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Flight Control System EICAS Messages ...................... 9.30.1
Thrust Asymmetry Compensation and Primary Flight Computers Controls

1. Thrust Asymmetry Compensation (THRUST ASYM COMP) Switch
   - AUTO – the thrust asymmetry compensation system operates automatically if a thrust asymmetry condition is detected.
   - OFF – disconnects the thrust asymmetry compensation system from the flight control system.

2. Thrust Asymmetry Compensation OFF Light
   - Illuminated (amber) – the thrust asymmetry compensation system has been automatically or manually disconnected.

3. PRIMARY FLIGHT COMPUTERS Disconnect Switch
   - DISC –
     - disconnects the primary flight computers (PFCs) from the flight control system
     - puts the flight control system in the direct mode
     - AUTO can be reselected to attempt restoration of secondary or normal mode operation.
   - AUTO –
     - the flight control system operates in the normal mode
     - system faults automatically cause the system to switch to the secondary or direct modes.
4 PRIMARY FLIGHT COMPUTERS Disconnect (DISC) Light
Illuminated (amber) – the primary flight computers are disconnected automatically or manually and the system is in the direct mode.

Pitch and Stabilizer Trim Systems

Control Wheel and Column

1 Pitch Trim Switches
Spring–loaded to neutral.
Push (both switches) –
• in the normal mode in flight, changes the trim reference airspeed
• in the normal mode on the ground, moves the stabilizer
• in the secondary and direct modes, moves the stabilizer.

2 Control Wheel
Rotate – deflects the ailerons, flaperons, and spoilers in the desired direction.
Moves and remains displaced with aileron trim.

3 Control Column
Push/pull – commands the airplane to pitch in the desired direction:
• in the normal mode, deflects the elevator and horizontal stabilizer
• in the secondary and direct modes, deflects the elevator.
Does not move with pitch trim operation.
Stabilizer Trim System

1. Alternate (ALTN) PITCH TRIM Levers

   Spring–loaded to neutral.

   Push/pull (both levers) –
   
   • in the normal mode, changes trim reference airspeed and moves the stabilizer directly
   • in the secondary and direct modes, moves the stabilizer directly.

2. Stabilizer (STAB) Position Indicator

   Indicates stabilizer position in units of trim.
3 Takeoff Trim Green Band

The green band indicates the allowable takeoff trim range, based on gross weight, takeoff thrust, and CG information from the FMC. When no information is available, the green band defaults to midrange.

If the stabilizer signal is not present or is invalid, the green band and the pointer are not displayed.

4 Stabilizer (STAB) Cutout Switches

NORM –
- hydraulic power is supplied to the related stabilizer trim control module
- if unscheduled stabilizer motion is detected, center and/or right system hydraulic power to the related stabilizer trim control module is automatically shut off.

CUTOUT – shuts off the respective center or right hydraulic system power to the related stabilizer trim control module.

Aileron and Rudder Trim Controls

![Aileron Trim Control](image-url)
1 AILERON TRIM Indicator
Indicates units of aileron trim.

2 RUDDER TRIM Indicator
Indicates units of rudder trim.

3 AILERON Trim Switches
Push (both switches) – moves the control wheel, ailerons, flaperons, and spoilers in the desired direction (spring–loaded to neutral).

4 RUDDER Trim Selector
Spring–loaded to neutral.
Rotate –
- trims the rudder in the desired direction
- the trim runs at high speed with the knob rotated past the first left or right detent
- the rudder pedals move with rudder trim operation.

5 MANUAL TRIM CANCEL Switch
Push – cancels manual rudder trim in the normal and secondary flight control system modes.
Rudder/Brake Pedals

Rudder Pedals
Push – deflects the rudder in the desired direction.
Refer to Chapter 14, Landing Gear, for brakes and nosewheel steering description.
Speedbrake Lever

On the ground:

- the speedbrake lever moves to DOWN and all spoiler panels retract if either thrust lever is advanced to the takeoff thrust position
- the speedbrake lever moves to UP and all spoiler panels extend if either reverse thrust lever is raised to the reverse idle detent.

1 Speedbrake Lever

DOWN (detent) – all spoiler panels are retracted.

ARMED –

- the auto speedbrake system is armed
- after landing, the speedbrake lever automatically moves to UP and the spoiler panels extend.

UP – the required spoiler panels extend to their maximum in-flight or on-ground position (intermediate positions can be selected).
## Flap System

### Flap Controls

1. **Flap Lever**
   Primary mode – positions the slats and flaps hydraulically.
   Secondary mode – positions the slats and/or flaps electrically if hydraulic operation fails.

2. **Flap Gates**
   1 – prevents inadvertent retraction of the slats.
   20 – prevents inadvertent retraction of the flaps past the go-around position.

3. **Alternate Flaps Arm (ALTN FLAPS ARM) Switch**
   Push (ALTN displayed) –
   - arms the alternate flap control mode
   - arms the alternate flaps selector
   - disables primary and secondary flap/slat mode operation
• asymmetry/skew and uncommanded motion protection, autoslat, and flap/slat load relief are not available
• the flap lever is inoperative.

4 Alternate Flaps Selector

RET – the slats and flaps are electrically retracted.
OFF – alternate flaps are deactivated.
EXT –
• the slats and flaps are electrically extended
• maximum extension is flaps 20, with the slats at the midrange position.

Flap Limit Placard

[Basic 777-200]

CENTER FORWARD PANEL

[777-200ER]

CENTER FORWARD PANEL
Flap Limit Placard

Flaps extended speed limits.

**Normal Flap Position Indication**

Displays combined flap and slat positions when all surfaces are operating normally and control is in the primary (hydraulic) mode. The indicator shows continuous motion.

The indication is no longer displayed 10 seconds after slat retraction.
1 Flap Position (white)

UP – the slats and flaps are retracted.

1 – the slats extend to the midrange position.

5, 15, and 20 –
   • the slats remain in the midrange position
   • the flaps extend to the commanded position.

25 – the slats extend to the fully extended position. The flaps extend to 25.

30 – the flaps extend to 30.

2 Flap Lever Position (line and number)

Magenta – the slats or flaps are in transit to the commanded position.

Green – the slats and flaps are in the commanded position.

The line and number change color.

Flap Load Relief Indication
Flap LOAD RELIEF Indication

Displayed (white) –
- flap load relief is retracting the flaps, or inhibiting extension, as required to prevent air load damage due to excessive airspeed
- extension from UP is being inhibited due to either excessive airspeed or altitude.

Expanded Flap and Slat Position Indication

If any flap/slat is non–normal or if control is in the secondary mode, slat and flap positions are shown independently. Each wing is also shown separately.
Indicator motion is continuous between flap detents.

Expanded Flap and Slat Position Indications

The slat indication fills up (forward) for extension.
The flap indication fills down (aft) for extension.
Indication colors of outline and fill are:
- white when operating in secondary mode
- amber when the respective FLAPS DRIVE or SLATS DRIVE EICAS message is displayed.
Loss of position information is shown as a white outline with no fill and no flap lever position indication.

Flap Lever Position (line and number)

Magenta – the slats or flaps are in transit to the commanded position.
Green – the slats or flaps are in the commanded position.
The numbers are shown next to the flap position indicator only.

Alternate Flap and Slat Position Indications (white)

Slat and flap extension is limited to slats midrange and flaps 20.
Displayed automatically when the alternate control mode is armed.

Slats – displays the position of the slats.

Flaps – displays the position of the flaps.

Flap position index marks – reference flaps 5 and 20.

Loss of position information is indicated as a white outline with no fill and no position index marks or numbers.

**Flight Control Synoptic Displays**

The flight control synoptic is displayed by pushing the FCTL synoptic display switch on the display select panel. Display select panel operation is described in Chapter 10, Flight Instruments, Displays.
Normal Flight Control Synoptic
Non–Normal Flight Control Synoptic

- **Unknown Aileron Position**
- **Failed Control Surface or Trim Function (amber)**
- **Unknown Spoiler Condition**
- **Spoiler Condition**
- **Aileron Position or Trim Function (amber)**
- **Hydraulic System Failure Indications (amber)**
- **Flight Control Mode SECONDARY or DIRECT Indication (amber)**
- **Actuator Control Electronic Failure Indications (amber)**

**MULTIFUNCTION DISPLAY**
Introduction

The primary flight control system uses conventional control wheel, column, and pedal inputs from the pilot to electronically command the flight control surfaces. The system provides conventional control feel and pitch responses to speed and trim changes. The system electronic components provide enhanced handling qualities and reduce pilot workload.

The primary flight control system is highly redundant, with three operating modes: normal mode, secondary mode, and direct mode. The primary flight controls are powered by redundant hydraulic sources. The secondary flight controls, high lift devices consisting of flaps and slats, are hydraulically powered with an electrically powered backup system.

Pilot Controls

The pilot controls consist of:

- two control columns
- two control wheels
- two pairs of rudder pedals
- control wheel pitch trim switches
- alternate pitch trim levers
- the speedbrake lever
- the flap lever
- aileron trim switches
- rudder trim selector
- manual rudder trim cancel switch.

The columns and wheels are connected through jam override mechanisms. If a jam occurs in a column or wheel, the pilots can maintain control by applying force to the other column or wheel to overcome the jam.

The F/O’s control wheel can be rotated approximately 8 degrees beyond the initial stop if sufficient force is applied during ground checks.

The rudder pedals are rigidly connected between the two sides.

The speedbrake lever allows manual or automatic symmetric actuation of the spoilers.

The pilot controls command these system electronic components:

- four actuator control electronics (ACEs)
- three primary flight computers (PFCs).

The ACEs receive input signals from all pilot controls. The ACEs send control signals to the primary flight control surfaces. Each ACE is assigned to different actuators on the control surfaces. No single ACE controls more than one actuator on a control surface. Some ACEs are not assigned to all control surfaces.
The EICAS caution message FLIGHT CONTROLS is displayed if:

- multiple ACE and/or hydraulic system failures cause the loss of a significant number of control surfaces, or
- other flight control system faults are detected.

The ACEs can transmit pilot control inputs directly to the control surfaces, or they can send the pilot inputs to the PFCs. When the ACEs are sending pilot inputs to the PFCs, the ACEs receive control commands back from the PFCs and use the commands to position the flight control surfaces.

The PFCs use information from other airplane systems (such as air data, inertial data, flap and slat position, engine thrust, and radio altitude) to compute control surface commands for enhanced handling qualities. See Primary Flight Control System Modes in this Section for a description of these handling quality enhancements.

The autopilot also sends commands to the PFCs, which then produce control surface commands. See Chapter 4, Automatic Flight.

**Flight Control Surfaces**

Pitch control is provided by:

- two elevators
- a movable horizontal stabilizer.

Roll control is provided by:

- two flaperons
- two ailerons
- fourteen spoilers.

Yaw control is provided by:

- single rudder
- partial span tab.

The two elevators and horizontal stabilizer work together to provide pitch control. A detailed description of pitch control is given in a separate section later in this chapter.

The flaperons and ailerons provide roll control, assisted by asymmetric spoilers.

The flaperons are located between the inboard and outboard flaps on both wings. In the normal mode, they are used for roll control with the flaps either retracted or extended. For increased lift, the flaperons move down and aft in proportion to trailing edge flap extension.

The ailerons are located outboard of the outboard flaps on each wing. For increased lift, the ailerons move down for flaps 5, 15, and 20, to improve takeoff performance.
In the normal mode, the ailerons and spoilers 5 and 10 are locked out during high-speed flight; the flaperons and remaining spoilers provide sufficient roll control. During low speed flight, these panels augment roll control.

Yaw control is provided by a single rudder, which is almost the same height as the vertical tail. The lower portion of the rudder has a hinged section (tab) that deflects twice as far as the main rudder surface to provide additional yaw control authority. During takeoff, the rudder becomes aerodynamically effective at approximately 60 knots.

Flaps and slats provide high lift for takeoff, approach, and landing.

Symmetric spoilers are used as speedbrakes.

**Flight Control Surface Locations**
Actuator Control Electronics/Hydraulic Power Distribution

Outboard Spoilers

Inboard Spoilers

Flaperon

Aileron

Rudder

Tab

Stabilizer

Elevator

ACE Source
Left 1, left 2, center, or right.

Hydraulic System Source
Left, center, or right.

Outboard Spoilers

Inboard Spoilers

Tab
Primary Flight Control System Modes

There are three primary flight control system modes (flap and slat system modes are described later in this section):

- normal
- secondary
- direct.

All the modes use the same pilot controls and flight control surfaces.

Flight Control System Normal Mode

In the normal mode during manual flight, the ACEs receive pilot control inputs and send these signals to the three PFCs. The PFCs verify these signals and information from other airplane systems in order to compute control surface commands. These commands are then sent back to the ACES. The four ACES send enhanced signals to the flight control surface actuators.

When the autopilot is engaged, the autopilot system sends commands to the PFCs. The PFCs generate control surface commands, which are then sent to the ACES in the same manner as pilot control inputs. The autopilot commands move the pilot controls to provide indications of what the autopilot is doing. If the pilot overrides the autopilot with control inputs, the PFCs disconnect the autopilot and use the pilot control inputs. The autopilot is only available during normal mode operation. Refer to Chapter 4, Automatic Flight, for autopilot operation.

After the hydraulic systems are shut down, the PFCs self-test. During the test, various EICAS alert and status messages display, trim indicator information blinks, and various failure indications display on the flight controls synoptic. When the self test is complete, the EICAS messages disappear, and the trim indicator and synoptic display return to normal. This happens about two minutes after the EICAS caution message HYD PRESS SYS L+C+R is displayed.

Flight Envelope Protection

The flight envelope protection system reduces the possibility of inadvertently exceeding the airplane's flight envelope. The flight envelope protection system provides crew awareness of envelope margins through tactile, aural, and visual cues. The protection functions do not reduce pilot control authority. The protection functions are described later in this section and include:

- stall protection
- overspeed protection
- roll envelope bank angle protection.
Normal Mode

Pilot or autopilot control inputs command the PFCs to generate control surface commands.

PFCs
- redundant
- contain enhanced control features
- generate all control surface commands.

Mode Control Panel Inputs

Pilot Control Inputs

ACEs
Provide redundant control in each axis

Surfaces
- SPOILERS
- FLAPERONS
- ELEVATORS
- RUDDER
- STABILIZER

Pilot Control Inputs ACEs

Primary Flight Computers

Primary Flight Computers

Mode Control Panel Inputs

Autopilots
Flight Control System Secondary Mode

When the PFCs can no longer support the normal mode due to internal faults or lack of required information from other airplane systems, they automatically revert to the secondary mode. The ACEs continue to receive pilot control inputs and send these signals to the three PFCs. However, the PFCs use simplified computations to generate flight control surfaces commands. These simplified commands are sent back to the ACEs, where they are sent to the control surface actuators the same way as in the normal mode.

The simplified PFC control laws used in the secondary mode affect airplane handling qualities. All flight control surfaces remain operable. The elevator and rudder are more sensitive at some airspeeds.

The following functions are not available in the secondary mode:

- autopilot
- auto speedbrakes
- envelope protection
- gust suppression
- tail strike protection
- thrust asymmetry compensation
- yaw damping (may be degraded or inoperative).

The EICAS caution message FLIGHT CONTROL MODE is displayed when the primary flight control system is in the secondary mode. The secondary mode cannot be manually selected.
Secondary Mode

Pilot control inputs command the PFCs to generate control surface commands. The autopilot is not available.

Pilot control inputs → Pilot Control Inputs → Actuator Control Electronics → Control Surfaces

- Primary Flight Computers (PFCs) Generate all control surface commands.
- Control Surfaces: Spoilers, Ailerons, Flaperons, Elevators, Rudder, Stabilizer
Flight Control System Direct Mode

The ACEs automatically transition to the direct mode when they detect the failure of all three PFCs or lose communication with the PFCs. The direct mode can also be manually selected by moving the PRIMARY FLIGHT COMPUTERS DISCONNECT switch to DISC.

In the direct mode, the PFCs no longer generate control surface commands. Pilot inputs received by the ACEs are sent directly to the control surface actuators. The direct mode provides full airplane control for continued safe flight and landing. Airplane handling qualities are approximately the same as in the secondary mode. The EICAS caution message PRI FLIGHT COMPUTERS is displayed when the system is in the direct mode.

In the direct mode, the following functions are not available:
- autopilot
- auto speedbrakes
- envelope protection
- gust suppression
- tail strike protection
- manual rudder trim cancel switch
- thrust asymmetry compensation
- yaw damping.

Direct Mode

Mechanical Backup

In the unlikely event of a complete electrical system shut–down, cables from the flight deck to the stabilizer and selected spoilers allow the pilot to fly straight and level until the electrical system is restarted.
Normal Mode Pitch Control

In the normal mode, airplane pitch control characteristics are like conventional airplanes, with improved handling qualities. Unlike conventional airplanes, the control column does not directly position the elevator in flight. The control column commands the PFCs to generate a pitch maneuver. The PFCs automatically position the elevator and the stabilizer to generate the commanded maneuver. The PFCs constantly monitor airplane response to pilot commands and reposition the elevator and stabilizer to carry out these commands. Airplane pitch responses to thrust changes, gear configuration changes, and turbulence are automatically minimized by PFC control surface commands.

The PFCs also provide compensation for flap and speedbrake configuration changes, and turns up to 30° of bank. The PFCs automatically control pitch to maintain a relatively constant flight path. This eliminates the need for the pilot to make control column inputs to compensate for these factors. For turns up to 30° of bank, the pilot does not need to add additional column back pressure to maintain altitude. For turns of more than 30° of bank, the pilot does need to add column back pressure.

As airspeed changes, the PFCs provide conventional pitch control characteristics by requiring the pilot to make control column inputs or trim changes to maintain a constant flight path.

Primary Pitch Trim Control

Primary pitch trim is controlled by the dual pitch trim switches on each control wheel. Both switches must be moved to command trim changes. The primary pitch trim switches are inhibited when the autopilot is engaged. Pitch trim does not move the control column.

In the normal mode, primary pitch trim operates differently on the ground than it does in flight. On the ground, the stabilizer is directly positioned when the pilot uses the pitch trim switches. In flight, the pitch trim switches do not position the stabilizer directly, but make inputs to the PFCs to change the trim reference speed. The trim reference speed is the speed at which the airplane would eventually stabilize if there were no control column inputs. Once the control column forces are trimmed to zero, the airplane maintains a constant speed with no column inputs. Thrust changes result in a relatively constant indicated airspeed climb or descent, with no trim inputs needed unless airspeed changes.

When pilot trim inputs are made, the PFCs automatically move the elevators to achieve the trim change, then move the stabilizer to streamline the elevator. Stabilizer motion may also automatically occur to streamline the stabilizer and elevator for thrust and configuration changes.
Alternate Pitch Trim

Alternate pitch trim is controlled by the dual alternate pitch trim levers on the control stand. Both levers must be moved to command trim changes. These levers move the trim reference airspeed (normal mode) and also move the stabilizer (all modes). The alternate pitch trim levers are linked to the stabilizer trim control modules (STCM) via control cables, and then mechanically to the stabilizer. Alternate pitch trim commands have priority over wheel pitch trim commands in all flight control modes.

Moving the alternate pitch trim levers with the autopilot engaged does not disconnect the autopilot, but does move the stabilizer. Moving the alternate pitch trim levers during stall or overspeed protection does move the stabilizer, but does not remove column forces.

Note: The alternate pitch trim levers should not be used with the autopilot engaged, or during stall or overspeed protection.

Pitch Envelope Protection

The pitch envelope protection functions include:

- stall protection
- overspeed protection.

Stall Protection

Stall protection reduces the likelihood of inadvertently exceeding the stall angle of attack by providing enhanced crew awareness of the approach to a stall or to a stalled condition.

Stall protection limits the speed to which the airplane can be trimmed. At approximately the minimum maneuvering speed, stall protection limits the trim reference speed so that trim is inhibited in the nose up direction. The pilot must apply continuous aft column force to maintain airspeed below the minimum maneuvering speed. Use of the alternate pitch trim levers does not reduce the column forces. When flying near stall speed, the column force increases to a higher level than would occur for an equivalent out–of–trim condition above the minimum maneuvering speed.
The autothrottle can support stall protection if armed and not engaged. If speed decreases to near stick shaker activation, the autothrottle engages in the appropriate mode (SPD or THR REF) and advances thrust to maintain minimum maneuvering speed (approximately the top of the amber band) or the speed set in the mode control panel speed window, whichever is greater. The EICAS message AIRSPEED LOW is displayed.

**Note:** When the pitch mode is FLCH or TOGA, or the airplane is below 400 feet above the airport on takeoff, or below 100 feet radio altitude on approach, the autothrottle will not automatically engage.

Refer to Chapter 10, Flight Instruments, Displays, for PFD indications.

Refer to Chapter 4, Automatic Flight, for an explanation of PFD flight mode annunciations, and for mode control panel and autothrottle operation.

**Overspeed Protection**

Overspeed protection limits the speed to which the airplane can be trimmed. At VMO/MMO, overspeed protection limits the trim reference speed so that trim is inhibited in the nose down direction. The pilot must apply continuous forward column force to maintain airspeed above VMO/MMO. Use of the alternate pitch trim levers does not reduce column forces.

**Elevator Variable Feel**

The PFCs calculate feel commands based on airspeed. In general, control column forces increase:

- as airspeed increases for a given column displacement, or
- as column displacement increases.

**Tail Strike Protection**

During takeoff or landing, the PFCs calculate if a tail strike is imminent and decrease elevator deflection, if required, to reduce the potential for tail skid ground contact. Activation of tail strike protection does not provide feedback to the control column.

**Secondary and Direct Mode Pitch Control**

Airplane pitch control is different in the secondary and direct flight control modes. The control columns now command a proportional elevator deflection instead of a maneuver command. Secondary and direct modes do not provide automatic pitch compensation for:

- thrust changes
- gear configuration changes
- turbulence
- flap and speedbrake configuration changes
- turns to 30° bank angle.
In secondary and direct modes, the elevator variable feel system provides two feel force levels instead of a continuous variation with airspeed. The force levels change with flap position. With the flaps up, the feel forces provide maneuver force levels that discourage overcontrol in the pitch axis at high speeds. With flaps extended (flaps 1 or greater), the feel forces decrease to provide force levels appropriate for approach and landing.

In the secondary and direct modes, both the primary pitch trim switches and the alternate pitch trim levers move the stabilizer directly. There is no trim reference speed.

Stabilizer Hydraulic Power and Non–Normal Operation

The stabilizer is powered by the center and right hydraulic systems. Stabilizer position commands from the PFCs and alternate pitch trim levers are sent to the stabilizer trim control modules, which control hydraulic power to the stabilizer. There are two modules, one for each stabilizer hydraulic source.

Stabilizer Shutdown

If uncommanded stabilizer motion is sensed, hydraulic power to the stabilizer trim control module that caused the motion is automatically shut off. If a module is inoperative due to an automatic shutdown or another failure, the EICAS advisory message STABILIZER C or STABILIZER R is displayed. The stabilizer remains operative through the remaining stabilizer trim control module.

If both stabilizer trim control modules automatically shut down or fail, the EICAS warning message STABILIZER is displayed. The STABILIZER warning is also displayed if automatic shutdown fails to stop uncommanded motion.

The center and right stabilizer cutout switches, located on the aisle stand, control hydraulic power to the respective stabilizer trim control module. Placing both switches in the CUTOUT position removes all hydraulic power from the stabilizer. The EICAS advisory message STABILIZER CUTOUT is displayed when both stabilizer cutout switches are in the CUTOUT position. The STABILIZER warning message is no longer displayed.

In the normal flight control mode, when the stabilizer is manually shut down or failed, pitch trim is still available. Pilot pitch trim inputs change the PFC trim reference speed. The PFCs then reposition the elevators to trim the airplane.

The control column can be used to interrupt pitch trim commands from the wheel pitch trim switches. This feature allows the pilot to quickly stop uncommanded trim changes due to stuck pitch trim switches. The pitch trim commands are interrupted if the control column is displaced in the opposing direction.
Stabilizer Position Indication and Greenband

Stabilizer position is displayed on two stabilizer position indicators located on the aisle stand. Stabilizer position is also displayed on the flight controls synoptic. The stabilizer position indicators also display the takeoff green band indication. The green band automatically displays the acceptable range for takeoff stabilizer positions. There are three greenband segments that can be illuminated for takeoff:

- the midband
- the nose down band (which includes the midband)
- the nose up band (which includes the midband).

The greenband is calculated using the FMC inputs of CG, gross weight, and takeoff thrust. A nose gear oleo pressure switch provides an automatic cross-check of the CG to ensure that the correct greenband has been selected. When either the nose up or nose down band is selected, the pressure switch position is compared to the computed greenband. The EICAS advisory message STAB GREENBAND is displayed if the pressure switch and the greenband disagree. If the stabilizer signal is not present or is invalid, the greenband and the pointer are not displayed.

Normal Mode Roll Control

Roll control is similar to conventional airplanes. Aileron and flaperon surface deflections are proportional to control wheel displacement. Spoilers begin to extend to augment roll control after several degrees of control wheel rotation. Control wheel forces increase as control displacement increases. Control wheel forces do not change with airspeed changes. The ailerons are locked out at high speeds.

Spoilers 4 and 11 are mechanically controlled through a cable from the control wheel. These spoilers are available for roll control until the speedbrake lever is moved to near the UP position, when they function as speedbrakes only. Spoilers 5 and 10 are locked out at high speed.

Aileron Trim

Dual aileron trim switches located on the aisle stand must be pushed simultaneously to command trim changes. Use of aileron trim causes control wheel rotation.

The amount of aileron trim is indicated on a scale on the top of each control column.

Aileron trim is inhibited when the autopilot is engaged.
Roll Envelope Bank Angle Protection

Bank angle protection reduces the likelihood of exceeding the bank angle boundary due to external disturbances, system failures, or inappropriate pilot action.

Bank angle protection provides roll control wheel inputs when airplane bank angle exceeds the bank angle protection boundary of approximately 35°. If the boundary is exceeded, the control wheel force rolls the airplane back within 30° of bank. This roll command can be overridden by the pilot. Maximum control wheel deflection always commands maximum control surface deflection. The autopilot disengage bar disables bank angle protection.

Excessive bank angles are indicated on the PFD bank indicator. The indicator changes color to amber at bank angles exceeding 35°. Refer to Chapter 10, Flight Instruments, Displays, for PFD indications.

Secondary and Direct Mode Roll Control

Roll control in the secondary and direct modes is very similar to roll control in the normal mode. Bank angle protection is not available in either the secondary or direct mode. Spoilers 5 and 10 are always locked out.

Normal Mode Yaw Control

Yaw control operation is similar to a conventional airplane. Rudder surface deflections are proportional to rudder pedal movements.

Pedal forces increase as pedal displacement increases. Pedal forces do not change with airspeed changes.

The rudder ratio changer automatically reduces rudder deflection (for a given pedal input) as airspeed increases. This protects the vertical tail structure from stresses resulting from large rudder surface deflections at high airspeeds. Sufficient rudder authority is provided at all airspeeds to maintain airplane control in engine–out conditions, as well as during takeoffs and landings in crosswinds.
Thrust Asymmetry Compensation

The thrust asymmetry compensation (TAC) system significantly reduces uncommanded flight path changes associated with an engine failure. TAC continually monitors engine data to determine the thrust level from each engine. If the thrust level on one engine differs by 10 percent or more from the other engine, TAC automatically adds rudder to minimize yaw. When TAC is operating, the pilot can still recognize the initial onset of an engine failure through airplane roll/yaw cues. These roll/yaw cues are greatly reduced when compared to an airplane operating without TAC. After several seconds, TAC applies sufficient rudder to make it possible for the pilot or autopilot to center the control wheel. The amount of rudder used is proportional to the engine thrust difference. Rudder movement is back-driven through the rudder pedals and the rudder trim indicator to provide rudder control awareness to the pilot.

TAC is available except:

- when airspeed is below 70 knots on the ground, or
- when reverse thrust is applied, or
- when automatically disengaged due to system malfunction or loss of engine thrust data.

TAC automatically disengages if engine thrust data is lost. Also, if the engine is damaged or surges, TAC disengages because there is no accurate prediction of engine thrust. TAC may still cause some rudder deflection in the appropriate direction just before automatically disengaging.

TAC can be manually overridden by making manual rudder pedal inputs. TAC is only available in the normal flight control mode. To manually disarm TAC, push the THRUST ASYM COMP switch on the overhead panel. If TAC is automatically or manually disconnected, the EICAS advisory message THRUST ASYM COMP displays.

Wheel to Rudder Cross–Tie

A wheel to rudder cross–tie function provides the capability of being able to control the initial effects of an engine failure using control wheel inputs only. Control wheel inputs can deflect the rudder up to 8 degrees.

Wheel to rudder cross–tie is operative in flight below 210 knots in the normal mode.

Yaw Damping

In the normal mode, the yaw damping function provides turn coordination and Dutch roll damping.
Gust Suppression

A gust suppression function reduces the effects of lateral gusts and improves lateral ride quality through a combination of yaw and roll commands. Operation does not result in either rudder pedal or control wheel movement.

Rudder Trim

The rudder trim control can be used to command manual rudder trim in all three flight control modes. Two rudder trim speeds are available. Low rate rudder trim is commanded by rotating the control to the detent. High rate rudder trim is commanded by rotating the control past the detent. MANUAL TRIM CANCEL switch actuation causes manually set rudder trim to return to zero at the high speed trim rate. The switch has no effect on rudder trim inputs from TAC.

Secondary and Direct Mode Yaw Control

Secondary and direct mode yaw control is similar to normal mode yaw control. Pedal feel forces are unchanged from normal mode; however, rudder response is slightly different.

In secondary and direct modes, the rudder ratio changer is degraded to two fixed ratios determined by flap position. With flaps up, the rudder response to pedal inputs is less than with the flaps down.

In the secondary mode:
- gust suppression is inoperative
- yaw damping is degraded (for some failures, it may be inoperative)
- thrust asymmetry compensation is inoperative.

In the direct mode the following are inoperative:
- gust suppression
- yaw damping
- the manual rudder trim cancel switch
- thrust asymmetry compensation.

Spoilers

There are 7 sets of spoilers, 5 outboard and 2 inboard of the flaperons, on the upper surface of each wing. The spoilers are numbered from left to right, 1 through 14. Spoilers on opposing wings are symmetrically paired.

Spoiler panels are used as speedbrakes to increase drag and reduce lift, both in flight and on the ground. The spoilers also supplement roll control in response to control wheel commands. Spoiler panels 5 and 10 are locked out during cruise, depending on altitude and airspeed.
All three hydraulic systems supply the spoilers. Each hydraulic system is dedicated to a different set of spoiler pairs to provide isolation and maintain symmetric operation in the event of hydraulic system failure. If a single spoiler fails, the corresponding spoiler on the other wing retracts. Failure of a single or multiple spoiler pairs causes the EICAS advisory message SPOILERS to display.

**Spoiler Speedbrake Operation**

The 14 spoiler panels are used as speedbrakes. In the normal mode, when used as speedbrakes, spoilers 5 and 10 are available as ground speedbrakes only. In the secondary and direct modes, spoilers 4, 5, 10, and 11 are locked out.

The speedbrake spoilers are controlled by the speedbrake lever located on the control stand. The speedbrake lever has three marked positions:

- **DOWN**
- **ARMED**
- **UP**.

The speedbrake lever can be placed in intermediate positions between ARMED and UP.

In the ARMED position, the speedbrake lever is driven aft to the UP position when the landing gear is fully on the ground (not tilted) and the thrust levers are at idle.

On the ground when either reverse thrust lever is moved to the reverse idle detent, the speedbrakes automatically extend. The speedbrake lever does not need to be in the ARMED position. A mechanical link between the speedbrake lever and the reverse thrust levers raises the speedbrake lever out of the DOWN detent. The speedbrake lever is then driven aft and the speedbrakes extend. If either thrust lever is advanced to a takeoff position, the speedbrake lever is driven to the down position.

Automatic speedbrakes are not available in the secondary and direct modes.

There is no limitation for extension of speedbrakes in a landing configuration.

**Flaps and Slats**

The flaps and slats are high lift devices that increase wing lift and decrease stall speed during takeoff, approach, and landing.

The airplane has an inboard and an outboard flap on the trailing edge of each wing, and one inboard and six outboard slats on the leading edge. A two–position Krueger flap provides a seal between the inboard slat and engine nacelle on each wing.
In the flaps 1 position, only the slats move. Flaps 5, 15, and 20 are takeoff flap positions. Flaps 25 and 30 are landing flaps positions. Flaps 20 is used for some non-normal landing conditions.

[777-200]
To protect against inadvertent deployment during cruise, flap and slat extension from the UP position is inhibited when speed is more than 250 knots or altitude is above approximately 20,000 feet.

[777-200ER and 777-300]
To protect against inadvertent deployment during cruise, flap and slat extension from the UP position is inhibited when speed is more than 265 knots or altitude is above approximately 20,000 feet.

[777-200LR and 777-300ER]
To protect against inadvertent deployment during cruise, flap and slat extension from the UP position is inhibited when speed is more than 275 knots or altitude is above approximately 20,000 feet.

If the flap handle is moved out of UP while the flaps are inhibited, LOAD RELIEF displays.

Flap and Slat Sequencing

When the flap lever is in the UP detent, all flaps and slats are commanded retracted. Moving the flap lever aft allows selection of flap detent positions 1, 5, 15, 20, 25 and 30. The flaps and slats sequence so that the slats extend first and retract last.

Starting from flaps UP, selection of flaps 1 commands the slats to move to the midrange position. The flaps remain retracted.

Selection of the flaps 5, 15, and 20 positions commands the flaps to move to the position selected. The slats remain in the midrange position.

Selection of flaps 25 commands both the flaps and slats to move to landing positions. First the slats extend to the fully extended position, then the flaps extend to the landing flaps 25 position.

Selection of flaps 30 commands the flaps to extend to the primary landing position.

During retraction, flap and slat sequencing is reversed.

The mechanical gate at the flaps 20 detent prevents inadvertent retraction of the flaps past the go-around flap setting. The mechanical gate at flaps 1 prevents inadvertent retraction of the slats past the midrange position.
Flap and Slat Modes

Three modes of flap and slat operation are possible:

- primary (hydraulic)
- secondary (electric)
- alternate (electric).

The flaps and slats can operate independently in either the primary or secondary mode. However, independent flap and slat operation in the alternate mode is not possible.

Primary mode hydraulic power is supplied by the center hydraulic system. Secondary and alternate mode electrical power is supplied by the left and right AC busses.

The secondary mode is automatically engaged whenever the primary mode fails to move the flaps or slats to the selected position. Once engaged, the secondary mode remains engaged until the affected system surfaces are fully retracted or center hydraulic system pressure is restored.

**[777-200]**
In the secondary mode, the flaps and slats are positioned by electric motors. Because autoslats are unavailable, the slats are fully extended at all flap positions (if airspeed is less than 215 knots) to improve stall handling characteristics. If airspeed exceeds 215 knots, the slats retract to the midrange position (the midrange index on the slat position indicator), or will not extend beyond the midrange position.

**[777-200ER]**
In the secondary mode, the flaps and slats are positioned by electric motors. Because autoslats are unavailable, the slats are fully extended at all flap positions (if airspeed is less than 239 knots) to improve stall handling characteristics. If airspeed exceeds 239 knots, the slats retract to the midrange position (the midrange index on the slat position indicator), or will not extend beyond the midrange position.

**[777-300]**
In the secondary mode, the flaps and slats are positioned by electric motors. Because autoslats are unavailable, the slats are fully extended at all flap positions (if airspeed is less than 246 knots) to improve stall handling characteristics. If airspeed exceeds 246 knots, the slats retract to the midrange position (the midrange index on the slat position indicator), or will not extend beyond the midrange position.
In the secondary mode, the flaps and slats are positioned by electric motors. Because autoslats are unavailable, the slats are fully extended at all flap positions (if airspeed is less than 256 knots) to improve stall handling characteristics. If airspeed exceeds 256 knots, the slats retract to the midrange position (the midrange index on the slat position indicator), or will not extend beyond the midrange position.

If the slats are in the midrange position (flaps 1 through 20) when the secondary mode is engaged, they remain in that position until the flaps are retracted to UP, or extended beyond 20.

On the ground, secondary electric mode extension or retraction is inhibited when groundspeed is less than 40 knots, center hydraulic system pressure is low, and two of the following three items are true:

[GE, PW Engines]
- left engine N2 is less than 50 percent,
- right engine N2 is less than 50 percent,
- primary external power is available.

[RR Engines]
- left engine N3 is less than 50 percent,
- right engine N3 is less than 50 percent,
- primary external power is available.

The alternate mode allows direct manual operation of the flaps and slats through the secondary drive electric motors. The alternate flaps ARM switch:

- disables normal control
- arms the alternate mode
- engages the electric motors
- the flap lever no longer controls flaps/slats.

The three–position alternate flaps selector extends and retracts the flaps and slats. The flaps and slats extend simultaneously, but slat retraction is inhibited until the flaps are up. Alternate mode flap and slat extension is limited to slats midrange and flaps 20. Asymmetry protection, uncommanded motion protection, autoslats, and flap/slat load relief are not available in the alternate mode.

The alternate mode must be manually selected. Slat and flap operation time in the secondary and alternate modes is greatly increased.

Flap/Slat Load Relief

In the primary mode, the flap load relief system protects the flaps from excessive air loads. If flap airspeed placard limits are exceeded with the flaps in the 15 through 30 position, LOAD RELIEF is displayed and the flaps automatically retract to a position appropriate to the airspeed. Load relief retraction is limited to flaps 5.
When airspeed is reduced, the flaps automatically re–extend as airspeed allows. Re–extension is limited to the commanded flap position.

If a flap overspeed exists, load relief prevents flap extension beyond the 5, 15, 20, or 25 positions until airspeed is sufficiently reduced. Flap load relief is available only in the primary mode. The EICAS flap display indicates an in–transit flap condition and shows actual flap position. The flap lever does not move during flap load relief operation. Load relief for slats is not required in the primary or alternate modes.

[777-200]
Slat load relief is available in the secondary mode. If airspeed exceeds 215 knots with the slats fully extended, they retract to midrange and LOAD RELIEF is displayed.

[777-200ER]
Slat load relief is available in the secondary mode. If airspeed exceeds 239 knots with the slats fully extended, they retract to midrange and LOAD RELIEF is displayed.

[777-300]
Slat load relief is available in the secondary mode. If airspeed exceeds 246 knots with the slats fully extended, they retract to midrange and LOAD RELIEF is displayed.

[777-200LR and 777-300ER]
Slat load relief is available in the secondary mode. If airspeed exceeds 256 knots with the slats fully extended, they retract to midrange and LOAD RELIEF is displayed.

**Autoslats**

The autoslat system enhances airplane stall characteristics. Upon receiving a signal from the stall warning system, the slats automatically extend from the midrange position to the fully extended landing position. The slats retract a few seconds after the signal is removed. Slats are fully extended to improve stall handling characteristics.

Autoslat operation is armed at flaps 1, 5, 15 and 20 and is available only in the primary slat mode.

**Flap and Slat Asymmetry Detection**

A detection system detects asymmetrical extension or retraction of an individual flap. After detection, the flap drive shuts down and the EICAS message FLAPS DRIVE is displayed.
A detection system detects slat asymmetry. Loss of all but the most outboard slats on each wing is also detected. When slat loss or asymmetry occurs, the system shuts down the slat drive and displays the SLATS DRIVE EICAS message.

**Uncommanded Flap or Slat Motion**

Uncommanded motion is detected when the slats or flaps:

- move away from the commanded position
- continue to move after reaching a commanded position
- or move in a direction opposite to that commanded.

If the flap or slat is operating in the primary mode, uncommanded motion first causes an automatic transfer to the secondary mode. The EICAS message FLAPS PRIMARY FAIL or SLATS PRIMARY FAIL is displayed. If motion continues, the system shuts down. The EICAS message FLAPS DRIVE or SLATS DRIVE is displayed.

**Flap Indications**

Flap position indications are displayed on the primary EICAS display. A single vertical indicator displays combined flap and slat position. The position commanded by the flap lever is also displayed. Ten seconds after all flaps and slats are up, the entire indication is no longer displayed. A loss of position sensing removes the tape fill and flap lever position indications.

If flap/slat control is in the secondary or alternate mode, or if any non–normal condition is detected, an expanded flap indication is displayed automatically. The position of the left and right flaps and slats are separately indicated. In the alternate mode, the position commanded by the flap lever is replaced by flap position index marks at all flap and slat positions, and numbers at flaps 5 and flaps 20. The index marks are used as a guide to position the flaps to the desired setting.
Intentionally Blank
Flight Control System EICAS Messages

Note: Configuration (CONFIG) warning messages are described in Chapter 15, Warning Systems.

The following EICAS messages can be displayed.

<table>
<thead>
<tr>
<th>Message</th>
<th>Level</th>
<th>Aural</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTO SPEEDBRAKE</td>
<td>Advisory</td>
<td></td>
<td>A fault is detected in the automatic speedbrake system.</td>
</tr>
<tr>
<td>FLAPS DRIVE</td>
<td>Caution</td>
<td>Beeper</td>
<td>Flap drive mechanism has failed.</td>
</tr>
<tr>
<td>FLAPS PRIMARY FAIL</td>
<td>Caution</td>
<td>Beeper</td>
<td>Flaps are operating in the secondary mode.</td>
</tr>
<tr>
<td>FLAP/SLAT CONTROL</td>
<td>Caution</td>
<td>Beeper</td>
<td>Flap/ slug electronics units are inoperative.</td>
</tr>
<tr>
<td>FLIGHT CONTROL MODE</td>
<td>Caution</td>
<td>Beeper</td>
<td>Flight control system is operating in the secondary mode.</td>
</tr>
<tr>
<td>FLIGHT CONTROLS</td>
<td>Caution</td>
<td>Beeper</td>
<td>Multiple flight control surfaces are inoperative or other flight control system faults are detected.</td>
</tr>
<tr>
<td>FLT CONTROL VALVE</td>
<td>Advisory</td>
<td></td>
<td>One or more flight control valves are failed closed or one or more flight control shutoff switches are in SHUTOFF.</td>
</tr>
<tr>
<td>PITCH DOWN AUTHORITY</td>
<td>Caution</td>
<td>Beeper</td>
<td>Pitch down authority is limited.</td>
</tr>
<tr>
<td>PITCH UP AUTHORITY</td>
<td>Caution</td>
<td>Beeper</td>
<td>Pitch up and flare authority is limited.</td>
</tr>
<tr>
<td>PRI FLIGHT COMPUTERS</td>
<td>Caution</td>
<td>Beeper</td>
<td>Flight control system is operating in the direct mode.</td>
</tr>
<tr>
<td>SLATS DRIVE</td>
<td>Caution</td>
<td>Beeper</td>
<td>Slat drive mechanism has failed.</td>
</tr>
<tr>
<td>SLATS PRIMARY FAIL</td>
<td>Caution</td>
<td>Beeper</td>
<td>Slats are operating in the secondary mode.</td>
</tr>
<tr>
<td>SPEEDBRAKE ARMED</td>
<td>Memo</td>
<td></td>
<td>Speedbrakes are armed.</td>
</tr>
<tr>
<td>Message</td>
<td>Level</td>
<td>Aural</td>
<td>Condition</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SPEEDBRAKE EXTENDED</td>
<td>Caution</td>
<td>Beper</td>
<td>Speedbrake is extended when radio altitude is between 15 and 800 feet, or when the flap lever is in a landing position, or when either thrust lever is not closed.</td>
</tr>
<tr>
<td>SPOILERS</td>
<td>Advisory</td>
<td></td>
<td>One or more spoiler pairs are inoperative.</td>
</tr>
<tr>
<td>STAB GREENBAND</td>
<td>Advisory</td>
<td></td>
<td>Nose gear pressure switch disagrees with computed stabilizer greenband.</td>
</tr>
<tr>
<td>STABILIZER</td>
<td>Warning</td>
<td>Siren</td>
<td>Uncommanded stabilizer motion is detected or stabilizer is inoperative.</td>
</tr>
<tr>
<td>STABILIZER C</td>
<td>Advisory</td>
<td></td>
<td>Center stabilizer control path is inoperative.</td>
</tr>
<tr>
<td>STABILIZER CUTOUT</td>
<td>Advisory</td>
<td></td>
<td>Both stabilizer cutout switches are in CUTOUT.</td>
</tr>
<tr>
<td>STABILIZER R</td>
<td>Advisory</td>
<td></td>
<td>Right stabilizer control path is inoperative.</td>
</tr>
<tr>
<td>THRUST ASYM COMP</td>
<td>Advisory</td>
<td></td>
<td>Thrust asymmetry compensation is inoperative.</td>
</tr>
</tbody>
</table>