is detected and the engine has not been returned to its running condition.
- The fuel display consists of digital readouts for left and right fuel flow, left and right fuel tank quantities, and total fuel quantity.
- The Fuel Flow in lbs per hour is displayed for both engines as digital readouts directly under the N2 display. If the Fuel Flow data is invalid or outside of the displayable range, the readout is replaced with three dashes.

- The Integrated Engine Vibration Monitoring system indication on the EICAS consists of one indicator for each engine, and is divided into an LP and an HP scale.
- The LP indicator represents the N1 rotor and the HP indicator represents N2 rotor.
- The indication will be shown in green from 0 to 3.9 and in amber from 4 to 5.
- In case the Integrated Engine Vibration Monitoring values are higher than 5, the maintenance computer and flight data recorder will be able to continue recording vibration levels up to 10 units.

System Limitations:

Due to engine compressor stall possibility, a static takeoff is not recommended with a crosswind component greater that **25kts.**

Using FLEX Thrust, the total thrust reduction must not exceed **25%** of the Full Takeoff Thrust.

Starter Duty Limits – Dry Motoring:

Start Attempt	Max Time	Cool Down
1	90 Sec	5 Min
2 through to 5 (1)	30 sec	5 Min

NOTE:

1) After five sequential motorings, cycle may be repeated following a 15-minute cool-down period.

During Engine Starting:

Start Attempt	Max Time	Cool Down
1	90 Sec (Ground)	10 Sec
	120 Sec (Flight)	
3 through 5	90 Sec (Ground)	5 Min
	120 Sec (Flight)	

- For ground starts, the maximum cumulative starter run time per start attempt is 90 seconds (monitoring plus start time).

- For in-flight starts, the maximum cumulative starter run time per start attempt is 120 seconds (monitoring plus start time).

Operational Limits:

Parameter	Minimum	Maximum
N1	-	100%
N2	59.27%	100%
ITT for Engine Start – GRD	-	740°
ITT for Engine Start - FLT		875°
Normal Takeoff and G/A	-	947° (1)(3)
Max Takeoff and G/A	-	983°C (1) (2) (3)
Max Continuous	-	960°
Oil Pressure	25psi (4)	-
Oil Temp	-	-
Max Cont Oil Temp	-	155°

NOTE:

1) Time limited to 5 minutes. The ITT limits for Takeoff/Go-around and Maximum Takeoff/Go-around Reserve (ATTCS) thrust ratings are based on ten minutes periods.

2) Automatically engaged mode in one engine inoperative or windshear conditions, when the thrust lever is in the TOGA position.

3) ITT transients above the nominal ITT limits are allowed to Normal and Maximum takeoff, up to 5.5°C for 2 seconds, 4.4°C for 5 seconds, 3.6°C for 15 seconds and 2.4°C for 30 seconds.

4) During starts with oil temperature below –22°C the minimum oil pressure is 5 psi, time limited to 2 minutes.

Recall Items:

Dual Engine Flameout

EICAS Indication: "FAIL" icon inside both N1 gages. Both oil pressure indications in Red.

Airspeed ....Min 250kts

RAT Manual Deploy Handle ....PULL

Land at the nearest suitable airport.

Engine Abnormal Start

Affected Engine:

Start/Stop Selectors ....STOP

Engine Fire, Severe Damage or Separation

Autothrottle ....Disengage

Affected Engine:

Thrust Lever ....Idle

Start/Stop Selectors ....STOP

Fire Extinguishing Handle ....PULL

Land at the nearest suitable Airport.

ENG 1 (2) FIRE

Autothrottle ....Disengage

Affected Engine:

Thrust Lever ....Idle

Start/Stop Selectors ....STOP

Fire Extinguishing Handle ....PULL

Land at the nearest suitable Airport.

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