Embraer-Jet family
E-170/E-175/E-190/E-195

REFRESHER COURSE
The **Embraer E-Jet family** is a series of narrow-body medium-range twin-engine jet airliners produced by Brazilian aerospace conglomerate Embraer. Launched at the Paris Air Show in 1999, and entering production in 2002, the aircraft series has been a commercial success.[3] The aircraft is used by mainline and regional airlines around the world. As of 31 December 2014, there is a backlog of 249 firm orders for the E-Jets, 502 options and 1090 units delivered.[1]

### Contents

1. Design and development
   1.1 E-Jets Second Generation
2. Operational history
3. Variants
   3.1 E-170 and 175
   3.2 E-190 and 195
   3.3 Embraer Lineage 1000
   3.4 Undeveloped variants
       3.4.1 E-195X
4. Operators
5. Orders and deliveries
6. Accidents and incidents
7. Specifications
8. See also
9. References
10. External links

---

**Embraer E-170 of Alitalia CityLiner at BCN (2015)**

<table>
<thead>
<tr>
<th>Role</th>
<th>Narrow-body jet airliner</th>
</tr>
</thead>
<tbody>
<tr>
<td>National origin</td>
<td>Brazil</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Embraer</td>
</tr>
<tr>
<td>First flight</td>
<td>February 19, 2002</td>
</tr>
<tr>
<td>Introduction</td>
<td>March 17, 2004 with LOT Polish Airlines</td>
</tr>
<tr>
<td>Status</td>
<td>In service</td>
</tr>
<tr>
<td>Primary users</td>
<td>Republic Airlines</td>
</tr>
<tr>
<td></td>
<td>Azul Brazilian Airlines</td>
</tr>
<tr>
<td></td>
<td>JetBlue</td>
</tr>
<tr>
<td></td>
<td>Compass Airlines</td>
</tr>
<tr>
<td></td>
<td>SkyWest Airlines</td>
</tr>
<tr>
<td>Produced</td>
<td>2001–present</td>
</tr>
<tr>
<td>Number built</td>
<td>1,158 as of September 30, 2015[1]</td>
</tr>
<tr>
<td>Unit cost</td>
<td>E-170: US$28.5 million; E-195: $47.0 million[2]</td>
</tr>
<tr>
<td>Variants</td>
<td>Embraer Lineage 1000</td>
</tr>
<tr>
<td>Developed into</td>
<td>Embraer E-Jet E2 family</td>
</tr>
</tbody>
</table>
**Design and development**

The Embraer E-Jets line is composed of two main commercial families and a business jet variant. The smaller E-170 and E-175 make up the base model aircraft. The E-190 and E-195 are stretched versions, with different engines and larger wing, horizontal stabilizer and landing gear structures. The 170 and 175 share 95% commonality, as do the 190 and 195. The two families share near 89% commonality, with identical fuselage cross-sections and avionics, featuring the Honeywell Primus Epic Electronic flight instrument system (EFIS) suite.[4] The E-jets also have winglets to improve efficiency.

All E-Jets use four-abreast seating (2+2) and have a "double-bubble" design, which Embraer developed for its commercial passenger jets, that provides stand-up headroom. The E-190/195 series of aircraft have capacities similar to the initial versions of the McDonnell Douglas DC-9 and Boeing 737, which have always been considered mainline airliners. The E-Jets have jet engines that produce less noise, which allows them to operate in airports that have strict noise restrictions, such as London City Airport.[5]

Embraer first disclosed that it was studying a new 70-seat aircraft, which it called the EMB 170, in 1997, concurrently with announcing the development of its ERJ 135.[6] The EMB 170 was to feature a new wing and larger-diameter fuselage mated to the nose and cockpit of the ERJ 145.[7][8] In February 1999 Embraer announced it had abandoned the derivative approach in favour of an all-new design.[9][10]

The E-jet family was formally launched at the Paris Air Show in June 1999. Launch customers for the aircraft were the French airline Régional Compagnie Aérienne Européenne with ten orders and five options for the E-170; and the Swiss airline Crossair with an order for 30 E-170s and 30 E-190s.[11] Production of parts to build the prototype and test airframes began in July 2000.[12] Full production began in 2002, at a new factory built by Embraer at its São José dos Campos base.[13] After several delays in the certification process, the E-170 received type certification from the aviation authorities of Brazil, Europe and the United States in February 2004.[14][15]

**E-Jets Second Generation**

In November 2011, Embraer announced that it would develop revamped versions of the E-Jets family with improved engines, rather than an all-new aircraft.[16] The new variants are to be powered by new more efficient engines with larger diameter fans, and include slightly taller landing gear, and possibly a new aluminum or carbon fiber-based wing. The new E-Jet variants are to be better-positioned to compete with the Bombardier CSeries. The new variants are to enter service in 2018.[17]
GE, Pratt & Whitney, and Rolls-Royce were all possible engine suppliers.\[18\] Pratt & Whitney's geared turbofan engine was selected in January 2013 for the new E-Jets versions.\[19\][20\] The Honeywell Primus Epic 2 was selected as the avionics package.\[21\]

In February 2012, Embraer announced it was studying the development of a new variant with 130 seating capacity.\[22\] The study was expected to be completed by the end of 2012.\[23\]

### Operational history

The first E-170s were delivered in the second week of March 2004 to LOT Polish Airlines, followed by US Airways subsidiary MidAtlantic Airways and Alitalia\[14\][24\] (launch customer Crossair had in the meantime ceased to exist after its takeover of Swissair; and fellow launch customer Régional Compagnie Aérienne deferred its order,\[25\] not receiving its first E-jet—an E-190LR—until 2006.\[26\]) LOT operated the first commercial flight of an E-jet on 17 March 2004, from Warsaw to Vienna.\[27\] The largest single order for any type of E-Jets has come from JetBlue for 100 E-190s, and options for 100 more.\[4\]

The 400th E-jet was delivered in 2008, to Republic Airlines in the U.S.\[28\] On 6 November of that year, JetBlue set the record for the longest flight of the E-190 family when one of its aircraft made a non-stop flight from Anchorage, Alaska (Ted Stevens Anchorage International Airport) to Buffalo, New York (Buffalo Niagara International Airport), a total of 2,694 nmi (4,989 km). This was an empty aircraft on a non-revenue flight. The aircraft eventually returned to JFK after a two-month-long charter service with Vice Presidential candidate Sarah Palin.\[29\] In September 2009 the 600th E-jet built was delivered to LOT Polish Airlines.\[30\] Kenya Airways received its 12th Ejet from Embraer which was also the 900th Ejet ever produced on October 10, 2012.\[31\]

On 13 September 2013 a ceremony was held at the Embraer factory in São José dos Campos to mark the delivery of the 1,000th E-jet family aircraft, an E-175, to Republic Airlines. The E-175 was delivered in an American Eagle colour scheme with a special "1,000th E-Jet" decal above the cabin windows.\[28\][32\]

### Variants

#### E-170 and 175

The E-170/E-175 models in the 80-seat range are the smaller in the E-Jet family. They are powered with General Electric CF34-8E engines of 14,200 pounds (62.28 kN) thrust each. The E-170 and E-175 directly compete with the Bombardier CRJ-700 and Bombardier CRJ-900, respectively, and loosely compete with the turboprop Bombardier Q400. They also seek to replace the market segment occupied by earlier competing designs such as the BAe 146 and Fokker 70.

An Air Canada ERJ-175 on climb-out
The Embraer 170 was the first version produced. The prototype 170-001, registration PP-XJE, was rolled out on 29 October 2001, with first flight 119 days later on 19 February 2002. The aircraft was displayed to the public in May 2002 at the Regional Airline Association convention. After a positive response from the airline community, Embraer launched the E-175. First flight of the stretched E-175 was on June 2003.[33] The launch U.S. customer For the EMB 170 was US Airways, after FAA certification, the aircraft entered into revenue service on April 4, 2004 operated by the MidAtlantic division of US Airways, Inc. The first E-175 was delivered to Air Canada and entered service in July 2005.[33] The 170-001 prototype performed its last flight on April 11, 2012. Its destiny was disassembly in the US for spare parts.

E-190 and 195

The E-190/195 models are a larger stretch of the E-170/175 models fitted with a new, larger wing, larger horizontal stabilizer and a new engine, the GE CF34-10E,[4] rated at 18,500 lb (82.30 kN). These aircraft compete with the Bombardier CRJ-1000 and CS100, the Boeing 717-200 and 737-600, and the Airbus A318. It can carry up to 100 passengers in a two-class configuration or up to 124 in single-class high density configuration.[34]

The first flight of the E-190 was on March 12, 2004 (PP-XMA),[35] with the first flight of the E-195 (PP-XMJ)[35] on December 7 of the same year. The launch customer of the E-190 was New York-based low-cost carrier JetBlue with 100 orders and 100 options. British low-cost carrier Flybe launched the E-195 with 14 orders and 12 options.[36]

As the 190/195 models are of mainline aircraft size, many airlines operate them as such, fitting them with a business class section and operating them themselves, instead of having them flown by a regional airline partner. For example, Air Canada operates 45 E-190 aircraft fitted with 9 business-class and 88 economy-class seats as part of its primary fleet. JetBlue and American Airlines also operate the E-190 as part of their own fleet thus allowing airlines increased crewing flexibility by having the ability of air crews to work aboard narrow-body or widebody aircraft all the same.

Embraer Lineage 1000

On 2 May 2006, Embraer announced plans for the business jet variant of the E-190, type name ERJ190-100 ECJ. It has the same structure as the E-190, but with an extended range of up to 4,200 nmi, and luxury seating for up to 19. It was certified by the USA Federal Aviation Administration on 7 January 2009. The first two production aircraft were delivered in December 2008.

Undeveloped variants

E-195X
Embraer considered producing an aircraft which was known as the E-195X, a stretched version of the E-195. It would have seated approximately 130 passengers. The E-195X was apparently a response to an American Airlines request for an aircraft to replace its McDonnell Douglas MD-80s.[37] Embraer abandoned plans for the 195X in May 2010, following concerns that its range would be too short.[38]

Operators

- **Embraer 170** (or EMB 170-100)—As of July 2015, 180 Embraer 177 aircraft (all variants) are in airline service, with 5 orders. Major operators include: Shuttle America (50), Republic Airlines (22), HOP! (16), Saudia (15), J-Air (15), EgyptAir Express (12), Aeroméxico Connect (8), LOT Polish Airlines (7), Compass Airlines (North America) (6) and BA CityFlyer (6). Nine other airlines operate the type in smaller numbers.[39]

- **Embraer 175** (or EMB 170-200)—As of July 2015, 285 Embraer 175 aircraft are in airline service, with 165 further orders. Major operators include Republic Airlines (85), Compass Airlines (North America) (44), SkyWest Airlines (38), Mesa Airlines (30), Shuttle America (16), Sky Regional Airlines (15), Alitalia CityLiner (15), LOT Polish Airlines (12) and Flybe (11). Major firm orders include 55 aircraft for Shuttle America, and 40 aircraft for Envoy Air.

- **Embraer 190** (or EMB 190-100)—As of July 2015, 506 Embraer 190 aircraft (all variants) are in airline service, with 47 orders. Major operators include JetBlue Airways (60), Air Canada (45), Tianjin Airlines (45), Aeroméxico Connect (30), KLM CityHopper (28), Azul Brazilian Airlines (22), Austral Lineas Aereas (22), China Southern Airlines (20), American Airlines (19), Virgin Australia (18), Conviasa (15) and other operators with fewer aircraft.[39]

- **Embraer 195** (or EMB 190-200)—As of July 2015, 134 Embraer 195 aircraft (all variants) are in airline service, with 25 firm orders. Major operators are Azul Brazilian Airlines (61), Lufthansa CityLine (24), Air Europa (11), Air Dolomiti (10), Flybe (7), LOT Polish Airlines (6) and other operators with fewer aircraft. Azul Brazilian Airlines have ordered an additional 5 aircraft of this type.[39]

Orders and deliveries

List of Embraer's E-Jet family deliveries and orders:
<table>
<thead>
<tr>
<th>Model</th>
<th>Photo</th>
<th>Firm Orders</th>
<th>Options</th>
<th>Deliveries</th>
<th>Firm Order Backlog</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-170</td>
<td><img src="image" alt="E-170" /></td>
<td>193</td>
<td>7</td>
<td>188</td>
<td>5</td>
</tr>
<tr>
<td>E-175</td>
<td><img src="image" alt="E-175" /></td>
<td>477</td>
<td>332</td>
<td>311</td>
<td>166</td>
</tr>
<tr>
<td>E-190</td>
<td><img src="image" alt="E-190" /></td>
<td>586</td>
<td>92</td>
<td>518</td>
<td>68</td>
</tr>
<tr>
<td>E-195</td>
<td><img src="image" alt="E-195" /></td>
<td>165</td>
<td>2</td>
<td>141</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1421</td>
<td>433</td>
<td>1158</td>
<td>263</td>
</tr>
</tbody>
</table>

Source: Embraer's order book on September 30, 2015.[40]

**Accidents and incidents**

- On 24 August 2010, Henan Airlines Flight 8387, an Embraer E-190 that departed from Harbin, People's Republic of China, crash landed about 1 km short of the runway at Yichun Lindu Airport, resulting in 42 deaths.[41]
- 29 November 2013: LAM Mozambique Airlines Flight 470, an Embraer 190, crashed in Namibia, killing all 33 aboard (27 passengers, 6 crew members).[42] The co-pilot reportedly left the cockpit to use the toilet. He was then locked out by the captain, who dramatically reduced the aircraft’s altitude and ignored various automated warnings ahead of the high-speed impact.[43]

**Specifications**

<table>
<thead>
<tr>
<th>Variant</th>
<th>E-170 (ERJ170-100)</th>
<th>E-175 (ERJ170-200)</th>
<th>E-190 (ERJ190-100)</th>
<th>E-195 (ERJ190-200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight deck crew</td>
<td>2 pilots</td>
<td>2 pilots</td>
<td>2 pilots</td>
<td>2 pilots</td>
</tr>
<tr>
<td>Passenger capacity</td>
<td>80 (1-class, 29 in/30 in pitch) 78 (1-class, 30 in/31 in) 70 (1-class, 32 in)</td>
<td>88 (1-class, 30 in pitch) 86 (1-class, 31 in) 78 (1-class, 32 in)</td>
<td>114 (1-class, 30 in/31 in pitch) 106 (1-class, 31 in) 98 (1-class, 32 in)</td>
<td>122 (1-class, 30 in/31 in pitch) 118 (1-class, 31 in) 108 (1-class, 32 in)</td>
</tr>
</tbody>
</table>

General Electric CF34 engine on JetBlue E-190
<table>
<thead>
<tr>
<th></th>
<th>32 in) 70 (2-class, 36 in/32 in)</th>
<th>78 (2-class, standard)</th>
<th>32 in) 94 (2-class, standard)</th>
<th>106 (2-class, standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[44]</td>
<td>[45]</td>
<td>[46]</td>
<td>[47]</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>29.90 m (98 ft 1 in)</td>
<td>31.68 m (103 ft 11 in)</td>
<td>36.24 m (118 ft 11 in)</td>
<td>38.65 m (126 ft 10 in)</td>
</tr>
<tr>
<td><strong>Wingspan</strong></td>
<td>26.00 m (85 ft 4 in)</td>
<td>26.00 m (85 ft 4 in)</td>
<td>28.70 m (94 ft 2 in)</td>
<td>28.72 m (94 ft 3 in)</td>
</tr>
<tr>
<td></td>
<td>(Enhanced Wing Tip version)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>9.67 m (32 ft 4 in)</td>
<td>10.28 m (34 ft 7 in)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Empty Weight</strong></td>
<td>21,140 kg (46,610 lb)</td>
<td>21,810 kg (48,080 lb)</td>
<td>28,080 kg (61,910 lb)</td>
<td>28,970 kg (63,870 lb)</td>
</tr>
<tr>
<td><strong>Maximum takeoff weight</strong></td>
<td>35,990 kg (79,340 lb) (STD)</td>
<td>37,500 kg (82,700 lb) (STD)</td>
<td>47,790 kg (105,360 lb) (STD)</td>
<td>48,790 kg (107,560 lb) (STD)</td>
</tr>
<tr>
<td></td>
<td>37,200 kg (82,000 lb) (LR)</td>
<td>38,790 kg (85,520 lb) (LR)</td>
<td>50,300 kg (110,900 lb) (LR)</td>
<td>50,790 kg (111,970 lb) (LR)</td>
</tr>
<tr>
<td></td>
<td>38,600 kg (85,100 lb) (AR)</td>
<td>40,370 kg (89,000 lb) (AR)</td>
<td>51,800 kg (114,200 lb) (AR)</td>
<td>52,290 kg (115,280 lb) (AR)</td>
</tr>
<tr>
<td><strong>Max payload weight</strong></td>
<td>9,100 kg (20,100 lb) (STD&amp;LR)</td>
<td>10,080 kg (22,220 lb) (STD&amp;LR)</td>
<td>13,080 kg (28,840 lb) (STD&amp;LR)</td>
<td>13,650 kg (30,090 lb) (STD&amp;LR)</td>
</tr>
<tr>
<td></td>
<td>9,840 kg (21,690 lb) (AR)</td>
<td>10,360 kg (22,840 lb) (AR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Takeoff Run at MTOW</strong></td>
<td>1,644 m (5,394 ft)</td>
<td>2,244 m (7,362 ft)</td>
<td>2,056 m (6,745 ft)</td>
<td>2,179 m (7,149 ft)</td>
</tr>
<tr>
<td><strong>Powerplants</strong></td>
<td>2× GE CF34-8E turbofans 61.4 kN (13,800 lbf) thrust each</td>
<td>63.2 kN (14,200 lbf) APR thrust each</td>
<td>2× GE CF34-10E turbofans 82.3 kN (18,500 lbf) thrust each</td>
<td>89 kN (20,000 lbf) APR thrust each</td>
</tr>
<tr>
<td><strong>Maximum speed</strong></td>
<td>890 km/h (481 kn, Mach 0.82)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STD:
<table>
<thead>
<tr>
<th>Range</th>
<th>STD: 3,334 km (1,800 nmi)</th>
<th>LR: 3,889 km (2,100 nmi)</th>
<th>AR: 3,892 km (2,102 nmi)</th>
<th>STD: 3,334 km (1,800 nmi)</th>
<th>LR: 4,260 km (2,300 nmi)</th>
<th>AR: 4,448 km (2,402 nmi)</th>
<th>STD: 2,593 km (1,400 nmi)</th>
<th>LR: 3,334 km (1,800 nmi)</th>
<th>AR: 4,077 km (2,201 nmi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum fuel load</td>
<td>9,335 kg (20,580 lb)</td>
<td>12,971 kg (28,596 lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service ceiling</td>
<td>12,500 m (41,000 ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrust-to-weight</td>
<td>0.42:1</td>
<td>0.39:1</td>
<td>0.41:1</td>
<td>0.39:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fuselage and cabin cross-section**

<table>
<thead>
<tr>
<th>Outer width</th>
<th>3.01 m (9 ft 11 in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabin width</td>
<td>2.74 m (9 ft 0 in)</td>
</tr>
<tr>
<td>Outer height</td>
<td>3.35 m (11 ft 0 in)</td>
</tr>
<tr>
<td>Cabin height</td>
<td>2.00 m (6 ft 7 in)</td>
</tr>
</tbody>
</table>
INTRODUCTION

The Flight Control System is comprised of the primary and the secondary flight control systems and their associated system components.

The primary flight control system consists of:

- Ailerons and the multi function roll spoilers for roll axis control.
- Elevators for pitch axis control.
- Rudder for yaw axis control.

The secondary flight control system consists of:

- Horizontal stabilizer.
- Flaps and Slats.
- The multi-function spoiler (when used as speed brakes or ground spoilers).
- Dedicated ground spoilers.

Hydraulic actuators control the respective flight control surfaces. These are generally referred to as Power Control Units (PCUs).

The ailerons are driven by conventional control cables that run from each control wheel back to a pair of hydro-mechanical actuators.

Elevators, rudders and roll spoilers as well as all secondary flight control systems, including the horizontal stabilizer, flaps and slats, ground spoilers and speed brakes, are controlled electronically using Fly-by-Wire (FBW) technology.

The primary flight control electronics are generally comprised of two complementary parts:

- The Primary Actuator Control Electronics (P-ACE).
- The Flight Control Module (FCM).

Primary Actuator Control Electronics (P-ACE) and/or Flight Control Modules (FCM) are employed to operate the respective electro-hydraulic or electro-mechanical actuators.
CONTROL SURFACE LOCATION
CONTROLS AND INDICATIONS

CONTROL WHEEL

1 – PITCH TRIM SWITCH (SPRING-LOADED TO NEUTRAL)
   - Trims the airplane when the autopilot is not engaged.

   **NOTE:** Captain's pitch trim switch actuation has priority over the first officer’s.

2 – AP/TRIM DISCONNECT BUTTON (MOMENTARY ACTION)
   - Disable both HS-ACE channels as long as the switches remain pressed, thus disconnecting the autopilot and stopping any active trim command.
   - Releasing the switch will activate the channel again.
SLAT/FLAP SELECTOR LEVER

- Selects slat/flap position by unlatching the lever and lifting a trigger below the head.
- Intermediate positions are not enabled. If lever is left at an intermediate position, flaps/slats remain in the last selected position. Position 4 is gated for normal Go Around and Takeoff. Position 5 is used for landing.

<table>
<thead>
<tr>
<th>Lever position</th>
<th>Slat position</th>
<th>Flap Position</th>
<th>Detent/Gated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0°</td>
<td>0°</td>
<td>Detent/Stop</td>
</tr>
<tr>
<td>1</td>
<td>15°</td>
<td>7°</td>
<td>Detent</td>
</tr>
<tr>
<td>2</td>
<td>15°</td>
<td>10°</td>
<td>Detent</td>
</tr>
<tr>
<td>3</td>
<td>15°</td>
<td>20°</td>
<td>Detent</td>
</tr>
<tr>
<td>4</td>
<td>25°</td>
<td>20°</td>
<td>Gated/Stop</td>
</tr>
<tr>
<td>5</td>
<td>25°</td>
<td>20°</td>
<td>Detent</td>
</tr>
<tr>
<td>Full</td>
<td>25°</td>
<td>37°</td>
<td>Detent/Stop</td>
</tr>
</tbody>
</table>
SPEED BRAKE LEVER

CONTROL PEDESTAL

− Symmetrically deploys the multi-function panels. All multi function spoilers’ panels deploy the same angle as a response to the speed brake lever position.
TRIM PANEL

CONTROL PEDESTAL

1. LEFT
2. LWD
3. DN
4. UP
5. RWD
6. TRIM
7. PITCH
8. BACKUP SW
9. RWD
10. SYS 1 CUTOUT
11. SYS 2 CUTOUT
12. RIGHT
13. YAW
14. ROLL
15. SYSTEMS 1
16. SYSTEMS 2

Embraer 190 - Systems Summary [Flight Controls]

Page 6
1 – YAW TRIM KNOB (SPRING-LOADED TO NEUTRAL)
   - Actuates the yaw trim to left or right.

2 – ROLL TRIM SWITCH (SPRING-LOADED TO NEUTRAL)
   - Actuates the roll trim to left or right.

3 – PITCH TRIM BACK-UP SWITCH (SPRING-LOADED TO NEUTRAL)
   - Actuates the pitch trim through the back-up channel.
   - Operation of the switch while the autopilot is engaged causes the autopilot to disengage.

4 – PITCH TRIM SYS 1 CUTOUT BUTTON (GUARDED)
   PUSH IN: disables the HS-ACE channel 1.
   PUSH OUT: enables the HS-ACE channel 1.

5 – PITCH TRIM SYS 2 CUTOUT BUTTON (GUARDED)
   PUSH IN: disables the HS-ACE channel 2.
   PUSH OUT: enables the HS-ACE channel 2.
1 – FLIGHT CONTROL MODE BUTTON (GUARDED)

**PUSH IN**: turns the associated flight system into direct mode.

**PUSH OUT**: turns the associated flight system into normal mode.
DISCONNECT HANDLE

1 – ELEVATOR DISCONNECT HANDLE
   PULL: disconnects the elevator control system.

2 – AILERON DISCONNECT HANDLE
   PULL: disconnects the aileron control system.
FLIGHT CONTROLS SYNOPTIC PAGE ON MFD

The flight controls synoptic page provides a visual representation of the flight control system operation and parameters, and can be selected by the flight crew for viewing on either MFD.
1 – AIRPLANE GRAPHIC

- A static display that shows the location of flight control surfaces, status of the flight control actuators and flight controls mode of operation.

2 – SURFACE POSITION STATUS

- RETRACTED: a green line aligned with the wings, elevator or rudder.
- DEPLOYED: a green line and the surface with green stripes. A white dashed box is shown only for surface position greater than 50% of its deflection.
- FAILED RETRACTED: an amber line, a white dashed box and an amber cross.
- FAILED DEPLOYED: white dashed box, surface with amber stripes and amber cross.
- NOT AVAILABLE WITH NO FAIL INDICATION: shows a white dashed box for surfaces with deflection in one direction (e.g. spoilers) and two white dashed box for surfaces with deflection in two directions (e.g. ailerons).
- NOT AVAILABLE WITH FAILURE INDICATION: shows a white dashed box and an amber cross for surfaces with deflection in one direction (e.g. spoilers) and two white dashed box and two amber crosses for surfaces with deflection in two directions (e.g. rudder).
- DIRECT MODE: shows the surface with amber stripes. A white dashed box is shown only for surface position greater than 50% of its maximum deflection. As for flap zero the maximum surface deflection is about 50% of the full deflection, the white dashed box may not be shown, due to system tolerances.

3 – FLIGHT CONTROL SYSTEM STATUS ANNUNCIATIONS

- The status annunciations are shown in a table format for three surfaces. Three surfaces are listed in a column labeled SURFACE: RUDDER, ELEV LH, and ELEV RH.
4 – ACTUATOR STATUS ANNUNCIATION

- The rudder has two actuators, upper and lower. Each left and right elevator surfaces have two actuators, inboard and outboard.

- NORMAL/ACTIVE: a green ON annunciation inside a green rectangle box.

- NORMAL/STANDBY: a white STBY annunciation inside a white rectangle box.

- DIRECT/STANDBY: a white STBY annunciation inside a white rectangle box.

- DIRECT/ACTIVE: an ON annunciation presented in an amber rectangle box background.

- FAIL: a “—“ annunciation written in an amber rectangle box background.

5 – AXES MODE ANNUNCIATION

- Axes mode annunciations are shown for the rudder, the left and the right elevator. It is presented as NORMAL, DIRECT, FAIL or “—“, which represents the axes mode annunciation invalid.

6 – HYDRAULIC SYSTEM SOURCE ANNUNCIATION

- Hydraulic system source annunciations are shown for the rudder, the left and the right elevator. It is presented as 1, 2, 3 or “—“, which represents the source annunciation invalid.

7 – PBIT REMAINING TIME READOUT

- For airplanes Post-Mod. SB 190-31-0007 (Primus Epic Load 4.5) or an equivalent modification factory incorporated, a digital remaining time readout displays the hours until the electrical and hydraulic PBIT expire.

- If the value of the PBIT remaining time readout is higher or equal to 5, the numbers will be displayed in green, otherwise will be cyan. Invalid data will be represented by 2 dashes (“- -“) in amber.
EICAS INDICATIONS

SLAT/FLAP/SPEEDBRAKE INDICATION ON EICAS

1 – SLAT/FLAP POSITION
- Displays the slat/flap position. If the information is invalid, the indication will be removed from the display.
  GREEN: real-time surface position.
- The pointer shows the slat/flap commanded position along the scale and moves up the scale for decreasing values of slat/flap angle. The flap scale has tic marks at each end, representing positions at 0º and 35º while the slat scale has tic marks at each end, representing positions at 0º and 25º.

2 – SLAT/FLAP READOUT
- Displays the slat/flap surface position. If the information is invalid, the indication will be removed from the display.
  GREEN DASHES: slat/flap in transit.
  NOTE: In case of surface jamming, an additional box will be displayed in amber, as well as the readout.

3 – SPEEDBRAKE INDICATION
- Displays a white SPDBRK annunciation when the speed brakes are open.
  AMBER BOXED: in case of failure.
**NOTE:** An OPEN and GREEN speedbrake position indication and a white GND SPLR annunciation display on EICAS after airplane touchdown and below 50 knots of ground speed.

![EICAS Diagram](image1)

**NOTE:** For SLAT/FLAP/SPDBRK position 0 the legend and arrows will be removed from the display as presented below:

![EICAS Diagram](image2)
OVERALL DISPLAY SITUATIONS
ROLL/PITCH/YAW TRIM INDICATION ON EICAS

1 – ROLL/PITCH/YAW TRIM SCALE

- Trim position configuration is indicated through a solid green pointer in the scale.
- There are five tic marks displayed along the roll and yaw scale, positioned at −100%, -50%, 0%, 50%, 100%.
- There are five tic marks displayed along the pitch trim scale, positioned at 4º, 0.25º, -3.5º, -7.25º, and −11º. There is a green takeoff band on the scale extending from 2º to −4º, corresponding to the allowable pitch trim position for takeoff.

2 – PITCH TRIM DIGITAL READOUT

- Digital indication of the horizontal stabilizer trim position in tenth degrees
- An UP or DN indication displays above or below the readout according to the trim set.
FLY BY WIRE

Fly-by-wire is an electronic system designed to operate the flight controls replacing the control cables of a conventional airplane.

The EMBRAER 190 FBW system is composed of a set of six Actuator Control Electronics (ACEs) and four Flight Control Modules (FCMs):

- Two Primary-ACEs (P-ACE) installed in the forward electronics bay.
- Two Slat/Flap ACEs (SF-ACE) installed in the middle electronics bay.
- One Horizontal Stabilizer ACE (HS-ACE) and one P-ACE installed in the aft electronics bay.
- FCM 1 and 2 are located in the Modular Avionics Units # 1 (MAU 1).
- FCM 3 and 4 are located in the Modular Avionics Unit # 3 (MAU 3).

The three P-ACE units connect the control column directly to the respective control surface, providing direct analog control of the rudder and elevator surface actuators.

The two SF-ACE units control the slat and flaps and the HS-ACE unit controls the horizontal stabilizer.

The FCMs provide software-based assistance to the P-ACE and is required for normal-mode operation of the flight control system. The FCM units are connected to the P-ACE via the Controller Area Network Bus (CAN BUS), providing digital inputs to the P-ACE, which are combined with pilot inputs. This is used to augment pilot inputs for different airspeeds, and provides other high level functions such as Angle-of-attack (AOA) limiting to the P-ACE units.
FLOW-BY-WIRE SCHEMATIC
MODES OF OPERATION

The Flight Control System provide two basic modes of operation:

- **NORMAL MODE**: The Flight Control Mode (FCM) provides software based airspeed gain schedules and control limits to the P-ACE, as well as high level functions such as:
  - Elevator control laws scheduling with airspeed.
  - Auto-thrust compensation with elevator.
  - Angle-of-Attack (AOA) limiting with elevator offset.
  - Rudder airspeed gain scheduling and stroke limiting.
  - Yaw damper and turn coordination via AFCS.
  - Rudder ground/lift authority change.
  - Roll spoiler scheduling with airspeed and speedbrake deployment.
  - Configuration change compensation with Horizontal Stabilizer.
  - Mach Trim as a function of Mach number.
  - Configuration change compensation with Horizontal Stabilizer due to landing gear, flap/slat and speed brakes actuation.

- **DIRECT MODE**: The FCM is removed from the control loop (for instance, due to loss of airspeed data) and the control limits default to values set by hardware in the P-ACE.
  - Direct mode of operation is primarily the result of loss of data from all FCMs (no airspeed input) or; multiple ACE failures.
  - Operation is defaulted to fixed control laws configuration.
  - Control input provided by Captain and First Officer's sensors is sent directly to the surface.
Mode selection is automatic, when a channel failure is detected or manual, by using a “Mode Select” switch on the Flight Control Panel. The “Mode Selection” switch toggles the Normal Channel of the active P-ACE to the Direct Channel of the standby P-ACE and continues as shown:

Pilot always has supreme control authority of the airplane since the FCMs cannot override a pilot input.

**FCM, P-ACE AND AIRPLANE LEVEL COMMUNICATION**

The Controller Area Network BUS (CAN BUS) is the communication link between the FCMs and the P-ACE units while the Avionics Standard Communication Bus (ASCB) provides data exchange between all FCMs, and with other components of the avionic system. The following systems provide data to the flight control system:

- Smart probes and the Air Data Application (ADA) modules provide air data for various airspeed augmentation commands.
- IRS provides aircraft attitude and accelerations to the FCMs used for AOA limiting function computation.
- The Proximity Sensor Electronic Module (PSEM) provides Weight-On-Wheels (WOW) and ground spoiler position data to the FCMs.
- Brake Control Modules (BCM) provide wheel speed signals used for ground spoiler deployment.
- The FADEC provide Thrust Lever Angle (TLA) to the FCMs used for elevator thrust compensation, and the Automatic Flight Control System (AFCS) provides autopilot commands.
- Data is shared for the EICAS to display warnings, cautions, advisory and system status and also provided to the central maintenance computer (CMC) for system diagnostics.
POWER UP BUILT IN TEST (PBIT)

The Power Up Built in Test (PBIT) reduces the flight control system exposition to latent faults, ensuring that the system components remain capable of executing their functions.

The PBIT expires after 20 hours (elapsed time) since the last successful PBIT and in this case the FLT CTRL BIT EXPIRED EICAS CAUTION message is displayed. These EICAS CAUTION message is related to the Electrical PBIT and Hydraulic PBIT. The message remains on EICAS until a new Electrical and Hydraulic PBIT is successful ran.

No action is required if the PBIT expires in-flight, as the EICAS CAUTION message will only be displayed after landing.

ELECTRICAL POWER UP BUILT IN TEST

The Electrical PBIT provides detection of out-of-tolerance conditions and failures in the FCMs, P-ACEs and SF-ACEs.

The Electrical PBIT is automatically performed during power up after the airplane is powered by any AC source and takes approximately 3 minutes to complete. In this point if the FLT CTRL BIT EXPIRED message is presented, the hydraulic built in test must be performed.

For airplanes Post-Mod. SB 190-31-0007 (Primus Epic Load 4.5) or an equivalent modification factory incorporated, FLT CTRL TEST IN PROG Status message is presented while electrical PBIT is in progress.

If the airplane is already powered up, the crew may check the PBIT REMAINING TIME READOUT before staring the taxing out procedure. Hence, if the remaining time is sufficient for the taxing and taking off, the crew may elect to reset the PBIT on the next flight.

The Electrical PBIT will be interrupted if any electric hydraulic pump is running or if the FCP switches are cycled or if AC power is interrupted while the test is running.
HYDRAULIC POWER UP BUILT IN TEST

The Hydraulic PBIT provides functional test of the flight control actuators.

The Hydraulic PBIT is performed automatically, only on the ground, when the flight controls are not moved for one minute and all the three hydraulic systems are pressurized. The test takes one minute to complete.

The Hydraulic PBIT will be interrupted if any flight control surface is moved while the test is running.

FLY BY WIRE (FBW) BACKUP BATTERY

In case of an extremely improbable failure that would render complete loss of normal and emergency electrical power to the FBW, the backup power system, with no pilot intervention, keeps the appropriate number of elevator and rudder actuators operating for at least 15 minutes. Besides that, there is no dedicated message to indicate the failure of this system; therefore there is no flight crew compensatory action if this happens.

A dedicated and independent backup electrical power system is provided for some elevators and rudder Actuator Control Electronics (ACEs) that are considered essential for airplane controllability even in an utmost case of total loss of the normal and emergency electrical power sources.

This backup system is comprised by a dedicated battery, distribution bus and circuit breakers.

The backup battery, charged by the DC ESS 3 bus during normal operation, consists of sealed lead acid cells with built-in-test (BIT) capability and internal heater that guarantees the minimum battery temperature.

Although the battery is connected to the airplane buses, the use of an internal rectifier keeps it from powering back the buses, assuring isolation in case of failure in the main electrical power system.
PITCH CONTROL

Pitch axis control is by means of electro-hydraulic commanded elevators and an electro-mechanical horizontal stabilizer.

ELEVATOR CONTROL SYSTEM

Pilot’s inputs to the elevators are through the forward and after movement of the cockpit control columns. Also, the elevators can be automatically controlled through the FCM via autopilot.

A total of four P-ACE channels are used to independently control each of the four PCUs, providing the analog elevator control functions implemented in the P-ACE units.

Four independent FCM units, located in the MAU 1 and 3, provide high-level system augmentation to the P-ACE units, such as gain scheduling as a function of airspeed, elevator thrust compensation and AOA limiting.

The hydraulic systems responsible for actuating the actuators are:

- Hydraulic System 1: left outboard actuator.
- Hydraulic System 2: left & right inboard actuators.
- Hydraulic System 3: right outboard actuator.

Since the actuators on each surface operate on active/standby mode, the P-ACE automatically alternates the active actuator every time the elevator system is powered up. The loss of hydraulic supply forces the standby PCU to become active.

If a jam in one of the elevator actuator is detected, the respective elevator surface will remain fixed at the position where the jam occurred. The pilot will be able to control the airplane using the remaining elevator.

With the elevator control system operating in normal mode, the elevator moves according to gain scheduling as a function of airspeed, reducing elevator movement with increasing airspeeds. In the event of loss of airspeed information, the FCM is removed from the control loop, and the associated P-ACE reverts to direct mode. FCM functions like elevator thrust compensator and AOA limiting are than no longer available.
A dedicated button on the Flight Control Mode panel provides the capability to the pilots to reset the elevator system to Normal Mode in case of the system defaulting to Direct Mode, or to manually default the elevator system to Direct Mode in case of wrong gain computed by the FCMs being transmitted to the P-ACEs.

When the flight control panel elevator button is pushed in, it commands all four elevators channel to change from Normal to Direct mode. In addition, pushing the button also results in the active elevator channels transitioning to the standby state, and the channels that were previously in standby would become active. This feature is also included to allow the system to transition away from the present controlling channels.

When the flight control panel elevator button is pushed out, the system recovers the Normal Mode.

The Elevator Thrust Compensation Function (ETC) helps to reduce the pilot workload by applying elevator commands to reduce the pitching moment produced by increasing or decreasing engine thrust. The ETC function is computed in the FCM as a function of N1, mach and pressure altitude. Elevator command is limited to plus or minus 5 degrees, and is applied proportional to the amount of engine thrust above or below the reference thrust setting.

If one or more sensors required to perform the ETC function fail, the function is no longer available and the respective message will be displayed on the EICAS.
TAIL STRIKE AVOIDANCE (TSA)

Tail Strike Avoidance (TSA) function is a fly-by-wire feature designed to avoid tail strikes occurrences during takeoffs and landings.

TSA function controls airplane pitch angle by reducing control column authority in the nose up direction. The maximum pitch angle that can be achieved by the airplane is a function of height above ground level (HAGL), measured at the main landing gear wheel. HAGL calculation depends on:

- Landing: HAGL calculated via two radio altimeters.
- Takeoff: estimated HAGL by means of the vertical speed.

The authority of TSA function depends on whether in takeoff or landing configuration. Go around is considered a landing configuration mode.

In case of TSA function engagement during takeoff, the maximum pitch down elevator deflection in order to correct airplane attitude by reducing its pitch rate is limited to 8°. In case of a negative pitch rate, the maximum pitch up elevator deflection is limited to 0°. For TSA engagement during landing situations, the pitch down authority is also limited to 8° of elevator deflection, while pitch up is limited to Normal Mode commands generated by other fly-by-wire functionalities.

TSA commands are limited to only 8° of elevator deflection.

NOTE: In case of exceedance of the angle of attack threshold defined by the AOA limiter due to an TSA elevator command, the FBW system switches to AOA limiter operation, smoothly transitioning to pitch angle control to angle of attack control over 2 seconds. The TSA function and the AOA limiter function never operate simultaneously and AOA limiter has priority over TSA.

TAKEOFF AND LANDING OPERATION

TSA operation is limited up to 20 ft for takeoffs and 70 ft and below for landings. Also, there is no TSA operation for landing flap configuration other than 5 or 6.

For GO AROUND scenarios, TSA operates as if it were in takeoff mode but using radio altimeter altitudes rather than estimated altitude as the source of HAGL computation.
ARTIFICIAL FEEL UNITS (AFU)

With no mechanical connection between the control column and the elevator surfaces, two independent feel units provide artificial feel and centering to the control columns, which increase as a function of control column displacement.

The feel units consist of a preloaded spring, which returns the columns to the neutral position. Hence there is one feel unit attached to each torque tube, in case of separation of the control column commands, the feel system is still active for the non-jammed column.

With the columns disconnected or with a single AFU disconnected, the feel loads on the column are reduced to one half of the normal loads.

DISCONNECT MECHANISM (JAMMED COLUMN)

A disconnect mechanism is provided in order to allow separation of the First Officer and Captain’s control column. In the event of a jam in one of the control columns, the disconnect mechanism can be actuated by pilots through the disconnect handle in the cockpit.

Following a disconnection the pilot of the non-jammed side retains pitch control by means of the on-side elevator. The system will remain disconnected for the remainder of the flight and ground maintenance is required to reset the disconnect unit.
ELEVATOR SYSTEM SCHEMATIC
ELEVATOR SYSTEM INTERFACE
HORIZONTAL STABILIZER CONTROL SYSTEM

Control of the horizontal stabilizer is by means of an electromechanical system commanded by:

- Manual selection of the Captain or First Officer’s wheel main trim switches or pedestal mounted backup trim switches which directly controls an electrical servo motor coupled to the Horizontal Stabilizer Actuator (HSA).
- Flight Controls Module (FCM) for autopilot trim and speed brake auto trim in order to actuate the electrical servomotor coupled to the Horizontal Stabilizer Actuator (HSA).

Horizontal Stabilizer Actuator Control Electronics (HS-ACE) and one Horizontal Stabilizer Actuator (HSA) are used to move the control surface.

The HSA is a single electrical-mechanical actuator. Two DC motors drive the actuator in an active/standby configuration. Stabilizer position is provided to the HS-ACE and is used for monitoring and EICAS indication.

STABILIZER TRIM

MANUAL TRIM

The manual trim is achieved through switches installed on the control columns and standby switch located on the main pedestal. Signal from either the control columns switches or the main pedestal switch controls the electric trim motor.
The HS-ACE responds to all trim commands with the following priority:

1. Backup switches.
2. Captain.
3. First Officer.
4. FCM (auto-trim) commands.

In order to avoid a possible pitch trim runaway condition, manual pilot trim commands are limited to 3 seconds. In case of stick shaker activation, the HS-ACE is prevented from responding to any pitch trim commands by a stick shaker signal from the AFCS.

The backup trim switches and the control wheel trim switches are dual split switches, which have a 7 second time limitation when actuated separately. If only one half of the switch is actuated for more than 7 seconds, this switch is automatically deactivated.

In the event of an electrical emergency, only the HS-ACE channel 2 is operational at low rate. A loss of airspeed data from the FCM also results in low rate operation of the horizontal stabilizer, providing structural protection of the surface.

**AUTOPilot TRIM**

The autopilot can directly operate the electric trim motor when the autopilot is engaged. If the autopilot trim function is inoperative, the autopilot cannot be engaged. If this function is lost with autopilot operations, the autopilot will be disengaged.

Autopilot trim function will be active only if:

- Autopilot is engaged.
- Configuration trim is operational.
- Manual electric trim is not active.
- On-side autopilot channel is priority.

**NOTE:** In case of an electrical failure, followed by RAT deployment, the trim function will work at half speed operation, for either manual trim or autopilot trim.

**MACH TRIM**

Automatic Mach trim compensate pitch down tendency due to aft change in location of aerodynamic center for increasing Mach number.

For further information about Mach trim operation refer to chapter 14-03 Automatic Flight.
ROLL CONTROL

Roll control is provided simultaneously by the ailerons and the multifunction spoilers.

AILERON CONTROL SYSTEM

Aileron control is accomplished through a conventional cable system, which transmits pilot control wheel inputs to two hydro-mechanical actuators for each aileron.

The hydraulic systems responsible for actuating the actuators are:

- Hydraulic System 2: left & right inboard PCU.
- Hydraulic System 3: left & right outboard PCU.

Captain and First Officer aileron control system are connected via a disconnect mechanism. In the event of a jam, the disconnect mechanism can be actuated by the pilots by means of the disconnect handle in the cockpit. Following a disconnect, half of the system remains operational. If the jam occurs on the First Officer’s half of the system, the Captain retains control of the left aileron with normal artificial feel.
If the jam occurs on the Captain’s side, the First Officer remains in
command of the right aileron without artificial feel and roll trim since
the feel mechanism is attached to the pilot’s half of the system. Only
one pair of multifunction spoilers will remain available after the
disconnection

Following a disconnect, the system remains separated for the
remainder of the flight. Maintenance action is required to reconnect the
disconnect device.

In the event of a disconnect of one aileron PCU from the surface or
wing structure, the other PCU attached to the surface will operate
normally, but the force authority will be halved. Hence the aileron
PCUs normally share air-loads during flight, if the FCM detects a
difference in load sharing from the actuators, a message will be
displayed on the EICAS.

MULTIFUNCTION SPOILER CONTROL SYSTEM

The multifunction spoiler control system consists of 6 panels
numbered from inboard to outboard as:

- L3, L4, L5 (left wing) and
- R3, R4, R5 (right wing).

The roll spoiler function drives all six multifunction spoiler panel
deployment asymmetrically as a function of control wheel position.

As airspeed increases, less spoiler surface deflection is required and
the spoiler system will limit the deployment of the surfaces for roll
control.
In the event of a jam, the control wheel and the aileron on the jammed half of the system will be locked at the current position. The other half of the system can be separated from the jammed side through the aileron disconnect handle located at the control pedestal. In this case, the Captain controls the outboard spoilers, while the First Officer controls the middle spoilers. With disconnection due to jamming, the inboard spoilers become disabled.

ROLL TRIM

The aileron control system is manually trimmed by using the roll trim switch on the trim control panel, located in the cockpit on the center pedestal. The trim system is operated via the roll trim switch on the trim control panel, commanding the actuator to move, and repositioning neutral feel position of the aileron system.

The actuator is equipped with a timer, limiting a single trim command to three seconds. A quick disconnect switch, located on the control wheels, disables the roll trim actuator by interrupting DC power to the trim motor, as long as the switch remain depressed.
YAW CONTROL

Yaw control is performed by means of an electronic control system that commands electrohydraulic actuators of the rudders.

RUDDER CONTROL SYSTEM

The rudder control system is controlled either by the pilots, FCM high-level functions and additionally, in airplanes equipped with Autoland, the Autopilot.

The rudder control system moves a single rudder surface attached to the vertical stabilizer. Two actuators, or PCUs, electrically commanded and hydraulically powered, are connected to the rudder control surface, receiving signals from the rudder control’s Fly By Wire system (FBW).

Either the upper or the lower rudder actuator can control the rudder surface. The Captain commands only the upper actuator and the First Officer commands only the lower actuator.

Two independent P-ACE modules drive the upper and lower PCU, providing the analog rudder control functions implemented in the P-ACE hardware, such as pedal shaping to vary the pedal-to-surface gearing as a function of pilots input.

Four independent FCM units, located in MAU 1 and 3, provide high-level system augmentation on the P-ACE units, such as yaw damping, turn coordination, as well as gain scheduling as a function of airspeed.

The rudder actuators operate in an active/standby configuration, hence the P-ACEs alternate between the active PCU every time the rudder system is powered-up.

The hydraulic systems responsible for actuating the actuators are:

Hydraulic System 1: upper actuator, or PCU.

Hydraulic System 3: lower actuator, or PCU.

In the normal mode, the FCMs add further high-level functions to the pilot pedal inputs. With increasing airspeed, rudder gain is reduce by the FCM in order to compensate for the increase in rudder effectiveness, and providing structural protection to the rudder surface.
A dedicated button on the Flight Control Mode panel provides the capability to the pilots to reset the rudder system to Normal Mode in case of the system defaulting to Direct Mode, or to manually default the rudder system to Direct Mode in case of wrong gain computed by the FCMs being transmitted to the P-ACEs.

When the flight control panel rudder button is pushed in, it commands both rudder channels to change from Normal to Direct mode. In addition, pushing the button also results in the active rudder channels transitioning to the standby state, and the channels that were previously in standby would become active. This feature is also included to allow the system to transition away from the present controlling channels.

When the flight control panel rudder button is pushed out, the system recovers the Normal Mode.

The two pedals assemblies (Captain and First Officer) are connected by an interconnect rod, in such a way that the movement made by the pilot flying (PF) assembly will be transmitted to the pilot not flying.

In the event of a jam in the Captain’s rudder pedal assemblies, the rudder remains active and will be actuated by high-level functions (yaw dumping and turn coordination). In case of a jammed PCU actuator the rudder will be hydraulically locked at the current position. Aircraft control will be established through the ailerons and roll spoilers.
RUDDER TRIM SYSTEM

Rudder trim function is limited to three seconds. If further displacement of the trim system is required the command must be released and reapplied. Position indication of the trim actuator is provided on the EICAS.

RUDDER SYSTEM INTERFACE
SLAT/FLAP SYSTEM

The high lift control system consists of flaps and slats.

The slat system controls eight slat surfaces on the leading edge of the wing (four per wing) and the flap system controls four double slotted flap surfaces on the trailing edge (two per wing).

SLAT/FLAP PANEL LOCATION

Surface position commands are given to the Slat/Flap-ACE (SF-ACE) via a Slat/Flap control lever installed on the center pedestal in the cockpit. Each SF-ACE is a dual channel unit, with one channel for flap control and one channel for slat control.

There are seven slat/flap control lever positions. Slat and flap motion is sequenced such that slats extend first and flap retracts first when the motion command requires both surfaces to move. The system uses electrical power to move the surfaces.
Deployment of both slats and flaps surfaces is commanded by two SF-ACEs and electrically operated using Power Driver Units (PDUs). A total of four flap actuators per side provide the actuation force to extend and retract the flap panels mounted on the trailing edge of each wing. The double-slotted flap consists of a main flap panel and an aft flap panel for both inboard and outboard flaps.

**SLAT/FLAP SYSTEM SCHEMATIC**
SLAT/FLAP PROTECTION LOGIC

SKEW PROTECTION

Electronic skew sensors monitor differential movement between neighboring panels of flap (slat). If differential movement of a panel exceeds acceptable limits, the SF-ACES shuts down the flap (slat) system and the FLAP (SLAT) FAIL message displays on EICAS.

The SLAT-FLAP LEVER DISAG may appear, as the affected surface has not reached the position selected on the Slat/Flap Lever. The affected surface is inoperative for the remainder of the flight whereas the non-affected surface operates normally (i.e., in case of FLAP FAIL the Slats operates normally and vice-versa).

STRIKE PROTECTION

The SF-ACE monitors PDU load and if an excessive load is detected it stops the electrical power to the respective PDU for further movement to the selected direction. The FLAP (SLAT) FAIL message displays and the SLAT-FLAP LEVER DISAG also displays, as the affected surface has not reached the selected position.

In such cases, the affected surface can be commanded in the opposite direction (i.e., for FLAP FAIL during retraction, the Flap can be commanded for extension and vice-versa).

When the strike protection actuates, the affected surface accepts to be commanded in both directions if it is returned to the previously selected position. After three unsuccessful attempts to select a position, the strike protection cuts the PDU power for both directions.
SLAT/FLAP SYSTEM INTERLOCKS

The SF-ACE has two independent channels that are powered by different electrical power sources. If the Ram Air Turbine (RAT) is the only source of electric power, the flap and slat operate in half speed, as only one channel remains available. Additionally, when RAT is the only source of electrical power, the SF-ACE prevents deployment of slats and flaps beyond position three to assure adequate airspeed for the RAT.

In case of a Flap or Slat failure, when the affected surface is deenergized, the SF-ACE still commands the non-affected surface upon S/F Lever movement. That permits to improve the landing performance even in the event of failure by selecting a more appropriate position of the non-affected surface. However, there are some combinations of Slat and Flap that are automatically protected by the system, as they would induce poor airplane controllability. Thus, the SF-ACE does not command the Flap beyond 10° (S/F Lever on position 2) with the Slat below 15°. In this failure scenario, if the S/F Lever is commanded beyond the position 2, the SF-ACE limits the Flap deflection to 10° and the SLAT-FLAP LEVER DISAG message displays.
SPOILER SYSTEM

The spoiler control system consists of ten spoiler panels numbered inboard to outboard as:

- L1, L2, L3, L4, L5 (left wing) and
- R1, R2, R3, R4, R5 (right wing).

Panels L3, R3, L4, R4, L5 and R5 are called multifunction spoilers and have three modes of operation:

- Roll Control: deployed asymmetrically for roll augmentation as commanded by the pilots control wheel. Displacement angle is proportional to control wheel displacement.
- Speed Brakes: deployed symmetrically during flight by speed brake handle to increase aerodynamic drag to reduce airspeed or increase rate of descent. Panel displacement is proportional to speed brake handle position.
- Ground Spoilers: deployed symmetrically during landing roll to increase wheel braking efficiency and aerodynamic drag to reduce the stopping distance. Panels are fully and automatically extended when ground spoiler deployment conditions are met.
The hydraulic systems responsible for actuating the multi function PCUs are:

- Hydraulic System 1: left and right inboard and middle PCUs (L3, R3, L4, R4).
- Hydraulic System 2: left and right outboard PCUs (L5, R5).

The hydraulic systems responsible for actuating the dedicated ground spoilers PCUs are:

- Hydraulic System 1: left and right outboard PCUs (R2, L2).
- Hydraulic System 2: left and right inboard PCUs (R1, L1).

GROUND OPERATION

The spoiler control system provides automatic ground spoiler deployment to increase wheel-braking efficiency reducing the lift generated by each wing and to reduce the stopping distance producing aerodynamic drag.

During ground operation, all spoiler panels function as ground spoilers and are commanded to the fully extended or fully retracted positions.

The ground spoiler function drives all ten spoiler’s panels to the limit deflection of the actuators.

MULTI-FUNCTION AND GROUND SPOILERS DEPLOYMENT

After touchdown the FCM will command all multifunction spoiler surfaces to the 40 degrees extended position and the ground spoiler surfaces to 60 degrees when the following conditions are simultaneously met:

- Weight on wheels on ground.
- Wheel speed is above 45 kts or airspeed is above 60 KIAS.
- Thrust Lever Angle (TLA) below 26 degrees

Following rollout, the spoilers will automatically retract when wheel speed is below 45 kts for at least 5 seconds. If the throttles are moved beyond 35 degrees (TLA) after landing, the spoiler panels will automatically retract.

NOTE: In the direct mode, ground spoilers are not available.
IN-FLIGHT OPERATION

ROLL SPOILERS

The roll spoiler function drives the multifunction spoiler panels asymmetrically as a function of control wheel position.

In normal mode, the roll spoilers are also gain scheduled as a function of airspeed. A roll spoiler augmentation command, computed in the FCM, is added to the normal pilot input in order to modify the roll inputs for changes in airspeed results or different flaps settings.

In case of loss of airspeed data, the respective FCM is removed from the control loop, and the system reverts to direct mode. A fixed gain is then applied to the respective roll spoiler system for the entire flight, independent of airspeed or flap setting.

SPEED BRAKES

When actuating as speed brakes, the spoiler control system deploys all six multi function spoiler panels symmetrically up to the in-flight limit of 30 degrees following speed brake handle position.

If extended during approach, the speed brakes will automatically retract upon selection of slat/flap 2 or above.

Speed brakes will not be deployed if airspeed is below 180 KIAS, and will also automatically retract if airspeed decreases below this threshold.

In order to prevent inadvertent operation during a go-around maneuver the speed brakes will automatically retract anytime the thrust levers are advanced beyond Thrust Lever Angle (TLA) 70 degrees.

In the event of a disagreement of the speed brake handle position with actual surface position, the EICAS advisory message SPDBRK LEVER DISAG is displayed on the EICAS.

NOTE: In the direct mode, speed brakes are not available.
## EICAS MESSAGES

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNING</td>
<td>ELEV (RUDDER) NML MODE FAIL</td>
<td>Normal mode of the associated system is no longer operative.</td>
</tr>
<tr>
<td></td>
<td>GROUND SPOILERS FAIL</td>
<td>One of the ground spoiler surfaces has extended inadvertently or has failed to extend when commanded.</td>
</tr>
<tr>
<td></td>
<td>AOA LIMIT FAIL</td>
<td>Stall protection function has failed.</td>
</tr>
<tr>
<td></td>
<td>ELEV THR COMP FAIL</td>
<td>One or more sensors required to perform Elevator Thrust Compensation function have failed and the function is no longer available.</td>
</tr>
<tr>
<td></td>
<td>ELEVATOR FAULT</td>
<td>Left and right elevator control system has reverted to direct mode.</td>
</tr>
<tr>
<td></td>
<td>ELEVATOR LH (RH) FAIL</td>
<td>Left (right) elevator control system is no longer available.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>FLAP FAIL</td>
<td>Both flaps electronic control channels are inoperative and the flaps system is no longer available or there is a jam in the mechanical portion that precludes the flaps from moving.</td>
</tr>
<tr>
<td></td>
<td>FLT CTRL BIT EXPIRED</td>
<td>20 hours or more has passed since the last time PBIT was activated.</td>
</tr>
<tr>
<td></td>
<td>FLT CTRL NO DISPATCH</td>
<td>One of the components associated with the flight control system has failed to a No-Go condition.</td>
</tr>
<tr>
<td>TYPE</td>
<td>MESSAGE</td>
<td>MEANING</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>PITCH TRIM FAIL</td>
<td></td>
<td>Pitch trim function is no longer available.</td>
</tr>
<tr>
<td>RUDDER FAIL</td>
<td></td>
<td>Active and standby rudder channels have failed or rudder has jammed.</td>
</tr>
<tr>
<td>RUDDER FAULT</td>
<td></td>
<td>Indicates that the rudder control system has reverted to direct mode.</td>
</tr>
<tr>
<td>RUDDER LIMITER FAIL</td>
<td></td>
<td>Indicates that rudder ground authority is retained after take-off.</td>
</tr>
<tr>
<td>SLAT FAIL</td>
<td></td>
<td>Both slats electronic control channels are inoperative and the slats system is no longer available or there is a jam in the mechanical portion that precludes the slats from moving.</td>
</tr>
<tr>
<td>SLAT-FLAP LEVER DISAG</td>
<td></td>
<td>Flaps were commanded above $V_{FE}$.</td>
</tr>
<tr>
<td>SPOILER FAULT</td>
<td></td>
<td>Airspeed gain scheduling has failed in one or more pairs of multifunction spoilers, and the system(s) has defaulted to a fixed gain.</td>
</tr>
<tr>
<td>STAB LOCK FAULT</td>
<td></td>
<td>The mechanical device, which locks the horizontal stabilizer, has failed. Direct mode is not allowed.</td>
</tr>
<tr>
<td>TYPE</td>
<td>MESSAGE</td>
<td>MEANING</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>AILERON LH (RH) FAIL</td>
<td>Indicates that the left (right) aileron is no longer available or there is a mechanical disconnection in the left (right) aileron surface.</td>
<td></td>
</tr>
<tr>
<td>AUTO CONFIG TRIM FAIL</td>
<td>Pitch Trim Auto Configuration function is inoperative.</td>
<td></td>
</tr>
<tr>
<td>FLAP LO RATE</td>
<td>One of the flaps electronic control channels is inoperative and the flap system is still available but running at low speed.</td>
<td></td>
</tr>
<tr>
<td>FLT CTRL FAULT</td>
<td>One of the components associated with the flight control system has failed.</td>
<td></td>
</tr>
<tr>
<td>PITCH CONTROL DISC</td>
<td>Control columns are disconnected.</td>
<td></td>
</tr>
<tr>
<td>PITCH TRIM BKUP FAIL</td>
<td>Backup pitch trim switch is inoperative.</td>
<td></td>
</tr>
<tr>
<td>PITCH TRIM SW 1 FAIL</td>
<td>Captain’s pitch trim switch is inoperative.</td>
<td></td>
</tr>
<tr>
<td>PITCH TRIM SW 2 FAIL</td>
<td>First Officer’s pitch trim switch is inoperative.</td>
<td></td>
</tr>
<tr>
<td>PITCH TRIM LO RATE</td>
<td>Pitch trim system can only operate at a low rate.</td>
<td></td>
</tr>
<tr>
<td>ROLL CONTROL DISC</td>
<td>Control wheels are disconnected.</td>
<td></td>
</tr>
<tr>
<td>SLAT LO RATE</td>
<td>One of the Slats electronic control channels is inoperative and the slat system is still available but in low speed.</td>
<td></td>
</tr>
<tr>
<td>TYPE</td>
<td>MESSAGE</td>
<td>MEANING</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ADVISORY</td>
<td>SPDBRK LEVER DISAG</td>
<td>A mismatch exists between the speedbrake handle position and the multifunction spoiler surfaces or the ventral speed brake.</td>
</tr>
<tr>
<td>STATUS</td>
<td>FLT CTRL TEST IN PROG</td>
<td>Electrical PBIT in progress.</td>
</tr>
</tbody>
</table>
EMBRAER 190

Automatic Flight System
The Automatic Flight Control System (AFCS) is an integrated system that processes inputs from several airplane systems and sensors, applying the processed data to the Flight Guidance Control System (FGCS) and Thrust Management System (TMS), thus enabling their operation and producing visual and aural information.

1. GUIDANCE PANEL

The Guidance Panel (GP) provides means for selecting functions and modes as follows:

- Lateral Guidance Control,
- AFCS Management Control,
- Vertical Guidance Control.

The GP contains two independent channels (A and B), each one providing independent communication to the FGCS.
## 2. LATERAL GUIDANCE CONTROLS

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NAV BUTTON :&lt;br&gt;- Enables and disables the LNAV mode (FMS selected lateral modes). The FMA lateral mode annunciation displays LNAV.</td>
</tr>
<tr>
<td>2</td>
<td>HDG BUTTON :&lt;br&gt;- Activates and deactivates the heading select mode,&lt;br&gt;- The FMA lateral mode annunciation displays HDG.</td>
</tr>
<tr>
<td>3</td>
<td>HDG SELECTOR KNOB :&lt;br&gt;- Manually selects the desired heading. Pressing this knob synchronizes the heading select to the current heading.</td>
</tr>
<tr>
<td>4</td>
<td>BANK BUTTON :&lt;br&gt;- Selects a bank angle limit of 17° used by the FGCS,&lt;br&gt;- A white arc is automatically displayed on the PFD when above 25000 ft. The white arc is manually indicated whenever the Bank Button is pushed and HDG is the active roll mode.</td>
</tr>
<tr>
<td>5</td>
<td>APP BUTTON :&lt;br&gt;- Activates and deactivates the mode for interception of an ILS.&lt;br&gt;- The FMA lateral mode annunciation displays the following :&lt;br&gt;• LOC : ILS approach mode.&lt;br&gt;- The FMA vertical mode annunciation displays the following :&lt;br&gt;• GS : ILS approach mode.&lt;br&gt;- The Autopilot Approach Status Annunciator displays the following :&lt;br&gt;• APPR 2 : CAT II ILS approach capable.&lt;br&gt;• APPR 1 : CAT I ILS approach capable.&lt;br&gt;• APPR 1 ONLY : CAT I ILS approach capable. Requirements for CAT II ILS approach mode not accomplished.</td>
</tr>
</tbody>
</table>

**NOTE :** When the APP mode is intercepted, the heading mode (HDG) is automatically deactivated.
3. VERTICAL GUIDANCE CONTROLS

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | **FLCH BUTTON** :  
- Activates and deactivates the Flight Level Change mode,  
- The FLCH mode is associated to Climb or Descend depending on the selected altitude,  
- The Flight Mode Annunciation (FMA) vertical mode displays FLCH. |
| 2  | **VNAV BUTTON** :  
- Activates and deactivates the VNAV mode (FMS vertical navigation). |
| 3  | **ALT BUTTON** :  
- Activates and deactivates the altitude holding mode (ALT),  
- The FMA vertical mode annunciation displays ALT. |
| 4  | **ALT SELECTOR KNOB** :  
- Selects the desired altitude,  
- Clockwise rotation: increases the altitude target,  
- Counter clockwise rotation: decreases the altitude target.  
**NOTE:** A pushbutton in the center of the ALT SEL selector knob provides the selected altitude in meters to be displayed on the meters window (metric altitude) readout and above the ALT pre-selected window on the PFD. |
| 5  | **FPA BUTTON** :  
- Activates and deactivates the Flight Path Angle mode,  
- This is the basic vertical mode,  
- The FMA vertical mode annunciation displays FPA.  
**NOTE:** Engaging the autopilot when no FD mode is active causes FPA mode to become the active mode, and the FD guidance cue to come into view. |
| 6  | **FPA SELECTOR KNOB** :  
- Manually selects the desired Flight Path Angle,  
- The flight path angle is limited to 9.9 degrees nose up or nose down. |
| 7  | **VS BUTTON** :  
- Activates and deactivates the Vertical Speed mode,  
- The FMA vertical mode annunciation displays VS. |
| 8  | **VS THUMB WHEEL SELECTOR** :  
- The thumb wheel selector manually selects the desired vertical speed rate.  
**NOTE:** The VS mode must be active for the thumb wheel selector to become effective. |
VERTICAL GUIDANCE CONTROLS

MAIN PANEL

1. FLCH
   - PUSH FT-M
2. VNAV
3. ALT
   - ALT SEL
4. FPA
   - FPA SEL
5. VS
6. VS
7. DN
8. UP
## 4. AFCS GUIDANCE CONTROLS

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>FD BUTTON</strong>:&lt;br&gt;- Declutters the FD cue presentation on the PFD. With the FD decluttered, the FD is still active and the FD modes are still selectable in the FGP.&lt;br&gt;- If the AP is engaged, the FD can not be removed from the PFD in the side selected to be the AFCS source.</td>
</tr>
<tr>
<td>2</td>
<td><strong>AP BUTTON</strong>:&lt;br&gt;- Commands the autopilot engagement or disengagement.</td>
</tr>
<tr>
<td>3</td>
<td><strong>A/T BUTTON</strong>:&lt;br&gt;- Commands the autothrottle engagement or disengagement.</td>
</tr>
<tr>
<td>4</td>
<td><strong>YD BUTTON</strong>:&lt;br&gt;- Engages or disengages the Yaw Damper/Turn Coordination function.</td>
</tr>
<tr>
<td>5</td>
<td><strong>SRC BUTTON</strong>:&lt;br&gt;- Alternates the Captain or First Officer AFCS side as data source. A green arrowhead on the FMA indicates the respective source selected.</td>
</tr>
</tbody>
</table>

### AFCS GUIDANCE CONTROLS

![AFCS Guidence Controls Diagram](image)
## 5. SPEED AND MODE CONTROLS

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SPEED SELECTOR KNOB:</td>
</tr>
<tr>
<td></td>
<td>- <strong>FMS</strong>: FMS speed control,</td>
</tr>
<tr>
<td></td>
<td>- <strong>MAN</strong>: The desired speed is controlled manually, displayed in cyan on the PFD.</td>
</tr>
</tbody>
</table>

**NOTE**: The alternate speed selection (IAS or Mach) can be selected by pressing the speed selector knob.

### SPEED AND MODE CONTROLS

![SPEED AND MODE CONTROLS Diagram](image_url)
### 6. AUTO PILOT/FD TCS BUTTON

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOUCH CONTROL STEERING BUTTON (TCS) :</td>
</tr>
<tr>
<td>1</td>
<td>- The TCS button allows manual airplane maneuvering (primary servos) to any desired pitch, overriding autopilot function. Release of the button cause :</td>
</tr>
<tr>
<td></td>
<td>• Primary servos reengage,</td>
</tr>
<tr>
<td></td>
<td>• The airplane maintains the new attitude requested,</td>
</tr>
<tr>
<td></td>
<td>• Lateral control returns to previous selected lateral mode.</td>
</tr>
<tr>
<td></td>
<td><strong>NOTE</strong> : After glide slope capture in APP mode with the autopilot engaged, if the TCS button is pressed and released, the autopilot regains the control and turns the airplane back towards the ILS center beam.</td>
</tr>
</tbody>
</table>

**AUTO PILOT/FD TCS BUTTON**

![Image of the TCS button]
7. AUTOPILOT QUICK DISCONNECT BUTTON

<table>
<thead>
<tr>
<th>№</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AP DISCONNECT BUTTON:</td>
</tr>
<tr>
<td></td>
<td>- Provides the means to disengage the autopilot.</td>
</tr>
<tr>
<td></td>
<td>NOTE: Captain and first Officer's buttons are interconnected to allow autopilot cancellation from either side.</td>
</tr>
</tbody>
</table>

AUTOPILOT QUICK DISCONNECT BUTTON
### 8. AUTOTHROTTLE DISCONNECT AND GO-AROUND BUTTONS

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>AUTOTHROTTLE DISCONNECT BUTTON</strong>&lt;br&gt;- Manually disengages the autothrottle.</td>
</tr>
<tr>
<td>2</td>
<td><strong>TAKEOFF AND GO AROUND BUTTON</strong>&lt;br&gt;- Selects the TO or GA modes according to the airplane status.&lt;br&gt;- The FMA lateral mode annunciation displays the following:&lt;br&gt;  • TRK: go-around lateral mode.&lt;br&gt;  • ROLL: take-off lateral mode.&lt;br&gt;- The FMA vertical mode annunciation displays the following:&lt;br&gt;  • TO: take-off vertical mode.&lt;br&gt;  • GA: go-around vertical mode.&lt;br&gt;  • WSHR: vertical mode in windshear detection.</td>
</tr>
</tbody>
</table>
9. AUTOTHROTTLE INDICATIONS ON FLIGHT MODE ANNUNCIATION (FMA)

The AT mode labels displayed on FMA are the following:

- SPD, 
- SPDE, 
- TO, 
- GA, 
- HOLD, 
- LIM, 
- OVRD.

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AUTOTHROTTLE ENGAGEMENT ANNUNCIATION:</td>
</tr>
<tr>
<td></td>
<td>- Color:</td>
</tr>
<tr>
<td></td>
<td>• Green: Autothrottle engaged,</td>
</tr>
<tr>
<td></td>
<td>• Amber: Autothrottle failed.</td>
</tr>
<tr>
<td>2</td>
<td>AUTOTHROTTLE ARMED MODE:</td>
</tr>
<tr>
<td></td>
<td>- Color: WHITE.</td>
</tr>
<tr>
<td>3</td>
<td>AUTOTHROTTLE ACTIVE MODE:</td>
</tr>
<tr>
<td></td>
<td>- Color:</td>
</tr>
<tr>
<td></td>
<td>• Green: Autothrottle active mode,</td>
</tr>
<tr>
<td></td>
<td>• Amber: The LIM label is displayed to indicate that vertical speed and target speed are incompatible with thrust rating available.</td>
</tr>
</tbody>
</table>

AUTOTHROTTLE INDICATIONS ON FLIGHT MODE ANNUNCIATION (FMA)
### 10. AUTOPILOT INDICATIONS ON FMA

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>①</strong></td>
<td><strong>AUTOPILOT ENGAGED ANNUNCIATION</strong>:</td>
</tr>
<tr>
<td></td>
<td>- Color:</td>
</tr>
<tr>
<td></td>
<td>• GREEN: Autopilot engaged.</td>
</tr>
<tr>
<td></td>
<td>• AMBER: Autopilot failed.</td>
</tr>
<tr>
<td><strong>②</strong></td>
<td><strong>FLIGHT DIRECTOR SOURCE ANNUNCIATOR</strong>:</td>
</tr>
<tr>
<td></td>
<td>- A green arrow indicated the selected AFCS source.</td>
</tr>
<tr>
<td></td>
<td><strong>NOTE</strong>: Mode annunciation is removed if Flight Director fails.</td>
</tr>
</tbody>
</table>

![Auto Pilot Indications on FMA Diagram]
11. LATERAL MODE INDICATIONS ON FMA

The lateral mode labels displayed on FMA are the following:

- ROLL,
- HDG,
- LNAV,
- LOC,
- BC,
- TRACK.

<table>
<thead>
<tr>
<th>Nº</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | FGCS LATERAL ACTIVE MODE :  
- Color :  
  • GREEN : manually commanded on the GP.  
  • MAGENTA : FMS commanded. |
| 2  | FGCS LATERAL ARMED MODE :  
- Color : WHITE. |
12. VERTICAL MODE INDICATIONS ON FMA

The vertical mode labels displayed on FMA are the following:

- FPA,
- TO,
- ASEL,
- FLCH,
- ALT,
- VS,
- OVSP,
- GS,
- GA.

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FGCS VERTICAL ACTIVE MODE:</td>
</tr>
<tr>
<td></td>
<td>- Color:</td>
</tr>
<tr>
<td></td>
<td>- GREEN: manually commanded on the GP.</td>
</tr>
<tr>
<td></td>
<td>- MAGENTA: FMS commanded.</td>
</tr>
<tr>
<td>2</td>
<td>FGCS VERTICAL ARMED MODE:</td>
</tr>
<tr>
<td></td>
<td>- Color: WHITE.</td>
</tr>
</tbody>
</table>

NOTE: In event of AFCS fails the respective mode annunciation is removed.
13. **AUTOPILOT APPROACH STATUS ANNUNCIATOR**

The autopilot approach labels displayed are the following:

- **APPR 2,**
- **APPR 1,**
- **APPR 1 ONLY.**

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| ① | ARMED STATUS:  
- Color:  
  - WHITE: Armed approach mode.  
  - AMBER: Alert condition. |
| ② | ENGAGED STATUS:  
- Color:  
  - GREEN: Engaged approach mode. |

**AUTOPILOT APPROACH STATUS ANNUNCIATOR**

![Auto-pilot approach status annunciation diagram](image-url)
FLIGHT GUIDANCE CONTROL SYSTEM (FGCS)

The FGCS is the AFCS functionality that indirectly drives the primary flight controls, through either the cockpit control column or through other AFCS processing modules.

The FGCS function includes:

- Flight Director (FD) guidance,
- Autopilot (AP) with coupled Go-Around (GA), Windshear modes and Automatic Pitch Trim,
- Yaw Damper (YD) with the Turn Coordination capability.

FLIGHT DIRECTOR (FD)

A magenta diamond displayed on the Primary Flight Display (PFD) represents the FD. It provides lateral and vertical guidance integrated with the Flight Management System (FMS) or manually commanded.

The FD engagement or disengagement is commanded via FD button on the guidance panel.

The FD automatically turns on as follows:

- TO/GA button actuation,
- Autopilot activation,
- Windshear detection.

The FD is released when the Touch Control Steering (TCS) button is pressed and it resynchronizes the references when TCS is released (deactivated).

Selecting FD OFF on the GP removes the flight director information from the non-coupled side on the PFD, if AP is engaged. Flight director information is removed from both PFDs if AP is disengaged and FD is selected OFF. FD declutter does not deactivates the current lateral and vertical modes.

Ground power-up causes both flight directors to become active, regardless of the last FD status selected.
AUTOPilot (AP)

The autopilot provides automatic pitch and roll control of the airplane commanding dedicated servos. The elevator AP servo is mechanically linked to the control column. The aileron AP servo is mechanically linked to the aileron control cables and wheels.

1. AP ENGAGEMENT/DISENGAGEMENT

Autopilot is engaged pushing the AP button on the guidance panel. The automatic pitch trim is ON when AP is engaged. The yaw damper automatically engages on AP engagement, although the yaw damper can be engaged or disengaged independently of the AP status.

Autopilot engagement is inhibited on the ground.

The Autopilot has two channels. One channel works as a hot spare channel. The system alternates the channel automatically if the active channel fails. The pilot can alternate the AP channel manually on the SETUP MCDU page.

SETUP MCDU PAGE
The autopilot disengages when any of the following conditions occur:

- The AP button is pressed on the guidance panel,
- The manual pitch trim switches are activated,
- Either quick disconnect switches are activated,
- Column shakers are activated,
- Reversion of fly-by-wire system to direct mode,
- Either the aileron or elevator control system disconnects,
- A column and control wheel force monitor sensors trips,
- Various internal monitors failure.

The autopilot commands the servos to disengage when TCS button is pressed. The autopilot automatically reengages the servos and resynchronizes the flight director when TCS button is released.

Anytime the autopilot is disengaged, an aural alarm "AUTOPILOT" is triggered and the FMA displays a flashing red "AP" indication for at least 5 seconds.

An EICAS message is also displayed for abnormal disengagement of AP. Pressing once either AP disconnect button cancels the flashing "AP" on FMA and the aural alarm. The EICAS message remains displayed.

**NOTE:** AP disengagement by application of force on control column and control wheel is indicated in red on FMA. The AP disengagement by application of force only on control wheel may be indicated in red on FMA and AP FAIL message may be displayed on the EICAS.

Pressing the AP disconnect button manually disengages the AP. If the pitch trim is being commanded by the elevator thrust compensation (ETC) or auto configuration trim, the EICAS CAUTION message AP FAIL momentarily displays, and the FMA AP disengagement indication will be green. The second press in the AP disconnect button cancels the aural alarm, which sounds at least once.
AUTOPILOT/FLIGHT DIRECTOR SCHEMATIC
**AFCS INDICATIONS ON PFD**

1. **FLIGHT MODE ANNUNCIATION (FMA)**

The FMA is displayed on the top of PFD. The FMA displays indications of autothrottle, autopilot, active AFCS channel, lateral mode and vertical mode.

The FMA color code for normal operation is the following:

- Magenta: FMS commanded active/engaged mode,
- Green: Non-FMS commanded active/engaged mode,
- White: Armed mode,
- Amber: Alert condition,
- Red: Abnormal condition.

![FLIGHT MODE ANNUNCIATION (FMA)](image)

2. **AUTOPILOT APPROACH STATUS ANNUNCIATOR**

Autopilot Approach Status Annunciator is displayed on top of FMA upon pressing of APP button full line to clearly describe to flight crew current approach status, and some alert levels, necessary.

Left side of the annunciator displays either the armed status (white) or the discrepancy by system capability and flight crew intention (amber). Alert function associated to amber flashing invites for correction of RA Minimums, which has a digital read-out on PFD.

Right side of annunciator displays current engaged status.

The terminology used for the two system capability levels are:

- APPROACH 2 (APPR 2) - ILS CAT II capable,
- APPROACH 1 (APPR 1) - ILS CAT I capable.
Only one lateral mode can be activated and only one can be armed at a time. The FGCS provides Lateral navigation as follows:

The FGCS pilot selectable lateral navigation modes are:
- Roll Hold - Basic Lateral Mode (ROLL),
- Heading Select (HDG),
- Lateral Navigation (LNAV),
- Localizer (LOC),
- Back-course (BC).

Pilot non-selectable mode is:
- Track Hold (TRACK).

### 1. ROLL HOLD (ROLL)
Roll hold is the basic lateral mode and it is activated when:
- The active lateral mode is deactivated,
- The TO mode is selected on ground by pressing TOGA button.

The AP takes different actions considering the different airplane bank angles at the moment of ROLL activation.
- Bank angle at 6° or below: AP levels the wings,
- Bank angle above 6° and below 35°: AP holds present bank angle,
- Bank angle at 35° or above: AP maintains bank angle at 35°.

The TCS button can be used to adjust the bank angle between 6° and 35°.

### 2. HEADING SELECT (HDG)
The heading select mode activates when one of following conditions occur:
- The HDG pushbutton on the GP is pressed,
- LNAV, LOC or BC modes are armed.

The Heading Select mode is deselected when:
- HDG pushbutton is pressed a second time,
- Selecting a different lateral mode,
- LNAV, LOC or BC modes are activated.

Pressing the HDG selector knob synchronizes the heading bug to the current heading.

The FD follows the selected heading and respects the side to which the turn was commanded, regardless of turn being greater than 180 degrees.
FGCS LATERAL MODES

3. LATERAL NAVIGATION (LNAV)
The FD provides flight director lateral guidance commands for interception, capture, and tracking.
LNAV guidance and automatic transitions are computed based on PFD data. The LNAV mode is
selected when NAV button is pressed on the guidance panel. The FMS is the navigation source.
The flight director shall be capable of performing an automatic transition from LNAV to LOC mode or
from LNAV to Back-Course mode (BC) via the approach preview mode.

4. LOCALIZER (LOC)
Localizer mode guidance is computed based on PFD data.
The LOC mode is selected via the APP button on the GP. The FD Localizer mode is selected when
there is no GS signal available.
The FD automatically manages the LOC and Back-Course according to Localizer frequency, PFD
information and airplane's position.

5. BACK-COURSE (BC)
The FD will automatically select a BC approach on the PFD.
The FGCS provides commands for capture and tracking of BC localizer indicated on the selected PFD.

6. TRACK HOLD (TRACK)
The track select mode is used to intercept and maintain an inertial derived airplane track from the IRS.
This mode is engaged automatically when GA or TO is selected by the TOGA.
The automatic transition from ROLL to TRACK occurs when :
• IAS is greater than 100 kt,
• Bank angle is at 3° or below for more than 10 seconds.
Selecting another lateral flight director mode disengages track mode.
Canceling the vertical mode of GA does not disengage the TRACK lateral mode automatically.
FGCS VERTICAL MODES

One vertical mode can be active and up to two vertical modes can be armed at a time.

The FGCS vertical navigation modes are:
- Flight Path Angle (FPA) - basic vertical mode,
- Takeoff (TO),
- Altitude Select (ASEL),
- Flight Level Change (FLCH),
- Altitude Hold (ALT),
- Vertical Speed (VS),
- Vertical Navigation (VNAV),
- Overspeed (OVSP),
- Glide Slope (GS),
- Go around (GA).

1. FLIGHT PATH ANGLE (FPA)

The FPA is the basic vertical mode (except for the TO).

FPA mode becomes the active FD mode when:
- FPA pushbutton in the guidance panel is pressed,
- Engaging the autopilot when no FD mode is active,
- When a lateral mode is activated and there is no vertical flight director guidance mode active,
- Deselecting the current vertical mode.

The flight path reference line (FPR) is displayed when the FPA is active. Pressing the FPR button in the display controller panel displays the FPR line, regardless of vertical mode active.

Flight path angle (± 9.9°) is selected in the FPA SEL selector knob on the guidance panel.
2. TAKEOFF (TO)

The takeoff mode is a FD only mode and is represented by crossbars on PFD. TO mode commands the airplane to maintain a pitch attitude reference. In takeoff the autopilot engagement is not accept and FPA mode is inhibited. Lateral mode changes are allowed.

FPA indication is inhibited for 30 seconds after lift-off when taking off using raw-data information (no active mode on the FD).

Pressing the TOGA button activates the TO mode. Following a landing, the TO mode can be enabled after 5 seconds on ground (main gear weight on wheels).

The TO mode is deactivated when:
- Another vertical mode is selected,
- AP/FD TCS button is pressed,
- AP is activated.
The TO mode first guidance is the flap-pitch based guidance:

- FLAP 1 - pitch 11°,
- FLAP 2 - pitch 11°,
- FLAP 3 - pitch 9°,
- FLAP 4 - pitch 12°.

When airborne and IAS is greater than speed target, the guidance will be speed target according to the following:

- All engines operating: V2 + 10 kt.
- One engine inoperative:
  - Engine failure below V2: guides V2,
  - Engine failure between V2 and V2 + 10 kt: guides present speed,
  - Engine failure above V2 + 10 kt: guides V2 + 10 kt.

The V2 is inserted on the MCDU (PERF > PERF INDEX > PERF DATA > TAKEOFF 3/3).

If speed target is not valid, the airplane guides to a fixed pitch according to the flaps in use.

In TO mode the pitch is limited to a minimum of 8° and a maximum of 18°. The maximum speed target is Vfe - 5 kt and minimum speed target is Vshaker + 10 kt for all engines operating. For one engine inoperative the minimum speed target is Vshaker + 3 kt.

### 3. ALTITUDE SELECT (ASEL)

The altitude select mode captures and levels off at the selected altitude. A green ASEL is displayed on the FMA while altitude select mode captures the pre-selected altitude, then a green ALT takes place when leveled off at the selected altitude.

**NOTE:** Altitude select is armed automatically whenever any vertical FD mode is selected.

### 4. FLIGHT LEVEL CHANGE (FLCH)

The FLCH provides flight path command to Climb or Descend according to the speed selected in the Speed Selector knob. FLCH guidance is associated to SPDE.

The selected speed is displayed in the box on the top of speed tape and when the altitude is close to 29000 ft it switches from IAS to Mach readout during climb and from Mach to IAS readout during descent.

The FLCH button on the GP activates the FLCH mode.

The FLCH mode deactivates when:

- Another vertical mode is selected,
- TCS button is pressed.

The FLCH mode guides to the altitude selected via ALT SEL knob.

During a FLCH descent, selecting an altitude above the current airplane altitude will guide the airplane to climb. The airplane will not reach the altitude selected if AT is disengaged and sufficient thrust is not available.
5. ALTITUDE HOLD (ALT)
Pressing the ALT button on the GP enables the altitude hold mode. The altitude hold mode maintains a selected barometric altitude. The altitude can be selected via the ALT SEL knob.
After ALT mode engagement, change to another vertical mode is possible only selecting a different altitude via ALT SEL knob, otherwise the ALT indication on the FMA and the altitude digital readout in the PFD flash for 5 seconds. This logic is valid for all vertical modes, except for Glide Slope (GS). Switching from ALT mode to GS mode occurs without change in ALT SEL selection.
If the ALT Button is pressed while the altitude is varying, the altitude in the moment the ALT Button is pressed will be the new target altitude.

6. VERTICAL SPEED (VS)
The VS mode maintains a vertical speed rate. The VS mode is activated pressing the VS button on the GP. Vertical speed is selected rotating the vertical speed thumbwheel on the GP.
The vertical speed command range goes from -8000 ft/min to +6000 ft/min.
The increments of the Vertical Speed target value are: 50 ft/min (below 1000 ft) and 100 ft/min (above 1000 ft).

7. OVERSPEED PROTECTION (OVSP)
Flight Director provides overspeed protection during the following active vertical modes: ASEL, VASEL, FPA, FLCH, VS, VFLCH, and VPATH. Overspeed protection (OVSP) provides detection and prevention of airspeeds beyond the Vmo/Mmo flight envelope curve. When the FGCS detects that an overspeed condition is imminent, the FD generates guidance commands to maintain airspeed below the VLE or within +/- 5 knots or +/-0.01 Mach of VMO or MMO, whichever is applicable.
When the OVSP protection activates, an amber OVSP indication displays on the FMA. The previous active mode is displayed as armed (white) and becomes active again when OVSP protection is no longer active.

8. GLIDE SLOPE (GS)
The GS approach mode allows the ILS approach mode functions. The GS mode arms when the APP button is pressed and activates when the glide slope is captured.

9. GO-AROUND (GA)
The go-around mode automatically provides go-around guidance and thrust by pressing the TOGA switch. The flight path angle and flight director symbols are displayed when GA mode is activated.
The GA mode deactivates when:
• Another vertical mode is selected,
• TCS button is pressed.
The GA mode first guidance determines pitch 8°:
When IAS is greater than the speed target, the guidance will be the speed target according to the following:

- All engines operating: VREF + 20 kt,
- One engine inoperative: VAC (approach climb).

The VREF and VAC are inserted on the MCDU (PERF > LANDING 3/3).

If speed target is not valid, the airplane guides to pitch 8°.

In GA mode the pitch is limited to a minimum of 8° and a maximum of 18°. The maximum speed target is Vfe - 5 kt and minimum speed target is Vshaker + 10 kt for all engines operating. For one engine inoperative the minimum speed target is Vshaker + 3 kt.

10. WINDSHEAR (WSHR)

Although it is not pilot selectable, Windshear protection will display the label "WSHR" as the vertical active mode in the FMA.

The Windshear guidance is activated when any of following conditions is met:

- Windshear Caution or Windshear Warning condition is detected and Takeoff and Go-around button is pressed at the thrust lever,
- Windshear Warning condition is detected and thrust lever is set to TO/GA position,
- Automatically when Windshear Warning condition is detected and AFCS flight director mode is in TO or GA.

A green WSHR annunciation is displayed on the FMA when the Windshear guidance is activated.

The system provides flight path guidance angle, limited to stick shaker, wings level and aural alert.

The autopilot is disengaged when windshear guidance mode becomes active. After exit windshear conditions, lateral and vertical modes are selected pressing the respective buttons in the guidance panel.

Windshear protection is disabled above 1500 ft AGL.

11. VERTICAL NAVIGATION (VNAV)

The VNAV engages when:

- Upon crossing 400 ft during climb with the VNAV mode previously armed. In this case the system automatically engages,
- The airplane is above 400 ft and the VNAV button is pressed.

The VNAV mode automatically selects the appropriate FGCS mode in order to accomplish the vertical profile. However, the logics for the vertical modes reside within the FGCS. When the vertical mode is selected by the VNAV function, it is said to be a VNAV sub-mode.

11.1. VARM SUB-MODE

When VNAV is selected on the GP, the initial mode is VARM. The FMS keeps the mode VARM up to the moment that it is possible to determine which vertical mode should be used. If the FMS cannot determine which mode to use or cannot determine whether to climb or descend, it stays in VARM until the conflict is resolved. An example of conflict is to set the altitude selector to a higher altitude when the next waypoint constraint is below the current altitude. While in the VARM mode the previous AFCS vertical mode remains engaged.
11.2. VFLCH SUB-MODE
The VFLCH is the VNAV Flight Level Change that can be automatically selected by the FMS or manually by the flight crew. The manual selection of the VFLCH mode occurs when the active mode is VALT and the FLCH button is pressed in the GP. If the Alt Selector is set to an altitude different then the current airplane altitude, the VFLCH mode engages.

11.3. VASEL SUB-MODE
This is the VNAV altitude capture mode. It captures the Alt Selector altitude or the FMS waypoint altitude constraints.

11.4. VALT SUB-MODE
Maintains the altitude commanded by the FMS or the Alt Selector. If the VNAV is disengaged while in VALT, the active mode becomes FPA.

11.5. VPATH SUB-MODE
This is the VNAV FPA mode. In this mode the FMS flies a constant descent angle between two waypoints. The descent angle is defined with following priority:

- Manually entered by the flight crew,
- Defined by a procedure retrieved from the database,
- If no higher priority entry is made, the FMS automatically selects the descent angle.

The path angle can vary from 1° to 6° and it can be seen in the ACTIVE FLT PLAN page.

The FMS maintains a required geometric path sending a vertical speed command to the AFCS. If the descent angle is too steep, the system might not be able to maintain the speed command shown on PFD and on the ACTIVE FLT PLAN page.

The speed command is displayed in the ACTIVE FLT PLAN page 1/3 in CAS and MACH. VNAV selects the value, which results in the lower speed. This value is shown in bigger characters in the MCDU.

12. FLIGHT DIRECTOR OFF MODE
When there are no lateral and vertical modes active, the FD is in the OFF mode. The conditions when the FD can be turned off are:

- The AP is not coupled,
- The lateral modes are either HDG or ROLL.

If those conditions are verified, the FD is turned OFF when:

- FPA is the active vertical mode and is deselected pressing the FPA Button on the guidance panel.
- VS is the active vertical mode and is deselected by pressing the VS button on the guidance panel.

NOTE: Removal of the FD cue depressing FD Button on the Guidance Panel does not turn off the Flight Director.
13. SPEED CONTROL

Speed control can be manual or automatic (FMS position) depending on the selection on the Speed Selector Knob. The FMS selection allows the FMS to send its internally defined speeds as target speeds for FGCS.

13.1. MANUAL SPEED CONTROL

If the Speed Selector Knob is set to MANUAL the pilot is responsible for controlling the speed during all flight phases.

13.2. FMS SPEED CONTROL

In this mode the speed command is sent to the AFCS by the FMS. The departure, climb, cruise, descent, approach and go-around speeds are set in the PERFORMANCE INITIALIZATION page 1/3. If a new schedule is desired these settings can be modified in flight.

13.3. SPEED PROTECTION

The FMS incorporates speed reversion (transition from VPATH to VFLCH) and latched speed protection.

VPATH to VFLCH Transition: Speed reversion is active when the descent is too steep and it is not possible to maintain the selected speed. In this case, the FMS transitions to VFLCH, which maintains the speed within limits. The transition from VPATH to VFLCH automatically occurs if:

- The speed exceeds VMO/MMO + 10 kt during VPATH descents;
- FMS passes through a speed/altitude limit with a speed greater than 5 kt. In this case, the command is to level off until the speed deviation is below + 2 kt. Afterwards, the FMS commands VFLCH down to the Alt Selector altitude;
- Landing Gear/Flap speed limit is exceeded by more than 10 kt;
- In VPATH and the speed is less than VREF - 10 kt.

NOTE: If the Auto Throttle is not engaged the pilot is responsible for maintaining the speed.

Latched speed: It might occur when the FMS transitions from one VNAV sub-mode to another and there is a significant difference between those modes speed targets. It might also occur if there is a significant difference between the speed target and the current speed.
**ILS APPROACH**

During execution of the ILS approach, Autopilot Approach Status Annunciator displays the current status of the system and alerts whether the intended approach matches system capabilities.

The RA/BARO selector and RA Minimums setting inform the system what is the intended approach. When ILS modes are requested via APP button, system arms for the highest capability available. If all necessary requirements are not accomplished, an EICAS message is presented during flight and informs that category II ILS approach mode is not available.

The intended approach is informed to the system setting the barometric correction via control knobs on Display Controller panel (guidance panel).

- **CAT1** - set RA/BARO selector to BARO (both sides),
- **CAT2** - set RA/BARO selector to RA and adjust Minimums to 80 ft or above.

The operational conditions to accomplish a CAT II approach are:

- RA/BARO set to RA and Minimums set at 80 ft or above,
- Both NAV set to correct LOC frequency,
- Both PFDs set to correct LOC inbound course (V/L or Preview),
- Flap 5,
- All described conditions established at or above 800 ft RA.

If the flap setting is the only remaining condition to be satisfied for CAT II, the armed status will remain displayed down to 800 ft RA, suggesting there is still one pilot's action pending.

The ILS approach check points are the following:

- **1500 ft RA** - system starts trying to engage highest capability available,
- **800 ft RA** - system "freezes" highest capability available, not allowing approach "upgrades" anymore.
1. APPROACH SEQUENCE - CAT II

APPR 2 AVAILABLE

APR/AT ENGAGED IN HDG/ALT. AP HOLDING SELECTED HEADING AND ALTITUDE. AUTO THROTTLE HOLDING SELECTED SPD. APP PUSHBUTTON ON GP PRESS ARMING LOC/GS MODES. AP APPROACH STATUS ANNUNCIATOR SHOWS APPR2 ARMED.

- BELOW 1500 ft WITH RA MINIMUMS SET TO CAT2, AP APPROACH STATUS ANNUNCIATOR SHOWS APPR2 IN GREEN.
2. APPROACH SEQUENCE - CAT I

APPR 2 NOT AVAILABLE

· BELOW 1500 ft WITH RA/BARO SET TO BARO, AP APPROACH STATUS ANNUNCIATOR SHOWS APPR1, ALLOWING CAT1 APPROACH.
3. APPROACH SEQUENCE - CAT I (RA/BARO SET RA)

APPR 2 NOT AVAILABLE - RA/BARO INCORRECTLY SET TO RA

- BELOW 1500 ft
  SINCE APPR2 IS NOT AVAILABLE AND RA/BARO
  INCORRECTLY SET TO RA, AP APPROACH STATUS
  ANNUNCIATOR SHOWS BOTH APPR1 ONLY IN AMBER
  (ASSOCIATED WITH RA MIN. DIGITAL READ−OUT AT
  PFD'S) AND APPR1, IN GREEN.

UPON SELECTION OF RA/BARO TO BARO,
AP APPROACH STATUS ANNUNCIATOR
CHANGES TO NORMAL CAT1 CONFIGURATION.
**YAW DAMPER**

The Yaw Damper provides command to the rudder control surface and actuates independently of the autopilot and flight director system.

The YD function engages following successful AFCS on-ground power-up, assuming that valid data for calculating yaw damping is available. The YD remains engaged regardless of autopilot engagement or disengagement or even the loss of turn coordination function.

The yaw damper disengagement occurs as the following:
- The corresponding pushbutton on the GP is pressed,
- The fly-by-wire system turns to direct mode,
- The fly-by-wire system engagement status indicates that control of the rudder surface has failed.

**MACH TRIM**

The mach trim (MT) function positions the horizontal stabilizer surface as function of Mach number. The MT function is computed in the AFCS and the command is transmitted to HS-ACE via FCM.

Increase of Mach number moves aft the wing aerodynamic center of pressure, causing a pitch down moment. Horizontal stabilizer mach trim up command is required to compensate the pitch down moment.

MT function automatically engages when the conditions below are satisfied:
- Autopilot is not engaged,
- Indicated airspeed is above 0.70 Mach,
- Manual trim of horizontal stabilizer is not in progress,
- Neither of the quick disconnect switches are pressed,
- Any other trim function is not commanding.

If MT function disengages if at least one of conditions above is not satisfied. It also disengages if MT monitor detects a fault in trim rate command.

Mach trim is disabled with AP engagement due to AP trim operation.

The Mach Trim schedule stabilizer position reference will synchronize to the current stabilizer position upon a transition to engage state.

**PREVIEW FEATURE**

The preview feature allows the capture of an ILS course while still using the FMS as the basic NAV source.

The system automatically selects the ILS frequency and course if the PREV function is used with AUTO tuning enabled on the MCDU radio page. An ILS or BC procedure has to be part of the active flight plan on the FMS to allow automatic selection.

The PFD displays the CDI associated to the selected NAV frequency (LOC or VOR) with FMS selected on the PFD as the primary navigation source.

The AP will intercept the LOC while still displaying the FMS as the primary NAV source. Upon interception, the primary navigation source becomes LOC or BC, instead of FMS.
LOW VISIBILITY OPERATIONS

The system uses an ILS to generate flight guidance to the crew where the environment does not have enough visibility during approach. CAT I, CAT II or CAT III flight guidance is given by the AFCS.

ILS APPROCHES - AUTOLAND DISABLED

During execution of the ILS approach, Autopilot Approach Status Annunciator displays the current status of the system and alerts whether the intended approach matches system capabilities.

The intended approach is informed to the system setting the barometric correction via control knobs on Display Controller panel (guidance panel).

- CAT I - set RA/BARO selector to BARO,
- CAT II - set RA/BARO selector to RA.

When APP button is pressed, system tries to arm the highest capability available (APPR2 or APPR1 respectively) as follows:

- 1500 ft RA - system starts trying to engage highest capability available,
- 800 ft RA - system freezes highest capability available, not allowing approach upgrades.

1. CAT I OPERATION

1.1. APPROACH SEQUENCE - CAT I

APPRI 2 NOT AVAILABLE

GLIDESLOPE CAPTURE

BELOW 1500 ft
WITH RA/BARO SET TO BARO, AP APPROACH STATUS ANNUNCIATOR SHOWS APPR1, ALLOWING CAT1 APPROACH.
1.2. APPROACH SEQUENCE - CAT I (RA/BARO SET RA)

APPR 2 NOT AVAILABLE - RA/BARO INCORRECTLY SET TO RA

2. CAT II OPERATION

2.1. CONDITIONS TO ARM/ENGAGE

The operational conditions to arm a CAT II approach are:

- RA/BARO set to RA. For CAT II, the minimums can be set to a value of 80 ft or higher, in order to set the EGPWS call outs. The minimums can also be set to OFF in order to disable the EGPWS call outs,
- Both NAV radios set to correct ILS frequency,
- Both PFDs set to correct LOC inbound course (V/L or Preview).

The operational conditions to engage a CAT II approach are:

- Flap 5,
- Radio altimeters height below 1500 ft.
If the flap setting is the only remaining condition to be satisfied for CAT II, the armed status will
remain displayed down to 800 ft RA, suggesting there is still one pilot's action pending.

If all necessary requirements are not accomplished, an EICAS message is presented during flight and informs that category II ILS approach mode is not available.

2.2. APPROACH SEQUENCE - CAT II

APR 2 AVAILABLE

AP/AT ENGAGED IN HDG/ALT. AP HOLDING SELECTED HEADING AND ALTITUDE. AUTOTHROTTLE HOLDING SELECTED SPD. APP PUSHBUTTON ON GP PRESSED ARMING LOC/GS MODES. AP APPROACH STATUS ANNUNCIATOR SHOWS APPR2 ARMED.

3. FAIL PASSIVE CAT IIIA OPERATION

A fail passive system is one that in the event of a failure causes no significant deviation of airplane flight path or attitude. The capability to continue the operation is lost and an alternate course of action is required.

A fail passive CAT IIIa operation is conducted automatically using an Autoland system, with a decision high not less than 50 ft and a runway visual range not less than 600 ft.
AUTOLAND

Autoland 1 consists of approach, touchdown and 5 seconds of roll out with the autopilot engaged. This is accomplished under the capture of localizer and glideslope during an ILS approach (CAT I, II or III beams).

Autoland can be performed with or without autothrottle.

1. CONDITIONS TO ARM/ENGAGE

The operational conditions to arm autoland are:

- Autoland is enabled (MCDU),
- Autopilot and yaw damper engaged,
- RA/BARO set to RA and Minimums set at 50 ft or above,
- LOC 1 on left PFD and LOC 2 on right PFD,
- Both NAV set to correct LOC frequency.
- Both PFDs set to correct LOC inbound course (V/L),
- No miscompares on PFDs.

The operational conditions to engage autoland are:

- Flap 5,
- Both radio altimeters indicating less than 1500 ft.

If the flap setting is the only remaining condition to be satisfied for CAT II, the armed status will remain displayed down to 800 ft RA, suggesting there is still one pilot's action pending.

2. MINIMUM EQUIPMENT REQUIRED

To satisfy the system logic and arm/engage the Autoland 1 Mode, the following equipment are necessary:

- 2 Inertial Reference Systems,
- 1 Flight Director Channel,
- 2 Primary Flight Displays (PFD),
- 2 NAV Radios,
- 2 Radio Altimeter,
- 2 Air Data System (ADS),
- 1 Autopilot System Channel.
3. AUTOLAND DISABLE/ENABLE

When airplane is powered up the autoland default is ENABLE. Autoland can be disable/enable via the SETUP MCDU page. To disable/enable autoland proceed as follows:

- Press MENU button on MCDU to go to MENU page.

**MENU PAGE:**
- Press line select key 1L to go to MISC MENU page 1/1.

**MISC MENU PAGE 1/1:**
- Press line select key 2L to go to SETUP page 1/1.

**SETUP PAGE 1/1:**
- To disable/enable autoland press line select key 4L.
4. AUTOLAND MODES

Five modes are related specifically to Autoland:

- **Align (ALIGN):** engages at 150 ft and maintains the lateral guidance while the airplane aligns with the runway centerline by means of aileron and rudder control.
- **Flare (FLARE):** engages at 50 ft and provides vertical guidance for the transition from glideslope to main gear touchdown.
- **Retard (RETD):** if the autothrottle is engaged, retard engages at 30 ft and commands throttle to idle.
- **De-rotation (D-ROT):** engages at main gear touchdown and commands a nose pitch down, touching nose gear down.
- **Roll out (RLOUT):** engages at main gear touchdown and provides lateral guidance to maintain airplane on the runway centerline.

5. AUTOMATIC PITCH TRIM LOGIC

Two automatic pitch trim logics are related to Autoland operations:

- A pre-trim up is commanded at 800 ft radio altitude in order to prevent a nose down transient in an event of an autopilot disconnection. In case of autopilot disconnection a pitch up is expected due to the pre-trim, requiring pilot manual trimming.
- Automatic pitch trim inhibition below 50 ft.

6. PARALLEL RUDDER

In Autoland-equipped airplanes, yaw axis control is provided also through a rudder servo.

The parallel rudder servo engages at Autoland engagement and at go-around with AP engaged. When rudder servo is engaged a self-test is accomplished by a small and slow movement of pedals in both directions, but not causing any rudder movement.

During final approach (AEO or OEI) the system logic applies the crab technique in case of crosswind landing until 150 ft, below 150 ft sideslip is applied.

Loss of rudder servo during Autoland disengages the autopilot causing the loss of Autoland capability. The autopilot also disengages if it occurs in a go around following an Autoland approach.

The rudder servo failures during the attempt to engage the servo cause the AP RUDDER SERVO FAIL to latch. The failure is only reset on ground by a successful electrical power up.
7. ILS APPROACHES - AUTOLAND ENABLED

During execution of the ILS approach, Autopilot Approach Status Annunciator displays the current status of the system and alerts whether the intended approach matches system capabilities. The intended approach is informed to the system setting the barometric correction via control knobs on Display Controller panel (guidance panel).

- **AUTOLAND/CAT I** - set RA/BARO selector to RA. In order to disable the EGPWS call outs, the minimums can be set to OFF. After the capture of autoland, setting the selector knob to BARO will enable the callouts.
- **AUTOLAND/CAT II** - set RA/BARO selector to RA. The EGPWS minimums call outs can be set to a value of 80 ft or above. If a specific CAT II procedure chart does not authorize the use of RA, the EGPWS call outs can be disable setting the RA to OFF,
- **AUTOLAND/CAT III** - set RA/BARO selector to RA. The EGPWS minimums call outs can be set to a value of 50 ft or above.

When APP button is pressed, system tries to arm the highest capability available (AUTOLAND 1, APPR2 or APPR1 respectively) as follows:
- 1500 ft RA - system starts trying to engage highest capability available,
- 800 ft RA - system freezes highest capability available, not allowing approach upgrades.

8. APPROACH SEQUENCE

**Above 1500 ft :**
- Pressing APP button on glareshield panel and with all conditions to arm Autoland satisfied makes the white "AUTOLAND 1" announcement to display on the left side of FMA. The LOC lateral mode and the GS vertical modes arm. When the Autoland engages, the “AUTOLAND 1” annunciation displays in green on the right side of FMA,
- Localizer and glideslope engage when capture.

**Between 1500 ft and 800 ft :**
- When flap is set to 5 satisfying all conditions to engage Autoland, "AUTOLAND 1" changes place from the right to the left side of FMA. ALIGN and FLARE arm.
- The following buttons are inhibited when Autoland is engaged: TCS, SRC, NAV, APP, BANK, HDG, VNAV, FLC, ALT, FPA and VS,

*NOTE:* Pressing the IAS/MACH button adjusts the target speed to VFE improperly. Do not use this button during autoland operations.

- At 800 ft a pre-trim up is commanded.

**At 150 ft :**
- ALIGN engages. ROUT and RETD (if autothrottle is engaged) arm.

**At 50 ft :**
- FLARE engages,
- Automatic pitch trim is inhibited.

**At 30 ft :**
- RETD engages (if autothrottle is engaged).

**At main gear touchdown :**
- RLOUT and D-ROT engage. Autothrottle disengages.

**5 seconds after touchdown :**
- AP disconnects.
AUTOLAND APPROACH SEQUENCE WITH AUTOTHROTTLE DISENGAGED

NOTE: The Autoland approach sequences are identical both for AEO and OEI conditions.
THRUST MANAGEMENT SYSTEM

The TMS is a dual channel system comprised of the following dual components:

- Auto Throttle (AT),
- Thrust Rating Selection (TRS),
- Thrust Lever Angle (TLA) Trim.

Only one channel is operating at any given time. The priority channel can be selected via the MCDU.
AUTOTHROTTLE

The AT uses data from the FADEC, Thrust Control Quadrant, MCDU, AFCS Flight Director and Flight Management system to provide automatic, full flight regime energy management with a minimum of pilot inputs.

The AT system provides means to maintain the airplane within its thrust and speed envelopes. Thrust limiting is based on the active N1 rating, while speed limiting is based on the low speed and maximum speed limits (Vmo/Mmo, Gear and Flaps placard).

Gust compensation is provided to increase the lower speed limit above 1.2 Vs up to 5 kts in gusty conditions, with slat/flap position greater than 0 (zero).

The AT is engaged on the ground when:
- All parameters required are valid and AT is capable,
- AT TO mode armed (AT button in the GP is pressed),
- Both thrust levers above 50° TLA.

In flight, the AT engages when:
- All parameters required are valid and AT is capable,
- AT button in the GP is pressed,
- The airplane is 400 ft AGL or above.

Disengagement of AT occurs when:
- Either AT Disconnect Button on the thrust levers is pressed,
- AT button on the GP is pressed,
- TLA difference greater than 8°,
- AT monitor tripped,
- The required system parameters become invalid,
- Transition to on-ground condition (weight-on-wheels or wheels spinning), and thrust levers at Idle and AT in Retard mode.

Anytime the auto Throttle is deactivated, an aural alarm "THROTLLE" is triggered.

Pressing the AT Disconnect Button manually disengages the AT. The second press in the AT Disconnect Button cancels the aural alarm, which sounds at least once.

A single press in the AT Disconnect Button cancels the aural warning after the system automatic disengagement of AT.

"AT" flashes on the FMA anytime the Auto Throttle is disengaged. Pressing the AT disconnect button once cancels the alarm. The visual information will always flash for at least 5 seconds.

"AT" flashes green on the FMA for normal AT disengagement. For abnormal disengagement "AT" flashes red and an EICAS message is displayed. Pressing the AT disconnect button cancels the FMA visual warning but the EICAS message remains displayed.

**NOTE:** When the autothrottle is engaged, the thrust levers may have a misalignment of up to half of thrust lever handle diameter.
The AT modes is described as follows:

- Speed Control Mode - Speed on Thrust (SPDT),
- Flight Level Change Thrust Control Mode - Speed on Elevator (SPDE),
- Takeoff Thrust Control Mode (TO),
- Go-Around Thrust Control Mode (GA),
- Takeoff Thrust Hold Mode (HOLD),
- Retard Mode.

1. SPEED CONTROL MODE - SPEED ON THRUST (SPDT)

The thrust levers are commanded to provide thrust rate as programmed to maintain the desired speed. The selected speed is controlled by engine thrust during climb, descend and cruise phases.

The vertical modes related to SPDT mode are:

- Flight Path Angle (FPA) - basic vertical mode,
- Vertical Speed (VS),
- Glide Slope (GS),
- Altitude Hold (ALT),
- Altitude Select (ASEL).

The SPDT is also the Auto Throttle mode when the FD is turned OFF.

**NOTE:** With the AT in the SPDT mode and the AP off, excessive deviations from the FD guidance may cause AT degraded speed control.

2. FLIGHT LEVEL CHANGE THRUST CONTROL MODE - SPEED ON ELEVATOR (SPDE)

The AT maintains a fixed thrust setting, and the AP maintains the selected speed using the elevator command.

For small flight level changes (FLCH mode), the Auto Throttle commands only the necessary thrust in order to maintain a comfortable predetermined schedule based on vertical speed.

For large flight level changes (FLCH mode), the Auto Throttle commands climb setting CLIMB rating and descent in IDLE rating.

The vertical modes related to SPDE mode are:

- Flight Level Change (FLCH),
- Overspeed (OVSP).

3. TAKEOFF THRUST CONTROL MODE (TO)

Takeoff thrust mode (TO) advances the thrust levers to the TO/GA position when AT is engaged on the takeoff phase pressing the Takeoff and Go Around button on thrust levers.

4. GO-AROUND THRUST CONTROL MODE (GA)

The Go-Around thrust mode (GA) advances the thrust levers to the TO/GA position.
5. TAKEOFF THRUST HOLD CONTROL MODE (HOLD)

The HOLD mode prevents movements on the thrust levers that could cause undesirable thrust reductions during TO phase.

HOLD mode activates when TO mode is active and IAS is greater than 60 kt. The AT servos are deenergized and thrust lever movements are not commanded up to 400 ft AGL.

An EICAS message is displayed if HOLD mode engages with TLA position below TO/GA.

6. RETARD MODE

The Retard mode provides the retard of thrust levers to the idle thrust position during airplane flare on landing.

Retard mode is armed (white) based on the following conditions:

- Autothrottle engaged;
- Flap at 5 or FULL position and landing gear down;
- Radio Altitude below 150 ft AGL;
- Radio Altimeter with valid information.

Retard mode activates based on a Radio Altitude valid and less than 30 ft and airplane is in a landing configuration. Once the airplane touches down (weight-on-wheels or wheel spin-up) the auto throttle automatically disengages.

NOTE: Landing with RAT deployed requires selection of flap/slat 3, which not comply with the condition to arm and activate the Retard mode.

7. LIMITED THRUST (LIM)

Limited Thrust (LIM) is set when the selected vertical mode requires more or less engine thrust than that available for the thrust rating selected. In these cases the AT will not be able to maintain the selected speed for climbing or descending and an amber LIM displays on FMA.

LIM is associated to Speed on Thrust mode (SPDT).

8. OVERRIDE (OVRD)

The AT can be overridden by moving the thrust levers, causing no AT disengagement. In this case a green "OVRD" is displayed on the FMA. The thrust levers return to the AT commanded position after override is discontinued.

The Auto Throttle is disengaged when:

- Thrust lever is moved beyond TO/GA position,
- TLA is reduced below 40° (aborted TO case) during TO HOLD mode.

9. AT SINGLE ENGINE OPERATION

The AT deactivates the respective thrust lever when FADEC detects an engine failure or engine shutdown. The operating engine’s thrust lever remains active for AT operation.

Reducing the thrust lever to simulate an engine failure will cause AT disengagement due to thrust lever position split.
TLA TRIM

The TLA trim functions are the following:

• Perform small thrust adjustments, with limited authority,
• Reduce excessive thrust lever movements,
• Synchronize N1 rotation speed, increasing comfort.

The TLA Trim is set ON whenever AT is engaged. TLA Trim works even if AT is disengaged, if TLA Trim is set to ON on the MCDU TRS page.

The TRS page on the MCDU is available to set either TLA Trim ON or OFF manually whenever AT is not engaged.
THRUST RATING SELECTION (TRS)

The TRS automatically determines the appropriated engine thrust rating according to the flight phase. The thrust rating can also be manually selected via TRS page on the MCDU, pressing TRS key. The FADEC transmits the thrust rating and N1 values provided by TRS for display on the EICAS. The thrust ratings transmitted by the TRS are as the following:

- Take-off (TO),
- Go-Around (GA),
- Climb-1 : (CLB-1),
- Climb-2 : (CLB-2),
- Cruise (CRZ),
- Continuous (CON).

The Automatic Flight System has an Auto Rating Type Transition Logic that controls the engine rating changes according to flight phase, airplane configuration and number of engines running.
THRUST RATING SELECTION (TRS)

TO is the engine thrust rating selection on ground, and it remains in TO mode while airplane is below 400 ft AGL.

The change of engine thrust rating from TO to CLB is set when the following conditions occurs simultaneously:

- Any change in vertical mode is detected,
- Airplane altitude is above 400 ft AGL,
- Both engines are running,
- Landing gears are retracted.

If no change in vertical mode is detected, the engine thrust rating switches from TO to CLB at 3000 ft pressure altitude AFE.

The active TRS flight phase is set to CLB when the airplane is in air and the Altitude Pre-selector is above the current Baro altitude.

In one engine inoperative condition, the engine thrust rating changes from TO to CON at 3000 ft pressure altitude AFE.

The active TRS flight phase is set to CRZ when the airplane is in air and Baro Altitude is between 100 ft above and 100 ft below of Pre-selected Altitude for more than 90 seconds.
## EICAS MESSAGES

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAUTION</td>
<td>AP FAIL</td>
<td>Autopilot function is no longer operative.</td>
</tr>
<tr>
<td></td>
<td>AP PITCH MISTRIM</td>
<td>Pitch trim and autopilot commanding pitch trim control in opposite directions.</td>
</tr>
<tr>
<td></td>
<td>AP PITCH TRIM FAIL</td>
<td>Autopilot stabilizer trim is no longer operative.</td>
</tr>
<tr>
<td></td>
<td>AP ROLL MISTRIM</td>
<td>Roll trim and autopilot commanding roll trim control in opposite directions.</td>
</tr>
<tr>
<td></td>
<td>AT FAIL</td>
<td>Both AT have failed. Selected AT function is unavailable.</td>
</tr>
<tr>
<td></td>
<td>AT NOT IN HOLD</td>
<td>AT not in TO Hold following the transition above 60 knots during TO roll and until the aircraft transitions 400 ft AGL and Go Around.</td>
</tr>
<tr>
<td></td>
<td>ENG TLA NOT TOGA</td>
<td>TLA not at TO/GA position during takeoff and/or go-around phases.</td>
</tr>
<tr>
<td></td>
<td>FD LATERAL MODE OFF</td>
<td>Disconnection of the lateral mode due to invalid conditions.</td>
</tr>
<tr>
<td></td>
<td>FD VERT MODE OFF</td>
<td>Disconnection of the vertical mode due to invalid conditions.</td>
</tr>
<tr>
<td></td>
<td>SHAKER ANTICIPATED</td>
<td>Indication that Shaker activation angles have been advanced to conservative settings.</td>
</tr>
<tr>
<td></td>
<td>STALL PROT FAIL</td>
<td>Stall Warning function and Stall Protection functions are no longer operative.</td>
</tr>
<tr>
<td>ADVISORY</td>
<td>AFCS FAULT</td>
<td>Latent fault to AFCS functions.</td>
</tr>
<tr>
<td></td>
<td>AFCS PANEL FAIL</td>
<td>Both channels of the GP have failed.</td>
</tr>
<tr>
<td></td>
<td>AFCS PANEL FAULT</td>
<td>A single channel of the GP has failed.</td>
</tr>
<tr>
<td></td>
<td>AP FAULT</td>
<td>The AP has one channel failed.</td>
</tr>
<tr>
<td></td>
<td>AP PITCH TRIM FAULT</td>
<td>The AP pitch trim has one channel failed.</td>
</tr>
<tr>
<td></td>
<td>APPR 2 NOT AVAIL</td>
<td>The AP is not capable to perform a CAT 2 precision approach.</td>
</tr>
<tr>
<td></td>
<td>AT FAULT</td>
<td>The A/T has one channel failed.</td>
</tr>
<tr>
<td></td>
<td>ENG TLA TRIM FAIL</td>
<td>Selected Sync function is unavailable due to an internal failure or a required input failure. AT function is available.</td>
</tr>
<tr>
<td></td>
<td>FD FAIL</td>
<td>FD is no longer available.</td>
</tr>
<tr>
<td></td>
<td>FD FAULT</td>
<td>A single FD channel is no longer available.</td>
</tr>
<tr>
<td></td>
<td>SHAKER 1 (2) FAIL</td>
<td>Stall warning function has failed.</td>
</tr>
<tr>
<td>TYPE</td>
<td>MESSAGE</td>
<td>MEANING</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ADVISORY</td>
<td>STALL PROT FAULT</td>
<td>AOA Miscompare Monitor (Stall Warning Subsystem) has failed.</td>
</tr>
<tr>
<td></td>
<td>STALL PROT ICE SPEED</td>
<td>The reference speed has changed. Set reference speed to ice speed. Once the ice condition is detected, the system latches the ice condition active until 30 seconds after WOW becomes true.</td>
</tr>
<tr>
<td></td>
<td>YD FAIL</td>
<td>Yaw damper function is no longer operative.</td>
</tr>
<tr>
<td></td>
<td>YD FAULT</td>
<td>The yaw damper has one channel failed.</td>
</tr>
<tr>
<td></td>
<td>YD OFF</td>
<td>Yaw damper function is off.</td>
</tr>
</tbody>
</table>
EMBRAER 190

Communications
The EMBRAER 190 provides a complete set of Communication functions. The main interface for the system is done through the Audio Control Panel (ACP).

The audio system is controlled via three individual ACPs available to the captain, first officer and observer, and also provides interface with the Passenger Address (PA), Aural Warning, and Digital Voice and Data Recorder (DVDR) systems.

Optional communications equipment includes a third VHF COM, HF and Selcal systems.

**CONTROLS AND INDICATIONS**

1. **CONTROL WHEEL**

<table>
<thead>
<tr>
<th>No.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CONTROL WHEEL COMMUNICATIONS SWITCH:</td>
</tr>
<tr>
<td></td>
<td>- PTT (momentary): allows VHF transmissions, as well as voice communications to passengers.</td>
</tr>
<tr>
<td></td>
<td>- HOT: allows communication between crewmembers and between crewmembers and ramp station.</td>
</tr>
<tr>
<td></td>
<td>- OFF: allows only audio reception.</td>
</tr>
</tbody>
</table>

**CONTROL WHEEL**
2. GLARESHIELD COMMUNICATION

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>GLARESHIELD PTT BUTTON :</td>
</tr>
<tr>
<td></td>
<td>- Allows VHF transmissions and voice communications to passengers.</td>
</tr>
<tr>
<td>②</td>
<td>PASSENGER ADDRESS PTT BUTTON :</td>
</tr>
<tr>
<td></td>
<td>- Allows voice communications to passengers, regardless of any selection in the audio control panel.</td>
</tr>
</tbody>
</table>
### 3. HAND MICROPHONE CONTROLS

<table>
<thead>
<tr>
<th>Nº</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HAND MIC PTT BUTTON:</td>
</tr>
<tr>
<td></td>
<td>- Allows transmission through the ACP, as well as communication to passengers.</td>
</tr>
</tbody>
</table>

**HAND MICROPHONE CONTROLS**
### 4. CAPTAIN AND FIRST OFFICER JACK PANELS

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>CAPTAIN AND FIRST OFFICER JACKS:</td>
</tr>
<tr>
<td></td>
<td>- Allows plugging in headphone (PHONE), headset (ANR HDST), hand microphone (HAND MIC) and boom microphone (BOOM MIC).</td>
</tr>
</tbody>
</table>

**CAPTAIN AND FIRST OFFICER JACK PANELS**

![Diagram of captain and first officer jack panels](image-url)
### 5. OBSERVER JACK PANEL

<table>
<thead>
<tr>
<th>No</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>OBSERVER JACKS:</td>
</tr>
<tr>
<td></td>
<td>- Allows plugging in headphone (HDPH), headset (ANR HDST) and boom microphone (BOOM).</td>
</tr>
<tr>
<td>②</td>
<td>OBSERVER COMMUNICATIONS SWITCH:</td>
</tr>
<tr>
<td></td>
<td>- PTT (momentary): allows VHF and voice communications with passengers.</td>
</tr>
<tr>
<td></td>
<td>- HOT: allows communication between crewmembers and between crewmembers and ramp station.</td>
</tr>
<tr>
<td></td>
<td>- OFF: allows only audio reception.</td>
</tr>
</tbody>
</table>

**OBSERVER JACK PANEL**

![Diagram of Observer Jack Panel](image)
### 6. RAMP STATION

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | COCKPIT CALL BUTTON (momentary action) :
   - When pressed, generates a single HI/LO tone chime and the RAMP annunciator button flashes on the audio control panel. |
| 2  | MICROPHONE/HEADPHONE JACK :
   - Allow ground personnel to plug in a headphone and a microphone equipped with a PTT Button. |

**NOTE:** *Ground personnel panel is linked to the hot mic once the ramp button is selected.*
## 7. AUDIO CONTROL PANEL (ACP)

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | MICROPHONE SELECTOR BUTTONS:  
|    | - Related communication channel is enabled for transmission and reception.  
|    | - When selected, a green bar illuminates inside the button.  |
| 2  | AUDIO CONTROL BUTTONS:  
|    | - Related audio channel is enabled for reception.  
|    | - Automatically activated when a transmission channel is selected.  
|    | - More than one audio channel may be selected at the same time.  
|    | - When selected, a green dot illuminates inside the button.  |
| 3  | SATCOM CONTROL BUTTON (UNAVAILABLE) |
| 4  | PASSENGER ADDRESS CONTROL BUTTON:  
|    | - Enables PA announcements.  
|    | - When selected, a green bar illuminates on the transmission button and a green dot illuminate on the reception button.  |
| 5  | SERVICES INTERPHONE CONTROL BUTTONS:  
|    | - **EMER**: sounds a triple HI/LO tone chime through the PA system and illuminates a red light at ceiling of the flight attendant station. When selected, a green bar flashes on button until the flight attendant picks up the call. Once the flight attendant picks up the call the green bar flashes faster. Pressing the button again, the light becomes steady and the communication with the flight attendant is enabled.  
|    | - **RAMP**: enables communication with the ground personnel. For an incoming call, the ramp annunciator flashes and remains steady on when active. A single HI/LO tone chimes.  
|    | - **CABIN**: sounds a single HI/LO tone chime through the PA system and illuminates a green light at ceiling of the flight attendant station. When selected, a green bar flashes on button until the flight attendant picks up the call. Once the flight attendant picks up the call the green bar flashes faster. Pressing the button again, the light becomes steady and the communication with the flight attendant is enabled.  |
| 6  | MASTER VOLUME CONTROL KNOB:  
|    | - Allows adjustment of the most recently selected audio.  |
| 7  | ID FILTER BUTTON:  
|    | - Activates a filter that eliminates voice on VOR and ADF audio so the identification can be heard.  |
| 8  | AUDIO SELECTION BUTTONS:  
|    | - Enables the respective audio to be summed into the output on the headphone (HDPH), interphone (INPH) or cockpit speaker (SPKR).  
|    | - When selected, a green dot illuminates inside the button.  |
| 9  | ACP DISPLAY:  
<p>|    | - Displays the selected transmission channel and digital volume information.  |</p>
<table>
<thead>
<tr>
<th>Nº</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>AUTO/MASK MICROPHONE SWITCH :</td>
</tr>
<tr>
<td></td>
<td>- AUTO (PUSH IN) : allows audio communication via oxygen masks.</td>
</tr>
<tr>
<td></td>
<td>- MASK (PUSH OUT) : activates oxygen masks microphone when auto mode fails.</td>
</tr>
<tr>
<td></td>
<td>- Oxygen mask stowage box doors must be closed and reset in order to enable hand or headset microphone booms after using the oxygen mask microphone.</td>
</tr>
<tr>
<td>11</td>
<td>BACKUP VOLUME CONTROL BUTTON/KNOB :</td>
</tr>
<tr>
<td></td>
<td>- NORM (PUSH IN) : normal operation mode.</td>
</tr>
<tr>
<td></td>
<td>- BKUP (PUSH OUT) : activates backup operation when audio panel power fails or both digital audio buses fail.</td>
</tr>
<tr>
<td></td>
<td>- Minimum volume is at the extreme counterclockwise position and the maximum volume is at the extreme clockwise position.</td>
</tr>
<tr>
<td></td>
<td>- The VHF 1 is the radio available for Captain ACP and VHF 2 is the radio available for the First Officer ACP.</td>
</tr>
<tr>
<td>12</td>
<td>SELCAL ANNUNCIATOR BUTTON :</td>
</tr>
<tr>
<td></td>
<td>- Flashes when an incoming call is displayed.</td>
</tr>
<tr>
<td></td>
<td>- Pressing shows the code on the ACP display.</td>
</tr>
<tr>
<td></td>
<td>- Remains steady when active for transmission.</td>
</tr>
</tbody>
</table>
AVIATION LEARNING

EMBRAER 190 - SYSTEMS SUMMARY [Communications]

AUDIO CONTROL PANEL (ACP)

CONTROL PEDESTAL

OBSERVER STATION

1. MIC
2. VHF1
3. VHF2
4. VHF3
5. HF
6. SAT
7. PA
8. EMER
9. RAMP
10. CAB
11. SPKR
12. INPH
13. HDPH
14. SELCAL
15. BKUP
16. AUTO
17. MASK
18. VOL
19. NORM

VHF1: 47

Page 10

AMET LTD,
FOR TRAINING ONLY
Page 121 of 171
## 8. DIGITAL VOICE-DATA RECORDER

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>SELECTOR SWITCH</strong> :</td>
</tr>
<tr>
<td></td>
<td>- <strong>FWD</strong> : enables test functions of DVDR 1, which is located in the forward electronic bay.</td>
</tr>
<tr>
<td></td>
<td>- <strong>AFT</strong> : enables test functions of DVDR 2, which is located in the aft electronic bay.</td>
</tr>
<tr>
<td>2</td>
<td><strong>HEADPHONE JACK</strong> :</td>
</tr>
<tr>
<td></td>
<td>- Monitors tone transmission during test or to monitor playback of voice audio.</td>
</tr>
<tr>
<td>3</td>
<td><strong>TEST BUTTON</strong> :</td>
</tr>
<tr>
<td></td>
<td>- Simultaneously tests all CVR and FDR functions on each DVDR. The DVDR on which the test will be performed is selected on the Selector Switch.</td>
</tr>
<tr>
<td></td>
<td>- An aural tone is heard through the headset if the unit passes the test.</td>
</tr>
<tr>
<td></td>
<td><strong>NOTE</strong> : An aural tone is heard only for airplanes equipped with Honeywell DVDR. For airplanes equipped with L3 DVDR, observe that there are no FAIL messages on EICAS.</td>
</tr>
<tr>
<td>4</td>
<td><strong>CVR ERASE BUTTON</strong> :</td>
</tr>
<tr>
<td></td>
<td>- Erases the recorded audio information, provided that the airplane is on the ground and parking brake is set.</td>
</tr>
</tbody>
</table>

### DIGITAL VOICE-DATA RECORDER

**OVERHEAD PANEL**

**DVDR CONTROL PANEL**

![Diagram of digital voice-data recorder control panel]
### 9. PRINTER

<table>
<thead>
<tr>
<th>No</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | **PPR ADV**:  
|    | - Continuously advances paper while pushbutton is depressed. |
| 2  | **LOW PPR**:  
|    | - Illuminates when the printer senses the last remaining 10 feet of paper on the paper supply roll. |
| 3  | **TEST BUTTON**:  
|    | - Illuminates all indicators followed by a printout of test results and a test pattern.  
|    | - "TEST" button indicator bar will remain lit in conjunction with the "FAULT" indicator to report a self test failure. |
| 4  | **ALRT RST BUTTON**:  
|    | - Not functional. |
| 5  | **FAULT BUTTON**:  
|    | - Illuminates when senses no paper or printer door open.  
|    | - Illuminates in conjunction with test button in case of self-test failure. |
| 6  | **OFF BUTTON**:  
|    | - Alternately turns the printer off and on. When power is applied to the printer, it automatically is in the on state. |

The diagram shows the control pedestal with labels for each button and indicator.
COMMUNICATION SYSTEM

The communication system comprises the radio communication (VHF), interphone, audio control panels and digital data voice recorder.

1. RADIO COMMUNICATION SYSTEM

1.1. VERY HIGH FREQUENCY

The VHF digital radios (VDR) 1 and 2 are located in the Modular Radio Cabinets (MRC). VDR 1 and 2 interfaces with the audio system through the audio/microphone busses, and with the MCDU/PFD through the ASCB. VDR channels 1 and 2 are for voice communication only.

VDR 3 interfaces with audio system and MCDU/PFD indirectly via MRC 2 and directly to MAU 1 to data transmission. The VHF radio 3 is located on a separated radio Mini Cabinet. VDR 3 provides voice communication as well as data communications through ACARS (Aircraft Communication Addressing and Reporting System) applications.

The VHF frequency is tuned/activated through the MCDU (primary mean) or CCD (PFD).

A tuning backup is available in MCDU 2 in case of loss of both MAUs. In the same way, if the audio bus is lost there are audio backups.

The flight crew may tune the VHF frequency on the MCDU as follows:

- Press RADIO button on the MCDU to go to RADIO page 1/2.

RADIO PAGE 1/2:

- On RADIO page 1/2 is possible to tune and activate the VHF 1 and 2 frequencies. The tuning can be accomplished using the tuning knob or the numeric buttons. If the tuning knob is used the standby frequency must prior be boxed pressing its respective line select key. In case of the numeric keys, enter the standby frequency and press the respective line select key. To activate the standby frequency press the respective active frequency,
- Press the respective standby frequency twice if not boxed, otherwise press once, to go to COM page 1/1.

COM 1 (2) PAGE 1/1:

- On the COM page is possible to capture a frequency tuned in memory. Press 3L to box the memory tune and use the tuning knob to cycle the stored frequencies. Press the active frequency to capture the selected memory tune,
- Press line select key 1R to cycle to the squelch on or off,
- Press line select key 3R to cycle to the frequency spacing:
  - 8.33: frequency has three decimal places,
  - 25: frequency has two decimal places.
- Press line select key 6L to go to COM MEMORY page 1/2.
COM MEMORY PAGE 1/2:

- On the COM MEMORY page is possible to capture a frequency tuned in memory or store a frequency/identification. To capture a frequency press the respective memory frequency to box it and press 1L to activate the frequency. To store a frequency or its identification use the alphanumeric keys and press the respective memory line select key. Additionally the frequency can also be stored pressing the receptive memory line select key and rotating the tuning knob.

**RADIO PAGE 1/2**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COM1</td>
<td>COM2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>↑123 . 200</td>
<td>123 . 200 ↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>118 . 600</td>
<td>118 . 600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAV1</td>
<td>FMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>114 . 8</td>
<td>AUTO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DME H PXR</td>
<td>116 . 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>115 . 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCAS/ XPDR</td>
<td>N 123 XPDR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STBY TA/ RA</td>
<td>• 1471</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IDENT ■</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The VHF frequency selection through the CCD is as follows:

- Select the PFD through the CCD. The left and right format location buttons select respectively pilot's and copilot's PFDs,
- Tune the standby frequency through the tuning knob.

Activate the standby frequency by pressing the enter key.
RADIO PAGE 2/2:

- To bring up the RADIO PAGE 2/2, with the radio PAGE 1/2 displayed, press NEXT button,

- On RADIO page 2/2 is possible to tune and activate the VHF 3 frequencies for voice mode. Press line select key 6L twice to go to COM 3 page 1/1, and then press line select key 2R to cycle the operational mode (data or voice). It is possible to tune a radio frequency in the same manner as VHF 1 and 2,

- The frequencies to data transmission are selected in a specific ACARS page. With data mode selected, the indication 'DATA' displays, otherwise VHF 3 active and stand by frequencies display.

RADIO PAGE 2/2 (DATA MODE)

RADIO PAGE 2/2 (VOICE MODE)

---

Embraer 190 - Systems Summary [Communications]

Page 15

AMET LTD, FOR TRAINING ONLY

Page 126 of 171
COM 3 PAGE 1/1:

- The COM 3 page provides the same options as COM 1 (2) pages, except that it is possible to select the transmission mode for VHF 3. The transmission mode is selected pressing line select key 2R to cycle the operational mode (data or voice).
BACKUP RADIO PAGE:

- The BACKUP RADIO page provides means for tuning COM 1, VHF NAV 1 and XPDR 1 (ALT OFF mode) in case of loss of primary and secondary tuning means (tuning using MCDU and CCD). In such cases, radio access is done via backup connection available on MCDU 2.

- The BACKUP RADIO page is available pressing MENU function button on the MCDU and then line select key 4L on Menu page. The BACKUP RADIO page displays automatically on MCDU 2 for some failure conditions.
2. SELECTIVE CALLING
Selective Calling (SELCAL) monitors selected frequencies on the VHF and HF radios in case of the ground station is desiring to communicate with the flight crew. Each airplane is assigned of a unique four-letter SELCAL code.
3. INTERPHONE SYSTEM

The interphone system provides intercommunication between the flight crew, flight attendants and ramp personnel.

The flight attendants communicate between flight attendant stations or with the flight crew using any of the attendant handsets.

Communication between flight crew and flight attendants may be done through the ACP.

Call chimes are annunciated at the beginning of the call from the cockpit to the flight attendants and vice-versa.

3.1. PASSENGER ADDRESS (PA)

The PA system allows flight crew in the cockpit and flight attendants to make announcements to the passengers. Announcements are heard through speakers located in the cabin and in the lavatories.

The pilots can make announcements using hand, headset boom or oxygen mask microphones. The flight attendants can make use of PA handset located at their stations.

Pre-recorded announcements may be provided as well as recorded music for passenger entertainment.

PA system use is prioritized. Cockpit announcements have first priority and override all others. Flight attendant announcements override the pre-recorded announcements and this one overrides the music system.

3.2. ATTENDANT CALL

The call system is used as a mean for crewmembers to gain the attention of other crewmembers and to indicate that interphone communication is desired.

Attention is gained through the use of lights and aural signals (chimes or horn). The cockpit may be called from either flight attendant station or by the ground personnel. The ground personnel may only be called from the cockpit. Flight attendants may be called from the cockpit through interphone buttons on the ACPs or flight attendant call button on the overhead panel, the other attendant station, or from any passenger seat (PSU) or lavatory. Call lights in the passenger cabin identify, the source of incoming calls to the attendants.

Call system chime signals low, high or high/low tones are audible in the passenger cabin through the PA system speakers. The PA speakers also provide an alerting chime signal whenever the NO SMOKING, FASTEN SEAT BELT or RETURN TO SEAT (in the lavatory) signs and STERILE COCKPIT light illuminate or extinguish.

The attendant call lights located on the forward and aft main ceiling panel areas provide a visual indication to attendant when there is a call from the flight crew or passengers.
3.3. ATTENDENT CALL TABLE

<table>
<thead>
<tr>
<th>CALLING ORIGINATOR</th>
<th>CALLED POSITION</th>
<th>VISUAL SIGNAL AT CALLED POSITION</th>
<th>AURAL SIGNAL AT CALLED POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockpit</td>
<td>Attendant Station</td>
<td>Green light</td>
<td>Single high/low tone chime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red light</td>
<td>Triple high/low tone chime</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amber sterile cockpit light</td>
<td>Single high tone chime</td>
</tr>
<tr>
<td></td>
<td>Passenger cabin, lavatories and galleys</td>
<td>No smoking or fasten belt signs illuminate/extinguish</td>
<td>Single low tone chime</td>
</tr>
<tr>
<td>Cockpit (lateral console)</td>
<td>Ramp station</td>
<td>-</td>
<td>Horn in the nose wheel well</td>
</tr>
<tr>
<td>Cockpit (Overhead Panel)</td>
<td>Attendant station</td>
<td>-</td>
<td>Single high/low tone chime</td>
</tr>
<tr>
<td>Attendant station</td>
<td>Cockpit</td>
<td>CAB or EMER annunciator button flashes on the ACP</td>
<td>Single or triple high/low tone chime for CAB or EMER, respectively</td>
</tr>
<tr>
<td>Attendant station</td>
<td>Attendant station</td>
<td>-</td>
<td>Single high/low tone chime</td>
</tr>
<tr>
<td>Ramp station</td>
<td>Cockpit</td>
<td>RAMP annunciator button flashes on the ACP</td>
<td>Single high/low tone chime</td>
</tr>
<tr>
<td>Lavatory</td>
<td>Attendant station</td>
<td>Orange light</td>
<td>Single high tone chime</td>
</tr>
<tr>
<td>Passenger PSU</td>
<td>Attendant station</td>
<td>Blue</td>
<td>Single high tone chime</td>
</tr>
</tbody>
</table>

4. AUDIO CONTROL PANEL

There are three Audio Control Panels (ACP), located at the control pedestal and observer station. Each panel controls an independent crew station audio system and allows the flight crew to select the desired radios, navigation aids, interphones and PA systems for monitoring and transmission.

The audio panel receives inputs from all audio communication channels and aural warnings. Audio warning for altitude alert, ground proximity warning system (GPWS), traffic collision avoidance system (TCAS), and windshear among others, are also heard through the speakers and headsets. These warnings cannot be controlled or turned off by the flight crew. Audio from each ACP is monitored using a headset, headphone or the related speaker, except for the observer speaker.
5. DIGITAL VOICE DATA RECORDER SYSTEM (DVDR)

The digital voice data recorder system (DVDR) combines a flight data recorder (FDR) and a cockpit voice recorder (CVR) in a single unit. Two DVDR units are installed. DVDR 1 is installed in the forward electronic bay, and the DVDR 2 in the aft electronic bay. Each unit is capable of receiving, recording and preserving all required data parameters and voice recording from the cockpit crew and area microphones.

The DVDR unit is capable of recording the last 120 minutes of audio information from cockpit area microphone and primary crew microphones, 25 hours of flight data, 120 minutes of digital communication messages and GMT as well.

There is DVDR's FDR data available for maintenance purposes only through the MCDU.

6. COMMUNICATION MANAGEMENT FUNCTION

The Communication Management Function (CMF) provides the following functionalities:

- Character-oriented communication through ACARS network,
- Communication between different airplane devices.

CMF is a dual mode active/stand by system. CMF 1 resides in MAU 3 and is powered by DC bus 2. CMF 2 resides in MAU 1 and is powered by DC bus 1.

CMF has the following interfaces:

- ACARS network,
- MCDUs are the primary flight crew interface with CMF providing display and control for the CMF. CMF becomes available pressing MCDU DLK button,
- Printer receives ACARS exchanged messages via CMF,
- CMC receives fault/events reports from the CMF. CMC also provides communication between the CMF and Printer device,
- PFD displays a "MSG" flag when uplink messages are received from ground,
- EICAS alerts crew members of CMF faults,
- AWS alerts crewmembers of new ATS (Air Traffic Services) uplink messages.

6.1. ACARS

ACARS is a data link system that allows character-oriented messages to be exchanged between ground stations and the airplane. Messages divide in two groups:

- Addressed to or by crewmembers: data link requests or free text reports;
- Automatically sent: reports of flight data, performance data and routine events.

Communication to ground stations are made through VDR 3 channel. MCDU provides interface with ACARS applications to crewmembers.
ACARS applications are:

**AIR TRAFFIC SERVICE APPLICATIONS**

- **ATIS (Air Traffic Information Service)** Reports application enables the flight crew to send a downlink message requesting an uplink report that may be a specific airport information or an en route information,
- **Departure Clearance Application** is used to request a departure clearance through character-oriented messages instead of voice communication,
- **Expected Taxi Clearance** is used to request a taxi clearance through character-oriented messages instead of voice communication,
- **Flight System Message Application** is used to display unsolicited uplink messages that provide additional information then that provide in an Oceanic or Departure Clearance,
- **Oceanic Clearance Application** makes the oceanic clearance request through character-oriented messages instead of voice communication,
- **Pushback Clearance** is used to request a pushback clearance through character-oriented messages instead of voice communication,
- **TWIP (Terminal Weather Information for Pilots)** provides meteorological information to the flight crew.

**AIRLINE OPERATIONAL COMMUNICATIONS APPLICATIONS (AOC)**

The airline may customize AOC applications supported by CMF using a ground-based tool. Examples of AOC applications are:

- **Flight Initialization**, 
- **Free Text**, 
- **Weather Request**, 
- **Out, Off, On and In events** (OOOI events) are automatic reports sent to the airline operations control. Both reports and trigger events are configurable by the airline. Examples are:
  - **Out events** - doors closed, brakes released, etc,
  - **On events** - landing,
  - **Off events** - take off,
  - **In events** - gate arrivals.
ACARS WINDOW PAGES

Pushing the DLK button brings up CMF MAIN MENU page. Further access to other pages is provided through the LSK on MCDU. Although the AOC pages may be configured by the airline, the scheme below shows a basic AOC with most common functions required by airlines.

ACARS MAIN MENU

| 1L | < PRE FLT | NEW MSGS | 1R |
| 2L | < IN FLT | MSGS SENT | 2R |
| 3L | < POST FLT | MSGS RCVD | 3R |
| 4L | < FREE TEXT | VOX CONTACT | 4R |
| 5L | < FLT TIMES | STATUS | 5R |
| 6L | < SYS MENU | ATS MENU | 6R |
ACARS NAVIGATION WINDOWS

ATS MENU LSK 6R

SYS MENU LSK 6L

MAIN MENU

PRE FLT LSK 1L

IN FLT LSK 2L

POST FLT LSK 3L

FREE TEXT LSK 4L

FLT TIMES LSK 5L

NEW MSGS LSK 1R

MSGS SENT LSK 2R

MSGS RCVD LSK 3R

VOX CONTACT LSK 4R

REAL TIME LSK

COMMANDS LSK

DATA LSK
7. PRINTER

The airplane is equipped with a full-format thermal line printer device installed in the cockpit on control pedestal. DC BUS 1 powers the printer whereas a CB located in the cockpit Circuit Breaker Panel furnishes electrical protection.

The flight crew accesses printer via MCDU by CMF during all flight phases. On ground, maintenance personnel accesses printer via MFD 2 to print maintenance reports. CMF and CMC communicate with the printer via the LAN BUS.

The printer provides a self test which, in case of failure, illuminates the printer fault indicator in conjunction with printer test indicator. The Fault light also illuminates when printer door is open or paper out is sensed.

### EICAS MESSAGES

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAUTION</td>
<td>NAVCOM 1 (2) FAIL</td>
<td>All functions hosted in associated MRC are unavailable.</td>
</tr>
<tr>
<td></td>
<td>NAVCOM 1 (2) OVHT</td>
<td>MRC NIM has suffered an over temperature condition.</td>
</tr>
<tr>
<td></td>
<td>VALIDATE CONFIG</td>
<td>Top level system part number was updated.</td>
</tr>
<tr>
<td></td>
<td>VHF 1 (2) (3) OVHT</td>
<td>VHF COM has suffered an over temperature condition.</td>
</tr>
<tr>
<td></td>
<td>VHF 3 FAIL</td>
<td>Radio 3 COM function has failed.</td>
</tr>
<tr>
<td>ADVISORY</td>
<td>CMC FAIL</td>
<td>CMC has failed.</td>
</tr>
<tr>
<td></td>
<td>CMF 1 (2) FAIL</td>
<td>The respective CMF has failed.</td>
</tr>
<tr>
<td></td>
<td>XPDR 1 (2) FAIL</td>
<td>MRC 1 (2) has detected a transponder failure.</td>
</tr>
<tr>
<td>STATUS</td>
<td>PRINTER FAULT</td>
<td>Printer functionality is degraded.</td>
</tr>
</tbody>
</table>
EMBRAER 190

Powerplant
Two wing-mounted General Electric CF34-10E engines produce power to the EMBRAER 190. The General Electric CF34-10E is a high-bypass and dual rotor turbofan, fully integrated with a nacelle and thrust reverse. The N1 and N2 rotors are mechanically and independently operated. The engine is controlled via a dual channel FADEC system providing flexible engine operation and reduced workload. Engine indications and alerts are displayed on the Engine Indications and Crew Alerting System (EICAS).
ENGINE SCHEMATIC
## CONTROLS AND INDICATIONS

### 1. CONTROL PEDESTAL

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>THRUST LEVER DETENTS :</td>
</tr>
<tr>
<td></td>
<td>- <strong>MAX</strong> : provides the maximum thrust rating available for dual - or single - engine operation.</td>
</tr>
<tr>
<td></td>
<td>- <strong>TO/GA</strong> : selects takeoff, maximum continuous, and go-around mode settings.</td>
</tr>
<tr>
<td></td>
<td>- <strong>IDLE</strong> : selects flight idle, approach idle, final approach idle and ground idle thrust settings.</td>
</tr>
<tr>
<td></td>
<td>- <strong>MIN REV</strong> : provides minimum reverse thrust.</td>
</tr>
<tr>
<td></td>
<td>- <strong>MAX REV</strong> : provides maximum reverse thrust. The thrust lever must be pulled against a spring to achieve the MAX REV position. If the thrust lever is released it goes back to MIN REV position.</td>
</tr>
<tr>
<td></td>
<td><strong>NOTE</strong>: Positioning the thrust lever between the thrust control quadrant detents selects intermediate thrust settings.</td>
</tr>
<tr>
<td>②</td>
<td>THRUST REVERSER TRIGGER :</td>
</tr>
<tr>
<td></td>
<td>- Pulling the thrust reverser trigger, allows commanding of thrust levers from IDLE to MAX REV, thus providing reverser activation on the ground,</td>
</tr>
<tr>
<td></td>
<td>- For TO/GA and A/T DISC buttons descriptions, refer to B12-22 - Automatic Flight Control.</td>
</tr>
</tbody>
</table>
2. FIRE HANDLE

The Fire Handle, located on the Fire Protection Control Panel, enables emergency engine shutdown. For further information on fire protection system controls, refer to B12-26 - Fire Protection.
## 3. ENGINE CONTROL PANEL

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>START/STOP SELECTOR KNOB:</strong></td>
</tr>
</tbody>
</table>
| ①   | - **STOP**: commands the FADEC to shut down the engine, provided the associated thrust lever is in the IDLE position.  
    | - **RUN**: normal position for engine operation.                            |
|     | - **START**: (momentary action) : initiates the engine start sequence.       |
|     | **IGNITION SELECTOR KNOB:**                                                 |
| ②   | - **OFF**: deactivates the ignition system. FADEC disregards OFF position in flight.  
    | - **AUTO**: FADEC automatically controls the ignition system, depending on engine requirements.  
    | - **OVRD**: enables FADEC to continuously activate both exciters when the engine is running. |

### CONTROL PEDESTAL

![Engine Control Panel Diagram](image-url)

**ENGINE CONTROL PANEL**
## 4. EICAS INDICATION

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| 1  | THRUST REVERSER INDICATION :  
- Indicates the thrust reverser position.  
- Label : REV  
  - GREEN : fully deployed.  
  - AMBER : in transition.  
  - RED : discrepancy between selected and actual reverser positions. |
| 2  | N1 INDICATION :  
- Digital Indication : Displays the percentage of N1 RPM :  
  - GREEN : normal operating range.  
  - RED : operating limit exceeded.  
  - AMBER DASHED : invalid information or value out of displayable range.  
- Quantity Scale/Pointer :  
  - The pointer on the scale indicates a value equal to that shown on the digital readout.  
  - Scale :  
    - GREEN : normal operating range.  
    - RED : operating limit exceeded.  
  - The amber boxed FAIL indication is displayed on the center of the N1 dial when an engine has been flamed out or shut down without pilot action. The cyan OFF indication is displayed when the engine is shut down in flight by pilot action. |
| 3  | N1 WING ANTI-ICE CYAN LINE :  
- Set only in icing conditions during final approach (radio altimeter below 1200 ft) with landing gear down or flaps extended,  
- Indicates the minimum thrust level (N1 value) to meet bleed requirements. |
| 4  | N1 TARGET INDICATION :  
- Maximum N1 for the engine thrust rating mode indicated on EICAS,  
- If the requested value is invalid, the digits will be removed from the display,  
- A cyan V-shaped bug represents the N1 target on the dial indicator,  
- Digits :  
  - CYAN : normal indication.  
  - AMBER DASHED : invalid information or value out of displayable range. |
| 5  | THRUST RATING MODE INDICATION :  
- Indicates the current thrust-rating mode. Indications are displayed in cyan,  
- Label: TO-1, TO-2, TO-3, TO-1 RSV, TO-2 RSV, TO-3 RSV, FLEX TO-1, FLEX TO-2, FLEX TO-3, CLB-1, CLB-2, CON, CRZ, GA or GA-RSV. |
<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6  | ATTCS INDICATION:  
- An ATTCS indication is displayed to indicate the Automatic Takeoff Thrust Control System status.  
- Label: ATTCS  
  - GREEN: armed.  
  - WHITE: enabled.  
  - BLANK: not selected. |
| 7  | ASSUMED TEMPERATURE INDICATION:  
- Displays the temperature set on the MCDU. This indication is also used as a reference for flexible thrust. |
| 8  | N1 REQUEST INDICATION:  
- Indicates the momentary difference (transient) between actual N1 and requested N1 applied by thrust lever position (TLA). |
| 9  | MAXIMUM N1 INDICATION:  
- Green tickmark.  
- Indicates the maximum allowable N1 (maximum thrust) for the current thrust rating and operating conditions. If the thrust lever is set to MAX position, the N1 Request value will be equal to the Maximum N1 value. |
| 10 | N1 RED LINE:  
- Indicates the N1 limit.  
- The digital and dial readout colors change if this value is exceeded. |
| 11 | INTERTURBINE TEMPERATURE INDICATION:  
- Quantity Scale/Pointer:  
  - The pointer on the scale indicates a value equal to that shown on the digital readout.  
  - Scale:  
    - GREEN: normal operating range.  
    - RED: operating limit exceeded.  
  - AMBER dashes will display on digital readout when an invalid information or a value out of displayable range is available.  
  - A red fire warning indication is displayed on the center of ITT dial to indicate engine fire condition. |
| 12 | ITT RED/AMBER LINE:  
- Maximum allowable ITT.  
- Limits thrust, thereby avoiding the maximum allowable ITT to be exceeded.  
- The red line will change to amber after the end of the takeoff phase. The red line will be shown in flight if the ITT goes above the CON thrust rating limit. |
<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>IGNITION CHANNEL INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Indicates the enabled ignition channel.</td>
</tr>
<tr>
<td></td>
<td>- Colors :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : IGN A, IGN B or IGN AB.</td>
</tr>
<tr>
<td></td>
<td>• CYAN : IGN OFF.</td>
</tr>
<tr>
<td></td>
<td>- A WML icon is displayed whenever the FADEC has detected an engine flameout and the autorelight system is actuating to restart the engine. It is also displayed whenever an assisted start is commanded.</td>
</tr>
<tr>
<td>14</td>
<td>N2 INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Digital Indication.</td>
</tr>
<tr>
<td></td>
<td>- Displays the percentage of N2 RPM :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : normal operating range.</td>
</tr>
<tr>
<td></td>
<td>• RED : operating limit exceeded.</td>
</tr>
<tr>
<td></td>
<td>• AMBER DASHED : invalid information or value out of displayable range.</td>
</tr>
<tr>
<td>15</td>
<td>FUEL FLOW INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Indicates fuel flow in kilograms per hour (KPH) or pounds per hour (PPH).</td>
</tr>
<tr>
<td></td>
<td>- Digit colors :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : normal indication.</td>
</tr>
<tr>
<td></td>
<td>• AMBER DASHED : invalid information or value out of displayable range.</td>
</tr>
<tr>
<td>16</td>
<td>OIL PRESSURE INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Indicates the engine oil pressure.</td>
</tr>
<tr>
<td></td>
<td>- Digit colors :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : normal operating range.</td>
</tr>
<tr>
<td></td>
<td>• AMBER : cautionary operating range.</td>
</tr>
<tr>
<td></td>
<td>• RED : operating limit exceeded.</td>
</tr>
<tr>
<td></td>
<td>• AMBER DASHED : invalid information or value out of displayable range.</td>
</tr>
<tr>
<td>17</td>
<td>OIL TEMPERATURE INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Indicates the engine oil temperature.</td>
</tr>
<tr>
<td></td>
<td>- Digit colors :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : normal operating range.</td>
</tr>
<tr>
<td></td>
<td>• AMBER : cautionary operating range.</td>
</tr>
<tr>
<td></td>
<td>• AMBER DASHED : invalid information or value out of displayable range.</td>
</tr>
<tr>
<td>18</td>
<td>ENGINE VIBRATION INDICATION :</td>
</tr>
<tr>
<td></td>
<td>- Indicates low-pressure (LP) and high-pressure (HP) vibration levels for both engines.</td>
</tr>
<tr>
<td></td>
<td>- Digit colors :</td>
</tr>
<tr>
<td></td>
<td>• GREEN : normal operating range  (0 to 3.9)</td>
</tr>
<tr>
<td></td>
<td>• AMBER : cautionary operating range (4.0 to 5.0).</td>
</tr>
<tr>
<td></td>
<td>• AMBER DASHED : invalid information or value out of displayable range.</td>
</tr>
</tbody>
</table>
## 5. STATUS PAGE - MFD

<table>
<thead>
<tr>
<th>N°</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| ① | OIL LEVEL INDICATION:  
- GREEN: normal operating range.  
- AMBER: cautionary operating range.  
  - AMBER dashes will display on digital readout when an invalid information or a value out of displayable range is available. |

### ENGINE OIL LEVEL INDICATION ON MFD

![MFD Diagram]

![Engine Oil Level MFD Display]

- **ENG OIL LEVEL:**
  - Green range: Normal operating range.
  - Amber range: Cautionary operating range.
  - Amber dashes displayed when invalid information or value out of displayable range.

- **Measurement:**
  - 6.5 QT
  - 2.4 QT

---

Note: Illustrations and diagrams are meant for training purposes and should be used accordingly. For actual operations, consult the aircraft manufacturer's manual and adhere to all safety guidelines.
ENGINE FUEL SYSTEM

1. GENERAL
The engine fuel system provides fuel pressurization, filtering, heat exchange and operation of engine vanes and bleed valves.

2. FUEL PUMP
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.

3. FUEL/OIL HEAT EXCHANGER
The fuel-cooled oil cooler (FCOC) maintains the oil temperature within an acceptable range and heats the engine fuel to prevent freezing.

4. FUEL METERING UNIT (FMU)
The FMU, controlled by the FADEC, meters and distributes the proper amount of fuel for combustion to the injectors under all operating conditions. The FMU controls the shutoff valve used during all normal shutdowns and provides overspeed protection.

5. FUEL FILTER
The fuel filter removes contaminants from the engine fuel. The impending bypass switch indicates fuel filter blockage and an imminent bypass condition.

6. VARIABLE STATOR VANES
The Variable Stator Vanes system consists of two fuel driven actuators controlled by the FADEC via FMU.

The purpose of the actuators is to optimize the position of the compressor stators as a function of corrected N2 to provide optimum compressor efficiency.

7. FUEL INJECTORS
The fuel injectors atomize the fuel from the FMU and direct it into the combustion chamber.
LUBRIFICATION SYSTEM

Each engine has an independent lubrication system.
The oil system lubricates and cools the turbine engine main shaft bearings and the accessory gearbox.
Oil is pressurized in the lubrication pump, passes through the filter, passes through the fuel-oil heat exchanger and is then divided into several circuits to lubricate the engine.

1. OIL TANK
Oil quantity indication is provided for each engine oil tank and is displayed on the MFD.
Sensors in the tank detect low oil quantity and trigger the low oil level caution whenever this occurs.

2. OIL PUMPS
The pump will provide oil flow any time the core engine is turning.
The pump contains five pumping elements, one supply and four scavenge elements.
The lube and scavenge pumps delivers oil under pressure to the engine bearings and gears, and then recovers the oil to the tank for reuse.

3. OIL FILTER
Oil filter module incorporates a filter bypass and cold start relief valve.
The oil filter bypass valve permits oil flow if the filter becomes clogged. The filter impending bypass switch monitors the differential pressure at the filter.
The filter module has a relief valve to bypass high viscosity oil during cold start conditions.
1. STARTING SYSTEM
The engine starting system comprises:

- Air turbine starter (ATS),
- Starter air valve (SAV).

The pneumatic system provides bleed air to increase rotor speed and start the engine cycle.

The FADEC opens the Starter Air Valve (SAV), providing bleed air from the APU, a ground source, or the opposite engine. The Air Turbine Starter (ATS) is a turbine that accelerates the engine to a self-sustaining RPM level.

The FADEC closes the SAV when the starter cutout speed is reached.

2. IGNITION SYSTEM
The ignition system provides an electrical spark for fuel combustion during on ground engine starts, in flight starts, in flight auto-relights, and when the ignition selector knob is set to OVRD position.

The FADEC energizes one igniter for on ground engine starts and both igniters for in flight engine starts.

Setting the ignition selector knob to OVRD position provides means to keep both igniters energized. Igniters 1B and 2B are connected to SPDA 2. In case of SPDA 2 failure, setting the selector knob to OVRD energizes at least the igniter A.

3. STARTER OPERATION
The engine starter is controlled via the engine start selector knob on the powerplant control panel. For on ground starts, the SAV opens providing bleed air to increase rotor speed.

4. GROUND START
The FADEC initiates ignition at approximately 7% N2 and the fuel flow (Metering valve opens) at approximately 20% N2. After a light off occurs, the FADEC commands the starter to cutout at approximately 50% N2, and controls the FMU fuel metering valve to accelerate the engine to ground idle.

5. IN FLIGHT START
Engine cross-bleed air, APU bleed air, or windmilling can be used for in flight engine starts.

An in flight cross-bleed start is identical to an on ground start, but the FADEC automatically controls fuel flow to begin (Metering valve opens) if N2 has not reached 15% after 15 seconds.

For windmill starting, the SAV configures the pneumatic system. The engine start is controlled by the START/STOP selector knob and the FADEC controls ignition at 7% N2 and fuel flow at a minimum of 7.2% N2, or after 15 seconds, whichever occurs first.

The FADEC has no protection for hot starts or hung starts for in flight engine starts.

6. AUTO RELIGHT
The FADEC monitors N2 and automatically turns on both igniters and schedules the relight fuel flow in the event of an engine flameout. In addition a WML icon is displayed next to the respective engine N2 and represents an auto relight actuation during the engine auto relight attempts.

If the engine relight does not occur within 30 seconds or N2 falls below 7.2 %, the automatic relight can be considered unsuccessful and should be manually terminated by moving the START/STOP selector knob to the STOP position.

During ground operations, auto relight attempts are terminated and fuel is shutoff if the engine RPM falls below 52 percent N2.
THrust Reverser System

The Thrust Reverser System is hydraulically actuated and controlled from the cockpit via the thrust lever.

Thrust reverses 1 & 2 operate independently, and are actuated by the respective hydraulic system.

The FADEC provides an interlock function to protect against inadvertent thrust reverser deployment and also to protect against inadvertent thrust reverser stowing.

A locking system consists of two actuator locks and the independent cowl lock. The cowl lock prevents inadvertent deployment of the thrust reverser.

1. REVERSER OPERATION

Moving the thrust lever to Idle enables the lifting of the Thrust Reverser Trigger. Moving the thrust lever to the reverse position commands thrust reverser deployment.

Thrust reverser deployment occurs only if the airplane is on the ground. The thrust reverser trigger can be lifted up to 30 seconds after an engine inoperative condition is detected. After 30 seconds the engine inoperative condition does not release the thrust reverse trigger, so the respective thrust lever cannot be moved to reverse position.

The IDLE REV thrust is commanded until the thrust reverser cowls are not totally deployed, after total deployment the MAX REV is commanded if thrust levers are held in MAX REV position.

The thrust reverser is not designed to operate in flight. Uncommanded thrust reverser deployment limits engine thrust to idle.
ENGINE CONTROL SYSTEM

The engine control system performs engine control and thrust management, providing information to the cockpit, maintenance reporting and engine condition monitoring.

The FADEC manages the engine control system, monitoring the inputs from the airplane and engine. These inputs control the thrust management from the Thrust Lever Angle and Air Data.

The T2 sensor provides engine inlet air temperature for use in FADEC control calculations.

The N1 Fan Speed Sensor provides N1 data for the FADEC and airplane vibration monitoring system.

1. FULL AUTHORITY DIGITAL ELECTRONIC CONTROL (FADEC)

The FADEC controls the operation, performance and efficiency characteristics of the engine through full authority control over the engine fuel metering unit, variable stator vanes, operability bleed valve, T2 sensor heater, thrust reverser actuation, engine starting, ignition and also providing engine limit protection during ground starts.

Fan speed is the parameter used to set engine thrust. The FADEC controls fan speed for the necessary thrust based on pressure altitude, temperature and Mach number.

The FADEC has two identical isolated channels. During operation with two capable FADEC channels, the software logic will alternate the channel in control of each engine start.

One FADEC channel operates as the in-control channel and provides electronic control outputs. The other channel operates as standby and processes all inputs and software, taking control upon a failure of the active channel. Built in test features shutdown of a channel whenever a critical internal components malfunction is detected.

The FADEC is primarily powered by the Permanent Magnet Alternator (PMA) above approximately 50% N2. Below this value or in case the PMA becomes inoperative, the airplane’s electrical system provides the required backup power.

2. AUTOMATIC TAKEOFF THRUST CONTROL SYSTEM (ATTCS)

The ATTCS, controlled by the FADEC, automatically provides maximum engine thrust reserve (RSV) according to the current rate (TO-1, TO-2, TO-3, FLEX TO-1, FLEX TO-2, FLEX TO-3 and GA) previously selected on the Takeoff Data Set page on the MCDU.

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.

Even if ATTCS is selected OFF for takeoff, it will be armed automatically during go-around mode.

The ATTCS automatically commands RSV whenever it is armed, thrust levers are at TOGA position, and one of following conditions occurs:

- Difference between both engine N1 values is greater than 15%;
- One engine failure during takeoff;
- One engine failure during go-around;
- Windshear detection.

Whenever the ATTCS is activated, the green ATTCS indication on the EICAS disappears and the cyan thrust mode will be displayed with an additional "RSV" indication.
2.1. ATTCS LOGIC TABLE

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PHASE OF FLIGHT</th>
<th>ATTCS STATUS</th>
<th>THRUST LEVER SET</th>
<th>ENGINE THRUST</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Engine Failure</td>
<td>Takeoff</td>
<td>ATTCS ON</td>
<td>TOGA</td>
<td>TO-x RSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAX</td>
<td>TO-x RSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATTCS OFF</td>
<td>TOGA</td>
<td>No Thrust Increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAX</td>
<td>TO-x</td>
</tr>
<tr>
<td>Go-Around</td>
<td>ATTCS ON</td>
<td>TOGA</td>
<td>GA RSV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAX</td>
<td>GA RSV</td>
<td></td>
</tr>
<tr>
<td>Windshear</td>
<td>Takeoff</td>
<td>ATTCS ON</td>
<td>TOGA</td>
<td>TO-x RSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAX</td>
<td>GA RSV</td>
</tr>
<tr>
<td></td>
<td>ATTCS OFF</td>
<td>TOGA</td>
<td>No Thrust Increase</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAX</td>
<td>GA RSV</td>
<td></td>
</tr>
<tr>
<td>Go-Around</td>
<td>ATTCS ON</td>
<td>TOGA</td>
<td>GA RSV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAX</td>
<td>GA RSV</td>
<td></td>
</tr>
</tbody>
</table>

3. FLEXIBLE TAKEOFF
Flexible takeoff is a reduced takeoff thrust based on assumed temperature. The assumed temperature is set on the MCDU takeoff page. The FADEC determines flexible takeoff rates for any of three possible takeoff modes, reducing the takeoff thrust based on assumed temperature set on the FMS.

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 25% maximum rated takeoff thrust. Deselecting the ATTCS on the MCDU does not change the flex reduction limit.

4. ENGINE N1
The N1 indicates the engine thrust based on Fan speed.

The N1 "target" is the maximum thrust available in any given mode of operation and is obtained considering fan inlet temperature, pressure, altitude, and engine bleed configuration.

The N1 "Rating" is the maximum N1 value for the current engine thrust mode.

The N1 "Request" is the N1 value requested based on the current TLA position. FADEC may limit the N1 Request value for some conditions, such as during thrust reverser operation.
5. ENGINE THRUST RATINGS

Engine thrust ratings are controlled by the FADEC, which automatically provides the required thrust rating for engine operation.

The thrust rate modes are the following:

- Takeoff (TO-1, TO-2, TO-3),
- Takeoff Reserve (TO-1 RSV, TO-2 RSV, TO-3 RSV),
- Go-Around (GA),
- Go Around Reserve (GA-RSV),
- Maximum Continuous Thrust (CON),
- Maximum Climb (CLB-1, CLB-2),
- Maximum Cruise (CRZ),
- Idle.

5.1. TAKEOFF (TO-1, TO-2, TO-3)

TO-1 is the highest thrust rating available with all engines operating normally considering the thrust levers at TOGA position.

The takeoff modes are designated as TO-1, TO-2 or TO-3.

TO-1, TO-2 and TO-3 are limited to 5 minutes during the takeoff phase.

5.2. MAXIMUM TAKEOFF RESERVE (TO-1 RSV, TO-2 RSV, TO-3 RSV)

The maximum takeoff reserve (TO-1 RSV, TO-2 RSV, TO-3 RSV) is the highest thrust rating available according to the TO rate selected. TO-1 RSV, TO-2 RSV and TO-3 RSV are limited to 5 minutes during the takeoff phase.

5.3. GO-AROUND (GA)

The GA mode is the highest thrust rating available with all engines operating normally considering the thrust levers at TOGA position during a go-around. The GA mode is limited to 5 minutes during the go-around phase.

5.4. GO-AROUND RESERVE (GA-RSV)

The GA-RSV is the highest thrust rating available considering the thrust lever at TOGA, one engine inoperative or windshear detected.

Even with dual engine operation, advancing the thrust levers to the MAX position during go-around mode can also provide GA-RSV. The GA-RSV is limited to 5 minutes during the go-around phase.

5.5. MAXIMUM CONTINUOUS RATING (CON)

The maximum continuous rating is the maximum thrust rating available for continuous dual or single engine operation.
5.6. MAXIMUM CLIMB RATING (CLB-1, CLB-2)

Maximum Climb rating is the maximum thrust rating for climb operation. Climb modes are designated as CLB-1 and CLB-2.

The Maximum Climb rating does not have a fixed thrust levers position. It is selectable through thrust lever adjustments between the IDLE and TOGA positions, or even manually selecting (CLB-1 or CLB-2) on the MCDU.

5.7. MAXIMUM CRUISE RATING (CRZ)

Maximum Cruise is the maximum thrust for cruise operations with all engines operating and is not subject to time-limited operation. The Maximum Cruise (CRZ) thrust ratings does not have a fixed TLA position. It is selectable through thrust lever adjustments between the IDLE and CLB positions.

5.8. IDLE

The idle mode selections are the following:

- Flight Idle,
- Approach Idle,
- Final Approach Idle,
- Ground Idle.

Automatic selection between IDLE modes is accomplished by the FADEC based on inputs from the airplane.

5.8.1. FLIGHT IDLE

The engine offers the minimum necessary thrust to provide minimum engine bleed pressure to the airplane. Flight Idle fan speed varies with altitude and can change as a function of ECS bleed, and anti-ice bleed requirements. The flight idle mode is activated as follows:

- Weight off wheels,
- Approach idle not selected.

5.8.2. APPROACH IDLE

Approach Idle is used in flight to enable rapid acceleration to go-around thrust. Approach idle is activated as follows:

- Weight off wheels,
- The approach mode set (flaps 1 or greater or landing gear down and locked),
- Altitude less than 15000 ft.

5.8.3. FINAL APPROACH IDLE

The FADEC sets the Final Approach Idle for altitudes lower than 1200 ft and approach mode configuration. When in Final Approach Idle the FADEC considers anti-ice off, regardless of the actual anti-ice system status.
5.8.4. GROUND IDLE

Ground Idle is the minimum thrust setting. Ground Idle provides a stable and minimum engine thrust level for ground operations.

5.9. MINIMUM REVERSE

Min reverse is the minimum reverse thrust available with the thrust lever set in the MIN REVERSE position.

5.10. MAX REVERSE

Max reverse is the maximum reverse thrust available with the thrust lever set in the MAX REVERSE position.

5.11. THRUST RATINGS TABLE

<table>
<thead>
<tr>
<th>Ratings</th>
<th>Thrust (lbf)</th>
<th>Thrust (lbf)</th>
<th>Thrust (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CF34-10E5A1</td>
<td>CF34-10E5</td>
<td>CF34-10E2</td>
</tr>
<tr>
<td>Thrust Mode</td>
<td>All Engine</td>
<td>One Engine</td>
<td>All Engine</td>
</tr>
<tr>
<td>T/O-1</td>
<td>ON</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>18500</td>
<td>18500</td>
</tr>
<tr>
<td>T/O-2</td>
<td>ON</td>
<td>17100</td>
<td>18500</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>17100</td>
<td>17100</td>
</tr>
<tr>
<td>T/O-3</td>
<td>ON</td>
<td>15450</td>
<td>17100</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>15450</td>
<td>15450</td>
</tr>
<tr>
<td>GA</td>
<td>ON</td>
<td>16650</td>
<td>18500</td>
</tr>
<tr>
<td>CON</td>
<td>-</td>
<td>16255</td>
<td>16255</td>
</tr>
<tr>
<td>CLB-1</td>
<td>-</td>
<td>15950</td>
<td>-</td>
</tr>
<tr>
<td>CLB-2</td>
<td>-</td>
<td>14020</td>
<td>-</td>
</tr>
<tr>
<td>CRZ</td>
<td>-</td>
<td>13830</td>
<td>-</td>
</tr>
</tbody>
</table>

*NOTE*: - Thrusts values for sea level and ISA conditions.
- Engines with flat rated temperature up to ISA+15°C.
### Thrust Values

**NOTE:**
- Thrust values for sea level and ISA conditions.
- Engines with flat rated temperature up to ISA+20°C.

<table>
<thead>
<tr>
<th>Thrust Mode</th>
<th>CF34-10E6A1</th>
<th>CF34-10E6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thrust Mode</td>
<td>ATTCS</td>
</tr>
<tr>
<td>T/O-1</td>
<td>ON</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>18500</td>
</tr>
<tr>
<td>T/O-2</td>
<td>ON</td>
<td>17100</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>17100</td>
</tr>
<tr>
<td>T/O-3</td>
<td>ON</td>
<td>15450</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>15450</td>
</tr>
<tr>
<td>GA</td>
<td>ON</td>
<td>16650</td>
</tr>
<tr>
<td>CON</td>
<td>-</td>
<td>16255</td>
</tr>
<tr>
<td>CLB-1</td>
<td>-</td>
<td>15950</td>
</tr>
<tr>
<td>CLB-2</td>
<td>-</td>
<td>14020</td>
</tr>
<tr>
<td>CRZ</td>
<td>-</td>
<td>13830</td>
</tr>
</tbody>
</table>
6. TAKEOFF DATASET

In the T/O DATASET MENU, on the MCDU, the flight crew may set the TO thrust rate mode, the TO temperature, the ATTCS ON or OFF, and assumed temperature for flexible takeoff.

If the FADEC does not receive a FLEX TEMP from the MCDU or receives a value lower than the TO TEMP, the FADEC will not perform a flex takeoff.

The T/O dataset is performed according to the sequence:

- Press MENU (mode button),
- Press MISC (line select key - 1L) on MENU page,
- Press THRUST MGT (line select key - 1R) on MISC MENU page,
- Press TO DATA SET (line select key - 6R) on THRUST RATING SELECT page.

7. ENGINE PROTECTION

7.1. FADEC ENGINE PROTECTION

The FADEC provides engine start protection on the ground as follows:

- Hung start,
- Hot start,
- No light-off.

Hung and hot start protections are inhibited in the air.
7.2. OVERSPEED PROTECTION

The FADEC monitors N2 and provides overspeed protection. Whenever N2 reaches 101% the FADEC automatically commands an engine shutdown.

In the event of three consecutive overspeed detection events within 30 seconds the FADEC will not relight the engine.

7.3. OVERTEMPERATURE PROTECTION

The FADEC will not allow fuel flow if ITT is above 120°C during ground start. In this case a dry motoring will be performed automatically and the fuel flow is commanded with ITT below 120°C.

ITT limit is variable according to the engine operation phase.
### EICAS MESSAGES

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WARNING</strong></td>
<td>ENG 1 (2) OIL LO PRESS</td>
<td>Engine 1 (2) oil pressure is low.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) REV DEPLOYED</td>
<td>Thrust reverser deployed unexpectedly, or not stowed when ordered to stow or thrust reverser position is undetermined.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) CONTROL FAULT</td>
<td>Thrust modulate is unenabled. OBV has failed open or engine will respond slowly.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) FADEC OVERTEMP</td>
<td>FADEC overtemperature has been detected.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) FAIL</td>
<td>Engine 1 (2) shutdown has occurred.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) FUEL IMP BYPASS</td>
<td>Fuel filter impending bypass.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) FUEL LO PRESS</td>
<td>Engine 1 (2) Fuel pressure low. Airplane backup fuel pump will be activated.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) NO DISPATCH</td>
<td>No dispatch condition detected by FADEC.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) OIL LO LEVEL</td>
<td>Engine 1 (2) oil level is below minimum.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) REV FAIL</td>
<td>Thrust Reverser is not available.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) REV PROT FAULT</td>
<td>Reverser fault detected, operation not inhibited.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) REV TLA FAIL</td>
<td>Respective reverser solenoid protection has failed.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) START VLV OPEN</td>
<td>Start valve not closed while engine running.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) T2 HEAT FAIL</td>
<td>T2 heater failed.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) TLA FAIL</td>
<td>Dual thrust lever angle sensor failure.</td>
</tr>
<tr>
<td></td>
<td>ENG EXCEEDANCE</td>
<td>In flight engine limit exceedance detected.</td>
</tr>
<tr>
<td></td>
<td>ENG NO TAKEOFF DATA</td>
<td>Takeoff data not entered successfully. Discrepancy between information entered in FMS for engine 1 and 2 detected.</td>
</tr>
<tr>
<td></td>
<td>ENG REF A-I DISAG</td>
<td>Ice protection mode selector knob set to the ON position with OFF or ENG in the take-off data set (TDS) menu.</td>
</tr>
<tr>
<td></td>
<td>ENG REF ECS DISAG</td>
<td>Discrepancy between REF ECS input and actual ECS bleed configuration.</td>
</tr>
<tr>
<td></td>
<td>ENG THR RATING DISAG</td>
<td>Discrepancy between maximum thrust rating of engines 1 and 2. Possible asymmetric engine thrust.</td>
</tr>
<tr>
<td></td>
<td>ENG TLA NOT TOGA</td>
<td>TLA not at TO/GA position during takeoff and/or go-around phases.</td>
</tr>
<tr>
<td>TYPE</td>
<td>MESSAGE</td>
<td>MEANING</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ADVISORY</td>
<td>ENG 1 (2) FADEC FAULT</td>
<td>One FADEC channel no longer sending data.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) FUEL SW FAIL</td>
<td>Fuel pressure switch indicates pressure is not low while all fuel pumps are off.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) OIL IMP BYPASS</td>
<td>Oil filter impending bypass.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) OIL SW FAIL</td>
<td>Oil impending bypass switch or oil pressure switch failure detected.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) SHORT DISPATCH</td>
<td>Short-time dispatch fault condition detected by FADEC.</td>
</tr>
<tr>
<td>STATUS</td>
<td>ENG 1 (2) REV INHIBIT</td>
<td>Reverser inhibited by maintenance action.</td>
</tr>
<tr>
<td></td>
<td>ENG 1 (2) TLA NOT IDLE</td>
<td>Thrust Lever Angle not set to idle position during either engine start or engine shutdown. A thrust higher than the expected will be reached if the TLA is above idle during engine start.</td>
</tr>
<tr>
<td></td>
<td>ENG TDS REF A-I ALL</td>
<td>REF A-I ALL is selected on take-off data set page on MCDU.</td>
</tr>
<tr>
<td></td>
<td>ENG TDS REF A-I ENG</td>
<td>Ice protection mode selector knob set to the AUTO position and REF A-I ENG is selected on take-off data set page on MCDU.</td>
</tr>
</tbody>
</table>
EMBRAER 190

Auxiliary Power Unit
INTRODUCTION

The Auxiliary Power Unit (APU) is a gas turbine engine located in the airplane tailcone, which provides pneumatic and electrical AC power. The pneumatic power is used for engine starting and to supply bleed air to the air conditioning packs of the Environmental Control System (ECS). An electrical AC generator supplies 115 Volts 40 KVA to the electrical system.

The APU is automatically monitored and controlled through a dedicated Full Authority Digital Electronic Control (FADEC) unit.
CONTROLS AND INDICATIONS

APU CONTROL PANEL

OVERHEAD PANEL

1 – APU SELECTOR KNOB (ROTARY ACTION)

OFF: normal position when the APU is not running.
ON: normal position when the APU is running.
START: (momentary action) initiates the APU start cycle.

NOTE: Moving this knob from ON to OFF effects the APU shutdown.
2 – APU EMERGENCY STOP BUTTON (GUARDED)

**PUSH IN:** closes the APU fuel shutoff valve, shutting down the APU with no cooldown period.

**PUSH OUT:** normal position, with the fuel shut off valve open.

**NOTE:** - In case of fire, the upper half of the button illuminates red.
- When pushed in, a white striped bar illuminates on the lower half of the button.

EICAS INDICATION

1 – APU RPM INDICATION
- Displays the APU RPM (%).
  - **GREEN:** normal operating range.
  - **AMBER:** cautionary operating range.
  - **RED:** operating limit exceeded.

2 – APU EGT (EXHAUST GAS TEMPERATURE) INDICATION
- Displays the APU temperature in degrees Celsius (°C).
  - **GREEN:** normal operating range.
  - **AMBER:** cautionary operating range.
  - **RED:** operating limit exceeded.
APU FUEL SUPPLY

When DC power is the only electrical power available, the DC fuel pump, located in the right wing tank, feeds the APU. If AC power is available and the engine is not running, fuel feeding will be provided by the AC fuel pump.

When the engine is running, the ejector fuel pump feeds the APU from the right wing tank. However, it is also possible to feed the APU from the left wing tank via a crossfeed valve.

APU BLEED

The Air Management System (AMS) controls the operation of the APU and the engine bleed valves. The engine bleed valve has priority over the APU bleed valve. When the engine starting cycle is in progress, the APU bleed valve opens and the engine pack valves close. After engine starting, the APU bleed valve closes and the engine pack valves open.

APU OPERATION

A Full Authority Digital Electronic Control (FADEC) monitors and controls the start/shutdown sequence, fault detection and APU status. The flight crew controls the APU start/shutdown sequence, using the APU selector knob.

In an abnormal condition, the flight crew can shut down the APU through a dedicated emergency stop button.

The APU is able to supply:

- Electrical AC power up to 33000 ft.
- Bleed air for engine starting up to 21000 ft.
- Bleed air for air conditioning up to 15000 ft.

Maximum altitude for APU start is 30000 ft.
APU START

Rotating the APU master switch to ON powers the FADEC and APU fuel shutoff valve opens.

Rotating the APU selector knob from ON to START (momentary position), initiates the APU automatic starting cycle. In automatic starting cycle the FADEC commands the electronic starter controller to energize the brushless starter generator, initiating APU rotation.

Three seconds after APU speed has reached 95%, electrical and pneumatic loading are available. If the APU does not reach proper speed or acceleration rate within the starting cycle time, the APU will automatically shut down.

GROUND START

The FADEC initiates ignition at approximately 6% RPM and the fuel flow after 0.5 seconds. The battery #2 energizes the electronic starter controller. After a light off occurs, the FADEC commands the starter to cutout at approximately 50% RPM.

IN FLIGHT START

The FADEC initiates ignition at approximately 7% to 17% RPM and the fuel flow after 0.5 seconds. After a light off occurs, the FADEC commands the starter to cutout at approximately 50% RPM.

APU SHUTDOWN

NORMAL APU SHUTDOWN

Rotating the APU selector knob from ON to OFF initiates a normal APU shutdown, which is monitored and controlled by the FADEC. During a normal shutdown sequence, the APU pneumatic power is removed at once and the electrical power is removed at the end of a 2 minutes cooldown period. Only at the end of that period the EICAS message APU SHUTTING DOWN disappears.

For airplanes Post-Mod SB 170-49-0003 or SB 190-49-0001 (APU FADEC 02.00) or with an equivalent modification factory incorporated, the cooldown period is 1 minute, followed by a spooldown period. The EICAS message APU SHUTTING DOWN disappears at the end of spooldown period.

NOTE: Turning the APU selector knob back to ON position during the shutdown sequence cancels the shutdown.
EMERGENCY APU SHUTDOWN

In the event that the APU emergency stop button has been selected, the APU fuel shutoff valve closes and the APU shuts down without a two-minute cooldown period.

APU PROTECTION

The FADEC provides automatic APU shutdown protection on ground and in flight as follows. The appropriate EICAS message is displayed for each situation.

<table>
<thead>
<tr>
<th>On the ground</th>
<th>In flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overspeed</td>
<td>Overspeed</td>
</tr>
<tr>
<td>Underspeed</td>
<td>Underspeed</td>
</tr>
<tr>
<td>FADEC critical fault</td>
<td>FADEC critical fault</td>
</tr>
<tr>
<td>APU fire</td>
<td></td>
</tr>
<tr>
<td>APU EGT overtemperature</td>
<td></td>
</tr>
<tr>
<td>APU high oil temperature</td>
<td></td>
</tr>
<tr>
<td>APU low oil pressure</td>
<td></td>
</tr>
<tr>
<td>Sensor fail</td>
<td></td>
</tr>
</tbody>
</table>
APU START
Rotating the APU master switch to ON powers the FADEC and APU fuel shutoff valve opens.

Rotating the APU selector knob from ON to START (momentary position), initiates the APU automatic starting cycle. In automatic starting cycle the FADEC commands the electronic starter controller to energize the brushless starter generator, initiating APU rotation.

Three seconds after APU speed has reached 95%, electrical and pneumatic loading are available. If the APU does not reach proper speed or acceleration rate within the starting cycle time, the APU will automatically shut down.

GROUND START
The FADEC initiates ignition at approximately 6% RPM and the fuel flow after 0.5 seconds. The battery #2 energizes the electronic starter controller. After a light off occurs, the FADEC commands the starter to cutout at approximately 50% RPM.

IN FLIGHT START
The FADEC initiates ignition at approximately 7% to 17% RPM and the fuel flow after 0.5 seconds. After a light off occurs, the FADEC commands the starter to cutout at approximately 50% RPM.

APU SHUTDOWN
NORMAL APU SHUTDOWN
Rotating the APU selector knob from ON to OFF initiates a normal APU shutdown, which is monitored and controlled by the FADEC. During a normal shutdown sequence, the APU pneumatic power is removed at once and the electrical power is removed at the end of a 2 minutes cooldown period. Only at the end of that period the EICAS message APU SHUTTING DOWN disappears.

For airplanes Post-Mod SB 170-49-0003 or SB 190-49-0001 (APU FADEC 02.00) or with an equivalent modification factory incorporated, the cooldown period is 1 minute, followed by a spooldown period. The EICAS message APU SHUTTING DOWN disappears at the end of spooldown period.

NOTE: Turning the APU selector knob back to ON position during the shutdown sequence cancels the shutdown.