RJ PROFESSIONAL

OPERATIONS MANUAL

Just Flight

More Just Flight add-ons for Microsoft Flight Simulator

PA-38 TOMAHAWK

AVRO
VULCAN
B MK. 2, K.2 & MRR

F28
PROFESSIONAL

FS Traffic

146
PROFESSIONAL

HAWK T1/A
ADVANCED TRAINER

Operations Manual

Please note that Microsoft Flight Simulator must be correctly installed on your PC prior to the installation and use of this RJ Professional simulation.

CONTENTS

INTRODUCTION

Just Flight are excited to bring you the RJ Professional for Microsoft Flight Simulator, featuring the RJ70, RJ85 and RJ100 variants of this famed British airliner.

With its four engines, high wing, T-tail, sturdy undercarriage and fuselage-mounted airbrake, the RJ's exterior bears a strong resemblance to its predecessor, the 146; this resemblance, however, stops short once you take a seat in the cockpit. Unlike its predecessor, the RJ has a full glass cockpit (including an FMS as standard) and new improved engines with FADEC, increasing the aircraft's performance and range.

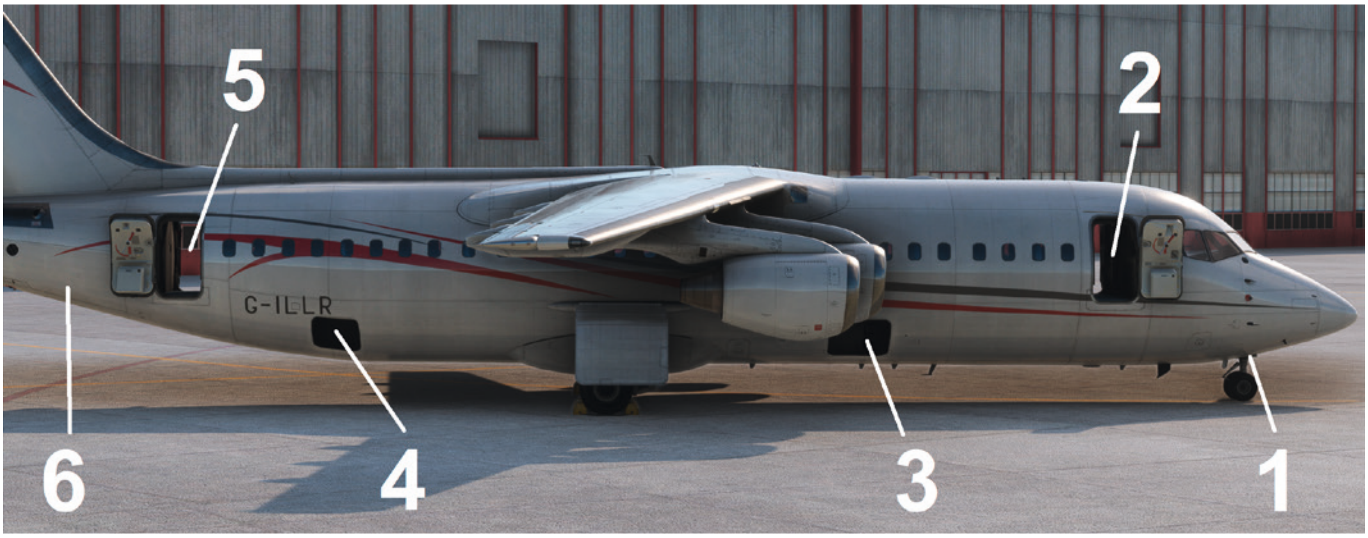
The RJ85 was the first RJ variant to fly, in March 1992, followed soon after by the first flights of the stretched RJ100 and shorter RJ70 in May and July of the same year. Since entering passenger service in 1994, the RJ has served with airlines on every continent (including Antarctica) and continues to do so into the mid-2020s.

This Just Flight simulation of the RJ is based on RJ100 SE-RJI, which at the time of our research trip was operated by the Swedish airline Braathen Regional Airlines. The aircraft has quite a varied history, having operated for airlines such as Crossair, Swiss, Atlantic Airways and Malmo Aviation in Europe, and now operating in South America with Bolivian airline EcoJet.

Aircraft specifications

Doors

1. Front passenger door
2. Rear passenger door
3. Main gear bay door
4. APU door



1. Nose gear bay door
2. Front service door
3. Front cargo bay door
4. Rear cargo bay door
5. Rear service door
6. Air conditioning bay door

Dimensions

RJ70

Length	26.19 m (85’ 11”)
Wingspan	26.34 m (86’ 5”)
Height	8.61 m (28’ 3”)
Wing area	77.30 m2 (832 ft^2)

RJ85

Length	28.55 m (93’ 8”)
Wingspan	26.34 m (86’ 5”)
Height	8.61 m (28’ 3”)
Wing area	77.30 m2 (832 ft^2)

RJ100

Length	31.00 m (101’ 8”)
Wingspan	26.34 m (86’ 5”)
Height	8.59 m (28’ 2”)
Wing area	77.30 m2 (832 ft2)

Weights

RJ70

Empty weight	52,690 lb (23,900 kg)
Maximum zero fuel weight	74,500 lb (33,792 kg)
Maximum take-off weight	95,000 lb (43,091 kg)
Maximum landing weight	83,500 lb (37,875 kg)
Maximum seating capacity (inc. crew)	100

RJ85

Empty weight	54,719 lb (24,820 kg)
Maximum zero fuel weight	79,000 lb (35,833 kg)
Maximum take-off weight	97,000 lb (43,998 kg)
Maximum landing weight	85,000 lb (38,555 kg)
Maximum seating capacity (inc. crew)	118

RJ100

Empty weight	56,593 lb (25,670 kg)
Maximum zero fuel weight	83,500 lb (38,875 kg)
Maximum take-off weight	101,500 lb (46,039 kg)
Maximum landing weight	88,500 lb (40,142 kg)
Maximum seating capacity (inc. crew)	118

Performance

RJ70

Economical cruise	394 TAS at 33,000 ft
Range with max. payload	1,465 NM / 1,687 M / 2,715 km
Take-off to 35 ft, surface level, ISA	4,101 ft (1,250 m)
FAR landing, surface level, ISA, max. landing weight	3,550 ft (1,082 m)

RJ85

Economical cruise	394 TAS at 33,000 ft
Range with max. payload	1,366 NM / 1,572 M / 2,531 km
Take-off to 35 ft, surface level, ISA	6,725 ft (1,509 m)
FAR landing, surface level, ISA, max. landing weight	3,730 ft (1,137 m)

RJ100

Economical cruise	394 TAS at 33,000 ft
Range with max. payload	1,217 NM / 1,401 M / 2,255 km
Take-off to 35 ft, surface level, ISA	4,528 ft (1,380 m)
FAR landing, surface level, ISA, max. landing weight	3.973 ft (1,211 m)

Engines

Type	Four x Avco Lycoming ALF507-1F turbofans
Thrust (sea-level, static)	7,000 lb (31 kN)
Bypass ratio	5.7:1
Length	5’ 5” (1.67 m)
Diameter	4’ 0” (1.23 m)
Dry weight	1,385 lb (628 kg)

Fuel

Fuel capacity	2,580 imp gal / 3,096 US gal / 11,728 litres

Liveries

The RJ is supplied in the following liveries:

RJ70

- Alitalia Express (EI-CPJ)
- Business Express Airlines (N832BE)
- ETPS (QQ102)
- Euro Manx (EI-CPJ)
- Formula One Management (M-STRY)
- QinetiQ (G-ETPK)
- SAS (SE-DJY)

RJ85

- Air France (EI-RJB)
- Airlink South Africa (ZS-TCO)
- Blue 1 (OH-SAO)
- Braathens (SE-DJO)
- Brussels Airlines (OO-DJX)
- CityJet (EI-RJO)
- Crossair (HB-IXH)
- Lufthansa Regional (D-AVRB)
- Northwest Airlink (N525XJ)
- Northwest Jet Airlink (N519XJ)
- Sabena (OO-DJK)

RJ100

- Aegean (SX-DVC)
- Atlantic Airways (OY-RCC)
- British Airways (G-BXAS)
- British Airways – Colum (G-BZAU)
- Brussels Airlines (OO-DWH)
- Cello Aviation (G-ILLR)
- Cobham Aviation Services (VH-NJQ)
- Jota Aviation (G-JOTS)
- Malmo Aviation (SE-DSU)
- North Cariboo Air (C-FSUA)
- Summit Air (C-FXRJ)
- Swiss (HB-IXT)
- Swiss ‘Zurich Airport Shopping Paradise’ (HB-IYS)

INSTALLATION, UPDATES AND SUPPORT

You can install this RJ Professional software as often as you like on the same computer system:

1. Log in to your Account on the Just Flight website.
2. Select the 'Your Orders' button.
4. A list of your purchases will appear and you can then download the software you require.

Accessing the aircraft

To access the aircraft:

1. Click on 'World Map'.
2. Open the aircraft selection menu by clicking on the aircraft thumbnail in the top left.
3. Use the Search feature or scroll through the available aircraft to find the 'RJ Professional'.
4. After selecting the aircraft, use the 'Liveries' menu to choose your livery.

Uninstalling

To uninstall this product from your system, use one of the Windows App management features:

Control Panel > Programs and Features

or

Settings > Apps > Apps & features

Select the product you want to uninstall, choose the 'Uninstall' option and follow the on-screen instructions.

Uninstalling or deleting this product in any other way may cause problems when using this product in the future or with your Windows set-up.

Updates and Technical Support

For technical support (in English) please visit the Support pages on the Just Flight website.

As a Just Flight customer, you can get free technical support for any Just Flight or Just Trains product.

If an update becomes available for this aircraft, we will post details on the Support page and we will also send a notification email about the update to all buyers who are currently subscribed to Just Flight emails.

Regular News

To get all the latest news about Just Flight products, special offers and projects in development, subscribe to our regular emails.

We can assure you that none of your details will ever be sold or passed on to any third party and you can, of course, unsubscribe from this service at any time.

You can also keep up to date with Just Flight via Facebook and X/Twitter.

SYSTEMS OVERVIEW

The Avro RJ is a short-range subsonic transport aircraft, powered by four Textron Lycoming turbofan engines pylon-mounted below a high swept wing. The tail comprises a single vertical stabiliser and a high-mounted horizontal stabiliser.

The flight deck has positions for a Captain, First Officer and observer. Passenger seat layouts vary depending on airline preferences.

Two separate channels of 115/200V AC electrical power are supplied by a generator mounted on each outboard engine, supplemented by an identical auxiliary power unit (APU) driven generator. A hydraulically driven AC/DC generator provides back-up for essential services. DC power is obtained from three transformer rectifier units (TRUs).

Two independent hydraulic channels are supplied via individual pumps driven by each inboard engine. In the event of failure, a mechanical transfer allows one pump to drive the other system. An AC-driven pump provides a hydraulic system support. A separate DC pump powers brakes and landing gear lock-down in an emergency.

Ice protection is provided for the wings, horizontal stabiliser, engine intakes, windscreens, pitot heads, front static vent plates and toilet drain masts. Windscreen wipers and rain repellent are fitted as standard.

The air conditioning and pressurisation systems maintain the air in the pressurised compartments at the desired level of pressure, temperature and freshness. Bleed air is cooled, conditioned and distributed to the individual compartments and then discharged overboard.

The primary pneumatic system is supplied with bleed air from the main engines and APU compressor. In addition to supplying air conditioning, pressurisation, airframe ice protection, engine and engine intake anti-icing, the primary pneumatic system also pressurises various subsidiary systems.

Duplicated pitch and roll flying controls have split circuits incorporating control jam or disconnect, permitting continued flight and landing. A hydraulically operated duplex yaw damper system is installed. Roll and lift spoilers are hydraulically operated.

Large under-wing flaps are hydraulically operated. Fuselage-mounted airbrakes, powered by a single hydraulic jack, are infinitely variable.

An automatic flight guidance system has an integrated autopilot and flight director system which provides three-axis stabilisation and two-axis manoeuvre computation in pitch and roll, in addition to flight director computation.

The wide-track hydraulically operated tricycle landing gear is short and sturdy and provides positive ground stability and ease of maintenance. A hydraulically assisted lock-down system for emergency lowering is installed. The duplex hydraulic brakes include anti-skid units.

A Digital Flight Guidance System has an integrated autopilot and Flight Director System which provides three-axis stabilisation and two-axis manoeuvre computation in pitch and roll, in addition to Flight Director computation.

An Electronic Flight Instrument System (EFIS) is fitted, which has two symbol generators supplying the two CRT Display Units (DU) on each pilot's instrument panel. The upper panel is the Primary Flying Display (PFD) and the lower panel is the Navigation Display (ND). EFIS control panels are located on the instrument panels and centre console.

The aircraft is capable of RNAV navigation through the implementation of dual GNLU-910A FMS units on the centre console. The FMS is LNAV and VNAV capable and is provided with altitude and navigation data via two Inertial Reference Systems (IRS). CAT 3 Autoland is also supported.

A Full Authority Digital Electronic Control (FADEC) Electronic Control Unit (ECU) is fitted to each of the four engines, electrically controlling the amount of fuel fed to the combustion chambers via a Hydro Mechanical Unit (HMU). Engine indications are displayed on the two electronic engine indicator displays on the centre instrument panel.

The aircraft is equipped with a pressurised water system, a waste disposal system and a waste water drainage system.

AIR CONDITIONING SYSTEM

The function of the air conditioning and pressurisation system is to maintain the air in the passenger cabin and the flight deck at a comfortable level of pressure and temperature with an adequate ventilating airflow.

There are two separate air conditioning systems. With both systems functioning:

- No.1 pack supplies the flight deck and augments the passenger cabin supply
- No.2 pack supplies the passenger cabin

Each system receives a separate supply from the pneumatic system. In the event of failure of either an air conditioning pack or a pneumatic supply, the flight deck and the passenger cabin air conditioning and pressurisation can still be maintained. The system can be operated manually in the event of failure of the automatic control.

The pressure controller is located on the flight deck overhead panel and the quad indicator on the First Officer's flight instrument panel. The system can be operated manually in the event of a failure of the automatic control.

Each pilot has personal air distribution selector levers on their side console. All other system controls are located on the flight deck overhead panel.

Air supply

The air conditioning and pressurisation systems are supplied by air bleed from the final stage of each engine's high-pressure compressor. This air supply is ducted through a combined electro-pneumatic shut-off and pressure-reducing valve to a precooler/heat exchanger.

Each valve is controlled by a switch labelled ENG AIR, 1, 2, 3, 4 – ON/OFF on the AIR SUPPLY sub-panel on the flight deck overhead panel.

In recirculation mode 40% of the cabin air is recirculated with 60% of air from the engines or APU. However, air can be bled from the engines to supply 100% fresh conditioned air by means of an electrically operated selector valve.

The selector valve regulates the air mass-flow to each pack to approximately 13.6 kg/min or 30 lb/min in the recirculation mode and 22.68 kg/min or 50 lb/min in the fresh conditioned air mode at any given altitude and selected cabin temperature. Recirculated air is drawn from the rear of the passenger cabin.

The No.1 air conditioning pack is supplied by the No.1 and No.2 engines; the No.2 pack is supplied by the No.3 and No.4 engines. The output of the No.1 and No.2 (left- and right-hand) packs are interconnected, but non-return valves prevent engine bleed air cross-feed. Control is by Pack 1 and Pack 2 – ON/OFF switches on the AIR CONDITIONING sub-panel of the flight deck overhead panel.

Recirculation or fresh air modes are selected by the CABIN AIR – RECIRC/FRESH switch on the AIR CONDITIONING sub-panel of the flight deck overhead panel. An Auxiliary Power Unit (APU) air bleed supply is also available and supplies both systems upstream of the No.1 pack and No.2 pack isolation flow control valves via the APU load control valve. Control is by the APU AIR – ON/OFF switch on the AIR SUPPLY sub-panel of the flight deck overhead panel.

Distribution

The output from both air conditioning packs feeds a common passenger cabin distribution system via sidewall outlets, exhausting to the pressurised under-floor compartments before discharging overboard.

A separate duct, off the delivery line from the No.1 pack, supplies conditioned air to the flight deck floor and ceiling outlets. A fan supplies air from the right-hand rear floor vent to louvres at each crew station and is controlled by the FLT DECK – FAN ON/OFF switch on the AIR CONDITIONING sub-panel of the flight deck overhead panel.

Two separate fans are provided for the cooling of the avionics racks. A switch is located on the maintenance panel in the electrical equipment bay to enable the selection of either fan 1 (normal operation) or fan 2 (standby if fan 1 fails) as required. Failure of the fan in use is indicated by an AVIONICS FAN OFF annunciator on the air conditioning section of the overhead panel, together with the AIR COND caption on the MWS.

The two fans are located below the floor. The running fan draws cooling air over the flight deck instrument panels, the avionics bay equipment racks and the flap computer. It also provides galley ventilation and moves air over the flight deck, cabin temperature sensors and the smoke detector. The fan selected runs continuously with either AC 1 or AC 2 busbars powered.

Individual louvres, located above each passenger seat, are supplied by fan air. The fan is controlled by a CABIN FAN – ON/OFF switch on the AIR CONDITIONING sub-panel of the flight deck overhead panel.

A ram air system permits the cabin to be ventilated at low altitude following failure or malfunction of the conditioned air supply. Ram air is controlled by a RAM AIR – SHUT/OPEN switch on the AIR CONDITIONING sub-panel of the flight deck overhead panel .

Pressurisation

The pressurisation system provides a means for controlling cabin pressure during all phases of flight and during ground operation. The control system ensures comfortable ascent and descent rates are maintained within the cabin, consistent with aircraft ascent and descent rates.

The cabin pressurised air source is derived from engine or APU bleed air which is conditioned by the environmental control system air conditioning packs. Pressure control is achieved by two electro-pneumatic outflow valves which regulate the outflow of air-conditioned air from the cabin. The required safety features are electrically and pneumatically implemented in each of the two outflow valves.

The system operates in either automatic or manual mode. In automatic mode the system aims to achieve a cabin altitude equal to the higher of that demanded by the principle schedule or the selected landing field altitude during aircraft climb, cruise and descent. The principle schedule is a single schedule relating cabin and aircraft altitude derived from the performance of an Avro RJ at 27,000 kg (60,000 lb) take-off weight at temperatures of ISA -10°C. In manual mode, the cabin rate of change is initially automatically set to zero, holding the cabin pressure by means of an isobaric hold function. The cabin rate of climb can be set between +/- 2,500 feet per minute referenced at sea level. The cabin rate of climb is set referenced to sea level, since passenger comfort criteria with respect to cabin rate of change is based on rate of change at sea level. Thus a comfortable cabin altitude rate can be selected irrespective of cabin altitude.

The system provides two types of built-in test: operator and automatic. Automatic testing is performed when power is applied to the system, during flight and after the flight. The relevant fault information is displayed on the controller. The operator test can be initiated on the ground by turning the landing field altitude selector knob anti-clockwise past -1,000 feet by five clicks. PASS is displayed on the controller LCD if no faults are found.

Displays and controls

The cabin pressure controller is located on the flight deck overhead panel and consists of a liquid crystal display (LCD) and several switches.

Row 1 of the display indicates the actual cabin rate of change in steps of 50 feet per minute. Two arrows show the direction and rate, and MR legend indicates the manually selected rate (when appropriate). Row 2 indicates the cabin to ambient pressure differential measured in PSI. Row 3 indicates cabin altitude in steps of 100 feet.

Operation of the MODE annunciator/switch removes the power supply from the auto controller circuits and energises the manual control circuitry. Once manual selection is made, the MODE annunciator changes, AUTO green goes out and MAN white is illuminated. Manual control of the discharge valves is then possible via the MAN – SHUT/OPEN rotary switch.

In the event of an expected landing on water, selecting DITCH operates the ditch control valve. Upon ditching, water will enter the discharge valve via the ditch control valve, closing the discharge valve and preventing an ingress of water into the cabin.

To minimise pressure surges on take-off with the system in AUTO, the discharge valves are automatically signalled by a switch on No.2 engine throttle to move to a partially closed position to pre-pressurise the cabin to 400 feet (maximum) below the take-off altitude. The system reverts to normal auto control at lift-off when the squat switches deactivate the system, and the No.2 engine is retarded to less than 80% or the aircraft has been airborne for 20 seconds.

With APU air not available and when take-off performance does not permit engine air to be used, to prevent cabin pressure surges after take-off the No.4 engine bleed air is selected ON, with both packs selected OFF. To prevent the MWS – AIR SEL ON GRND caption illuminating, the No.4 engine bleed is removed from the warning system.

With the landing gear squat switches compressed, the system in AUTO and the thrust levers set below 80% of full travel, a landing-gear-operated proximity sensor energises a relay in the selector/controller. The selector/controller automatically selects a cabin altitude of 14,000 feet at maximum rate setting. The discharge valves are fully opened by the jet pumps to reduce residual cabin pressure. This minimises the cabin pressure surges associated with the initiation and termination of air conditioning and the operation of the entrance doors.

Pressure cabin altimeter, differential pressure and rate of change indicator

This independent pressure instrument, located on the First Officer's instrument panel, utilises three separate needles to indicate:

1. Rate of change of pressure cabin altitude in feet per minute, over a range of 0-2,000 ft/min UP and DOWN, during climb and descent.
2. Differential pressure between cabin pressure and ambient pressure, over a range of 0-10 PSI.
3. Cabin altitude, over a range of 0-50,000 ft.

Cooling

The hot pneumatic air supply to the air conditioning packs is cooled to a predetermined level by passing through an air-to-air heat exchanger and a cold air unit within the pack. Ambient air from a single ram air intake supplies the cooling air for each heat exchanger before passing overboard. When the aircraft is on the ground, the cooling air is drawn through the heat exchangers by a fan, operated by the cold air unit in each system.

A condenser and a water extractor, fitted in each pack, prevent water accumulation in the distribution ducting.

Temperature control

Control of the temperature on the flight deck and in the passenger cabin is achieved by two independent control systems. Each system is normally operated in the automatic (AUTO) mode but can be controlled manually (MAN) in the event of failure of the automatic mode.

The components and functions of the two independent temperature control systems are identical, with the exception that only the temperature of the passenger cabin is indicated on the AIR CONDITIONING sub-panel.

In AUTO mode, each controller monitors the actual compartment temperature, compares this with the selected compartment temperature and, as necessary, adjusts the position of the temperature control valve of the respective air conditioning pack to achieve the selected temperature.

Each temperature control valve is automatically or manually controlled from the AIR CONDITIONING sub-panel on the flight deck overhead panel, by selection of the relevant FLT DECK TEMP CTRL or CABIN TEMP CTRL – AUTO/MAN switch.

With the switch selected to AUTO, the valve is controlled by a temperature controller and a COOL/AUTO/WARM rotary switch on the AIR CONDITIONING sub-panel on the flight deck overhead panel.

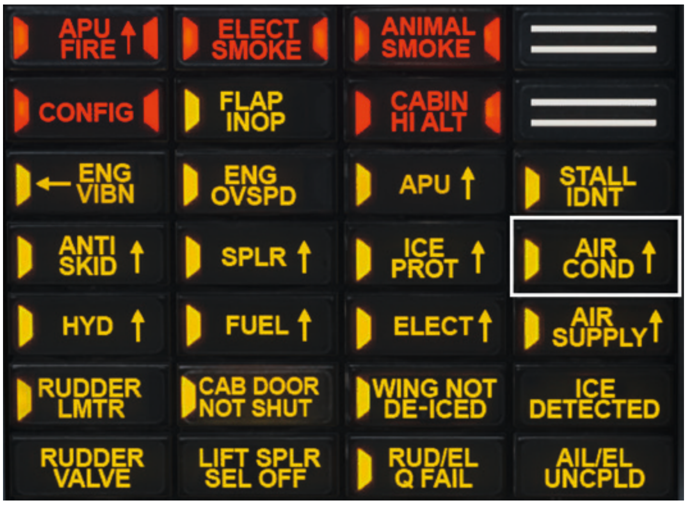
With the switch selected to MAN, the valve is controlled by a spring-loaded-to-centre switch labelled WARM/COOL, adjacent to the AUTO/MANUAL switch. Full-range movement of the valve from HOT to COLD or vice versa takes 20-30 seconds.

Controls and indicators

The air conditioning controls and indicators are located on the flight deck overhead panel, with the exception of the flight deck air controls which are located on the flight deck side walls.

The pressure selector/controller and associated controls and valve position indicators are located on the flight deck overhead panel. A single instrument which indicates cabin altitude, differential pressure and cabin rate of change is located on the First Officer's flight instrument panel.

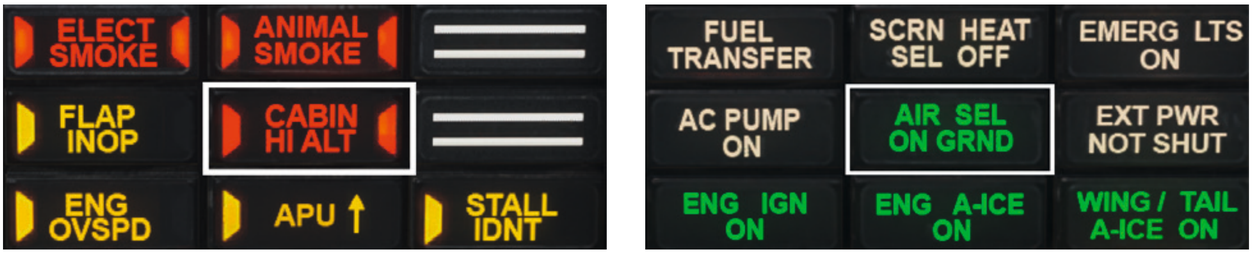
MWS system panel – air conditioning annunciator



Air conditioning panel (overhead)

Flight deck air conditioning selector handles

MWS system panel – pressurisation annunciators



Quad indicator

Pressurisation panel (overhead)

The controller has the following selectors and indicators:

- An illuminated push-button switch to select between automatic mode and manual mode. The switch shows a white MAN legend when manual mode is selected and a green AUTO legend for automatic mode.
- A three-line LCD display.
- A landing altitude (LDG ALT) selector for use in automatic mode.
- A cabin rate (MAN RATE) selector for use in the manual mode.
- A three-position OUTFLOW VALVES selector: DITCH, NORMAL and DUMP. At the NORMAL position, the valves are positioned by the controller to give the required cabin rate or altitude. At DITCH, the valves are forced closed on ditching. At DUMP, the valves are fully open. The switch must be pulled out before it can be rotated to DITCH or DUMP.
- Two green FULL OPEN outflow valve annunciators: one for the PRIMARY valve and one for the SECONDARY valve.
- A CLEAR DISPLAY FAULT button. The middle line of the display normally indicates differential pressure but it can display faults. If a fault were to be displayed, pressing this button removes the fault from the display and returns the display to differential pressure.

Row 1 of the display normally indicates actual cabin rate. An arrow indicates the direction of the cabin rate. In manual mode, the top line indicates the selected manual rate while the manual rate is being changed and for five seconds after it has been set. When manual rate is displayed, MR precedes the rate.

The bottom line of the display normally indicates actual cabin altitude. While the landing field altitude is being set, it replaces the cabin altitude. Landing field altitude remains displayed for five seconds after it has been set. A legend LA precedes the altitude while the landing altitude is displayed.

Operation

The landing altitude selector is used to select the landing altitude in steps of 100 feet. Initial movement causes the current landing altitude to be displayed and the LA legend to illuminate. The display persists for five seconds following selection. During ground operation the limits of landing altitude are -1,000 to +8,000 feet. In flight the limits of landing altitude are -1,000 to +14,000 feet.

The manual rate selector switch is used to select the cabin altitude rate of change in steps of 50 feet per minute when in manual mode. The first click of the switch causes the currently selected cabin altitude rate of change to be displayed on the controller LCD and quad gauge. The MR and MAN legends are illuminated. The controller LCD display persists for five seconds. The limits of cabin altitude rate of change are -2,500 to +2,500 feet per minute.

The clear display fault switch is used to restore normal cabin differential pressure display on the controller LCD following fault annunciation.

The mode selector indicator switch is used to select and indicate the controller operating mode to auto or manual.

The outflow valve selector indicator switch is used to select and indicate the controller operating mode to auto or manual.

The outflow valve selector is used to control the outflow valves. Select NORMAL for normal operation, DUMP to open both valves and DITCH to close both valves. The NORMAL position is pull-detented.

The PRIMARY FULL OPEN and SECONDARY FULL OPEN legends illuminate when their respective valves are fully open.

The quad gauge is a liquid crystal display and is mounted on the First Officer’s instrument panel. Row 1 of the display shows the actual cabin rate of change in steps of 50 feet per minute. Two arrows indicate rate direction and the MAN legend indicates manual control. Row 2 shows cabin to ambient pressure differential in PSI. Row 3 shows cabin altitude in steps of 100 feet. Row 4 shows the landing altitude in steps of 100 feet.

System indications

If the cabin altitude exceeds 8,700 feet, the cabin altitude display of both the quad gauge and controller LCD flash until the Clear Display Fault (CDF) button is pressed. If the cabin altitude continues to rise, the cabin altitude displays will again flash at 9,700 feet or above depending on the landing field altitude set. The CDF button will not clear the flashing display and the red CAB HI ALT MWS annunciator also illuminates at this time.

If the cabin differential pressure is outside the range -0.5 to +7.6 PSI, the differential display of the controller LCD and the quad gauge flash. This is accompanied by the MWS amber PRESSN annunciator.

When DUMP, DITCH or MAN are selected, the white PRESSN annunciator is illuminated on the MWP to indicate an abnormal system selection.

AIRCRAFT EQUIPMENT

Flight deck

The flight compartment normally provides accommodation for two crew members: the Captain and First Officer.

The crew seats are mounted on floor rails and the seats are manually operated to provide vertical and horizontal adjustment. Use the eye locator above the glareshield for correct positioning. An additional stowable seat provides accommodation for an observer. The seat is stowed when not in use behind the First Officer's seat. All seats are equipped with a full harness including inertia reel shoulder straps.

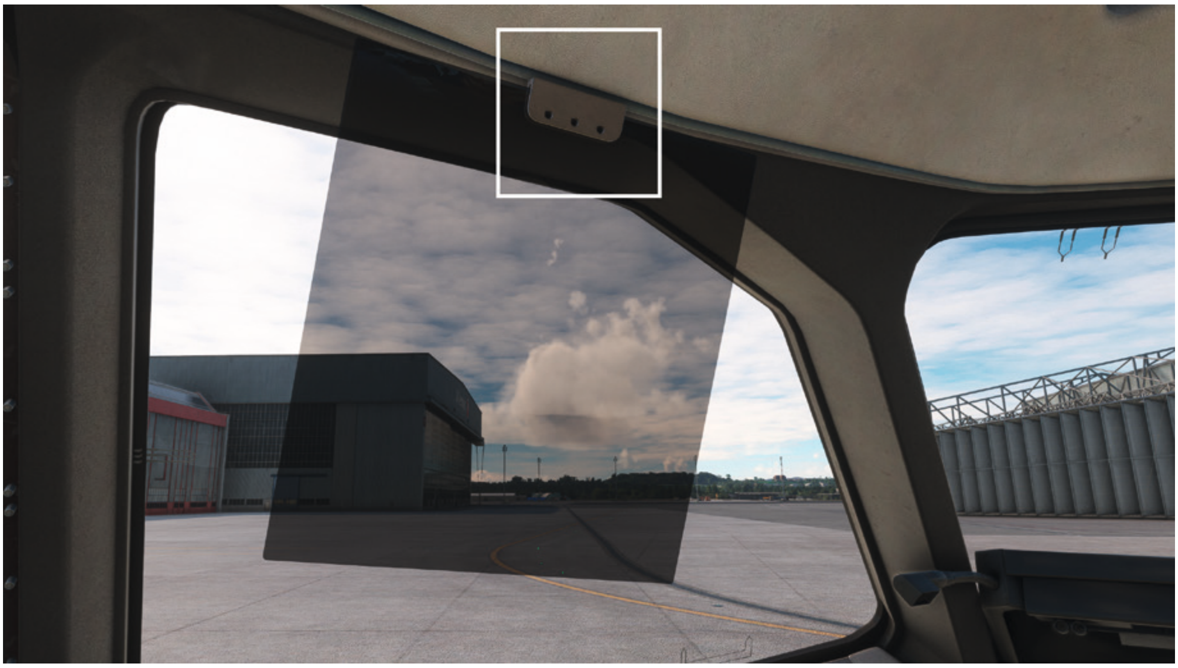
Click-and-drag or use the mouse-wheel on the seat handles to move them into the desired position.

An airfield approach chart holder is located on each pilot's handwheel. Side consoles, situated outboard of the Captain's and First Officer's stations, contain ashtrays, stowable chart/cup holders and stowage for both flight and operations manuals, checklists, sun visors and blind flying screens. Headset hooks are also provided. A document stowage area is installed immediately forward of the right aft bulkhead.

The cup holders can be extended or retracted by left-clicking on them.

The sun visors will start each flight in their stowed position in the side stowage area.

Click-and-drag or use the mouse-wheel on the sun visor clip to move it along its rail to position it as required, and return it to the fully aft position to move the visor back to its stowed position.



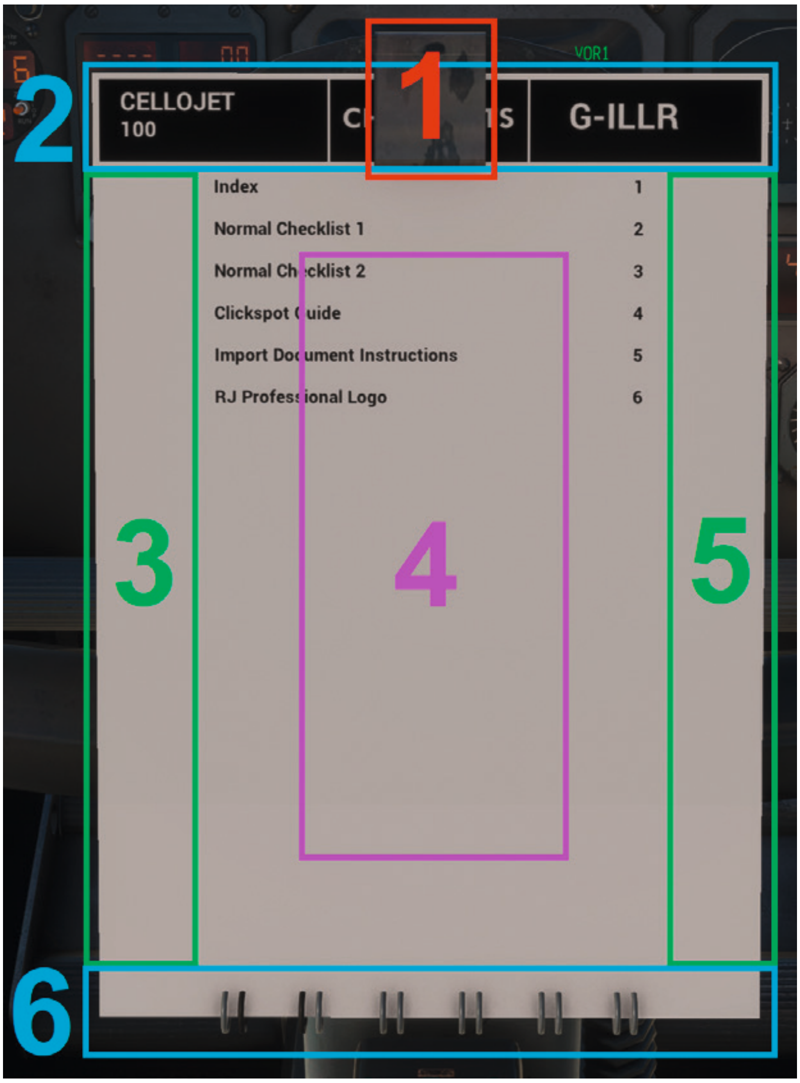
A recessed grab handle is located at each end of the glareshield.

Checklists and charts

The RJ Professional features fully customisable and interactable charts and checklists.

Checklists

Checklists can be fitted to both of the pilots' yokes by left-clicking the paper holder at the top centre of the yoke. Once fitted, one of up to 15 checklist pages can be selected from the index page, or you can cycle through the pages by using a variety of clickspots located around the page:



1. Hide/show checklist
2. Rotate anticlockwise
3. Previous page
4. Index page
5. Next page
6. Rotate clockwise

The checklist can be rotated to be in a horizontal or vertical orientation by clicking the relevant clickspots.

A useful tooltip will briefly appear at the bottom of the page when the mouse is over a clickspot, indicating that clickspot's purpose.

A selection of checklists is included by default with the RJ Professional and additional documents can be added by placing a .PNG file in the following file directory: *...\Community\justflight-aircraft-rj\Data\Images\Checklist*

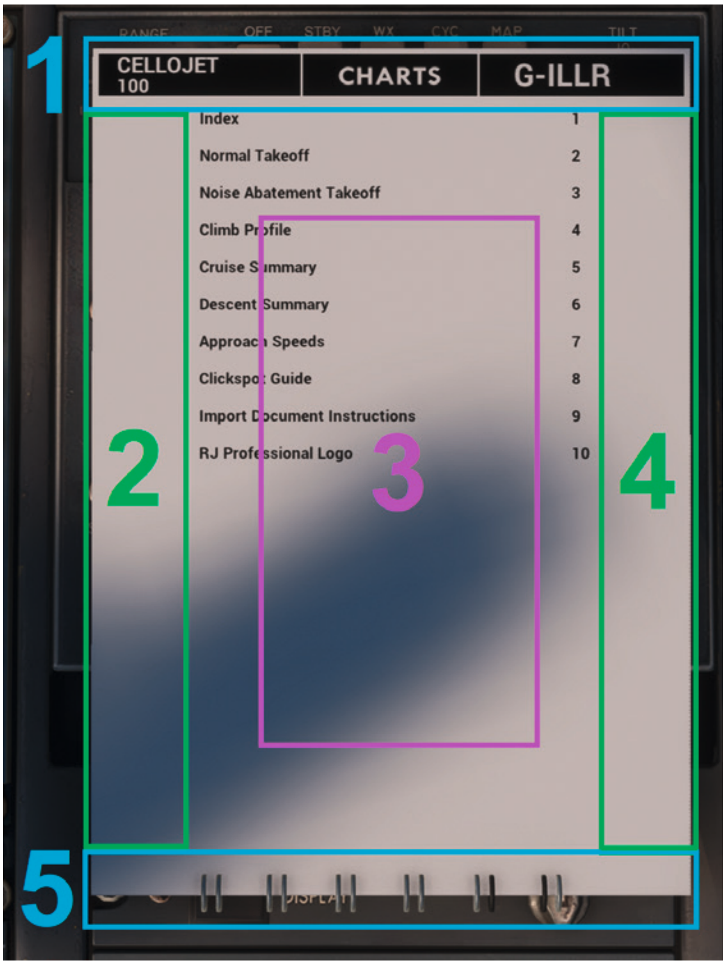
In order for documents to display correctly in the simulator, they should be A4 size and in a .PNG format. If you wish to change the file names of the checklists, or add any additional checklists, the RJ_checklist_list.ini file (located in the same file directory) must be updated to reflect the change in file name.

If the simulator is running when document changes are made, a restart of the flight will be required to see any changes to the checklists.

Charts

Charts have a very similar functionality to the checklists, but are stowed in the charts holder on top of the glareshield. Clicking on a chart whilst it is in this holder will move it down and place it on the top of the pedestal.

One of up to 20 charts can be selected from the index page, or you can cycle through the pages by using a variety of clickspots located around the page:



1. Rotate anticlockwise
2. Previous page
3. Index page
4. Next page
5. Rotate clockwise

The checklist can be rotated to be in a horizontal or vertical orientation by clicking the relevant clickspots.

A useful tooltip will briefly appear at the bottom of the page when the mouse is over a clickspot, indicating that clickspot's purpose.

A selection of charts is included by default with the RJ Professional and additional documents can be added by placing a .PDF file in the following file directory: *…\Community\justflight-aircraft-rj\Data\Images\Chart*

In order for documents to display correctly in the simulator, they should be A4 size and in a .PDF format. If you wish to change the file names of the charts, or add any additional charts, the RJ_chart_list.ini file (located in the same file directory) must be updated to reflect the change in file name.

If the simulator is running when document changes are made, a restart of the flight will be required to see any changes to the charts.

Front galley

The front galley provides accommodation for two cabin attendants. The stowable cabin attendants' seats are attached to the rear left-hand galley bulkhead.

A toilet compartment is located forward of the front passenger door. Aft-stowing air stairs are fitted at the front passenger door.

Worktop space is provided on the starboard side of the galley, with a functional work light, coffee maker and circuit breakers.

A potable water indicator shows the level of potable water on board. This level will decrease throughout the flight, with usage increasing if the coffee maker is used. The potable water will be refilled at the end of a flight when one of the service doors is opened.

Doors and stairs

The front galley has two doors: one passenger door located on the port (left) side of the aircraft and one smaller service door located on the starboard (right) side.

Either door can be opened by left-clicking the door operating handle and the door will raise above the abutments and swing outwards. Once fully open, a catch will lock the door to the fuselage.

To close the door, the catch must be withdrawn by left-clicking the door release handle. The door will then swing into the frame and lower into the abutments.

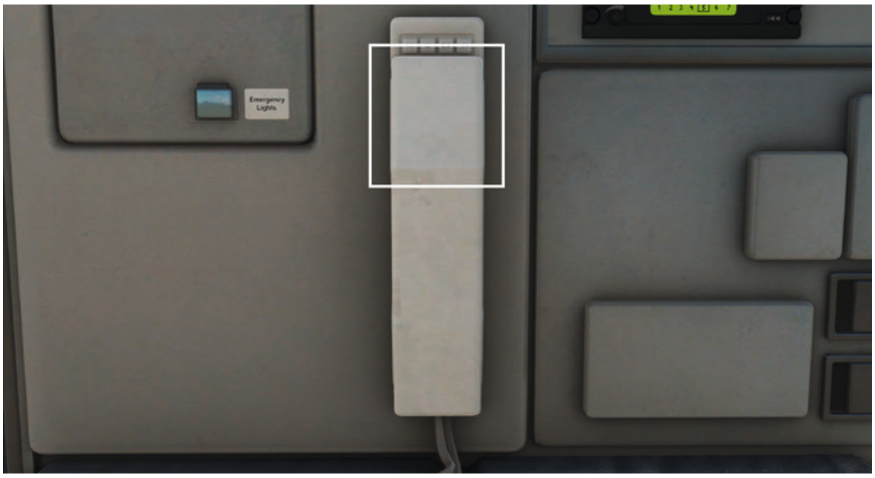
The passenger door also has airstairs that are stowed in a compartment beside the toilet. The airstairs can be deployed under their own weight by first setting the STAIR RETRACTION switch to the extended position and then opening the passenger door and left-clicking on the airstairs' handrail.

The airstairs are retracted hydraulically and require pressure from the Yellow hydraulic system, or from the airstairs accumulator (if fitted). To retract the airstairs, ensure the airstairs have sufficient hydraulic pressure either via the airstairs accumulator or by turning on the AC pump on the overhead panel in the cockpit, then set the STAIR RETRACTION switch to retract. Once the stairs are in the vertical position, left-click on one of the airstairs' handrails to stow them in their compartment.

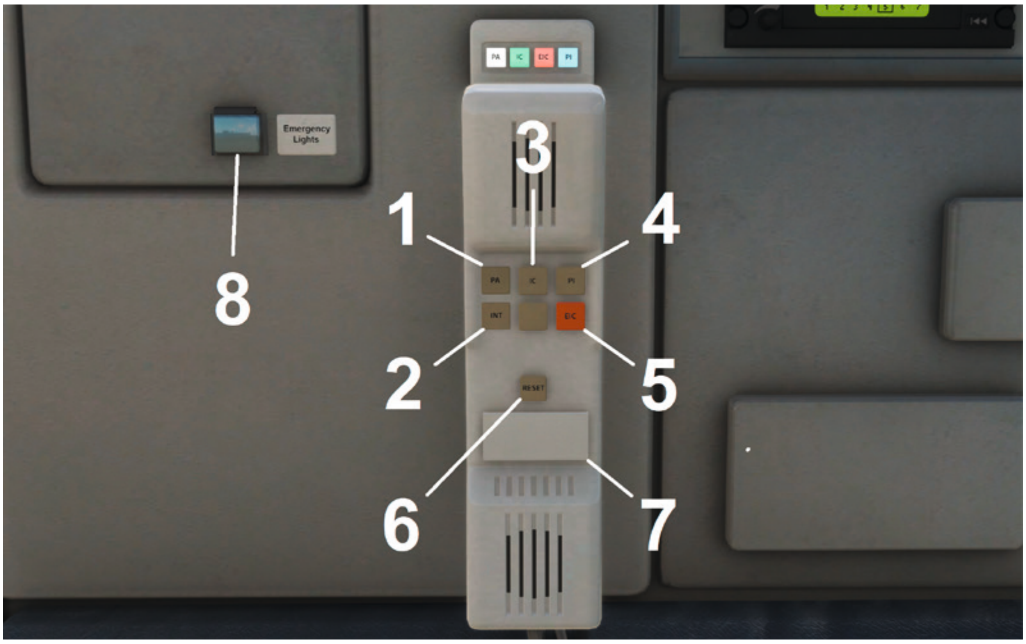
Cabin handsets

Two handsets are fitted in the cabin: one in the forward vestibule and one in the rear vestibule. The handsets are used for communications between the forward galley and the rear galley, passenger cabin and cockpit.

The handsets can be removed from their cradle by clicking on the top quarter of the handset.

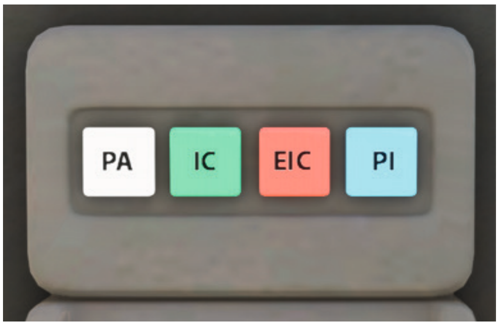


Each handset has a set of integral push-buttons:



1. PA – selects the handset to the PA (Public Address).
2. INT – connects the handset to the service intercom.
3. IC – makes a normal inter-cabin crew call.
4. PI – makes a normal cabin to flight deck crew call.
5. EIC – makes an emergency crew call from the cabin to the flight deck.
6. RESET – resets the call system.
7. PTT button – the push-to-talk button must be pressed to talk over either the PA or the service intercom.
8. Emergency lights – the cabin emergency lights switch is located on the panel adjacent to the handset and is used to illuminate the cabin emergency lighting. A switch guard prevents accidental activation.

Each handset cradle has a set of annunciators at the top which illuminate:



PA – illuminates with a white background. When the annunciator is illuminated, the handset is connected to the PA.

IC – illuminates with a green background. The annunciator is illuminated when a normal crew call is made from the front to the rear cabin or from the rear to the front cabin.

EIC – illuminates with a red background. Illuminates when an emergency crew call is made from the cabin to the flight deck or from the flight deck to the cabin.

PI – illuminates with a blue background. Illuminates when a normal crew call is made from the cabin to the flight deck or from the flight deck to the cabin.

Music player

A Becker DP4100 digital music player is fitted on the rear wall of the forward galley and allows you to play music in the cabin throughout the flight.

1. On/Off button
2. Repeat/Shuffle button
3. Volume knob / Mute button
4. Display
5. Play/Stop button
6. Skip Right button
7. Skip Left button

The music player can select and play up to seven different music tracks. It works much like a typical music player that you might find in your home or car, with Skip Left/Right buttons that are used to select the desired music track, Play/Pause button to play/pause the track and a volume knob which controls the volume when twisted or mutes the track when pushed in.

The volume of the music in the cockpit will vary depending on the position of the cockpit door. If the cockpit door is open, the music will be heard clearly in the cockpit, but with the cockpit door closed, the music volume will be significantly quieter.

A random music track will be selected when loading into the aircraft, meaning that a different music track will be heard the first time the music player is switched on during every flight. When the Shuffle function is selected, the order in which the music tracks play will be randomised. When the Repeat function is selected, the music track currently selected will play again at the end of the track.

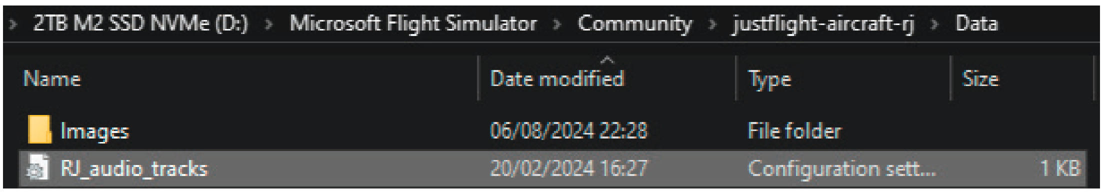
If the AUTO CABIN CREW option is enabled on the Aircraft page of the EFB, the cabin crew will begin to play music when the passenger door is opened to begin boarding at the start of the flight, as well as at the end of the flight when the aircraft has vacated the runway and the flaps are retracted.

Importing custom cabin music

Seven music tracks are provided with the RJ Professional, but custom music can also be imported and played through the cabin speakers. A maximum of seven music tracks can be loaded onto the music player.

To import custom music, a .wav file must be placed into the following file directory, with the same name as the file it is replacing (for example, 'cabin_music_01'): *…\Community\justflight-aircraft-RJ\SimObjects\Airplanes\JF_RJ_70\sound*

The name and duration of the imported track can be edited in the '146_audio_tracks.ini' file in the following file directory (instructions for editing the .ini file are included in the file itself): *…\Community\justflight-aircraft-rj\Data*



Any custom .wav file placed into this file directory must conform to the limitations of the simulator's core sound engine, therefore any .wav file must not exceed 16-bit stereo 44.1 kHz. A lower value of 22 kHz or 11 kHz may be used to reduce the quality of the sound, replicating the poor-quality speakers fitted to vintage aircraft. The reduction in bit rate will also reduce the file size of the track and thus reduce the simulator's memory usage. This can have a dramatic effect on performance, especially on tracks with a longer running time.

For users familiar with audio engineering, the imported music should also be normalised to approximately -23 dB to match the rest of the sound environment.

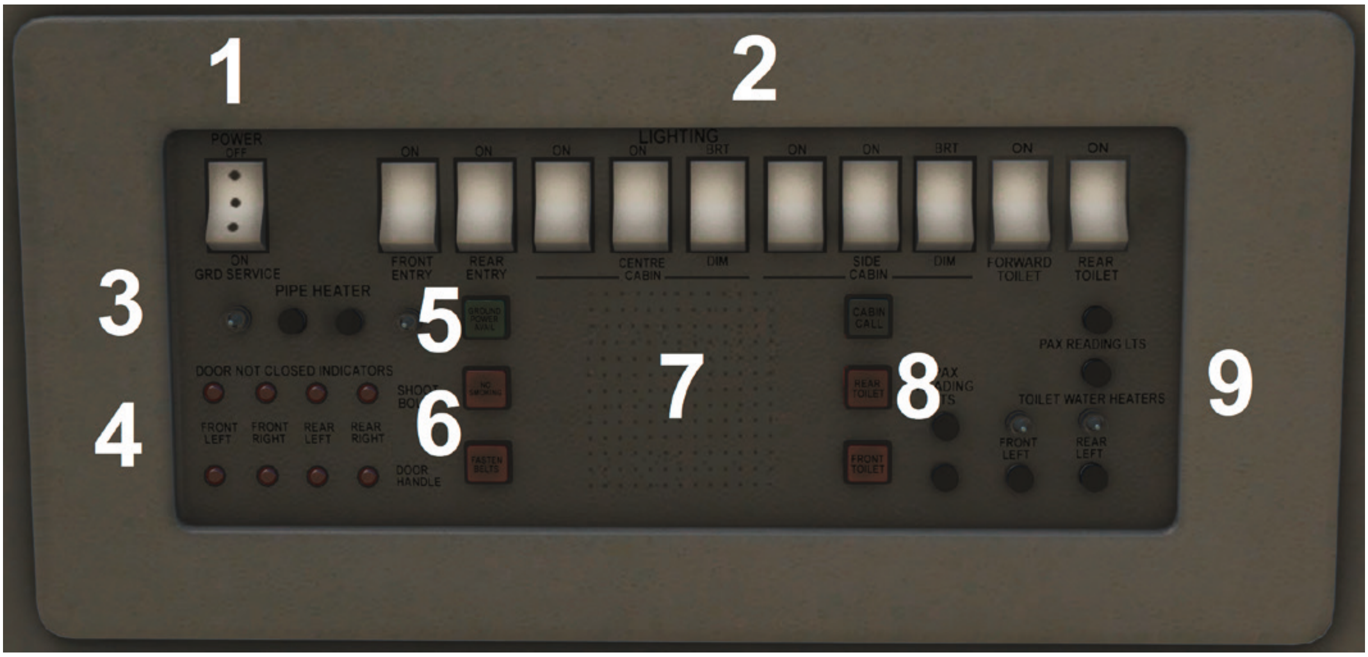
All the above requirements can be achieved with free audio software such as Audacity.

Note 1: *If the music.wav file does not conform to the MSFS sound engine limitations, the music will not be audible within the simulator.*

Note 2: *In MSFS 2024, the package's layout.json file (located in the root folder of the package) must be updated every time a change to the package's contents is made. We recommend using the free, community-created [MSFS Layout Generator Tool](#).*

Forward vestibule attendant panel

An attendant's panel is located above the service door in the forward galley and includes controls for cabin lighting and ground power, as well as various cabin-related indicators.

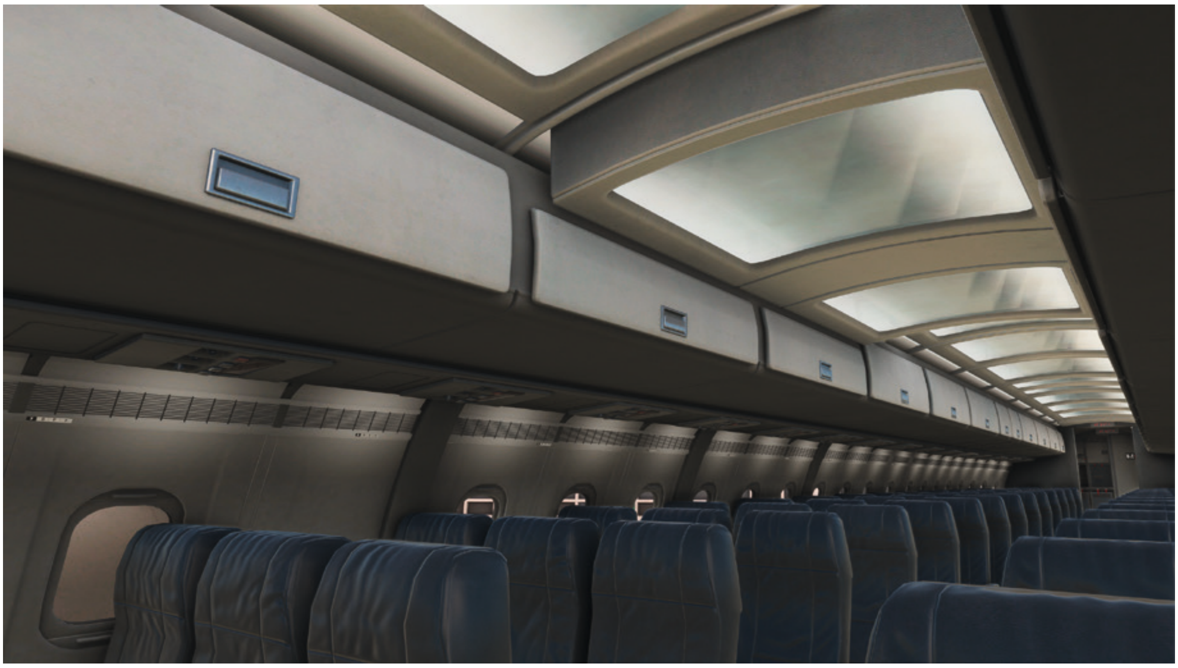


1. Ground power control
2. Cabin lights switches
3. Pipe heater switch and circuit breaker
4. Door warning indicators
5. Status indicator for the ground service busbar
6. Status indicators for seat belt signs and no smoking signs
7. PA speaker
8. Call indicators for cabin call, forward toilet and rear toilet
9. Toilet water heaters and cabin reading lights circuit breakers

Passenger cabin

The passenger cabin will accommodate a maximum of 100-118 seats (RJ70-RJ100), mainly six abreast and at 31 inches seat pitch. The RJ85 and RJ100 share the same maximum occupant limit due to the limited number of exit doors. Due to the curvature of the fuselage towards the rear of the cabin, the last two rows are reduced to four abreast.

Overhead stowage bins are provided on each side of the passenger cabin. Several rows of seats in the centre of the passenger cabin have smaller overhead stowage bins due to the lower ceiling caused by the wing structure.



The passenger cabin can be toggled on/off to improve FPS/performance via the Configuration menu on the Aircraft page of the EFB.

Rear galley

The rear galley provides accommodation for two cabin attendants. The stowable cabin attendants' seats are attached to the forward wall.

Both the passenger and service doors can be opened using the same method as for the doors in the forward galley.

A toilet compartment is located in the rear bulkhead.

Worktop space is provided on the starboard side of the galley, with a functional work light and circuit breakers.

A communications handset is fitted on the forward wall of the rear galley. This handset is functionally identical to the handset in the forward galley.

An attendant panel is located above the service door and features annunciators for no smoking and fasten seat belt signs, and calls from the cabin, front toilet and rear toilet.

AUXILIARY POWER UNIT (APU)

The auxiliary power unit (APU) is a gas turbine engine driving a generator installed in a fire-proof bay in the aircraft tail cone. The APU may be used on the ground and in the air to provide electrical power or bleed air. The generator supplies 115/200V to the main AC busbars which can be used as a power source to start the main engines on the ground (see the ELECTRICAL SYSTEM section). Air can be bled from the APU compressor for air conditioning (see the AIR CONDITIONING SYSTEM section). Both electrical and air supplies may be used independently or simultaneously within certain limitations (see LIMITS – APU).

Automatic shutdown protects the system against failures, including fire on the ground. Fire detection and protection is available (see the FIRE PROTECTION SYSTEM – APU section).

Controls and indicators are located on the flight deck overhead panel.

Bleed air and/or electrical power from the APU is available only when the APU is operating at speeds above 95% RPM during the start sequence. There are, however, maintenance cost advantages in allowing the APU to operate at no load-governed speed for at least one minute before application of bleed air load. In addition, the APU should be shut down directly from its current running state even if it is loaded.

APU panel – overhead

Air supply panel – overhead

Electric panel – overhead

APU – MWS annunciator

Operation

Starting, acceleration and operation of the engine is controlled automatically.

Air is bled from the APU by selecting the APU AIR switch to ON, which opens the load control valve (LCV). Load is limited by exhaust (turbine) gas temperature (TGT) and is controlled by temperature-sensing circuits.

Bleed air ducting from the APU incorporates a flow-limiting venturi, which limits APU bleed offtake to help prevent the EGT limit being exceeded.

Automatic shutdown protection

Automatic closure of the fuel shut-off valve provides automatic shut-down as follows:

In flight or on the ground:

1. Engine overspeed (110%)
2. TGT over-temperature
3. Engine oil low pressure (minimum 31 PSI above 95% RPM) with 10-second delay
4. Loss of RPM signal
5. Loss of TGT signal

The overspeed shutdown protection can be tested on the ground by pressing the APU OVSPD switch when the APU is running.

On the ground only:

1. APU fire (manual operation of the extinguisher is required)
2. Generator oil low pressure, when above 95% RPM
3. Generator oil high temperature, when above 95%

There is a 20-second delay on the operation of the automatic shutdowns associated with the generator.

Indication of an automatic shutdown is given by the APU OIL LO PRESS annunciator and the engine speed and TGT indicators.

All protective functions are reset when the APU START/STOP switch is set to STOP.

Emergency shutdown protection

On the ground the APU can be shut down in an emergency by manually selecting either of the two APU STOP switches to STOP.

Fuel supply

Fuel is suction-fed from the aircraft fuel system on starting. Thereafter it can be pressure-fed on a normal selection of L.INNER fuel pump to ON. On suction feed, the APU FUEL LO PRESS annunciator will be lit.

Electrical power supplies

The control and indicating systems are powered from an emergency DC source.

The APU FUEL VALVE, APU VLV NOT SHUT and APU NRV LEAK annunciators are fed directly from the emergency DC source, as is the fire warning system. Other warnings are supplied from the control supply via the APU START-STOP switch.

Starting

A 28V DC starting supply is taken from TRU 1, the aircraft battery or from an External DC supply. An External DC supply can only be selected by selecting the ENGINES START PWR switch to EXT DC and the START MASTER switch to ON. Selecting the APU START/STOP switch to START initiates the starting sequence, which is completed in approximately 30 seconds and indicated by the illumination of the APU PWR AVAILABLE annunciator at 97% RPM +4 seconds.

When the speed reaches 97%, ignition is terminated and a circuit is completed to the hour meter. Acceleration continues until the engine speed reaches no-load governed speed.

A start can be aborted by setting the APU START/STOP switch to STOP.

The APU can also be controlled with the 'APU STARTER' and 'APU OFF' control assignments.

Fuel consumption

The fuel consumption of the APU, running at maximum load, is given in the table below. The consumption when idling is approximately half of these values.

Altitude (ft)	**Fuel flow (lb/hour)**	**Fuel flow (kg/hour)**
Sea level	160	75
5,000	140	65
10,000	120	55
15,000	105	50
20,000	90	40
25,000	80	35
30,000	65	30

COMMUNICATION SYSTEM

The aircraft communication system consists of the following, interconnected elements:

- Speech communication, utilising a dual VHF (Very High Frequency) system
- Two Radio Management Panels (RMP)
- Passenger address and entertainment system
- Interphone, providing audio communication between the flight deck and ground crew
- Audio integrating, which includes a central audio system
- Audio monitoring, utilising a cockpit voice recorder
- Static discharging

VHF communication system

Two separate VHF COMM systems are provided. Each installation comprises a VHF transceiver and a Radio Management Panel (RMP). Audio and keying facilities are provided by the audio integrating system.

Radio Management Panel (RMP)

Each VHF transceiver is controlled by either of two RMPs, one located on either side of the centre console. Both RMPs allow for up to three VHF frequencies to be tuned in a range of 118.00 to 136.95 MHz in 25 kHz increments.

If HF aerials are fitted to the exterior of the aircraft (by enabling the HF AERIALS option on the Aircraft page of the EFB), the RMPs will also allow for up to two HF frequencies to be tuned in a range of 2.000 to 29.999 MHz in 0.1 kHz spacing. If HF aerials are not fitted to the exterior of the aircraft, the RMPs are simulated to reflect an aircraft that is not fitted with HF radios.

Note: *Due to MSFS limitations, HF radio communications are not possible.*

Power supplies are from 28V EMERG DC, through relays controlled by AVIONICS MASTER 1 for VHF 1 and RMP 1. From DC2, through AVIONICS MASTER 2, for VHF 2 and RMP 2.

Each RPM incorporates:

- Two LCD VHF/HF frequency display windows: ACTIVE and PRESELECT. During normal operation the upper half of each LCD indicates the selected radio, while the lower part shows the frequency. The ACTIVE display shows the last frequency entered to the selected radio and the PRESELECT display is used as a 'scratch pad' for entry using the frequency selection knobs. Testing of the LCDs is via the flight ANNUN TEST button on the Captain's instrument panel. Memory storage is provided for the two visible frequencies for each transceiver. FAIL messages are also annunciated on the LCD.
- A single set of concentric frequency selection knobs.
- A transfer button, located between the two windows, to exchange the two displays.
- Three VHF and two HF, mutually exclusive, radio selection buttons. If radio is deactivated the display shows dashes.
- An AM mode indicator (green), for HF only. Each press of the HF selector toggles the AM mode OFF/ON.

Cockpit voice recorder

The cockpit voice recorder (CVR) system provides automatic recording, on four channels simultaneously, of audio received on the flight crew headset telephones and audio from a flight deck microphone.

The tape can be bulk erased only after the aircraft has landed and one of the two passenger doors or one of the two service doors has been opened. When the ERASE push-button is depressed, it must be held for at least two seconds and bulk erase is initiated and is maintained for a period of five seconds.

When AVIONICS MASTER 1 is selected OFF, the CVR ceases to operate and, if bulk erase has not been carried out, the last thirty minutes of recording are held on tape. Playback of recorded information is only possible after removal of the CVR from the aircraft.

Power supply is from 115V ESS AC, via relays controlled by AVIONICS MASTER 1. If power supplies are interrupted for any reason, the CVR will stop recording with the last 30 minutes of recorded information held on tape.

A control unit is located in the flight deck. A TEST button on the control unit, when depressed, monitors the system and indicates a 'go" or 'no go' condition on the CVR LED light. In addition there is a distinctive tone which can be monitored on the headset when plugged into the control unit HEADSET jack socket.

Passenger address system

The passenger address system can be used with priority from the flight interphone stations when PA is selected on the respective audio selector panel, overriding transmissions from any other station.

High, high/low and low chime tones are activated by corresponding signals when received from passenger and toilet call, cabin crew call, fasten seat belts and no smoking signs. All chime tones are fed to the cabin attendant's panels, passenger cabin and toilet speakers.

A cabin announcement will also be made when the 'fasten seat belts' switch is used.

Audio selector panels

There are three audio selectors on the flight deck, situated on the pilots' and third crew member's side consoles. A panel is shown below. The top row of square buttons is for the selection of transmission and the buttons are spring-loaded so that they release when another selection is made. The associated round knobs are for reception; press to select and rotate to the right for increased volume.

The various knobs on this panel are labelled with the audio source for which they control the volume. In this simulation we have also provided controls for adjusting the volume of the interaction between cockpit and cabin crew.

The SER INT knob controls the volume of the calls between the flight deck and cabin ("Cabin crew, please take your seats for landing", "Cabin is secure" etc.).

The INT knob controls the volume of all pilot callouts during take-off and landing ("80 knots", "Rotate" etc.).

The panels are difficult to see from the normal pilot viewpoint so we have added an option to toggle the visibility of the large sills. This option is controlled by hidden clickspots located at the forward end of the sills.

DOORS AND STAIRS

The aircraft has two passenger and two cabin service exterior doors, two cargo compartment doors and several miscellaneous ground servicing doors. Interior doors consist of individual toilet doors and a separate flight deck door.

All doors are manually operated. Each pressurised door is connected to an upper or lower door warning system.

Lightweight airborne folding airstairs are fitted at the forward passenger door.

In this simulation the doors and stairs can be controlled either via their respective controls in the cabin or via the EFB tablet.

Doors

Passenger and service doors

Two outward-opening doors in the left-hand side of the fuselage, one located forward and one at the rear of the passenger compartment, provide entry and exit for passengers and crew and may be opened from the inside or outside of the aircraft.

Two outward-opening doors, in the right-hand side of the fuselage opposite the passenger doors, provide access to the flight deck and passenger compartment and may be opened either from inside or outside the aircraft.

All four doors incorporate an observation viewer and may be used for emergency evacuation of the aircraft.

Each passenger door and service door is fitted with an evacuation slide.

Cargo doors

The front and rear cargo compartment doors can be opened via the Aircraft page on the EFB/tablet.

Flight deck door

An enhanced-security cockpit door opens into the forward vestibule.

The door has two permanently open vent holes to equalise pressure between the flight deck and the cabin in the case of a rapid decompression. The holes are covered with decompression grilles on the cabin side.

The door can be opened/closed by clicking the door handle on either side of the door. An additional clickspot is available on the mechanical linkage on the hinged side of the door for ease of access from the Captain's seat.

Door locking can be achieved remotely via a LOCK/UNLOCK switch on the aft centre console. The switch should only be moved momentarily to the desired position as the solenoids used in the door locking mechanism are not continuously rated.

A mechanical latch locking handle on the door handle shows the current lock status of the door and can also be used to manually lock/unlock the door.

A NOT LOCKED indicator on the aft centre console illuminates whenever the door is not locked.

A viewing window in the door allows the forward vestibule to be viewed from the flight deck. A cover over the window is rotated when clicked.

Door warning systems

Separate upper and lower fuselage pressure doors unsafe warning systems are installed.

If a door is not locked, the associated MWS DOOR NOT SHUT amber annunciator will illuminate. A single audio chime will sound.

An EXT PWR NOT SHUT annunciation illuminates if the external AC power door is not shut.

Upper doors system

Each passenger and service door incorporates individual shoot bolts and door handle microswitches which are electrically connected to the flight deck Master Warning Panel and the front cabin attendant's panel located in the front vestibule.

If a door is not locked the associated light emitting diode (LED) on the front cabin attendant's panel and the associated MWS CAB DOOR NOT SHUT amber annunciator will illuminate; a single audio chime will be sounded.

Lower doors system

A microswitch, operated via a lockbolt, is fitted on each cargo compartment door. Each microswitch is electrically connected to the DOOR NOT SHUT amber annunciator, which will illuminate should any microswitch contact fail to be made.

External ground power panel

The open and closed positions of the external ground power panel are sensed by a microswitch. When the panel is open the MWS EXT PWR NOT SHUT white annunciator is lit.

Airstairs

Forward-stowed airstairs are installed at the front passenger entrance door.

The unit is mounted on a carriage located in two roller tracks fixed flush with the aircraft floor. This arrangement allows the whole unit to slide forward/aft into a designed storage area. Automatic locks are provided at both ends of the rails.

Yellow system hydraulic power is used to retract the stairway with manual operation for the sliding function and gravity for extension of the structure.

The airstairs are designed to accommodate varying floor to ground heights. Folding handrails are provided.

Before starting deployment, ensure the passenger door is latched open and the immediate area is clear of obstructions. With gentle pressure on the foot latch, unlock the unit and slide it to the end of the tracks. The stairs will lock automatically in the door aperture. The stairs are pushed outboard manually until over-centre, when gravity takes over. Extension speed is controlled and damped.

To retract the airstairs before engine start, both Yellow hydraulics and electrical power must be online. The HYDRAULIC AC PUMP must be selected ON. If No.2 engine is running and ENG 2 HYDRAULIC PUMP is selected ON, the AC PUMP is not required.

An AIRSTAIRS ACCUMULATOR can be fitted to the aircraft via an option on the EFB Aircraft page. With this option enabled, the airstairs accumulator stores enough pressure to facilitate two full retractions of the airstairs without requiring the Yellow hydraulic system to be pressurised. Once pressure in the airstairs accumulator has been depleted, they will fall under gravity and will require Yellow system hydraulic pressure to retract and to recharge the accumulator.

Integral airstairs lighting can be fitted to the aircraft via an option on the EFB Aircraft page. With this option enabled, the airstairs lighting will be lit whenever the STAIR RETRACTION switch is not in the retracted position. The lights are powered from the 28V AC ground service busbar.

ELECTRICAL SYSTEM

General

The basic network

The electrical power system has both AC and DC power services. AC power is supplied by two engine-driven generators, an APU-driven generator, a ground source and a hydraulically driven standby generator. The standby generator also supplies DC power.

DC power is normally provided by two transformer rectifier units (TRUs) which convert the AC, provided by the generators or AC external source, to DC. The TRUs supply the two normal DC busbars and, via suitable protection devices, the essential DC (SDC) and emergency DC (MDC) busbars.

A 24V battery provides an emergency DC (MDC) supply and also, through a standby static inverter, an emergency AC (MAC) supply.

The AC and DC supplies are distributed by a network of busbars designated as:

- Normal (AC 1 and AC 2, DC 1 and DC 2)
- Essential (ESS AC or DC)
- Emergency (EMERG AC or DC)

The normal busbars (AC 1, AC 2, DC 1 and DC 2) are duplicated to form the basis of a two-channel system, both having AC and DC busbars.

Normally the battery is connected to the battery busbar only, which is designated as BATT. When the battery provides an alternative supply, the battery source is additionally designated (essential DC/battery, for example) and is shown as SDCB on the flight deck circuit breaker panels.

Normal, essential and emergency AC busbar network

Primary AC electrical power is provided by two 40 kVA integrated-drive generators (IDG). One IDG is mounted on each of the No.1 and No.4 engines to give two separate 115/200V, 3-phase, 400 Hz channels with automatic transfer to supply all busbars from the remaining generator in the event of failure of the other generator.

The generator driven by engine No.1 (GEN 1) normally powers AC 1 on channel 1, and the generator driven by engine No.4 (GEN 4) normally powers AC 2 on channel 2.

The ESSential and EMERGency AC busbars are both on channel 1, so that AC 1 normally supplies the ESSential AC busbar which, in turn, normally supplies the EMERGency AC busbar. The EMERG AC busbar is powered with single-phase 115V AC.

The APU generator is available to supply AC power on the ground or in flight to compensate for failure of an ENG IDG. In flight the APU generator can only power one channel.

The APU generator or the external AC source can each supply channels 1 and/or 2, but in flight the APU can only feed one busbar at a time. If only one IDG is on-line, then it will power its associated busbar and the other available source is used to power the other busbar. If no other source is available, the IDG will supply both channels. On the ground the APU or external AC source can be used to power both channels.

Normal, essential and emergency DC busbar network

The normal DC busbars (DC1 and DC2) are supplied with nominal 28V DC from the two TRUs. In normal operation (BUS-TIE DC, AUTO) AC1 powers TRU1, which supplies DC1, and AC2 powers TRU2, which supplies DC2. The DC busbars are paralleled and feed the EMERG DC and ESS DC busbars.

When the busbars are split (BUS-TIE DC, OPEN), DC1 feeds the EMERG and ESS DC busbars, both in channel 1, and DC2 remains alone in channel 2. Battery supplies also form part of channel 1.

Avionics services power supplies

The avionics services are powered from 115V AC, 26V AC or 28V DC. The 26V AC is normally provided by transformers.

Standby generator

A hydraulically driven standby generator (STBY GEN) is provided which will, when armed, automatically supply 3-phase 115V AC to the ESS AC and 28V DC to the ESS DC busbars, in the event of loss of power to both normal AC busbars. The normal busbars (AC and DC) are not powered by the STBY GEN, but the EMERG AC and EMERG DC will be supplied from their associated ESS AC and ESS DC busbars.

A three-position STBY GEN switch is located on the overhead ELECTRIC panel. Switch positions are ARM, OFF and O/RIDE.

Standby inverter

Aircraft battery power will feed a nominal 24V DC to the EMERG DC busbar and also to the standby static inverter. The STBY INVerter feeds single-phase 115V AC to the EMERG AC busbar and single-phase 26V AC to the 26V EMERG AC busbar. The battery and the STBY INV are both in channel 1.

A three-position STBY INV switch is located on the overhead ELECTRIC panel. Switch positions are ARM, OFF and O/RIDE.

Bus-tie facilities

The electrical power system has two independent bus-tie facilities, BUS-TIE AC and BUS-TIE DC, each having a separate switch with OPEN and AUTO settings.

The AC channels 1 and 2 are split and the AC 1 and AC 2 busbars are normally fed by separate sources, but when there is only one source of power available and both busbars are serviceable, an automatic transfer system will allow the single source to power both busbars if the BUS-TIE AC switch is at AUTO. If the BUS-TIE AC switch is at OPEN, or if there is a busbar fault, the automatic transfer of power will be inhibited.

The DC channels 1 and 2 are normally paralleled when the BUS-TIE DC switch is at AUTO so that, if the busbars are serviceable, both DC 1 and DC 2 will be powered if only one source of power is available. If the BUS-TIE DC switch is at OPEN, the DC busbars will be split.

Ground servicing and domestic power supplies

Electrical power for ground servicing and domestic purposes is provided by a ground services busbar which, as a sub-busbar of AC 2, is powered whenever AC 2 is powered. Alternatively, if an external AC supply is available, it may be selected to power the ground services busbar only. The ground services busbar also has a single-phase 28V AC sub-busbar powered by a transformer.

Main engine starting power

The main engine starters can be powered via two TRUs on the aircraft or by an external DC supply.

Busbar protection and failure indication

The normal, essential and emergency AC and DC busbars have failure annunciators on the flight deck. In reality, each of these busbars consists of a primary busbar feeding several sub-busbars via protective devices. Busbar failure indication is given when there is a power supply fault on the associated primary busbar.

Indicators and controls

Indicators and controls for the electrical power system (including AC and DC voltmeters and ammeters and a frequency meter) are grouped on the ELECTRIC and APU sub-panels of the flight deck overhead instrument panel. An ELECT caption is on the Master Warning Panel on the centre instrument panel.

Electric panel (Overhead)

MWS system panel – electric annunciator

The following abbreviations are used to identify power supplies on the ELECTRIC and/or protective devices panels:

ELECTRIC panel	Protective devices panels	Power supplies
AC BUS 1 AC BUS 2	AC 1 AC 2	Normal AC, channel 1 Normal AC, channel 2
DC BUS 1 DC BUS 2	DC 1 DC 2	Normal DC, channel 1 Normal DC, channel 2
ESS AC	SAC	Essential AC
ESS DC	SDC	Essential DC
EMERG AC	MAC	Emergency AC
EMERG DC	MDC	Emergency DC
BATT	BAT 26 SAC 26 MAC	Battery 26V essential AC 26V emergency AC

Location of electrical system equipment

The generator control units, transformer rectifier units, static inverter and battery, together with primary busbars, control contactors and main junction box are located in the electrical equipment bay beneath the flight deck and front vestibule. Access can be gained through a door on the right side of the fuselage or through a hatch in the flight deck floor.

Circuit breakers that concern the flight crew are provided on the flight deck overhead circuit breaker panel. Two circuit breaker panels in the electrical equipment bay are not accessible to the flight crew.

A ground power services switch and indicator is located on the forward cabin attendant's panel in the forward vestibule.

An external 200V AC ground power receptacle is located, behind an access panel, on the right-hand side of the forward fuselage.

An external 28V DC connector, behind a smaller access panel, is located further aft on the right-hand side of the fuselage.

Main AC power system

Protective interlocks and controls

Electrical power from the engine- and APU-driven generators and the external AC source is connected to the busbar network via a series of electrical and mechanical protective interlocks which provide fault protection and establish the following priorities for the powering of busbars:

Priority	AC channel 1	AC channel 2
1	GEN 1	GEN 4
2	EXT AC *(if AC bus-tie auto)*	EXT AC
3	APU GEN *(if AC bus-tie auto)*	APU GEN
4	GEN 4 *(if AC bus-tie auto)*	GEN 1 *(if AC bus-tie auto)*

External AC is monitored by a unit on the aircraft; if the monitor finds it unacceptable, external AC cannot be connected to the busbars. If found acceptable, a green EXT AC PWR AVAILABLE illuminates on the flight deck and a green GROUND POWER AVAILABLE illuminates on the forward attendant's panel.

Each generator is protected and has its voltage regulated by a control unit (GCU). If the generators are switched ON, their output will be controlled automatically in conjunction with the automatic power transfer system. If a GCU senses a fault it will disconnect its generator from the busbar system. For all faults except under-frequency, the generator will also be de-energised and additionally, in the case of busbar over-current, the automatic transfer of power from the generator of the other engine or APU will be inhibited.

All transient faults, except under-frequency, require the generator to be RESET. After an over-current fault, the automatic power transfer system can only be reset by a mechanism which is not accessible in flight. In addition to the influence of its GCU and the automatic power transfer priorities, the APU generator will only come online if the APU is operating satisfactorily at governed speed.

If the engine No.1 or No.4 fire handle has been pulled out to its fullest extent the respective generator will be isolated.

The generators GEN 1, GEN 4 and APU GEN each have a control switch with three settings: ON, OFF LINE and OFF/ RESET. The EXT AC control switch also has three settings: OFF, centre and ON. When its control switch has been selected to OFF LINE, a generator is disconnected from the busbar system. But if there is no fault, the generator remains energised and its volts and frequency may be assessed by the flight deck instrumentation. When OFF/RESET has been selected, the generator is de-energised in addition to being disconnected from the busbar system. This selection allows an attempt to be made to reset an automatically de-energised generator.

The engine-driven and APU-driven generators are identical and each is capable of supplying the entire electrical demand. In flight, if there is a failure of supplies to both AC 1 and AC 2 busbars, the APU GEN will only supply one busbar – the AC 1 busbar when the BUS-TIE AC switch is at AUTO, or AC 2 if the BUS-TIE AC switch is at OPEN.

Usage of the APU generator is altitude-restricted (refer to the LIMITS section).

Generator control

The generators GEN 1, APU GEN and GEN 4 each have a three-position control switch located on the lower part of the overhead ELECTRIC sub-panel. The switch positions are ON – OFF LINE – OFF/RESET.

When selected OFF LINE the generator is disconnected from the busbar system, but if there is no fault it remains energised and its volts and frequency may be selected and shown on the associated volt and frequency meters.

When selected OFF/RESET, the generator is disconnected from the busbar system and de-energised. This selection allows an attempt to be made to reset an automatically de-energised generator.

Generator drive

Generator frequency is controlled by speed regulation. GEN 1 and GEN 4 each have an integrated drive (IDG) containing a constant-speed unit, whereas the APU GEN has a direct drive and its speed is controlled by governing the speed of the APU.

GEN 1 and GEN 4 IDGs each have an automatic disconnect mechanism and an associated DRIVE HI TEMP annunciator. The drive will disconnect at a temperature in excess of the DRIVE HI TEMP warning and cannot be reset in flight. The APU generator drive has oil temperature and pressure switches associated with an APU DRIVE FAIL annunciator; there is no automatic APU generator disconnect mechanism, but on the ground the APU will be shut down automatically in the event of an APU DRIVE FAIL.

Generator and AC busbar power status indication

The two main generators each have an offline annunciator, GEN 1 OFF LINE and GEN 4 OFF LINE. Either will illuminate if its generator is not online, provided the ESS DC busbar is powered.

There are two APU power annunciators:

1. APU PWR AVAILABLE (green) – indicates when the APU is operating satisfactorily at governed speed and is available for selection of electrical and pneumatic power.
2. APU GEN OFF LINE (amber) – indicates that, although the APU is operating at a satisfactory speed, the APU generator has failed to supply electrical power when commanded to do so, or is switched OFF, or EXT AC power has taken precedence in supporting the AC busbars.

If power is lost at any of the normal, essential or emergency AC busbars, the appropriate AC bus failure annunciator AC 1 BUS OFF, AC 2 BUS OFF, ESS AC OFF or EMERG AC OFF will illuminate.

External AC

External three-phase, 115/200V, 400 Hz AC may be connected to the aircraft via a receptacle on the right side of the fuselage, just forward of the electrical equipment bay. If the power supply is rejected by the monitor or inadvertently withdrawn, it is switched off automatically and must be reselected when a satisfactory supply is restored.

The external AC supply may be selected to power the entire AC busbar system by the EXT AC switch (on the ELECTRIC overhead sub-panel) or it may be selected to power the Ground Service busbar only, via the GRND SERVICE POWER switch on the forward cabin attendant's panel in the front vestibule. If external power has been selected on the flight deck EXT AC switch, the GRND SERVICE POWER switch is inoperative.

Both switches effectively have two settings: OFF and ON. The centre position is neutral and the switches are spring-loaded from ON to the centre position.

The AC ground service busbar allows power to be supplied for internal lighting and cabin cleaning from the external power supply when the main busbars are switched off.

If the APU is started with ground power connected and the APU generator selected ON, the APU power supply will take priority over the ground supply.

If external AC power has been connected, but is not switched ON, the following indications are given:

1. On the flight deck overhead ELECTRIC panel, a green annunciator EXT AC PWR AVAIL.
2. In the front vestibule, on the attendant's panel, a green annunciator GROUND POWER AVAIL.
3. Adjacent to the external AC receptacle:
    a) A green lamp, EXTERNAL POWER AVAILABLE.
    b) A white lamp, EXTERNAL POWER NOT IN USE.

When external AC has been connected and switched on, either by the EXT AC or GROUND POWER SERVICE switch, the EXTERNAL POWER NOT IN USE lamp, adjacent to the receptacle, goes out.

When the external AC panel is open and the main busbars are powered, a white EXT PWR NOT SHUT caption is illuminated on the Master Warning Panel (on the flight deck).

Standby generator – essential AC and DC supply

The STBY GEN will deliver three-phase 115/200V, 400 Hz AC to the ESS AC busbar and 28V DC to the ESS DC busbar which, in turn, power their respective EMERG AC and DC busbars. The STBY GEN may be signalled to operate automatically or by manual selection.

The Green hydraulic system drives the STBY GEN and, when it has been signalled to operate, all other services powered by the Green hydraulic system are isolated and rendered inoperative (see the HYDRAULIC POWER SYSTEM section for further details).

The STBY GEN has a central switch with three selections: ARM, OFF and O/RIDE. When ARM is selected the STBY GEN will operate automatically if there is a loss of power to both the AC 1 and AC 2 busbars; if O/RIDE is selected, the STBY GEN will run continuously.

The STBY GEN has an electro-hydraulic valve controlled by EMERG DC power. Loss of EMERG DC power will cause the STBY GEN to run regardless of the selection of its control switch, although it cannot deliver power with the switch at OFF.

A white annunciator, STBY GEN ON, will light up whenever the standby generator is running and delivering power. When the STBY GEN is running with either ARM or O/RIDE selected, the CABIN AIR is selected automatically to the FRESH air mode, and air, venting from the cabin, flows over a heat exchanger to cool the standby generator hydraulic drive fluid.

The AC output of the STBY GEN cannot be paralleled with the other primary AC sources. The DC output of the STBY GEN can be paralleled with the primary DC sources although, due to its lower operating voltage, the STBY GEN will not power the ESS DC busbar if it is being powered via the DC 1 and DC 2 busbars.

The STBY GEN is protected against reverse current flow and also has a control unit which regulates voltage and provides under-voltage and under-frequency fault protection. If a fault is detected, the STBY GEN will be tripped offline. After a transient fault the STBY GEN can be reset by selecting it OFF and then back to its original setting.

It is intended that the STBY GEN should be used only after loss of power to both the AC 1 and the AC 2 busbars. Use of the STBY GEN at other times is not recommended as it entails the loss of the Green hydraulic system and the shedding of electrical loads.

When the STBY GEN is operating, shedding some AC and DC loads is necessary to prevent overloading:

1. Automatic load shedding, associated with either automatic or manual STBY GEN selection, will switch the L SCREEN HEAT to one third heat and also, when either the L LANDING LT or the L TAXI LT is ON, the Q HTR will be switched OFF.
2. When the STBY GEN is operating, some EMERG DC and ESS DC loads are transferred automatically to the battery. They are generally low intermittent loads.
3. Normally, when the STBY GEN is operating, the battery will be isolated automatically from the EMERG DC busbar. If either the hydraulic system DC PUMP or the STBY INVerter is running, the battery will be reconnected to the EMERG DC busbar, leaving the STBY GEN powering the ESS DC busbar only. Thus, if there is no power on DC 1, only the battery will be supporting the EMERG DC busbar loads.

If the STBY GEN should operate as the result of failure of EMER DC power, the Green hydraulic system is not isolated, but switching the STBY GEN switch OFF will minimise the impact upon the Green hydraulic system by removing the electrical load on the generator.

Standby inverter – emergency AC supply

The standby inverter is powered from the EMERG DC supply and will provide single-phase 115V AC to the EMERG AC busbar and single-phase 26V AC to the 26V EMERG AC busbar.

The STBY INV has a control switch with three settings: ARM, O/RIDE and OFF. With the switch at ARM, if power is lost to the ESS AC busbar, the STBY INV will start automatically and power the EMERG AC busbars. When O/RIDE is selected, the STBY INV will start and feed the emergency AC busbars which will have been isolated automatically from their normal essential AC busbar supplies. When selected to OFF, the STBY INV will not start and the emergency AC busbar will be unpowered, isolated from the essential AC busbars.

The STBY INV should not be selected to O/RIDE when ESS AC is powered, because the heading bug on the left HSI will then wander in a random fashion. An amber EMERG AC OFF annunciator will normally light when the 115V EMERG AC busbar is unpowered.

Avionics services power supplies

Avionics services are powered from 115V and/or 26V AC and/or 28V DC supplies. Most, but not all, of these services are controlled by the AVIONICS MASTER switching circuit which has two (ON/OFF) control switches, labelled A and B.

Individual control switches are provided for some, but not all, services not controlled by the AVIONICS MASTER switch. (Details of avionics services are given in the COMMUNICATION SYSTEM, FLIGHT GUIDANCE SYSTEM and NAVIGATION SYSTEMS sections).

Some services other than avionics are controlled by the AVONICS MASTER switching circuit.

Main DC power and distribution

Transformer rectifiers and auto cut-outs

Any one TR can meet all the normal 28V DC loads apart from main engine starting. Auto cut-outs (ACOs) link the TRs to the DC busbar network. If the output of a TR is unsatisfactory, its ACO will remain open, holding the TR offline. Other ACOs provide the links between the relevant normal, emergency and essential DC busbars.

In addition to their ability to remain open if the input current is unsatisfactory, these ACOs embody switching facilities enabling their main contacts to be selected positively open or closed to allow the DC network to be split into channels 1 and 2 or to provide interlocks during engine starting.

When the DC system is operating in parallel (BUS-TIE DC switch at AUTO) and the DC load is less than approximately 50 amps, one TR normally takes the full load.

DC busbar power status indication

Any of the DC busbar failure annunciators DC 1 BUS OFF, DC 2 BUS OFF, ESS DC OFF and EMERG DC OFF will illuminate if power is lost at its associated busbar, provided DC 2 and/or the EMERG DC busbar is powered.

Battery power (nominal 24V DC) – emergency DC

The aircraft has two 24V Nickel Cadmium batteries located in the electrical equipment bay, each controlled via a battery contactor to supply the EMERG DC busbar. The batteries are designated BATT 1 and BATT 2 and have each have an ON/OFF switch and associated amber BATT NO CHARGE warning annunciators on the overhead ELECTRIC sub-panel.

The BATT NO CHARGE annunciator illuminates:

- When BATT 1 or BATT 2 is switched OFF or otherwise isolated from the EMERG DC busbar.
- If there is a difference of more than 1.34V between the BAT 1 BUS or BAT 2 BUS and the EMERG DC busbar.
- If the EMERG DC busbar voltage falls below 25V.

The above warning is given provided there is power on the EMERG DC or DC 2 busbar, which supply the WARN LTS BUS.

Battery charging is from the EMERG DC busbar and the battery ‘floats’ on the busbar when fully charged. The batteries each have an individual busbar (BAT 1 BUS and BAT 2 BUS) to which they are connected permanently. Certain services are supplied directly from the battery busbars, such as engine and APU fire extinguishers, APU controls etc.

If a battery overheats, a thermal switch operates the appropriate amber BATT HI TEMP annunciator on the overhead ELECTRIC sub-panel and the amber ELECT caption on the Master Warning Panel (MWP). If the battery temperature falls below the setting of the thermal switch, the annunciator will go out. If the temperature continues to rise, the warning will continue and the battery will be automatically isolated from the busbar, causing the BATT NO CHARGE annunciator to illuminate until the temperature falls below the setting of the lower thermal switch.

When the standby generator comes on (STBY GEN ON), the distribution of emergency DC power is altered to effect automatic load shedding.

APU starting power

The APU has a DC starter motor and can be started from the aircraft battery, an external DC supply (EXT DC), or from TRU 1 powered from EXT AC or from an engine generator.

If AC BUS 1 is energised, TRU 1 is selected automatically for APU starting. If both AC BUS 1 and 2 are off, the battery is selected automatically. If AC BUS 1 is off, but AC BUS 2 is energised, the APU cannot be started.

To start the APU using an EXT DC supply the following selections must be made on the overhead ENGINES sub-panel:

- The START PWR switch must be selected to EXT DC.
- The START SELECT switch to OFF.
- The START MASTER to ON.

Main engine starting power

Each engine has a DC starter motor which may be powered by EXT DC supply or from DC derived from the two TRUs; one TRU is inadequate and cannot be connected to the starter motor.

The aircraft's electrical system permits normal engine starting from three sources:

- Ground start from a 115V/200V, 3-phase 400 Hz ground power source with a minimum capacity of 60 kVA, or 90 kVA if cold start is selected.
- Ground start directly from any suitable 28V DC ground power source which has 2,000 ampere capability.
- Ground cross-start from an engine or APU generator on-line.

Start controls and annunciators

The engine start controls and annunciators are located on the overhead ENGINES sub-panel and consist of the following:

- START PWR switch, with three selections: EXT DC, NORM and COLD. Supplies 28V (NORM) or 35V (COLD) from the TRUs.
- START SELECT switch, with five selections: 1/2/OFF/3/4.
- START MASTER switch, with two selections: ON/OFF.
- Four annunciators:
    - START PWR ON (white)
    - ENG IGN A ON (green)
    - ENG IGN B ON (green)
    - STARTER OPERATING (white)
- FLT START switch, with two selections:ON/OFF.
- Two CONT IGN switches A and B, with two selections: ON/OFF.
- ENGINE switch, with three selections: START/RUN/MOTOR.

When the START PWR switch is selected to EXT DC the engine starter is supplied directly from the 28V ground supply, which is connected via a receptacle on the right side of the fuselage, just forward of the hydraulic equipment bay. When using EXT DC for starting, the APU may be used to power the AC and DC busbars.

When the START PWR switch is selected to NORM the TRUs may be supplied with AC from EXT AC, APU GEN or, for 'cross starting', GEN 1 or 4. During normal starts the TRUs power their normal DC busbars, in addition to powering the starter motors.

When the START PWR switch is selected to COLD, the TRUs are switched automatically to supply 35V DC to the engine starter only; the TRU auto cut-outs are held open so that the DC 1 and 2 busbars are not powered. When COLD is selected the APU GEN must not be used.

When the main engine starting system START MASTER switch has been switched ON, the following changes are made to the electrical power system:

1. The EMERG DC BUS is connected to the ESS DC BUS regardless of the power status of the normal DC busbars.
2. Neither GEN 1 nor GEN 4 can come on-line if any one of these conditions exist:
    - START PWR switch is at EXT DC.
    - APU GEN is on-line.
    - EXT AC is on-line.
3. When using GEN 1 or GEN 4 for 'cross starting' only one generator can stay on-line; whichever generator is on-line first stays on-line. If both generators are on-line when the START MASTER is selected ON, GEN 4 will drop off-line.
4. All galley electrical supplies are automatically disconnected.

Flight start

For in-flight start, the engine is windmilled to the required speed. Ignition for starting is provided by igniter units and igniter plugs. Power supply is from 28V ESS, EMERG DC and batteries.

Failure warnings

Electrical power failure can produce multiple failures; it is important to identify power failures as the source of these failures.

INDICATIONS		FAILURE
PANEL	ANNUNICATORS	
MWS	ELECT ↑	LOSS OF GEN 1 OR 4 (BUS-TIE SWITCHES AUTO) * May light momentarily
ELECTRIC	GEN 1 or 4 OFF LINE * AC BUS 1 or 2 OFF	
MWS	ELECT ↑	HIGH TEMPERATURE GEN 1 or 4 DRIVE
ELECTRIC	DRIVE 1 or 4 HI TEMP	
MWS	ELECT ↑	LOSS OF APU GEN (or EXT AC connected and has taken precedence over APU GEN)
ELECTRIC	APU GEN OFF LINE	
MWS	ELECT ↑	BATTERY HIGH TEMPERATURE * If overheat is severe
ELECTRIC	BATT 1 HI TEMP * BATT 1 OFF LINE	
MWS	ELECT ↑	BATTERY OFF-LINE OR EMERGENCY DC BELOW 25V
ELECTRIC	BATT 1	

FIRE PROTECTION SYSTEM

General

Engine

Each engine is equipped with a fire detection system which consists of four detector loops in two parallel pairs. When the loops are subjected to heat, a signal is transmitted to a warning system as soon as a preset temperature is reached.

The warning system comprises red and amber flight deck presentations with associated audio warnings.

Each engine is equipped with a fire extinguishing system consisting of two extinguisher bottles for each engine. The bottles are in the nose cowling of each engine.

Auxiliary power unit

The auxiliary power unit is equipped with a fire detection system which samples bay temperature.

The warning system comprises red and amber flight deck presentations with associated audio warnings.

The auxiliary power unit is equipped with a fire extinguishing system consisting of a single extinguisher bottle, located on the APU bay forward bulkhead.

Wings, pylons and fuselage spine

The wings, engine pylons and fuselage spine are equipped with an elaborate overheat warning system. When subjected to heat, overheat detectors transmit a signal to a two-level warning system as soon as a preset temperature is reached.

The warning system comprises both red and amber flight deck presentations with associated audio warnings.

Electrical equipment bay

The electrical equipment bay is equipped with a smoke detector. When smoke is sensed a signal is transmitted to a warning system.

The warning system comprises a red flight deck presentation with associated audio warning.

Animal bay

The animal bay is equipped with a smoke detector. When smoke is detected, a signal is transmitted to a warning system.

The warning system comprises a red flight deck presentation, with associated audio warning.

Air conditioning equipment bay

The air conditioning bay is equipped with overheat detectors. When the detectors are subjected to heat a signal is transmitted to a warning system as soon as a preset temperature is reached.

Engine

Engine fire and overheat warning

Continuous-length pneumatic detectors are installed on the engines, forward right-hand doors which cover the fan casing bay and on the engine core to monitor temperature conditions. The sensors activate visual and aural warning devices if a fire or overheat condition is sensed.

The four detectors on each engine are connected in two parallel pairs. Fault detection circuits, when operated, light an associated amber LOOP FAULT caption in the Master Warning System (MWS) annunciator panel and activate the following warnings:

- Red MWS alert flashers
- Red MWS ENG X FIRE captions
- Red engine X fire handle lamps
- Red engine X thrust lever lamps
- Audio warning system (fire bell)

The fire warning is also recorded on the flight data recorder.

The detectors monitor engine bay temperature conditions and are self-monitoring to establish loop integrity.

The alarms, once activated, will remain active until the temperature falls below an established safe value, at which point the alarm fault will be cancelled.

Four engine fire test push-buttons on the flight deck GRND TEST overhead panel are labelled ENG FIRE 1, 2, 3 and 4. When depressed, the following warnings are activated:

- Red lamp in fire extinguisher handle
- MWS red alert lights
- MWS amber caution lights
- Red ENG FIRE caption
- Amber LOOP FAULT caption
- Red thrust lever light
- MWS audio (fire bell)

In the event of a failure of a loop, loss of gas pressure within the loop will activate the amber LOOP FAULT caption on the MWS panel and light the MWS amber caution lights.

If two fire detection loops are fitted to the aircraft, four ENGINE FIRE DETECT switches are fitted on the overhead panel, one for each engine. Each switch selects the loop to be used for each engine. It is recommended that LOOP A is used on odd days and LOOP B on even days.

Engine fire extinguisher system

Two electrically operated fire extinguishers are fitted in the nose cowling of each engine. The contents of each extinguisher, when discharged, are ducted via a common-flow valve to a spray nozzle from whence they are sprayed into engine bay zone 1.

The electrically operated fire extinguisher system is only fitted in zone 1. A zone 2 fire is extinguished by shutting down the engine.

The extinguishers are discharged by manipulation of a fire handle which also shuts down the engine-mounted components and low-pressure fuel valve associated with the flammable systems and ignition sources.

Each fire extinguisher bottle installation is two-shot; when extinguishant is discharged from one bottle a flap is moved to close off the other bore, thus preventing flow in the pipeline to the second bottle or into a discharged bottle.

From the flow valve, piping is taken through the forward fireproof bulkhead to terminate in a spray nozzle mounted on the aft face of the bulkhead.

Firing of the cartridge units is accomplished by an operating handle (fire handle) assembly on the overhead panel. Each fire handle assembly includes the operating handle and a cluster of microswitches which are actuated by movement of the handle. The microswitches are electrically interlocked with those engine-associated hydraulic, electrical and bleed air systems which could engender engine fire; one microswitch lights a related ENG X FIRE HANDLE annunciator in the MWS panel to identify the handle selected. The fire handle also controls the selected fuel low-pressure valve via a cable and pulley system.

Testing

A two-pole push switch (ENG & APU EXTING) on the TEST panel provides a facility for checking the integrity of the bottle indicating circuit.

Operation

After receipt of a fire warning, the manipulation of the fire handle follows three quite distinct phases:

1. Pulled out to the initial baulk, a microswitch is actuated to light the related ENG FIRE HANDLE annunciator on the MWS panel. This permits a check to be made that the fire handle selection is correct.
2. Withdrawn to its limit of travel, three additional microswitches are actuated to:
    a) Close the engine bleed air isolation valve
    b) Trip the engine-driven generator (handles 1 and 4)
    c) Close the engine hydraulic pump isolation valve (handles 2 and 3)

    During this phase the handle operates through a system of pulleys and cables to close the engine low-pressure fuel valve.
3. If the fire still persists after phase 2, turning the fire handle through 90 degrees to the left or right will operate a microswitch to discharge No.1 or No.2 bottle respectively.

When the handle is turned to discharge a bottle, battery supply (SHOT 1) emergency DC (SHOT 2) is applied to the cartridge which fires, thereby creating pressure in the annulus above the charge plug via the flash hole. This causes the frangible section to rupture and the spigot and charge assembly is forced into the cap-nut, causing the extinguishant to be discharged and the electrical indicator circuit to be broken.

The bottle indicator circuit is an earthing switch which is normally 'made' to hold an MWS buffer circuit dormant. When the earth is broken, the circuit triggers to light a related annunciator on the overhead panel. For example, when the ENG 1 FIRE HANDLE is turned anti-clockwise (1 on handle), bottle No.1 on that engine is discharged and the related ENG EXT 1 USED annunciator lights. This situation will persist until the flight is restarted.

Extinguishant flows from the bottle via the flow valve to the spray nozzle where it is expelled into the bay.

The ENG & APU EXTING test push-button switch is a double-pole press-to-make switch which, when pressed, applies an input to the MWS test circuits from the emergency DC supply to trigger the test circuits and light the ENG EXT USED annunciators.


ENGINE FIRE DETECT
1
2
3
4
LOOP A
LOOP B
FIRE HANDLES
FUEL OFF
AIR OFF
GEN OFF
MWS
HANDLE OUT
TWIST
MWS
HANDLE OUT
FUEL OFF
AIR OFF
HYD OFF
ENGS 1 + 4
FULL
DOWN
ENGS 2 + 3


GRND TEST
ENG OVSPD
ENG FIRE
1
2
3
4
APU FIRE
APU OVSPD
ENG + APU EXTING
SMOKE
STALL WARN
1
2
ZONE LOOPS
A
B
STALL IDNT
1
2
NOSE SQUAT SW
1
2
ADC TEST
ANTI SKID FAULT


ENG 1 FIRE HANDLE
ENG 2 FIRE HANDLE
ENG 3 FIRE HANDLE
ENG 4 FIRE HANDLE
ENG 1 FIRE
ENG 2 FIRE
ENG 3 FIRE
ENG 4 FIRE
LOOP 1 FAULT
LOOP 2 FAULT
LOOP 3 FAULT
LOOP 4 FAULT
PYLON 1 OVHT
PYLON 2 OVHT
PYLON 3 OVHT
PYLON 4 OVHT

APU

APU fire warning system

The APU fire detection system employs a continuous-length detector to sample temperature conditions in the APU bay and to activate visual and audible warnings on the flight deck if abnormal fire or overheat situations develop.

When energised, the alarm relay activates the following warnings on the flight deck:

- Red MWS APU FIRE ↑ caption
- Red APU FIRE caption on the overhead panel
- Red MWS flashers
- Fire bell

An automatic APU shutdown is also initiated if the aircraft is on the ground. In the air this facility is inhibited by the aircraft squat switch circuit and the APU must be switched off manually.

When the ground crew horn interface is fitted an on-ground fire condition, in addition to the flight deck warnings, operates the ground crew horn which will sound continuously until the APU start/stop switch is set to stop.

A test push-button labelled APU FIRE on the flight deck GRND TEST overhead panel is provided to enable testing of the control loop. When depressed, the fire bell operates, MWS red and amber flashers operate with audio warning and associated APU FIRE (red) and LOOP FAULT (amber) annunciators light up.

APU fire extinguishing system

The APU fire extinguishing system consists of a single automatic fire extinguisher (bottle) mounted on the APU bay forward bulkhead, a remote control switch and associated annunciator on the APU control panel and an extinguishant spray nozzle in the APU bay.

The fire extinguisher bottle is similar to that used in the engine fire extinguishing system; the construction and function of the operating head is identical.

Bottle discharge is by operation of a two-pole, single-throw, rocker-type switch on the APU panel annotated FIRE EXT DISCH. The switch is spring-biased to ‘off’, in which position it is restrained by a spring-loaded flap.

The bottle incorporates an electrical discharge indicator in the operating head which is connected into an APU EXT USED annunciator circuit via a printed circuit board in the Master Warning System (MWS).

A push-button annotated ENG AND APU EXTING is provided on the GRND TEST panel to test the integrity of the bottle discharged indicator circuit.

Overriding the baulk and operating the FIRE EXT DISCH switch fires the cartridge in the bottle operating head. This causes the frangible section to rupture, thus allowing extinguishant discharge via the main discharge union and also causes the bottle discharge indicator circuit to be broken, triggering the APU EXT USED annunciator to light. This situation will persist until the flight is restarted.

When pressed, the ENG & APU test push-button switch applies an input to the MWS test circuits from the emergency DC supply to trigger the test circuits and light the ENG EXT USED annunciators.

Wings, pylon and spine overheat detection

To prevent possible damage to the structure resulting from a significant leakage of superheated air from the bleed air ducting, heat shields are installed wherever primary structures or fuel tanks and pipelines are vulnerable to direct impingement. Overheat detectors are fitted to activate viral and aural warning devices on the flight deck and to control, where possible, bleed air supplies.

The two elements in each wing trailing edge are designated loop A and B and may be operated together or independently of each other. Two single-pole, double-throw switches labelled ZONE TEMP DETECT, L.WING and R.WING, are located on the overhead panel to enable the desired selection to be made. Each switch has three selective positions annotated LOOP A – BOTH LOOPS – LOOP B. With LOOP A or LOOP B selected, the relevant loop is selected for independent operation, whereas with BOTH LOOPS selected, both loops must respond to an overheat situation for an alarm signal.

Zoning

For overheat detection purposes the aircraft is divided into two zones, one on either side of the fuselage centre line, designated ‘left zone’ and ‘right zone’. Each pylon is also divided into two zones.

The pylon lower fairings are divided into zones to discriminate between leaks from the engine bleed air supply ducting upstream or downstream of the precooler. Leaks downstream (zone 2) can be controlled by closing the engine bleed isolation to shut off the air supply. Leaks from zone 1 could be at full engine bleed pressure and temperature and therefore may not be controllable by closing the bleed isolation valve. Zone 1 leaks demand a different category warning to zone 2 leaks because hot air will continue to flow until the engine is shut down. Zone 1 warnings are therefore in the alert (red) category, whilst zone 2 and the left and right zone warnings are in the high caution (amber) category.

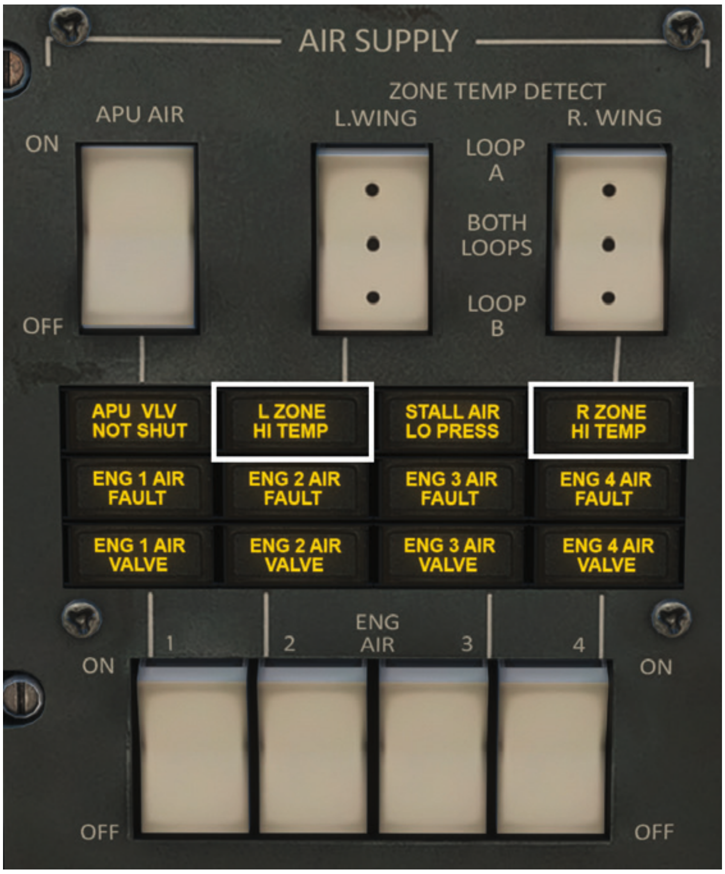
Alarm signals

An alarm signal from any of the detectors, excluding zone 1, is interconnected with the MWS caution mode on associated annunciator (L or R ZONE HI TEMP) on the AIR SUPPLY section of the overhead panel and the pneumatic system and airframe de-icing/anti-icing system electrical control circuits. The inputs into the latter circuits cause the relevant engine/bleed air isolation or APU load control valve to shut off the hot air supply and also cause both left or right wing anti-icing valves and the left or right tail anti-ice isolation valve to close.

The pylon zone 1 signal is applied via the alert section of the MWS to a red (PYLON x OVHT) in the MWS panel, to a red lamp in the associated thrust lever, and also to the audible warning system where it activates a triple-chime output.

Summary of alarm signals

Origin	Alarm category	Alarm function
Pylon zone 1	MWS alert	• Activates MWS red flasher lamps • Lights PYLON x OVHT annunciator • Lights lamp in thrust lever • Activates triple-chime output
Pylon zone 2 Leading edge overheat Left and right spine overheat – loops A and B	MWS caution	• Activates MWS amber flasher lamps • Lights AIR SUPPLY repeater (MWS panel) • Lights L/R ZONE HI TEMP annunciator on AIR SUPPLY panel • Closes engine/APU bleed air isolation valve • Closes left/right wing anti- and de-icing isolation valves • Closes left/right tail anti-icing isolation valve



Test facilities

Two double-pole push switches, annotated ZONE LOOPS A and B, are located on the GRND TEST section of the overhead panel. These switches, when operated in conjunction with the ZONE TEMP DETECT switches, check the overall integrity of the loops and associated warning circuitry, thus simulating an alarm condition.

Electrical equipment bay smoke detection

The smoke detection system comprises a smoke detector unit and areas of the Master Warning System (MWS). The system operates in conjunction with the avionics equipment forced-air cooling arrangement and the natural air convection induced by the pressurisation control system to detect the presence of smoke arising from the avionics equipment and control components located in the electrical equipment bay.

When smoke is detected in the airflow over the smoke detector an alarm is signalled to the MWS, which operates to light an associated red ELECT SMOKE caption and invokes a triple chime from the audio warning system.

A test push-button labelled SMOKE on the flight deck GRND TEST overhead panel simulates the effect of smoke within the smoke detector to initiate the alarms.

Animal bay smoke detection

The smoke detection system comprises a smoke detector unit and an annunciator located on the MWS. When smoke is detected in the airflow over the smoke detector, an input is fed to the Master Warning System which gives an immediate warning and the smoke detect relay energises after a 10-second delay.

As a result of this, both the inlet and outlet air valves close, turning the bay into a class ‘D’ compartment (i.e. self-extinguishing due to air starvation) .

Air conditioning equipment bay overheat warning system

To detect the existence of abnormal temperature conditions in the air conditioning equipment bay, overheat detectors are positioned at various locations within the bay.

Should abnormal temperatures develop due to the escape of hot air from the engine air bleed ducting, air conditioning racks or associated equipment within the bay, the detectors will respond to activate the following warnings on the flight deck from the MWS:

- Amber MWS flashing lamps
- Amber MWS AIR COND ↑ caption
- Amber REAR BAY HI TEMP caption
- Audio chimes

A test push-button labelled REAR BAY HI TEMP on the flight deck GRND TEST overhead panel will, when depressed, activate the warnings listed above.

FLIGHT CONTROLS

Primary controls

Conventional primary flight controls are provided for each pilot for control of roll, pitch and yaw. There is also a handwheel on a floor-mounted control column and foot pedals.

Manual trim wheels for roll, pitch and yaw, together with selectors for flaps, airbrakes and lift spoilers, are installed on the centre pedestal.

An electric elevator trim switch is fitted to each pilot's handwheel.

Roll is controlled using servo tab-operated ailerons in conjunction with hydraulically powered roll spoilers.

Yaw is controlled by the rudder, operated hydraulically by power control units.

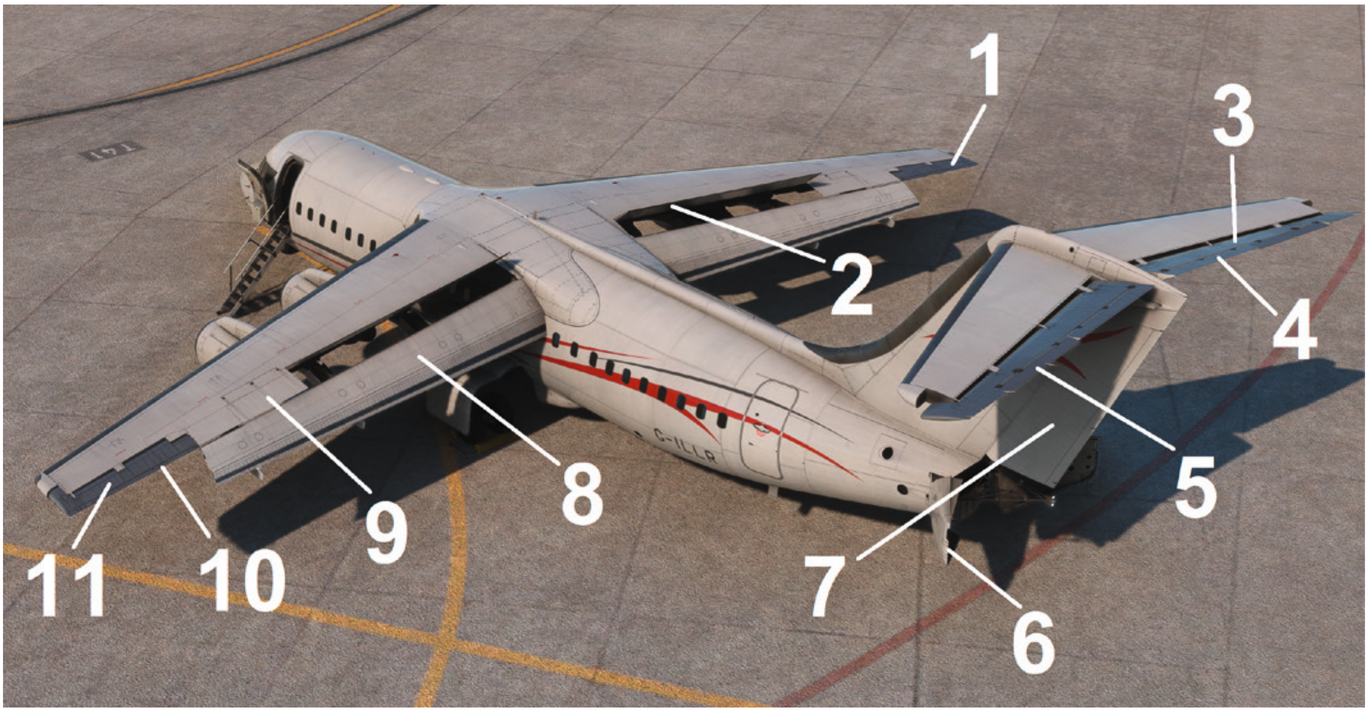
Pitch is controlled by servo tab-operated elevators.

Cable control runs are used extensively in the roll, pitch and yaw primary control and trimming circuits.

The pitch and yaw control systems embody gust dampers to limit control surface deflection and damage that may be caused by overstressing.

The handwheels are fitted with a control lock. When in the central position (ailerons and elevators at neutral), clicking on the handwheel microphone will toggle the control lock. When enabled, the lock prevents any movement of the control wheel.

The control wheel can be hidden by pulling out the rudder pedal adjust lever on the corresponding side panel.



1. Ailerons
2. Lift spoilers
3. Elevators
4. Servo tabs
5. Trim tabs
6. Airbrakes
7. Rudder
8. Fowler flaps
9. Roll spoilers
10. Servo tabs
11. Trim tabs

Secondary controls

A single-piece tabbed Fowler flap, hydraulically powered, mechanically operated and electronically controlled, is fitted to each wing.

Two petal-type airbrakes, functioned hydraulically and electronically signalled, are fitted as a vertically split tail cone.

Four spoilers are provided on each wing, three lift spoilers and one roll spoiler, all powered hydraulically. An automatic lift spoiler system is provided with manual selection as back-up. Interlocks prevent operation before take-off and during flight.

Controls configuration warning system

Visual and aural warnings will be given prior to take-off if an ‘unsafe to take-off’ situation exists due to an incorrect setting of the aileron trim, elevator trim, flaps, airbrakes, lift spoilers or parking brake.

The system can be activated either by pressing the CONFIG CHECK button on the central control pedestal or by advancing any thrust lever into the take-off sector. When the system has been activated, if any one of the inputs to the configuration warning system is outside the allowed take-off conditions, the MWS red CONFIG caption will light, the red ALERT lights will flash and the intermittent horn will sound. Only the ALERT lights can be cancelled by depressing either lamp. The horn and MWP warning can only be cancelled by correction of the unsafe condition, retarding the thrust levers or by releasing the CONFIG CHECK button.

Checking of the aircraft ‘doors not closed’ warning system is also associated with the CONFIG CHECK button (see the DOORS AND STAIRS section).

Roll control

Roll control is provided by aerodynamically and mass-balanced ailerons, each operated by a servo tab, in conjunction with roll spoilers (one per wing) powered by the Yellow hydraulic system. A geared trimming tab is also fitted to each aileron.

Normally the roll control circuits in the left and right wing are coupled, but a disconnect device is provided so that, in the event of a jam occurring in either circuit, they may be operated separately.

Two separate conventional cable and rod circuits, one connected to each pilot’s handwheel, provide control over the respective aileron servo tab and roll spoiler in each wing. An interconnect cable links both ailerons and a ‘break-out’ detent strut links both handwheels. A spring-operated ‘feel unit’ complements the natural servo tab feel at large inputs and provides a handwheel centring force at small handwheel angles. The feel unit is in the captain’s aileron servo tab control circuit.

Another conventional cable and rod circuit drives the aileron trim tabs, each through a screw jack. An aileron trim wheel and trim indicator are fitted on the centre console. When the aircraft is on the ground, if the aileron trim setting is outside the take-off configuration and any thrust lever is moved into the take-off sector, the CONFIGuration warning will be activated.

Each servo tab circuit has a blowback spring which limits the authority of the tab in accordance with the airspeed.

Autopilot servos are connected in parallel with the aileron tab circuits of the left and right wing, so that AP inputs move the handwheels and tab circuits. FGC 1 AP servo is connected to circuits in the left wing and FGC 2 AP servo to circuits in the right wing.

Roll spoiler position indicators are fitted to the centre instrument panel.

Gust dampers prevent excessive aileron movement when the aircraft is parked in windy conditions.

Roll control disconnect system

If a jam occurs in one roll control circuit, the application of heavy rotational pressure to the handwheel of the other circuit will cause the rigid detent strut to ‘break out’ and transform to a sliding strut. The free circuit will then be operable independently, allowing control to be maintained.

During its transition to the sliding state, the ‘break out’ detent strut closes a microswitch which causes a solenoid-operated disconnect device to operate, separating the aileron interconnect cable circuit. As an alternative, the solenoid-operated disconnect device may be operated by way of another microswitch which closes when the AIL PULL DISCONNECT handle on the centre control pedestal is pulled. Pulling the AIL PULL DISCONNECT handle has no effect on the ‘break out’ detent strut linking the two handwheels.

Before the AIL PULL DISCONNECT handle can be pulled out, a button in the centre of the handle must be depressed.

When the solenoid-operated disconnect device has operated, its microswitches cause the MWS amber caption AIL/EL UNCPLD to light.

After their operation, both the solenoid-operated disconnect device and the detent strut cannot be reset in flight.

Roll spoiler control

Each roll spoiler is operated by a hydraulic power control unit. Displacement of the spoiler on the down-going wing is harmonised with the operation of the aileron servo tab but, for the first few degrees’ rotation of the handwheel from neutral, the spoiler remains closed.

The power control units each have dual control valves which normally permit a single valve to maintain control if the other fails. For example, should control of the spoilers fail due to failure of the Yellow hydraulic system, limited roll control will be provided by the ailerons alone.

The power control unit servo control valves are spring-loaded to the closed position so that, should the input control linkage fail, the spoiler will be retracted.

Pitch control

Pitch is controlled by two aerodynamically and mass-balanced elevators, each operated separately by a servo tab and an elevator trim tab.

Two separate conventional cable and rod circuits, one connected to each pilot's control column, provide control over the respective elevator servo tabs. A spring-loaded 'disconnect' device links both control columns.

Normally, both elevator control circuits are coupled but, if a jam occurs in either circuit, they can be uncoupled and operated separately.

Separate, conventional cable and rod circuits control the elevator trim tabs, each through a screw jack.

Each elevator servo tab circuit has a blowback spring to limit the authority of the tab relative to the airspeed.

A 'G ' weight incorporated in the First Officer's elevator servo tab control circuit enhances the sense of feel of the pitch controls by imparting an extra level of force proportional to the applied G.

A pneumatic 'Q' pot, fitted to the Captain's elevator servo tab control circuit, increases control column feel as the airspeed increases. If there is a failure in the pressure or static air supply system to the elevator 'Q' pot, causing it to sense an airspeed less than that of the aircraft, the stick forces will be lighter than normal, with the effect becoming more marked as speed increases. Warning of this failure will be given by the lighting of the MWS amber caption RUD/EL Q FAIL.

An electrically heated 'Q' feel pitot-static head fitted on the left side of the fuselage nose supplies the elevator and rudder 'Q' pots.

Normally, both the 'Q' pot and 'G' weight affect overall pitch control but, should a jam occur in one circuit only, the device fitted to the free circuit will be effective.

Gust dampers prevent excessive elevator movement when the aircraft is parked in windy conditions. When the aircraft is parked or taxiing, movement of the control columns (induced by gusts acting on the elevators) may be avoided by engaging a constraining device pivoted on the front face of the captain's control column. Release from the constraining device is effected by pushing or pulling on either control column.

Autopilot servos positioned in the tail are connected to the left and right servo tab control circuits and apply inputs in parallel with the control column so that the AP moves the control column in addition to the servo tab. FGC 1 and FGC 2 control the left and right servo respectively.

Prior warning of stall is given by stick shakers, one on each control column. A stall identification system to provide a nose-down stick force in the event of a stall is also provided.

Elevator trim wheels, one for each pilot, and an ELEV TRIM indicator are provided on the centre console. Pitch trim may also be adjusted by an elevator trim motor in response to inputs from the autopilot or electric elevator trim switches. When the aircraft is on the ground, if the elevator trim setting is outside the green band take-off limitation and any thrust lever is moved into the take-off sector, the CONFIGuration warning system will be activated.

Elevator disconnect system

If a jam occurs in one elevator control circuit, application of a heavy force to the control column of the other circuit will cause the 'disconnect' device to separate the two control circuits, allowing control to be maintained. Manual operation of the ELEV PULL DISCONNECT handle on the centre pedestal allows the circuits to be uncoupled, so relieving the 'break out' load. After the circuits have been separated by operation of the ELEV PULL DISCONNECT handle, an MWS amber AIL/EL UNCPLD caption will provide a warning that the disconnect mechanism has been operated.

After disconnection of the circuits by differential force, prior to operation of the ELEV PULL DISCONNECT handle, the magnitude of the control operating force required diminishes as the control column is deflected out. If allowed, the control column will spring forward and the circuits will re-engage as the control column positions are matched. After operation of the ELEV PULL DISCONNECT handle, the control operating force diminishes considerably and is reasonably constant throughout its range.

The elevator disconnect can be reset in flight by depressing the button in the centre of the disconnect handle and then pushing the handle fully forward.

Elevator trim system

The elevator trim system has three sources of input:

1. From either one of the two pilots' manually operated trim wheels.
2. From either of the electric elevator trim switches (electric trim).
3. Autotrim from the autopilot (FGS).

All the trimming inputs operate from trim servos located on each elevator. Operation of either manual trim overrides the electric trim inputs, allowing the pilot to overcome a runaway electric trim motor by holding a manual trim wheel.

When the trim system is operated it also drives the trim position indicator and the 'Q' pot datum change. Resetting the latter automatically maintains 'feel' forces in phase with the aerodynamic forces.

Control of the electric elevator trim system is provided by two spring-loaded (DN-UP), thumb-operated, split switches, one on the outboard horn of each pilot's handwheel. The system operates at either of two speeds: low speed at flap selections of UP and 18 degrees, and high speed at flap selections of 24, 30 and 33 degrees.

The electric elevator trim switches are dormant with the autopilot engaged except when the autopilot SYNC switch is held depressed.

In flight, to effect a trim change, both halves of either switch are operated together but, prior to flight, each half of each switch must be operated separately for system test. A trim change should occur only when both halves of a switch are operated together.

The electric elevator trim system must not be used in flight if operation of half a switch causes a change to the trim setting.

Failure of the electric elevator trim is annunciated EL TRIM on both pilots' flight annunciator panels.

Flap trim compensation (FTC)

FTC is performed during flap extension and retraction, when flaps are between 0 and 18 degrees, in order to compensate for associated trim changes. FTC is a function of the selected flight guidance computer (FGC) and operates regardless of the engagement status of the AP or flight directors. Failure is indicated on the flight annunciator panels by the illumination of an amber FTC legend; this will extinguish when power is removed from the selected FGC via the AP MASTER switch. FTC does not cause the trim to run with weight on wheels when flaps are selected.

FTC is fitted to all three RJ variants.

Stall warning and stall identification systems

Warning of an impending stall is given by two electrically driven stick shaker motors, one on each pilot's control column. When a stall is identified, a nose-down stick force is applied to the control columns by a pneumatically powered ram.

Airflow direction sensor vanes supply vane angle signals directly to the ADCs, DFGS and the stall Signal Summing Units (SSUs). The ADAU converts digital data from the ADCs to provide airspeed signals to the stall SSUs.

On receipt of a preset vane angle signal, the stall warning summing units compute an operate point, modified relative to the FLAP or airspeed signals received, to provide an output to operate the stall warning system and arm the stall identification system.

On being armed, the stall identification summing units compute an operate point, modified relative to the angle of the airflow direction sensor vanes and (except when the flaps are UP and the airspeed is above 180 KIAS) the rate of rotation of the vanes, to provide an output to operate the stall identification system.

The stall warning and stall identification systems each have dual control channels. Either stall warning summing unit will operate the stick shaker motors but, to obtain a nose-down stick force, either the left stall warning and the right stall identification summing units or the right stall warning and the left stall identification summing units must be activated.

The mechanical parts of the stall identification system comprise a low-pressure air reservoir, a pneumatic ram (coupled to both pilots' control columns) and two electrically controlled air valves. The reservoir is charged with air bled from engines No.2 and 3. Operation of the pneumatic ram is controlled by the two electrically controlled air valves (STALL VALVE A & STALL VALVE B), both of which must operate to obtain a nose-down stick force according to the prevailing flight conditions.

When the stall identification system operates below 180 knots there is an initial rapid application of nose-down force to the control columns, followed by a slower action. When the stall identification system operates above 180 knots, an additional electrically controlled inlet valve closes, restricting the flow of air to the pneumatic ram, slowing the rate of application of the nose-down force to the control columns.

If there is a loss of engine bleed air supply to the reservoir, its fully charged capacity is sufficient to provide a minimum of three complete operations. An amber STALL AIR LO PRESS annunciator, on the overhead instrument panel, will light if the reservoir pressure falls below normal. The amber MWS caption AIR SUPPLY will also light.

To prevent nuisance triggering by wind gusts, both the stall warning and identification systems are inhibited on the ground by the squat switches. The stall identification system remains inhibited for a brief period immediately after take-off.

In addition, the FGC inhibits or delays the operation of the stall identification system when providing windshear guidance following a 'decreasing performance' windshear (red) alert.

In flight, operation of the stall identification system is accompanied by the automatic disengagement of the autopilot when a stall warning and stall ident have occurred. The DFGS independently calculates the stall warning threshold and, if exceeded for two seconds, will also cause autopilot disengagement.

Normal operation of the stall identification system is indicated by the simultaneous lighting of the two red annunciators STALL VALVE A OPEN and STALL VALVE B OPEN on each pilot's instrument panel.

The lighting of the caption STALL IDNT on the MWS master panel, in association with either the IDNT 1 or 2 amber annunciator on each pilot's instrument panel, indicates a fault requiring the faulty channel to be inhibited. This can be achieved by pushing the annunciator IDNT 1 or 2 as appropriate. Total inhibition of the stall identification system can be achieved by pushing both IDNT 1 and 2 annunciators. When one or both channels have been inhibited, the relevant amber IDNT INHIB annunciators will be lit.

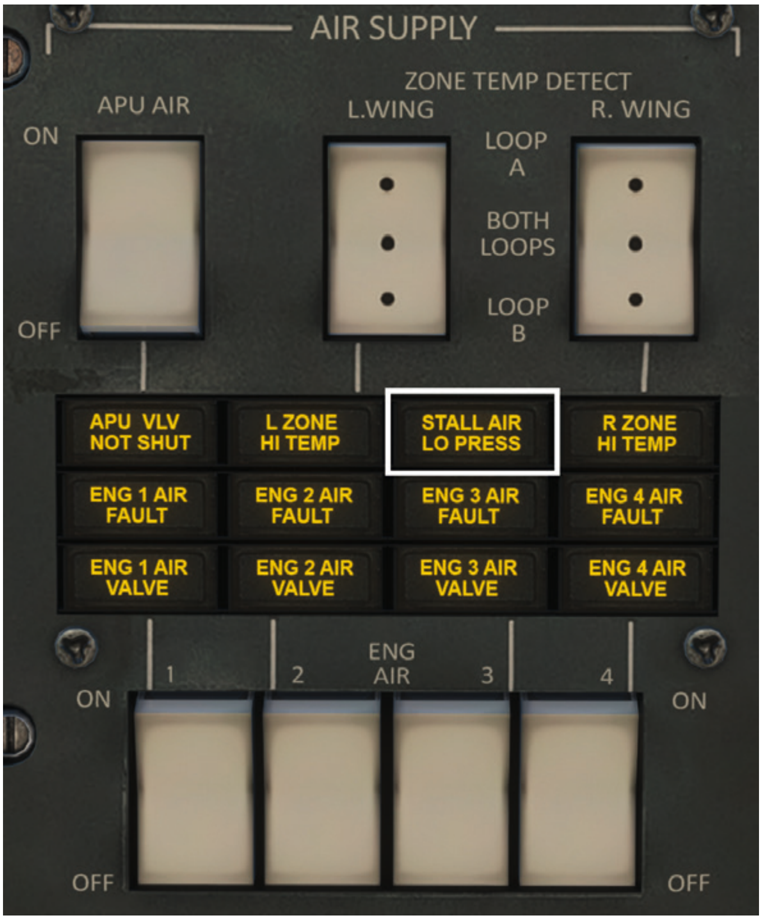
Operation of the stall warning and/or identification systems must always be accepted as indicative of a stall condition.

On the flight deck overhead GRND TEST panel, press-to-test buttons STALL WARN 1 & 2, and STALL IDENT 1 & 2 provide means of testing the systems. The stall warning system can be tested both on the ground and in the air, but the stall identification system can be tested on the ground only. The squat switch inhibition is overridden when the test buttons are pressed.

For a pre-flight check, pressing each STALL IDENT test button in turn will cause the appropriate amber IDNT annunciator and the MWS amber STALL IDNT caption to light if the system is serviceable. Pressing each STALL WARN test button in turn will cause both stick shakers to operate if the system is serviceable.

After the annunciator test switch has been pressed and released, the FGC will keep each IDNT annunciator illuminated for five seconds. The FGC continually monitors the state of the stall identification system (stick push) windshear inhibit relays. If it detects that one of the relays has inadvertently opened, then the FGC will illuminate the IDNT 1 (amber) or IDNT 2 (amber) and the MWS STALL IDNT (amber) annunciators to indicate this fault to the crew.

The airflow direction sensor vanes are electrically anti-iced. See the ICE AND RAIN PROTECTION SYSTEM section for details.



Yaw control

The rudder is operated by two servo units, one powered by the Yellow hydraulic system and the other by Green. Rudder 'feel' is provided by a spring strut.

Each servo unit has dual control valves operated by common linkage, but with two separate conventional cable and rod control circuits. One circuit is linked directly to the interconnected pair of rudder pedals, and the other is connected by way of a screw jack to the rudder trim wheel.

An MWS amber RUDDER VALVE caption will illuminate if any servo unit control valve should stick, or if either or both hydraulic systems should fail or lose pressure. There is a built-in time delay to eliminate spurious RUDDER VALVE warnings caused by transient falls in system pressure.

The RUDDER TRIM wheel and indicator are fitted to the centre console. Movement of the rudder trim wheel, while causing the displacement of the rudder control surfaces, also adjusts the datum for the 'Q' pot to allow equal left/right pedal movement throughout the trim range. With trim application, the pedals are offset from centre by approximately one third of the displacement that would otherwise be necessary to achieve the same rudder deflection from manual control.

A rudder limiter limits the rudder pedal travel to prevent excessive sideslip and fin loads which could result in structural failure. The limiter is driven by a rudder Q-pot. At approach speeds and below, the pedal limit corresponds to a rudder surface deflection of ±30°; as speed increases, pedal travel is reduced; at VMo the corresponding rudder deflection is ±2°.

If there is a failure in the pressure or static air supply system to the rudder Q-pot, causing it to sense an airspeed less than that of the aircraft, the amount of rudder authority available will be such that the aircraft could be overstressed. Therefore, warning of this failure will be given by the MWS amber caption RUD/EL Q FAIL.

Additionally, if the rudder 'Q' pot should jam in a position relative to an airspeed of approximately 160 knots or more, warning of the reduced rudder pedal travel available at lower speed will be given by the lighting of the MWS amber RUDDER LMTR caption, when the aircraft speed is reduced below 160 knots.

Single or twin yaw dampers (YD) are fitted and are part of the FGS. The YD provides rudder movements (maximum of ± 4 degrees) by controlling the rudder surface. Rudder movements are produced by a series YD actuator in order to overcome Dutch roll characteristics and to provide enhanced turn co-ordination. Engagement of the YD is independent of AP or FD engagement and normally operates full time when the YAW DAMPER MASTERS are switched ON. However, the YD is inhibited (actuator brake applied) if a YD system failure is detected or if the parallel rudder is engaged. Engagement of parallel rudder occurs automatically in TOGA and CAT 3 FGS modes. On engagement, parallel rudder maintains the directional balance (or unbalance) currently experienced and disengages the YD; it performs all of the YD functions in addition to its own.

Flaps

The single-piece tabbed Fowler-type flaps, one on each wing, are each operated by two screw jacks, chain-driven by separate torque limiters and driven by a transmission shaft assembly extending along the rear soar of each wing.

The left and right wing sections of the transmission shaft assembly are linked at their inboard ends by a flap control unit comprised of a gearbox driven by two separate hydraulic motors, one driven by the Yellow system and the other by the Green system.

Asymmetry brakes, one fitted at the outboard end of each wing's transmission shaft assembly and powered by the Yellow hydraulic system, automatically lock the flap operating mechanism in the event of any failure resulting in the flap symmetry varying by more than a few degrees or other unselected operation such as blowback or runaway.

Each of the hydraulic motors in the flap control unit has a brake which locks its drive when the flaps reach the selected setting, there is a control system fault or the associated hydraulic system is depressurised. If there is a loss of hydraulic pressure in any one system, the flaps will operate at half normal speed. If there is a loss of pressure in both hydraulic systems, both hydraulic motors will be braked, preventing further movement of the flaps.

Flap control system

The flaps may be selected to any of five gated positions (UP, 18, 24, 30 and 33). The selector lever is spring-loaded into each position but can be moved only after it has been lifted out of a gated position. Baulks at the 18 and 24 positions ensure that these positions cannot be inadvertently passed over as the lever must drop back into the gated position to clear the baulks. Selection of flaps, away from the UP position, is restricted to speeds of less than 220 knots by a solenoid-operated baulk mechanism controlled by a speed switch. A manual override may be operated by pressing a FLAP BAULK OVRD lever which is adjacent to the flap selector UP position.

The FLAP position indicator is situated on the pilot's centre panel. A visual indication of flap position in the event of electrical failure is provided in L/H flap track No.2. Four black lines on the fairing line up with yellow painted web in the track at flap angles of 18, 24, 30 and 33 degrees.

The flaps are fitted with dual-position sensors to provide discrete information to the FGCs. One of the sensor's outputs is fed to FGC 1 and the second output to FGC 2.

The flap control system has an electronic control unit which controls the flap control unit in response to signals via the pilot's FLAP selector lever switch and the flap position 'feedback' circuit.

The electronic unit has two control circuits and two safety circuits, referred to as Control and Safety Lanes.

The Control Lanes control the functioning of the Yellow and Green hydraulic system powered motors, in the flap control unit.

The Safety Lanes monitor the system for faults resulting from electrical or hydraulic failures, physical jamming or other faults capable of producing flap asymmetry, blowback, runaway or uncommanded operation.

The Control Lanes also have self-monitoring facilities to further enhance system reliability.

A single fault within a Control Lane will cause the MWS amber caption FLAP FAULT to light. The operational effect may vary from minor, i.e. full normal speed available, to a total loss of drive but it is probable that most faults will leave the system operable either at half or full speed.

Faults causing both Control Lanes to be disabled or a mechanical disconnect fault in the flap drive system will cause the flaps to be locked and the MWS amber caption FLAP INOP will light.

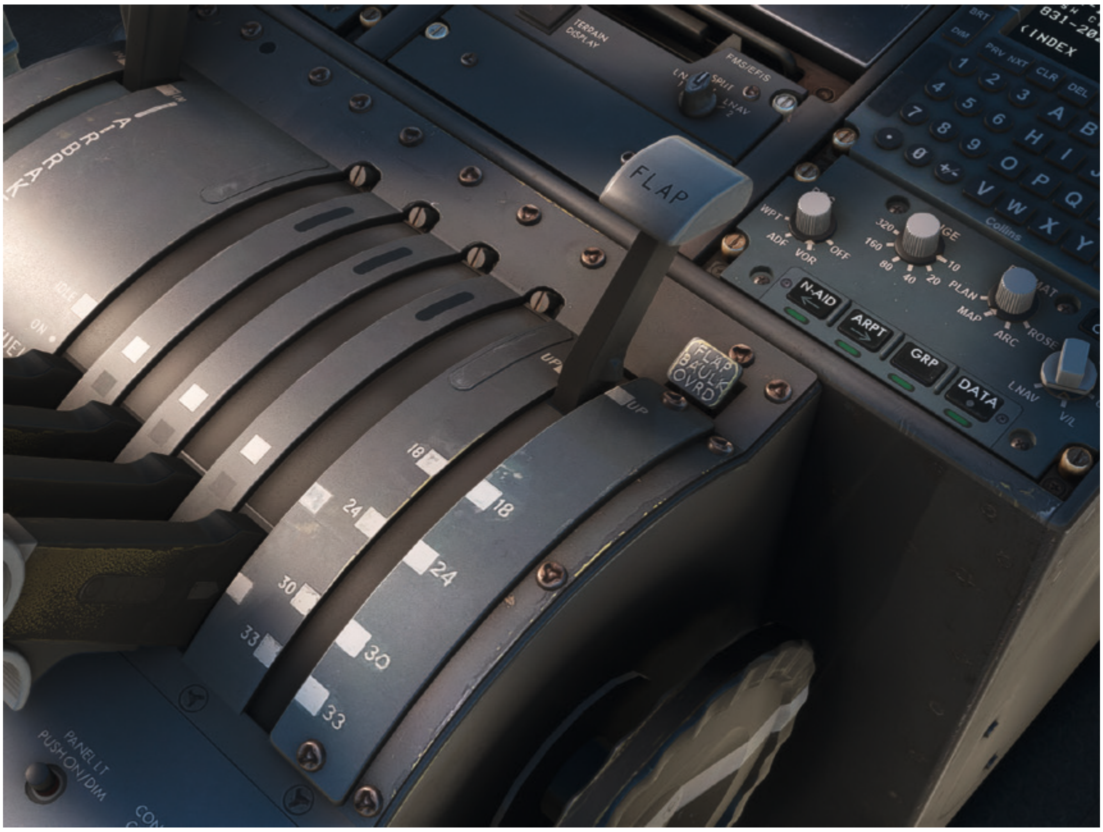
Electrical power supplies are segregated so that each Control Lane is powered by a separate source and a third source powers the Safety Lanes.

System GRND TEST facilities provided comprise FLAP SAFETY, FLAP CTRL FAULT YEL and FLAP CTRL FAULT GRN test buttons.

To test the system, press and then release the FLAP SAFETY button and observe that the MWS amber caption FLAP INOP lights up for 12-15 seconds. If the MWS FLAP FAULT caption was lit before the test, it will go out within 12-15 seconds. Repeat the test procedure by pressing and then releasing the FLAP CTRL FAULT YEL button. Observe that the MWS FLAP FAULT amber caption lights up for 12-15 seconds. Repeat the test procedure for the FLAP CTRL FAULT GRN button. During each phase of the test procedure the MWS amber caution lamps should flash. The single-tone chime should sound only on FLAP SAFETY check.

When the aircraft is on the ground, if the flaps are not in a take-off configuration and any thrust lever is moved into the take-off sector, the CONFIGuration warning system will be activated.

In flight, if the flaps are selected to a position of more than 30 degrees and the landing gear is not locked down, a steady non-cancellable horn will sound and the red lamp in the landing gear selector handle will light.



Lift spoilers

There are four spoilers on each wing: three lift spoilers and one roll spoiler, all hydraulically powered. The system is divided into two channels, with the Yellow system powering both roll spoilers and the inboard lift spoilers, and the Green system powering both centre and outboard lift spoilers, which are also mechanically interconnected. Spoiler deployment will thus remain symmetrical if one hydraulic system fails.

An automatic system for spoiler operation is provided and is available for landing and rejected take-off. The system provides status indication and the capability of reversion to manual operation by placing the airbrake lever in the LIFT SPOILER position.

The lift spoilers are for ground use only and must not be manually selected in flight. They are normally automatic in operation. The three switches marked AUTO SPLR, LIFT SPL YEL and LIFT SPLR GRN are on the overhead ANTI SKID & LIFT SPOILERS sub-panel and each have an ON/OFF position.

For automatic lift spoiler deployment the following conditions must be satisfied:

- The three spoiler switches mentioned above must be set to ON.
- Three of the four thrust levers must be retarded below flight idle.

- The three landing gear oleos must be compressed as follows:
    a) The Yellow spoilers deploy immediately on compression of both main oleos, or one main oleo and the nose oleo, or one main oleo compressed and then released followed by a nose oleo compression within ten seconds. In addition, the left or right inner main wheel must have reached a 'spin-up' speed of 33 knots.
    b) The Green system spoilers deploy 1.5 seconds after the main oleos have been compressed and the left or right outer main wheel must have reached a 'spin-up' speed of 33 knots.

If there is a failure of the autospoiler system, full reversion to manual control is possible by selecting the airbrake/spoiler lever to the LIFT SPLR position. This selection effectively parallels the wheel 'spin-up' signals.

Positive indication of lift spoiler deployment is given by the illumination of the two annunciators, SPLR Y (yellow) and SPLR G (green), on the left and right flight annunciator panels.

Failure of the lift spoilers to deploy is indicated by two amber push-button captions, one at each end of the glareshield, annotated LIFT SPLR and PUSH TO CANCEL. The warning is activated by either of the following conditions:

a) With the autospoilers armed (AUTO SPLR – ON), if the lift spoilers have not deployed within three seconds of touchdown.

b) In manual (AUTO SPLR – OFF), if the lift spoilers have not deployed within three seconds of selection of the airbrake lever to LIFT SPLR or if the manual selection has not been made within six seconds of touchdown.

Deploying the lift spoiler will cancel the caution annunciator. The caution will cancel automatically after 14 seconds or can be cancelled immediately by pressing either LIFT SPLR caption.

Anti-skid and lift spoilers sub-panel

Three switches and five annunciators, associated with the spoilers, are on the overhead sub-panel as follows:

AUTO SPLR - ON/OFF switch – arms the autospoiler system. Normally ON.

LIFT SPLRS YEL & GRN - ON/OFF switches – control the hydraulic selector valves. Normally ON.

AUTOSPOILER FAULT (amber) annunciator – switch off (AUTO SPLR – OFF) system and use manually. An AUTO SPLR OFF (white) status annunciator will illuminate on the CSP.

SPLR UNLOCKED (amber) annunciator – unselected unlocking of any spoiler jack.

MAN SPLR FAULT (amber) annunciator – indicates that there is a fault in one of the squat switch systems. Some or all of the spoilers may deploy on landing. Deployment will always be symmetrical.

Note: *Illumination of MAN SPLR FAULT (amber) in flight indicates that protection against in-flight lift spoiler deployment is degraded. Caution must be exercised in selecting AIRBRAKE fully OUT to avoid inadvertent LIFT SPLR selection.*

YELLOW FAIL & GREEN FAIL (amber) annunciators – indicate that there is a fault in the associated selector valve. As airborne deployment could result in a further failure, the associated LIFT SPLRS switch must be selected OFF to inhibit the channel. An associated warning on the MWP acts as a reminder, and annunciator LIFT SPLR SEL OFF (amber) is illuminated.

Illumination of any of the spoiler annunciators on the overhead panel will also illuminate the MWS amber SPLR caption.

Note 1: *Faults associated with the anti-skid system will affect autospoiler deployment. The manual system is not affected.*

Note 2: *The airbrake lever must not be moved to the LIFT SPLR position while in flight.*

The lift spoilers each have a separate jack with a lock mechanism to retain the spoiler in the retracted position should the hydraulic power fail.

A CONFIGuration warning is given on the ground if any lift spoiler jack is unlocked and any thrust lever is moved into the take-off sector.

Airbrake

A twin petal-type airbrake is fitted as a vertically split tail cone.

The airbrake is operated by a hydraulic jack, powered by the Green hydraulic system. Symmetrical deployment is assured by a mechanical interlink.

Airbrake control system

The combined AIR BRAKE/LIFT SPLR selector lever mounted on the centre pedestal enables the airbrake to be selected to any position between IN and OUT. Control is maintained by an electro-hydraulic system using command and response signals.

A status AIR BRK (white) annunciator illuminates on the left and right flight annunciator panels whenever the airbrakes are not closed.

The CONFIGuration warning is activated on the ground if the airbrake is not closed and any thrust lever is moved to the take-off sector.

A mechanical lock on the airbrake petals is designed to keep the airbrakes closed when the Green hydraulic system is not powered. This lock has a tendency to fail and will cause the airbrake to gradually open when on the ground with the green hydraulic system not pressurised. The airbrake will close as soon as Green system hydraulic pressure is increased.

FLIGHT GUIDANCE SYSTEM (FGS)

The Flight Guidance System (FGS) is an integrated autopilot and flight director system and can be regarded as consisting of the following:

- One or two flight guidance computers (FGCs)
- Mode control panel (MCP)
- Thrust rating panel (TRP)
- Associated switches, annunciators, servos and sensors (one for each system)

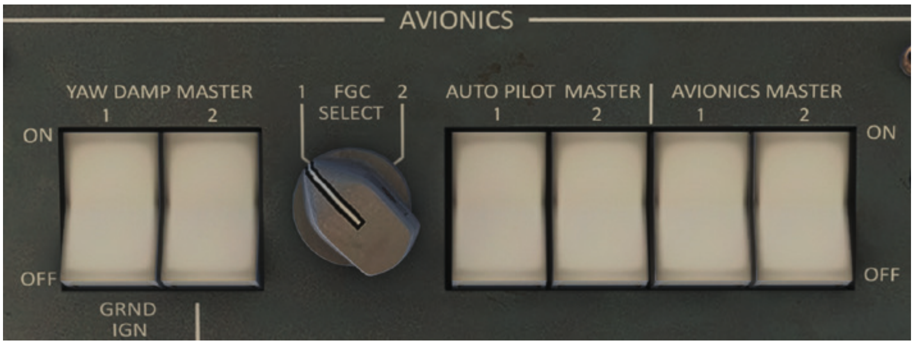
The FGS provides the following:

- Control of elevator, aileron and parallel rudder servos to provide three-axis control
- Yaw damping
- Flap trim compensation
- Automatic pitch trim control
- Autopilot (AP), with the following modes included:
    - Glideslope (GS)
    - Vertical speed (VS)
    - Altitude acquire and hold (ACQ/ALT)
    - Level change (IAS/MACH)
    - Localiser (LOC) and back localiser (BLC)
    - Heading select and heading hold (HDG/ROLL)
    - VOR
    - LNAV
- Coupled approach and automatic landing
- Coupled or FD, Take-off and Go-around
- Flight Director (FD), commands on EFIS primary flight displays (PFD)
- FD take-off guidance mode (TO)
- AP and FD mode annunciations on EFIS PFD
- Autothrottle (A/T) and thrust control system (TCS)
- Windshear, detection, alerting and guidance, coupled/FD recovery control (sub-mode of TO/GA)
- Built-in test equipment (BITE)
- Warning and status annunciation as follows:
    - Altitude alerting with visual and aural warnings
    - Windshear visual and aural warnings and failure warnings
    - AP disengage visual and aural warnings
    - A/T disengage visual warning
    - FGC fault annunciation (FGC1/FGC2)
    - Yaw damper failure annunciation (YD1/YD2)
    - Elevator out-of-trim annunciation
    - Pitch trim and flap trim compensation failure
    - Autoland status and progress annunciation

Flight Guidance Computer (FGC)

The FGC is the control computer for the FGS. If multiple FGCs are fitted, the non-selected FGC remains at standby expect for its yaw damper input. The FGC provides for a number of flight control and guidance functions.

The YD provides rudder movements (maximum of +/- 2.9 degrees single YD, +/- 2.9 degrees single YD, +/- 4 degrees dual YD) by controlling the rudder surface. Rudder movement are produced by a series YD actuator in order to overcome Dutch roll characteristics and to provide enhanced turn co-ordination. Engagement of the YD is independent of AP or FD engagement and operates full time when the YAW DAMPER MASTER and AUTOPILOT MASTERS are switched ON.



The YD is inhibited (actuator brake applied) if a YD system failure is detected or if the parallel rudder is engaged during take-off, during go-around or for automatic landings. The YD command on a dual FGC fit is a sum of the FGC1 and FGC2 signals; either system has sufficient rudder authority should the other system fail.

The parallel rudder function of the DFGS provides increased rudder authority, relative to that of the YD, and is used for the ALN (align) manoeuvre during automatic landings and in engine-out situations during take-off, approach (with FLARE armed) and go-around. Engagement of parallel rudder is automatic in APP/FLARE armed, ALN and TRK modes, and disengages the YD and performs all of the YD functions in addition to its own.

DFGS Mode Control Panel (MCP)

The MCP is located in the centre of the glareshield. It contains all the controls for mode selection and provides the means for setting target values for:

- VOR/ILS course
- Heading
- Altitude
- Airspeed
- Vertical speed
- Bank angle limit

The autopilot, flight director and autothrottle are all engaged from the MCP.

Six LCD indicators and six selectors are grouped along the top of the MCP.

Course selectors and displays – one course selector knob and display is located at either end of the MCP. The left course selector and display control the NAV 1 course, and the right course selector and display controls the NAV 2 course. The selected course information is provided to the FGCs and the EFIS for ND course pointer display on the NDs.

IAS/Mach speed selector and display – the detented select knob allows speed to be set in 1-knot or 0.01-Mach increments. Pushing the C/O (changeover) push-button will toggle between IAS or MACH. Automatic changeover between IAS and Mach occurs when climbing through FL245, when descending through FL235, when IAS is displayed and the equivalent selected Mach exceeds the Mmo limit, or when Mach is displayed and the equivalent selected IAS exceeds the Vmo limit. Changeover from IAS to Mach is inhibited when the resultant Mach is less than 0.50. The left-hand digit of the display flashes when associated with operation that exceeds either Vmo/Mmo or is below Vmin.

Heading selector and display – a combined heading selector and bank angle limit select knob is fitted below the heading window. The window displays the selected heading of 000 to 359 degrees in increments of one degree. When in HDG SEL or VOR mode the bank angle limit selector (outer) knob allows selection of maximum bank angle from 10 to 30 degrees, in increments of five degrees (actual bank angle is limited to 28 when selected to 30 degrees). The switch is inhibited in LNAV or LOC mode where computed limits apply.

Altitude selector and display – an altitude select knob and window displays selected altitude between 0 and 50,000 feet in 100-foot increments. The displayed altitude is used by the FGS as a reference for altitude alerting and for altitude control. If altitude reference fails, the display shows five dashes: '-----'.

Vertical speed selector and display – a vertical speed thumbwheel and display window show the selected vertical speed between -7,900 and +6,000 feet per minute when V/S mode is active. The thumbwheel is used when in V/S mode; the window is blank when the mode is not active. The thumbwheel increments the vertical speed by either:

- +/- 100 feet/minute when the displayed vertical speed is above +/- 1,000 feet/minute.
- +/- 50 feet/minute when the displayed vertical speed is below +/- 1,000 feet/minute.

Upward rotation of the wheel decreases the display value and downward rotation increases this value.

Autothrottle ARM/OFF switch and engage annunciator (green)

ARM – engages the autothrottle provided that no faults are detected and at least three engines are being controlled electronically, as indicated by their associated FADECs. When armed the annunciator is illuminated.

OFF – autothrottle disengaged and the annunciator is extinguished. The switch will 'drop' to the off position if the autothrottle is disconnected manually via the disconnect buttons (on the outer throttles) or automatically by the FGS.

A/P engage NAV select – the AP ENGAGE/NAV 1 and NAV 2 selector push-buttons are used to engage the autopilot and to change the selection of the navigation source and Baro correction source (left and right altimeter settings). The appropriate button illuminates 'ON' when pushed and the other button extinguishes if lit. During an approach when dual lane status is satisfied, both 'ON's will illuminate.

A/P DISENGAGE switch – the DISENGAGE switch is a two-position switch with the down position being the disengaged position. The autopilot is normally disengaged by use of the AP disconnect buttons on the outboard horn of either control wheel. The disengage switch provides a positive disengage function of the servos for emergency use. The switch must be returned to its normal up position to allow re-engagement of the AP. Disengagement will result in an automatic disconnect warning.

FD ON/OFF engage selectors – one flight director selector is located at each end of the MCP and is used to select the associated flight director on the respective PFD. When the AP is not engaged, the switching is also used to determine the NAV source and Baro-correction that is used by the FGS. Baro-correction source is required for ALT hold and ACQ modes.

Windshear recovery guidance given by the FD is independent of the FD engage selector position. Engagement of the FD is annunciated on the PFDs only when the AP is not engaged, otherwise the AP annunciator takes priority. The FD is biased out of view when FLARE mode engages during an automatic landing.

Master indicator lights (MA) – one MA indicator light is located at each end of the MCP and illuminates to show the respective left- or right-hand NAV (1/2) and Baro-correction that has been selected by either the FD switches or the AP engage/NAV buttons.

Note: *With no FD or AP selected, the baro-correction source is from ADC 1.*

When the FGS is in APP mode with both NAV sources in use, valid and tracking, both MA lights are illuminated. When the AP is not engaged, the NAV source and baro-correction are determined by the first flight director selected.

Mode select push-buttons

THRUST – a non-illuminated push-button which interacts with the TRP. It provides an alternative method of reducing thrust rating with easy accessibility from the Captain's position. When pressed in normal circumstances (after take-off above 350 feet radio altitude) thrust rating is reduced from TOGA to CLIMB NORM. Further operation of the push-button will have no effect. Concurrent with the thrust rating reduction, if A/T is armed, the A/T will become active in either a thrust mode with the AP/FD in use or in IAS mode without the AP/FD engaged.

Note: *If an engine failure is sensed, by a 10% N1 disparity between either engines 1 and 4 or 2 and 3, the THRUST button is inoperative.*

LVL CHG – selects speed mode (IAS or MACH) and the push-button will illuminate ON. Pressing the button a second time deselects level change and the light is extinguished, with control reverting to the basic vertical mode (VS) with the V/S button illuminating ON. Engagement of this mode can occur automatically while in the V/S mode, due to speed protection. Annunciations (IAS or MACH) are shown on the PFDs.

LNAV – arms or engages the LNAV mode and the push-button will illuminate ON. Pushing the button a second time deselects LNAV mode and the light is extinguished. FGS LNAV source is selected using the NAV 1 / NAV 2 source select button or FD selection. If LNAV is engaged, deselection will result in reversion to the basic lateral mode of heading hold (ROLL). Source annunciations (LNAV1/LNAV2) are shown on the PFD.

VNAV – the vertical navigation push-button is inoperative. The aircraft is not fitted with a VNAV autopilot mode, but advisory VNAV is available via the FMS with vertical deviation indicators appearing on the EFIS PFDs to indicate the aircraft's descent path versus the target descent path. Normal vertical modes used for climb/descent are LVL CHG and V/S.

Note: *This is simulated accurately based on the real-world RJ which also had a non-functional VNAV autopilot button. The button was only fitted to the real aircraft in anticipation of future growth, which never materialised.*

HDG SEL – engages heading select mode (HDG) and the push-button will illuminate ON. Pushing the button a second time will extinguish the light and the mode will revert to the basic lateral mode of heading hold (ROLL). This mode is used in conjunction with the heading and bank angle select knob and the HEADING window. Selected heading is also shown on the EFIS NDs. As a quality-of-life feature in this simulation, a hidden clickspot has been added to the screw immediately to the right of the APP button and will synchronise the selected heading with the aircraft's present heading.

VOR LOC – arms or engages the VOR, LOC or back localiser (BLC) mode depending on the selected frequency. The push-button will illuminate ON. Pushing the button a second time will deselect the mode, the light will extinguish and the FGS will revert to the basic lateral mode of heading hold (ROLL). FGC VOR LOC source is selected depending on the NAV 1 / NAV 2 select buttons or FD selection. If aircraft track is within 100 degrees of the set course and a localiser frequency set, LOC mode is selected and the current vertical mode is retained. If aircraft track is 100 degrees or more from the set course and a localiser frequency set, BLC mode is selected and the current vertical mode is retained. Source annunciations (VOR1/VOR2, LOC1/LOC2, BLC1/BLC2) are shown on the EFIS PFDs. During VOR mode the bank angle is limited to that selected on the MCP.

MLS – the microwave landing system push-button is inoperative. The autopilot is capable of ILS approaches using the VOR LOC and APP modes.

Note: *This is simulated accurately based on the real-world RJ which also had a non-functional MLS autopilot button. The button was only fitted to the real aircraft in anticipation of future growth, which never materialised. After a trial at several airports in the USA and Europe, MLS landing systems were removed in favour of alternative systems.*

APP – arms or engages either the LOC and GS modes or the BLC mode. If aircraft track is within 100 degrees of the set course, pressing the APP push-button will result in it illuminating ON and the VOR LOC button will extinguish if VOR LOC has previously been armed or engaged; the PFDs will show LOC armed (white) or engaged (green) and GS either armed (white) or engaged (green). Until LOC and GS are engaged and while still above 1,500 feet RA, APP can be deselected by pushing the button again. If both are engaged, selection of any other mode will have no effect and when below 1,500 feet RA deselection of APP is no longer possible. Disengagement of LOC mode reverts to basic lateral mode of heading hold (ROLL) and disengagement of GS reverts to basic vertical mode of V/S with the V/S mode button illuminating ON.

WARNING! *Do not use APP mode to arm or capture a localiser only or a back localiser procedure. This will prevent false GS captures.*

Note: *If aircraft track is 100 degrees or more from the set course, the VOR LOC push-button will illuminate ON when APP is pressed. The PFD will show BLC armed (white) or engaged (green) and the previously selected vertical mode (V/S, ALT or IAS); in addition, the PFD vertical scale will show -BKCRS.*

ALT HLD – engages the altitude hold mode (ALT) and the push-button will illuminate ON. Pushing the button a second time deselects the mode, the light is extinguished and the AP FD reverts to basic vertical mode (V/S) with the V/S button illuminating ON. Altitude hold is also engaged automatically during FGS control for capture of the selected altitude.

V/S – engages the vertical speed mode (V/S) and the push-button will illuminate ON, enabling the use of the vertical speed thumbwheel and V/S window. The V/S button is also illuminated whenever the AP or FD is in the basic vertical mode. When the mode is not selected the VS window is blank.

Thrust Rating Panel (TRP)

The TRP is located on the right side of the main instrument panel and provides the following control and indicators:

MSTR 1/2 selection switch – this is used to toggle between setting engine No.1 or engine No.2 as the master for engine N1 synchronisation when the A/T is not engaged and the TRP is selected to CLIMB (not MCT or TOGA). Moving the thrust lever of the master engine will cause the FGC to send an N1 command signal to the slave engines to keep them synchronised with the master engine. If the FADEC has insufficient trim authority to match the master engine, the FGC will illuminate the appropriate trim arrow on the FADEC status panel above the PED. If either engine No.1 or engine No.2 fails, or there is a FADEC failure, then the failed engine is inhibited as master and the other engine is automatically designated as master.

N1 TEMP / V-speeds display – shows the selections made by the setting knob. N1 limit is for display only as this is dependent on the thrust rating altitude and temperatures. TEMP is the pilot-selected ground reference temperature (ambient or Tflex), and V-speeds are V1 and Vdot.

TOGA push-button – used to select one of two TOGA sub-modes: MAX and REDU (FLEX). MAX produces the maximum N1 for take-off at the current altitude and temperature. Selection of REDU will display a precalculated reduction from the TOGA MAX N1REF value. Any further increases in the selected temperature will then cause a flexed N1 to be displayed (N1 FLEX), and allows for less than N1REF to be used (if performance allows) to save engine life and reduce noise levels on the runway. On the ground, the sub-mode defaults to MAX. Subsequent presses of the button toggles between the two modes. The relevant mode will illuminate when active.

MCT push-button – used to select MCT (Maximum Continuous Thrust) mode, which produces a predetermined N1 for the current altitude and outside air temperature (OAT). The mode will illuminate when active. MCT mode cannot be selected on the ground.

CLIMB push-button – used to select one of two CLIMB sub-modes: MAX and NORM which sets a predetermined N1 for the current altitude and outside air temperature (OAT). Subsequent presses of the button toggles between the two modes. The relevant mode will illuminate when active. CLIMB mode cannot be selected on the ground.

Two concentric knobs – the outer knob is used to select the speed bugs V1, Vdot and Vcross, which are displayed on the EFIS, as well as the setting of TEMP and display of N1. The inner knob is used to control the values of the setting selected by the outer knob.

Flight deck switches

Control column handwheel switches

Elevator trim switches – one on each control wheel. A split thumb-operated switch controls the electric elevator trim and both halves have to be moved together.

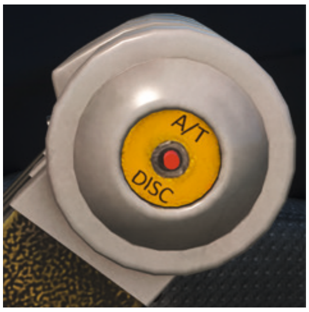
AP disconnect button – one on each control wheel. Allows either pilot to disengage the AP or cancel an AP un-commanded disconnect warning. An aural and visual warning is given on AP disconnection.

Flight director synchronisation (SYNC) button – one on each control wheel. Either switch will operate the FD pitch synchronisation mode when the vertical mode is level change or vertical speed. This will re-datum the selected airspeed or vertical speed. The SYNC mode is inhibited when the AP is engaged.

Thrust lever switches

TOGA push-buttons – on the front face of the two inner thrust levers (2 and 3). Either switch selects Take-off/Go-around mode. On the ground the thrust levers must be forward of the upright position (45% N1) to activate the autothrottle.

Autothrottle disconnect switches – on the outside faces of the two outer thrust levers (1 and 4). Either switch is pressed to disconnect the autothrottle. The switches are also used to inhibit the thrust rating panel by pressing and holding for three seconds.



Instrument panel switches

AIR DATA transfer switch – allows either pilot to select the alternative air data computer for display of airspeed and Mach number. A yellow cautionary legend (ADC1 or ADC2) is displayed on both EFIS PFDs whenever a single air data source is displayed to both pilots, indicating which source is in use.

ATT HDG transfer switch – allows either pilot to select the alternate inertial reference system (IRS) for display of pitch and roll attitude and heading. A yellow cautionary legend (ATT1 or ATT2) is displayed on both EFIS PFDs and HDG1 or HDG2 is displayed on both EFIS NDs whenever a single IRS source is displayed to both pilots.

HDG MAG/TRUE guarded selector switch – on the lower part of the left-hand instrument panel. Selection of TRUE is annunciated on the EFIS ND.

S.APP annunciator push-button – used for steep approach (ILS glideslopes of 4.5 to 6.0 degrees) to reset FGS parameters and to modify GPWS warning thresholds. White S.APP indicates selection and green indicates steep approach enabled, which will occur when 33-degree flap and landing gear are both down.

Avionics switches (overhead panel)

YAW DAMPER MASTER 1 and 2 – two OFF/ON switches, which connect power to the YD actuator. Engagement of the YD is dependent on the AUTOPILOT MASTER 1 and 2 switches being selected ON, but is independent of AP or FD engagement.

FGC SELECT 1/2 – two-position rotary switch that selects either FGC 1 or 2 as the active system. The other system is available as standby. This switch does not affect the yaw damper operation.

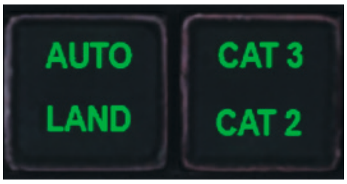
AUTOPILOT MASTER 1 and 2 – two OFF/ON switches, which energise/de-energise a relay that connect power to the FGS, YD, A/T systems, AP servos and trim servos.

AVIONICS MASTER 1 and 2 – two OFF/ON switches that provide power supplies for the avionics sensors used by the FGCs, through relays controlled by the No.1 and No.2 switches respectively.

Annunciators

Autoland annunciators

Autoland annunciators are duplicated on the left and right sides of the coaming above the glareshield.



AUTOLAND FAIL (red) – illuminates if the autoland system fails during an automatic landing or an autopilot disconnect occurs during an automatic landing. Extinguished by the selection of TOGA mode, AP disengagement or by re-engaging the AP.

FLARE (green) – flare mode engaged. Also shown on the EFIS PFD and extinguished at nose lower engagement.

Flight annunciators

Two banks of annunciators are located on the left and right instrument panels adjacent to the PFDs.

AP (red) – autopilot disconnect. Illuminates momentarily (0.75 seconds) if manual autopilot disconnect or steady 'red' if disconnection due to system failure. Also shown on EFIS PFDs and coupled with a 'cavalry charge' audio warning. Extinguished by pushing either disconnect button or by re-engaging the autopilot.

A/T (amber) – autothrottle disconnect. Illuminates momentarily (four seconds) if manual autothrottle disconnect or steady 'amber' if due to system failure. Extinguished by pushing either A/T disconnect button or by re-engaging the autothrottle.

FTC (amber) – flap trim compensation failure.

EL TRIM (amber) – manual electric trim or autotrim failure.

AIR BRK (white) – indicates airbrake is not closed.

YD (amber) – total loss of yaw damper.

AUTOLAND (green) and CAT 3 (green) – CAT 3 status achieved, extinguished at TOGA, disengagement of AP or loss of CAT 3 status. Indicates system configured for autoland.

CAT 2 (green) – CAT 2 integrity achieved, autoland may not be available. Extinguished on TOGA, disengagement of AP or loss of CAT 2 status.

SPLR Y (green) – hydraulic pressure sufficient to deploy yellow spoilers.

SPLR G (green) – hydraulic pressure sufficient to deploy green spoilers.

Status annunciators

Three status annunciators and two spares are located on the left- and right-hand instrument panels and adjacent to the PFDs.

NO AUTOLAND (amber) – illuminates if automatic landing is not available and the aircraft is on the approach (at or below 900 feet radio altitude).

WINDSHR (amber) – increasing performance windshear detection.

WINDSHR (red) – decreasing performance windshear detection.

Master warning panel annunciators

WINDSHEAR INOP (white) – windshear detection or guidance has failed or WS unavailable due to sensor failure.

FADEC (amber) – fault on particular engine control unit.

Stall system annunciators

Two stall system annunciators are located on each pilot's instrument panel:

IDNT 1 (amber) – fault detected by stall system or DFGC in stall channel No.1.

IDNT 2 (amber) – fault detected by stall system or DFGC in stall channel No.2.

Advisory annunciators

Five advisory annunciators with two spares are located on the centre instrument panel below the primary engine display.

YD 1 (white) – YD failure detected in FGC 1.

YD 2 (white) – YD failure detected in FGC 2.

NO CAT 3 LAND (white) – integrity of FGS and required sensors not suitable for automatic landing. This annunciator will illuminate for any detected failure in the following systems, which will prevent CAT 3 operating status being achieved:

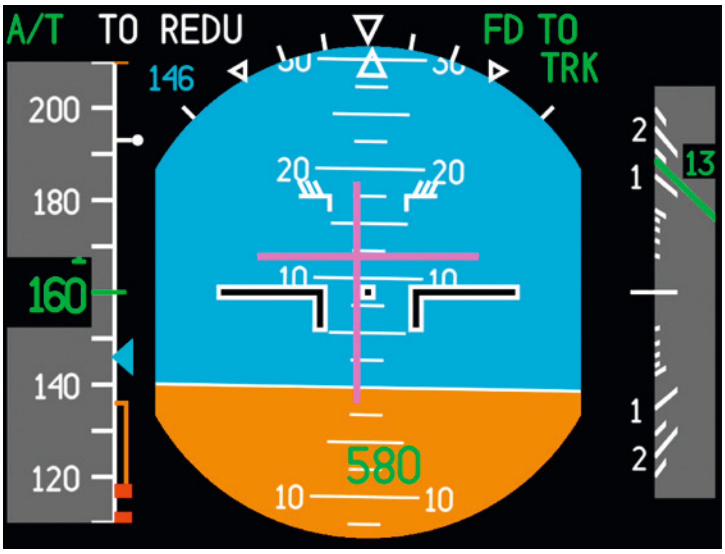
- IRS
- ADC
- Radio altimeter
- ILS
- Autopilot (server loop and control circuit failures)
- MCP course
- Flaps
- Lift spoilers
- Undercarriage

FGC 1 (white) – fault detected in FGC 1. This white FGC advisory annunciator indicates a degradation of the FGC or its associated system.

FGC 2 (white) – fault detected in FGC 2. This white FGC advisory annunciator indicates a degradation of the FGC or its associated system.

EFIS flight mode annunciations

The AP/FD and A/T status engagement information is annunciated on the EFIS primary flight display (PFD). The legends may be one of five colours: green, white, magenta, red or amber. Active modes are shown in green and armed modes in white. Normally changing pitch or roll modes results in a flashing mode annunciation of the final colour for five seconds prior to steady annunciation. Automatic mode changes during a Cat 3 approach do not cause flashing annunciation. A/T mode transitions are not flashed except for the TO thrust freeze to ARM transition after take-off.



The annunciations are given in the sequence of left to right and top to bottom of the display and are as follows (colours are shown in brackets):

Autothrottle and thrust status

- **A/T (green)** – autothrottle engaged.
- **A/T (white)** – autothrottle ARMED.
- **A/T (flashing amber)** – autothrottle disengaged automatically.
- **A/T (magenta)** – either A/T WS MAX or A/T IAS with windshear (caution) detected and A/T controlling to ground speed.
- **Blank** – manual throttle operation.
- **'----' (white)** – ARINC discrete word No Computed Data (NCD) or AP Master not selected.
- **XXX (yellow)** – annunciator failure.

Thrust mode/rating

Active autothrottle modes/ratings are displayed in green and armed modes/ratings in white. If windshear thrust is engaged, WS MAX is shown in magenta.

- **WS MAX (magenta)** – windshear thrust.
- **TO MAX (green/white)** – TOGA maximum thrust.
- **TO REDU (green/white**) – TOGA reduced thrust and flexible thrust.
- **GA MAX (green/white)** – TOGA reduced thrust.
- **MCT (green)** – maximum continuous thrust.
- **CLB MAX (green)** – maximum climb thrust.
- **CLB NRM (green)** – normal climb thrust.
- **MACH (green)** – A/T controlling MACH.
- **IAS (green)** – A/T controlling IAS.
- **RETARD (green)** – A/T thrust retard.

AP, FD engagement status

- **AP (green)** – autopilot engaged.
- **AP (red)** – autopilot disengaged manually.
- **AP (flashing red)** – autopilot disengaged automatically.
- **FD (green)** – flight director engaged.
- **FD (white)** – flight director engaged in FD PITCH SYNCH.

AP, FD engaged vertical modes (all green except where shown)

- **VS** – vertical speed, basic pitch mode.
- **ALT** – altitude hold.
- **ACQ** – altitude acquire.
- **IAS** – level change, IAS on pitch.
- **MACH** – level change, IAS on pitch.
- **GS1** – GS engage on ILS 1.
- **GS2** – GS engage on ILS 2.
- **GS*** – GS engage on both ILS.
- **FLR** – flare.
- **GRND** – nose lower.
- **GA** – go-around.
- **GAWS (magenta)** – windshear, go-around.
- **TO** – take-off. FD-only mode unless A/P engaged after take-off.
- **TOWS (magenta)** – windshear, take-off.
- **'----' (white)** – invalid data.
- **XXX (yellow)** – annunciator failure.

Note: *Altitude capture is always armed but not annunciated.*

AP, FD armed vertical modes (all white)

- **GS1** – GS arm on ILS 1.
- **GS2** – GS arm on ILS 2.
- **FLR** – flare armed.
- **'----'** – invalid data.
- **XXXX (yellow)** – annunciator failure.

AP, FD engaged lateral modes (all green)

- **ROLL** – heading hold, basic roll mode.
- **HDG** – heading select.
- **VOR1, VOR2** – VOR capture/track on NAV 1/2.
- **LNV1, LNV2** – LNAV engaged on FMS.
- **LOC1, LOC2** – localise capture/track on NAV 1/2.
- **BLC1, BLC2** – back localiser capture/track on NAV 1/2.
- **LOC*** – localiser capture/track on both NAV1 and NAV2.

- **ALN** – runway align manoeuvre.
- **ROLL** – runway rollout.
- **TRK** – go-around and take-off tracking.
- **'----' (white)** – invalid data.
- **XXXX (yellow)** – annunciation failure.

AP, FD armed lateral modes (all white)

- **BLC1, BLC2** – BLC arm on associated NAV 1/2.
- **LOC1, LOC2** – LOC arm on associated NAV 1/2.
- **VOR1, VOR2** – VOR arm on associated NAV 1/2.
- **LNV1, LNV2** – LNAV arm on FMS.
- **'----' (white)** – invalid data.
- **XXXX (yellow)** – annunciation failure.

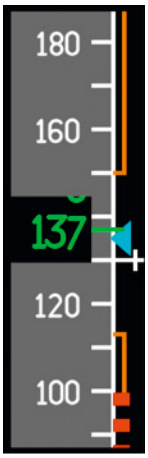
Flight director indications (magenta)

Split cue (cross pointer) flight directors are provided. Automatic display of FD bars occurs with TOGA windshear modes.

Pitch limit indication (PLT)

Windshear white 'eyebrows' are normally displayed when radio altitude is less than 2,000 feet (see Windshear detection and recovery guidance). The 'eyebrows' are double-stroked when windshear is detected, so that their white colour is intensified.

Speed tape indications



- **V_{SS} (red barber's pole)** – stick shaker indication.
- **V_{MIN} (yellow)** – minimum operating speed.
- **V_{MO}/M_{MO} (red barber's pole)** – maximum operating speed.
- **V_1 (magenta)** – take-off decision (speed only shown with weight on wheels)
- **V_{CROSS} (white)** – normally used for VR and VREF.
- **V_{DOT} (white**) – normally used for VFTO.
- **V_{SEL} (cyan)** – MCP selected speed, used for V2 on take-off.

Autopilot servos and position sensors

The AP controls the aircraft through four (eight for dual system) autopilot servos which operate the following control surfaces:

- Aileron tabs
- Elevator tabs
- Rudder
- Elevator trim tabs

The sensors and 13 position sensors are mounted in the wings, tail and fin.

Autothrottle servos and clutch assembly

Mounted under the flight compartment centre console throttle levers, one servo for each FGC in a common housing. Only one active FGC controls its servo at any one time.

Yaw damper actuator and brake

Yaw damping and turn co-ordination are provided by both FGCs through yaw damper actuators operating in series with the rudder controls. The YD actuators are fitted with two brakes which are electrically operated from the FGCs. The brakes are applied in the event of a failure.

Operation

Autopilot (AP) and Flight Director (FD)

For any operating mode to be operative, the AP or at least one FD must be engaged. The appropriate sensors are required for the engagement of each particular mode, and a subsequent loss of the necessary sensors will lead to disengagement of that mode.

The operation of the AP or FD is separated into vertical and lateral modes.

Engagement / NAV selection

The AP is engaged by pushing one of the two AP ENGAGE buttons labelled NAV 1 and NAV 2 on the MCP. The selected button will illuminate ON, the PFDs will annunciate AP in green and the associated master light (MA) will illuminate to indicate which navigation sensors and baro source has been selected. The DFGS can then be coupled to the associated NAV sensors (1/2), by use of the appropriate mode selector buttons:

- VOR – VOR LOC
- ILS – VOR LOC or APP
- LNAV – LNAV

If the (AP engage) NAV selection is subsequently changed after the initial engagement, the NAV sensor source will be changed. In the ALT or ACQ modes the baro-correction source will not change with AP engage NAV selection changes until these modes have been exited.

The FD is engaged, with or without the engagement of the AP, by the selection of either or both of the FD engagement selectors. The FD display will be shown on the associated PFD on the selected side. When the AP is not engaged the NAV source selection corresponds to the selected FD engagement switch. If both FDs are selected, the NAV source corresponds to the first switch selected. The appropriate MA light will illuminate to show the active source. Engagement of the FD is only annunciated on the PFDs (FD in green) when the AP is not engaged; otherwise AP is shown instead.

The AP can be engaged on the ground, but will disconnect automatically when the indicated airspeed exceeds 60 knots. Further engagement is inhibited until the aircraft has been airborne for 10 seconds.

AP disengagement

Disengagement of the AP can either occur manually or automatically. Manual disconnects are initiated by the AP disconnect buttons or from the DISENGAGE switch on the MCP (for warning purposes this is considered to be an automatic disconnect). Automatic disconnects are initiated by the FGS under the following conditions:

- When a fault is detected which precludes continued safe operation.
- When stick shaker angle is exceeded for two seconds (when windshear guidance is not being provided).
- When either stick push system operates (when windshear guidance is not being provided).
- When in level change climb or descent with speed limiting occurring to the extent that the climb or descent is reversed for longer than five seconds.

AP disconnect warnings

Disconnect	Visual warnings Flight Deck	Visual warnings EFIS	Aural warnings Audio System
Automatic	Red steady AP warning on flight annunciator panels. Duration: until cancelled.	Red flashing AP on PFDs. Duration: until cancelled.	'Cavalry charge' until cancelled.
Manual	Red steady AP warning on flight annunciator panels. Duration: 0.75 seconds.	Red AP on PFDs. Duration: 0.75 seconds.	'Cavalry charge' for 0.75 seconds.

For manual and automatic autopilot disconnects, the flight deck aural and visual warnings will cancel only when the AP disconnect button is released.

All approach modes are computed in both lanes of the FGC for cross monitoring, such that both lanes must agree before a servo movement can be demanded. Conflict between the two lanes results in an AP disconnect.

Vertical modes	EFIS legend	Armed condition	Autoland modes	Pilot selectable
Take-off	TO			Engagement of FDs on ground
Take-off Windshear	TOWS			
Vertical speed	VS			Deselection of current mode or MCP (V/S button)
Altitude hold	ALT			MCP (ALT HLD button)
Altitude acquire	ACQ			
Level change	IAS or MACH			MCP (LVL CHG button)
Glideslope	GS1, GS2 or GS*	YES		MCP (APP button)
Flare	FLR	YES	YES	
Nose lower	GRND		YES	
Go-around	GA			TOGA buttons (thrust levers 2 & 3)
Go-around windshear	GAWS			TOGA buttons or thrust levers >95%

Lateral modes	EFIS legend	Armed condition	Autoland modes	Pilot selectable
Roll take-off	TRK			Engagement of FDs on ground
Heading hold	ROLL			Deselection of current mode
Heading select	HDG			MCP (HDG SEL button)
Lateral navigation	LNAV1, LNAV2	YES		MCP (LNAV button)
VOR NAV	VOR1, VOR2	YES		MCP (VOR LOC button with VOR tuned)
Localiser	BLC1, BLC2, ILS1, ILS2 or LOC	YES		MCP (VOR LOC or APP buttons with ILS tuned)
Back localiser	BLC1, BLC2	YES		MCP (VOR LOC button with ILS tuned)
Align	ALN		YES	
Roll go-around	TRK			TOGA buttons (thrust levers 2 & 3)
Runway rollout	ROLL		YES	

Basic modes

The basic modes of the AP and/or FD are vertical speed and heading hold (ROLL). The AP engages in the basic modes unless the FD is engaged, in which case the AP engages in the selected FD modes.

Take-off modes

Take-off modes provide FD pitch (TO) and track (TRK) guidance during ground roll and climb-out. These modes are engaged when the aircraft is on the ground or immediately after take-off. Engaging .the AP with the FD in these modes also engages the AP in the same modes. The AP can only be engaged 10 seconds after take-off.

Prior to lift-off the FD commands a nose-up pitch attitude. After lift-off the pitch commands are referenced to the V2 speed, selected before take-off.

V2 cannot be changed after the airspeed reaches 80 knots until the aircraft goes above 350 feet radio altitude, or if radio altitude is inoperative at least 20 seconds after lift-off.

When the mode is engaged, the active vertical field annunciates TO and the active lateral field annunciates TRK on the PFDs.

The TO mode can be disengaged by the selection of another vertical mode, such as LVL CHG (IAS/MACH), but mode change is inhibited until radio altitude is above 350 feet or if radio altitude is invalid when flaps are retracted to less than 18 degrees.

Windshear detection will result in automatic transition to the take-off windshear sub-mode. Engaging the AP above 350 feet will result in the engagement of the take-off windshear sub-mode.

The track reference is that reached at 80 knots during the take-off roll. While on the ground in the TO mode the FD command is wings level. The maximum bank commanded after take-off is 10 degrees. TRK is annunciated in the active lateral FMA field of the PFDs and TO in the active vertical field.

If AP or FDs are selected after take-off the track reference is established at the time of engagement, unless the roll attitude is greater than three degrees. If greater than three degrees, the AP/FD commands wings level and the track is established at the time when the roll becomes less than three degrees. In this mode, with AP engaged, parallel rudder is engaged to provide yaw damping and engine-out compensation.

Track mode may be disengaged, independent of take-off mode (TO), by engaging or arming any other lateral mode. If another roll mode is armed while still in take-off mode, the lateral mode reverts to basic ROLL mode.

TRK will be annunciated if take-off windshear is automatically engaged.

Vertical modes

Vertical speed (V/S)

Vertical speed mode is the basic vertical mode and provides pitch AP servo and/or FD commands to capture and hold the selected vertical speed. The mode is engaged when the AP and/or FDs are initially selected on, or by deselection of another vertical mode. The mode can also be selected ON by pressing the V/S button on the MCP, with AP or FDs engaged and approach mode not engaged.

Engagement is confirmed by a VS (green) annunciation on the PFDs and the illumination of the ON legend on the button. The vertical speed datum is that which exists at the time of engagement of the mode.

The vertical speed is adjusted by using the vertical speed thumbwheel or, for FD only, by the use of the FD SYNC button.

V/S mode is disengaged by selection of any other vertical mode. V/S mode is inhibited at GS engagement or when altitude acquire and altitude hold modes are engaged at altitude capture.

There is a speed protection mode whereby, if the speed falls below Vmin or exceeds Vmo/Mmo, V/S automatically reverts to LVL CHG (IAS/MACH).

Altitude hold (ALT HLD) & altitude acquire (ACQ) modes

Altitude selection and display on the MCP, together with altitude alerting, comprise the altitude function of the FGS. When ALT HLD is selected by pressing the mode select button, the button illuminates ON and the FGS controls the pitch to acquire and hold the altitude datum. ACQ or ALT annunciations are shown on the EFIS PFDs.

Altitude control occurs in one of two ways:

1. Manually, by pressing the ALT HLD button. If the aircraft is not in level flight at the time of engagement, the FGS will enter the altitude acquire (ACQ) mode and carry out a smooth level off and altitude capture.

   Note: *The altitude captured depends on the rate of descent or climb; it is not the altitude at which the ALT HLD button is pressed.*

   Pushing the button again will deselect the ALT HLD mode and the DFGS will revert to the basic V/S mode, provided the altitude in the ALTITUDE display has been pre-selected to a new datum and is not showing the current altitude.

2. Automatically, by pre-selection of an altitude in the ALTITUDE display on the MCP and using TO, GA, V/S or LVL CHG (IAS/MACH) modes to fly to the selected altitude. The altitude acquire mode will automatically engage and provide a smooth capture of the selected altitude. At transition ACQ is annunciated on the EFIS PFDs, and at capture the ALT HLD button is illuminated on the MCP and the EFIS annunciation changes to ALT.

The altitude selected on the MCP is referenced to the master side (MA) altimeter and its barometric setting. However, changing the master barometric reference while the acquire or ALT HLD modes are engaged will not affect the altitude target and the barometric reference, which remains the same as at mode entry.

Level change LVL CHG (IAS/MACH) mode

The level change (LVL CHG) mode is used to effect a level change, in conjunction with the selected altitude, using IAS or MACH to control pitch. When engaged, the AP and/or FD captures and holds the commanded speed. The speed used is selected in the IAS/MACH display, using the speed select knob. The mode button is illuminated ON, either by selection or automatically by the speed protection mode, if the speed falls below Vmin or exceeds Vmo/Mmo when in V/S mode. The PFD annunciation in this mode is either IAS or MACH as selected by the changeover switch on the MCP. The selected value of the IAS is also displayed on the speed scale of the PFDs, as a cyan Vsel bug and again as a digital read-out at the top left of the PFDs.

LVL CHG mode is inhibited if glideslope is engaged or when altitude acquire (ACQ) or ALT HLD is engaged at the selected altitude. In the latter case, if the selected ALTITUDE in the display is changed from that currently held, the LVL CHG mode can be engaged.

Pressing the LVL CHG mode button when engaged in LVL CHG results in reversion to V/S mode.

Disengagement of LVL CHG mode will result from the engagement of another vertical mode, such as glideslope, altitude acquire or altitude hold.

Approach (APP) mode

Approach (APP) mode provides vertical and lateral guidance/control to capture and track an ILS glideslope and localiser.

Approach mode is armed by pressing the APP mode button with the ILS frequency selected on the controlling NAV.

The localiser front course QDM must be selected in the associated COURSE display.

Note: *Do not use APP to arm or capture a localiser-only procedure; this will prevent false GS captures.*

Glideslope deviation is displayed on the associated EFIS. Altitude alerts are inhibited at glideslope capture.

The glideslope can be approached from above or below and can be joined before or after localiser capture.

The APP mode button illuminates ON and the PFDs annunciate GS1(2) / LOC1(2) in white (armed). After beam capture the PFDs will annunciate GS1(2) / LOC1(2) in green (engaged) to indicate capture.

When both ILSs are engaged valid and tracking, this is termed the ‘dual ILS mode’ and the FGS uses the average of the two glideslope and localiser deviation signals and the annunciation is GS*/LOC*.

At the glideslope intercept point, the controlling vertical mode will disengage automatically and the aircraft will capture the glideslope. The GS annunciations on the PFDs change to green (engaged).

APP is deselectable above 1,500 feet by pushing the mode button with resultant reversion to heading hold (ROLL) and vertical speed (VS). Below 1,500 feet, if both LOC and GS are engaged, selection of APP or any other mode will have no effect.

The approach mode is disengaged when:

- TOGA switch is pressed (below 2,000 feet).
- AP is disengaged and both FDs are OFF.
- APP mode is pushed before localiser capture (reverts to ROLL).
- APP mode button is pressed above 1,500 feet.
- Flare is entered.
- Changing frequency from ILS to VOR on the controlling NAV set (tuning inhibited after CAT 2 (below 600 feet RA) or CAT 3 status achieved).

Localiser is inhibited in roll take-off and roll go-around modes, when below 350 feet with valid radio altitudes or with flaps at 18 degrees or more (if radio altitude is invalid).

It is normal to use HDG SEL mode to set up an intercept heading of the required QDM or QDR.

The G/S and LOC modes change from arm to engage when the capture criteria of the selected beam-course has been satisfied, at which point the white armed annunciation is removed and the appropriate green annunciation is shown in the active lateral field. The lateral/vertical mode used for capture then disengages.

Prior to starting the capture manoeuvre, the maximum angle of bank is 28 degrees. After capture the maximum bank angle is 10 degrees above 200 feet radio altitude and progressively reduced below 200 feet. If radio altitude is invalid, the 10 degree limit is maintained.

Autoland

The autoland facility engages automatically on the approach if CAT 3 status has been achieved.

With both ILS receivers tuned to the same frequency, both course pointers selected to the ILS front course and ATT/HDG transfer set to NORM, the FGS and associated sensors are functioning correctly.

When the above conditions are achieved and the aircraft descends below 1,500 feet radio altitude, the FGS begins to assess the CAT 3 status. If after about 10 seconds CAT 3 status is achieved, the green CAT 3 (green) and AUTOLAND annunciators are illuminated to show engagement of autoland. The flare mode (FLR) is armed and annunciated on the PFDs.

Once CAT 3 status has been achieved, the autoland system can perform automatic approach and landings. CAT 3 status refers to aircraft system integrity only. After touchdown the AP remains engaged until disconnected by the pilot.

When CAT 3 status is achieved, retuning of the ILS frequency is inhibited.

The sequence of modes for Cat 3 automatic landing is given in the following table:

Radio altitude	Vertical modes		Lateral modes		Flight annunciators
	Engaged	Armed	Engaged	Armed	
1,500 - 150 feet	GS*	FLR	LOC*		CAT 3, AUTO LAND
150 - 50 feet	GS*	FLR	ALN		CAT 3, AUTO LAND
50 feet - touchdown	FLR		ALN		CAT 3, AUTO LAND
Nose lower	GRND		ROLL		CAT 3, AUTO LAND

A failure of the autoland system can be annunciated in two ways, depending on the type of failure:

1. Illumination of AUTO LAND FAIL (red) with the AP engaged. This signifies that a failure has occurred which will prevent the safe continuation of an automatic landing, whilst allowing the pilot to initiate a coupled go-around (autopilot remains engaged). Upon illumination of the warning. the pilot has two seconds to select auto go-around by use of the TOGA push-button; failure to do so will result in an automatic AP disconnect.
2. AP disconnect warning (visual and aural) with simultaneous AUTO LAND FAIL (red) warning.

   After AP disconnect the pilot should take over control and perform either a manual landing or manual go-around.

Non-selectable modes

Flare (FLR) mode

Flare (FLR) mode is a vertical mode and is automatically armed when CAT 3 status is achieved. It is engaged when the radio altitude is 50 feet. The FDs are biased out of view at flare height.

The FMA annunciations are GS* (green) FLR (white) when armed, and at engagement FLR (green) replaces the GS* annunciation. In addition the FLARE (green) autoland annunciators on the glareshield illuminate.

The flare mode is disarmed if CAT 3 status is lost.

The flare mode is disengaged when the TOGA switches are pressed or when the nose lower (GRND) mode is entered in the autoland sequence.

Nose lower (GRND) sub-mode

The nose lower (GRND) sub-mode is entered automatically from FLR after touchdown is sensed. The pitch attitude is reduced to that required for nose-wheel touchdown.

Nose lower mode is inhibited if the flare mode is inhibited, and is disengaged if the TOGA switch is pressed after touchdown plus five seconds or if the AP is disengaged.

Runway align (ALN) mode

Runway align (ALN) is a lateral mode and is engaged automatically from the LOC mode. At 150 feet the AP implements a forward slip manoeuvre to align the aircraft with the runway centre line and compensate for lateral drift. CAT 3 status is required.

ALN is annunciated on the PFDs and replaces the LOC* annunciation.

The mode is disengaged by transition to the roll runway (ROLL) mode, by pressing either TOGA switch or by using the AP disconnect buttons.

Runway rollout (ROLL) mode

Runway rollout (ROLL) is a lateral mode and is engaged automatically from the ALN mode after touchdown is sensed by two out of three squat switches. The AP maintains wings level during the runway rollout by applying aileron into wind until speed is less than 60 knots (computed air speed), at which point the ailerons are centred.

It is annunciated by ROLL, which replaces the ALN annunciation on the PFDs.

The mode is disengaged by pressing either TOGA switch after touchdown plus five seconds or by using the AP disconnect buttons.

Alternative approach status

If certain aircraft system failures occur prior to starting an approach, the autoland facility will not be available and a degraded approach capability, down to CAT 2 or CAT 1 minimums, is provided. Annunciation of the engaged approach capability is shown as follows:

Approach Status	Flight Annunciators	Status/Advisory Annunciators	Steep Approach Switch	EFIS
CAT 2 Approach	CAT 2 (green)	NO AUTO LAND (amber) NO CAT 3 LAND (white)		GS (green) LOC (green) or GS* (green) LOC* (green)
CAT 1 Approach		NO AUTO LAND (amber) NO CAT 3 LAND (white)		GS (green) LOC (green) or GS* (green) LOC* (green)
CAT 1 Steep Approach		O AUTO LAND (amber)	S.APP (green)	GS (green) LOC (green) or GS* (green) LOC* (green)

Steep approaches

Steep approach (S.APP) is selected when the ILS has a glideslope of between 4.5 and 6.0 degrees. Discretes are sent to the FGS and GPWS computers, CAT 2 and CAT 3 status is inhibited, the NO AUTO LAND (amber) annunciators will be illuminated at 900 feet and the LOC only mode is inhibited. The switch illuminates white when selected and changes to green when enabled. This occurs automatically when the FGC senses that:

- The gear is down and locked.
- Landing flap (33 degrees) is selected.
- Weight is off wheels.

If at any time any of these criteria are no longer true, the switch colour reverts to white. Steep approach can only be selected or deselected prior to both LOC and GS capture, and can be cancelled by a second press of the illuminated switch. Once enabled it can only be cancelled by the selection of TOGA or by AP/FD disengagement.

Note: *It is important that S.APP is selected and enabled on ILS approaches with glideslope angles between 4.5 and 6.0 degrees.*

Vertical modes

Heading hold (ROLL) mode

Heading hold (ROLL) mode is a basic lateral mode and is annunciated by ROLL in the active lateral FMA field on the PFDs. The AP and/or FD is in heading hold if no other mode(s) is/are engaged and the AP and/or FD engaged. The reference heading is that existing at the time of mode activation plus a value to allow a smooth roll out to wings level. Bank angle limit is selectable on the bank angle limit selector on the MCP.

Lateral modes VOR LOC and LNAV can be armed while in heading hold. Heading hold is disengaged with the engagement of any other lateral mode.

Heading select (HDG SEL) mode

Heading select (HDG SEL) is a lateral mode that turns/commands the aircraft to capture and hold the heading selected on the MCP and is shown in the HEADING display. After engagement the aircraft will follow the selected heading up to 359 degrees in the direction in which the selector was turned.

Engagement is shown by an ON illumination in the HDG SEL mode button and HDG annunciation on the PFDs. The selected heading is shown as a digital read-out and as an ‘M’-shaped bug on the periphery of the compass display on the NDs.

The selected heading can be either magnetic or true, depending on the position of the HDG MAG/TRUE switch. When selected to TRUE, this is annunciated on the NDs.

Bank angle limit is selectable on the bank angle limit selector on the MCP. A selection of 30 gives a maximum bank angle of 28 degrees.

Pressing the HDG SEL button again, or changing the position of the MAG/TRUE switch, will result in reversion to basic heading hold (ROLL) mode.

Lateral modes VOR LOC and LNAV can be armed while in HDG SEL, and HDG SEL will be disengaged by the automatic engagement of the localizer, VOR or LNAV.

Lateral navigation (LNAV) mode

Lateral navigation (LNAV) mode controls/commands the aircraft to capture and track the roll commands from the selected navigation management computer.

Pushing the LNAV mode selection button arms the mode and illuminates the ON legend in the button; arming is confirmed by the annunciation of a white LNAV1 or LNAV2 annunciation in the armed lateral FMA field on the PFDs. Annunciation of LNAV1 or LNAV2 corresponds with the NAV 1 / NAV 2 autopilot engage switches or the FD master (MA) lights on the MCP.

LNAV transitions from arm to engage when the computer capture criteria of the selected LNAV course has been satisfied, at which point the colour of the annunciation changes to green and the current lateral mode disengages.

VOR localiser (VOR LOC) modes

VOR localiser (VOR LOC) are lateral modes that control/command the aircraft to capture and track either the VOR radial or localiser (shown in the COURSE display), selected by the appropriate course select knob.

Pushing the VOR LOC mode selection button arms the mode and illuminates the ON legend in the VOR LOC button; arming is confirmed by the annunciation of a white VOR1 or VOR2, LOC1 or LOC2, or BLC1 or BLC2 annunciation in the armed lateral FMA field on the PFDs. VOR/localiser deviation is displayed on the PFD and ND. TO/FROM annunciation is given on the ND when a VOR is selected.

VOR/LOC mode arming is available from all lateral modes except GS/LOC. Arming is also inhibited in take-off and go-around modes, when below 350 feet with valid radio altitudes or with flaps at 18 degrees or more if radio altitude is invalid.

It is normal to use HDG SEL mode to set up an intercept heading. The mode transitions from arm to engage when the computer capture criteria of the selected course has been satisfied, at which point the white armed annunciation is removed and the appropriate green annunciation is shown in the active lateral FMA field. The lateral mode used for capture disengages.

Armed mode is disarmed by:

- Pushing the VOR LOC mode button when illuminated (reverts to ROLL).
- Pushing the LNAV mode button (LNAV selected).
- Tuning the navigation receiver from ILS to VOR or VOR to ILS frequency (reverts to ROLL).
- Failure of the VOR/ILS navigation receiver (reverts to ROLL).
- Capture of the selected VOR/LOC/BLC radial (VOR/LOC/BLC engages).

During the capture phase the bank angle is limited to that selected on the bank angle limit selector. After capture and during the track phase the bank angle is limited to 10 degrees. Capture at intercept angles greater than 60 degrees is possible, but optimum performance is obtained at intercept angles of 30 degrees and, for LOC/BLC 170-200 knots, IAS or less.

Note 1: *Back course approach plates normally show the inbound approach course which is the reciprocal of the front course QDM. The front course QDM should be set in the MCP COURSE window.*

Note 2: *Departure plates printed for a back localiser normally show the departure course which is equivalent to the front course QDM. The front course QDM should be set in the MCP COURSE window.*

Beam guidance is inhibited during VOR over-station passage, signalled by high beam rate changes, and is replaced by track hold guidance. Track guidance will be to the track of the aircraft on entry to over-station or the selected master MCP COURSE if adjusted over-station. On exiting over-station, the FD and/or AP guidance reverts to capturing the selected course. The over-station time period is dependent on aircraft speed and altitude, and additionally above an altitude of 10,000 feet the bearing and course from the beacon have to be within 10 degrees for the aircraft to capture the intended radial. There is no change in annunciation when entering VOR over-station mode.

Steep approaches are not available in localiser-only approaches.

S.APP selection is inhibited after LOC arm.

Go-around modes

Go-around (GA) mode

Go-around (GA) is a mode which provides AP control and/or FD guidance in the case of a discontinued approach when either thrust lever TOGA switch is pressed below 2 000 feet. If FD only is engaged, the Flight Director Go-around guidance only is provided. If AP is engaged, a fully coupled Go-around is provided. Selection of GA with A/T engaged results in automatic advancement of the thrust levers and the application of GA MAX thrust rating, regardless of whether the AP and/or FDs are engaged.

TRK is annunciated on the PFDs and provides roll commands to maintain the reference track existing at the time of go-around entry. If the bank angle is greater than three degrees, the track that exists when the bank angle is reduced to less than three degrees becomes the reference track. If the bank angle is more than three degrees, the AP commands wings level until the track is established. The maximum bank angle in this mode is 10 degrees.

With AP engaged, parallel rudder is enabled to provide yaw damping and engine out compensation.

Initially the AP and/or FD is controlled to a pitch attitude before transition to speed control using the speed selected (Vsel) as the datum (not less than Vmin) .

The mode can be disengaged by selecting another vertical mode, but these are inhibited until above 350 feet radio altitude or when flaps are retracted to less than 18 degrees, if radio altitude is inoperative.

In the event of windshear detection during go-around, the AP, FD and/or AT transitions automatically to the windshear mode of operation. FD guidance for windshear recovery is displayed regardless of the position of the FD engage switches.

Miscellaneous functions

FD pitch SYNC

FD pitch SYNC is only available when the AP is not engaged and the FD is in the V/S or LVL CHG (IAS/MACH) modes. Use of the pitch sync button on either control wheel allows the pilot to re-datum the airspeed or vertical speed (selected on the MCP) for IAS/MACH and V/S modes respectively. Pressing and holding the sync button will establish the new datum. Releasing the button will cause the FD to command the new datum. The new value will be shown in the VERT SPEED or IAS/MACH window. When the sync button is pressed, the FD annunciators on the PFDs change colour from green to white.

Auto trim

Auto trim operates to relieve the loads on the elevator control tab servo when the autopilot is engaged. Failure is indicated by the illumination of an amber EL TRIM annunciator on the flight annunciator panel and will result in an automatic disconnection of the AP with the associated warnings and failure of the electric trim in manual flight.

Flap trim compensation (FTC)

Flap trim compensation (FTC) is performed during flap extension and retraction between 0 and 18 degrees, in order to compensate for associated trim changes. Failure is indicated on the flight annunciator panel by the illumination of an amber FTC annunciation. FTC is fitted to all RJ variants and inoperative on the ground.

Altitude alerting

Altitude alerting provides the flight crew with aural and visual indications of the approach to, or deviation from, a pre-selected altitude. Altitude alerting is operational on a full-time basis and is independent of FD or AP engagement, except when the AP or FD is engaged in the approach mode (glideslope capture) or landing gear is down and flaps greater than 0 degrees.

The reference altitude is set in the ALTITUDE display of the MCP by using the altitude setting knob. Alerting takes the form of a momentary tone together with illumination of the amber altitude alert light (ALT) located on the top right of each primary altimeter.

Alerting of the selected altitude is as follows:

- At 1,000 feet prior to altitude capture, the amber altitude alert light illuminates and remains on. A two-second tone is also given.
- At approximately 300 feet prior to capture, the altitude alerting light is extinguished.
- Prior to capture and within 1,000 feet and more than 300 feet, and if the deviation is increased to greater than 1,000 feet, the steady amber changes to a flashing amber and the two-second tone is given.
- After capture, if the aircraft deviates by more than 300 feet from the selected altitude a two-second tone is given and the amber altitude light starts flashing.

The flashing amber altitude alert light is extinguished either by setting a new reference altitude on the MCP or by returning the aircraft to within the altitude capture limits.

Altitude alert system failure warning is given if valid baro-corrected altitude data from both ADCs and altimeter is lost. The ALTITUDE display on the MCP shows '-----'.

An altitude failure warning is given, consisting of an aural warning that is given repetitively (two seconds on and eight seconds off) and the amber altitude alert light flashes at a rate of two flashes per second.

The warning can be cleared by turning the altitude select knob. The warning is inhibited if the radio altitude is below 350 feet or when flaps are greater than 24 degrees, if radio altitude has failed.

Built-in test (BIT)

The FGS provides extensive built-in test facilities, which are sub-divided into:

- Power up BIT, consisting of:
    - Hardware and installation tests
    - Functional tests
    - Continuous BIT
- Maintenance BIT

Power-up BIT confirms the correct functioning of the FGS when electrical power is first applied. The normal annunciation is the FGC PASS (green) message. An FGC failure message warns of a degraded system though the FGC may still function.

Continuous BIT continuously performs background confidence testing of the FGS and associated systems. Any faults found during operational BIT are logged in non-volatile memory (NVM) for later examination. Major faults will inhibit autoland operations or cause the AP to disconnect.

Maintenance BIT provides facilities for maintenance personnel to review logged faults in NVM and for the initiation of specific on-ground functional tests on the various system line replacement units. The FGS maintenance menu is displayed on the EFIS displays, on the ground only and is not intended for use by the flight crew.

Thrust control system – TRP ON

Flight deck controls

Primary engine control is through thrust lever modulation. Thrust lever modulation can be either by the pilot or by the FGC through the autothrottle with the MCP A/T armed. The FGC provides automatic throttle control via a servo motor individually clutched to each power lever. At all times the pilot can move the power levers independent of the commanded A/T servo position. Secondary engine control to limit the range of engine operation, trim and synchronise engines is achieved through the TRP controls and MCP THRUST button.

The TOGA push-button on thrust levers 2 and 3 will select the TOGA MAX rating from any other TRP-selected rating. Also, if the autothrottle is armed but not active, pressing a thrust lever TOGA button will activate the autothrottle above 350 feet radio altitude. On the ground the thrust levers must be forward of the upright position (greater than 45% N1) to activate the autothrottle.

With a WINDSHR warning (red) or caution (amber} annunciation, pressing a thrust lever TOGA button will select the windshear thrust rating (97% N1 / 649°C EGT). This is annunciated on the PFD by WS MAX, although on the TRP TOGA MAX will be annunciated. Alternatively, when windshear is detected, moving the thrust levers fully forward will select the windshear thrust rating. The buttons on the outboard faces of thrust levers 1 and 4 have three functions:

1. A momentary push will disconnect autothrottle.
2. A second push (and hold) selects TRP modes off.
3. Allows an automatic autothrottle disconnect caution to be cancelled.

A hidden clickspot is located on the MCP to trigger the TOGA buttons, which may be difficult to find in a simulator. The TOGA buttons can also be triggered using the 'AUTOTHROTTLE TO GA' control assignment.

N1 trimming and synchronisation

Each FADEC receives a commanded N1 (N1cmo) signal from the selected FGC. A comparison of N1cmo is made with the thrust lever / power lever angle N1 (N1pla) signal. The difference between N1cmo and N1pla is N1trim. Provided N1trim is within the FADECs trim authority, it is applied by the FADEC.

If the FADEC trim authority is exceeded and the actual engine N1 fails to reach N1cmo, the FGC illuminates the appropriate trim arrow on the FADEC status panel above the PEDs. A trim arrow requires pilot intervention to move the thrust lever in the direction of the arrow – blue arrow forward and white arrow aft.

FADEC trim authority is from 5% N1 at high power to 18% N1 at low power, however with the thrust lever fully forward or at idle, N1 trim is zeroed and the trim arrows will not illuminate.

The FGC outputs target N1cmo to drive the N1 bugs and N1 SET displays on the PED. In addition, the N1cmo signal is repeated on the TRP when N1 is selected. With the thrust levers set to idle, the FADEC controls the engine to an N2 floor value which caters for engine anti-icing and engine air to the PACKS at the aircraft altitude. The FGC provides discrete signals to the· FADEC to increase the N2 floor to cater for airframe anti-ice bleed.

During take-off from 80 knots until 350 feet radio altitude the N1croo signal is frozen.

Autothrottle

This is the normal level of operation and is entered by selecting the A/T switch on the MCP from OFF to ARM.

A/T OFF may be selected on the MCP or thrust levers 1 and 4 autothrottle disconnect buttons. The MCP switch is magnetically latched to ARM and requires a higher force to select OFF than to select ARM.

During take-off the autothrottle servo is 'clamped' from 80 knots to 350 feet radio altitude (or if rad alt 'inop' until flaps less than 18 degrees) and the T/O state is annunciated green. Above 350 feet radio altitude the autothrottle stays in the inactive armed state waiting for either a thrust rating command change or a flight guidance mode change. Changing modes from TO to LVL CHG will cause the autothrottle to control to the selected thrust rating. Changing modes from TO to VS, AQU or ALT will cause the autothrottle to control to the MCP selected speed.

In AQU and ALT mode the autothrottle will attempt to control to the MCP selected speed which may be set from 80 knots to Vmo/Mmo. If the MCP selected speed is set below Vmin the autothrottle will control to Vmin.

In VS or APP mode the autothrottle controls to speed. An excessive VS target may not be within the thrust capability of the autothrottle, so that exceeding Vmo or deceleration below Vmin will involve LVL CHG mode combined with the autothrottle reverting to the TRP thrust rating.

Entering LVL CHG descent will cause the autothrottle to enter RETARD, in which case the thrust levers retard at a set rate for 12 seconds. After 12 seconds the autothrottle reverts to ARM mode.

A flight guidance mode change, thrust rating change or thrust lever TOGA press below 2,000 feet radio altitude will activate the autothrottle from the armed mode. Descent below 50 feet radio altitude on landing will cause the autothrottle to change to the RETARD mode (Independent of AP engagement). Five seconds after landing the A/T reverts to armed TOGA MAX.

Selecting A/T ARM in flight with no FD/AP will give autothrottle speed control to the aircraft speed on selecting ARM, not the previously selected MCP speed.

Autothrottle thrust/mode annunciations

The three-character thrust status annunciation is displayed on the top left field of each EFIS PFD. The field can also be blank. The annunciations are as follows:

- **A/T (green) –** AT active.
- **A/T (flashing amber) –** AT disengaged (five seconds flashing manual disengaged).
- **A/T (white) –** AT armed, any thrust mode also white.
- **A/T (magenta) –** either WS MAX or A/T IAS in windshear (caution) control to ground speed.
- **Blank –** manual throttle control.
- **'----' (white) –** no computed data.
- **XXX (yellow) –** undefined status, invalid data.

Thrust or speed mode annunciation is a seven-character field and is displayed on the top left of each EFIS PFD, to the right and alongside the autothrottle status annunciation, described above. Active modes are shown in green and armed modes are shown in white. The field may also be blank. The thrust modes and annunciations are as follows:

- **WS MAX (magenta) –** the maximum thrust rating available under windshear conditions only.
- **TO MAX (green/white) –** the maximum thrust rating available for take-off. Only selectable on the ground. When FGS powered up on the ground this is the default rating. ***Note:*** *Do not select TFLEX with the TRP set to MAX.*
- **TO REDU (green/white) –** a fixed derate from TO MAX. Only selectable on the ground, it is selected by pressing the TRP TOGA push-button when the TO MAX rating is active (illuminated). With TO REDU selected, increasing the TRP temperature from the fixed derate value (Tredu) to a higher assumed temperature (Tflex) will give an N1FLEX. ***Note:*** *Only select TO REDU if aircraft performance allows.*
- **GA MAX (green/white) –** the maximum rating available for go-around. Only available in the air.
- **GA REDU (green/white) –** a fixed derate from GA MAX which is only available in the air. It is selected by pressing the TRP TOGA push-button when the GA MAX is active. Derating is achieved in the same manner as for TO REDU.
- **MCT (green) –** maximum continuous thrust.
- **CLB MAX (green) –** the maximum thrust rating available for operation outside the take-off/go-around regime with all engines operating. CLB MAX is entered by pressing the TRP CLIMB button when the CLB NRM rating is active.
- **CLB NRM (green) –** the normal thrust available for operation outside the take-off/go-around regime with all engines operating. The mode is entered by pressing the TRP CLIMB button, or MCP THRUST button after take-off.
- **MACH (green) –** MACH capture and hold.
- **IAS (green) –** IAS/increasing performance windshear A/T maintaining ground speed or Vref exceeded, throttles at idle.
- **RETARD (green) –** throttles retarding (descent or flare).
- **'----' (white) –** no computed data.
- **XXX (yellow) –** undefined status, invalid data.

A/T disconnect warnings

Thrust management system:

Disconnect	Visual warnings only	
	Flight Deck	**EFIS**
Automatic	Steady A/T amber warn on flight annunciator panels, until cancelled.	Amber flashing A/T on PFDs, until cancelled.
Manual	Steady amber warn on flight annunciator panels, for 4 seconds.	Flashing amber A/T on PFDs, for 4 seconds.

Automatic warnings should be cancelled by pushing either of the A/T disconnect buttons located on the outboard thrust levers; this will cause the A/T engage switch to drop from ARM to OFF. Disengage warnings are reset when the A/T is re-engaged.

If the autopilot disconnects below flare height the autothrottles will transitions to ARM mode, so the thrust levers will stay where they are placed.

Power supply

Primary power for the FGS comes from 115V AC and 28V DC. Power supplies go through relays controlled by the AUTOPILOT MASTER switch 1 for FGS 1 (and AUTOPILOT MASTER switch 2 for FGS 2, if fitted) and through the YAW DAMPER MASTER 1 (2) switch(es). If a dual system is fitted, active/standby power is selected by means of an additional FGC SELECT 1/2 switch.

There are two (four if dual system fitted) circuit breakers on the flight compartment FLIGHT CONTROLS circuit breaker panel and the remainder are on two under-floor circuit breaker panels in the equipment bay. The CBs (No.2 system are shown in brackets) visible to the pilots are:

- FGC1 ALTN PWR (FGC2 ALTN PWR) from 28V DC ESS/BAT, annotated SDCB.
- L AP WARN (R AP WARN) from 28V DC EMER, annotated MDC.

FGS 1 – servo power comes from 115V AC ESS (115V AC2 for FGS 2).

No.1 – clutch power autotrim from 28V DC ESS (28V DC2 for No.2).

FGS 1 – power comes from 28V DC ESS (28V DC2 for No.2).

YD 1 – power comes from 28V DC1 (28V DC2 for No.2).

A/T 1 - Power comes from 28V DC1 (28V DC2 for No.2).

Windshear detection and recovery guidance

General

Windshear detection, alerting, guidance and control are functions provided by the FGS. Alerting is provided for detection of ‘increasing and decreasing performance’ windshear at all altitudes up to 2,000 feet radio altitude (from 2,000 feet to 50 feet radio altitude on approach). Guidance is provided until safe flying conditions have been reached; these are defined as a ‘vertical speed greater than 750 feet/minute, with an airspeed greater than Vref minus five knots for more than 15 seconds’.

The hazard created by windshear is due to the deceleration of the air mass relative to the aircraft, causing a rapid reduction in airspeed and lift. This is known as a ‘decreasing performance windshear’ and is caused by a sudden increasing tailwind and/or downdraught. ‘Increasing performance windshear’ is caused by an increasing headwind and/or increasing updraught and results in an increase in airspeed and altitude. It is the less dangerous of the two, but they are often associated together, so that an increasing performance shear can be rapidly followed by a decreasing performance shear.

Detection of windshear is achieved by comparing the acceleration of the air mass (from the ADC) with the acceleration of the aircraft (from the IRS) and if the difference is sufficiently large a WINDSHR alert is annunciated. Whether the type of annunciation is amber caution or red warning depends on whether it is an ‘increasing’ or ‘decreasing’ performance shear respectively.

In conjunction with a WINDSHR (red) warning for decreasing performance windshear, an aural warning consisting of “windshear”, for three aural cycles, is given.

As part of the normal windshear escape guidance at low altitudes, the FGS provides guidance/control to fly the aircraft close to the stick shaker incidence. To prevent the inadvertent operation of the stall warning identification system when at these high incident angles, and in turbulent conditions, the FGC inhibits or delays the operation of the stall identification system (stick push) when providing windshear guidance following a ‘decreasing performance’ WINDSHR (red) alert. The operation of the stall warning system (stick shaker) is unaffected.

The annunciators remain on until safe conditions have been reached.

Component description

Flight Guidance Computer (FGC)

The Flight Guidance Computer (or the selected FGC in a dual FGS system) provides detection, alerting, guidance and control based on inputs from the IRS and from the ADC. Initially it computes a positive flight path to maintain a margin from stick shake; when performance of the aircraft is such that a negative flight path results, the FGC gives guidance reducing the margin to stick shake.

The FGC provides discrete signals to the GPWS and TCAS to inhibit warnings from these systems during a windshear alert.

The FGC provides discrete signals to inhibit stall identification operation when the AP (at any altitude) or FDs (below 350 feet RA) are engaged and the FGC is providing windshear guidance (TOWS or GAWS) following a ‘decreasing performance’ WINDSHR (red) alert. When the stall identification is inhibited, the FGC guidance provides down commands to prevent the aircraft exceeding stick shake. If the FDs are engaged above 350 feet RA, the operation of the stall identification system (stick push) is delayed by one second.

Pitch limit indications (PLI)

The PLI is shown on each PFD, when the radio altitude is at or below 2,000 feet (or, if radio altitude is invalid, when flaps are selected to 18 degrees or more). The white ‘eyebrows’ are double-stroked (intensified) when a windshear warning is given. The PLI indicates the incidence margin to ‘stick shaker’ angle of attack.

Windshear failure annunciation

In the event that windshear detection/guidance is unavailable due to the FGC detecting an internal failure or associated sensor failure, the WINDSHR INOP (white) caption will be illuminated on the Central Status Panel (CSP).

In addition, during the annunciator test the FGC performs a check to ensure that the stall identification system (stick push) can be inhibited if a windshear event should occur. If the FGC finds the stall identification system (stick push) cannot be inhibited, the WINDSHR INOP (white) caption will be illuminated and latched on.

Whenever the FGC is not providing TOWS or GAWS control/guidance (not on the ground), the FGC continually monitors the stall identification system (stick push) for the following occurrences:

a) If the stall system indicates the aircraft is in a stall condition but the stick push does not operate within five seconds, the FGC will illuminate and latch the WINDSHR INOP (white) caption. Normally the stall system will independently indicate this fault to the crew by the illumination of the IDNT 1 (amber) or IDNT 2 (amber) annunciators and MWP STALL IDNT (amber) caption).

b) If the FGC detects that the stall identification (stick push) system has become inadvertently inhibited, the FGC will illuminate the IDNT 1 (amber) or IDNT 2 (amber) annunciators and MWP STALL IDNT (amber) caption to indicate this fault to the crew.

In a dual FGC system it is possible to change over to the second FGC in an attempt to isolate the failed windshear system.

Operation

The guidance and control function provides FD and/or AP, and/or A/T commands, to assist in recovery from the windshear condition. It has three modes of operation:

1. Take-off control (annunciated by TOWS in magenta on the PFD pitch mode field).
2. Go-around control (annunciated by GAWS in magenta on the PFD pitch mode field).
3. Approach control.

During either a take-off or a go-around, detection of windshear will automatically invoke windshear guidance whether the FDs are selected or not. During an approach, after windshear is detected, windshear guidance must be selected by pressing a thrust lever TOGA button or advancing at least three thrust levers close to the full forward position.

If the A/T is engaged the WS MAX thrust rating is automatically selected and the thrust levers are advanced to achieve the relevant N1 value.

Windshear guidance/control

Windshear flight director guidance is available five seconds after take-off. AP and A/T control is subject to their engagement. Bank angles for TRK guidance are limited to five degrees for ‘decreasing performance’ windshear only. If engaged, the A/T will advance to 97% N1 no matter what the ambient conditions. Over-thrusting above N1ref in this case is acceptable.

Reversion to other modes

Normal mode reversion

Normal mode reversion to TO TRK or GA TRK occurs when safe flying conditions have been restored. If the FD was previously switched off it will bias out of view. The A/T will derate to TOGA MAX. The stall identification system (stick push) will revert to normal uninhibited operation.

The FGC determines that safe flying conditions have been achieved when a rate of climb greater than 750 FPM has been established, and the airspeed is greater than the appropriate take-off or go-around MCP VSEL speed, minus five knots for more than 15 seconds. This is indicated to the flight crew by the PFD pitch mode TOWS/GAWS (magenta) annunciation reverting to TO/GA (green), with the AP and/or FD on, or to no mode with both the AP and FD off.

Manually selected reversion

Manually selected reversion can only occur above 350 feet RA when one of the MCP ALT HLD, VS or LVL CHG push-buttons are selected, with the AP and/or FD on. The lateral mode remains TRK and the bank angle is limited to 10 degrees. If the FD was previously switched off (i.e. AP only) the FD will bias out of view. The A/T will revert to the mode appropriate for the new pitch mode and will derate the thrust rating to TOGA MAX. The stall identification system (stick push) will revert to normal uninhibited operation. If the AP and/or FD are selected off with windshear guidance displayed, FD windshear guidance will be maintained until safe flying conditions are achieved.

Note: *To ensure safe flying conditions have been achieved and that a windshear is no longer detected, pilots must wait for normal mode reversion from windshear guidance to occur.*

During 'increasing performance' windshear, selection of a new roll mode does not affect the pitch sub-mode. During 'decreasing performance' windshear (red), selection of a new roll mode prior to the selection of a new pitch mode is inhibited.

Aural warning

An aural warning is only given in conjunction with a WINDSHR (red) warning for a 'decreasing performance' windshear. This consists of the annunciation of 'windshear', for three aural cycles.

Typical operation

For all flight phase descriptions in this manual, the aircraft is manoeuvred automatically by the FGS. If the autopilot is disengaged, the aircraft may be manually flown to satisfy the flight director demands.

Take-off and climb

The FGS may be used during take-off and climb-out by setting the MCP and TRP controls as follows:

1. Prior to take-off set the speed values for V1, Vr and Vfto on the TRP:
    - Set the thrust rating required.
    - Set the heading of the departure runway into the MCP heading window.
    - Set the initial clearance altitude and V2 into the respective MCP windows.
    - Selecting FD switches to ON will display the initial take-off pitch attitude on the PFDs and activate TO TRK mode.
2. Raise the autothrottle (A/T) switch to ARM:
    - Initiate movement of the thrust levers towards the mid-section of the throttle quadrant and depress the TOGA switches on the No.2 and No.3 thrust levers. The thrust levers will automatically advance to the take-off N1.
    - At 80 knots the FGS and FADEC freeze the thrust computations.
3. At Vr the aircraft should smoothly rotate in about four seconds to the initial pitch attitude:
    - FD bars command a speed of V2 + 10. Vmin will be indicated on the PFD speed tape.
    - At 350 feet the A/T mode changes to ARM, indicating the availability of another A/T mode and/or thrust reduction.
    - At flap retraction altitude reset Vsel to Vfto + 10 and accelerate through the flap retraction schedule.
4. The autopilot may be engaged 10 seconds after take-off. In the take-off mode the parallel rudder provides yaw damping and engine-out compensation. Continued climb may be accomplished using the LVL CNG mode. On reaching the selected altitude, ACQ will be annunciated on the PFD, followed by ALT as capture is complete. The A/T then changes to IAS.

Localiser departure

Tune the localiser frequency:

1. To track a front course beam going away from the transmitter antenna (front course departure), set the course pointer to the front course QDM. After take-off when more than 350 feet AGL, press VOR LOC; this will arm BLC. When BLC is armed the glideslope mode is locked out. Ensure the BLC 1 or 2 (white) legend is shown on the PFD and the vertical deviation scale shows BKCRS. On entering the localiser beam, automatic capture will occur and BLC (1 or 2 (green)) will be displayed.
2. To track a back course beam going away from the transmitter antenna (back course departure), set the course pointer to the front course. After take-off when more than 350 feet AGL, press VOR LOC; this will arm LOC. Ensure that the LOC 1 or 2 (white) legend is shown on the PFD. On entering the back course beam, automatic capture will occur and LOC 1 and 2 (green) will be displayed.

Note: *Do not use APP to arm or capture a localiser-only procedure – this will prevent false GS captures.*

VOR capture and tracking

The VOR mode of operation features automatic capture of the radial. This is usually accomplished with the autopilot or the Flight Director engaged in the HDG mode:

1. Tune the navigation receiver to the desired VOR station. Select the desired course.
2. Select VOR mode on the MCP. The VHF NAV receiver used is determined by the NAV selector / AP engage button or the master FD.
3. At VOR capture, VOR will be displayed, first in flashing green then in steady green on the PFD. The aircraft will capture and track the radial with crosswind correction.
4. If loss of ground station occurs whilst VOR tracking, the autopilot will revert to the basic roll mode, annunciating ROLL on the PFD. On the ND the deviation bar will be removed, although the VOR annunciation will remain green.
5. Over station if course changes are to be made, select HDG mode and adjust the HEADING to intercept the desired outbound course; select the outbound COURSE and re-arm VOR mode.

ILS approach and CAT 3 automatic landing

During an ILS approach, the localiser and glideslope are automatically captured provided the APP mode is armed. The localiser is normally captured first, but can be accomplished after glideslope capture using roll mode in the same manner as the VOR radial. The glideslope can be captured from any vertical mode previously selected and from above or below the beam. Primary ILS information can be shown on both PFD and ND. To make an ILS approach and CAT 3 automatic landing, perform the following:

1. Tune the navigation receivers to the desired ILS frequency. Set the DH on the PFD, using DH control on the EFIS dimming panel.

Note: *If the aircraft track exceeds 100 degrees from the selected course, prior to capturing the localiser, the armed mode will revert automatically to BLC mode.*

2. Select a heading such that the track is within +/- 100 degrees of the inbound course and press the APP button on the MCP. Capture criteria having been met, the aircraft will fly the ILS localiser and glideslope (GS and LOC).
3. After capture of the glideslope, the appropriate missed approach altitude is selected in the MCP window. Both MA lights and NAV selectors on the MCP will illuminate. All altitude alerts and further mode selections are inhibited once glideslope mode has become engaged. When CAT 3 integrity is achieved the FGS engages the parallel rudder.

Note: *The FGC determines the integrity of the flight control system and CAT 3 status becomes active 10 seconds after the aircraft has descended below 1,500 feet. If the FGS cannot establish CAT 3 status it will attempt to achieve CAT 2 status and annunciate accordingly.*

4. If CAT 3 status has not been achieved by 600 feet, the NO AUTOLAND annunciator illuminates. After CAT 3 status has been achieved, if the FGS senses any conflict of data inputs the aircraft is incapable of making an automatic landing. Dependent on the detected conflict, the autopilot will either disconnect immediately with the simultaneous illumination of the AUTOLAND FAIL annunciator, or the AUTOLAND FAIL annunciator will illuminate with the autopilot remaining engaged. The pilot then has two seconds to select auto go-around via the thrust lever TOGA push-buttons; failure to do so will result in an automatic autopilot disconnect.
5. At 600 feet the autopilot applies a nose-up trim bias. At 150 feet the lateral mode will automatically change from localiser Track LOC to Align ALN and the PFD will annunciate accordingly.
6. At 50 feet above decision height the cyan DH legend and digital read-out will start to flash. At decision height the DH changes to yellow and an aural warning “MINIMUMS” is given.
7. At 50 feet the Flare mode is activated automatically. The autothrottle thrust mode changes to RETARD. The Flight Director bars are biased out of view and the glareshield AUTO LAND annunciator (FLARE) illuminates in green.
8. When aircraft is weight-on-wheels, the vertical mode changes to NOSE LOWER and the appropriate GRND annunciator is displayed.

Note: *Weight-on-wheels is determined when any two out of three landing gear struts are compressed.*

Go-around

Go-around can be selected at or below 2,000 feet Rad Alt (RA) by pressing either of the TOGA push-buttons located on the front face of number 2 and 3 thrust levers.

On engaging TOGA the vertical mode display on the PFDs change to GA and lateral mode engages TRACK.

On the TRP CLIMB thrust is replaced by TOGA MAX and its associated thrust annunciator illuminates.

When safely climbing, the thrust may be reduced to CLB NRM and the Vsel selected to Vfto.

The aircraft climbs until the ALT capture point is reached. The PFD will display the appropriate ACQ legend until ALTITUDE HOLD criteria are met. The A/T then reverts to IAS.

Back course approach

Tune the localiser frequency and set the course pointer to the front course QDM of the localiser. Back localiser (BLC) mode is armed when the VOR/LOC button is pressed with the aircraft track greater than +/- 100 degrees of the selected front course.

Note: *If the aircraft track subsequently transitions to within 100 degrees of the selected course prior to capturing the localiser, the armed mode will revert automatically to LOC.*

Ensure the BLC1 or BLC2 (white) legend is shown on the PFDs and that the vertical deviation scale shows BKCRS.

When the aircraft approaches the back localiser, automatic capture will occur. At capture the BLC (white) legend will change to BLC (green).

After localiser tracking has begun, the descent phase of the approach should be initiated, normally using V/S mode. The appropriate missed approach altitude should be selected in the MCP ALTITUDE window.

VS mode should be selected to give the appropriate descent rate, the A/T may be used to control speed.

Note 1: *Use of the localiser display on the standby attitude indicator is not permitted for back course guidance because the azimuth display will be in the reverse sense.*

Note 2: *A back course must be flown coupled to the FD and/or AP, otherwise uncoupled raw azimuth data on the PFD can contradict the ND.*

Note 3: *The altitude selector must be moved away from the initial procedure altitude in order to select VS mode.*

VOR approach

1. To fly a typical VOR, track to the station in VOR mode with the NAV receiver tuned to a VOR frequency. When passing overhead the beacon, set the course to the published outbound track. After station passage, arm the VOR mode and the system will capture and track the selected course.
2. Deselect VOR and set the course pointer to the inboard track. Select HDG and turn to intercept. Whilst in the turn arm the VOR mode and the aircraft will automatically capture the inbound track.
3. Use VS mode to provide vertical guidance throughout the approach. The A/T may be used to control speed.

Note: *The altitude selector must be moved away from the initial procedure altitude in order to select VS mode.*

Holding

To establish a holding pattern over a VOR/DME beacon, perform the following:

1. Select HDG mode on the MCP. Tune the required VOR frequency and set the desired course. Maintain course to the holding facility by adjusting the heading bug.
2. When the aircraft reaches the holding facility, turn the heading bug in the direction of the outbound turn, making due allowance for drift.
3. After the required time, move the heading bug in the direction of the inboard turn, again making due allowance for drift.
4. If automatic capture and tracking of the inbound radial is required, select VOR/LOC mode after the inboard turn has been initiated. Ensure that the VOR display on the PFDs shows white and changes to green on capture. Crosswind/drift corrections are automatically computed.

Note: *Use the EFIS ND track symbol to give correct inbound track. Display wind vector in ND data field.*

FUEL SYSTEM

Fuel is carried in three integral tanks, one in each wing and one in the centre section. The centre tank transfers to wing tanks which feed the engines. Two optional auxiliary tanks can be fitted on the top of the fuselage behind the centre tank; these are also called pannier tanks. The auxiliary tanks can be enabled/disabled via the EFB tablet.

There are four electric fuel pumps, two in each wing. These are designated as left outer, left inner, right inner and right outer fuel pumps and are situated in the corresponding feed tank. The mechanically driven fuel pumps supply fuel under pressure to their corresponding engine. The electric fuel pumps also supply fuel to energise jet pumps which are used to maintain a supply of fuel to the inner and outer feed tanks. The fuel supply for each engine is normally separated but common feed and cross-feed facilities are provided which enable any engine to be fed by any electric pump.

In the event of power failure, hydraulically operated standby fuel pumps also provide fuel to energise the jet pumps in order to maintain the supply of fuel to the inner and outer feed tanks.

Gravity feed from wing tanks will ensure normal engine operation up to at least 20,000 ft. Centre tank fuel requires at least one electric fuel pump in order to transfer to wing tanks.

High-pressure fuel valves are controlled via the thrust lever FUEL ON and FUEL OFF positions. The low-pressure fuel valves can be closed by operation of the corresponding engine fire handle.

Each wing incorporates an integral non-spill surge tank through which the tanks vent to atmosphere.

The fuel tanks may be refuelled by pressure from the refuel panel situated in the underside of the right wing leading edge or by using the three over-wing gravity fuelling points.

There are five water drains under each wing, with one being for the centre tank and one for the surge tank.

Control of the fuel system is provided by switches on the overhead FUEL panel. System status indication is provided by captions on the Master Warning Panel (MWP) and Central Status Panel (CSP). Contents indicators on the pilot's centre panel show wing and centre tank contents. The contents indicators are repeated on the external refuel panel.

A fuel temperature sensor is installed in the right wing and a fuel temperature gauge is provided on the overhead fuel panel.

Fuel tanks

Each wing is divided into three compartments:

1. Main wing compartment
2. Feed tanks
3. Surge tank

The feed tanks are further subdivided by internal baffles formed by the ribs. The contents of each of the four feed tanks is approximately 75 imperial gallons (272 kg). The purpose of the feed tank is to ensure that a constant head of fuel is available to each of the four electrical fuel pumps.

An AC fuel pump is situated within each feed tank and within a further sub-division known as a pump compartment. In normal operation each pump feeds the associated engine from the fuel in its own pump compartment.

The inner and outer feed tanks are separated by a high-level weir, which allows fuel to overflow from the inner to the adjacent outer feed tank. With low fuel levels in the feed tanks, overflow cannot take place and each feed tank will maintain a separate fuel supply for each fuel pump.

Non-return flap valves allow fuel to flow under gravity from the main fuel compartments into the feed tanks.

Surge tanks, with an associated non-icing NACA intake duct, form the outer portion of the wing and are used for venting and overflow conditions. The centre tank vents separately to the left wing surge tank. The wing centre section forms the centre tank.

If auxiliary tanks are fitted, the left auxiliary tank fuel is transferred to the left wing main compartment and the right auxiliary tank fuel is transferred to the right wing main compartment.

Fuel quantity indication

A capacitance system measures the quantity of the fuel in the centre and wing tanks.

The contents of each wing and centre tank are displayed on the pilot's centre panel. The fuel in the feed tanks (approximately 600 lb / 272 kg in each) is included in the wing tank contents. The contents of each feed tank are displayed on the overhead fuel panel.

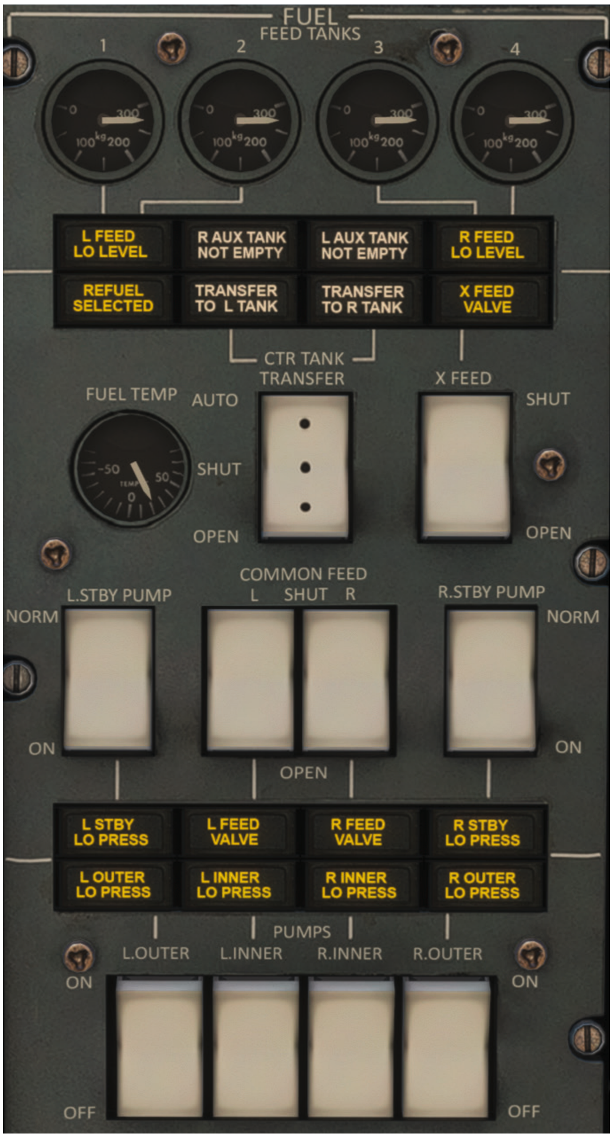
If auxiliary tanks are fitted, the left wing tank quantity indicator includes the left auxiliary tank contents and the right wing tank quantity indicator includes the quantity in the right auxiliary tank.

Low fuel levels in the feed tanks are indicated by amber annunciators on the fuel panel. These illuminate (L or R FEED LO LEVEL) when the fuel level is less than full in any feed tank of either wing. They would be illuminated in low fuel or asymmetric fuel conditions.

Amber warnings on the fuel panel will initiate the FUEL warning on the Master Warning Panel.

A push-button on the pilot's centre panel allows the fuel contents to be read using battery power.

Controls and indicators



All amber warnings on the overhead fuel panel activate the amber FUEL annunciator on the MWP and are accompanied by the single-chime audio warning. The letters A and W indicate the colour (amber or white) of an annunciator.

Four white ENG FIRE HANDLE annunciators on the MWP indicate that a fire handle has been pulled and the fuel low-pressure valve will have been closed by this action.

A white FUEL FEED OPEN annunciator on the MWP indicates when a feed valve is open (i.e. cross-feed or common feed valve).

A white FUEL TRANSFER annunciator on the MWP indicates when centre tank transfer is in progress.

If auxiliary tanks are fitted, two 'auxiliary tank not empty' annunciators are fitted: L AUX TANK NOT EMPTY and R AUX TANK NOT EMPTY. These annunciators indicate that the associated auxiliary tank still contains some fuel.

A fuel temperature indicator on the fuel panel shows the temperature of fuel in the right wing tank.

Associated fuel circuit breakers are situated on the flight deck overhead circuit breaker panel.

Loss of power to DC 1 or DC 2 bus will cause the associated standby hydraulic fuel pump to run, provided that the STBY PUMP switch is selected to the NORM position and that there is pressure in the Yellow hydraulic system.

The inner fuel pumps (or in the case of electrical power failure, the standby pumps) energise four jet pumps in the inner feed tanks, which transfer fuel from the main wing compartments into the inner pump compartments. The inner feed tanks overflow the high-level weir into their outer feed tanks. The inner fuel pumps also energise the jet pumps used for the transfer of the centre and auxiliary tanks. However, these transfer-jet-pumps cannot be energised by the hydraulic standby pumps.

Centre tank transfer valve (DC) & TRANSFER TO L/R TANK (W)

- AUTO – inhibited on the ground. Fuel transfers from the centre to both wing tanks automatically.
- SHUT – used if no fuel is in the centre tank or on completion of transfer. Both valves shut.
- OPEN – used on completion of AUTO transfer to remove the last of the fuel. Both valves selected open. Not inhibited on the ground.

White annunciators show 'TRANSFER TO L/R TANK' with the valves open. A white annunciator on the MWP warns of 'FUEL TRANSFER'.

2 x standby pumps (hydraulic) & L/R STBY LO PRESS (A)

- NORM – pump is dormant. It will operate with the loss of DC 1 (left pump) or DC 2 (right pump). Equivalent to AC power failure. Powered from the Yellow hydraulic system.
- ON – used if pump fails in NORM or with mechanical failure of an inner electrical pump.

'STBY LO PRESS' (A) indicates failure of output of standby pump.

Cross-feed valve (DC) & 'X FEED VALVE' (A)

With valve open, 'FUEL FEED OPEN' (W) shows on MWP. The amber 'X FEED VALVE' (NIPS) remains illuminated when valve fails.

2 x common feed valves (DC) & 'L/R FEED VALVE' (A)

Allows pump to feed both wing engines when open. With any valve open, MWP shows white FUEL FEED OPEN annunciator. Amber 'L/R FEED VALVE' (NIPS) indicates valve failure.

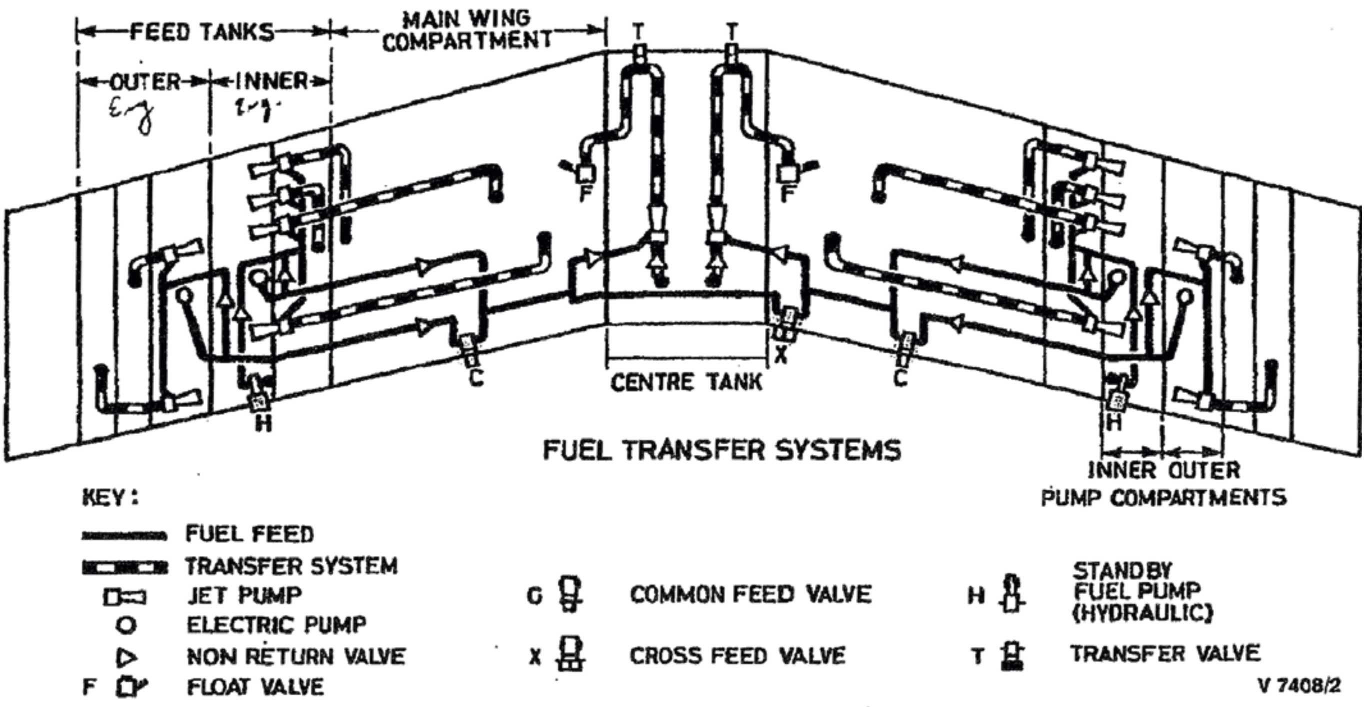
4 x AC fuel pumps & 'LO PRESS' (A)

Power supply from left to right: AC 1, AC 2, AC 1, AC 2.

Amber 'LO PRESS' indicates failure of output of pump. Overheat of a pump will cause shutdown.

Note: *Amber annunciators will illuminate while valves are moving.*

Fuel transfer system



Centre tank transfer is controlled by a single three-position switch on the overhead fuel panel, which operates two transfer valves (T). The float valve (F) controls transfer rate to match engine fuel demand and maintain the wing tank almost full. Back-up is provided by the wing high-level float switch which operates the transfer valve. Centre tank jet pumps, normally energised by fuel from the inner fuel pumps, effect the transfer. A minimum of one electrical pump is required for centre tank transfer.

If auxiliary tanks are fitted, the auxiliary fuel is transferred to the wing main compartments: the left auxiliary fuel to the left wing and the right auxiliary fuel to the right wing. Auxiliary fuel transfer is achieved by gravity and jet pumps. The motive flow for the jet pumps comes from the feed tank pumps.

Further jet pumps are energised by the fuel pumps and operate automatically to move the fuel outwards from the main wing compartments. Other jet pumps transfer fuel outwards within the inner feed tanks to the inner pump compartments and inwards within the outer feed tanks to the outer pump compartments.

The feed tanks are normally kept full by the transfer system, which has the effect of reducing the amounts of unusable fuel in other parts of the wing.

Two switches on the fuel panel control the hydraulically operated standby pumps. These pumps are powered from the Yellow hydraulic system and provide back-up to transfer fuel from the main wing fuel compartments to the inner feed tanks; they do not feed fuel to the engines.

The high-level weir allows fuel to overflow from the inner to the outer feed tank, but the two outer jet pumps are not activated by the standby fuel pump. Non-return flap valves assist in reducing the amounts of unusable fuel in the outer compartments of the feed tanks.

Loss of power to DC 1 or DC 2 bus will cause the associated standby hydraulic fuel pump to run, provided that the STBY PUMP switch is selected to the NORM position and that there is pressure in the Yellow hydraulic system.

The inner fuel pumps (or in the case of electrical power failure, the standby pumps) energise four jet pumps in the inner feed tanks, which transfer fuel from the main wing compartments into the inner pump compartments. The inner feed tanks overflow the high-level weir into the outer feed tanks. The inner fuel pumps also energise the jet pumps used for the transfer of the centre tank. However, these transfer-jet pumps cannot be energised by the hydraulic standby pumps.

Useable fuel capacities

Without auxiliary tanks fitted:

Tank	Imp Gals	US Gals	Litres	lb	kg
Left wing	1,015	1,219	4,614	8,120	3,683
Centre	550	661	2,500	4,400	1,996
Right wing	1,015	1,219	4,614	8,120	3,683
Total	**2,580**	**3,099**	**11,728**	**20,640**	**9,362**

With auxiliary tanks fitted:

Tank	Imp Gals	US Gals	Litres	lb	kg
Left wing	1,015	1,219	4,614	8,120	3,683
Left aux	129	155	587	1,032	468
Centre	550	661	2,500	4,400	1,996
Right wing	1,015	1,219	4,614	8,120	3,683
Right aux	129	155	587	1,032	468
Total	**2,838**	**3,409**	**12,902**	**22704**	**10,298**

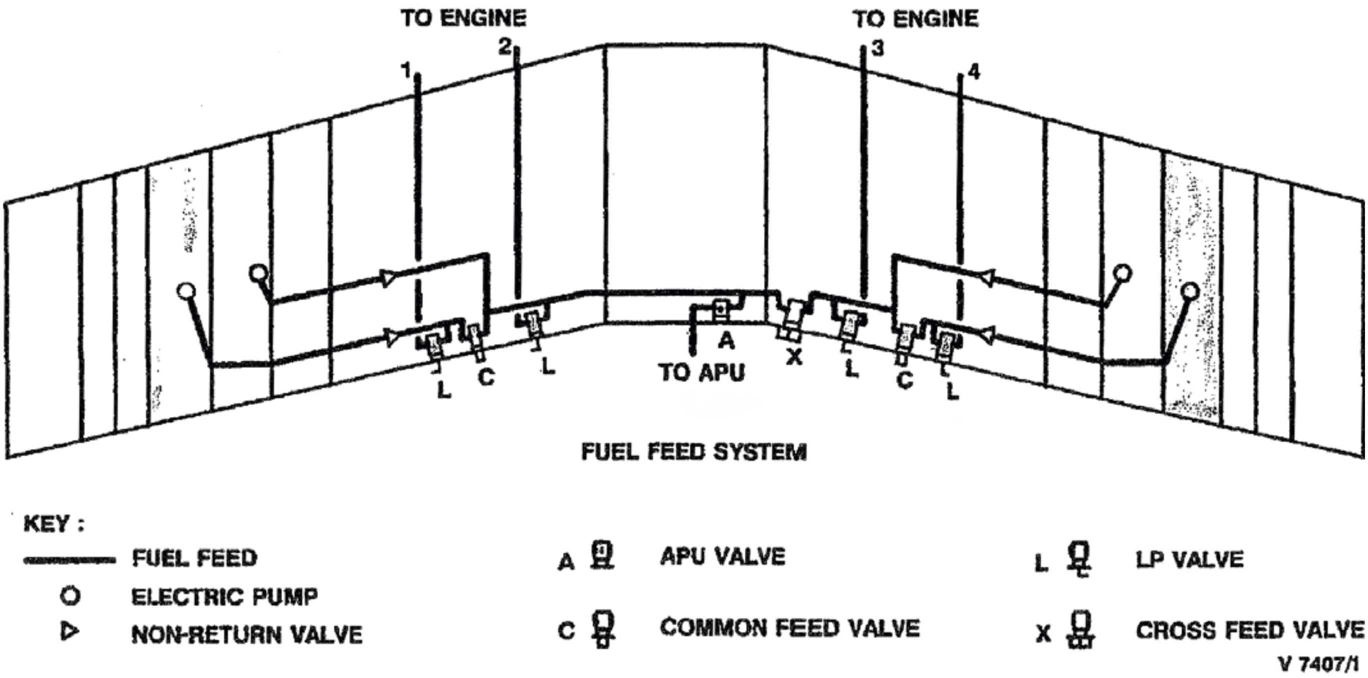
Note: *A specific gravity of 0.8 is assumed in conversions between volume and mass. These quantities represent usable fuel.*

Conversion factors used:

- kg to Imp gal – divide by 3.6286
- kg to litre – multiply by 1.2528
- lb to kg – multiply by 0.4536
- Imp gal to US gal – multiply by 1.2009
- Imp gal to litre – multiply by 4.5460

Contents indicators and flow meters are calibrated in kilograms.

Fuel feed system



The overhead fuel panel provides control of the following items:

- Four AC fuel pumps (0)
- Two common feed valves (C)
- One cross-feed valve (X)

There are four low-pressure fuel valves (L), one for each engine. These are normally open but can be closed by pulling the associated engine fire handle.

Arrows on the NRVs show the direction of fuel flow from the electric fuel pumps to the engines. With both common feed valves (C) and the cross-feed valve (X) closed, each engine is fed independently from its associated pump. Opening a common feed valve permits one pump to feed both engines in a wing and opening the cross-feed valve permits fuel from one wing to be fed to the engines of the opposite wing.

The APU valve (A) is controlled from the START/STOP switch on the APU overhead panel and the fuel supply is taken from the cross-feed pipe in the centre tank. The left inner electric pump is the normal source of fuel pressure, but the APU will run and start under suction feed.

HYDRAULIC POWER SYSTEM

Hydraulic power is provided by two independent systems, Yellow and Green, each having an engine-driven pump (EDP) as its main source of power as well as a standby power facility.

Yellow system EDP is driven by engine No.2 and Green system EDP is driven by engine No.3.

The standby power facilities are:

- Yellow system – AC-powered pump (AC PUMP)
- Green system – power transfer unit (PTU)

Emergency 'back-up' facility:

- Yellow system only – DC-powered pump (DC PUMP)

The hydraulic power system controls and indicators are powered electrically.

The engine-driven pumps and the AC and DC electrically driven pumps are each of the variable displacement type – capable of varying their output to meet the demand.

The major power generation components (except the engine-driven pumps) are housed in a vented and pressurised hydraulic equipment bay, situated immediately forward of the main landing gear bay.

The systems operate at a nominal pressure of 3,100 PSI and use a synthetic fire-resistant fluid (fluid IV phosphate ester).

Each system has a hydraulic tank, pressurised by regulated air bled from the engine driving its respective engine-driven pump.

The engine-driven pumps each have an associated isolation valve and each system incorporates a relief valve. Pressure and return line filters each incorporate a 'partial clogging' indicator.

The DC PUMP has its own pressure filter, which includes a 'partial clogging' indicator.

If the fire handle of engine No.2 or 3 is pulled to its fullest extent, its respective engine-driven pump isolation valve will close automatically, thus isolating the hydraulic fluid supply to the engine pump.

Hydraulic power operates the following services:

SERVICE	HYDRAULIC SYSTEM		
	YELLOW	GREEN	EMERG
Electrical power			
Standby AC/DC generator	–	YES	–
Flight controls			
Flaps	YES	YES	–
Flap asymmetry brakes	YES	–	–
Roll spoilers	YES	–	–
Lift spoilers (2 Yellow, 4 Green)	YES	YES	–
Rudder servo controls (1 Yellow, 1 Green)	YES	YES	–
Airbrakes	–	YES	–
Fuel			
'Standby' fuel pumps (left and right)	YES	–	–
Landing gear			
Landing gear (normal operation)	–	YES	–
Nose gear steering	–	YES	–
Landing gear (emergency lock down)	YES	–	YES
Wheelbrakes (excluding parking)	YES	YES	YES
Wheelbrakes (parking)	YES	–	YES
Doors and stairs			
Airstairs	YES	–	–

Details of each hydraulically operated service are provided in the respective aircraft system section of this manual.

Main system operation

A two-position switch controls the respective system EDP isolation valve. When in the OFF position, the isolation valve provides an idling circuit to offload pump during engine start-up and pump failure positions and ensure lubrication during engine running.

The respective system relief valve will open to allow excess pressure back to the tank at 3,500 PSI.

Yellow system standby

A three-position ON/OFF/AUTO switch controls the standby AC PUMP, which is continuously rated and capable of maintaining the system pressure at 3,100 PSI in the following ways:

- AUTO – pump armed for automatic operation
- OFF – central position
- ON – manual selection of pump operation

When the AC PUMP switch is selected to AUTO, a pressure switch in the Yellow and the Green delivery line will, in the event of either EDP delivery pressure falling below 1,500 + 250 PSI, switch and latch the pump ON. This prevents the pump being switched ON and OFF continuously due to fluctuating hydraulic fluid pressure on operation of a service or windmilling engine.

Warning! *With AUTO selected, there is no indication that the AC PUMP is operating, therefore a failed EDP could be undetected.*

The pump has an integral overheat switch giving the following protection:

- On the ground – activates an AC PUMP HI TEMP annunciator, switches OFF the pump and latches it off until reset by the AC PUMP switch.
- In flight – activates the AC PUMP HI TEMP annunciator. The pump will continue to run until selected OFF or until it fails.

Yellow system emergency back-up

The Yellow emergency 'back-up' system allows emergency locking down of the main landing gear and operation of the Yellow wheelbrakes, if both the Yellow and the Green systems have failed, by selecting ON the DC PUMP. The system has an accumulator, isolated by non-return valves (NRVs) from all services except the Yellow wheelbrakes, pressurised by the No.2 EDP, the AC PUMP or the DC PUMP, which is continuously rated.

A three-position ON/OFF/BATT switch controls the DC PUMP in the following way:

- ON – held to operate pump.
- OFF – central position spring-loaded.
- BATT – guard button is moved to the left; switch can then be pressed down and latched.

The DC PUMP is also automatically selected ON when the brake selector handle is set to PUSH EMERG YEL.

A reserve reservoir in the Yellow tank provides a fluid supply to the DC PUMP and the return line from the emergency system feeds directly into this reservoir.

Green system standby

The power transfer unit (PTU) allows the Yellow system to power all the Green system services, except the STBY GEN, when the Green system EDP is inoperative or the system pressure falls below that of the PTU output (approximately 2,600 PSI).

An accumulator in the system maintains stability of operation when the PTU is functioning, and for the start-up of the standby generator. When the PTU is operating, selecting the Yellow system AC PUMP to ON to supplement the Yellow system EDP ensures adequate capacity to drive the PTU and also the normal Yellow system services.

Standby generator

When the standby AC/DC generator (STBY GEN) is operating, its selector valve is open and the Green system shut-off valve is closed, thereby rendering the remaining Green system services inoperative. Details of the STBY GEN are given in the ELECTRICAL SYSTEM section.

When the standby generator is functioning, the Green system LO PRESS annunciator will be illuminated but the system pressure indicator will register the Green system operating pressure.

Controls and indicators

The hydraulic system controls and annunciators are located on the HYDRAULIC section of the overhead instrument panel. An associated amber HYD caption, on the Master Warning System (MWS) panel, is lit to draw attention to any fault warnings on the system panel, together with a single-chime audio warning.

The annunciators associated with ENG 2 VALVE, ENG 3 VALVE and PTU VALVE indicate if the valve is not in the position selected and will also be lit during normal valve transit.

The AC PUMP FAIL annunciator is lit if the pump:

- Fails to operate when selected ON
- Continues to operate when selected OFF

The LO QTY annunciator is lit when the system fluid (in flight) is at or below the minimum operating level.

The hydraulic system quantity indicators are fitted to the overhead instrument panel. With the hydraulic system depressurised, induction below the amber mark on the quantity indicator shows the tank must be filled to the correct level.

The HI TEMP annunciator is lit when the system fluid temperature, sensed at the tank outlet, reaches 95°C; it will go out when the temperature falls to 80°C.

The LO PRESS annunciator is lit when the system pressure falls below 1,500 PSI; it will go out when the system pressure rises above 1,750 PSI, as will be evident from the system pressure gauge.

The AIR LO PRESS annunciator is lit when the tank air pressure is low, requiring an engine speed in excess of flight idle for the annunciator to go out.

ICE AND RAIN PROTECTION SYSTEM

The aircraft is certificated for flight in severe icing conditions.

Ice protection is provided for the wings, the horizontal stabiliser, engine air intakes, each engine intake bullet, windscreens, pitot heads, front static vent plates, airflow direction sensor vanes and toilet drain masts.

The airframe system is inhibited via a squat switch when the aircraft is on the ground. Automatic shutdown of the system, or part of the system, is initiated in the air by the overheat fault detection system.

Visual and aural warnings are initiated in the event of a fault condition arising.

The ice detection system provides automatic warning for the flight crew when the aircraft is in flight at the beginning of, and throughout, an icing encounter.

Wing and horizontal stabiliser

Selection of Outer Wing Anti-Ice supplies hot air for anti-ice protection of the respective outer wings, and also maintains an anti-icing parting strip along the inner wing. Bleed air from the inner wing de-ice is used for de-icing the inner wings, a function which is used for shedding accreted ice prior to landing.

Under normal circumstances, if icing is encountered above 25,000 feet in flight, only the outer wing is maintained ice-free and ice is permitted to. accrete on the inner wing leading edge. Inner wing de-ice is used after an icing conditions encounter for one minute and whilst in the hold. When the approach configuration is selected, de-icing must be initiated to shed this ice build-up, and if this action has not been carried out a WING NOT DE-ICED (amber) warning illuminates to remind the crew. This warning is triggered by the flap selection lever when 18-degree flap is selected.

De-icing is achieved by jets of hot air from two piccolo tubes routed along the upper and lower surfaces in the inner wing leading edge. This melts the adhesion layer, allowing the build-up of ice to be shed, with the parting strip ensuring the ice leaves the wing cleanly.

There is no interconnection between left and right wing ducts, but in the event of a single engine failure, the remaining engine on that side can supply both the anti-icing and de-icing hot air. The anti-icing and de-icing air is finally vented to atmosphere via vents in the wing lower skin.

Hot air for the tail anti-icing is tapped from the two bleed air distribution ducts after passing through the spine. A selector valve is fitted in both supplies which enables bleed air from either the left-hand or right-hand engines to be used for tail ice protection. Immediately downstream of the valves, the supplies merge and a single duct runs up the vertical stabiliser, forward of the front spar up to the horizontal stabiliser where it branches left and right into two piccolo tubes. On leaving the tubes the air is ducted back to the centre of the horizontal stabiliser and leaves via vents on either side of the vertical stabiliser.

The hot air for wing ice protection is tapped from the engine bleed downstream of the engine isolation/pressure-reducing valve. In the event of a duct failure, overheat sensors are located in the adjacent structure in the pylon, wing leading edge, spine and vertical stabiliser. An overheat detection loop is also fitted along the rear spar of each wing. If the temperature in these areas rises above a safe figure, both wing bleed isolation valves on the associated side of the aircraft are automatically closed.

The system is controlled via three switches situated on the ICE PROTECTION sub-panel of the flight deck overhead panel; these are labelled OUTER WING ANT ICE, INNER WING DE-ICE, and TAIL ANT ICE, ON/OFF respectively. Amber fault annunciators are located immediately above each individual switch. Associated MWS warnings are provided.

Nacelles and engines

To prevent the formation of ice on the engine air intakes, hot air is tapped from the engine high-pressure compressor to a piccolo tube diffuser ring within the air intake cowling. Engine compressor bleed air is also routed internally to anti-ice the hollow splitter and compressor inlet vanes.

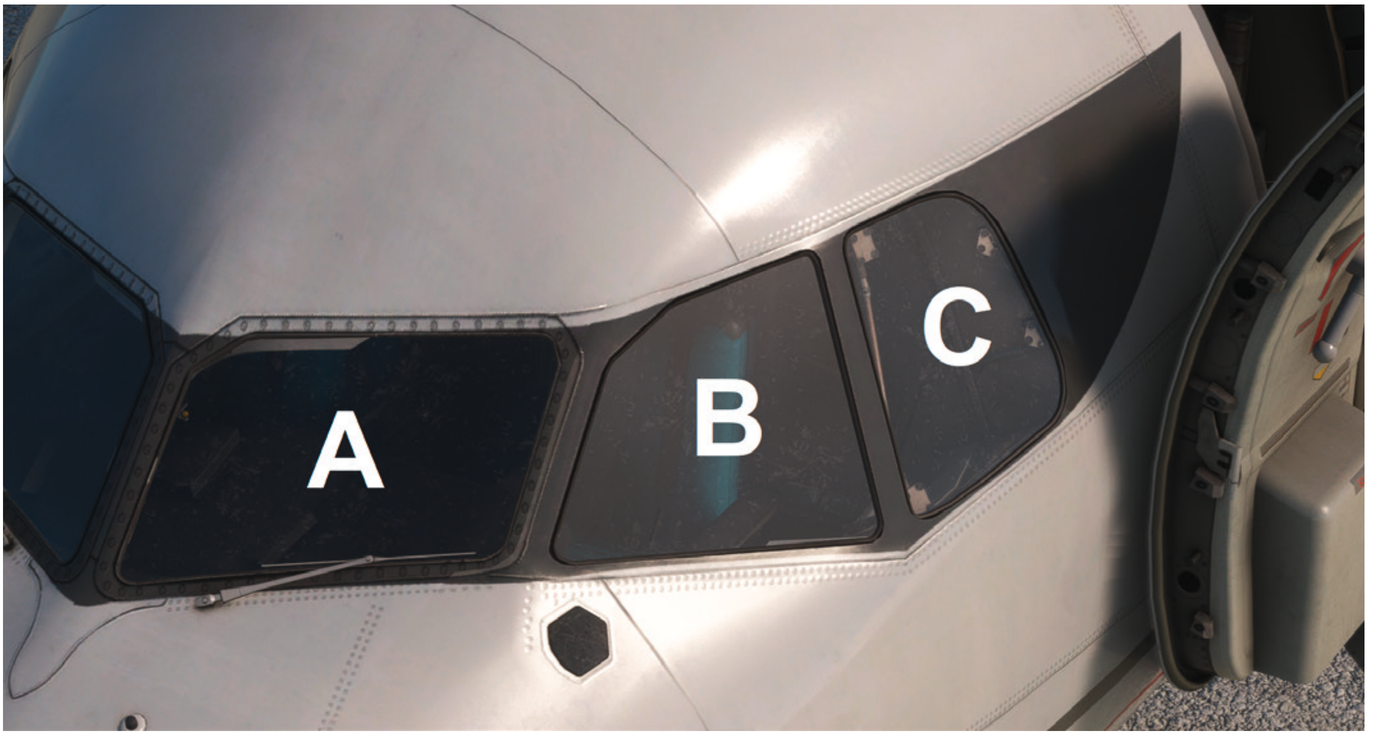
Annunciators give indication of high and low pressure in the air intake diffuser ring.

Flow is controlled by a solenoid-operated valve. When engine anti-icing is selected ON, the valve is simply de-energised to permit the passage of anti-icing air. In the case of electrical power failure, the valve will automatically open, or remain open if it has previously been selected, and provide a continuous flow of anti-icing air until electrical power has been restored to the solenoid.

The air intake anti-ice system and the engine anti-ice system are interconnected where selection is concerned. Selection is via the four ENG ANT ICE switches on the ENGINES – ICE PROTECTION panel on the flight deck overhead panel.

In addition, the engine rotating fan spinner is anti-iced by recirculated engine oil; no control or indications are incorporated.

Windscreens



The flight deck has six windscreen panels, known as panels A, B and C respectively, and lettered from the aircraft centre line outwards. The A and B panels are resistant to bird impact and incorporate an electrically heated coating which prevents exterior ice formation and interior misting. The C panels are demisted by air conditioning air but are not heated.

When three-phase power is applied across A and B panels, the panels are heated. The A panels are heated at reduced power while the aircraft is on the ground, automatically switching to full power when in flight. B panels are heated at full power under all normal conditions. Under abnormal conditions, with power supplied from the standby generator, the left-hand B panel is not heated, the left-hand A panel is heated at one-third power and the right-hand panels are not heated.

The temperature of the heated panel is monitored by three sensors connected to a thermal controller. An overheat condition triggers the SCREEN HI TEMP annunciator to activate the MWS and to operate the controller fault magnetic indicator. When the panel temperature drops below the specified value, the overheat channel cuts in to restore heating supplies and to cancel the fault warnings. The fault magnetic indicator will remain in the operated condition until reset by operation of the TEST push-button.

Windscreen heating is normally switched on immediately before engine start and should remain on throughout the flight. Failure to select windscreen heat ON will cause the MWS white SCRN HEAT SEL OFF annunciator to illuminate. Windscreen heat is controlled via two switches on the ICE PROTECTION sub-panel of the flight overhead panel labelled L/R SCREEN HEAT ON/OFF.

Pitot, ‘Q’ pot and static vent plate heat

The electrical supply to the left-hand pitot head heater is controlled by a switch annotated L PITOT HTRS, ON, OFF. The switch connects the AC essential busbar to the pitot head heater. The supply from the 115V AC essential busbar is reduced by a transformer to 28V.

The electrical supply to the right-hand pitot head and right airflow sensor vane heaters is controlled by a double-pole switch annotated R & R VANE. In the ON position, one pole supplies the right airflow sensor vane from the AC essential busbar and the other supplies the right pitot heater from the AC 2 busbar.

The electrical supply to the auxiliary pitot head and left airflow sensor vane heaters is controlled by a double-pole switch annotated AUX & L VANE.

In the ON position, one pole supplies the left airflow sensor vane heater and the other supplies the auxiliary pitot head heater. Both supplies are taken from the AC essential busbar.

The three-phase electrical supply to the ‘Q’ pot pitot head heaters is controlled by the ‘Q’ pot control relay. The relay is energised from the AC essential busbar, with the supply being routed via a load-shed relay in the de-energised position and a squat relay in the flight position. With the control relay energised, phases A, B and C of the AC essential busbar are connected to the three elements within the ‘Q’ pot pitot head at the mast, nose and tail respectively.

Annunciators on the flight deck overhead ICE PROTECTION panel denote Q FEEL HTR FAIL, L PITOT HTR FAIL, R PITOT HTR FAIL, AUX PITOT HTR FAIL, L VANE HTR FAIL and R VANE HTR FAIL.

The four HTR FAIL amber annunciators illuminate if electrical power fails.

Windscreen wipers

Windscreen wipers, fitted to each panel ‘A’, are controlled by two switches on the flight deck overhead panel. They are labelled SCREEN WIPERS Land R, FAST/SLOW/OFF.

Windscreen wash system

A windscreen wash system provides each pilot with the capability to clean the external surface of the forward-facing windscreens.

Individual push-buttons, labelled L and R SCREEN WASH, are situated on the flight deck overhead panel. The fluid is stored in a reservoir located with the self-priming pump and control valves in the electrical equipment bay. The pump and valves are electrically operated and fluid can be directed to either screen or to both screens simultaneously.

The system caters for both ground static and all flight phases.

Rain repellent system

The system is used to clear heavy rain from the external surface of both pilots' forward-facing windscreens while in flight or on the ground. During heavy rain the system is used with the windscreen wipers. At high airspeeds the system is used on its own.

Repellent fluid is contained in a disposable nitrogen-pressurised reservoir. Fluid is piped to two twin-ported spray nozzles mounted one in front of each forward-facing windscreen. Each has an associated solenoid-operated valve. Each valve is operated by its own time delay and controlled by two L and R RAIN REPellent push-buttons on the flight deck overhead panel.

Ice detection

An electro-mechanical rotary ice detector initiates a Master Warning Panel visual amber ICE DETECT annunciator warning on the flight deck. This signal is maintained until 60 seconds after the icing encounter has passed.

A guarded ICE DETECT ON/OFF switch on the flight deck overhead panel is switched on before the start of each flight.

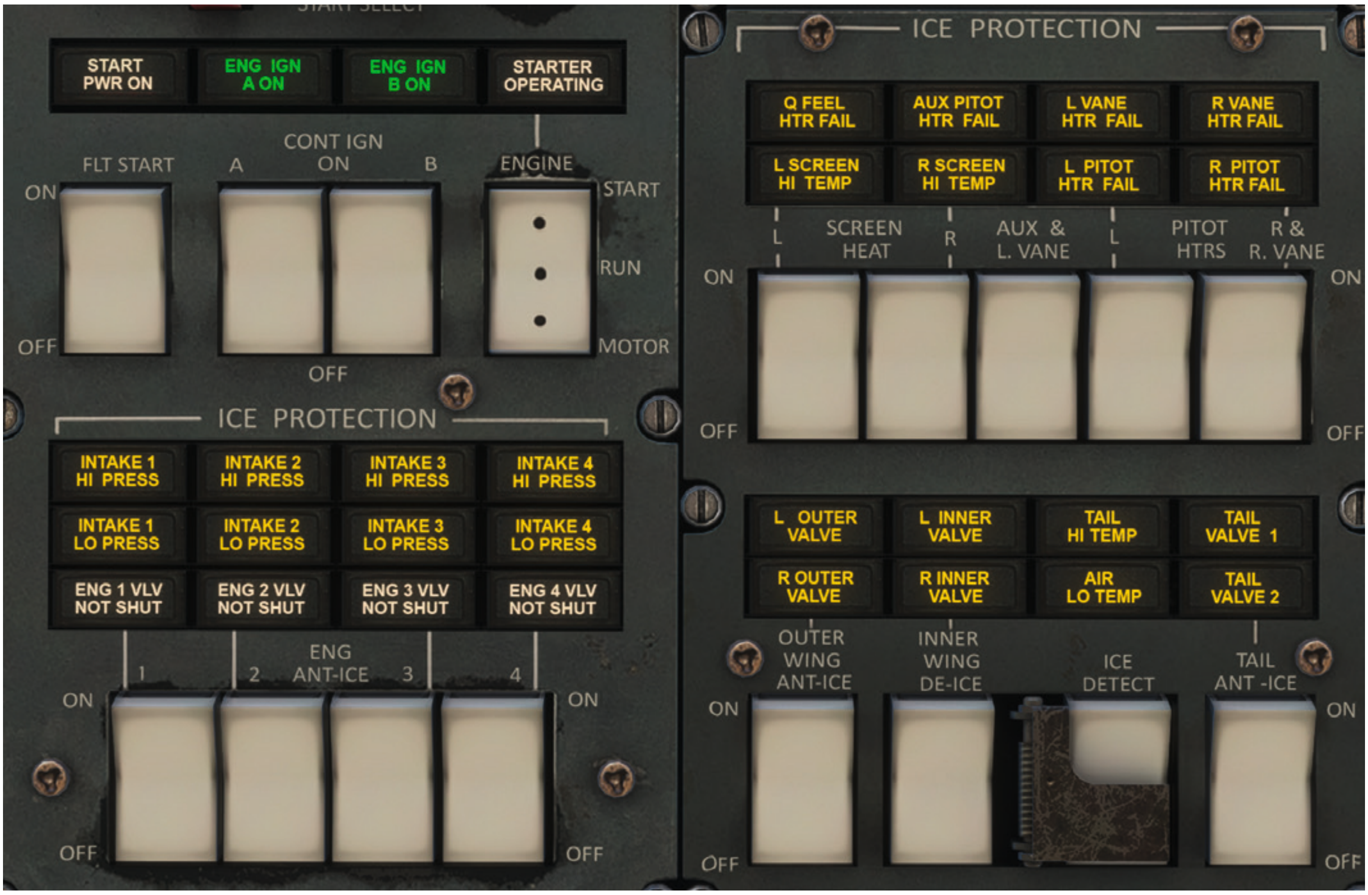
When selected, a single WING LTS ON/OFF switch on the flight deck overhead panel provides illumination of the inboard area of both wing leading edges.

Drain mast heating

The water waste drain masts are electrically heated to prevent ice accretion restricting the free flow of waste water to the atmosphere.

Controls and indicators

The associated ice and rain protection controls and indicators are located on the flight deck overhead panel.


START PWR ON
ENG IGN A ON
ENG IGN B ON
STARTER OPERATING
CONT IGN
FLT START
A
ON
B
ENGINE
START
RUN
MOTOR
ON
OFF
OFF
ICE PROTECTION
INTAKE 1 HI PRESS
INTAKE 2 HI PRESS
INTAKE 3 HI PRESS
INTAKE 4 HI PRESS
INTAKE 1 LO PRESS
INTAKE 2 LO PRESS
INTAKE 3 LO PRESS
INTAKE 4 LO PRESS
ENG 1 VLV NOT SHUT
ENG 2 VLV NOT SHUT
ENG 3 VLV NOT SHUT
ENG 4 VLV NOT SHUT
ENG ANT-ICE
1
2
3
4
ON
OFF
ICE PROTECTION
Q FEEL HTR FAIL
AUX PITOT HTR FAIL
L VANE HTR FAIL
R VANE HTR FAIL
L SCREEN HI TEMP
R SCREEN HI TEMP
L PITOT HTR FAIL
R PITOT HTR FAIL
L
SCREEN HEAT
R
AUX & L. VANE
L
PITOT HTRS
R & R. VANE
ON
OFF
L OUTER VALVE
L INNER VALVE
TAIL HI TEMP
TAIL VALVE 1
R OUTER VALVE
R INNER VALVE
AIR LO TEMP
TAIL VALVE 2
OUTER WING ANT-ICE
INNER WING DE-ICE
ICE DETECT
TAIL ANT -ICE
ON
OFF

INDICATING AND RECORDING SYSTEMS

The aircraft has a Digital Flight Data Recorder (DFDR) system which samples and records the mandatory flight parameters as well as additional parameters for performance monitoring. An underwater acoustic beacon is fitted to the DFDR.

A Cockpit Voice Recorder (CVR) system provides automatic recording of all sounds and speech from the flight deck.

The Master Warning System (MWS), in association with glareshield-mounted red/amber warning lights and a number of audio warnings, indicates aircraft system faults or emergencies on the Master Warning Panels (MWP). Illuminated legends are provided on the MWP and appropriate indications are given (an arrow pointing upwards) where additional warnings show on the overhead panel.

MWS annunciator captions are illuminated in red, amber, green or white according to the categories of alert, caution or status. Any red or amber (with triangles) warnings will cause the glareshield flashing warning lights to illuminate and activate the audio warning system.

The audible warning system provides audible tones which can be heard at a constant level and are unaffected by the position of any volume controls on the audio selector panels.

Two digital clocks are fitted, one on the left and one on the right instrument panel.

An optional Quick Access Recorder (QAR) can be fitted.

Digital flight data recording system

The system consists of a 64-channel Digital Flight Data Recorder (DFDR), a Flight Data Acquisition Unit (FDAU), an FDR control panel, a tri-axial accelerometer and associated flying control position transducers.

Digital flight data recorder

The DFDR consists of a crash-protected magnetic tape recorder. The unit is located at the rear of the aft cargo bay.

The recorder holds data from the last 25 hours of flight on a continuous tape.

A remotely mounted DFDR test/data-dump socket is located in the frame of the rear cargo bay door.

Flight data acquisition unit

An FDAU is located in the avionics rack. Its function is to acquire and process operational data from the various aircraft systems for output to the DFDR and QAR.

As part of the built-in-test monitoring function, a number of the analogue inputs are tested for ‘reasonableness’ against a corresponding upper and lower limit. If any of these parameters for which a limit has been set fall outside the limit for a significant period of time, the FDAU FAIL annunciator on the FDR control panel illuminates.

FDR control panel

A Flight Data Recorder / Quick Access Recorder panel is located on the rear of the central pedestal. It has four annunciators, an EVENT push-button and a GROUND TEST toggle switch. The two left-hand annunciators are provided for the DFDR system and the two right-hand annunciators are provided for the QAR.

Fault annunciation

Annunciators are provided on the FDR panel for FDR FAIL and FDAU FAIL. A white FLT REC OFF annunciator is on the MWP status panel.

The associated FAIL annunciator illuminates when a fault has been detected in the DFDR or FDAU.

The FLT REC OFF annunciator illuminates when either the DFDR or FDAU have failed or when there is no 28V DC power to the system.

Event button

When the EVENT button is pushed it inserts an event marker on the recording to highlight a particular flight event.

Ground test switch

The GROUND TEST toggle switch is used to apply power to the DFDR and QAR, and bypasses the micro-switching that provides the auto start facility (see the Auto switch-on section below).

A ground test of the DFDR/QAR can be performed as follows (the No.1 AVIONICS MASTER switch must be in the ON position):

1. Press the annunciator test button on the Captain's instrument panel and ensure that the fault annunciator lamps illuminate, then release and check that the lamps extinguish.

   Note: *FDR fail annunciator will illuminate when FDR is off.*

2. Toggle the GROUND TEST switch to the test position and hold. If there is no fault in the systems the FAULT legends will not illuminate. If there is a fault the appropriate lamp will illuminate. Release the GROUND TEST switch.

Auto switch-on

The DFDR system is automatically energised if any of the following apply:

- The parking brake is off.
- Any engine N1 is greater than 20%.
- Any squat switch indicates a 'flight' condition.

Power supplies

Power supplies are routed via relays controlled by the No.1 AVIONICS MASTER switch and are from the following busbars:

- DFDR, 115V AC ESS
- FDAU, 28V DC ESS
- Accelerometer, 28V DC ESS

Master Warning System (MWS)

The Master Warning System (MWS) provides the flight crew with indications of aircraft systems malfunction and status.

Indications are displayed by hidden legend captions on the MWS central warning panel, on an auxiliary MWS central status panel (below the warning panel), and on system sub-panels located on the overhead panel. Both master warning panels are located on the centre instrument panel.

To draw attention to an indication on the overhead panel, system caption annunciators on the MWP have arrows pointing upwards (↑) engraved on them, bearing the identification of a particular system.

The annunciators are colour-coded, depending on the type of indication.

Red alert

A red warning indicates a hazardous fault condition which requires immediate crew attention.

To highlight the annunciators, illuminated truncated triangles on either side of the legend are used. Red warnings are accompanied by audible tones, either discrete (fire bell) or a triple chime where no discrete tone exists.

The red alert flasher lamp system incorporates a time delay to minimise false alerts. The lamps are mounted on the glareshield, one in front of each pilot, and are press-to-cancel in operation. Pressing either will:

- Extinguish the alert lamps
- Initiate the dimming circuit
- Silence the audio tones (fire bell or triple chime)

High category amber caution

A high category amber caution requires crew action as soon as practicable.

Each high category annunciator incorporates a single truncated illuminated triangle on the left side of the legend and is accompanied by an audible single-chime tone and the amber caution flasher lamps.

The amber caution flasher lamp system incorporates a time delay which prevents transient warnings under normal operation. The lamps are mounted on the glareshield, one in front of each pilot, and are press-to-cancel in operation. Depressing either will:

- Extinguish the caution lamps
- Initiate the dimming circuit
- Silence the audio tone

A green annunciator indicates normal system operation and is advisory. No crew alerts are given.

Normal category amber warning

The normal category amber caution denotes a condition which is not immediately hazardous but requires attention, subject to crew workload.

The amber warning annunciator has no illuminated truncated triangle. No additional audible warning is given but the amber flashers operate.

White

A white annunciator indicates the functioning of a support system associated with specific or transient operational conditions. It may also indicate a ground function. No crew alerts are given.

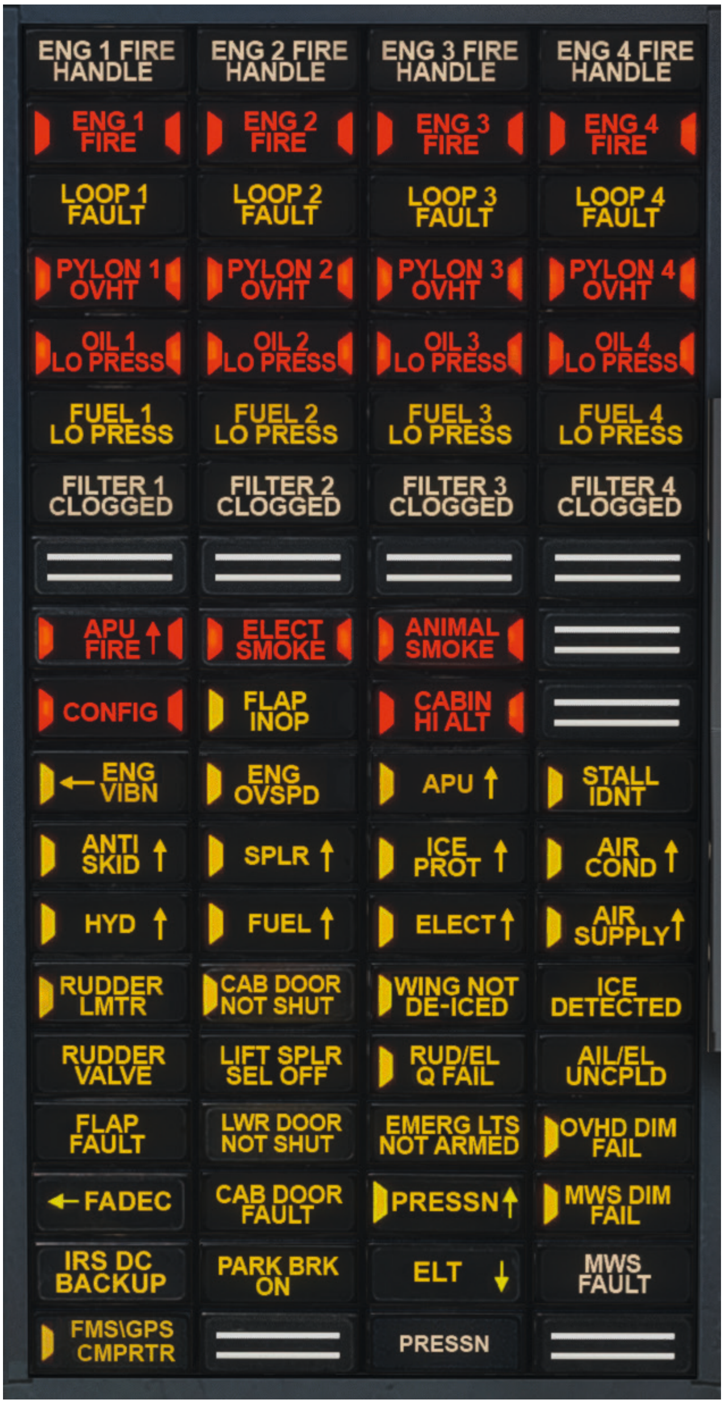
Green

A green annunciator indicates normal system operation and is advisory. No crew alerts are given.

MWS test panel

A combined TMS/MWS test panel is situated on the First Officer's instrument panel and incorporates the following MWS controls:

- An MWS rotary DIMmer switch facilitates control of the light intensity of the Master Warning Panel annunciators after a glareshield 'alert' or 'caution' lamp is pressed.
- The MWS control (CTRL) switch has two positions: NORM (up) and O/RIDE (down). For normal system operation the switch is set to NORM. In the event of the dimming circuit becoming unserviceable, as indicated by the MWS annunciator DIM FAIL caption, the switch should be set to O/RIDE and the dimming circuit is bypassed; each annunciator would then be at full brilliance.
- The MWS PUSH TEST – PULL GRND OP switch incorporates an integral red lamp which illuminates when PULL-GRND OP is selected. In this position the MWS annunciator panel is dimmed and the 'alert' and 'caution' flashers and audio tones are inhibited. If the switch is left at GRND OP, the muting facility will be cancelled by the 'squat' switch during lift-off. When the red PUSH TEST is operated, all the filaments on the MWS annunciator panel are illuminated at full brilliance, the 'alert' and 'caution' lamps flash and the triple chimes sound.



When an MWP red or amber caption first illuminates, it does so at full brilliance regardless of how the MWS dim control is set; any other captions that are lit on the MWP will also be driven to full brilliance, regardless of their colour. This condition is known as ‘bright-up’.

Bright-up is maintained until any one of the four attention-getting lights on the glareshield is pressed. Bright-up is not initiated when a white or green caption illuminates.

The MWS red and amber warnings can also be cancelled with the ‘TOGGLE GPWS’ control assignment.

Audible warning system

The audible warning system provides audible warning tones to the flight crew via the aircraft audio system.

The unit synthesises eight discrete tones. When a warning input is received, the appropriate tone is outputted to the flight deck loudspeaker amplifiers and audio integration amplifiers. The tones are heard at a constant volume and are unaffected by the position of any volume controls on the audio station boxes. An exception to this is the fire bell, which is an external electro-mechanical bell driven by the audible warning system.

The ground proximity warning system tone is fed into the audible warning system and outputted via its audio amplifiers.

The audible warning system has been designed to minimise the possibility of loss of more than one tone if a fault occurs in the system. Outputs to the flight deck are duplicated.

Audible flight deck warning tones

List of flight deck audible warning tones:

NAME OF INPUT	TONE DESCRIPTION	HOW CANCELLED	HOW TESTED
FIRE WARNING - Engine 1 - Engine 2 - Engine 3 - Engine 4 - APU	BELL (electro-mechanical)	Pressing either red ‘Alert’ lamp on glareshield coaming	Fire warning test switches on overhead panel. Switches activate the appropriate fire warning detector.
OVERSPEED (MACH/IAS) CONFIGURATION (Take-off). Flaps up, thrust levers 2 & 3 at >80% N2	INTERMITTMENT HORN	Only by corrective action. No isolate switch.	Test switches on overhead panel wired in parallel with speed switches. Config check switch on centre console.
LANDING GEAR (throttles idle) LANDING GEAR	STEADY HORN	Horn cancel switch on centre console. Only by corrective action.	Test switch on overhead panel.
AUTOPILOT DISCONNECT (DFGS)	CAVALRY CHARGE	Manual A/P disconnect – automatic after 0.75 seconds. Auto A/P disconnect – pressing either A/P cut-out button.	Pre-flight autopilot engage/disengage checks. Note: The Auto/Manual cancel logic is within the autopilot.
ALTITUDE ALERT	MUSICAL ‘C’ CHORD	Automatic after 2 seconds.	Set selected altitude close to alt. shown on Capt. alt. meter. Move altitude to +/- 300 ft.
RED ALERT on MWS	TRIPLE CHIME High tone repeated at five-second intervals	Pressing either red ‘Alert’ lamp on glareshield.	Test button on MWS test panel and SMOKE DETECTOR test switch on overhead panel.
HIGHER CATEGORY AMBER WARNING	SINGLE CHIME Single stroke high tone unrepeated	Pressing either amber ‘caution’ lamp on glareshield coaming.	Can be tested by a number of circuits on overhead panel, such as REAR BAY HI TEMP.
CABIN ATTENDANT OR GROUND CREW	GONG (single stroke low tone)	Gong is inhibited for 0.5 seconds after input removed then automatically reset.	

Aircraft clock

Two identical digital clocks are provided, one on the Captain's panel and one on the First Officer's panel. Standby power is provided by a 6V battery attached to each clock in order to maintain the time function when aircraft electrical power (and hence the digital display) is switched off.

The clocks can display clock TIME, flight time (FT) or elapsed time (ET} as selected on the TIME-FT-ET display selection switch.

The battery is installed at the factory and at the same time all three functions are activated and the clock function is set to accurate time.

The clock time is easily adjusted in one-hour increments using the '1 hr up' DIM switch. This does not affect the actual time in minutes and seconds, which can be changed by use of the 'UP' or 'D' positions of the SET switch (i.e. one second at a time, up or down).

The flight time recording is started and stopped automatically by the operation of the squat switch relays on take-off and landing. The total flight time, over a number of sectors, is recorded and the flight time is not reset to zero between each sector.

The flight time (FT) can be reset to zero by:

- On the ground with DC power off, selecting FT on the TIME switch and the elapsed time meter switch to ZERO momentarily.
- On the ground or in flight, operation of the TIME REST push-button located adjacent to the clock plus operation of the elapsed time meter switch to zero momentarily.

1. This switch makes minor time corrections:
   - o UP is a momentary position and sets the clock one second up for every second held.
   - o SET is the normal position.
   - o D is a momentary position and sets the clock one second down for every second held.
2. This switch sets Bright/Dim and makes one-hour changes:
   - o B is the bright position of the display for daytime use.
   - o DIM is for night-time use.
   - o 1hr up is a momentary position and sets the clock one hour ahead for every time the switch is moved to this position and released.

3. This switch controls the elapsed time meter:
    - ZERO is a momentary position and sets the Elapsed Time meter to zero. ***Note:*** *Flight Time will only be reset to zero if power to the clock is off.*
    - STOP will stop the Elapsed Time meter.
    - RUN starts the Elapsed Time meter.
4. This switch selects which channel is to be displayed:
    - TIME selects real time. This channel may be set to GMT time or local time. Reads in hours, minutes and seconds.
    - F.T. selects Flight Time and reads in hours, minutes and seconds of actual flight.
    - E.T. selects Elapsed Time and reads in hours, minutes, and seconds.

Quick access recorder

The optional quick access recorder (QAR) records the same data as the FDR, though this recorded data is easier to remove or transfer from the aircraft to a PC-based data analysis tool.

A cartridge-tape-type QAR (TQAR) is fitted in this simulation and is located in the avionics bay.

The QAR is powered whenever AVIONICS MASTER A is ON and does not record when the FDR is switched off. The QAR takes its data from the FDR.

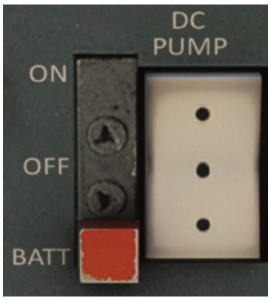
Two white QAR annunciators are fitted to the FDR panel: QAR FAIL and QAR TAPE LOW. The QAR FAIL annunciator illuminates if the QAR detects a fault. The QAR TAPE LOW annunciator indicates that the available tape storage spaces is less than 20% of the total tape capacity.

The QAR is tested when the FDR test switch is moved to FDR GRND TEST. If the test is successful, the QAR FAIL annunciator is out while the switch is at FDR GRND TEST.

INSTRUMENT PANELS

The location of the instrument panels on the flight deck are shown below. All instruments are integrally lit; panel inscriptions and selector switches are edge-lit.

Some of the rocker switches have baulks – the DC PUMP switch, for example. The baulk prevents the switch being inadvertently moved to the baulked position. Only one position of a rocker switch will have a baulk – either the top or the bottom position. The centre position of a three-position switch will not have a baulk.



A red baulk operating control is next to the baulked switch position. The baulk is removed by sliding the control away from the switch. The baulk control is spring-loaded to the baulked position.

To select the baulked position, the baulk must be removed. If the switch is at the baulked position, the switch can be moved away from the baulked position without operating the baulk control.

1. Captain's panel
2. Centre panel
3. First Officer's panel
4. Glareshield
5. Centre console
6. Overhead panel
7. Side consoles

Flight Management System (FMS)

The real RJ aircraft could be fitted with a variety of different FMS units depending on airline preferences; these included the Universal UNS-1, Honeywell GNS-X and Collins GNLU-910A.

This simulation of the RJ features a fully custom-coded Collins GNLU-910A FMS, the most modern and most capable FMS that could be fitted to the RJ.

The GNLU-910A is a type of FMS that can be seen fitted to some of the largest operators of the real-world RJ and provides a large selection of LNAV functions that are fully integrated with the autopilot, including the ability to manually enter flight plans using waypoints and airways; import and export flight plans that are stored locally on your PC; enter SIDs, STARs and transitions, and perform holding patterns.

As in the real aircraft, the RJ does not feature any VNAV autopilot functions, but the GNLU-910A does feature fully functional VNAV pages that allow you to view and edit climb, cruise and descent performance and to calculate the top of climb (T/C) and top of descent (T/D) points.

Documentation for the GNLU-910A can be found in the dedicated GNLU-910A Operations Manual which is located in the same folder as this manual: *…\Community\justflight-aircraft-rj\Documents*

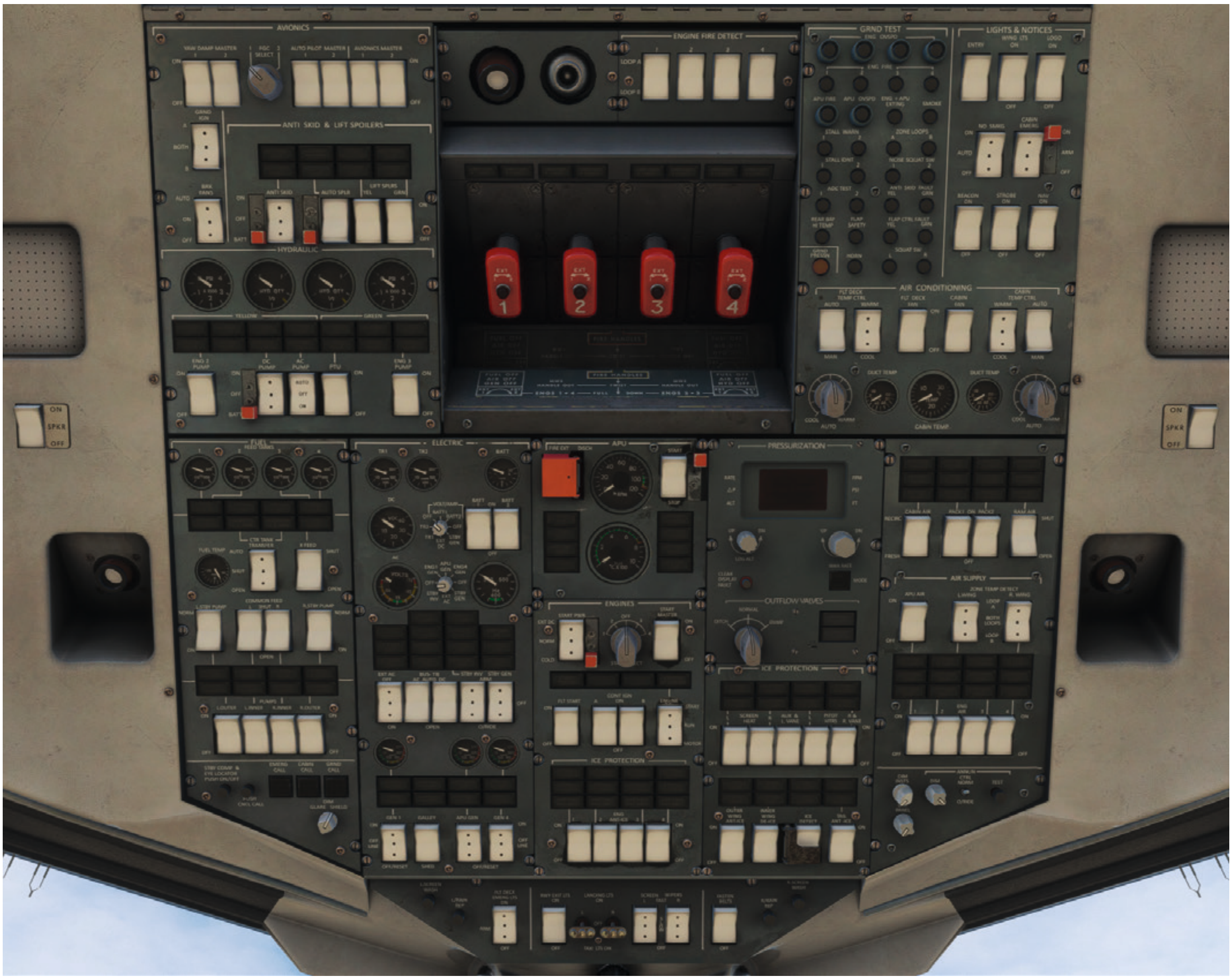
Captain's panel

Centre panel

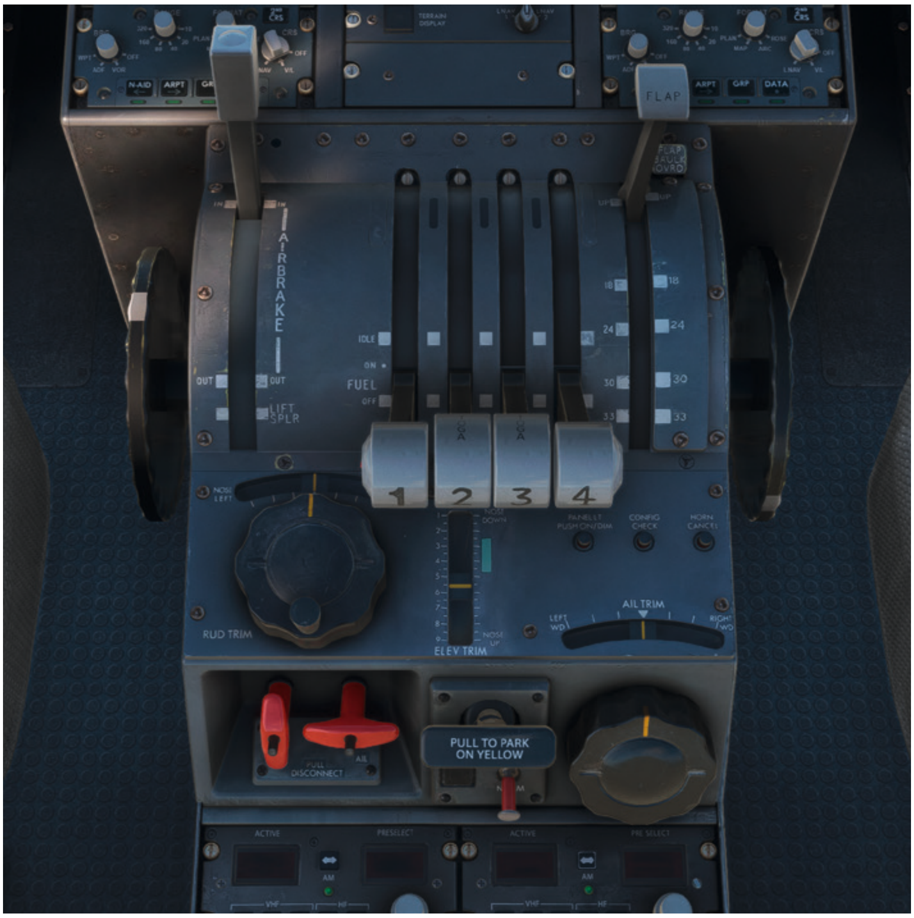
First Officer's panel

Glareshield

Overhead panel



Centre console




PULL TO PARK
ON YELLOW
YEL
PULL
DISCONNECT
AIL
ACTIVE
PRESELECT
AM
VHF
HF
ACTIVE
PRE SELECT
AM
VHF
HF
XPDR
FAIL
IDENT
ALT RPTG
TRAFFIC
CLR
RNG
STBY
XPDR
TA ONLY
TA/RA
ADF 1
ADF 2
ANT
ADF
BFO
OFF
BFO
OFF
ANT
ADF
BRAKE
TEMP°C
TEST
OUTER
INNER
INNER
OUTER
FDR
GRND
TEST
EVENT
STORE
DATA
ELC
ELT
REMOTE CONTROL
ON/TEST
ARM
RESET
FLT. DECK DOOR
AUTO
UNLOCK
LOCK
FAILED
DOOR
AJAR
LOCK
UNLOCK
FWD
CONSOLE
AFT
CONSOLE
CONSOLE
FLOOD

Side consoles

LANDING GEAR

The landing gear comprises two main units, each retracting inboard into the fuselage, and a steerable nose unit which retracts forwards into the fuselage. An oleo/pneumatic shock absorber is fitted to each unit. Fairing doors are linked mechanically to their respective units.

High-speed low-pressure tubeless tyres are fitted throughout and a fusible plug is embodied in each main wheel.

A carbon multi-disc wheelbrake assembly is fitted for each main wheel.

An optional tail skid is incorporated in the air conditioning bay door of the RJ70 and RJ85 variants. The tail skid is automatically fitted to liveries which have a tail skid fitted in the real world and can be toggled on/off via the EFB tablet.

Green system hydraulic power actuates the nose gear steering, the wheelbrakes and the landing gear retraction and normal extension mechanism. Emergency extension (Yellow system) may be selected if the normal extension system is inoperative.

As the nose gear is retracted into the nose wheel gear bay, the wheels each contact a separate spring-loaded 'free fall assister' which causes them to stop rotating.

Ground lock pins are provided for each unit of the landing gear.

Nose-wheel steering

The single-leg nose gear unit has twin wheels and self-centres, with weight off wheels, from 20 degrees either side. It is steerable through 70 degrees either side and during towing it can castor 180 degrees either way without manual disconnection.

The supply of hydraulic fluid to the steering system is taken from the Green landing gear 'down' supply and is only available when the gear is selected down. A mechanical interlock immobilises the steering system when the leg is retracted and during its initial extension.

Steering may be controlled by hand-wheels fitted at the Captain's or First Officer's station. See the Electronic Flight Bag manual for more information on controlling the tiller and other nose-wheel steering options.

Normal extension and retraction

Movement of the landing gear selector switch on the centre panel is sensed electronically (DC 2) and causes a motorised valve to direct Green system fluid to the appropriate hydraulic lines of the main and nose gear systems.

To prevent inadvertent selection, the selector is gated at both positions and held by a strong spring that is released by pulling out a collar on the handle. To prevent inadvertent retraction, a solenoid-operated lock mechanism prevents the selector being moved to the UP position with weight on wheels. A mechanical O/RIDE lever is provided.

Emergency extension and retraction

Should Green system hydraulic pressure not be available for normal extension of the landing gear, an emergency selection can be made by raising the emergency selector handle via a panel in the floor immediately aft of the Pilot's centre pedestal.

This initiates:

1. Mechanical operation of a dump valve which connects all the Green system landing gear lines to 'return', thus avoiding hydraulic locks.
2. Mechanical release of the 'up' locks for each main gear, its door and the nose gear, allowing each gear unit to 'free fall'.
3. Mechanical operation of a valve to direct Yellow system hydraulic fluid to the combined assister jack which will force both main gear units into a position where the side stays will lock down. If Yellow main system is not available, the emergency Yellow system may be energised via the DC pump.

In this simulation the first click on the floor panel will 'open' the panel. The second click will action the lever.

Indicators and controls

Non-mechanical proximity sensors activate the visual and aural gear position indication.

For the indicators associated with operation of the gear there are 'up' and 'down' sensors for each leg and an 'up' sensor for each main gear door.

Visual indicators

Twin-filament visual position indicators are provided on the flight deck:

- Within the handle of the normal gear selector
- Adjacent to the gear selector

The indicator within the handle of the gear selector comprises a red warning which lights when either the gear or the motorised gear selector valve is not in the position selected (NIPS) or an aural gear position warning is active.

The indicators adjacent to the main gear selector comprise two annunciators, one red and one green, for each leg of the gear. When each leg is locked down its green annunciator is lit, and when each leg is unlocked its red annunciator is lit. The annunciators are unlit when the gear is locked up.

The brightness of the gear position indicator annunciators may be selected to either bright or dim by the ANNUNCIATOR BRT/DIM switch.

If the NO SMKG placard light switch is selected to AUTO, the NO SMOKING and RETURN TO SEAT placards are lit whenever the nose gear is not locked 'up'.

Aural warnings

A horn, with a steady note, and HORN cancel and test buttons form the basis of the landing gear aural warning system.

The horn will sound and the gear selector handle warning will light if either:

a. The flaps are selected to more than 30° down but the gear is not locked down. This warning cannot be cancelled.

   OR

b. The airspeed is below 145 knots and one or more thrust levers are below the cruise power setting but the gear is not locked down. This warning can be cancelled.

   OR

c. The test button is depressed in flight or on the ground.

Wheelbrakes

Carbon multi-disc, hydraulically operated wheelbrakes with duplicated anti-skid facilities are fitted to both wheels on each main landing gear leg. The brakes may be with or without the anti-skid system.

The brake units incorporate a self-adjusting wear mechanism and brake wear indicators. Installed within the hollow core of each main gear wheel axle is a wheel speed transducer and a brake cooling fan.

Independent cable runs link each pilot's brake pedals to the brake control valves, which meter hydraulic fluid up to a pressure of 3,000 PSI. If anti-skid is selected on, the anti-skid valves modulate the metered pressure from the brake control valves.

The wheelbrakes can be operated from either the Yellow or Green hydraulic system. The normal selection is Yellow system. If Green is selected, automatic changeover from Green to Yellow occurs if DC 1 busbar fails or if park brake or emergency Yellow system is selected.

The left-hand brake pedals operate the Yellow system brake control valves and the right-hand pedals operate the Green. Mechanical interlinks convey control of the operative system to whichever pilot is applying the brakes. Only those pedals operated by the controlling pilot move.

A brake accumulator supplies the brakes in the event of loss of pressure in both Yellow and Green systems. It is charged either by the Yellow system (No.2 engine EDP or AC pump) or by the DC pump, which obtains its fluid from the reserve compartment of the Yellow system reservoir. During towing the AC or DC pumps may be used to maintain the accumulator pressure.

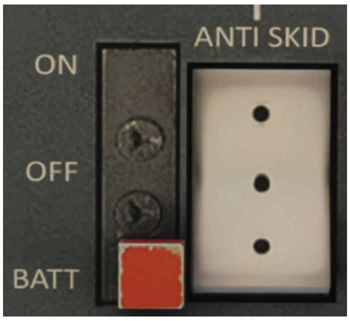
When the landing gear retracts, the brakes are automatically applied via the brake auxiliary pistons in each brake unit. After approximately 24 seconds, the brakes are released.

Hydraulic fuses prevent fluid loss in the event of a brake unit or associated pipeline leak.

Anti-skid system

The anti-skid system modulates pilot-applied brake pressure to obtain optimum braking. This facility is electronically controlled by the anti-skid control box which receives wheel speed signals from transducers fitted at each main wheel. Separate power supplies to the inboard and outboard anti-skid control circuits are taken from DC BUS 2 with manual transfer possible to EMERG DC busbar.

An ANTI SKID - ON/OFF/BATT switch is on the overhead panel. Anti-skid is selected ON prior to take-off to provide anti-skid protection in the event of a rejected take-off and continuous monitoring of circuit integrity.



Anti-skid is available for a rejected take-off when the wheel speed increases above 33 knots and remains operative until the wheel speed decreases below 15 knots, after which direct braking is progressively transferred to the pilot. On landing, anti-skid commences either five seconds after the receipt of weight-on-wheels signals or on wheels spin-up, whichever occurs first. This allows wheels spin-up on low-friction surfaces.

Where a fault is detected by the continuous monitoring circuitry, it will cause the amber ANTI-SKID INOP and/or ANTI-SKID FAULT annunciators to be lit, together with the amber ANTI-SKID caption on the MWP. ANTI SKID FAULT indicates reduced integrity of the system but anti-skid performance is unlikely to be affected. However, use minimum braking consistent with the runway length available. ANTI SKID INOP indicates a failure of the anti-skid system where touchdown protection and anti-skid may not be available. It may be possible to reduce the INOP condition to a FAULT condition by selecting BATT on the ANTI SKID switch or selecting the alternative hydraulic system.

Note: *If the INOP indication cannot be removed, the wheelbrakes must be used with extreme caution. Use minimum braking consistent with the runway length available; landing distance may be increased by 60%.*

If an electrical failure of either the DC BUS 2 or the EMERG DC busbar occurs, the weight-on-wheels switch signal for that circuit will not be present. When at 15 knots the anti-skid circuit is de-energised, braking will be available on inner brakes only (DC BUS 2 OFF) or outer brakes only (EMERG DC OFF).

With the ANTI SKID switch selected OFF, the brake pressure from the brake control valves is transmitted through the anti-skid valves direct to the brake units. Without anti-skid protection the brakes must be used with extreme caution.

Two test buttons on the GRND TEST panel test the YEL and GRN electrical circuits of the anti-skid control system. For this test, the brakes should be at PARK, the AVIONICS MASTER A switch ON and the FDR circuit breaker made.

Brake temperature indicator

The brake temperature indicating system comprises four sensor assemblies, one for each wheel, and a brake temperature indicator located either on the left console or, as a customer option, on the centre console of the flight deck. Power supply is from the DC 1 busbars.

Temperature sensors on the brake units provide an input to the indicator unit to drive four coloured bar graph displays on the front panel of the unit. Each bar of the display consists of sixteen LEDs which constantly display the brake temperature, according to the height of the bar. On each bar the LED which has indicated the highest brake temperature is latched on as the brakes cool, giving an indication of the maximum brake temperature reached since the unit was last reset. Four colours of LED are used to indicate the various operating temperature ranges of the brakes: BLUE, AMBER, GREEN and RED.

BLUE – the single blue LED at the bottom of the bar graph comes on only when brake temperature is less than 50 ±10 °C and is a reminder that brake icing is possible under certain conditions below this temperature. When brake temperatures are greater than 50 ±10 °C the blue LED extinguishes.

GREEN – when brake temperature is between 50 ±10 °C and 200 ±10 °C, green LEDs come on to indicate minimum cooling period requirements if the brake fans are off.

AMBER – above the green band, amber LEDs indicate that increased cooling period requirements are needed if the brake fans are off.

RED – brake overheat is indicated by red LEDs which come on when the brake temperature is 750 ±10 °C or higher. Maintenance action must be taken if brake temperature reaches the red band.

Brake temperature is indicated to within 50 ±10 °C between 50 ±10 °C and 550 ±10 °C and 100 ±10 °C above 550 ±10 °C. The highest LED which comes on indicates the brake temperature reached. For example, when the LED adjacent to 100 comes on, the brakes are at 100 ±10 °C at that moment. The next LED will not come on until the brake temperature is 150 ±10 °C As the brakes cool, the highest LED which has come on will remain latched on to indicate the highest temperature reached as the other LEDs go off in turn.

A light sensor in the display panel automatically sets the correct bar graph display brightness. Panel illumination is controlled by the dimmer switch on the applicable instrument console.

A TEST push-button located in the centre of the display panel initiates, when pressed or when the electrical power is recycled, a built-in test (BIT) function which checks the correct operation of the unit. In addition, all previous latched indications of maximum brake temperature are reset to the current temperature.

Failure of a sensor during normal operation is indicated by all the green, amber and red LEDs on the relevant bar coming on and remaining on.

Brake fans

An integral electric fan and transducer are built into each of the four main landing wheel axles.

Control of the fans is by a three-position switch AUTO/ON/OFF. With AUTO selected the fans will be automatically switched on with the nose gear locked down and switched off as soon as the nose gear is unlocked. In effect the fans will be on with the undercarriage locked down and off with the undercarriage selected up.

There are no failure warnings for the brake fans. Fan operation can be verified by an external check.

Note that the minimum brake cooling period is 15 minutes with all brake fans operative.

Power supplies to the brake fans are AC and are crossed so that a single AC busbar will provide one fan to each main wheel assembly. The brake fan switch is from DC 1.

Indicators and controls

The brakes panel has three controls:

- **BRAKE SELECT** – a maintained alternate illuminated push-switch with a split screen; YELLOW/GREEN to indicate the selected hydraulic system. If Green system has been selected, automatic changeover to Yellow system is indicated by both the YELLOW and GREEN indicator lights remaining on in the switch light.
- **EMERG YEL/NORM** – a pull-to-unlock two-position toggle switch which selects the emergency Yellow system, starts the DC pump and switches off anti-skid. If Green system has been selected, automatic changeover to Yellow system is indicated by both the YELLOW and GREEN indicator lights remaining on in the switch light.
- **PULL TO PARK ON YELLOW** – when the Captain's brake pedals are fully depressed, selection of PULL TO PARK ON YELLOW mechanically locks the pedals and also operates three microswitches: two to control two motorised brake valves and one to switch the flight recorder off. When both motorised brake valves are fully closed, limit switches light the PARK BRAKE ON caption on the MWP and arm the CONFIG warning. If Green system has been selected, automatic changeover to Yellow system is indicated by both the YELLOW and GREEN indicator lights remaining on in the switch light.

The brake fans are controlled by a three-position switch on the overhead panel labelled AUTO/ON/OFF.

Two double-pointer indicators on the Captain's instrument panel are graduated 0,1,2,3,4 x 1,000 PSI. One indicator is for the Yellow system and the other for the Green system.

Brake accumulator pressure is monitored by a pressure switch which lights the ERK ACC LO PRESS annunciator on the HYDRAULIC panel should the pressure decay below 2,500 PSI.

A brake temperature indicator is fitted on the centre console.

The brakes panel is on the centre console and the brake pedals are integral with the rudder pedals.

LIGHTS AND NOTICES

The aircraft's internal illumination (general, floodlighting and lighting of specific areas) is provided by fluorescent tubes and filaments. Filaments are used for navigation lights, but landing, taxiing, runway exit and wing inspection lights are sealed beam units. The anti-collision beacons use Xenon flashtubes.

Internal lighting

Roof-mounted filament units provide overall illumination of the flight deck, while other flexible, adjustable or fixed units illuminate the centre pedestal, pilot lap, chart board and flight kit stowage. All the instruments are integrally lit, as are the panels on which they are mounted, with additional lighting mounted under the glareshield for the instrument panels.

Cabin, vestibule, toilet and galley lighting is provided by fluorescent tubes, with additional filament lighting in the front vestibule when ground power is connected.

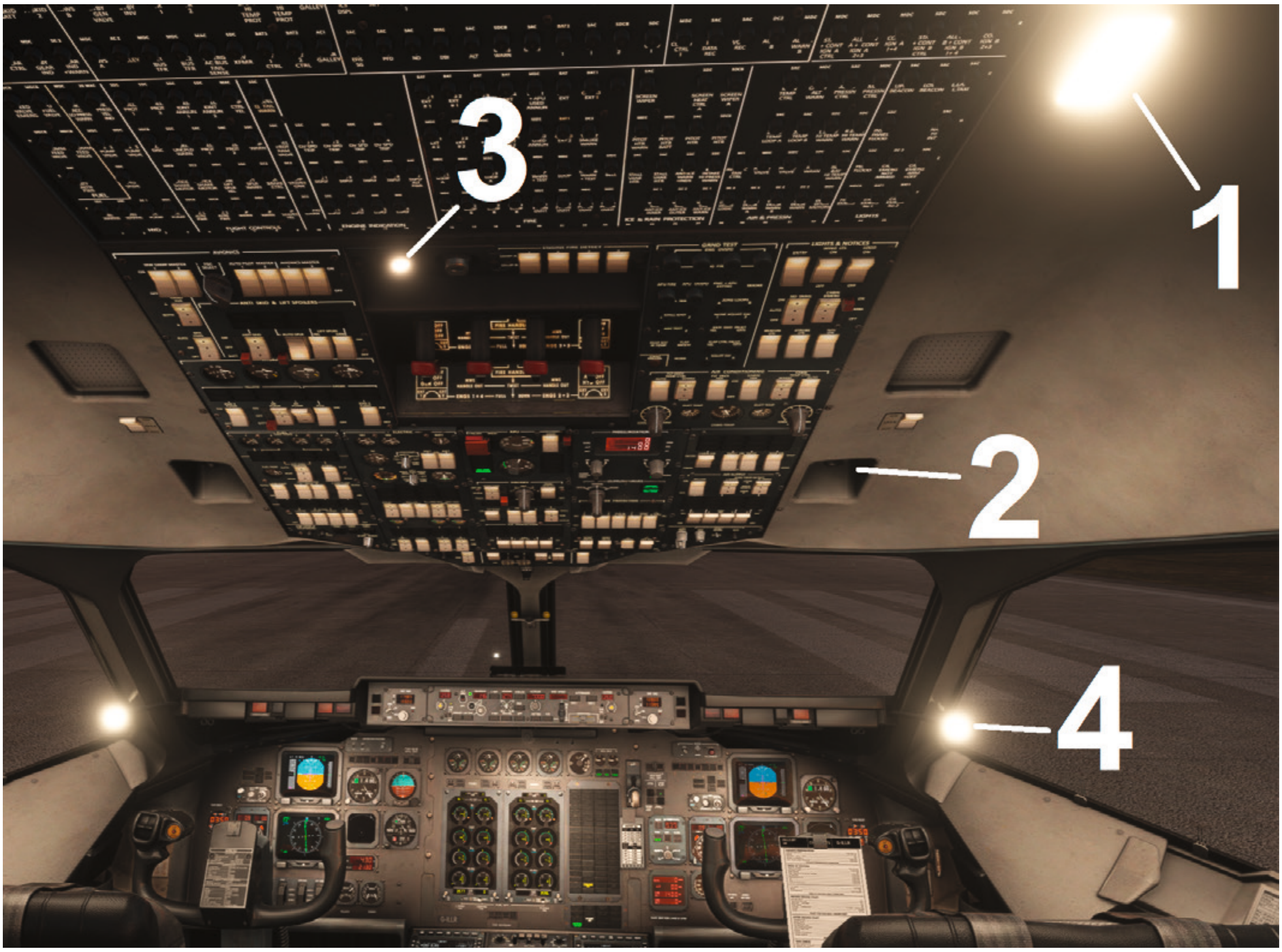
Call systems permit signalling between the ground crew and the flight crew, and between the flight crew and cabin crew.

Illuminating signs indicate 'fasten seatbelts', 'no smoking' and 'toilet engaged', with a 'return to seat' sign in each toilet.

Two emergency lighting systems are incorporated in the aircraft: one for the flight deck and another for the cabin, vestibules and toilets. The flight deck system gives overall illumination plus additional lighting of the instrument panels. The toilet emergency lights are run directly from the aircraft busbars but the lights in the cabin and vestibules are run via power units which can supply the filaments from internal batteries if the busbars fail.

Both cargo compartments are lit when either cargo bay door is opened.

Flight deck lighting



1. Entry lights
2. Lap lights
3. Console floodlight
4. Sill lights

Entry lights

Two filament flight deck entry lights are located on the left- and right-hand side of the overhead panel, aft of the pilots' seats, to provide general illumination of the flight deck area.

The lights are controlled by either of two switches:

1. An ON/OFF switch on the flight deck overhead LIGHTS & NOTICES panel and annotated ENTRY.
2. An ON/OFF switch on the top right-hand side of the flight deck entrance aisle.

Lap lights

The two lap light units are located on the flight deck roof above each pilot to provide local illumination for reading purposes. Each unit may be moved within its mounting to direct the light as required. The units are controlled by push-button switches annotated LAP, located on the side console dimmer panel. Each lap light is dimmed by a potentiometer shared with its corresponding sill light unit.

Console floodlight

A single unit located on the flight deck overhead panel, the console floodlight provides general illumination to the centre console. The console floodlight is controlled by a potentiometer annotated CONSOLE FLOOD which is part of the centre console dimmer panel on the aft centre console.

Sill lights

Sill lights are fitted on flexible stalks at both ends of the glareshield to illuminate the pilots' chart boards. The sill light units are fitted with filament bulbs and are controlled by push-button switches annotated SILL, located on the side console dimmer panels. Each sill light is dimmed by a potentiometer shared with its corresponding lap light unit.

Flight kit light

For general illumination of the book and flight kit stowage areas, dimmable lights are fitted to the side bulkheads, aft of the pilots' seats. The flight kit lights are controlled by potentiometers, annotated FLT KIT, part of the side dimmer panels on the left- and right-hand side consoles.

Instrument panel and console integral lighting

Integral lighting of the flight deck instrument panels and consoles is provided by miniature filaments which are controlled in groups by dimmers. The locations of the dimmers, and the panels to which they relate, are as follows:

1. Left and centre flight and engine instrument panels and left side console are controlled by a dimmer annotated PANEL INSTS, part of the dimmer panel on the left side console.
2. Right flight instrument panel and right-side console are controlled by a dimmer annotated PANEL INSTS, part of the dimmer panel on the right side console.
3. The overhead panels, including the fire handles and the overhead panel instruments, are controlled by two dimmers annotated DIM PANEL and DIM INSTS respectively, both located at the bottom of the AIR SUPPLY panel on the right side of the flight deck overhead panel.
4. The glareshield panel lights are controlled by a dimmer annotated DIM GLARESHIELD, located at the bottom of the FUEL panel on the left-hand side of the flight deck overhead panel.
5. The forward and aft centre console lights are controlled by two dimmers annotated FWD CONSOLE and AFT CONSOLE respectively. The potentiometers are part of the console dimmer panel which is located on the aft centre console.
6. Additionally, a button located on the trim control panel, part of the forward centre console, is annotated PANEL LT, PUSH ON/DIM and provides supplementary control over the forward centre console panel lights in the vicinity of the trim panel.

Standby compass and eye locator lighting

The standby compass is integrally lit. The eye locators are lit by a filament concealed behind the standby compass. The lights for both are controlled by a common push-button switch annotated STBY COMP & EYE LOCATOR, PUSH ON/OFF, located at the bottom of the FUEL panel, on the left-hand side of the flight deck overhead panel.

Flood and storm lighting

Six filament floodlights and three fluorescent tube storm lights are located beneath the glareshield to provide variable-intensity general illumination to the flight and engine instrument panels.

The left and centre instrument panel flood and storm lights are controlled by a dimmer/switch annotated PANEL FLOOD/STORM, part of the L/H dimmer panel located on the left side console. Clockwise rotation of the dimmer control will increase the intensity of illumination of the floodlights and further rotation through a detent will cause the storm lights to be lit. The right-hand instrument panel flood and storm lights are similarly controlled by the PANEL FLOOD/STORM dimmer/switch on the R/H dimmer panel on the right side console.

Annunciator dim control

The overhead panel annunciators and the instrument panel annunciators are separately controlled.

The overhead panel annunciator controls are located on the overhead AIR SUPPLY panel and are collectively annotated ANNUN. A switch, annotated CTRL, has two positions:

- NORM – the overhead panel annunciators, when lit, will be controlled by the associated potentiometer.
- O/RIDE – the overhead panel annunciators, when lit, will be lit at full brilliance.

A potentiometer annotated DIM controls the brilliance of the overhead panel annunciators, if lit, when the CTRL switch is at NORM.

When pressed, a push-button, annotated TEST, will cause all overhead panel annunciators to be lit at full brilliance for inspection purposes.

The instrument panel flight annunciator controls are located on the Captain’s instrument panel and are collectively annotated FLT ANNUN.

The potentiometer annotated DIM controls the brilliance of the flight annunciators when lit. A push-button, annotated TEST, will cause the flight annunciators to be lit at full brilliance for inspection purposes.

Flight deck emergency lights

To provide low-intensity illumination of the flight deck and flight instrument panels, an emergency flight deck lighting system is provided which may be selected to operate manually if required, or automatically if failure of the essential DC busbar is detected.

The flight deck emergency light system is comprised of:

1. An overhead light unit, with diffuser lens, mounted above and aft of the overhead circuit breaker panel.
2. Three light bulb units located under the glareshield, above the left, centre and right instrument panels.
3. An isolation relay.
4. A three-position control switch, labelled OFF-ARM-ON.

The flight deck emergency lights are supplied from the emergency DC busbar. For normal operations, when the control switch is selected to ARM, the flight deck emergency lights will be isolated from their power source by an energised relay powered from the essential DC busbar. In the event of a total generator failure, power to the essential DC busbar is lost and the isolation relay relaxes. In these circumstances, the emergency DC busbar is connected to the flight deck emergency lighting system which in consequence will be lit.

A switch, annotated FLT DECK EMERG LTS, is located on the left-hand side of the lower roof panel and controls the flight deck emergency lights. It has three positions, OFF, ARM and ON:

- OFF – flight deck emergency lights will not be lit.
- ARM – for normal operations the flight deck emergency lights will not be lit. If total aircraft generation failure should occur, the flight deck lights will be lit.
- ON – flight deck emergency lights will be lit.

Crew call lights

A crew call system is provided which permits the flight deck crew to summon the attention of the cabin attendants or the ground crew and vice versa.

The cockpit crew call panel is located on the flight deck overhead front panel.

The flight deck crew call panel comprises three light modules annotated EMERG CALL, CABIN CALL and GRND CALL and a reset button annotated PUSH CNCL CALL.

The EMERG CALL light module is lit by red filaments and cannot be dimmed. The CABIN CALL and GRND CALL light modules are lit by blue filaments and are dimmed by the flight deck overhead panel dim circuit.

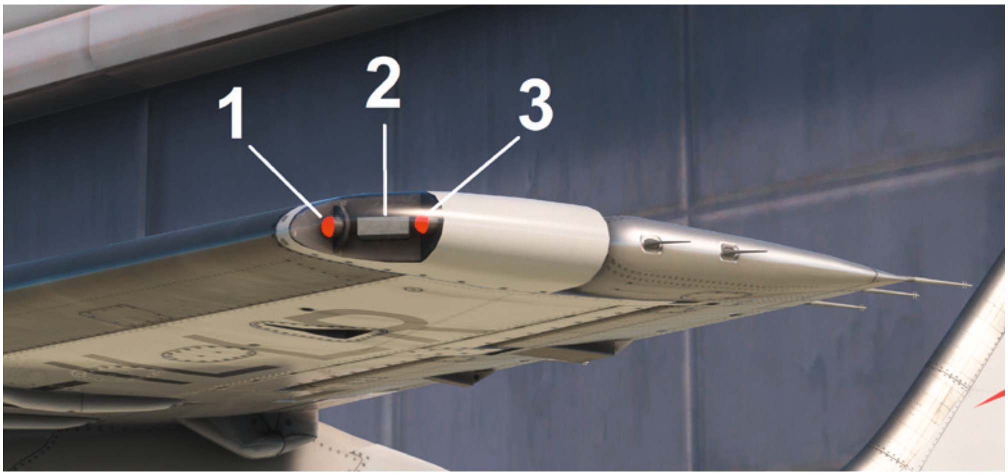
When the appropriate light module to summon the attention of the cabin attendants or the ground crew is pressed, it will be lit for incoming calls only until reset by the PUSH CNCL CALL button.

Audio tones over the intercom system accompany calls received on the flight deck. Calls from the cabin attendants' intercom panels are announced by a single chime and calls from the ground crew are announced by a gong.

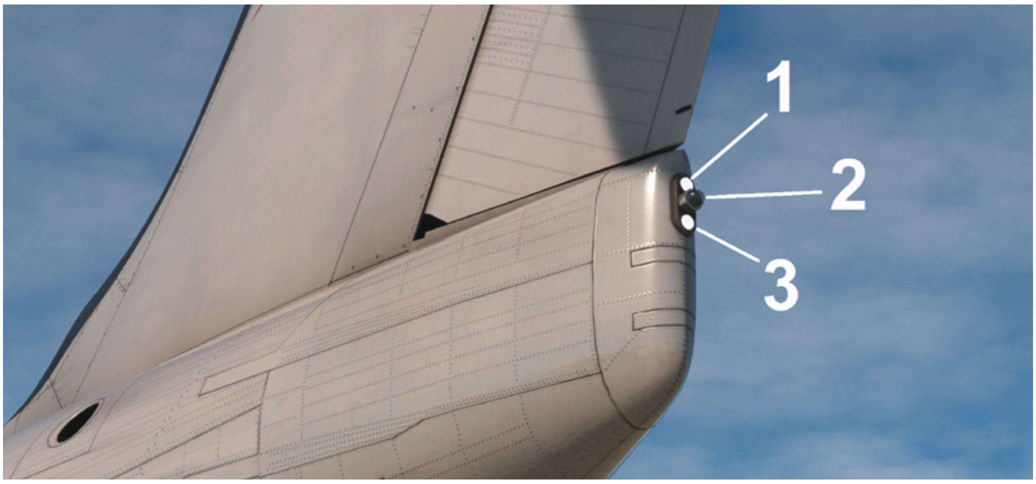
Pressing the CABIN CALL button will trigger the "Seats for take-off", "Cabin crew released" and "Seats for landing" cabin announcements, depending on the phase of flight.

Exterior lighting

1. Upper anti-collision beacon (red)
2. Wing leading edge inspection and runway exit lights
3. Lower anti-collision beacon (red)
4. Landing/taxi light



1. Navigation light (red)
2. Strobe light
3. Navigation light (red)



1. Navigation light (white)
2. Strobe light
3. Navigation light (white)

Navigation lights

Navigation lights are fitted at each wingtip leading edge and in the tail cone. Two lights are located at each of these three positions, each light having a high-intensity filament.

One high-intensity filament is AC-powered from the essential AC busbar via a step-down transformer and the other filament is powered from the AC ground services busbar.

The navigation lights are controlled by a single switch on the flight deck overhead LIGHTS & NOTICES panel. The three-position switch is annotated NAV HI INT, OFF, LO INT.

Anti-collision beacon

Two red anti-collision beacons are located on the top and bottom surfaces of the fuselage. They provide high intensity flashes of light to indicate the presence of the aircraft.

Both anti-collision beacons are controlled by a single ON/OFF switch located on the flight deck overhead LIGHTS & NOTICES panel. The switch is annotated BEACON-ON-OFF.

Strobe lights

The strobe lights provide high energy pulses of white light for additional collision avoidance protection. The strobe lights are co-located with the navigation light units and are inhibited from use on the ground by the weight-on switches.

The strobe lights are controlled by a single ON/OFF switch on the flight deck overhead LIGHTS & NOTICES panel. The switch is annotated STROBE-ON-OFF.

Landing and taxi lights

Lighting for landing and taxiing is provided by a dual-filament, sealed-beam light unit mounted approximately midway along the leading edge of each wing. The light units are recessed into the wing and covered by a glass fairing.

The left and right landing/taxi light units are controlled independently by two switches located on the flight deck front overhead panel and are distinguished by L (left) and R (right) respectively. The switches have three positions: LANDING LTS ON, OFF and TAXI LTS ON.

The landing light filaments provide a 600-watt concentrated beam of light. The taxi light filaments provide a 400-watt dispersed beam.

Runway exit lights

The runway exit lights project beams of light displaced 55 degrees either side of the aircraft's centre line to provide a wide field of illumination during ground manoeuvres.

The two sealed-beam light units are located in recesses on the top left-hand and right-hand sides of the fuselage in front of the wing and covered by a perspex fairing. The runway exit lights are inhibited from use in the air by the weight-on switches.

The runway exit lights are controlled by a single ON/OFF switch on the flight deck front overhead panel. The switch is annotated RWY EXIT LTS.

Wing inspection lights

The wing inspection lights direct light along the leading edges of both wings for inspection purposes.

The two sealed-beam light units are located in recesses on the top left-hand and right-hand sides of the fuselage in front of the wing and are covered by a perspex fairing.

The wing inspection lights are controlled by a single ON/OFF switch on the flight deck overhead LIGHTS & NOTICES panel. The switch is annotated WING LTS.

Logo lights

The logo lights are recessed into the undersides of the horizontal stabiliser to illuminate both sides of the vertical stabiliser.

Both lights are controlled by a single ON/OFF switch located on the flight deck overhead LIGHTS & NOTICES panel. The switch is annotated LOGO.

NAVIGATION SYSTEMS

Navigational services include the equipment used for the transmission, reception and presentation of air data, attitude, heading and navigational information required by the flight crew during all phases of flight. The audio output of the navigation aids are fed into the audio integrating system (see the COMMUNICATION SYSTEM section).

Aircraft attitude and direction are displayed on the Primary Flight Displays (PFD) and the Navigation Displays (ND) of the Electronic Flight Instrument System (EFIS). Attitude and direction references are taken from the dual Inertial Reference System (IRS). Direction is also displayed on the Distance Bearing Indicators (DBI).

Standby navigation services include a standby attitude indicator with ILS indication, standby compass, standby altimeter / airspeed indicator and an outside air temperature indicator.

The air data system includes separate pitot heads and static vents from which are fed pressure signals to the standby altimeter / ASI and various other units, including the air data computers.

Radio navigation

Dual VOR/ILS systems are provided. The instrumentational outputs of either system can be shown on both EFIS displays. ADF and VOR is also displayed on both DBIs.

Dual Distance Measuring Equipment (DME) systems provide slant distance from DME ground stations and send information to the EFIS, DBIs and Navigation Management Systems (NMS).

A dual Automatic Direction Finding (ADF) system, utilising fixed loop and sense aerials, provides bearing information to the EFIS and DBIs. Marker signals are detected by a single marker system. The received outputs are fed as tones into the audio integrating system and as annunciations on the EFIS.

Radar systems

A weather radar system is fitted and is used for weather detection and analysis.

A dual ATC transponder system is fitted. Height information is from the servo altimeter.

A dual Mode-S transponder system is fitted. Height information is provided from either air data computer {ADC).

A dual radio altimeter system is fitted and provides accurate altitude information during low approach and landing manoeuvres. Radio altitude is shown on the EFIS PFDs.

Ground Proximity Warning System

A Ground Proximity Warning System (GPWS) is fitted and provides visual and audio annunciation of a hazardous approach to the terrain. The GPWS is inhibited when the aircraft is in the stall condition and when windshear is detected. The system receives navigation information from the Flight Management System (FMS) or the Inertial Reference System (IRS) for the purpose of envelope modulation. In areas of known difficult terrain, the approach warnings are modified during steep approach.

Flight Management System

A dual GNLU-910A Flight Management System is fitted. The GNLU-910A uses input from the IRS and VOR/DME ground stations, and blends the data to derive a composite aircraft position.

Instrument displays

Altimeters

The altitude system consists of two primary altimeters and one standby altimeter / airspeed indicator. One primary and one standby altimeter are located on the Captain's panel and the other primary altimeter is located on the First Officer's panel.

The altimeter uses microprocessor circuitry and derives its information from the associated air data computer (ADC). Each ADC processes information from the pitot/static system, temperature sensor probe and baro set controls to provide electrical outputs to the altimeter, through a digital databus. These are then converted into an analogue display.

Altitude is shown by a single pointer reading against a dial and by a five-figure, four-drum counter. The pointer turns through one revolution for every one thousand feet of altitude and the dial is marked at 20-foot increments with the figures 0 to 9, representing hundreds of feet. The range of the display is from -1,000 feet to +50,000 feet. The display is integrally lit with white incandescent light.

Baroscale counters show the pressure set by the BARO set knob on the bottom left of the front case. Set pressure is shown in MB (millibars) and IN.HG (inches of mercury) and is also transmitted to both ADCs. The baroscale range is 745 to 1,049 in units of one millibar and 22.00 to 30.99 in units of 0.01 inches.

A white altitude set marker bug is on the periphery of the scale and is manually driven by the ALT set knob on the bottom right of the front case.

There is an amber alert light (ALT) on the top right of the bezel. This is lit by the altitude alerting function of the FGS.

To alert the crew to altitudes below 10,000 feet, the left-hand digit position on the 10,000 feet drum is green. In the case of a negative altitude the counter digits are partially obscured by a 'NEG' flag.

Failures detected by internal monitoring are indicated by a fire-orange OFF flag which obscures the counter digits.

Primary power supplies, for the left and right altimeters, are 115V from ESSENTIAL AC and AC 2 busbars respectively. Baro set supplies are from 26V AC.

A hidden clickspot on the screwhead located to the top left of both the primary Captain and Co-pilot altimeter will automatically set the standard barometric setting (29.92inHg / 1013.2mb) on all altimeters.

A 'Sync Altimeters' option on the EFB tablet enables the automatic synchronising of the standby and Co-pilot/Captain altimeter barometric settings. The 'master setting', which is sync'd to the other altimeters, is based on your current camera selection.

Metric altimeter

A metric altimeter can be fitted to the Captain's main instrument panel via a METRIC ALTIMETER option on the EFB tablet. By default, the metric altimeter will be fitted to liveries that have one fitted in the real world.

The metric altimeter is comprised of one LCD displays with two read-outs:

- ALT – the aircraft's current barometric altitude displayed to the nearest 10 metres.
- SEL ALT – the selected altitude in the MCP ALTITUDE window meters displayed to the nearest 10 metres.

Electrical supply for the metric altimeter is from AVONICS MASTER 1.

Standby altimeter / airspeed indicator

The standby ALT/ASI consists of two separate mechanisms, housed in a single case and connected to the pitot/static system. It is located on the left-hand instrument panel.

The standby altimeter is capsule-operated and consists of:

- A single altitude pointer which moves over a graduated scale.
- Altitude counters that show altitude in thousands of feet, with a range of -1,000 feet to +50,000 feet.
- Barometric counters that show MB and IN.HG as set.
- A BARO set knob located on the lower left of the front case.

A standby airspeed indicator is installed in the lower part of the case. As airspeed changes, a capsule expands or contracts and causes a graduated 'airspeed drum' to rotate behind a fixed IAS KNOTS pointer. The airspeed drum has tick marks at ten-knot intervals and has a range of 60 to 450 knots.

The instrument contains an electrical vibrator to prevent a 'sticking' display and has integral lighting. Electrical supply for the vibrator is from 28V EMERG DC.

Note: *When the needle is between 950 and 0 (12 o'clock) the altitude counter over-reads by 1,000 feet.*

Outside air temperature indicator

The outside air temperature (OAT) indicator provides the flight crew with a continuous display of the outside air temperature over a range of -60°C to +60°C. When electrical power is off, the indicator will register -60°C.

Standby attitude indicator

The standby attitude indicator displays pitch and roll attitude with horizon reference on a two-coloured sphere against a fixed aircraft symbol. The upper part of the drum is blue, representing the sky, and the lower part is brown, representing the earth. A white line dividing the two colours represents the horizon. With ILS selected on the VHF NAV1 selector, a non-linear ILS display is shown on the attitude indicator.

The instrument gyro can be temporarily caged to enable fast erection. The power supply for the standby attitude indicator is from Emergency DC.

Should electrical power fail to the indicator a gyro warning flag is displayed, LOC and GS flags are also shown in the event of failure.

A test facility is available from the VHF NAV 1 / DME control panel.

Note: *Use of the localiser display on the standby attitude indicator is not permitted for back course approach or front course departure guidance, because the localiser needle works in the reverse sense.*

Distance bearing indicator (DBI)

The DBI displays magnetic heading, radio bearing and DME indications. A HDG MAG/TRUE selector switch is on the lower part of the left-hand instrument panel. Selection of TRUE is annunciated on the EFIS ND.

Radio bearing information is displayed by two selectable radio pointers, either of which may indicate ADF or VOR bearings. Mode annunciators indicate the mode selected. Warning flags appear when the respective radio pointer does not have a valid receiver input.

Caution! *When a radio beacon is out of range or the received signal is too weak for use, the radio pointers are positioned at 3 – 9 o'clock. Red warning flags are not shown.*

Two digital read-outs display distances for DME 1 and DME 2.

Compass information for each DBI is normally from the opposite side; IRS 1 supplies DBI 2 and IRS 2 supplies DBI 1. Heading displays on the DBIs are not affected by the ATT HDG transfer switch, but in the event of operation on emergency power levels, DBI 1 automatically transfers to IRS 1.

Heading failure is shown by a HDG flag. The absence of computed data is indicated by a series of dashes in the distance displays.

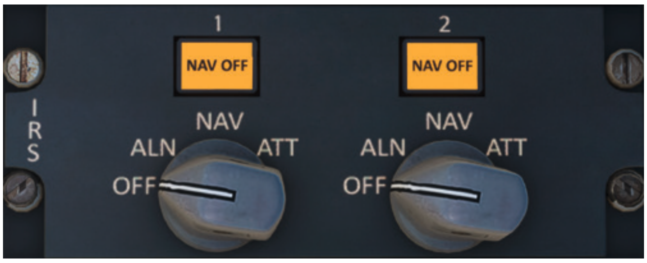
A test function for the DME and VOR is provided on the associated VHF NAV DME control panel.

Inertial Reference System (IRS)

A dual IRS system is fitted and provides:

- Selectable true or magnetic heading data for display on EFIS and DBI.
- Pitch and roll attitude data for display on EFIS.
- Vertical speed for display on EFIS.
- Pitch, roll and yaw data to DFGS.
- Stabilisation for the weather radar system.
- Latitude and longitude, and inertial accelerations to the FMS and GPWS.

The system consists of two Inertial Reference Units (IRU), located in the avionics rack, and a common Mode Selection Panel (MSP) mounted on the First Officer's side console.



A HDG selection switch is located on the lower part of the Captain's instrument panel and is used to select MAG or TRUE heading display on the EFIS and DBIs. An ATT HDG transfer switch is also located on the lower left instrument panel (see the Transfer switching section).

The IRS uses laser gyros and accelerometers to derive signals from which navigation and attitude information is calculated. Additional information from the digital air data computers (ADC) is used to compute and calculate aircraft motion and velocity. The IRU accepts the position entered as the starting point of its computations.

Position initialisation is from either Control Display Unit (CDU) of the NMS and mode selection is from the MSP.

The aircraft must not be moved during the alignment period for the ALIGN or NAV mode.

The MSP has two identical switches and indicators with the following functions:

- The amber NAV OFF annunciator goes out when NAV mode is selected and NAV alignment is complete, but remains illuminated in the OFF, ALIGN and ATT modes. The amber annunciator will come on in the NAV mode if a system fault is detected. A flashing annunciation indicates that position initialisation is required. The annunciator will continue to flash until the correct position co-ordinates have been entered.
- A four-position mode selector switch:
    - **OFF** – when selected, the IRU goes to a 30-second power off mode and data such as last calculated position is stored in non-volatile memory. Position initialisation is necessary if the 'present position' is more than one degree from the last position prior to power off (which is stored in non-volatile memory).
    - **ALN** – the present position has to be entered into the FMS after the IRS is selected from OFF to ALIGN; the alignment is then started. The longer the alignment time, the more accurate the alignment.
    - **NAV** – when selected from OFF, the present position has to be entered into the FMS in the same way as when using align and the alignment time is started. This provides the quickest, but not necessarily the most accurate, alignment. At the end of the alignment navigation data is available for output.
    - **ATT** – outputs attitude and heading information. This information is used to provide a quick restart capability in the event of a temporary power loss in flight. The magnetic heading value must be inputted via the FMS.

Amber annunciation of IRS cooling fan failure is provided on the lower part of the First Officer's instrument panel (IRS 1 / IRS 2).

If there is a DC power failure to the IRU, an amber IRS DC BACKUP caution annunciator will light on the master warning panel (MWP). At the same time, the alert caution flashers, mounted on the glareshield, will flash.

IRS power on mode

Power on mode begins when the mode select switch is set from OFF to ALIGN, NAV or ATT, provided the IRS's AC power is available. During this period the IRU will perform internal checks.

Power on mode can only be entered if the primary AC power supply is available. The IRS cannot be started if only the back-up power supply is available. The back-up power supply just keeps the IRS running if the main supply is lost after the power on mode is complete.

IRS power up align mode

The power up align mode is entered when the power on tests are complete. The NAV OFF annunciator will illuminate. The switch may be moved from ALN to NAV during the alignment process. Alignment can be satisfactorily completed at latitudes between 78.25° North and 78.25° South. Power up align mode cannot be entered when airborne.

During alignment, the IRS:

- Establishes aircraft attitude.
- Establishes true north.
- Estimates latitude.

The IRS cannot calculate or estimate longitude; it can only estimate latitude. To allow entry to the navigation mode, a position must be entered through the FMS. The position must be entered as accurately as possible because it is the starting point for subsequent inertial navigation.

No aircraft movement is permitted during the alignment process.

If a position is not entered by the end of the alignment process, the NAV OFF annunciator will flash.

Once a position is entered, the IRS makes a position compare test. For the test to be successful, the entered position must be within one degree of longitude and one degree of latitude of the stored position. If the test fails, the entered position is not accepted and the NAV OFF annunciator flashes.

A second position entry is accepted if the second position passes the comparison tests, or the second position is identical to the first.

Once the test has been passed, the NAV OFF annunciator will stop flashing.

When the alignment is complete and the position compare test has been passed, an alignment performance test is performed. The test compares trigonometric functions of the entered latitude and the computed latitude. If the test fails, the NAV OFF annunciator flashes. If the next entry fails the test but is different from the previous latitude, the annunciator continues to flash. If two successive identical latitudes are entered but both fail the test, the NAV OFF annunciator illuminates steadily. Once an entry is made that passes the test, the system will be allowed to enter the navigation mode.

The duration of the alignment process depends on aircraft latitude. It varies from 2.5 minutes at the equator to 15 minutes at latitudes greater than 70°. The time to completion of alignment is known as 'time to NAV' mode (TTN). TTN can be seen on the MSFS tooltips for the IRS switches (tooltips must be enabled in MSFS settings). TTN values greater than 7 minutes are shown as 7 minutes. When alignment is complete, TTN will be shown as 0.0 and an IRS NAV READY message will be given.

As a quality-of-life addition in this simulation, it is possible to 'fast align' the IRS by quickly moving the IRS switch from OFF > ALN > NAV > ALN. Alignment will then be completed within 30 seconds of a position being entered into the FMS.

When starting a flight at a gate in a cold and dark state, both IRS switches will default to the OFF position and the IRS will require alignment. When starting a flight on the runway, the IRS will be aligned automatically based on the aircraft's present position.

IRS navigation mode

An IRS will automatically enter navigation mode once the following conditions are satisfied:

- Alignment is complete.
- The position compare test has been passed.
- The alignment performance test has been passed.
- The mode selector switch is at NAV.

In the navigation mode, the IRS computes the necessary data which is then passed on to the aircraft system.

If the mode select switch is selected to NAV during the alignment process, then the system will automatically move to the navigation mode when the first three conditions above are satisfied. If the switch is left at ALN after the IRS NAV READY message is given, the IRS will continue to refine its alignment. Delaying the selection of NAV as long as practicable will produce a better alignment and thus smaller drift rates. However, the alignment achieved if the navigation mode is entered once the alignment performance test has been passed is adequate.

The mode select switch must be pulled up before it can be moved away from NAV.

IRS align down mode

An IRS will automatically enter navigation mode once the following conditions are satisfied:

During flight or long periods of ground operation in navigation mode, velocity and position errors will accumulate. These errors can be corrected using the align down mode. Align down mode can only be entered from the navigation mode.

The IRS enters the align down mode from the navigation mode if the mode select switch is moved back to ALN providing the aircraft is stationary. In down mode align:

- Residual velocity errors accumulated during the previous period in navigation mode are zeroed.
- Pitch, roll and heading are updated.
- The NAV OFF annunciator is illuminated.

Down mode alignment takes a minimum of 30 seconds. Return to navigation mode is accomplished simply by selecting the mode select switch to NAV.

Simply going to ALN and returning to NAV just corrects attitude, heading and velocities; the IRS position is not corrected. To correct the position, a new position is entered via the L NAVs. The position compare test will be run; the latitude limit is tighter than that for the compare test in align mode: 0.5°. The alignment performance test is not performed.

IRS power down mode

The power down mode is entered three seconds after the mode select switch is selected OFF. The three-second delay allows the desired mode to be retained if a brief inadvertent selection to OFF is made.

After the delay, power is maintained to the IRU for about eight seconds. During this period the last calculated position and other IRU parameters are transferred to non-volatile memory.

It is important to switch IRS 1 OFF when the aircraft is powered down; if the IRS is left powered, it will continue to be powered from the battery after the aircraft is powered down. It is a good idea to check that IRS 1 is switched off before leaving the aircraft.

IRS drift

During flight or long periods of ground operation in navigation mode, velocity and position errors will accumulate. The position error is known as position drift.

The relevant time is the time since navigation mode was entered following:

- Power up alignment
- Down mode alignment with position update

The time that NAV mode was entered, after a down mode alignment without position update, is not relevant to the allowable position drift.

The flight time or number of flights since NAV was entered is not relevant to the allowable position drift.

The GNS generates an IRS sensor miscompare message if the IRS position differs significantly from the GNS composite position. The threshold for the warning increases with time from the start of a flight, not from the time that alignment with position update was made. If a number of flights have been made without an IRS position update, a sensor miscompare message may be given, even though there is nothing wrong with the IRS.

It is important to update the IRS position between flights; this will ensure the best position accuracy during the subsequent flight.

Transfer switching

Heading information comes from the onside IRS and can be selected on the HDG switch to either MAG or TRUE. Transfer switching· is available from the ATT HDG transfer switch. Both switches are on the left-hand instrument panel. TRUE (white) and HDG1/2 (yellow) annunciators, on the EFIS navigation displays (ND) indicate HDG and transfer selection respectively; also ATT 1/2 (yellow) is displayed on the EFIS PFD for transfer selection.

Three transfer (guarded) switches are provided below the ND on the left instrument panel. These are marked as BOTH 1 / NORM / BOTH 2:

EFIS – allows either pilot to select the alternative symbol generator (SG) information for display. Yellow cautionary legends (SG1 or SG2) are displayed on both PFDs and NDs to indicate that all displays are from the same source,

AIR DATA – allows either pilot to select the alternative air data computer for display of airspeed / vertical speed and Mach number. A yellow cautionary legend (ADC1 or ADC2) is displayed on both PFDs whenever a single air data source is displayed to both pilots.

ATT HDG – allows either pilot to select the alternative Inertial Reference System for display of pitch and roll attitude and heading. A yellow cautionary legend (ATT1 or ATT2) is displayed on both PFDs and HDG1 or HDG2 is displayed on both NDs whenever a single IRS source is displayed to both pilots. A LNAV1/SPLIT/LNAV2 switch located on the centre console below the weather radar indicator allows selection of LNAV data to be fed to either EFIS display, i.e. in LNAV1 position, both EFIS displays are fed from LNAV1; in SPLIT, LNAV1 feeds the left-hand EFIS and LNAV2 feeds the right-hand EFIS; in LNAV2, both EFIS displays are fed from LNAV2.

Standby compass system

A standby magnetic compass is provided on the centre strut of the front windscreen. The indication accuracy is within 10 degrees.

The STBY COMP and EYE LOCATOR switch controls the light in the standby compass, which also illuminates the EYE LOCATOR mounted on the central windshield frame.

Electronic Flight Instrument System (EFIS)

The Electronic Flight Instrument System (EFIS) performs all the functions of the conventional ADI and the HSI. Additional information is also displayed, such as:

- Airspeed and Mach number
- Vertical speed
- Decision height
- Radio altitude
- Marker beacons
- Bearing pointers
- Distance displays
- LNAV, selectable data
- Flight Director bars
- Glideslope
- Lateral deviation
- Windshear annunciation and recovery guidance
- TCAS resolution advisories
- Autopilot mode annunciators
- Autothrottle mode annunciators

The EFIS is a dual system (left-hand and right-hand) and each system uses the following components:

- Symbol generator
- Two display units (DU)
- EFIS control panel
- Dimming panel
- EFIS master switch
- Flight Director bars switch

Both systems make use of an EFIS transfer switch and a flight annunciator test switch.

Symbol generator (SG)

SG1 and SG2 are located on a shelf in the avionics rack. The SG contains all the circuitry necessary to:

- Interface with the aircraft sensors and systems.
- Compute the appropriate display parameters.
- Transmit display data to the DUs.
- Provide an output to the comparator warning annunciator (CMPTR MSTR).
- Provide a decision height signal to the Ground Proximity Warning System (SG1 only).
- Detect, display and store sensor and processing failures.

A cross-talk data bus links the two SGs. In the event of the failure of an SG, all four DUs can be driven from the serviceable SG.

Display unit (DU)

Two DUs are installed, one above the other on each main instrument panel. The DU contains a high-resolution colour cathode ray tube (CRT). All DUs are identical and may be used in either the upper display position as a Primary Flight Display (PFD) or the lower position as a Navigation Display (ND). A slip indicator is fitted to all displays and is illuminated in the PFD position.

Two light sensors are located on each DU, one on either side. The sensors modify the manually set brightness control signals in response to the ambient light conditions.

EFIS control panel (ECP)

The ECPs are located on each side of the forward central pedestal. Each ECP controls its associated ND and has the following functions:

FORMAT switch – provides selection of ROSE, ARC, MAP or PLAN formats.

RANGE switch – allows selection of range for ARC, MAP or PLAN formats. The selectable ranges are 10, 20, 40, 80, 160 and 320 nautical miles. Each range position has click stop. Weather radar is displayed on the ND only in the ARC and MAP formats. As the range marker is displayed halfway down the ND screen, the range marker shows half scale of the range selected, i.e. 80 nautical miles selected shows 40 nautical miles.

Three-position CRS switch – allows the selection of primary course information from VOR/LOCaliser (V/L) or LNAV. An OFF position removes all data associated with primary course to provide a declutter facility.

BRG switch – selects onside VOR, ADF or WPT (LNAV) pointers. In the case of a single LNAV or ADF system, the bearing information comes from the No.1 system and is displayed on both sides. When LNAV is selected to OFF, bearing pointer and sensor annunciation are removed. When ADF signal is not available, the pointer is removed from the display.

A second CRS push-switch – each successive push of the switch selects in turn:

- OFF – no selected sensor or display.
- VOR/LOC1
- VOR/LOC2
- LNAV (ONSIDE, or as selected on LNAV transfer switch).

Whichever sensor is selected as primary course is removed from the above sequence.

Four map data momentary push-switches (only the six nearest of each item are displayed)

- N-AID – selects and deselects VORTAC/TAC navigation aids.
- ARPT – selects and deselects airports with runway lengths of 5,000 feet or more.
- GRP – selects and deselects Ground Reference Points.

The above data require the selection of LNAV as primary or secondary course and are displayed in MAP or PLAN formats.

- DATA – supplied by the onside LNAV. Each succeeding push selects the following sequence:
    - o OFF – no data displayed.
    - o GSPD – ground speed.
    - o WND – windspeed and direction arrow.
    - o DIST – distance to waypoint, but removed from sequence when LNAV is selected as primary course.
    - o ETA – estimated time of arrival at the active waypoint.

When the data switches are selected, an associated white bar is illuminated below each switch. The data for the display is provided from the Navigation Management System. In a single LNAV installation only the map data switches on the LH ECP are operational and map data switches on the RH ECP are inoperative.

Dimming panel (DP)

An EFIS dimming panel is located on each associated instrument panel. The DP provides the following functions:

BRT PFD dimmer control – adjusts the intensity of the associated upper DU.

BRT ND/WX concentric dimmer controls – independently adjust the intensity of the navigation information and the weather radar information on the ND. A click stop (WX OFF) is provided to deselect the weather radar display (smaller diameter control). When the ND dimmer is set to the COMPACT position (click stop), a compact display is shown on the upper DU and the lower DU is blanked. Weather radar information is not available in the ROSE or PLAN format or when the COMPACT display is selected.

DH SET – rotary selector for setting PFD decision height between zero and 500 feet, in one-foot increments. DH read-out is inhibited if set below zero. The DH read-out is removed above 2 500 feet after five seconds following selection.

TEST – provides for EFIS test (ground only) and radio altimeter test {ground and flight). The EFIS test has two levels of operation: pilot initiated test and maintenance test. The pilot initiated test is described below:

Pressing and holding the test switch (aircraft on ground) will show a failed condition for all display parameters, with the exception of radio altitude, VOR/ILS and marker information. The radio altimeter should display the test height of 40 feet. Displayed VOR/ILS and marker information are not affected by this test and have their own test switches.

EFIS master switch

Each system has an ON/OFF EFIS MSTR switch on its associated instrument panel. Associated with the RH master switch (on the RH instrument panel) are four amber AVIONICS COOLING FANS press-to-reset annunciators with the legends L EFIS, R EFIS, IRS 1 and IRS 2. These warnings come on in conjunction with the AVIONICS FAN OFF warning on the overhead panel, which is associated with the AIR COND t caption on the MWS panel.

The EFIS master switches incorporate a locking device requiring the toggle to be lifted when moved from the ON position. The primary purpose of these switches is to reduce equipment operating time during maintenance or extended turn-rounds. They are also provided for use during electrical smoke drill procedures.

Flight Director bars switch

A Flight Director (FD) engage selector switch is provided at each end of the FGS mode control panel to control the display of FD bars on the associated PFD. With the switch selected to the ON position the bars are displayed. If an FD failure occurs the bars are removed and a yellow FD legend appears to the left of centre of the PFD display. Selecting the FD switch to OFF removes the warning legend and declutters the display. The FD bars are also displayed, independently of the position of the FD switch, when windshear is detected.

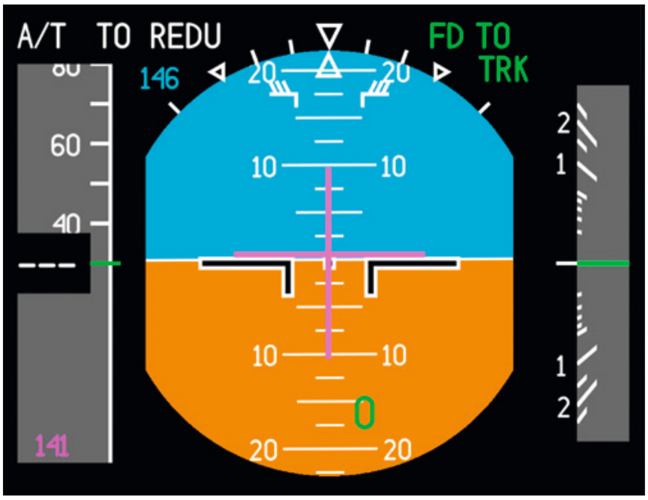
Flight annunciator test switch

The flight annunciator test switch is located on the left-hand instrument panel. It provides a filament test of all flight annunciators.

When the test switch is released, it causes the DUs to display comparator caution legends as well as the CMPRTR MSTR to come on. These indications are removed after five seconds.

Primary Flight Display (PFD)

The Primary Flight Display (PFD) provides a truncated attitude sphere with associated aircraft reference symbol compatible with Flight Director displays.



Attitude display

The attitude display includes:

- Attitude sphere (white horizon, raster cyan above and raster brown below the horizon).
- Pitch tape (white, ± 30 degrees nose up or nose down).
- Roll scale and roll pointer (white, ± 45 degrees).
- Aircraft symbol (yellow, filled ‘chevron’ for V bar flight director).
- Flight Director (magenta, cross bars).
- Windshear pitch limit indication (white, ‘eyebrows’).
- Source annunciator of pitch and roll (yellow, ATT1 and ATT2).
- Failure flag (red ATT).
- Miscompare annunciation (yellow ATT).

Pitch and roll attitude are normally derived from the onside IRS, via the associated symbol generator (SG). Failure of an IRS source will cause the removal of the pitch and roll display and the display of a red ATT annunciator. Selection of the cross-side IRS will result in the appearance of yellow source annunciations (ATT1 or ATT2) on both PFDs.

Airspeed display

The airspeed display is on the left of the PFD. This includes:

- An airspeed tape (white, 30-450 knots).
- A three-digit airspeed read-out (green/yellow/red, source ADC).
- A speed trend vector line (magenta, derived from ADC data)
- Speed warnings:
  - o VMO/MMO – Vss (red on black, barber’s pole)
  - o Vmin (minimum speed, yellow line)
  - o Vfgl (flap/gear limit speed, yellow line)

- Associated speed bugs and digital read-outs:
    - Vcross (white dagger)
    - V1 (magenta '-1' marker) with digital read-out
    - Vdot (white, filled circle on end of line)
    - Vsel (cyan-filled triangle pointer) with digital read-out
- Digital Mach read-out (green from > M0.4, red 'M---' invalid).
- Source annunciation (yellow, ADC1 or ADC2).
- Failure flags.
- Miscompare annunciation (SPD).

The digital airspeed read-out is normally green, but changes colour to yellow or red depending on the speed trend vector with respect to VMO/MMO/VSS and the airspeed in respect to the speed warnings Vss, Vmin, Vfgl, Vmo).

Lateral deviation scale

The lateral deviation scale (white) is provided below the attitude display.

This shows deviation from VOR/LOC or LNAV. The colour and shape of the indicator varies with the type of deviation shown:

ILS – magenta rectangular pointer moves over a white scale of two 'hollow dots', one on either side of a short vertical centre line. A red LOC annunciator replaces the pointer and scale in the event of failure. A yellow LOC annunciator indicates a miscompare. With excessive deviation and RA above 35 feet and a CAT2 or CAT3 approach in progress, a flashing yellow LOC symbol is displayed.

VOR – a green pointer and deviation bar is displayed within the compass rose on the ND. Red VOR legend is only displayed in the event of a data failure between the VOR receiver and EFIS symbol generator.

LNAV – a white pointer (diamond shaped) and scale is displayed on the PFD. A red LNAV annunciation replaces the pointer and scale in the event of a system failure.

If any source indicates 'NO COMPUTED DATA', the scale and pointer are removed from the display, but no failure annunciation is displayed.

Glideslope scale

A glideslope scale (white with magenta pointer) is on the right of the attitude display. With radio altitude in excess of 100 feet (or invalid) excessive glideslope deviation will cause the pointer to change to yellow and flash. In the event of failure, a red GS annunciation is shown in place of the glideslope scale and pointer.

Additional features

Additional features on the PFD are:

- FGS mode annunciators
- Autothrottle status and mode annunciations
- Flight Director
- Marker annunciation:
    - Inner marker – white 'I' in a white circle
    - Middle marker – yellow 'M' in a yellow circle
    - Outer marker – cyan 'Q' in a cyan circle

- Radio altitude four-digit read-out is shown in green, in the lower centre of the attitude display. The colour changes to yellow at DH and below. In the event of failure, a red RA annunciation replaces the read-out. Failure of one RA causes automatic reversion; the failed side displays the cross-side RA value and annunciates RA in white.
- DH set annunciation is displayed (in cyan) when below 2,500 feet, on the bottom right of the PFD. At 50 feet above DH the DH read-out flashes to indicate approach to DH. At DH the read-out is replaced by a steady yellow DH warning and an aural 'minimum' is given. Above 2,500 feet the DH read-out will show momentarily when reset. The maximum value that can be set is 500 feet, using the DH setting knob on the dimming panel.
- Comparator warnings for attitude, radio altitude, glideslope and localiser and internal comparator warnings.
- Windshear annunciation and recovery guidance, pitch limit indication (PLI), white 'eyebrows' are displayed continuously with weight off wheels and radio altitude up to 2,000 feet. Associated annunciators are GAWS (go-around windshear), TOWS (take-off windshear) and WS MAX (maximum thrust).

Navigation display (ND)

Heading information comes from the onside IRS and can be selected on the HDG switch to either MAG or TRUE. Reversionary switching is available from the ATT HDG transfer switch. Both switches are on the left-hand instrument panel. TRUE (white) and HDG1/2 (yellow) annunciators indicate HDG and transfer selections respectively.

The ND provides four formats:

- ROSE
- ARC
- MAP
- PLAN

Peripheral information remains in the same location, regardless of format.

ROSE format

The ROSE format provides a 360-degree compass rose. A selected heading cursor and heading read-out are provided. A single bearing pointer is displayed as selected from the BRG switch on the ECP. If two sources exist, SG1 always displays bearing pointer 1 and SG2 displays bearing pointer 2, otherwise bearing pointer I is displayed on both displays. Both bearing pointers are green, but pointer 1 is solid and pointer 2 is hollow.

Given valid bearing data, a bearing pointer is shown together with an appropriate green annunciator (ADF/VOR or WPT). With failed data the annunciator shows red and the bearing pointer is not shown.

If data is NCD, the pointer is removed but the legend remains green.

A primary course pointer and deviation indicator is selectable (from VOR, LOC or LNAV) on the CRS selector of the associated ECP. TO/FROM annunciation is provided when VOR is selected. Normally only the onside sensors may be selected as primary course.·

A glideslope deviation scale is displayed on the right-hand side of the ND when a localiser is selected as primary course.

Additional ROSE format information is as follows:

- A second course pointer and deviation scale may be selected from VOR/LOC or LNAV.
- Navigation data from the LNAV system may be selected from:
    - OFF, no data displayed
    - Ground speed
    - Wind speed and direction
    - Estimated time at active waypoint

Distance to waypoint may also be selected as LNAV data when LNAV is not selected as a primary course.

The navigation data is shown at the bottom right-hand side of the ND.

With LNAV selected as primary course, a white DIST annunciator replaces the DME annunciator and a white ‘distance to waypoint’ read-out is shown below.

Secondary course is differentiated by its symbology display and annunciator. Secondary course is displayed by a hollow pointer, and is orientated and displays exactly as the primary course. Controlled by the LNAV system, the secondary course pointer is colour-coded CYAN. No scale marks (dots) are displayed for secondary course.

With VOR/ILS information displayed as primary course, selection of DME HOLD is annunciated by a yellow ‘H’ next to the DME1(2) annunciation field. If ILS is selected, the displayed DME distance read-out is magenta. If VOR is selected the read-out will display green.

Comparator warnings are provided for heading, glideslope and localiser.

Should a configuration error exist, this is indicated by a yellow maintenance check (MAINT CHECK) annunciation on the left-hand side of the ND.

ARC format

The ARC format provides an expanded section of the compass rose of approximately 110 degrees (± 55 degrees of the compass heading).

At the bottom of the display there is an aircraft symbol. In order to assist selection of the required heading, the selected heading cursor is enhanced by dashed line drawn between the cursor and the aircraft symbol. A TRUE annunciation is shown when HDG is selected to TRUE and the system is in the ROSE mode.

The primary course, secondary course and bearing pointers retain a similar shape to the ROSE format but the length of the deviation bars is increased. TO/FROM annunciation is shown TO or FROM a tuned VOR station.

A half-range arc is drawn midway between the compass sector and the aircraft symbol whenever valid radar information has been selected. A half-range read-out is provided on the left-hand side, which is controlled by the RANGE switch on the ECP.

Yellow LNAV annunciations of MSG or DR are displayed on the top left of the ND (with any mode selected) and white LNAV annunciations of WPT and/or XTK are displayed on the top right of the ND.

SG 1 or SG 2 source annunciation, MAINT CHECK and weather radar annunciations are on the lower left-hand side of the ND.

The location of the peripheral data is the same as for the ROSE format.

MAP format

The compass arc, aircraft heading and weather radar indications are identical to the ARC mode. The aircraft symbol changes to that of a yellow 146/RJ aircraft.

The bearing and drift pointers are the same as in the ARC format. The half-range arc is the same as that for the ARC format except that it is always displayed.

Glideslope information is not displayed in this mode.

Primary course VOR information is provided as a green VORTAC symbol in correct relation to the aircraft symbol. The VOR symbol is only shown when the VOR bearing and DME signals are both received; otherwise, if only the VOR signal is received, the display is identical to the ARC mode. It is essential that the VOR and DME idents are checked before use. The VORTAC is overlaid with a green line representing the selected course. A solid line is drawn TO the station and a dashed line FROM the station. TO/FROM annunciation is also shown. When the DME of the associated VOR is not available, or is in HOLD, then the VORTAC symbol and course line are removed.

Primary course LNAV information is displayed in white with the active waypoint in magenta. Waypoint identifiers are displayed adjacent to the waypoint symbol (star shaped). If the associated VOR or active waypoint is off screen, an arrowhead is drawn to show the direction of the station or waypoint.

Second course information is displayed similarly to primary, but is always shown in cyan to distinguish it from primary course information.

Providing a suitable flight plan has been loaded, and with LNAV selected as primary or second course information, an actual flight plan with interconnected waypoints is displayed. Using the ECP, CRS and FORMAT switches, together with the select buttons, the following displays may be selected:

- **N-AID** – selects and displays the ten closest navaids (excluding the tuned VOR/DME which are consistent with the selected range on the ECP.
- **ARPT** – selects and displays the ten closest airports (with runway larger than 5,000 feet) which are consistent with the selected range. The symbol used is a white circle with adjacent identifier.
- **GRP** – selects and displays the ten closest ground reference points. The symbol used is a cyan triangle with adjacent identifier.
- **DATA** – selects in turn from the following sequence: GSPD, WND, ETA and DIST.
- **OFF** – no data displayed.
- **GSPD** – ground speed.
- **WND** – windspeed and direction arrow.
- **DIST** – distance to next waypoint.
- **ETA** – estimated time of arrival at the active waypoint.

Distance to next waypoint is removed from the DATA list when LNAV is selected as primary course.

These DATA functions are available in ROSE, ARC and MAP modes.

The location of peripheral data remains the same as in the ROSE and ARC formats.

SG1 or SG2 source annunciation, MAINT CHECK and weather radar annunciations are the same as the ARC formats.

PLAN format

The PLAN format is primarily for use with LNAV selected on the ECP.

The compass arc is identical to the ARC and MAP modes. A TRUE annunciation is shown when HDG is selected to TRUE.

Aircraft heading is displayed in the same manner as the ARC and MAP modes.

Selected heading is similar in display and function to the ARC and MAP modes, except that there is no dashed line extending from the selected heading cursor to the aircraft symbol.

LNAV is the only type of primary course displayed in the PLAN mode. When LNAV is selected, a ‘North up’ plan view of the current LNAV flight plan is displayed with the active waypoint always in the centre of the display. Indication of the ‘North up’ display is a white arrow, pointing straight up, with a white ‘N’ above.

Any waypoint in the active flight plan can be selected to be in the centre of the range ring by using the STEP function on the FMS LEGS page.

LNAV annunciations of MSG, DR, WPT and XTK are displayed as in the ARC format. Second course, bearing pointers, vertical deviation, LNAV-selectable data and weather radar are not displayed in the PLAN mode.

DME distance is displayed if VOR/LOC has been selected as primary course on the ECP, but no VOR/LOC information is displayed below the compass arc.

SG1 or SG2 source annunciation, MAINT CHECK and weather radar annunciations are the same as in the ARC and MAP formats.

LNAV data (GSPD, WIND, DIST and ETA) is not available in PLAN format, but N-AID, ARPT and GRP selections are available.

Power supplies

EFIS 1 is supplied from the ESSENTIAL AC bus and EFIS 2 is supplied from the AC2 bus.

Power supplies from the EFIS are not available at the emergency level, but the standby horizon includes an ILS cross-pointer display and operates from EMERGENCY DC/BATT.

Colour coding

Red

- Failure warnings

Yellow

Cautionary legends and warnings, such as:

- Cross-side (reversionary) source legends (SG1/2, HDG1/2, ATT1/2)
- Decision height warnings (DH) on PFD
- Pitch and roll references on PFD
- Aircraft reference symbol on PFD and ND
- LNAV MSG and DR annunciations
- Comparators and MAINT CHECK annunciation
- ILS excessive deviation warnings
- FD bars not available
- Airspeed limits

White

- Scale markings
- LNAV nav data, WPT and XTK annunciations on ND
- Armed FGS modes
- Half-range arc
- Inner marker annunciation
- TRUE compass annunciation
- TO/FROM VOR annunciation
- Primary course LNAV mode
- Compass card

Green

- Onside VOR and DME data
- Bearing pointers and legends
- Active FGS modes
- Current data, such as radio altitude height

- Drift pointer
- Primary course VOR mode

Cyan

- Second course information
- Selected values, e.g. heading cursor and read-out, DH read-out, map range read-out (PLAN only).

Magenta

- ILS pointers and legends
- FD bars
- Primary course active waypoint
- Primary course LOC mode
- Speed trend vector

Blue and brown

- Provided for PFD sky/ground

Shape coding

MAP and PLAN format WAYPOINTS, VOR, VOR-DME/VOR-TAC and DME/TACAN, airports and ground reference points are shape coded.

Shape coding is also used to identify symbols. The following examples are given:

- Bearing pointers, single for pointer 1 and double for pointer 2
- Localiser and glideslope deviation use rectangular deviation pointers
- PFD lateral deviation pointers use a:
    - Green triangle for VOR
    - Magenta triangle for LOC
    - White diamond for LNAV
- PFD lateral deviation scales use:
    - Four circles for VOR
    - Two circles for LOC
    - Two vertical lines for LNAV

Comparator

There are two CMPRTR MSTR amber annunciators, one on each flight annunciator panel. Normally each comparator master is driven from its associated symbol generator. If a single SG is selected, both annunciators are driven from the same source.

The annunciator combines the alerting function for:

- Attitude and heading miscompare (ATT, pitch and roll greater than four degrees; HDG greater than six degrees).
- Speed miscompare (SPD, 3-8 knots depending upon airspeed).
- Glideslope, localiser and radio altitude miscompare (GS, LOC, RA).

When an SG detects a miscompare for one of the above parameters, it causes the EFIS annunciator to flash for five seconds. In addition, the CMPRTR MSTR is illuminated flashing for five seconds.

After five seconds, if the rniscompare conditions no longer exist, the warnings are removed. If the condition remains, the annunciators and legends become steady.

If the SG detects a comparator failure (or a failure of the cross-talk bus), which may prevent correct operation of any of the compared parameters, then the CMPRTR MSTR annunciator will flash and then become steady. A yellow CMPRTR legend is displayed on the lower right of the PFD.

Pitot-static system

Three independent pitot-static systems are installed in the aircraft, designated as 1, 2 and 3. Numbers 1 and 2 are duplicated and provide pressure inputs to air data computer (ADC) 1 and ADC 2. The number 3 system provides pressure inputs to the standby ASI/ALT and to the combined cabin altimeter/vertical speed/differential pressure indicator.

In addition, the number 3 system provides inputs to the Q-pot failed pressure switch. The elevator and rudder Q-pots are supplied by a separate combined pitot-static head.

Air Data Computer (ADC)

Two ADCs are located in the avionics racks, designated ADC 1 and ADC 2. Only one ADC is described. The ADC receives inputs from the:

- Associated pitot-static system (1 or 2)
- Associated outside air temperature sensor probe (1 or 2)
- Associated angle-of-attack sensor (1 or 2)
- Baro set controls from both altimeters.

The inputs are processed by the ADC, which outputs the following air data to the user systems:

- Altitude
- Computed airspeed
- Mach number
- True airspeed
- Static air temperature
- Altitude rate
- Angle of attack
- Overspeed (VMO/MMO)

The following components or systems (1 and 2) receive information from their respective ADCs:

- Flight Guidance System (FGS)
- EFIS (airspeed/Mach, vertical speed when IRS input invalid)
- Altimeters (Captain’s and F/O’s)
- Flight Management System (FMS)
- Inertial Reference System (IRS)
- Mode-S transponders
- Ground Proximity Warning System (GPWS) computer
- Flight Data Recorder (FDR)
- Air Data Accessory Unit (ADAU)

Note: *The FGS, EFIS, altimeters, IRS and ADU systems can receive data from both ADCs. If the primary ADC source fails, the alternate system is selectable by the ADC transfer switch.*

Air data accessory unit (ADAU)

The ADAU is located in the avionics rack and interfaces between the two ADCs and the aircraft system, to provide airspeed and altitude discrete inputs to the various systems. In addition, the ADAU provides analogue versions of computed airspeed and standard pressure altitude to the ELC, and computed airspeed to the stall warning and identification system. The following systems are supplied with discrete signals:

- Rudder limiter
- Flap baulk control
- Landing gear not down warning
- MWS (for take-off inhibit)
- APU anti-surge control
- Stall system
- Engine Life Computer (ELC)

ADC transfer

An AIR DATA transfer switch on the lower left-hand instrument panel allows selection of the alternate ADC for display of airspeed, MACH number, vertical speed, altitude and temperature.

In the event of an ADC failure, the pilot is able to switch complete control of the ADAU to either of the two ADCs via mutually exclusive ‘ALL ON ONE’ or ‘ALL ON TWO’ earth-seeking signals. These signals are derived from the pilot’s BOTH 1 - NORM - BOTH 2 switch mounted on the air data instrument panel. A yellow cautionary legend (ADC 1 or ADC 2) is displayed on both PFDs whenever a single air data source is displayed to both pilots.

Note: *ADC transfer is a manual operation which is performed after an ADC failure indication; it does not occur automatically. However, if the aircraft is operating at essential power levels, the ADAU will switch to ‘ALL ON ONE’ operation automatically when AC 2, which supplies ADC 2, is unpowered.*

Radio navigation

VHF navigation

The VHF navigation system receives signals from ground-based VHF Omni-range (VOR) and ILS glideslope/ locator transmitters and provides deviation and bearing outputs for display on the EFIS displays and the distance bearing indicators (DBI).

The system is comprised of two glideslope antennae, two DME antennae, two VOR/LOC antennae, two VOR receivers, two ILS receivers and two VHF NAV/DME control units.

The VHF navigation system is an airborne system that combines the VOR, localiser and glideslope functions. It operates on frequency ranges of 108 MHz to 118 MHz with 50 kHz channel spacing.

The test facilities for the VOR and ILS are on the VHF NAV/DME control units.

Power supply is through AVIONICS MASTER switch 1 for system 1 and AVIONICS MASTER switch 2 for system 2. The number 1 system is supplied from the EMERG AC busbar for the number 1 controller from the EMERG DC bus. The number 2 system is supplied from the AC 2 busbar and the controller from the DC 2 bus.

Distance measuring equipment (DME)

The dual DME system measures the slant-range from the aircraft to the DME ground stations. Up to five stations can be interrogated in a continuous sequence. The range of the manually tuned station is displayed on the EFIS and on the DBIs. The other four stations are automatically selected and tuned by the navigation management systems (NMS).

Control of the DME, with HOLD and TEST facility, is integral with each VHF NAV/DME control unit.

Power supply for DME 1 is ESS AC (via AVIONICS MASTER 1) and for DME 2 is AC 2 (via AVIONICS MASTER 2).

When STBY is selected, the receiver is immediately available and power is supplied to the transmitter but operation is inhibited. After a time delay the system is held ready for immediate operation and four dashes are displayed.

When NORM is selected, the DME transmitter is inhibited for approximately one minute to enable warm-up, but the receiver is immediately available. When a ground station signal is received, the identification code is fed to the audio integrating system and the distance indication show four dashes.

As soon as the airborne DME transmits, the DME circuits start to search for reply pulses and four dashes are displayed until these are detected, when distance is displayed.

When HOLD is selected, a new frequency may be selected but the DME will continue to operate on the previous frequency and an ‘H’ is annunciated on the EFIS. The held frequency is shown in the lower read-out of the controller.

Operation of the ILS/VOR/DME TEST (depending on the frequency selected on the VHF NAV controller) provides a functional test of the entire system. During the test (after a delay of approximately five seconds) the distance display on the DBIs and EFIS ND shows 0.0. These remain as long as the test switch is held.

During periods of self-test, a continued display of dashes confirms correct operation.

Automatic direction finder (ADF)

The automatic direction finding (ADF) system is a medium-frequency system which provides continuous indication of the magnetic bearing of any selected radio station which operates within the frequency range of 190 to 1,750 kHz.

The system is comprised of a control panel, a receiver and associated loop and sense antennas.

The magnetic bearing is shown on the distance bearing indicators (DBI) and on the EFIS navigation displays (see the Instrument displays and EFIS sections).

The dual control panel has the following controls and indications:

- Two frequency read-out windows with ADF 1 and ADF 2 inscribed above each window.
- Three concentric knobs under each frequency window allow selection of the desired frequency. The large knob is for 100 kHz increments, the middle knob for 10 kHz and the small centre knob for 0.5 kHz increments.
- Two BFO-OFF switches for ADF 1 and 2 respectively, when set to BFO, permit reception of carrier wave (CW) signals to the audio integrating system for the purpose of station identification. In OFF, the BFO is off and the receiver reception is normal.
- Two ANT-ADF switches, one for each system, select the mode of operation:
    - o ANT mode – in this mode the system operates as an audio receiver and the bearing indication shows 90-degree relative bearing on DBI and pointer is removed from EFIS.
    - o ADF mode – in this mode the system operates as an automatic radio compass.

Power supply for ADF 1 is from 115V EMERG AC bus and is controlled through the AVIONICS MASTER switch No.1. ADF 2 is supplied from 115V AC 2 bus and is controlled through AVIONICS MASTER switch No.2.

Marker system

The marker system is tuned to a fixed frequency and has a MKR HI/LO sensitivity switch installed on the left-hand instrument panel. The receiver circuits are part of the No.1 VOR receiver.

Receiver outputs are sent to the EFIS for display on the PFDs. Simultaneous outputs go to the audio integrating system.

Power supply is through AVIONICS MASTER switch 1 and comes from the EMERG AC busbar.

The marker system can be tested by selecting a VOR frequency and pressing the TEST button on the NAV controller. This will cause the marker legends to flash in turn on the EFIS PFDs.

Radar navigation

Radio altimeter

The radio altimeter (RAD ALT) system provides continuous accurate height (terrain clearance) information during low approach and landing from altitudes of 2,500 ft to touchdown.

A dual radio altimeter system is installed, each consisting of:

- A dual-channel monitored transceiver, suitable for CAT 3A operation.
- Two strip-line antennas, one for transmit and one for receive.

The system operates in the frequency range of 4,250 to 4,350 MHz. Indications are shown on the associated EFIS PFDs. No.1 RAD ALT is shown on the left PFD and No.2 RAD ALT is shown on the right PFD. Radio altimeter read-outs are shown in green and a failure is shown by a red RA annunciation. A radio altitude miscompare warning (yellow RA) shows to the right of the radio altitude read-out.

A decision height (DH) knob on the EFIS dimming panel is used to set the decision height on the associated PFD. The DH read-out can be set between zero and 500 feet in one-foot increments. DH read-out is removed and DH warnings are inhibited if the DH is set below zero. The read-out is also removed above a radio altitude of 2,500 feet, but is shown momentarily if the DH knob is rotated.

As the aircraft descends through 50 feet above the selected DH, the read-out starts flashing to indicate approach to DH. At DH read-out is replaced by a yellow DH warning and an aural ‘minimums’ is given.

A radio altimeter system self-test is incorporated in the EFIS test sequence, which is initiated from the TEST button on the left and right EFIS dimming panels. When pushed and held, a test altitude of 40 feet is momentarily displayed on the associated PFD until the button is released. The test can be performed with the aircraft on the ground or in the air.

Power supply for the No.1 radio altimeter goes through AVIONICS MASTER switch 1 and is from the ESS AC busbar; for No.2 radio altimeter it goes through AVIONICS MASTER switch 2 and is from the AC2 busbar.

Single radio altimeter failure is shown by a white ‘RA’ on the EFIS PFD; both PFDs displays are driven from the operational RA.

Transponder

The Air Traffic Control (ATC), Secondary Surveillance Radar (SSR) system provides the airborne element of the auto digital communications system for ATC. Following interrogation by the ground station, the ATC/SSR responds, allowing the aircraft to identify itself and its altitude to the interrogator.

The transponder has the capability of operating with Mode-S as well as with the standard interrogators. Mode-S uses additional pulses to encode the data necessary for TCAS operation.

The dual system consists of two Mode-S transponders, a single control unit and two pairs of antennas (an upper and lower antenna for each system). The system receives signals on the frequency of 1,030 MHz and transmits on a frequency of 1,090 MHz.

The ATC controller has nine keys which are used to select the ATC code. The selected code is shown on a four-digit LCD. The following controls and indicators are fitted:

- ALT RPTG (1/OFF/2) – a three-position switch used to select ADC No.1 or No.2 as the altitude source, or to switch off the altitude reporting mode.
- XPDR (1/2) – a two-position switch to select the transponder system. The appropriate legend ATC 1 or ATC 2 is shown on the display.
- An amber XPDR FAIL lamp indicates failure of the selected system.
- A STBY/ON rotary switch is combined with the TST push-button. During the test the XPDR FAIL lamp will illuminate for three seconds and PASS or F (fail) codes are shown on the display.
- An IDNT button activates the identification mode.

Weather radar

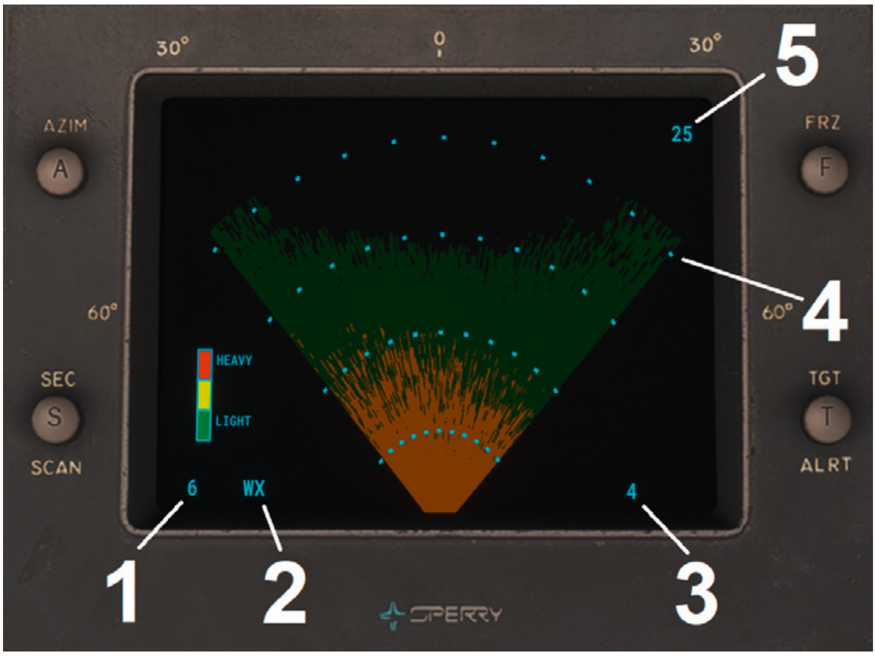
The weather radar system detects and locates precipitation along the aircraft's flight path and gives the pilot a visual indication, in contours, of its intensity. Intensity levels are displayed in bright colours contrasted against a deep black background.

The areas of heaviest rainfall will appear in red, the next level of rainfall in yellow, and the least rainfall in green. A colour-bar legend to confirm each displayed colour and a range/mode alphanumeric to facilitate the evaluation of data are displayed on normally unused areas of the screen. After proper evaluation, the pilot can chart his course either through or around precipitation.

The indicator contains the following selectors:

- **INT** – the intensity control adjusts the brightness of the WXR return shown on the display.
- **RANGE** – rotary switch with seven detent positions, used to select one of six ranges or TEST mode. Range selections are 10, 25, 50, 100, 200 and 300 nautical miles. The TEST mode provides a special test pattern in which all colours are displayed. In TEST mode the range selection is automatically 100 nautical miles, gain is set to the preset level and transmitter energy is switched into a dummy load.
- **GAIN** – system gain is controlled via the rotary control. Clockwise rotation increases gain and anticlockwise rotation reduces it. Current gain is displayed in the bottom left corner of the display.
- **OFF** – push-button switch used to turn radar off.
- **STBY** – after the warm-up period it is ready to operate in any selected mode. Radar can also be turned on by depressing any other mode selection switch and it will automatically go into operation at the end of the warm-up period. STBY is displayed.
- **WX** – toggles whether the unit displays the WXR return.
- **CYC** – toggles the unit's cyclic weather detection function which causes red areas in the display to flash on and off at half-second intervals.

- **MAP** – toggles whether a map with waypoints, airport ICAO codes and your current flight plan is displayed on the WXR display.
- **TILT** – antenna tilt is controlled from 15 degrees down to 15 degrees up and has a fidelity of one-degree adjustment. The current tilt setting is displayed on the bottom right corner of the display.



1. Current gain setting
2. Mode in which the system is currently operating
3. Current tilt angle
4. Range rings
5. Current range setting

Ground Proximity Warning System (GPWS)

The ground proximity warning system (GPWS) provides visual, aural and

synthesised voice annunciation to warn of an impending hazardous situation with regard to terrain avoidance. Altitude call-outs are also given.

The system consists of:

- GPW computer in the avionics bay.
- Two combined PULL UP annunciators, TEST/GS INHIBIT switches on the glare shield.
- FLAP WARN OVRD override switch on the right instrument panel, which is used to prevent nuisance TOO LOW FLAP warnings when landing with abnormal flap setting.
- 24/33 landing flap selection on the right instrument panel, used when landing with 24° flap.

- S.APP (steep approach) selected (white) / engaged (green) push-button, also on the right instrument panel and used to prevent nuisance SINK RATE warnings during steep approaches.
- White GPWS INOP annunciator on the central status panel.

The GPW computer (GPWC)

The GPWC compares various inputs with the six warning mode envelopes which are stored in memory. When 'boundary penetration' is detected, the computer sends a visual and/or audio warning to the flight crew. Voice vocabularies, together with their order of priority, are stored in memory.

Mode 1 – excessive descent rate

Mode 1 provides a warning based on inertial vertical speed and radio altitude. If IRU 1 is inoperative, the GPWS uses barometric altitude rate from ADC 1.

Two different warning envelopes are provided: an outer and an inner envelope. The upper boundary of both envelopes is 2,450 feet AGL, and the lower boundary is normally 10 feet, but is reset to 30 feet for take-off to allow for ground effect.

Penetration or the outer envelope activates the GPWS warning lights and gives a voice warning of "SINK RATE". This continues until the penetration is rectified.

Further penetration of the outer envelope reaches the inner envelope and the voice message changes to "WHOOP WHOOP, PULL UP".

There is a delay to both of the above messages, which ensures that at least one "SINK RATE" warning is given before the "WHOOP WHOOP, PULL UP" warning message starts.

At airports with ILS glideslopes of 4.5 to 6.0 degrees, white S.APP indicates selection and green indicates enabled, which occur when landing flap and landing gear are down.

Mode 2 – terrain closure rate

Mode 2 provides warnings based on the 'rate of reduction' of altitude above ground (closure rate) as against altitude above ground, phase of flight and speed.

The mode has two envelopes, designated 2A and 2B. The warning given is the same for both and is described below.

Upon first penetration of the envelope, the GPWS warning lights come on and a voice message of "TERRAIN" is given. If the boundary penetration lasts for more than two such messages, the warning changes to "WHOOP WHOOP, PULL UP", which is repeated continuously until the envelope is departed. Once the warning ceases, the lamps remain ON for a period of time dependent on the rate of altitude gain.

Mode 2A – flaps not down and aircraft not on glideslope

The lower boundary of this envelope is set at 30 feet with the normal upper limit set at 1,650 feet at 220 knots or less and a computer maximum closure rate of 5,733 feet/minute. As airspeed increases from 200 to 310 knots, the upper boundary is linearly increased to 2,200 feet and the maximum closure rate is linearly increased to 9,800 feet/minute.

Mode 2B – landing flap or aircraft on glideslope during ILS approach

Lowering the flaps to the landing position (as defined by the 24/33 flap selection switch) automatically switches the GPWS to Mode 2B. The envelope is the same as for Mode 2A except that the upper boundary is lowered from 1,650 feet down to 789 feet. The maximum closure rate is reduced to 3,000 feet/minute so as to be consistent with the approach phase. The lower part of the boundary is controlled as a function of radio altitude and altitude closure rate.

This mode is also selected when the aircraft is on an ILS approach with the glideslope deviation less than 1.3 degrees (i.e. less than required to give Mode 5 soft glideslope warning). In this case the envelope is slightly different from the flaps down case such that the lower boundary is controlled only as a function of radio altitude with a lower cut-off of 200 feet.

Mode 3 – excessive altitude loss after take-off or go-around

Mode 3 provides a warning for excessive altitude loss after take-off or go-around, based primarily on radio altitude and altitude loss. Penetration of the envelope results in the GPWS lights illuminating and the voice message “DON’T SINK”. The amount of height loss necessary to activate a warning depends on the flight profile and time. The message is repeated until such time as the situation is rectified.

The original altitude at which the height loss started is retained in memory until the aircraft climbs above the stored altitude.

Mode 3 is active during the take-off phase of flight, switching from take-off phase to approach phase during the third segment climb-out (due to high radio altitude). This usually occurs at 667 feet radio altitude. In the event that the airspeed has increased to greater than 190 knots, the mode switching is delayed.

Switching from approach mode to the take-off mode (GA) is accomplished when the aircraft passes below 245 feet with gear and landing flap down.

Mode 4 – unsafe terrain clearance

Mode 4 has three sub-modes, each with a different voice warning and designated 4A, 4B and 4C. The warnings are based on radio altitude, computed airspeed and aircraft configuration. Initial penetration of all three envelopes will cause the GPWS warning lights to come on. The envelopes are modified at problem airports.

Mode 4A – active during cruise and approach phases

The upper boundary for Mode 4A is normally 500 feet radio altitude. If this is penetrated with the landing gear still up, a voice message “TOO LOW, GEAR” is given. When the landing gear is down the warning is cancelled.

At 190 knots the upper boundary increases linearly to a maximum of 1,000 feet at a speed of 250 knots or more. Penetrating this upper boundary produces a repetitive message of “TOO LOW, TERRAIN”.

Mode 4B – active during approach phases

When the landing gear is lowered, the upper boundary is decreased to 245 feet. At 159 knots the boundary increases linearly to 1,000 feet with increased speed of 250 knots. Penetration of the boundary at speeds of less than 159 knots, with landing flap not down, results in the warning “TOO LOW, FLAPS” (when the landing flap is down the warning is cancelled). At higher speed the warning is changed to “TOO LOW, TERRAIN”.

Mode 4C – activated during take-off phase

This mode is provided to prevent collision with rising ground after take-off, which produces insufficient closure rate to produce a Mode 2 warning. It is based on a minimum terrain clearance that increases with radio altitude during take-off. The mode is activated at 100 feet radio altitude and is deactivated when the radio altitude is below 30 feet or the approach phase is entered.

A value equal to 75% of the current radio altitude is stored in such a way that it is only allowed to increase in value. If the radio altitude decreases, the maximum attained value is stored and a further decrease below 75% stored value, with landing gear and flaps up, results in a warning of “TOO LOW, TERRAIN”.

Mode 5 – activated by glideslope capture during an ILS approach

Mode 5 provides two levels of warning, soft and hard, when the aircraft descends below the glideslope on an ILS approach.

The upper boundary is a nominal 1,000 feet; other heights are used at problem airports.

The first level of warning is given when the aircraft is more than 1.3 dots below the glideslope and is called a ‘soft’ “GLIDESLOPE” warning, because the volume level is half that of the other warnings.

The second level of warning occurs below 300 feet radio altitude, with glideslope deviations of more than 2.0 dots, and is called a ‘hard’ “GLIDESLOPE” warning because it is given at the normal volume level.

Both boundaries allow additional deviation below 150 feet radio altitude to allow for normal variations near the runway threshold.

The repetition rate of the “GLIDESLOPE” message varies as a function of radio altitude and glideslope deviation. The rate is slow at 1,000 feet and 1.3 dots deviation and increases in repetition rate as altitude decreases or as deviation increases.

The “GLIDESLOPE” warning can be manually cancelled below 1,000 feet radio altitude by pushing either of the GPWS GS INHIBIT annunciator push-button switches on the glareshield. The mode is automatically reset when the aircraft climbs above 1,000 feet or descends below 30 feet.

Mode 6 – altitude call-outs and minimums

No visual warnings are given in this mode. All other GPWS voice messages take priority over the altitude call-outs which are as follows:

- “FIVE HUNDRED”
- “ONE HUNDRED”
- “FIFTY”
- “FORTY”
- “THIRTY”
- “TWENTY”
- “TEN”

Additionally, a voice annunciation of “MINIMUMS” is given when the aircraft descends below the decision height (DH) set on the EFIS dimming panel. This annunciation is given a high priority, e.g. between “TERRAIN” and “TOO LOW, TERRAIN”.

GPWS self-test

There are three types of flight deck tests:

- Short test
- Airborne short test
- Long test

All of the above are initiated by pushing either of the two GPWS PULL UP annunciator TEST switches on the glareshield. The type of test, short or long, depends on the length of time that the test switch is pushed.

The short test

Momentarily push in the GPWS TEST switch and the short test sequence is as follows:

- The white GPWS INOP annunciator comes ON, on the CSP.
- One GLIDESLOPE voice warning is given.
- The red GPWS PULL UP annunciators come on.
- One “WHOOP WHOOP, PULL UP” warning is given.
- The GPWS PULL UP annunciators go off.
- The GPWS INOP annunciator goes off.

The airborne short test

The test sequence is the same as the short test given above, but can only be carried out above 1,000 feet.

The long test

Push and hold the GPWS TEST switch until the “SINK RATE” message is heard, and the long test sequence is as follows:

- The white GPWS INOP annunciator comes on, ON the CSP.
- One “GLIDESLOPE” voice message is given.
- The red GPWS PULL UP annunciators come on.
- One “WHOOP WHOOP, PULL UP” warning is given.
- The red GPWS PULL UP annunciator goes off.

The following voice warnings are then given:

- “SINK RATE”
- “WHOOP WHOOP, PULL UP”
- “TERRAIN”
- “WHOOP WHOOP, PULL UP”
- “DON’T SINK”
- “TOO LOW, TERRAIN”
- “TOO LOW, GEAR”
- “TOO LOW, FLAPS”
- “TOO LOW, TERRAIN”
- “GLIDESLOPE”
- “MINIMUMS”

The altitude call -outs are then given and the GPWS INOP annunciator goes out.

Power supplies

Power supplies are from 115V ESS AC, through a GPWS circuit breaker. Switching is through the AVIONICS MASTER switch 1. The warning circuits are powered from the 28V ESS DC/BATT bus, through a GPWS WARN circuit breaker.

OXYGEN SYSTEM

High-pressure gaseous oxygen is stored to supply oxygen to the flight crew and passengers. The oxygen system cylinders and charging equipment are located in the front cargo compartment, immediately forward of the door. Flight crew breathing equipment is the diluter demand type. The passengers' equipment is the continuous-flow type.

Flight crew oxygen supply

Gaseous oxygen is supplied from two cylinders installed behind an access panel in the lining on the right-hand side of the front cargo compartment, immediately forward of the compartment door. The cylinders are charged to 1,850 PSI from a charging valve mounted forward of the cargo compartment door. A pressure indicator is located adjacent to the charging valve. In addition, each cylinder head incorporates a contents indicator.

The supply is routed to a manually operated system isolation valve and a system pressure (contents) indicator in the First Officer's side console. From a system regulator, set at 70 PSI, the supply passes to a mask stowage in each side console. The regulator has an integral relief valve which limits downstream pressure to 100 PSI.

Passenger oxygen supply

The passenger oxygen supply is tapped from the flight crew piping downstream of the regulator through parallel passenger system isolation valves, one on each side console, enabling the passenger supply to be selected ON by either pilot. A passenger system pressure indicator is located in the First Officer's side console.

From the passenger system isolation valves, the supply is routed to the drop-out units providing an oxygen mask at each passenger seat and in each toilet.

PNEUMATIC SYSTEMS

The pneumatic system supplies the following services:

- Engine air intake anti-icing
- Air conditioning and pressurisation
- Airframe ice protection
- Hydraulic tank pressurisation (No.2 and No.3 engines)
- Potable water tank pressurisation
- Toilet flushing (No.1 and No.2 engines)
- Pressurisation control discharge valve jet pump operation
- Stall identification and warning pneumatic system

Note: *The APU or ground supply cannot provide engine intake anti-icing, airframe ice protection or hydraulic tank pressurisation.*

Engine air is taken from the final HP compressor stage of each engine to a peripheral manifold on the engine. The engine intake supply is taken from the bottom, and the airframe systems supply is taken from the top of the manifold.

The air destined for the airframe systems is ducted to its respective engine pylon. Within each pylon is a bleed air control system. The control system includes an isolation valve and components which regulate the temperature and pressure of the bleed air. The isolation valve is automatically closed if over-temperature or over-pressure is sensed within the pylon bleed air ducting.

Ducting in the pylons, wing leading edges, wing trailing edges, spine fairing, fin leading edge and air conditioning bay distributes the bleed air to the airframe systems. The No.1 and No.2 engines supply a left duct system, and the No.3 and No.4 engines supply a right duct system.

The auxiliary power unit can supply air for cabin conditioning in the following phases of operation: turn-around, taxi, take-off, initial climb, approach and landing.

Main engine air supply

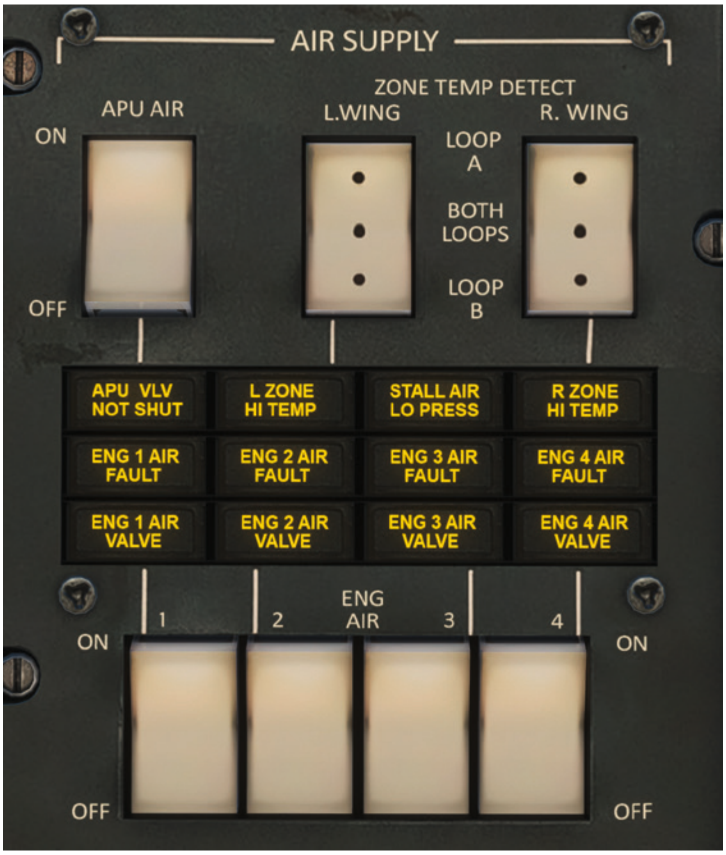
The air flows from the engine outlet to a combined isolation and pressure-regulating valve. The isolation valve is electro-pneumatic; it requires both electrical power and compressor delivery air pressure to open. From the isolation valve the air passes into a precooler; the precooler cooling medium is engine fan air which is ducted through a temperature control valve.

From the precooler outlet, the HP compressor air passes through a flow-limiting venturi. The temperature control valve is pneumatically controlled by a temperature sensor downstream from the flow limiter. A non-return valve downstream from the venturi prevents flow into the pylon control system from one of the other engines or the APU.

Located upstream from the non-return valve is a low-temperature switch. If any airframe anti-ice switch is ON and any low-temperature switch senses a low-temperature condition, an amber AIR LO TEMP annunciator (on the ICE PROTECTION panel) illuminates together with the associated ENG AIR FAULT annunciator.

If an ENG AIR switch is selected ON when the aircraft is on the ground, a green AIR SEL ON GRND annunciator illuminates on the MWP. The 'on ground' condition is sensed by a squat switch.

When a fire handle is pulled to its fullest extent, the electrical open signal will be removed from the associated isolation valve, causing it to close. The relevant ENG AIR VALVE annunciator will remain illuminated until its ENG AIR switch is selected OFF.



On the AIR SUPPLY panel of the flight deck roof instrument panel are four ENG AIR switches, one for each engine. Above each switch is an associated ENG AIR VALVE amber annunciator. Each switch operates its engine's isolation valve. On the outlet side of each valve is a pressure switch which inferentially senses the position of the isolation valve. The pressure switch and flight deck switch operate together to illuminate their ENG AIR VALVE annunciator. Above each ENG AIR VALVE annunciator is an associated ENG AIR FAULT amber annunciator.

Between the isolation valve and the precooler is an over-pressure switch and immediately downstream from the precooler is an over-temperature switch. If either an over-pressure or over-temperature condition is sensed, the appropriate switch electrically removes the isolation valve electrical open signal (thus the valve closes) and illuminates the associated ENG AIR FAULT annunciator. The associated ENG AIR VALVE annunciator will remain illuminated until its ENG AIR switch is selected OFF. The ENG AIR FAULT annunciator will extinguish when the over-pressure or over-temperature condition is no longer sensed. In the case of a transient fault, the valve can be reset by selecting the ENG AIR switch OFF and then ON.

Located upstream from the non-return valve is a low-temperature switch. If any airframe anti-ice switch is ON and any low-temperature switch senses a low-temperature condition, an amber AIR LO TEMP annunciator (on the ICE PROTECTION panel) illuminates together with the associated ENG AIR FAULT annunciator.

If an ENG AIR switch is selected ON when the aircraft is on the ground, an amber AIR SEL ON GRND annunciator illuminates on the MWP. The 'on ground' condition is sensed by a squat switch.

When a fire handle is pulled to its fullest extent, the electrical open signal will be removed from the associated isolation valve, causing it to close. The relevant ENG AIR VALVE annunciator will remain illuminated until its ENG AIR switch is selected OFF.

On the AIR SUPPLY panel of the flight deck roof instrument panel are four ENG AIR switches, one for each engine. Above each switch is an associated ENG AIR VALVE amber annunciator. Each switch operates its engine's isolation valve; on the outlet side of each valve is a pressure switch which senses the position of the isolation valve. The pressure switch and flight deck switch operate together to illuminate their ENG AIR VALVE annunciator on the NIPS principle. Above each ENG AIR VALVE annunciator is an associated ENG AIR FAULT amber annunciator.

Between the isolation valve and the precooler is an over-pressure switch, and immediately downstream from the precooler, is an over-temperature switch. If either an over-pressure or over-temperature condition is sensed, the appropriate switch electrically removes the isolation valve electrical open signal (thus the valve closes) and illuminates the associated ENG AIR FAULT annunciator; the associated ENG AIR VALVE annunciator will remain illuminated until its ENG AIR switch is selected OFF. The ENG AIR FAULT annunciator will extinguish when the over-pressure or over-temperature condition is no longer sensed. In the case of a transient fault, the valve can be reset by selecting the ENG AIR switch OFF and then ON. In the case of a spurious continuous warning, ENG AIR FAULT will remain illuminated and the valve cannot be reset.

A low-temperature switch is located upstream of the non-return valve. If any airframe anti-ice switch is ON, and any low-temperature switch senses a low temperature condition, an amber AIR LO TEMP annunciator (on the ICE PROTECTION panel) illuminates together with the associated ENG AIR FAULT annunciator.

APU air supply

Air is taken from the APU via a load control valve (LCV). From the LCV the delivery ducting splits to join the ducting from left and right engine bleed systems. The APU is protected from engine bleed air by three non-return valves. These non-return valves also prevent engine bleed air from one side entering the ducting of the other side.

The LCV is controlled by an APU AIR switch on the AIR SUPPLY panel and the APU electronic control unit. When the APU is running at governed speed, the LCV can be opened by selecting the APU AIR switch to ON. If the combination of electrical and bleed air demands on the APU cause its EGT to rise towards the maximum value, the electronic control unit signals the LCV to reduce the bleed airflow to keep the EGT below the limit. Thus the electrical demand takes priority over the air demand.

Immediately below the APU AIR switch is an APU VLV NOT SHUT annunciator. It illuminates if the valve is not fully closed, except when both the APU master switch is at start and the APU AIR switch is ON.

A pressure switch is installed in the APU bleed ducting downstream of the first non-return valve. The pressure switch provides a means of warning that either of the downstream non-return valves has failed in the open position. When there is pressure in the duct, the pressure switch illuminates an amber APU NRV LEAK annunciator (on the APU panel) provided that the LCV is fully closed and either the APU master switch is at STOP or the APU AIR switch is OFF.

Airframe anti-icing

The supply ducting in each pylon splits just downstream from the pylon non-return valve. One branch feeds the wing anti-icing via an anti-icing isolation valve. The other branch joins the supply ducting from the other pylon on that side. The anti-ice valve in each outboard pylon feeds the associated wing anti-icing system, while the anti-ice valve in each inboard pylon feeds the associated wing de-icing system. The two wing ice protection systems on a side can be fed by either engine on that side.

The ducting, which joins downstream of the inboard and outboard pylons on a side, continues through the wing and down the spine of the aircraft. The left and right wing supplies are routed separately down the spine. At the rear of the spine each duct splits into two. One branch enters the air conditioning bay to feed an air conditioning pack, while the other enters the fin leading edge to supply the tailplane anti-icing via an isolation valve.

Water tank pressurisation

A tapping from each wing bleed air duct is connected via a shuttle valve, pressure-regulating valve and non-return valves to the potable water tank.

Hydraulic tank pressurisation

A tapping from the main bleed air duct from No.2 and 3 engines, upstream of the isolation/pressure-reducing valve, is connected via pressure-regulating and non-return valves to the hydraulic tanks. A relief valve and a bursting disc are incorporated. Air LO PRESS annunciators are described in the HYDRAULIC POWER SYSTEM section.

Air conditioning and pressurisation

In the ducting between each spine ducting and its air conditioning pack there is a pressure relief valve. Between the relief valve and the air conditioning pack there is a combined isolation and flow-regulating valve.

A tapping from the water tank pressurisation line, downstream from the shuttle valve, supplies air to the two cabin discharge valve jet pumps.

Toilet flush system

A tapping from upstream of the No.1 pack air conditioning isolation/flow control valve supplies pressurised air to the recirculating fluid chemical toilet units.

Controls and indicators

Controls and indicators associated with the pneumatic system are located on the flight deck overhead panel, the master warning panel and the central status panel located on the centre instrument panel. System caption annunciators on the MWP have an engraved arrow pointing upwards to draw attention to an indication located on the overhead panel.

POWER PLANT

General

The aircraft is powered by four Textron Lycoming LF507-1F high-bypass turbofan engines, numbered 1 to 4 from left to right.

A pylon attached to the underside of the wing structure supports each power plant. Hydraulic, electrical, fuel and engine air bleed system service lines are carried within the pylon structure, which is divided into compartments for system segregation.

Fire warning and protection

Firewalls divide each power plant into two fire zones: the fan casing zone (Zone 1) and the core engine zone (Zone 2), both of which are ventilated by fan air. A fire detector system is fitted to both Zone 1 and Zone 2 to give a common warning. A two-shot extinguisher system discharges into Zone 1 only.

Two engine fire extinguisher bottles and fire bottle relief indicators are located in the nose cowl.

The compartments of the pylon are each bounded by a sealed face or firewall. Overheat detection sensors, which cut off the bleed air in the event of duct failure, are incorporated in the pylon.

For details of the power plant fire protection system, see the FIRE PROTECTION SYSTEM section.

Air bleed system

Air for the aircraft anti-icing and the aircraft environmental system is taken from the passenger bleed manifold. The hot charge air is passed through an engine isolation pressure-reducing valve and a precooler mounted in the pylon. Cooling air for the precooler is tapped from the engine fan exhaust duct and ducted overboard after passing through the precooler.

Engine anti-icing

To prevent the formation of ice within the engine and nose cowl air intakes, each power plant has an integral anti-icing system (see the ICE AND RAIN PROTECTION SYSTEM section).

Engine controls

Four independent thrusts levers are used for manual control of the thrust for the four engines and also operate the high pressure (HP) fuel shut-off valve of the associated engine. Movement to the first detent of the thrust lever from the FUEL OFF position opens the HP fuel valve, the second detent is the idle position and the remaining movement controls the engine thrust.

The thrust levers are mechanically linked to a power lever mounted on each engine's Full Authority Digital Engine Control (FADEC) hydro-mechanical unit (HMU). Dual potentiometers convert the Power Lever Angle (PLA) into electrical signals for use by the associated FADEC Electronic Control Unit (ECU).

Full Authority Digital Engine Control (FADEC)

The FADEC provides the prime means of controlling and limiting the engines, via an ECU mounted on each engine. The associated hydro-mechanical unit (HMU) meters the ECU-demanded fuel flow and also provides a mechanical reversion mode for controlling the engines with FADEC OFF. FADEC status panels (one for each engine) are located above the primary engine displays (PEDs).

The ECU performs the following functions:

- Controls the fuel flow with FADEC ON via a stepper-motor-controlled metering valve (within the HMU).
- Interfaces with the engine and airframe sensors.
- Interfaces with the Flight Guidance Computer (FGC) for N1 trimming when thrust lever / PLA command is insufficient.
- Provides full authority, closed-loop control of engine parameters.
- Provides EGT data to the primary engine display.
- Provides engine limitation protection.
- Determines the mode of operation: FADEC or HMU.
- Provides N2 floor protection for all bleed conditions when connected to the FGC, but no allowance for airframe anti-ice is made when not connected to the FGC.
- Provides N2 floor for ambient conditions.
- Provides N2 floor for ground or flight state.

FADEC status panel

The panel is located above the associated PEDs on the centre instrument panel. Each of the four FADECs has:

- A FAULT/OFF annunciator switch, which allows a FADEC to be switched OFF (W) after a FAULT (A) light illuminates. An amber ‘FADEC’ caution annunciator is situated on the MWP and illuminates with FADEC FAULT.
- A trim annunciator, the top half of which is backlit and shows the respective engine number. The bottom half is split so that a blue ‘UP’ trim arrow is positioned on the left and a white ‘DOWN’ trim arrow on the right.

By comparing FGC N1 command with thrust lever (PLA) N1, the difference can be trimmed by the FADEC. FADEC trim authority varies from 5% N1 at high power to 18% N1 at idle.

The trim arrow illuminates when the FADEC has run out of authority and requires pilot intervention to move the thrust lever in the direction of the arrow.

The associated trim indicators for any engine will not illuminate when either it has a failed FADEC or when the FADEC is not linked to the FGC.

Thrust Control System (TCS)

There are three levels of powerplant control as follows:

1. **Thrust Rating Panel ‘ON’ (operative)** – with autothrottle ON or OFF. FGC 1 and FGC 2 are connected to their own autothrottle actuators on the left and right respectively. Both FGC 1 and FGC 2 are linked directly to each engine’s FADEC.
2. **Trust Rating Panel ‘OFF’ (inoperative)** – ARINC FAIL (amber flashing), when the FGC to FADEC link is disconnected. The FADEC is still operative, providing control and limiting to a maximum 97% N1 and 649°C EGT. In addition, the FADEC provides N2 floor (engine idling) control, varying with the following:
    a) Ambient condition.
    b) ENG ANT-ICE ON or OFF.
    c) Aircraft in flight or on the ground.

__Note:__ FADEC will not adjust N2 floor for airframe anti-ice selections. The pilot must ensure that the engines produce sufficient air to support airframe anti-ice selections.

3. FADEC OFF – the pilot is responsible for monitoring the engine within all limits and N2 floor requirements. This level of control may be used on one engine while the other three are controlled with TRP ‘ON’ or ‘OFF’.

__Caution!__ The autothrottle must not be used when any engine has its FADEC selected OFF.

FADEC OFF

In HMO mechanical operation (FADEC FAULT or selected OFF), the power lever directly moves the HMU fuel metering valve (FMV). When FADEC is operative, the mechanical link between the power lever and the FMV is disconnected and a stepper motor, commanded by the ECU, moves the FMV instead.

Mechanical fail freeze protection within the HMU prevents full transfer of control to the HMU manual mode whilst power levers are in the high power range. Full transfer to HMU is attained immediately when the associated power lever is below approximately mid-travel between idle and take-off.

__Note:__ Transition time from HMU reversionary control to full ECU control is 12 seconds; avoid moving the thrust level during this transition.

Starting

Ground starting is effected by a DC electric starter motor which transmits its drive through the engine accessory gearbox to turn the HP shaft. Starting can be effected by using the APU, cross-engine starting or with power supplied from an external source. FADEC ON starts can be performed using batteries or External DC. For an in-flight start, the engine is windmilled to the required speed; the starter motor cannot be used.

Engine

General

Each engine is a two-spool 5.7:1 high-bypass turbofan engine consisting of a front-mounted fan driven by the low-pressure turbines through a reduction gear and a high-pressure core engine.

Due to the high-bypass-ratio design, thrust is primarily generated by the fan driven by the low-pressure (LP) turbines through the LP spool whilst the core engine driving the concentric high pressure (HP) spool through the HP turbines is used primarily to sustain combustion and supply engine and certain aircraft systems.

Each engine has an annular combustion chamber incorporating fuel spray nozzles. Ignition for ground starting, Relighting in flight or continuous ignition is by high energy plugs from a duplicated ignition system.

Engine operating indicators

Primary engine operating indications are shown on two identical electronic Primary Engine Display panels (PEDs). Secondary engine indications are given on triple indicators above the PEDs. Each PED panel contains the instrumentation required to display data for two engines. The units are mounted to form four columns of indicators, for engines 1 to 4 (from left to right), on the centre instrument panel. The FADEC status panels are located above the PEDs and below the triple indicators.

The PED system displays engine N1, EGT, N2 and Fuel Flow (FF) in both analogue and digital form. Fuel Used (FU), Fuel Quantity and Vibration have digital displays.

The N1 indicator shows the fan speed as percentage RPM. The indicator has a graduated circular dial with LEDs around the periphery which form an electronically controlled pointer.

N1 SET displays the N1 appropriate to TRP selection and FGC N1 commands. An amber command bug (dual LEDs) gives an analogue scale indication of N1 SET valve. With the TRP ‘OFF’, AF (ARINC FAIL) is displayed in the N1 SET window, to indicate that there is no FGC N1 command to the FADEC.

N1 SET and its associated command bug can be manually adjusted by the PULL SET N1 knob on the bottom of the PEDs. In the latter case the N1 SET displays an ‘M’ in front of the digits and acts only as a pilot prompt. It can be set between 78% N1 and 97% N1.

Each engine is fitted with a calibrated electrical compensator which applies bias to the engine N1 speed signal to make certain that the indicated N1 value at rated RPM will not exceed the rated thrust. This bias is activated by an FGC signal when the TRP is ‘ON’. When the TRP or FADEC are OFF, the bias is not applied.

The EGT indicator shows exhaust gas temperature. The indicator has a circular dial with LEDs around the periphery which form an electronically controlled pointer. A numeric display is positioned within the circular dial. The scale has a green normal operating band to MCT, and an amber band from MCT to the red line limit with a red dot transient windshear placard.

The N2 indicator shows the high-pressure shaft speed (HP turbine) as percentage RPM. The indicator has a circular dial with LEDs around the periphery which form an electronically controlled pointer. A numeric display is positioned within the circular dial.

The N2 scale has a green normal operating band to the MCT limit and then an amber band to the maximum red line limit.

When a maximum operating limit is reached, the leading matrix block of the display illuminates. If a digit is displayed in this position it is shown in reverse video. If an overlimit condition occurs for more than ten seconds the whole numeric display will flash.

Engine vibration (VIB) is shown on a numeric display positioned at the top of the PED.

If a vibration level of 1.2 IPS (inches per second) is exceeded, the ENG VIBN amber caption on the MWP is illuminated. Operation of the VIBN TEST push-button on the centre panel causes all four vibration displays to rise to 2.0 IPS and, after three seconds, the amber ENG VIBN caption is illuminated on the MWP.

Certain operating parameters and conditions are monitored by the Master Warning System (MWS), which activates the glareshield red/amber warning lights and audio warnings.

Fuel system

Fuel is delivered from the aircraft tanks to an engine-mounted fuel boost pump. The pump delivers the fuel through a dual heat exchanger and main fuel filter to the main fuel pump and control unit. During starting, fuel is directed initially through primary orifices of the combustion fuel spray nozzles at power settings above idle, and after ignition through the secondary orifices in the nozzles are used.

Engine fuel flow is displayed on the PED by a graduated circular dial with LEDs around the periphery which form an electronically controlled pointer. A numeric display within the circular dial also displays fuel flow (FF). When there is no fuel flow, the digital display shows KG or LBS, appropriate to the units selected on the Aircraft page of the EFB tablet. When the PUSH FUEL USED button at the bottom of the PED is pushed, the numeric displays show fuel used (FU), but revert to fuel flow ten seconds after the button is released. When the RESET button is momentarily pushed, the FU counters are reset to zero. The FU counters are automatically reset to zero after approximately 20 minutes without electrical power.

Fuel tank contents are shown by FUEL QTY numeric displays at the bottom of the PED. The leftmost display indicates fuel in the left wing tank. The second display from the left indicates fuel in the centre tank. The rightmost display indicates fuel in the right wing tank. A push-button, at the top of the centre instrument panel, allows fuel contents to be displayed using battery power.

Amber FUEL (1, 2, 3 & 4) LO PRESS captions on the MWP illuminate if the associated fuel booster pump feed pressure is inadequate.

White FILTER (1, 2, 3 & 4) CLOGGED captions on the MWP illuminate if the associated main fuel filter element is clogged.

Oil system

The oil system is completely self-contained. It includes an oil tank, a lubrication and scavenge pump, a dual heat exchanger, a filter and a centrifugal air/oil separator. The dual heat exchanger cools the hot scavenge oil. The main oil filter has a bypass system with a blockage indicator.

Each engine system incorporates a triple reading indicator showing oil pressure, temperature and tank quantity.

The oil pressure indicator has a colour-coded calibrated scale, coded green for normal operation, amber for caution and red for pressure below 25 PSI. If pressure falls into the red sector, or is less than 50 PSI when N2 is 80% or greater, the appropriate red OIL (1, 2, 3 & 4) LO PRESS caption illuminates on the MWP.

The temperature scale is coded green, amber and red. The minimum oil temperature for take-off is 30˚C and the maximum operating temperature is 133˚C. A transient increase in temperature up to 160˚C during power reduction is permissible but a recovery to maximum operating temperatures should be expected within two minutes.

The oil quantity scale is annotated in quarters. After engine start, the indication will fall by approximately one quarter division at ground idle and a further quarter division at full power. This is due to the migration of oil throughout the engine when running.

Drains system

The engine drains system consists of an ecology fuel drain system that drains fuel from the combustion area into a tank during the engine shutdown. This fuel is drawn by an ejector pump on engine start-up at ground idle RPM to the inlet side of the engine boost pump.

The tank is vented to atmosphere by a pipe which acts as a drainpipe in the event of the tank becoming overfull.

Engine controls

The thrust levers are connected to the power levers in the hydro-mechanical units (HMU). The autothrottle clutch assembly connects the autothrottle actuators to the thrust levers. The first movement of the thrust lever, from FUEL OFF, opens the HP fuel valve and the remaining forward movement controls the HMU power lever.

When at ground idle, closure of the HP fuel valve is prevented by a baulk mechanism, consisting of a detent roller and operating trigger which raises the detent roller clear of a ground idle stop, allowing rearward movement of the thrust lever to close the valve (FUEL OFF). Similarly, to advance the throttle forward from fuel OFF, the trigger must be depressed. As the throttle is moved forward towards the idle stop a detent will be felt, provided the trigger has been released. This detent is used as the initial position for fuel ON when carrying out a FADEC OFF start.

A red fire warning light is fitted into the rear face of each thrust lever. The two outer thrust levers incorporate an autothrottle disconnect button and, if pressed for more than three seconds, the FGC is disconnected from the FADEC (TRP OFF).

The front face of the two inner thrust levers each incorporates a TOGA select push-button. For easier access in the simulator, a TOGA clickspot is provided on the lower left screw on the VHF NAV panel. TOGA can also be triggered using the 'AUTOTHROTTLE TO GA' control assignment.

LP turbine overspeed

Should the LP turbine exceed 104% N1 and 'overspeed' occurs, a dual-channel emergency electronic overspeed limiter shutdown system operates automatically. This overspeed system is independent of other systems.

Signals from magnetic speed pick-up on the engine energise a solenoid valve to cut off the fuel supply, and the ENG OVSPD amber annunciator on the MWS will illuminate. The system can be tested by operating the appropriate ENG OVSPD switch on the GRND TEST section of the overhead panel. Pressing the test button effectively multiplies the actual N1 by four.

The overspeed trip is reset automatically during a subsequent engine start procedure.

Engine life computer (ELC)

An engine life computer (ELC) system is provided to monitor, compute and store information derived from the following:

1. **Each engine's instrumentation circuits –** N1, N2, EGT, fuel flow, vibration, oil temperature and pressure, engine anti-ice and bleed-air selected.
2. **Other aircraft systems –** altitude, CAS, left, right and centre fuel tank contents, OAT, airframe anti-ice and ECS discretes and weight-on-wheels discrete.

The ELC system stores a snapshot of all input parameters on demand, normally once or twice per flight, for example at take-off and at a stabilised cruise condition. The ELC also provides a time-temperature banding facility where durations of EGT within certain predefined bands are recorded. These data are used in trend analysis and to support maintenance cost guarantees.

The ELC system continuously monitors and compares specific input parameters for exceedance of predefined limits. Parameters monitored outside the first level of 'exceedance' limits are stored and annotated with details of date, time, magnitude and duration of exceedance. Parameters monitored outside the second level of 'incident' limits are stored together with all parameter values for five seconds before an incident value is exceeded to 15 seconds after the incident.

The ELC system is powered whenever the aircraft's 28V DC system is activated, except the unit's date/time clock, which is powered continuously by a separate internal battery.

A FAIL warning annunciator on the ELC control panel illuminates if the memory of the ELC becomes 80% full or if the built-in self-test detects a computer failure. The STORE DATA toggle switch, adjacent to the warning annunciator, allows the flight crew to store a 'snapshot' of information at any time.

The stored information is removed, when required for analysis, by ground engineers using a handheld Data Transfer Unit.

Engine starting system

An electric DC starter motor is fitted to each engine to crank it on the ground during a starting or motoring cycle. For an in-flight start the engine is windmilled to the required speed. Ignition for starting is provided by either or both of the two ignition units and igniter plugs per engine. Fuel to the engine is controlled by selecting the relevant thrust lever to the appropriate ground or flight idle position.

The duration of the cranking and igniting phase of a ground start is controlled automatically by switch functions of the N2 speed indicators, which terminate starter motor and ignition unit operation when the engine has reached the self-sustaining speed of 40% N2 RPM. A ground start can be aborted by selecting the START MASTER switch off immediately after selecting the thrust lever off.

After an aborted start, or before an in-flight start, adequate time must be allowed to ensure combustor drainage.

On the ground when the START MASTER switch is ON, the aircraft electrical power system is put into a special mode appropriate to engine starting (see the ELECTRICAL SYSTEM section for more details). Electrical power supplies to the START MASTER switch are routed via the squat switch circuit so that, in flight, the engine cranking system is immobilised and it is not possible to select the electrical power system to the starting mode.

Indicators and controls for the starting system are located on the ENGINES sub-panel of the flight deck overhead panel.

Engine cranking

The starter motors are powered by a nominal 28V DC for all ground starts except ‘cold’ starts, for which 36V DC is required.

For normal starts, 28V DC may be obtained from an external DC supply or via two transformer rectifiers (TRs) in the aircraft electrical DC system. The TRs may be powered by an external 115/200V, 400 Hz AC supply, or the APU generator, or either engine 1 or 4 generator (cross-starting). During cross-starting the power input is automatically limited to a single generator; the other is inhibited.

For cold starts 36V DC is normally obtained by the automatic switching of the TRs when a ‘cold’ start is selected. During a ‘cold’ start the TRs may be powered by external AC (EXT AC) or main engine generator (GEN 1 or GEN 4). A ground power unit (GPU) of at least 90 kVA rating is required.

Caution! *If the APU is running, select APU GEN OFF during cross-starts and EXT AC starts to prevent power interruption causing starter torque spikes.*

The APU cannot support a ‘cold’ start.

When there is a choice of starting power, it is operationally simpler to use the APU if it is available, in preference to external AC or DC. External AC is preferable to external DC for normal starts because external AC also permits the aircraft AC and DC busbars to be powered. External DC powers the starter motors only, so if the APU is available, but environmental factors prevent its usage for starting, it should be used to permit powering of the aircraft AC and DC busbars.

To facilitate engine starting, air is bled from the engine’s compressor by the automatic opening of the engine and intake anti-icing valves. During a ground start, brief indication of these valves being open may be given by the ENG VLV NOT SHUT annunciator on the ENGINE ICE PROTECTION sub-panel. During an air start this indication will be given all the time the start is selected. To further enhance engine starting it is necessary to switch off the engine’s generator or hydraulic pump.

For ground starting only, the GRND IGN (A - BOTH - B) switch on the overhead AVIONICS panel provides for the isolation of either of the igniter systems. This reduces the demand on the igniter plugs, increasing their useful life, and allows the identification of an unserviceable ignition system. This switch does not affect the switching of igniters for continuous operation or dual ignition during an ‘in-flight relight’. It is recommended to use A on odd days and B on even days.

Ground starting and motoring

When start power has been established and START PWR has been selected to the appropriate source (EXT DC, NORM or COLD), selecting the START MASTER switch to ON will cause the white START PWR ON annunciator to illuminate (for a start from the aircraft batteries, NORM must be selected and the EMERG START switch must be pressed), indicating that start power is available for selection and distribution to the starter motors.

A rotary, START SELECT (1 - 2 - OFF - 3 - 4) switch allows the appropriate engine for starting to be selected so that, when the ENGINE (START, RUN, MOTOR) switch is held to START for one second and then released, power is routed to operate the starter motor and either or both of the two ignition systems, as selected (A - BOTH - B). The STARTER OPERATING white annunciator and the ENG IGN A and/or B green annunciator(s) will illuminate simultaneously.

On opening the thrust lever to IDLE (FADEC ON), the engine should light up and accelerate.

With FADEC OFF, the thrust lever is advanced to FUEL ON. After ‘light-up’, and when N2 acceleration reduces to 1% in four seconds, the thrust lever is advanced to IDLE, allowing the engine to accelerate further. Due to mechanical hysteresis, idle N2 may not be achieved until the thrust lever is advanced slightly and then returned to IDLE.

As the engine accelerates, and after light-up has occurred, the associated ENG VLV NOT SHUT white annunciator may illuminate briefly. At self-sustaining STARTER OPERATING, ENG IGN A and ENG IGN B annunciators are extinguished.

The engine then accelerates under its own power to idle speed. The next engine to be started is selected on the START SELECT switch and the start cycle is repeated by reselecting the ENGINE switch to START. On completion of all engine starting, the START PWR switch should be switched to NORM, the START SELECT switch must be set to OFF and the START MASTER must be selected OFF to restore the electrical power system to normal operating mode.

In the event of an aborted start, or for maintenance purposes, a motoring (MOTOR) cycle, in which the ignition system is inoperative, may be performed. The procedure is the same as for a start cycle except that the ENGINE switch is held to MOTOR for one second and then released. Power is supplied to the starter motor until cancelled, and, as there is no ignition, the ENG IGN ON annunciators do not illuminate. To cancel the motoring cycle, .select the START MASTER switch to OFF and the START PWR switch to NORM. Observe the starter motor operating restrictions.

In-flight starting and relighting

In-flight starting is controlled by a two-position (ON, OFF) FLT START switch in conjunction with the engine START SELECT switch. When the engine has been selected and the FLT START switch is ON, the selected engine's two ignition systems, A and B, will both operate and the engine and intake anti-icing valves will open. The annunciators ENG IGN A & B ON, and ENG VLV NOT SHUT will light. Prior to selecting the FLT START switch ON, the engine's thrust lever must have been in the OFF position, allowing the engine to drain for approximately 20 seconds. The aircraft must be within the 'air start envelope' with respect to altitude, airspeed and engine windmill speed.

On opening the thrust lever to IDLE (FADEC ON), the engine should light up and accelerate to a stable speed appropriate to the aircraft altitude and airspeed. As the engine accelerates, the ENG VLV NOT SHUT annunciator will illuminate and remain so until the FLT START or START SELECT switches are selected OFF. To complete the starting procedure, the FLT START and START SELECT switches must be selected OFF.

With the FADEC OFF, FUEL ON is first selected. After light-up and when N2 acceleration reduces to 1% in four seconds, the thrust lever is advanced to IDLE and the engine will accelerate to an idle speed appropriate to the aircraft altitude and airspeed.

Should an engine 'flame out' in flight, the engine must be shut down; a flight start (FLT START) may be attempted if there are no indications of engine damage.

FLYING THE RJ

In this tutorial flight we will be departing from Zurich Airport, the largest airport in Switzerland and once the hub for an entire fleet of RJs. We will depart to the west, crossing the border into France before then turning north over Luxembourg, where we will begin our descent into Brussels Airport, the largest airport in Belgium and also once a hub for several fleets of RJs.

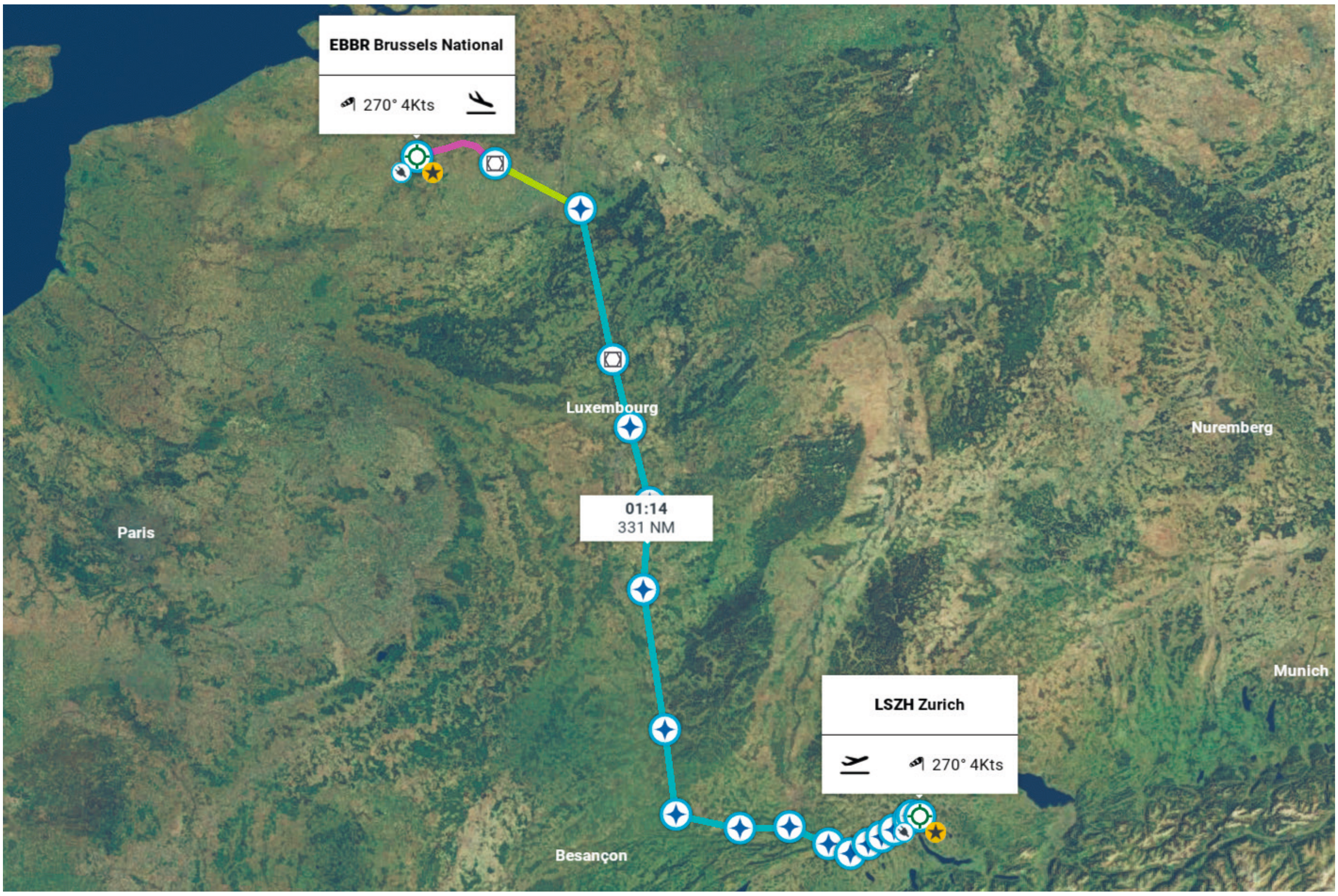
Covering approximately 330 nautical miles, this regional flight is an ideal length for learning about the important systems on board the RJ.

For this tutorial flight we recommend using the RJ100 Swiss ‘Zurich Airport Shopping Paradise’ livery as well as downloading the free ‘MSFS World Update VI: Germany, Austria, Switzerland’, which includes a hand-crafted Zurich Airport.

The flight plan in this tutorial flight was created using the 2401 AIRAC cycle that is included with the RJ Professional. Some minor differences in the flight plan may occur if you are using a newer AIRAC cycle.

Here are the details for today’s flight:

LSZH/28 VEBIT1X VEBIT T51 LASUN T14 LUMEL T10 TORPA DCT EDOPI DCT GIVOR DCT SORAL DCT IBERA N853 DIK Y37 BATTY BATTY6A EBBR/25R



Estimated time en route: 60 minutes

Route distance: 332 nautical miles

Departure time: 1000 (local time)

Weather: Few Clouds

Now that we are prepared for the flight, we can proceed to the cockpit to begin our pre-flight checks. To load up the RJ tutorial flight, follow these steps (PC only):

1. Start Microsoft Flight Simulator.
2. Click **World Map** (MSFS 2020).

   Click **Free Flight** (MSFS 2024).
3. Click **More**, then **Load/Save** (MSFS 2020).

   Click **EFB**, then **Flight Planner**, then **Route** (MSFS 2024).
4. Choose **Load From This PC**.
5. Browse to… Community\justflight-aircraft-RJ\Documents\Tutorial
6. Select **Just Flight RJ tutorial flight** from the list of saved flights.
7. Click on **OK**.
8. Click **Fly**.

We should now find ourselves sitting in the cockpit on remote stand H85 at Zurich Airport. As the flight has been started at a parking spot, the aircraft has automatically loaded in a 'cold and dark' state, with all the cockpit systems switched off, just as you would find the aircraft prior to the first flight of the day. Beginning in this configuration means we will need to spend some additional time setting up the cockpit, but doing so will allow us to learn a considerable amount about the features and functions on board the RJ.

If you wish to skip ahead and start this tutorial flight with more systems already set up, you can load the aircraft in a 'COLD & DARK', 'READY FOR TAKEOFF' or 'TURNAROUND' state via the EFB/tablet.

MSFS 2024 users can load into the flight in 'walkaround' mode and will need to trigger the 'TAKE CONTROL OF CHARACTER' control assignment to enter the cockpit.

This tutorial will cover the necessary steps for you to get from point A to point B, but it will not explore each system in depth. Please refer to the rest of this manual for a detailed description of each system. A separate dedicated GNLU-910A FMS Operations Manual describes the FMS's features in depth and can be found in the same location as this manual.

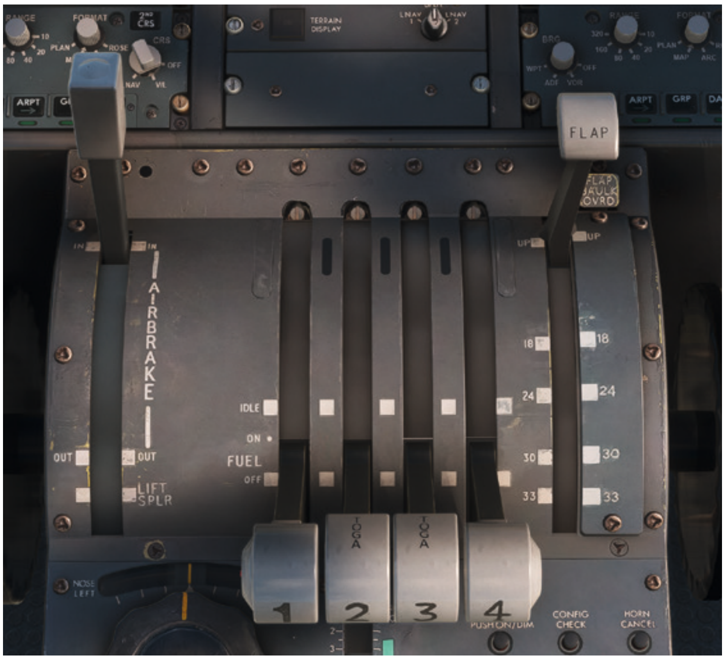
Pre-flight checks

After entering the cockpit, we first need to work through the flight deck safety checks to prepare the aircraft for the first flight of the day.

On the centre console, set the weather radar to **STBY** and the tilt is set to **+15° UP**.

Check that the transponder is set to **STBY**.

Confirm that the airbrake is selected **IN** and the flaps are selected **UP**.



Setting the NAV lights switch to **ON** will illuminate the NAV lights as soon as electrical power is applied to the aircraft, indicating to the ground crew that there is crew onboard.

We can now power up the electrical system.

On the ELECTRIC section of the overhead panel, set the BATT 1 and BATT 2 switches to **ON**.

Confirm that the battery ammeter is showing a discharge and rotate the DC selector to the **BATT 1** and **BATT 2** positions in turn to check for a minimum of 23 volts.

On the centre console, confirm that the brake selector is set to **YELLOW** (button out) and the parking brake is set to **PARK** (lever out).

Moving to the AVIONICS section of the overhead panel, switch **ON** the YAW DAMP MASTER 1 and 2, AUTO PILOT MASTER 1 and 2 and AVIONICS MASTER 1 and 2 switches. The FGC SELECT switch should be alternated each day of the week, setting 1 on odd days and 2 on even days.

Set the ground ignition (GRND IGN) switch to **A** or **B** depending on the day of the week (A for odd days, B for even days).

Moving down to the ANTI SKID & LIFT SPOILERS panel, switch ON the ANTI SKID, and YEL and GRN lift spoilers.

Moving back to the ELECTRIC panel, ensure both BUS-TIE switches are set to **AUTO** and the standby inverter (STBY INV) and standby generator (STBY GEN) switches are set to **ARM**.

Set both engine generators (GEN 1 and GEN 4) to **OFF/ RESET** and set the APU generator (APU GEN) to **ON**.

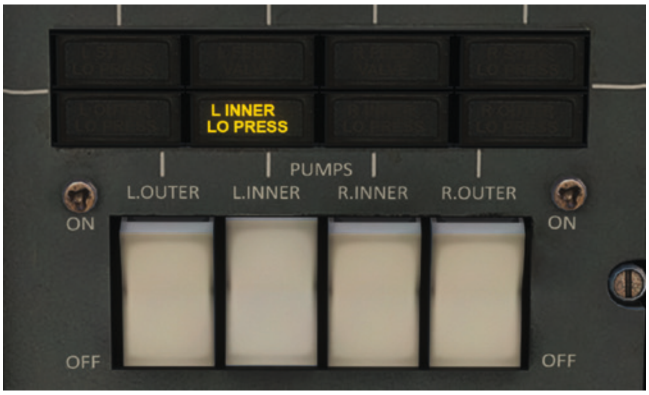
Switch **ON** the APU GEN switch in preparation for APU start.

Moving up the overhead panel, ensure that all four fire handles are IN and set the engine fire loops depending on the day of the week (LOOP A for odd days, LOOP B for even days).

At this point we should also complete engine and APU fire tests and engine and APU extinguisher tests. The full test procedures for all ground tests can be found in the MSFS Checklist window in the simulator.

We will be using APU power to start the engines today.

On the FUEL panel, ensure the L INNER fuel pump is switched **ON**.



On the APU panel, start the APU by moving the master switch to **START**. Monitor the APU RPM and TGT during the start-up.

The APU PWR AVAILABLE light will illuminate once the APU RPM have reached 97% +4 seconds, indicating that the APU is ready to supply both generated and pneumatic power. With the APU generator already selected ON, the APU will now be supplying electrical power.

On the air supply panel, set the APU AIR switch to **ON** and set one PACK switch to **ON** to provide air conditioning to the cabin. To extend component life, only one pack is required when the aircraft is on the ground. To ensure equal wear, the pack used is typically alternated on a daily basis, with PACK 1 being used on odd days of the month and PACK 2 used on the even days.

We can now test the MWS by fully pushing in the MWS CTRL switch on the First Officer's main instrument panel. Confirm that all the MWS annunciators are illuminated and the audible chimes can be heard before cancelling the MWS warnings. Now return the MWS CTRL switch to its middle position with the red light extinguished.

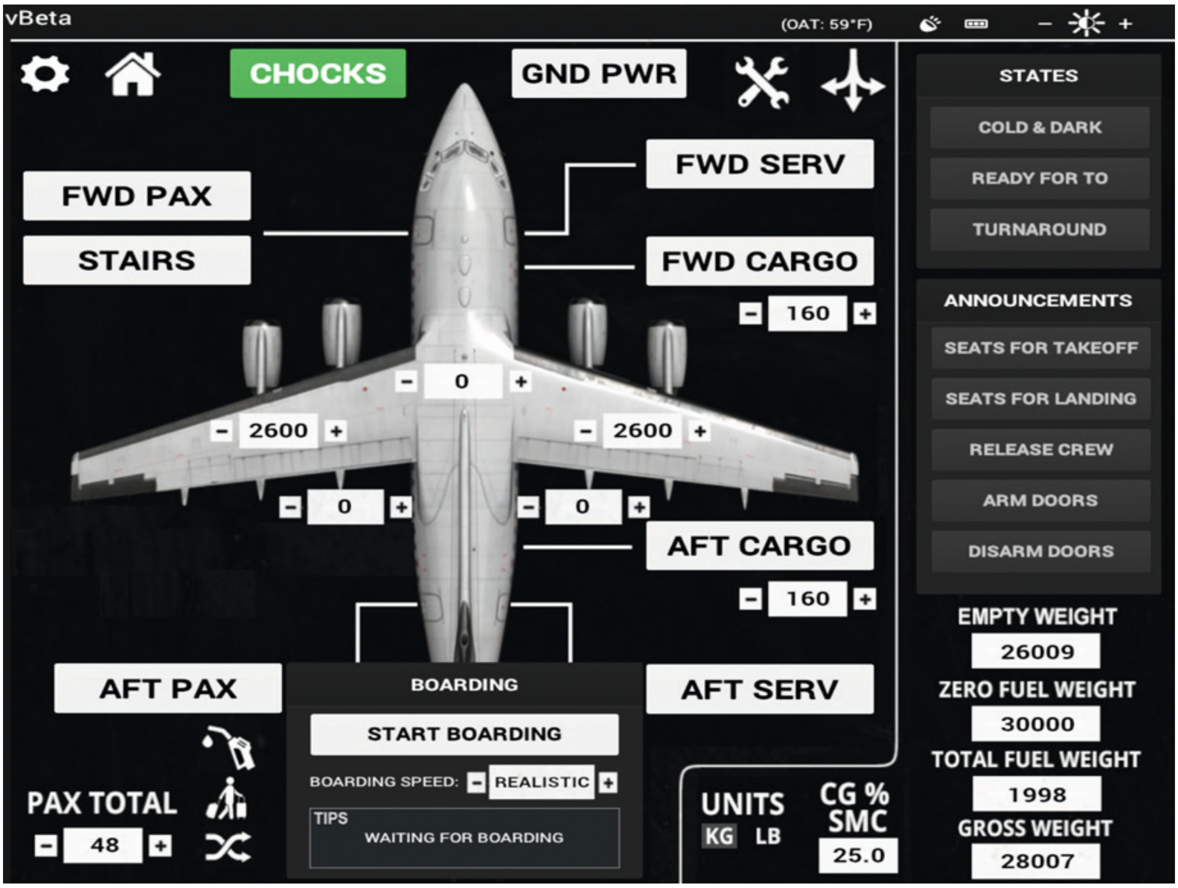
With electrical power now supplied to the aircraft, MWS cautions can be triggered at various stages of the flight. This is normal as we make selections in the cockpit and they can be cancelled by pressing the MWS amber or red buttons on the glareshield.

Before we begin to set up our navigation systems for departure, it makes sense to begin the passenger boarding and refuelling.

Open the Aircraft app on the EFB, click on the ZERO FUEL WEIGHT field, input **30000** and press ENTER. This provides us with a relatively light load for this short flight today.

We can set our required fuel level by clicking on the TOTAL FUEL WEIGHT field, inputting **5200** and then pressing ENTER.

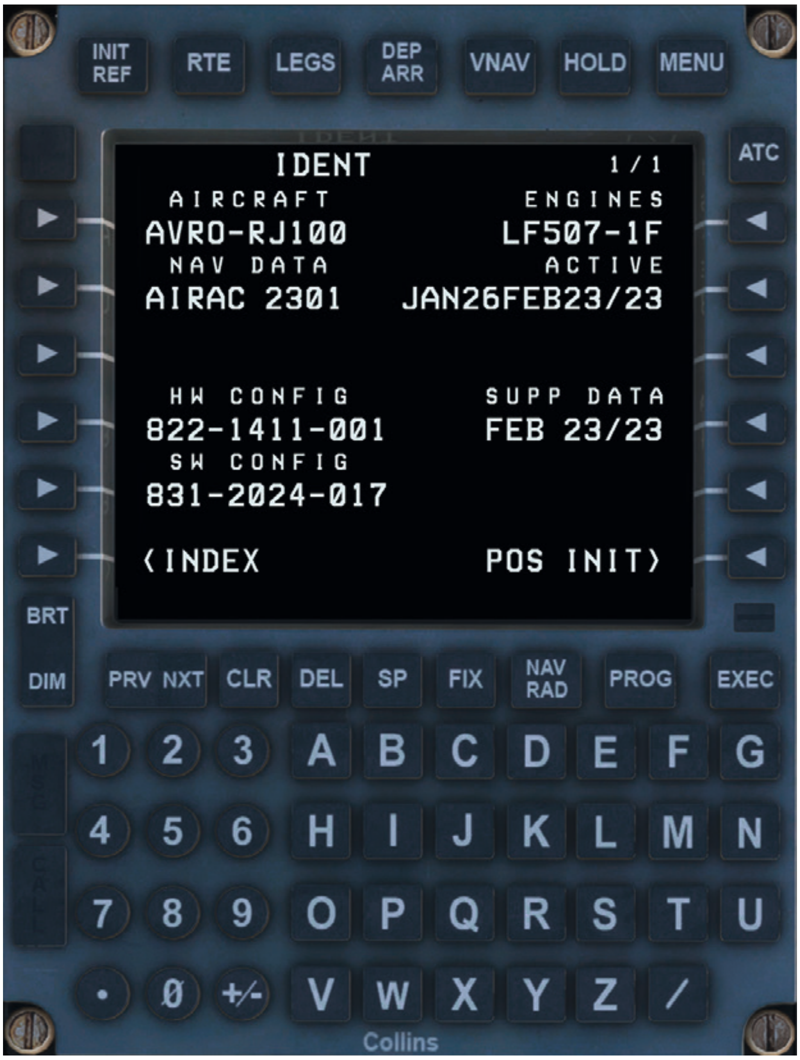
With our planned fuel and payload set, press the boarding and refuelling icons at the bottom left of the EFB, ensure the boarding/refuelling speed is set to **REALISTIC** and press the **START BOARDING / START REFUELLING** buttons to begin the boarding process.



With boarding and refuelling under way, we can now begin the process of aligning the Inertial Reference Systems (IRS) and inputting our flight plan into the FMS.

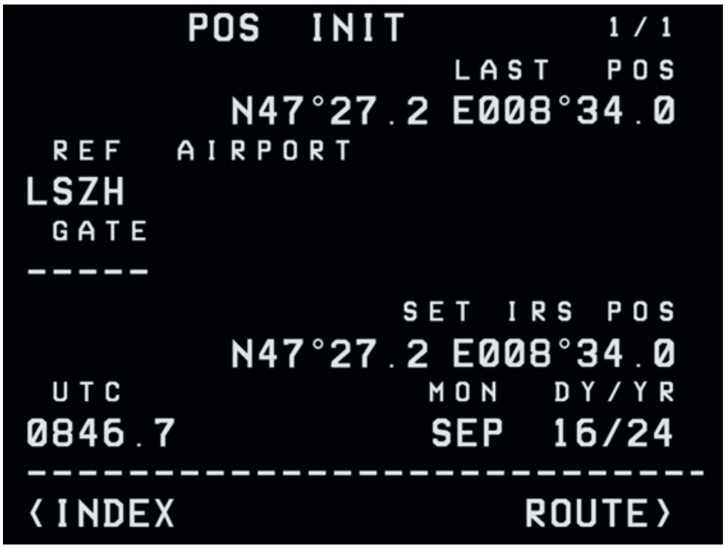
On the First Officer's side panel, set both IRS switches to **ALN**.

On the Captain's FMS, press the **1L** key to access the FMC and the IDENT page will then open. Confirm that all information displayed on the IDENT page is correct before pressing the **6R** key to open the POS INIT page.



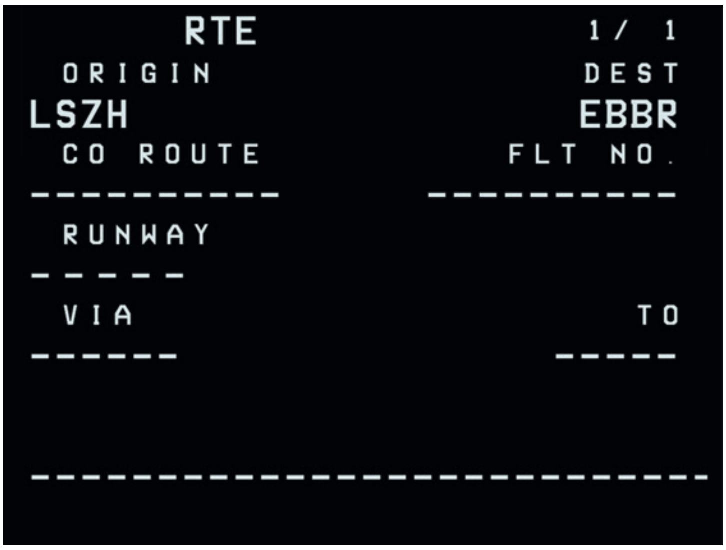
On the POS INIT page we can find information that tells the system what our present position is. The coordinates for the position are displayed on the right side of the page.

Press one of the right line select keys to copy the coordinates into the scratchpad and then press the **4R** key to move it into the SET IRS POS field. With this set, the IRS now has an initial position to align to.



Press the **6R** key to open the ROUTE page.

Enter **LSZH** into the scratchpad and press the **1L** key to move it into the ORIGIN field, then enter **EBBR** into the scratchpad and press the **1R** key to move it into the DEST field.



With the origin and destination airports now set, we can input the SID (Standard Instrument Departure) procedure into the flight plan.

Press the **DEP ARR** key to open the DEP/ARR page and then press the **1L** key to open the DEPARTURES page for LSZH.

On the DEPARTURES page we first need to select a runway for departure. As we have light winds out of the west today, we will be departing from runway 28 so we need to press the line select key adjacent to the runway 28 field. Once selected, '<SEL>' will be displayed next to the selected runway.

Note: *To prevent any confusion with future updates to the Nav database changing the order of the displayed data on the FMS, we will not be referring to specific line select keys when explaining how to input a flight plan into the FMS. We will instead be referring to the necessary line select key as the 'adjacent line select key'.*

We can follow a similar procedure when selecting our SID. Use the PRV/NXT keys to cycle through the available SIDs and press the line select key next to the **VEBI1X** SID.

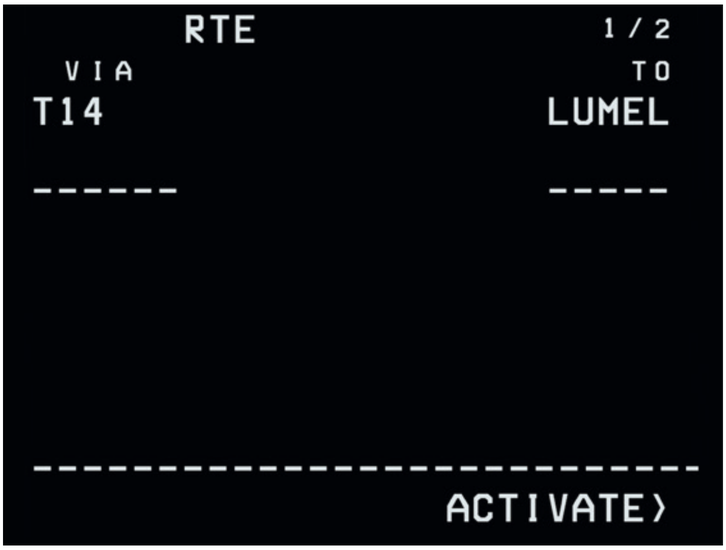
With a departure runway and SID selected, press the **6R** key to return to the RTE page; the runway and SID will now be displayed in the flight plan.

We can now begin to enter the remainder of our flight plan. Our flight plan consists of waypoints that are connected by airways which we can see at the start of our flight plan. After departure we will be flying the VEBI1X SID to VEBIT before then flying the T51 airway to LASUN.

To enter this in the FMS, we first need to find the next empty line in the flight plan (you may need to use the PRV/NXT keys to move to the next page). Airways are to be entered on the left side of the page and waypoints on the right side.

Input **T51** into the scratchpad and press the line select key to the left of the first empty line in the flight plan. Then input **LASUN** into the scratchpad and press the right line select key on the same line as the inputted airway.

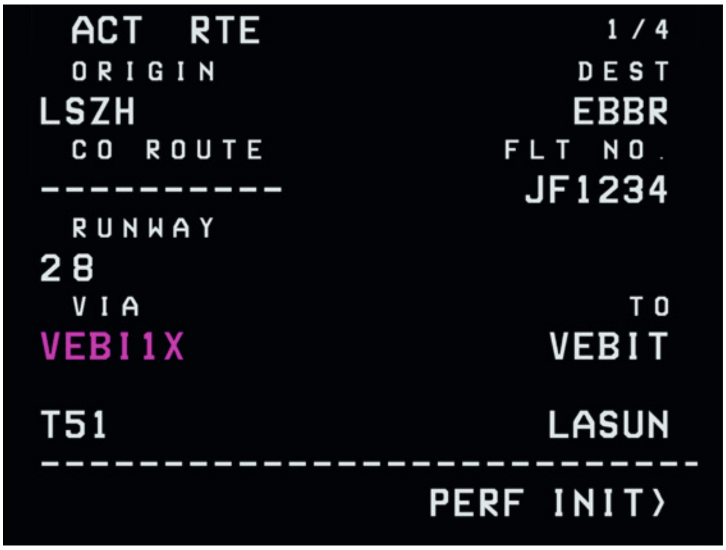
We can repeat this process to input the next airway and waypoint into the flight plan: **T14** to **LUMEL**.



Continue to add the remaining airways and waypoints of the flight plan into the route page until the last waypoint in the flight plan, BATTY, has been entered. If no airway exists between two waypoint, the flight plan will list this a ‘DCT’ (Direct) leg. Waypoints can be entered into the RTE page without an airway simply by inputting the waypoint into the scratchpad and moving it to the next empty line on the right side of the page.

Once the flight plan has been entered, check that it is displayed correctly on the RTE and LEGS pages before pressing the **6R** key to activate it. Then press **EXEC** (execute) to confirm the activation of the flight plan. The flight plan is now loaded in the FMS and will be followed by the autopilot's LNAV mode once engaged after departure.

On the RTE page, now is also a good opportunity to enter our flight number for today. Enter JF1234 into the scratchpad and then press the 2R key to move it into the FLT NO field.



To minimise our workload during the flight, we can now also set up our arrival procedure. The process for adding our arrival into the flight plan is very similar to that of adding the departure procedure.

Press the DEP ARR key to open the DEP/ARR INDEX page and then press the 2R function key to open the ARRIVALS menu.

We first need to select the approach, which for our flight today will be the **ILSY25R**. We can select this by pressing the line select key adjacent to this approach.

We can now select the STAR, which for our flight today is **BATY6A**, and the transition point is **FLO**. With the approach procedure selected, check the flight plan is displayed correctly on the RTE and LEGS pages before pressing the **EXEC** key to activate the changes to the flight plan.

With all waypoints having now been entered into the flight plan, we now need to input the performance figures for our flight. With the RTE page selected, press the **6R** key to open the PERF INIT page.

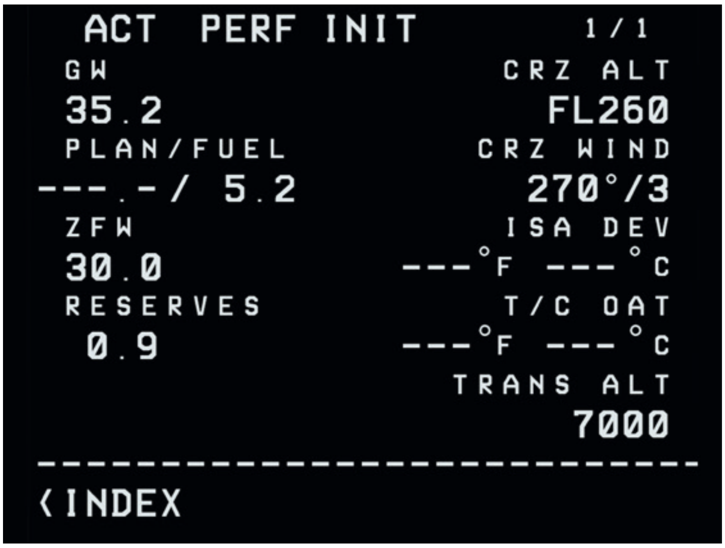
On the PERF INIT page, enter **30** in the ZFW field (the aircraft's planned ZFW in tonnes rounded up to the nearest decimal place) and the GW field should automatically populate.

Enter the planned reserve fuel of **0.9** in the RESERVES field.

Enter our planned cruising altitude of **26000** in the CRZ ALT field.

Enter the estimated average cruise wind of **270/3** in the CRZ WIND field.

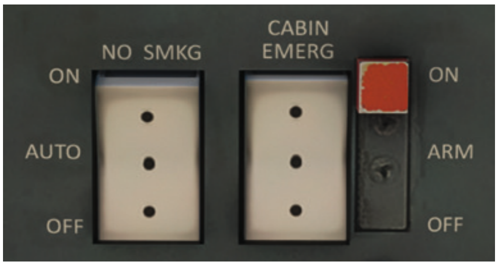
Finally, enter **7000** as the transition altitude for our departure airport and press the **EXEC** key.



With the FMS now configured for flight and the IRS alignment in progress, set the Captain's and First Officer's EFIS master switches to ON and adjust the display brightness as required.

We can then move back to the First Officer's side panel and set both IRS switches to **NAV**. This will ensure that the IRSs automatically move to the navigation mode once the alignment process has been completed.

Returning to the overhead panel, on the LIGHTS section set the cabin emergency lights to **ARM**.



Ground tests (smoke, stall, fire loops, speed, anti-skid, rear bay temperature, flap and horn) can now be carried out using the GRND TEST section of the overhead. The full test procedures for all ground tests can be found in the MSFS Checklist window in the simulator.

On the HYDRAULIC panel, set the DC PUMP to **ON** and check for a rise in the YELLOW brake pressure on the brake pressure indicator at the bottom of the Captain's instrument panel. Once a pressure rise has been confirmed, move the DC PUMP back to the **OFF** position.

Continuing on the HYDRAULIC panel, set the AC PUMP to **ON** and check for a rise in YELLOW system hydraulic pressure. Now set the PTU switch to **ON** and check for a rise in GREEN system hydraulic pressure. With both systems pressurised, check all annunciator lights have been extinguished before setting the PTU and AC PUMP back to **OFF**.

Moving down the overhead panel, select the four engine anti-ice switches to **ON**.

Moving further down the overhead panel to the lower lighting panel, **ARM** the flight deck emergency lighting.

Perform a FLT ANNUNS test by pressing the FLT ANNUN **TEST** button on the Captain's instrument panel.

On the PRESSURIZATION panel we can now set the landing altitude of our destination airport: **100 ft**.

On the Captain's left side panel, test the cockpit voice recorder (CVR) by momentarily pressing the TEST button and confirming CVR LED is flashing alternately yellow/green for 10 seconds, then lit steadily green for 10 seconds before extinguishing.

On the standby attitude indicator, pull the fast erection knob out until the altitude indicator indicates zero pitch and roll, then release the fast erection knob so it fully returns to its original position.

Perform a test of the EGPWS by momentarily pressing the **GROUND PROX** button on the glareshield and confirming that audible alerts can be heard.

Perform a TCAS test by momentarily pressing the **TEST** button on the transponder and verifying that the correct test pattern is shown on the TCAS display, the correct RA is shown on the PFD and that the audio test passed message is heard.

Perform a ground check of the flight data recorder (FDR) by holding the ground check switch at **GROUND CHECK** and confirming that the FDR FAIL light extinguishes.

On the right side panel, open the oxygen main valve and confirm positive supply.

Finally, use the test feature to test the operation of both pilot regulators.

Before Start checks

Once passenger boarding and refuelling is complete we can then work through the Before Start checklist.

Confirm that the parking brake is still engaged and that sufficient brake accumulator pressure remains. If the YELLOW brake pressure is less than 2,500 PSI, turn **ON** the DC PUMP or AC PUMP until the pressure has risen sufficiently.

On the overhead, confirm that all switches on the HYDRAULIC panel are **OFF**.

Moving down to the ICE PROTECTION panel, set the ICE DETECT switch to **ON**.

On the LIGHTS panel, **ARM** the CABIN EMERG and NO SMKG switches before moving down the overhead and switching **ON** the fasten seatbelts signs.

On the centre panel, confirm that we have sufficient fuel for the flight. We are carrying 2,600 kg of fuel in each of the wing tanks today and 0 kg in the centre tank.

If you have not already done so, set the MWS GND OP switch to the middle **RESET** position.

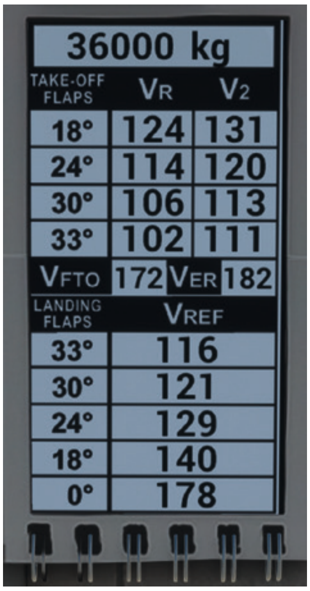
We can now configure the TRP (Thrust Rating Panel) for take-off. This is an unusual and interesting system that requires a bit of study.

The TRP is powered ON and defaults to the TOGA MAX setting on the ground. This is the maximum power the engines can provide at the current outside air temperature. If we wanted to perform a derated take off, we would push the TOGA button once until REDU (reduced) is illuminated. We can then rotate the outer control knob to the TEMP position and adjust the assumed temperature for the derate. The higher the temperature, the larger the derate.

For today's flight we will be performing a **REDU** departure with a temperature of **30 degrees**, so we can set that now on the TRP. This should provide us with an N1 SET of 92.3 which is displayed on the TRP with N1 set and at the top of the PED.

The TRP is also used to set the V-speed bugs on the PFD for take-off and landing. The V-speeds for our current weight are shown on the speeds flipchart adjacent to the TRP and we now need to input them into the TRP. We will cover the manual method in this tutorial flight, but the V-speeds can be automatically set in the TRP by clicking on the respective flap setting on the speeds flipchart.

Based on our current weight and a take-off flap of 18°, we can deduce that our V1 speed is 124 knots, VR is 124 knots, V2 is 131 knots and VFTO is 172 knots.



Rotate the outer control knob to the V1 position and then rotate the inner knob until the TRP display shows our V1 speed of **124**. This is the speed at which we are committed to taking off.

Rotate the outer control knob to the VCROSS position and then rotate the inner knob until the TRP display shows our VR speed of **124**; this is our rotation speed.

Rotate the outer control knob to the VDOT position and then rotate the inner knob until the TRP display shows our VFTO speed of **172**; this is our final take-off speed and the speed at which we begin to retract the flaps.

We can then set our V2 speed of **131** in the IAS/MACH window on the MCP. This is our climb-out speed in the event of an engine failure. In normal operations we will climb out at a speed of V2 + 10 knots.

Starting the engines

Close the cockpit door either by clicking on the handle or by clicking on the mechanical linkage on the hinged side of the door.

The cockpit door can be locked by momentarily moving the FLT. DECK DOOR switch on the aft centre console to **LOCK**. The NOT LOCKED annunciator will extinguish when the door is locked.

Switch **ON** the beacon lights.

Set both PACK switches and the APU AIR switch to **OFF**.

We do not require a pushback tug for this flight but, if we did, this would be a good time to request it by clicking the three-arrowed icon at the top right corner of the EFB.

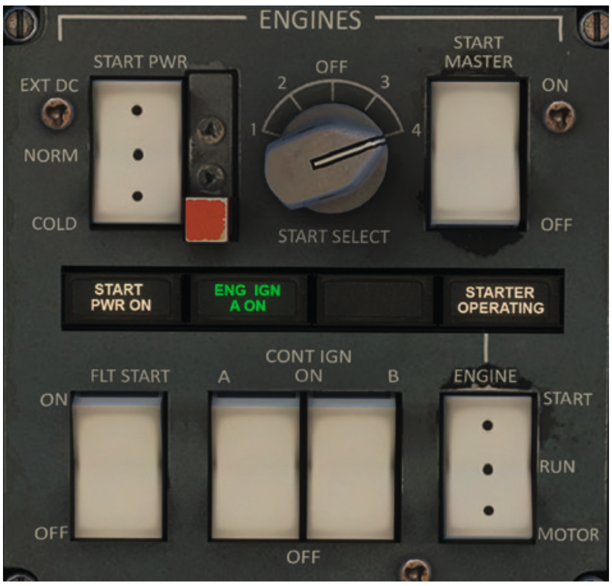
On the ICE PROTECTION panel, ensure that all four engine anti-ice switches are **ON**.

On the FUEL panel, switch **ON** all four fuel pumps.

Move over to the ENGINES section of the overhead, which is where the engine start controls are located.

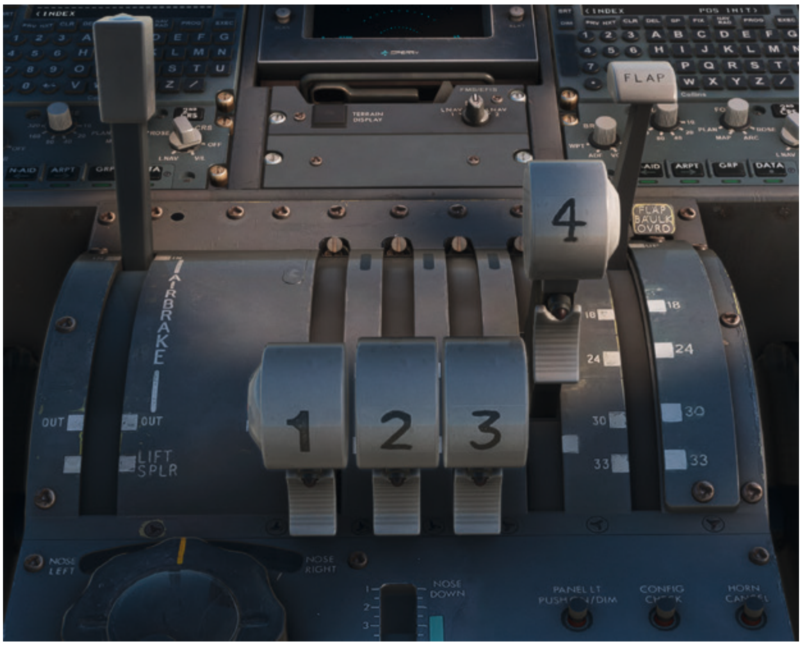
Confirm that the START PWR switch is set to **NORM** and then set the START MASTER switch to **ON**. We will start the engines in the order 4, 3, 2 and 1, so first rotate the start selector to engine **4**.

Press the engine start switch to select the **START** (up) position for one second and then release it. The ENG IGN A (B) ON and STARTER OPERATING lights will illuminate.



Engine 4 will begin to spool up. Monitor the N1, EGT and N2 values.

Once N2 reaches approximately 10%, advance the thrust lever from FUEL OFF to **FUEL ON**. Confirm fuel flow and that N1/EGT/N2 are increasing.



Once engine 4 is stabilised at idle thrust, rotate the start selector to engine **3** and repeat the process, before doing the same for engines 2 and 1.

With all four engines started, rotate the start selector to **OFF** and set the START MASTER switch to **OFF**.

As we are not expecting any icing conditions on our flight today, we can now turn **OFF** the engine anti-ice.

On the ELECTRIC panel, set GEN 1 and GEN 4 to **ON**. The generators on engines 1 and 4 are now providing electrical power to the aircraft.

Set the BRK FANS (brake fans) switch to **AUTO**.

Switch **ON** the ENG 2 and 3 hydraulic pumps and monitor the pressure increase. Once 3,000 PSI has been confirmed in each system, set the AC PUMP to **AUTO** and the PTU to **ON** to supplement hydraulic power in the event of failure during take-off.

On the ICE PROTECTION panel, switch **ON** all five heater switches.

If we have animals in the animal bay, we must switch **ON** the ANIMAL BAY HEAT switch on the First Officer's intrument panel.

Switch the APU AIR back **ON** to supply air conditioning to the cabin during taxi and take-off and switch **ON** both PACK switches.

On the EFB, remove the **CHOCKS** and ensure all doors are closed.

Finally, rotate the transponder mode knob to **TA/RA**.

Taxi

We can now begin the short taxi to runway 28 via taxiway A and holding point A1.

Select **flaps 18** and confirm extension using the flap position indicator.

Switch **ON** the taxi lights and then slowly advance the thrust levers to get the aircraft moving. Taxi to runway 28 and hold short so we can run through the Before Take-off checklist.

On the MCP we can set our flight instruments for departure. Ensure our V2 speed of **131** is set in the IAS/MACH window, runway heading of **273** is set in the HEADING window and an altitude of **26000** in the ALTITUDE window.

As we will be using the flight directors for departure, we will now switch **ON** both flight directors, starting with the Captain's FD and then the First Officer's FD. An 'MA' light will illuminate on the side of the pilot flying. With no modes selected, the autopilot will default to TO TRK mode and the flight director bars will indicate runway heading and a vertical climb at a speed of V2 + 10 once the aircraft's speed is greater than 70 knots.

Confirm that the rudder and aileron trims are centred and that the elevator trim is within the green band range. The correct take-off trim for your current weights can be set automatically by clicking the CG% SMC box on the EFB.

Press and hold the CONFIG CHECK button. If the config horn is not audible, the aircraft is correctly configured for take-off.

Confirm that the correct V-speeds are set on the EFIS, MCP and TRP and that the correct N1 SET is displayed on the PED. Ensure flaps have extended to the take-off position of 18 degrees.

Press the CABIN CALL button on the overhead panel to inform the cabin crew of an imminent take-off. Await verbal confirmation from the cabin crew that the cabin is secured.

Switch **ON** the landing and strobe lights.

Select the A/T to **ARM** and confirm a white A/T legend is displayed on the PFD.

Check that the controls are unlocked and that the elevator, ailerons and rudder all have full and unrestricted movement.

Confirm all MWS captions are extinguished except for appropriate green captions.

Take-off

Line up with the runway centre line and then come to a stop.

Hold the aircraft on the brakes as you bring the thrust levers forward to around 55% N1, check that the engines are stable using the engine instruments and then smoothly advance the thrust levers to approximately N1 whilst simultaneously pressing the TOGA buttons. With TOGA engaged, the A/T will automatically set the correct take-off thrust to the computed N1 REF value.

The TOGA buttons are located on the rear of the throttles, but can also be trigged by using the 'AUTO THROTTLE TO GA' MSFS control assignment or via a hidden clickspot on the VHF NAV panel.

Once N1 thrust has been achieved, release the brakes and keep the aircraft running down the centre line with small rudder inputs. As we approach **124 knots** a "GO" call-out will be heard, indicating that you have passed the V1 speed, followed by a "Rotate" call-out. Gently raise the nose of the aircraft to approximately 10 degrees as you lift off the runway.

The aircraft will begin to climb away from the runway and you should be clear of the ground by the time you reach V2 + 10. Raise the landing gear and follow the flight director to maintain the initial V2 + 10 speed of **141 knots**. Use elevator trim as necessary.

Passing through 2,000 ft, engage the left autopilot master and engage **LNAV** mode.

As we pass through our acceleration altitude, increase the speed set in the IAS/MACH window to our acceleration speed of **210 knots** and engage **LVL CHG** mode. The aircraft will now accelerate to the selected speed and then maintain that speed in a climb.

Passing through our VFTO speed of **172 knots** we will select **Flap 0**. Monitor the speed on the PFD to ensure the aircraft's flap limit speeds are not exceeded during flap retraction.

Once flaps are retracted we can set the speed in the IAS/MACH window to our normal climb speed of **250 knots** and we can set climb power by pressing the TRP CLIMB button once to set **CLIMB NORM** power. Alternatively, the THRUST button on the MCP can also be used to set CLIMB power.

Climb

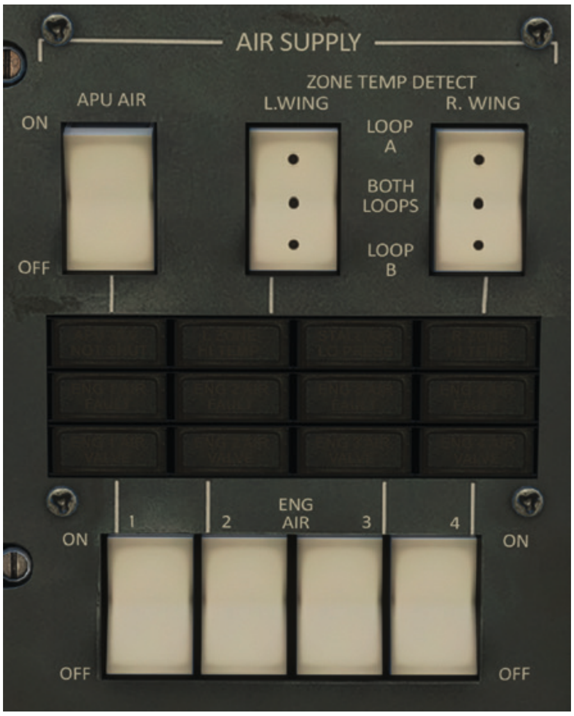
As the aircraft climbs away from Zurich, the autopilot is engaged, with LNAV managing the lateral navigation and LVL CHG managing vertical speed.

We can now carry out the After Take-off checks.

Confirm that the gear and flaps are **UP/RETRACTED**.

Confirm that the TRP is in **CLIMB NORM** mode.

Set all four engine air switches to **ON** and then switch **OFF** the APU air. Confirm that the aircraft is still pressurising.



Shut down the APU by moving the master switch to **STOP**.

Now that we are in a stable climb, we can allow the cabin crew to begin their duties by pressing the **CABIN CALL** button on the overhead.

When passing through 10,000 ft we can carry out the Climb checks.

Set **STD** on the altimeters either by manually rotating the baro knob to 1013/29.92 or by clicking the hidden clickspot at the top left corner of the altimeter.

Switch **OFF** the PTU and leave the AC PUMP at **AUTO**.

Switch **OFF** the landing lights and Fasten Seatbelts signs and increase the climb speed set in the IAS/MACH window to **280 KIAS**. The aircraft will then accelerate to 280 knots and maintain that climb speed until the IAS/MACH changeover altitude at approximately 24,000 ft. At the changeover altitude, the speed set in the IAS/MACH window will change to the Mach number displayed on the PFD at the time of the changeover occurring, which is typically Mach 0.66. We will then climb at Mach 0.66 until reaching our cruise altitude.

The aircraft may be sluggish to climb at higher weights as altitude increases. The use of CLIMB MAX power on the TRP is therefore permitted when the vertical speed drops below +1,000 ft/min, although this does come at the expense of increased engine wear.

During all phases of flight it is important to continue to monitor the navigation and engine instruments to ensure the aircraft is flying on the correct course and altitude.

Cruise

On reaching the pre-selected cruise altitude of 26,000 ft, ALT HLD mode will automatically engage and the aircraft will level off.

The cruise speed for the RJ varies depending on each airliner's operating procedures, but a good intermediate climb speed for the RJ is Mach 0.67. Set **Mach 0.67** in the IAS/MACH window.

Using the quad pressurisation indicator on the First Officer's instrument panel, confirm that the cabin altitude has stabilised at the selected value, with a differential pressure that is within limits. The landing altitude should still be set to the landing altitude of the destination airport.

On the GNLU-910A, press the VNAV key to open the VNAV CRZ page. This page will be a useful one to keep open on at least one of the FMS units as it provides time and distance information to the top of descent.

Cockpit tour

This short sector doesn't give us much time in the cruise but this is a good opportunity to briefly explore the cockpit and cabin.

Next to your left leg is the left side panel; this contains the Captain's lighting controls and audio panel, and the cockpit voice recorder (CVR).

The RJ cockpit has an extensive array of lighting options. Each pilot has individual controls for their instruments and overhead lighting. Rotate each knob in turn to see the effect of the associated light. PANEL INSTS and PANEL FLOOD are the most commonly used. The SILL and LAP controls share a brightness knob so you'll need to increase that and then use the relevant push-button to toggle the lights.

Other lighting controls can be found on the overhead panel, controlling the overhead and glareshield lighting, and on the aft centre console.

Moving forward to the audio selector, rotate the NAV 1 knob to increase the volume for that audio identifier. After a short time you should hear the Morse code ident if a VOR is tuned into the VHF NAV 1 radio. Decrease the volume fully before moving on.

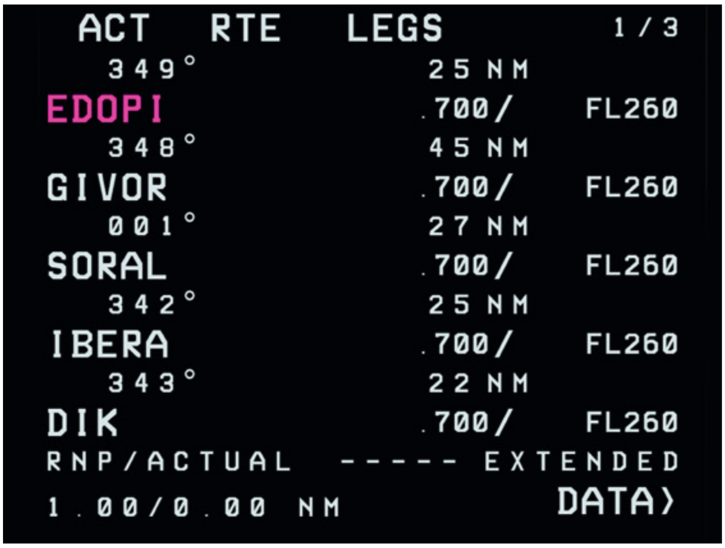
Another system which might require adjustment during the cruise is the air conditioning. With the temperature control switches for the flight deck and cabin in the AUTO position, the temperature selector knobs can be rotated to set the desired zone temperature. Rotate the cabin (right) knob and watch the duct temperature change, followed by a gradual change in the cabin temperature. The temperatures and rates of change are affected by outside air temperature, air supply and even by whether the doors are open!

Over on the electrical panel, you can monitor the load of the two transformer rectifiers (TRs) that convert AC to DC for the various electrical systems. Rotate the DC and AC meter knobs to see the output from the batteries, TRs and engine generators.

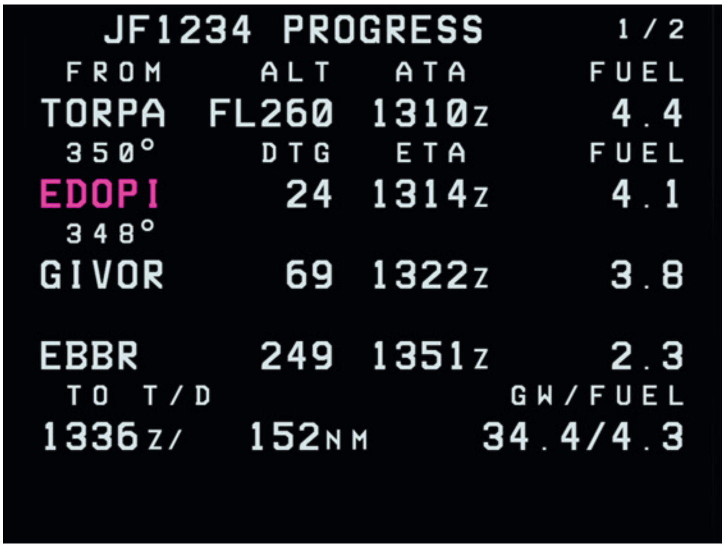
The load on the engine generators can also be seen lower down on the panel.

On the GNLU-910A, several pages can be useful for providing situational awareness of the aircraft's present position on the flight plan, as well as for looking ahead to the destination airport to ensure that we arrive there on time and with sufficient fuel.

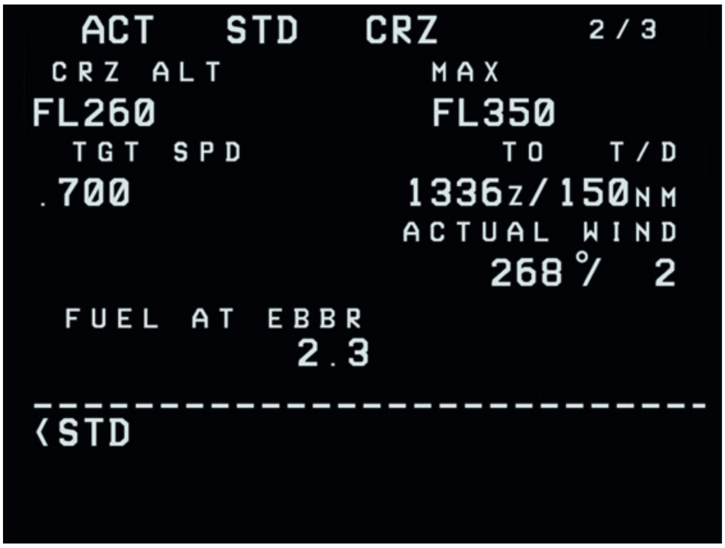
On the **LEGS** page we can view an overview of our position on the flight plan, and also see the distance to the next waypoint and any speed or altitude restrictions that may lie ahead. If we set the FORMAT of the EFIS ND to PLAN, we can press the 6R key to STEP through each of the waypoints in the flight plan and on the ND.



On the **PROG** page 1/2, we can see the aircraft's current fuel situation, including the time we are currently estimated to arrive at EBBR and the amount of fuel we expect to have remaining once we land. PROG page 2/2 is useful for viewing information regarding the aircraft's present position, such as the current headwind/tailwind, crosswind, temperature, cross-track deviation (XTK) and true airspeed (TAS).



The **VNAV CRZ** page is also a useful page to monitor as it provides information such as the current assigned cruise altitude, target speed, the maximum altitude the aircraft can climb to in its current configuration, the distance to the top of descent, actual wind conditions and the expected fuel level at the destination airport.



Using a combination of the left-alt and arrow keys on your keyboard (or LB and the thumbsticks on your Xbox controller), you can move your camera rearwards into the passenger cabin. The passenger cabin is fully simulated in the RJ, including communications panels in the forward and aft galleys that communicate with each other and the cockpit, cabin lighting controls above the service door and even a functional coffee maker that you can hear the cabin crew using throughout the flight.

The doors and airstairs are also fully interactable and can be opened and closed when on the ground. It's probably best that we don't try to open them at 26,000 ft!

We can return to the cockpit either by moving the camera back manually or by pressing the **[F]** key on your keyboard.

Descent

To reduce the workload in the descent and approach phases, we can tune the ILS frequency for the approach into the VHF NAV radios now and set the localiser course.

On the VHF NAV 1 radio, set a frequency of **108.90** in the standby field before swapping it into the active field. Repeat this process for the VHF NAV 2 radios.

On the MCP, rotate both course selectors until they both display **244**.

The ILS course and frequency are now set for the ILS25R at EBBR.

On the main altimeter, we can set our barometric decision height to **300**. On the EFIS dimming panel, rotate the DH knob to set a radio altitude decision height of **200** on the PFD.

The GNLU-910A FMS automatically calculates the top of decent (T/D) based on our current flight conditions and our flight plan, and displays that information on the EFIS ND in the form of a green 'T/D' symbol on the flight plan. The time and distance to the top of descent is also displayed on the VNAV CRZ and VNAV DES pages.

Although the FMS will calculate the top of descent, it is still up the pilot to initiate the descent.

When crossing over the top of descent point, the green 'T/D' symbol will disappear from the ND.

Descents in the RJ are typically conducted using VS mode, although LVL CHG mode can also be used. There are no descent speed limitations in the RJ until we reach the ATC-applied 250 knots restriction below 10,000 ft.

To initiate the descent, reduce the altitude set in the MCP ALTITUDE window to **7000**. This is the first altitude restriction on our approach procedure and we have to remain above 7,000 ft when passing over the FLO VOR. Engage **VS** mode and rotate the VS wheel until **-2000** is displayed in the VERT SPEED window. The aircraft will now begin a descent at -2,000 ft/min and the autothrottle will maintain the speed set in the IAS/MACH window.

We can now work through the Descent checklist.

Switch **ON** the PTU.

Confirm the landing altitude is still set at 100 ft on the pressurisation quad indicator and that the cabin is depressurising nominally.

We can now set our speeds for the approach. We can do this manually using the TRP or automatically by clicking on the desired flap setting on the speeds flipchart. We will cover the manual method in this tutorial flight.

We will be using **33 degrees** of flap today which gives us a VREF speed of 111 knots, a VFTO of 165 and a VER of 175.

On the TRP, rotate the outer control knob to the VCROSS position and then rotate the inner knob until the TRP display shows our VREF speed of **111**. This is our landing reference speed.

Rotate the outer control knob to the VDOT position and then rotate the inner knob until the TRP display shows our VFTO speed of **165**. This is our final take-off speed that we will use in the case of a go-around and we can also easily calculate our minimum flap-up speed of VFTO + 10 (VER).

As we continue to descend, continue to monitor the green arc on the ND and adjust the vertical speed as necessary to keep the arc positioned just before the FLO VOR.

When approaching 12,000 ft we can begin to decelerate to the ATC speed restriction of 250 knots below 10,000 ft. Set **250** in the IAS/MACH window and the autothrottle will adjust power to reach the newly assigned speed. Adjust the vertical speed and use airbrakes as necessary.

Approach and landing

Passing through 10,000 ft we can begin to run through our Approach checks.

Set the altimeters to the destination airport's reported barometric pressure.

Switch **ON** the Fasten Seatbelts sign.

Switch **ON** the landing lights.

With 7,000 ft set in the ALTITUDE window, the aircraft will level off upon reaching 7,000 ft and maintain the altitude. Once the aircraft has passed the FLO VOR there are no further altitude restrictions until joining the ILS approach. We can therefore set **2000** in the ALTITUDE window, engage VS mode and adjust the vertical speed to provide a smooth descent to the ILS intercept point.

When passing through 5,000 ft, select the APU master to **START** and confirm that the RPM and TGT rise.

Once the APU has started, switch **ON** the APU AIR and switch **OFF** the four ENGINE AIR switches.

Reduce speed to **210 knots**, a comfortable speed we can fly at with flaps retracted.

Once within range of the ILS beams, the DME displays on the DBIs will display the distance to the runway and the localiser and glideslope deviation indicator will appear on the EFIS PFD and ND.

Arm **VOR LOC** mode on the MCP. In this mode the aircraft will automatically capture the localiser once in range.

As we near the final approach fix, tell the cabin crew to prepare for landing by pressing the **CABIN CALL** button on the overhead and await confirmation that the cabin is secured.

Reduce speed to our VFTO + 10 speed of **175 knots** and then select **flaps 18** once the co-pilot's call-out is heard. The co-pilot will provide useful airbrake, flap and gear extension call-outs throughout the approach when the aircraft is at the correct speed and altitude for each action.

Reduce speed to **160 knots** and, once the co-pilot call-out is heard, lower the landing gear. Confirm three green lights are illuminated.

Once the localiser has been intercepted, the autopilot will turn the aircraft onto the approach. We can then engage **APP** mode and the aircraft will automatically capture the glideslope once within range.

Begin to reduce speed further to the VREF24 + 5 speed of 129 knots and select **flaps 24**.

Once below 145 knots, extend the flaps to **33 degrees** and reduce speed further towards our VREF33 + 5 speed of 116 knots. This is our final approach speed.

We can now carry out the Landing checks.

Confirm the landing gear are down and three greens are indicated.

Confirm the brakes are set to YELLOW.

Confirm that the flaps are indicating **33 degrees**.

Confirm the AIRFRAME ANT and DE-ICE is **OFF**.

Passing through 500 ft, if the CAT 3 autoland conditions have been met, CAT3 and AUTO LAND annunciators will be illuminated on the flight annunciator panel, indicating that a CAT3 autoland is armed. However, as conditions are perfect for flying today, this is a good time to disconnect the autopilot and autothrottle and to fly the remainder of the approach manually.

As the aircraft crosses the runway threshold, extend the airbrakes and begin to flare, gently raising the nose just above the horizon. Reduce the thrust levers to Flight Idle and the aircraft should touch down smoothly.

After touchdown, move the thrust levers to Ground Idle and gently lower the nose-wheel onto the runway. The lift spoilers will deploy automatically. Apply gentle braking and, once the aircraft has slowed, turn onto the first available taxiway to the left.

We can carry out the After Landing checks once we are safely off the runway.

Ensure the autothrottle is **OFF**.

Retract the flaps, airbrakes and lift spoilers.

Switch **ON** the taxi lights and switch **OFF** the strobe lights.

Set the weather radar to **STBY** and set the tilt to **+15° UP**.

Set the transponder to **STBY**.

Begin to taxi to the nearest available gate.

Shutdown

When turning into the gate, switch **OFF** the taxi lights.

Once the aircraft has come to a stop at the gate, engage the parking brake.

Confirm that the aircraft is depressurised – the cabin altitude should match the airfield elevation and the differential pressure and cabin rate should be zero.

Before shutting down systems, pull the MWS GRND OP switch to the fully out **GRND OP** position with red light illuminated. This silences any non-critical MWP alarms that will sound as systems are shut down.

Switch **OFF** all hydraulic pumps.

Set the GEN 1 and 4 switches to **OFF/RESET**.

Move each thrust lever in turn to the **FUEL OFF** position and the engines will begin to shut down.

Switch **OFF** the Fasten Seatbelts sign to release the passengers.

Switch **OFF** the fuel pumps, leaving just the L INNER pump running for the APU.

Switch **OFF** the engine anti-ice.

Switch **OFF** all five heater switches.

Switch **OFF** the ice detection switch.

Switch **OFF** the beacon light.

Use the EFB as we did at the start of the flight to open the passenger and cargo doors, extend the airstairs and enable the chocks ready for deboarding.

We can begin the passenger deboarding by opening the Boarding menu and then clicking the START DEBOARDING button.

Leaving the aircraft

Switch **OFF** the oxygen main valve.

Select both IRS switches to **OFF**.

Switch both EFIS masters to **OFF**.

Switch **OFF** the avionics, AP and yaw damper master switches from right to left.

Once the brakes have sufficiently cooled, as shown on the brake temperature gauge on the centre console, the brake fans can be switched **OFF**.

Switch **OFF** anti-skid and both the YEL and GRN lift spoilers.

Switch **OFF** the cabin emergency lights and confirm that the EMERG LTS NOT ARMED caption is illuminated on the MWP.

Switch **OFF** both PACK 1 and PACK 2 switches, the Flight Deck and Cabin Fans switches, and the APU Air switch. Confirm that the APU VLV NOT SHUT annunciator extinguishes within five seconds.

Shut down the APU by pressing and holding the **APU OVSPD** test button on the ground test panel on the overhead. The button can be released once a decrease in RPM and TGT is observed.

Once the APU has shut down, switch **OFF** all remaining fuel pumps.

Move the Galley switch on the overhead to **SHED**.

Switch **OFF** all remaining exterior, interior and emergency lighting.

Finally, switch **OFF** the BATT 1 and BATT 2 switches.

Congratulations – you have completed the RJ Professional tutorial flight!

LIMITS

Airspeed limitations

Maximum operating speed (VMO)	300 KIAS (RJ100: 305 KIAS)
Maximum operating Mach number (MMO)	M0.72 or M0.73
Bird impact speed	250 KIAS below 8,000 ft
Landing gear operating speed (VLO/VLE)	205 KIAS
Manoeuvring speed (VA)	220 KIAS (flaps up) 175 KIAS (flaps 18°)
Maximum speed with YD system inoperative	240 KIAS

Wing flaps extended (VFE) – the maximum permissible air speeds for extending the wing flaps and flights with flaps extended are given below for various control lever gate positions:

Flap Airspeed Limits (kt)				
Flap Angle		**RJ70**	**RJ85**	**RJ100**
18°	VFE	205	215	220
	Max for holding	170	175	175
VFE 24°		170	180	180
VFE 30°		160	170	170
VFE 33°		150	150	155

Compartment loading

The maximum permissible loads for the various compartments are shown in the table below:

Compartment	Maximum total load	
	lb	**kg**
Forward baggage	3,350	1,520
Aft baggage	3,320	1,506
Passenger cabin	–	–

Miscellaneous limitations

Manoeuvres

The maximum normal accelerations (i.e. load factor) which the structure has been designed to withstand without permanent deformation are:

Flaps retracted: -1G to 2.5G

Flaps extended: 0G to 2.0G

The table below gives the manoeuvring airspeed (VA) for each series. VA is the maximum speed for full control deflection and manoeuvres that involve angles of attach near the stall.

Design Manoeuvring Speed – VA (kt)		
Series	**Flaps Retracted**	**Flaps 18°**
RJ70	230 or 235	170
RJ85	230 to 235	175
RJ100	240 to 245	175

Maximum operating altitude

The maximum operating altitude depends on the type of pressurisation system fitted. If a fully automatic system is fitted, the maximum operating altitude is 35,000 ft.

The landing gear must not be operated at altitudes higher than 20,000 ft. The flaps must not be operated at altitudes higher than 19,000 ft.

Maximum and minimum airfield altitude for take-off and landing

The maximum airfield pressure altitude for take-off and landing can vary between 8,000 ft and 9,300 ft.

The minimum airfield pressure altitude for take-off is -1,000 ft.

The maximum airfield pressure altitude for autoland is 6,000 ft.

Maximum ambient air temperature for take-off and landing

The maximum air temperature for take-off and landing is +50˚C at altitudes below 2,525 ft and ISA +40˚C at altitudes above 2,525 ft.

The maximum en route temperature is ISA +35˚C.

Minimum ground ambient air temperature

The minimum temperature for dispatch is either -40˚C or -50˚C.

Maximum crosswind

The maximum crosswind component in which the aircraft has been demonstrated to be satisfactory is 35 knots for take-off and landing, at 90° to the flight path.

Maximum tailwinds

The maximum tailwind component for take-off is either 10 kt or 15 kt.

The maximum tailwind component for landing is either 10 kt or 15 kt.

ILS/Autoland limits

For an ILS approach / Autoland:

Maximum headwind component:	25 knots.
Maximum crosswind component:	15 knots.
Maximum tailwind component:	10 knots.

Maximum certificated approach angle

The maximum certificated approach angle for the RJ70 and RJ85 is 6 degrees. For the RJ100 it is 5.5 degrees.

Critical engine

The critical engine is the outer engine on the upwind side.

Cabin pressure

For aircraft with a maximum operating altitude of 35,000 ft the maximum pressure differential is 7.5 PSI up to 27,000 ft. Above 27,000 ft the maximum differential pressure is 7.6 PSI.

The cabin differential pressure must not exceed 0.1 PSI during take-off and landing.

Weight and loading limits

RJ70	Range of Maximum Weights	
Limit	**Kg**	**Lb**
Maximum ramp weight	38,328 to 43,318	84,500 to 95,500
Maximum take-off weight	38,101 to 43,091	84,000 to 95,000
Maximum landing weight	37,874	83,500
Maximum zero fuel weight	32,431 to 33,792	71,500 to 74,500

RJ85	Range of Maximum Weights	
Limit	**Kg**	**Lb**
Maximum ramp weight	41,708 to 44,225	91,950 to 97,500
Maximum take-off weight	41,308 to 43,998	91,068 to 97,000
Maximum landing weight	36,740 to 38,555	81,000 to 85,000
Maximum zero fuel weight	34,019 to 35,833	75,000 to 79,000

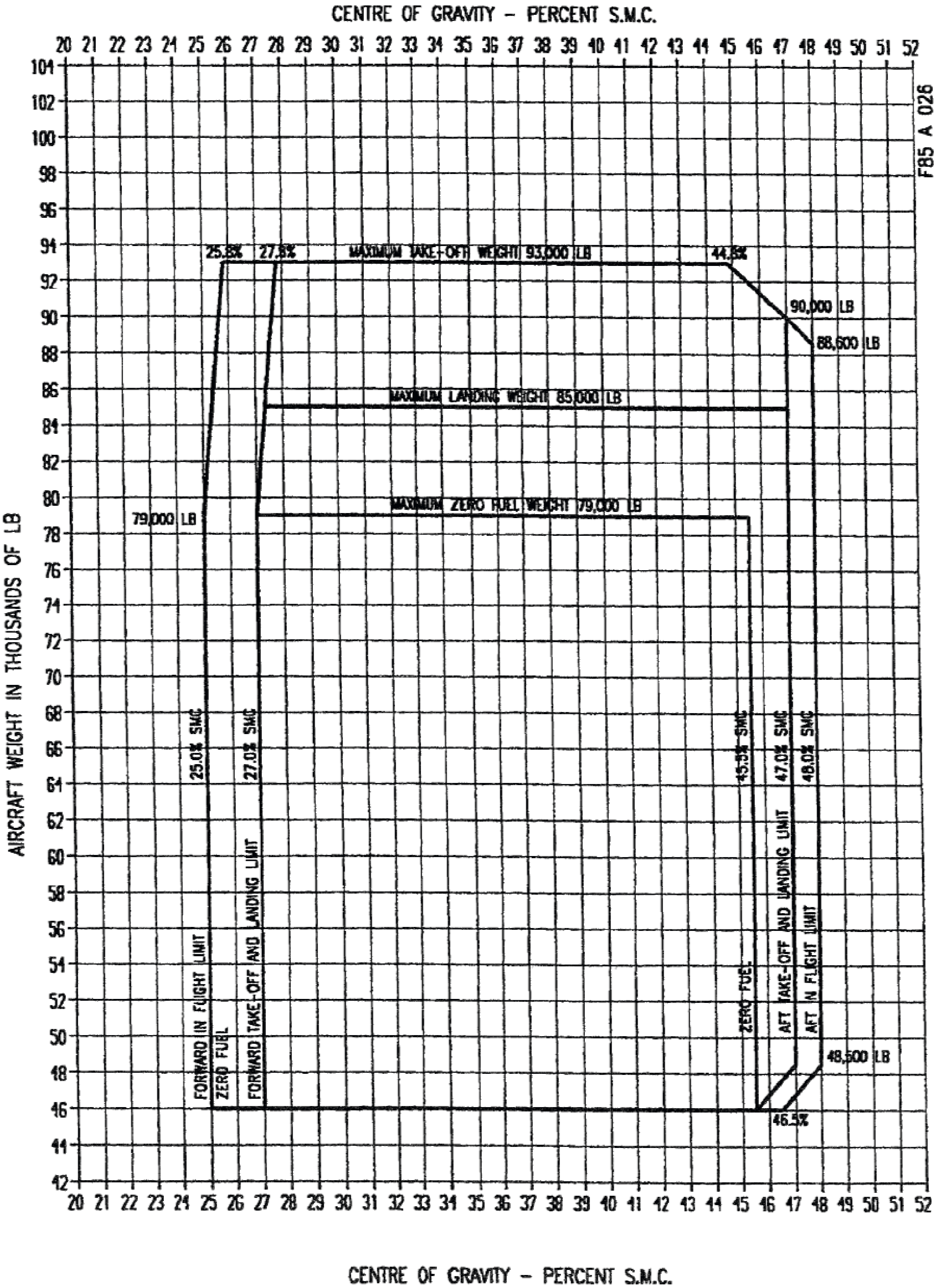
RJ100	Range of Maximum Weights	
Limit	**Kg**	**Lb**
Maximum ramp weight	44,400 to 46,266	97,885 to 102,000
Maximum take-off weight	44,000 to 46,039	97,003 to 101,500
Maximum landing weight	39,235 to 40,142	86,500 to 88,500
Maximum zero fuel weight	36,514 to 37,874	80,500 to 83,500

The centre of gravity of the aircraft should always lie between the forward and aft limits defined in the envelope below.

The in-flight and zero fuel limits are shown with flaps and landing gear retracted. The take-off and landing limits are shown with landing gear extended.

The centre of gravity datum is at:

- Fuselage station AXO 1,138.25 cm (448.13 inches) for RJ70 series aircraft.
- Fuselage station AXO 1,249.2 cm (491.81 inches) for RJ85 series aircraft.
- Fuselage station AXO 1,383.8 cm (544.81 inches) for RJ100 series aircraft.


CENTRE OF GRAVITY - PERCENT S.M.C.
F85 A 026
AIRCRAFT WEIGHT IN THOUSANDS OF LB
25.8%
27.8%
MAXIMUM TAKE-OFF WEIGHT 93,000 LB
44.8%
90,000 LB
88,600 LB
MAXIMUM LANDING WEIGHT 85,000 LB
MAXIMUM ZERO FUEL WEIGHT 79,000 LB
79,000 LB
25.0% SMC
27.0% SMC
45.5% SMC
47.0% SMC
48.0% SMC
FORWARD IN FLIGHT LIMIT
ZERO FUEL
FORWARD TAKE-OFF AND LANDING LIMIT
ZERO FUEL
AFT TAKE-OFF AND LANDING LIMIT
AFT IN FLIGHT LIMIT
48,500 LB
46.5%
CENTRE OF GRAVITY - PERCENT S.M.C.

Elevator trim

Elevator trim must be set according to the aircraft's centre of gravity. The trim setting is the same for all take-off flap settings:

RJ70	Elevator Trim setting for Take-off								
CG% SMC	28	31	32	34	36	38	40	42	44
ELEV TRIM	4.0	4.0	3.9	3.7	3.5	3.3	3.1	2.9	2.7

RJ85	Elevator Trim setting for Take-off											
CG% SMC	27	28	30	32	34	36	38	40	42	44	46	47
ELEV TRIM	4.4	4.3	4.1	3.9	3.7	3.5	3.2	3.0	2.8	2.6	2.4	2.3

RJ100	Elevator Trim setting for Take-off													
CG% SMC	22.5	25	27	29	31	33	35	37	39	41	43	45	47	48.5
ELEV TRIM	4.7	4.5	4.3	4.1	4.0	3.8	3.6	3.5	3.3	3.1	3.0	2.8	2.6	2.5

Number of occupants

The total number of occupants carried, including crew, must not exceed the number for which seating accommodation is provided.

The total number of occupants, including crew, must not exceed:

- 100 for the RJ70
- 118 for the RJ85
- 118 for the RJ100

APU

General

If the APU malfunctions in flight it must be shut down. No attempt to restart it must be made.

The APU must be shut down before the APU FIRE EXTinguisher is discharged.

When the APU is running and the APU generator is selected ON, the following limitations apply:

- APU AIR must be selected OFF above 15,000 ft.
- APU generator must not be used above 25,000 ft.
- When the APU is running and APU GEN is selected ON, the AC pump should be selected OFF above 17,000 ft to ensure that the generator load remains below 65 amps.

Operating limitations

Maximum TGT during running	746°C
Maximum TGT during starts	870°C (974°C for no more than 10 secs)
Overspeed shutdown	110% RPM
Starting envelope	Max. altitude – 20,000 ft
Maximum operating altitude	31,000 ft

Autopilot

Take-off

Do not engage the autopilot in the TO mode below 350 ft AGL. Do not deselect the TO mode until obstacle clearance is assured.

Climb, cruise and descent

The autopilot must not be engaged in ALT mode below 500 ft AGL.

Approved categories of precision ILS approach and landing

The aircraft is approved only for the following types of ILS approach and landing:

- Category 1
- Category 2
- Category 3

Category 1 approaches are approved as follows:

- Manually flown with or without the flight director
- Automatic approach followed by a manual landing or automatic landing

Category 2 approaches must be autopilot-coupled approaches followed by manual or automatic landing.

Category 3 approaches must be autopilot-coupled approaches followed by an automatic landing.

Autopilot-coupled ILS approaches

A minimum of three engines must be operating at the start of the approach.

Flap 33° must be selected for landing.

When coupled to the ILS glideslope and localiser:

- The autopilot must not remain engaged below 160 ft AGL if both radio altimeters are inoperative.
- The autopilot may remain engaged down to 50 ft AGL provided that the CAT 2 status annunciator is lit.

Non-precision approach

A minimum of three engines must be operating at the start of the approach.

The autopilot must not remain engaged below 300 ft AGL.

For autopilot engagement between 1,000 ft AGL and 500 ft AGL, the rate of descent must be less than 1,000 ft/min and only LVL CHG or VS modes are permitted.

If a GNLU-910A FMS is fitted, approaches using the FMS may only be flown if the FMS APP annunciators are illuminated AND the AP or FD is coupled to LNAV.

Approaches using the GNLU-910A FMS may only be flown down to the applicable non-precision approach minimums.

Steep approach

Steep approaches are only permitted if a steep approach monitor system is fitted. The approach angle must be between 4.5° and 6° for the RJ70, RJ85 and RJ100.

Landing with a tailwind component:

- Is not permitted in the RJ100.
- Is allowed in the RJ7O and RJ85; the maximum tailwind component is 5 kt. The wind speed relates to a height of 10 m (33 ft).

For non-precision approaches, a visual precision approach path guidance (PAPI) relative to the steep approach angle must be used for the final visual segment of the approach.

For autopilot-coupled ILS approaches, a visual precision approach path guidance (PAPI or flight deck display of ILS) appropriate to the steep approach angle must be used.

The decision height must not be less than 200 ft AGL or the OCA/H, whichever is the greater.

The autopilot and autothrottle may remain engaged down to 160 ft AGL provided they are coupled to an ILS glideslope and localiser.

The flap angle for the landing must be 33°.

The airbrake must be operative.

Crosswind limitations

For an automatic landing (Category 1 approach, Category 2 approach or Category 3 approach and automatic landing), the maximum allowable wind components with all engines operating are:

- 25 kt headwind
- 15 kt crosswind
- 10 kt tailwind

Category 2 and 3 minimums

The aircraft complies with the airworthiness Category 2 and Category 3 performance standards; this compliance does not constitute operational approval to operate to Category 2 or Category 3 minimums. Operational approval must be obtained to operate to Category 2 or Category 3 weather minimums.

A Category 2 decision height must be identified by radio altitude and must not be less than 100 ft AGL or the OCH. Where an OCH is not promulgated, the decision height may be determined by an alternative means acceptable to the NAA.

A Category 3 decision height must be identified by reference to radio altitude and must not be less than 50 ft.

Automatic landing

For an automatic landing:

- The autopilot must be engaged prior to 1,000 ft AGL and remain engaged thereafter.
- Flap 33° must be selected.
- A minimum of three engines must be operating at the start of the approach.
- The runway must be at least 45 m wide.
- The glideslope angle must be at least 2.5° and not more than 3.6°.

The autopilot must not remain engaged throughout an ILS approach, touchdown and rollout, unless the Category 3 status annunciator is lit.

Yaw damper

During flight with the yaw damper failed, the airspeed must not exceed:

- 230 kt for the RJ70
- 240 kt for the RJ85

For the RJ70 there is also an altitude limitation of 25,000 ft or below.

There are no limitations on flight for the RJ100 with the yaw damper failed.

Autothrottle

The autothrottle must not be used when any FADEC is inoperative.

The autothrottle must not be used when an RA (radio altimeter) comparator warning is displayed.

Engines

Operating limitations

Condition	N1 (%)	N2 (%)	EGT (°C)	Oil pressure (PSIG)	Oil temp (°C)
Start and relight	–	–	649 (713 for 10 secs)	–	133 max - 40 min
Ground idle	–	FADEC OFF - 49 to 54 FADEC ON - 49 to 75	–	25 min	133 max
Flight idle	–	ENG ANT-ICE OFF - 59 min ENG ANT-ICE ON - 67 min	–	35 min	133 max
Maximum continuous	97.0	96.9	613	85 min 107 max	133 max
Normal take-off	97.0 (100 for 10 sec)	98.8 (100 for 10 sec)	632 (685 for 15 sec)	87 min 107 max	30 min 133 max

Ground start

The engines must not be started in ground ambient air temperatures less than -50°C.

In-flight start

An in-flight start must not be attempted if N2 has indicated below 1% for more than seven minutes.

The normal in-flight start envelope is:

- N2 6% or greater
- Altitude 20,000 ft or below
- IAS between 185 and 240 kt

Ground idle

With FADEC ON, the ground idle N2 must be between 49% and 54%.

With FADEC OFF, the ground idle N2 must be between 49% and 75%.

At ground idle the minimum oil pressure is 25 PSI and the maximum oil temperature is 133 °C.

Flight idle

With ENG ANT-ICE selected OFF, the minimum flight idle N2 is 59%.

With ENG ANT-ICE selected ON, the minimum flight idle N2 is 67% above 200 ft AGL and 59% below 300 ft AGL.

At flight idle the minimum oil pressure is 35 PSI and the maximum oil temperature is 133°C.

Maximum continuous

At the maximum continuous rating:

- Maximum N1 is 97.0%
- Maximum N2 is 96.9%
- Maximum EGT is 613°C
- Maximum oil temperature is 133°C
- Maximum oil pressure is 85 PSI
- Maximum oil pressure is 107 PSI

Reduced or flexible thrust operation

Reduced or flexible thrust may only be used for take-off if the following conditions are met:

- The runway in use is not contaminated with standing water, snow, slush or ice.
- The availability of the rated thrust is periodically checked to ensure that take-offs are not made with excessive engine deterioration.

Fuel

Maximum fuel temperature (delivery to engine): +55˚C

Minimum fuel temperature (delivery to engine): +3˚C

The asymmetry of the fuel within the wings must not exceed 680 kg (1,500 lb).

The total amount of unusable fuel in each wing under normal conditions is 23 kg (49.4 lb). The unusable fuel in the centre tank is 6 kg (13.2 lb). Fuel quantity indicators are zeroed at the basic unusable fuel level.

Generator loading

Main engine generator

Continuous rating	110 amps
Two-hour rating	140 amps
Five-minute rating	165 amps
Five-second rating	220 amps

APU generator

Ground use

Continuous rating	105 amps
Two-hour rating	105 amps
Five-minute rating	155 amps
Five-second rating	200 amps

Flight use

Below 17,000 ft	90 amps
17,000 ft to 25,000 ft	65 amps

Manual lift spoilers

The airbrake lever must not be moved to the LIFT SPLR position while in flight.

NORMAL PROCEDURES

Checklists

CHECKLISTS

COCKPIT PREPARATION

CIRCUIT BREAKERS	CHECKED IN
RADAR	OFF
ELECTRIC / GPU / APU	SET
PANELS & PEDESTAL	CHECKED
OXY VALVE AND PRESSURE	CHECKED

COCKPIT PREPARATION COMPLETED

CREW AT STATION

PINS & COVERS	ON BOARD
AIRCRAFT LOG	CHECKED
PARK BRAKE	SET
FUEL QUANTITY & FLOW METERS	CHECKED
ALTIMETERS	CHECKED
PRESSURISATION	CHECKED
IRS	CHECKED
FMS	CHECKED
FLIGHT GUIDANCE	CHECKED

T/O DATA	CHECKED
TRIMS	SET
T/O BRIEFING	PERFORMED

CREW AT STATION CHECK COMPLETED

BEFORE ENGINE START

FASTEN BELTS	ON
PACKS & APU AIR	OFF
BEACON / STROBES	ON
FUEL PANEL	SET
DOORS / WINDOWS	CLOSED / REMOVED
SLIDES	ARMED
TCAS	TA/RA

READY FOR PUSH BACK / ENGINE START

AFTER ENGINE START

GENERATORS	ONLINE
BRAKE FANS	AUTO
HYDRAULICS	ON / AUTO
ICE PROTECTION	*AS REQUIRED*
AIR CONDITIONING	*AS REQUIRED*
AUTO-THROTTLE	ARMED
FLAPS	*__* SELECTED
FLIGHT CONTROLS	CHECKED
CLEAR SIGNAL	RECEIVED

READY FOR TAXI

TAXI CHECK

ATC CLEARANCE	VERIFIED
THRUST & T/O DATA	RECHECKED
FLAPS & SPEEDS	CHECKED
T/O BRIEFING	COMPLETED
CONFIG	CHECKED
MWS	CHECKED
CABIN	SECURED

READY FOR DEPARTURE

CHECKLISTS

SYSTEM CHECK

ENG AIR .... ON
APU AIR .... OFF
PACKS .... ON (Pressurising)
APU .... STOP
LIGHTS .... OFF
FLAPS .... 0°
GEAR .... UP
TRP .... CLIMB
ALTIMETERS .... X-CHECKED

SYSTEM CHECK COMPLETED

PREPARATION FOR APPROACH

FMS .... CHECKED
ACTUAL FUEL .... CHECKED
LANDING DATA .... SET / CHECKED
LAND FLAP / STEEP APPROACH .... *AS REQUIRED*
PRESSURISATION .... SET
BRIEFING .... COMPELTED

PREPARATION FOR APPROACH CHECK COMPLETED

AFTER LANDING

GUST LOCK / AIRBRAKE .... SET / IN
RADAR .... OFF
APU .... *AS REQUIRED*
FLAPS .... 0°

AFTER LANDING CHECK COMPLETED

PARKING

PARK BRAKE .... SET
SLIDES .... DISARMED
XPDR / TCAS .... STBY
HYDRAULICS .... OFF
GENERATORS .... OFF/RESET
AIR CONDITIONING .... *AS REQUIRED*
ENGINE SHUTDOWN .... PERFORMED
FASTEN BELTS .... OFF
EXTERNAL LIGHTS .... OFF
BRAKE FANS .... *AS REQUIRED*
FUEL PUMPS .... *AS REQUIRED*
IGNITION .... OFF
ICE PROTECTION .... ENGINE A/I ON / HEATERS OFF

PARKING CHECK COMPLETED

LEAVING AIRCRAFT

EMERGENCY LIGHTS .... OFF
ELEVATOR TRIM .... POS 1
AVIONICS .... OFF
FUEL PUMP .... OFF
AIR CONDITIONING .... OFF
LIGHTS & NOTICES .... OFF
APU .... OFF
ELECTRICS .... OFF
EFB STORAGE BOX .... LOCKED

LEAVING AIRCRAFT CHECK COMPLETED

Take-off procedure

Select the take-off flap setting appropriate to the prevailing airfield conditions and the scheduled performance data. The preferred flap setting for take-off is 18°. Flap 18° gives a better climb gradient, better noise footprint, and is the correct setting for possible windshear. The setting for take-offs from contaminated runways is 30°.

Set the elevator trim appropriate to the aircraft centre of gravity. Determine and display the relevant scheduled speeds and take-off power setting(s).

When all other take-off preparations are complete, advance the thrust levers to achieve take-off N1 setting.

Normally, some degree of flexible thrust is used for take-off, and so the TRP thrust is normally set to TOGA REDU. If a fully rated take-off is to be made, the TRP mode is set to TOGA MAX.

Set take-off power before releasing the brakes unless field length and obstacle clearance margins permit a rolling start to be made or high surface wind conditions require modified engine handling.

The A/T will set the target N1 automatically. If the A/T is used for take-off:

- The A/T switch is set to ARM when lining up.
- When cleared for take-off, more than 45% N1 is set and either TOGA button is pressed.
- At 80 knots, the thrust freeze mode is entered and the autothrottle servo is clamped; the trim arrows are extinguished regardless of whether or not target N1 is achieved. However, target N1 can still be achieved by adjusting the thrust levers.

Start the elapsed time clock when the target N1 is reached.

Maintain directional control with nose-wheel steering before transferring to normal use of the rudder at 50-60 knots.

During the take-off roll maintain the control handwheel at, or close to, the neutral fore and aft position and apply handwheel deflection as required to maintain wings level.

On reaching VR, begin a smooth continuous rotation that will establish, in about four seconds, the attitude required to achieve V2 + 10 knots. When a positive rate of climb is confirmed, retract the landing gear and maintain the speed at or above V2 + 10 knots. If the FD is used, it will command a speed of V2 + 10 knots.

At 350 ft with the TRP on, the thrust freeze mode is left. N1 will then be trimmed to the value appropriate to the ambient conditions and the bleed selection. Vsel can be changed once above 350 ft radio altitude,

During the initial climb it is recommended that the pitch attitude should not be allowed to exceed 20°. If this attitude is reached, allow the speed to rise above the target value.

When at or above 400 ft and clear of obstacles, allow the aircraft to accelerate through the standard flap retraction airspeed schedule to the required climb speed

FLAP RETRACTION AIRSPEED SCHEDULE			
Take-off Flap Setting	**Minimum speed to select flaps to:**		
	24°	**18°**	**0°**
18°	–	–	VFTO
24°	–	V2 + 10 KIAS	VFTO
30°	V2 + 10 KIAS	V2 + 10 KIAS	VFTO
33°	V2 + 10 KIAS	V2 + 10 KIAS	VFTO

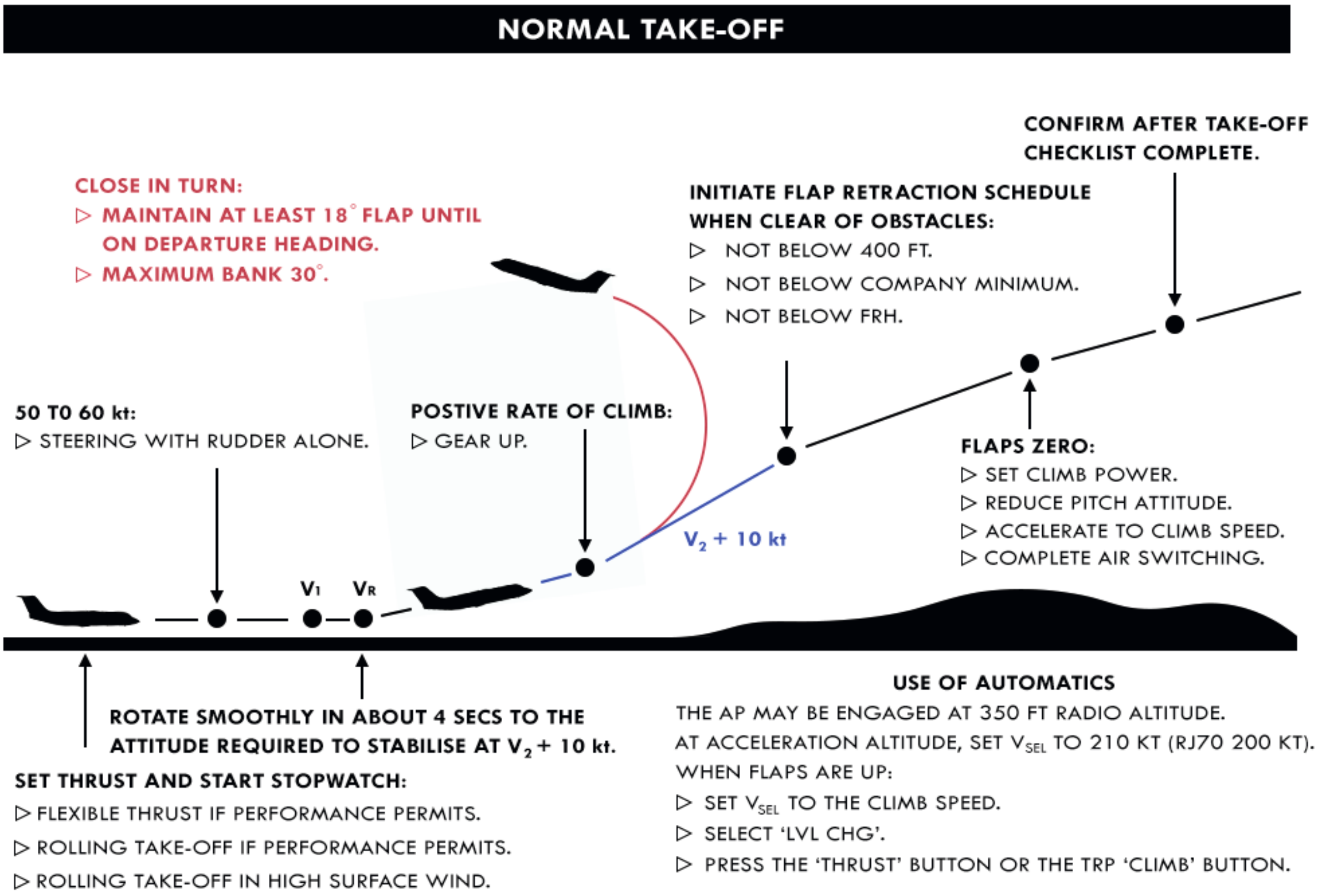
When flaps are retracted, set climb power and continue acceleration to the required en route climb speed.

If the AP or FD is used for acceleration, at the acceleration altitude set the MCP speed selector to 210 knots for an RJ85 or RJ100 and to 200 knots for an RJ70.

When flaps are up:

- Set the MCP speed selector to the climb speed, normally 250 knots.
- Press the LVL CHG button on the MCP. The AP/FD mode will become level change climb; IAS will be annunciated as the vertical mode on the PFDs.
- Press the MCP THRUST button or the TRP CLIMB button; the thrust rating will become CLIMB NORM. If CLIMB MAX is required, a further press on the TRP CLIMB button is required. If the A/T is engaged it will set climb power. If the A/T is not engaged, thrust must be set manually.

Air supply, air conditioning and airframe anti-ice switching should not be done until climb power has been set.



Noise abatement take-off

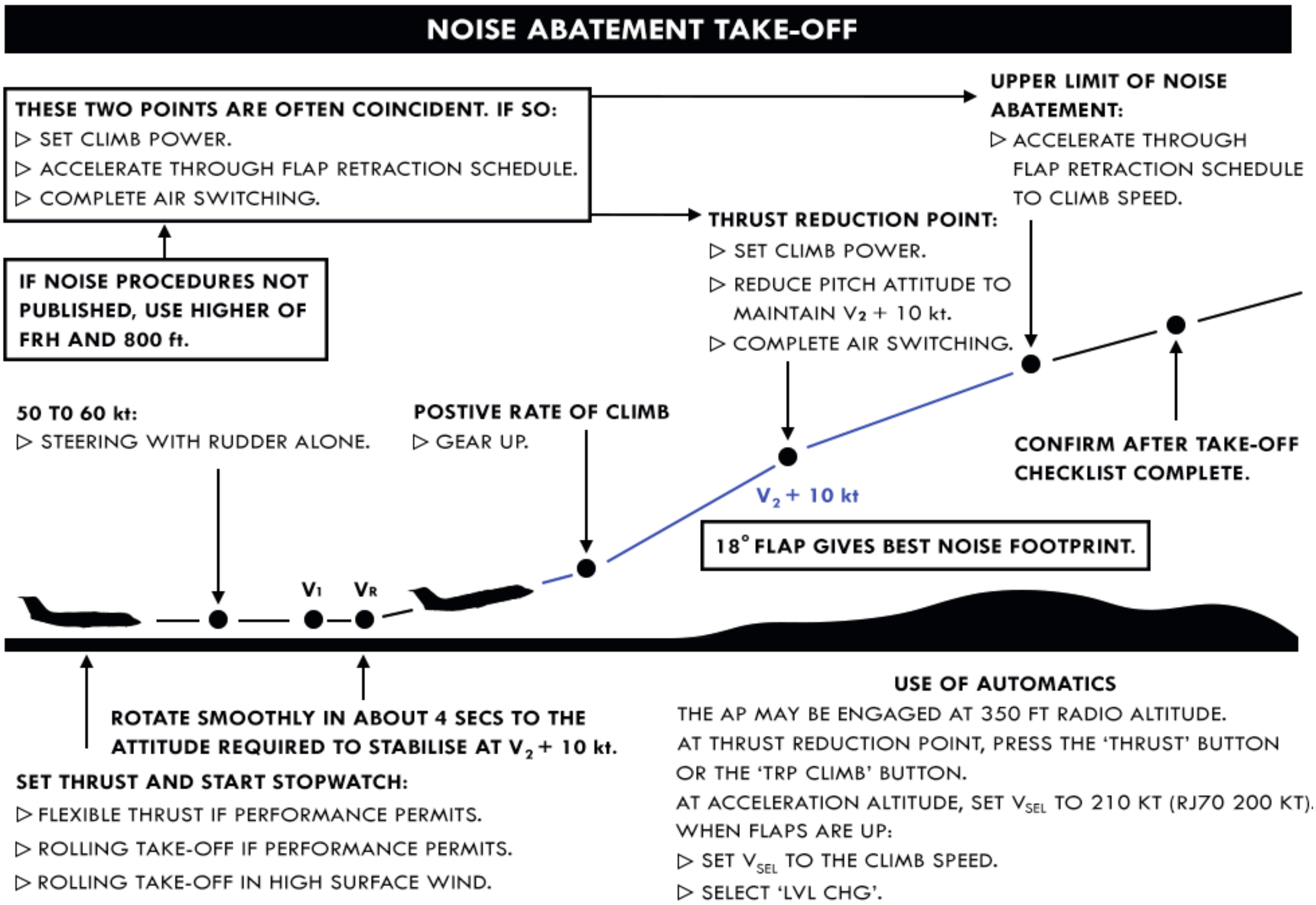
Use a take-off flap setting of 18° if airfield performance allows.

Maintain the initial climb with take-off flap at V2 + 10 knots until the thrust reduction point for the noise abatement procedure (800 ft above airfield level unless otherwise specified in airport procedures).

Set climb power and continue the climb at V2 + 10 knots.

On reaching the upper limit altitude of the noise abatement procedure, accelerate through the flap retraction airspeed schedule to the required climb speed.

During the initial climb it is recommended that pitch attitude should not be allowed to exceed 20° nose up. If this attitude is reached, allow speed to increase above target value.



Climb en route

Climb power can be set manually or through the FGS. Either CLIMB NORM or CLIMB MAX is set. It is recommended that:

- CLIMB NORM is set after take-off.
- CLIMB MAX is set when a climb rate of 1,000 ft/min can no longer be achieved at long-range climb speed with CLIMB NORM set.

When an FGS lateral mode is selected, the AP/FD mode changes from track to the selected lateral mode; the parallel rudder is no longer available.

When climbing in VS or LVL CHG mode, the MCP will automatically change from IAS to MACH on climbing through FL245.

On approaching the selected altitude, the FGS vertical mode will change to altitude acquire (ACQ) and then to altitude hold (ALT). If autothrottle is engaged, the thrust mode will change from CLIMB NORM or CLIMB MAX to IAS or MACH when ACQ is entered.

In altitude hold, the autothrottle will not use more than the TRP selected thrust rating to hold airspeed. If the airspeed set on the MCP is greater than that achievable in level flight with the selected rating, the autothrottle just sets the thrust rating and the speed stabilises below the MCP set airspeed.

For large changes of altitude or at high altitude, LVL CHG is used for the climb. To enter a level change climb from altitude hold, the selected altitude must be set above the held altitude.

On entering level change:

- The AP/FD will manoeuvre towards the selected altitude.
- The AP/FD will hold the speed in the IAS window. The vertical mode will be IAS if IAS is in the MCP speed window and will be MACH if Mach number is in the window.
- If the autothrottle is engaged, it will set the thrust rating N1.

For small changes (up to 3,000 ft) at low to medium altitude, it is recommended that VS mode is used to avoid large power changes and to improve passenger comfort.

Be careful about selecting VS. If VS is selected, the autothrottle will control airspeed and the AP/FD will control to the set vertical speed; a suitable vertical speed must be selected to ensure terrain clearance.

To enter vertical speed from altitude hold, the selected altitude must be different from the held altitude. However, neither the AP nor the FD will manoeuvre towards the selected altitude in vertical speed mode.

On entering vertical speed mode:

- The AP or FD initially holds the vertical speed existing when the VS button is pressed. The vertical speed can then be adjusted with the VS thumbwheel.
- The autothrottle will hold the set IAS within the limits of the TRP set thrust rating.

Climb speeds

There are three climb techniques:

- Long range
- High speed
- Steep gradient

The long range climb speed is 250 kt or 0.62 M. The Mach number is increased to 0.64 if the take-off weight is greater than 41,000 kg. The Mach and IAS values are coincident above FL 245. However, the automatic changeover to MACH occurs at FL 245, giving a Mach number of 0.60, so some adjustment is required.

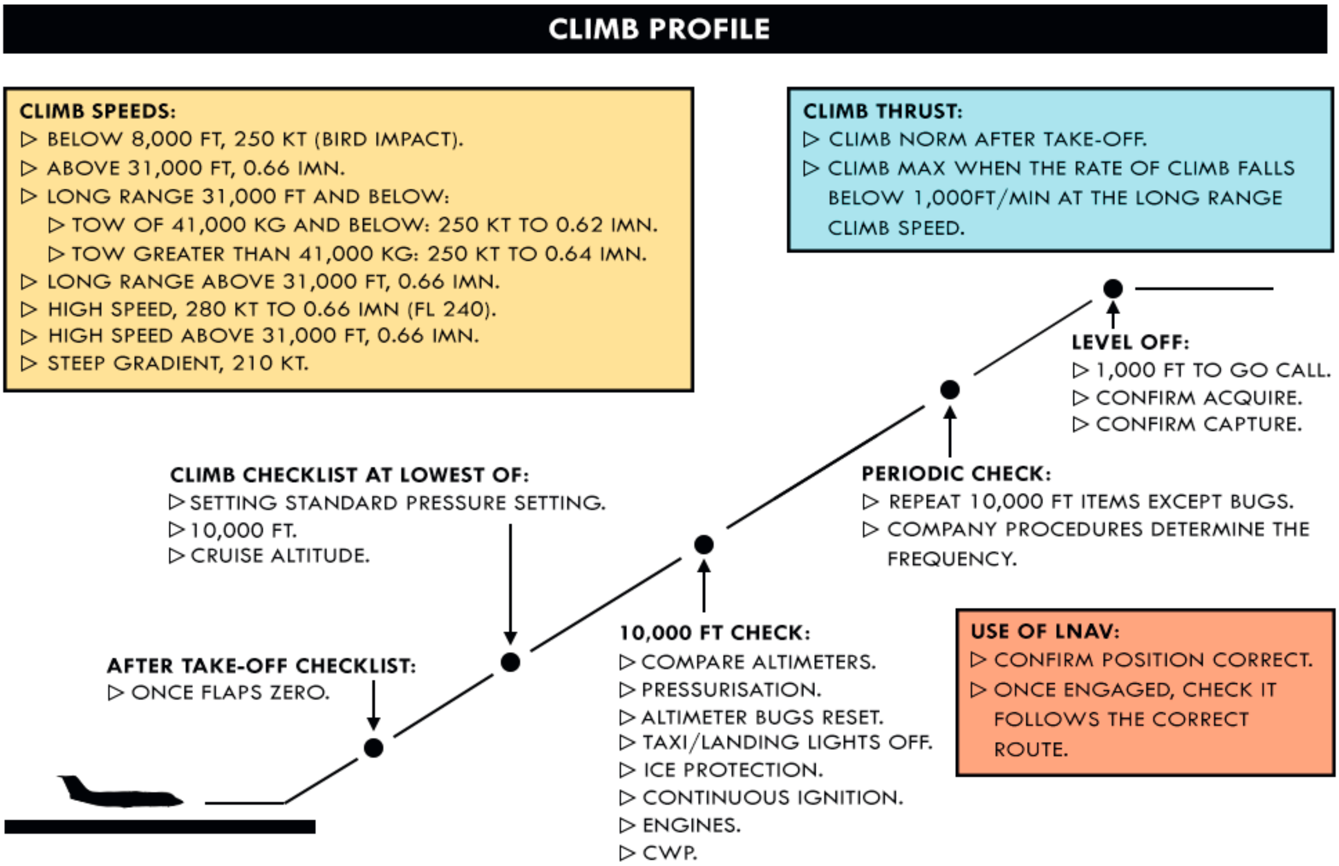
The high-speed climb speed is 280 kt or 0.66 M. The two values are coincident at about FL 240.

The steep gradient speed is 210 kt.

Some aircraft are cleared for flight above FL 310. Above FL 310, the climb speed is 0.66 M for all climb techniques.

The climb speed is restricted:

- Below 8,000 ft by the bird impact speed limitation (250 KIAS).
- By ATC speed limitations.
- For some operators, by a speed limit below MSA of around 210 knots.



Cruise

There are three cruise speeds:

- High speed – Vmo/Mmo for all series
- Intermediate – Vmo/0.67 M for all series
- Long range:
  - RJ70 and RJ85 – 235 kt / 0.68 M
  - RJ100 – 240 kt / 0.68 M

The best fuel economy is achieved using Intermediate Cruise technique for heavy aircraft and Long Range technique for light to mid-weight aircraft. The High Speed technique consumes the most fuel and requires the highest TGT.

Cruise thrust should normally be limited to CLIMB NORM. At unfavourable combinations of weight, altitude and temperature, CLIMB MAX may be required. However, under some conditions, Vmo/Mmo may not be achievable at the CLIMB MAX rating.

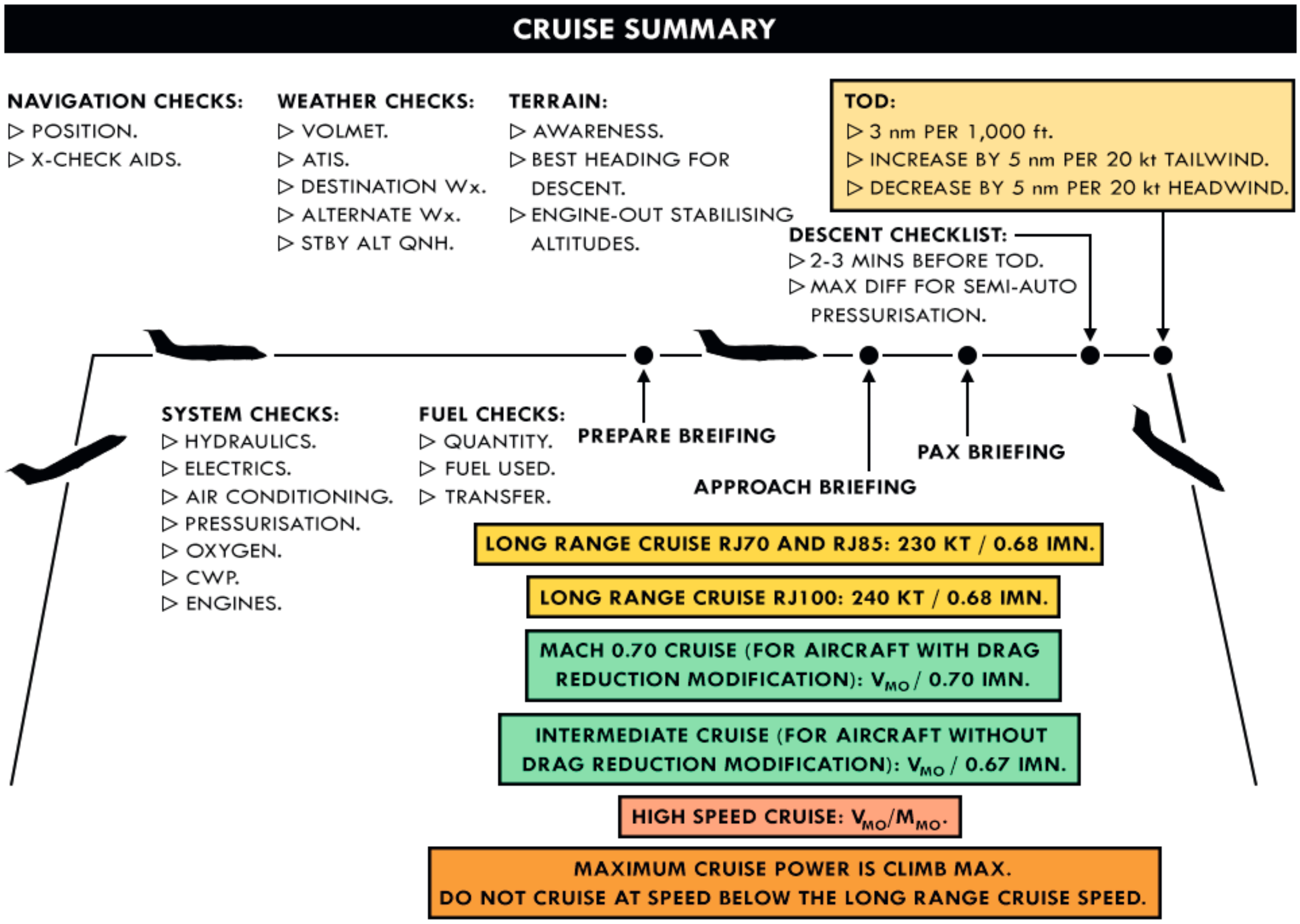
When using the high speed cruise it is often better to cruise a few knots below Vmo/Vmo to avoid nuisance over-speed warnings.

Using the high speed technique rather than the intermediate technique gains only a few minutes, but increases fuel burn and requires a higher EGT. If punctuality is a prime consideration, the high speed technique provides a method of regaining or maintaining schedule. However, direct routing is often a more powerful way of gaining time.

The cruise is normally made with the autothrottle engaged. The thrust setting used will be that required to achieve the cruise speed and limited by the thrust rating selected on the TRP. The FGC will automatically select an engine as master and synchronise N1. The MSTR 1/2 annunciators on the TRP will be out.

On very long sectors, fuel economy may be improved by disengaging the autothrottle and cruising at a constant power setting. In turbulence, passenger comfort will be increased by disengaging the autothrottle and manually setting a constant power to achieve a mean of the speed required.

When cruising close to Vmo or Mmo in unsteady air, it is generally better to set the thrust manually.



Flight in severe turbulence

Flight through areas of known severe turbulence should be avoided if possible.

If severe turbulence cannot be avoided, the airspeed should be stabilised at approximately 245 knots / 0.6M, whichever is lower. In severe turbulence large fluctuations in indicated airspeed and altitude may occur. Do not attempt to compensate for changes in airspeed or altitude by making large changes in attitude or engine thrust. Select CONT IGN A & B ON before entering turbulence.

On entering turbulence, maintain the desired pitch attitude and maintain wings level if possible. If a turn is required, do not exceed 20° bank. Large changes in attitude may occur. Correct attitude changes by making small control inputs. Avoid large control inputs and do not change elevator trim setting.

The yaw damper should remain engaged at all times during flight in severe turbulence. The autopilot may be used at the pilot's discretion. Do not engage ALT IAS or MACH modes during flight in severe turbulence.

Flight in icing conditions

Icing conditions exist when visible moisture is present and visibility is reduced to 1,000 m (3,000 ft) or less, and the OAT or SAT is 5˚C or below during ground operation, take-off, initial climb or go-around, or the OAT or TAT is 10˚C or below in flight.

In icing conditions and/or when the ICE DETECTED caption lights, select ENG ANT ICE and OUTER WING/TAIL ANT ICE ON and maintain a minimum of 67% N2. When clear of icing conditions, select INNER WING DE-ICE ON for one minute.

On descent, select as above prior to entering icing. Descend through the icing level, adjusting engine speed to maintain a minimum of 67% N2.

Below 2,500 ft AGL, the airframe anti-ice must be on irrespective of whether the ICE DETECTED caption is lit or ice has formed on the airframe.

For holding in icing conditions, maintain 0˚ flap and add 7 knots to the normal holding speeds. For prolonged holding, select INNER WING DE-ICE on for one minute at 8-10 minute intervals and when altitude is reduced for approach and landing.

If icing conditions exist, or if ice has formed on the airframe prior to the approach, select ENG ANT ICE and OUTER WING/TAIL ANT ICE ON. At 200 knots, prior to selecting flap, select INNER WING DE-ICE and keep ON.

Carry out the normal approach, landing and missed approach procedures. All speeds, including the recommended minimum manoeuvring speeds, should be increased by 7 knots relative to the normal speeds.

If airframe anti-ice/de-ice is required for the approach, delay the changeover from ENG AIR to APU AIR until 200 ft.

At 200 ft on final approach, select OUTER WING/TAIL ANT ICE, INNER WING DE-ICE and ENG AIR OFF.

Descent

There are two descent techniques:

- High speed – made at Mmo / 290 kt
- Long range – made at 0.60 IMN / 250 kt.

In practice, any combination of speeds can be used. The long-range technique is generally too slow for the modern ATC environment.

The minimum time in the descent (and thus the maximum average aircraft rate of descent) is determined by the pressurisation system.

A rate of descent of 2,000 ft/min is normally sufficient (normally 1,000 ft/min to 18,000 ft).

Buffet due to airbrake increases with speed and deflection, but the level of buffet is not pronounced in the cabin. Ideally, the descent should be made without airbrake, but ATC restrictions often force its use.

Always change the airbrake position smoothly and slowly when the AP is engaged. Avoid changing the airbrake position when the FGS is in the altitude acquire phase, as this can lead to an untidy level-off.

If the TRP is on and the thrust levers are at idle, the minimum flight idle allowed for the selected bleed status is maintained.

If the TRP is off and the thrust levers are at IDLE, the FADECs will set the correct idle for air conditioning and engine anti-ice but not for airframe ice protection. The general rule for setting idle N2 with the TRP off and airframe anti-ice on is 72% + 2% per 5,000 ft above sea level.

The fully automatic pressurisation system operates to a much higher cabin differential pressure and will automatically follow a schedule of cabin altitude versus aircraft altitude.

At the higher aircraft altitudes, the cabin altitude is lower than in the analogue systems. The descent rate is a pressure rate equivalent to 325 ft/min at sea level.

At 35,000 ft the cabin altitude is 8,000 ft and it takes 22 minutes to descend the cabin to sea level from an aircraft altitude of 35,000 ft. However, at an aircraft altitude of 31,000 ft, the cabin altitude is 6,500 ft and the time to descend the cabin to sea level is 18 minutes.

The improvement in descent performance and the automatic schedule together give a performance that meets most descent requirements, so the need for monitoring is not so high. A simple rule of 'cabin ahead of ΔP' cannot be used because the indicator is numeric. However, the same basic rule applies: cabin altitude must get to landing field altitude before the ΔP gets to zero.

The digital system does not require the checklist to be completed a few minutes before the descent because it automatically follows its descent schedule.

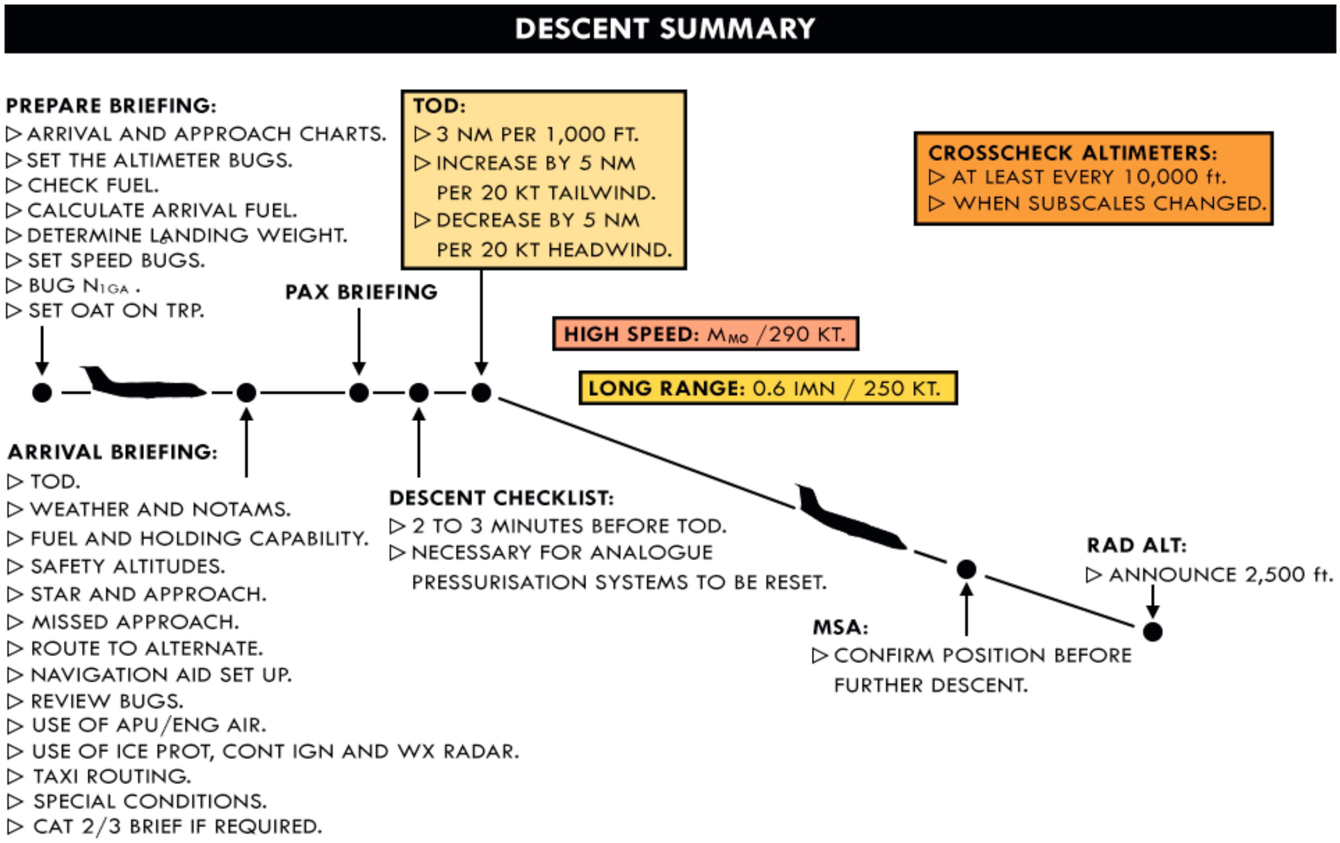
Normally, LDG ALT is set before departure and it is only necessary to confirm the value in the descent checklist. However, the landing altitude must be referenced to the left altimeter sub-scale setting for landing.

If neither APU air nor engine air is available for landing, set LDG ALT to 500 ft above the landing field.

Before the descent is initiated, the new altitude must be set on the MCP. The descent may be made in VS or LVL CHG.

Vertical speed is generally the best mode for the descent because, with the autothrottle engaged, both the vertical speed and airspeed will be held by the FGS. There are occasions, however, when the level change should be used rather than vertical speed.

When descending at high speed, so that the speed can be reduced to 250 kt at 10,000 ft, set Vsel to 250 kt at around 12,000 ft.



Holding

Start reducing to the holding speed three minutes before the ETA at the holding fix.

Best endurance is obtained by holding with flaps and gear up. With flaps up, speed should not be reduced below Vfto + 10 kt.

It is often more comfortable to hold at a speed higher than the optimum performance speed; the body angle is reduced, speed stability is increased and the fuel penalty is small. A comfortable clean holding speed is 210 kt.

Lower holding speeds can be used with 18° of flap but the fuel consumption will be increased.

With flap at 18°, speed should not be reduced below Vref 33 + 30 kt.

Approach and landing

The maximum crosswind for landing is:

- RJ70 – 32 kt
- RJ85 – 35 kt
- RJ100 – 35 kt

In light crosswinds, either the wing-down technique or the crab technique may be used. Above 10 kt crosswind, the wing-down technique is preferred. Here, in the latter stages of the approach, co-ordinated use of rudder and handwheel is made to align the aircraft nose with the runway direction; this results in a few degrees of bank into the crosswind.

Use of the APU for landing has the benefit of extra redundancy in the electrical system. To minimise starting TGT/EGT, avoid starting the APU at high altitude and speed. Normally the APU should be started at 5,000 ft or below, but it is better to start the APU a little higher than to forget to start it.

Do not switch on the APU AIR switch until the APU has been running for at least two minutes; if practicable, allow five minutes.

Air Supply and Conditioning Settings for Landing		
Condition from the APU	No Air Conditioning	Conditioning from the Engines
APU AIR – ON ALL ENG AIR – OFF PACKS – ON	APU AIR – OFF ENG AIR 1, 2 & 3 – OFF ENG AIR 4 – ON PACKS – OFF	APU AIR – OFF ALL ENG AIR – ON PACKS – ON CABIN AIR – RECIRC

For most aircraft the normal landing flap angle is 33°.

Some aircraft have a FLAP 24/33 switch on the right instrument panel. If the switch is fitted, normal landings with 24° of flap are permitted. The switch tells the GPWS/EGPWS which flap angle is to be used for landing.

To make a normal landing with the flaps at 24°:

- Select the switch to 24.
- Calculate the landing speeds to 24° of flap.
- Use the landing performance for 24° of flap.

The flaps must be at 33° for automatic landings, Category 2 approaches and Category 3 approaches.

The autopilot is required for a Category 2 approach or a Category 3 approach.

If available, it is recommended that the autopilot is used for a Category 1 ILS approach when:

- The cloud base is within 200 ft of the DA.
- The RVR is within 500 m of the minimum for the approach.

For an ILS or VOR approach:

- FORMAT must be selected to ARC, ROSE or MAP. MAP is the preferred selection for best situational awareness.
- CRS must be selected to V/L.

Before intercepting the final approach track:

- Navigation aids must be tuned and identified.
- For ILS and VOR approaches, the VHF NAV inbound courses must be set.
- DBI pointers should be set as required for the approach.

The landing checklist should be completed by 500 ft.

Avoid selecting flap near the limit if practicable; 18° is noisy at the higher speeds. At high speeds, 24° and 33° flap require a steep nose-down angle that some passengers may find uncomfortable. Late selection of flap should be avoided to ensure that the final flight path is stable.

Normally flap is selected directly from 24° to 33°. However, if difficulty is experienced reducing speed to below the flap 33° limit, use the intermediate 30° setting to assist the speed reduction. The intermediate setting of 30° is also useful on a three-engined approach.

To preserve flap component life, make flap selections as far below the limit speeds as is practicable.

Similarly, avoid selecting the gear close to the limit, as the noise, vibration and buffet it produces are more intense at the higher speeds.

If practicable, avoid simultaneous operation of the Green system services (airbrake, gear and flap).

The nose-wheel steering is checked and centred as the last item in the landing checklist. If practicable, the check should be left until 500 ft.

Normal landing performance is predicated on the airbrakes being out. If airbrakes are not deployed, landing distance will be increased.

On a Category 2 approach, Category 3 approach or an approach for an automatic landing, the airbrakes must be selected out by 500 ft. On all other approaches airbrakes may be deployed at any time on the approach, but in order to reduce noise and reduce the number of actions during a go-around, the airbrakes should be deployed below decision height.

A stabilised approach must be achieved by 1,000 ft in IMC and 500 ft in VMC. The stabilisation criteria are:

- Aircraft is on the correct flight path.
- Aircraft is in the landing configuration.
- Only small changes in heading, pitch and speed are required to maintain the correct flight path.
- Vertical speed is no greater than 1,000 ft/min.
- Thrust setting is appropriate to the aircraft configuration.
- All briefings and checklists have been completed.
- Sustained aircraft speed is Vapp -5 to +10 kt.

Additionally, for the following approach types:

- A CAT 1 approach must be flown within one dot of the glideslope and localiser.
- A CAT 2 or CAT 3 approach must be flown within half a dot of the glideslope and localiser.
- A non-precision approach must be flown within ±5° of the inbound course.
- On a circling approach, the aircraft must be ‘wings level’ on final by 300 ft.

Vref is the landing reference speed for the aircraft weight and flap setting. It is 1.3 times the stalling speed for the flap setting. Apart from short term fluctuation, the speed on final approach must not be less than Vref.

The threshold speed is the speed at which the aircraft should cross the threshold. The basic threshold speed is Vref· The basic threshold speed may be increased by up to 14 kt by adding increments to Vref for gusts and for icing.

Vapp is the final approach speed. It is:

- The speed at which the final approach should be flown once the landing flap setting has been achieved.
- The threshold speed plus 5 kt.

The minimum manoeuvring speeds for each flap setting are listed in the table below:

Flap Setting	Minimum Manoeuvring Speed
0°	VFTO + 15 KIAS
18°	VREF33 + 30 KIAS or VREF24 + 20 KIAS
24°	VREF33 + 20 KIAS or VREF24 + 10 KIAS
30/33°	VREF33 + 10 KIAS

Flying the approach

The approach must be stabilised at the final approach speed by 500 ft in VMC and 1,000 ft in IMC. If an approach is not stabilised, a go-around must be made.

The minimum speed until established on the final approach is the minimum manoeuvring speed for the flap configuration. Apart from short-term fluctuations, the minimum speed on final is Vref for the flap configuration.

The initial approach can be flown clean between 250 and Vfto + 10 kt. A comfortable speed is 210 kt.

Aim to be at 160 kt, or minimum manoeuvring speed if higher, with 18° of flap in the final approach track approaching the final descent point.

Approaching the instrument descent point, or just before turning base on a visual circuit, select the landing gear down and, when the gear is down, select 24° of flap; reduce the speed to Vref 33 + 20 kt. By the stabilisation altitude, flaps must be at the landing setting and speed must be stabilised at Vapp.

Vapp is a target speed for the approach, not a minimum; take care not to carry excess speed, especially on approaches to short runways.

On a 3° glideslope with flaps 18° and gear up, speeds of between 160 and 180 kt can generally be held but the thrust is close to flight idle. Unfavourable weight/wind conditions can make stabilising at a speed within this band difficult; with the gear down there is no difficulty. The gear being down increases both approach path noise, cabin noise and fuel burn. Often a small amount of airbrake is all that is needed to stabilise the speed on target.

The landing

The aircraft does not lose speed easily in the flare so it is important to arrive over the threshold close to the target threshold speed. The touchdown speed should be about 7 kt lower than the speed over the threshold. The higher the gust factor, the lower the nose attitude at touchdown. The touchdown point should be about 1,000 ft past the threshold.

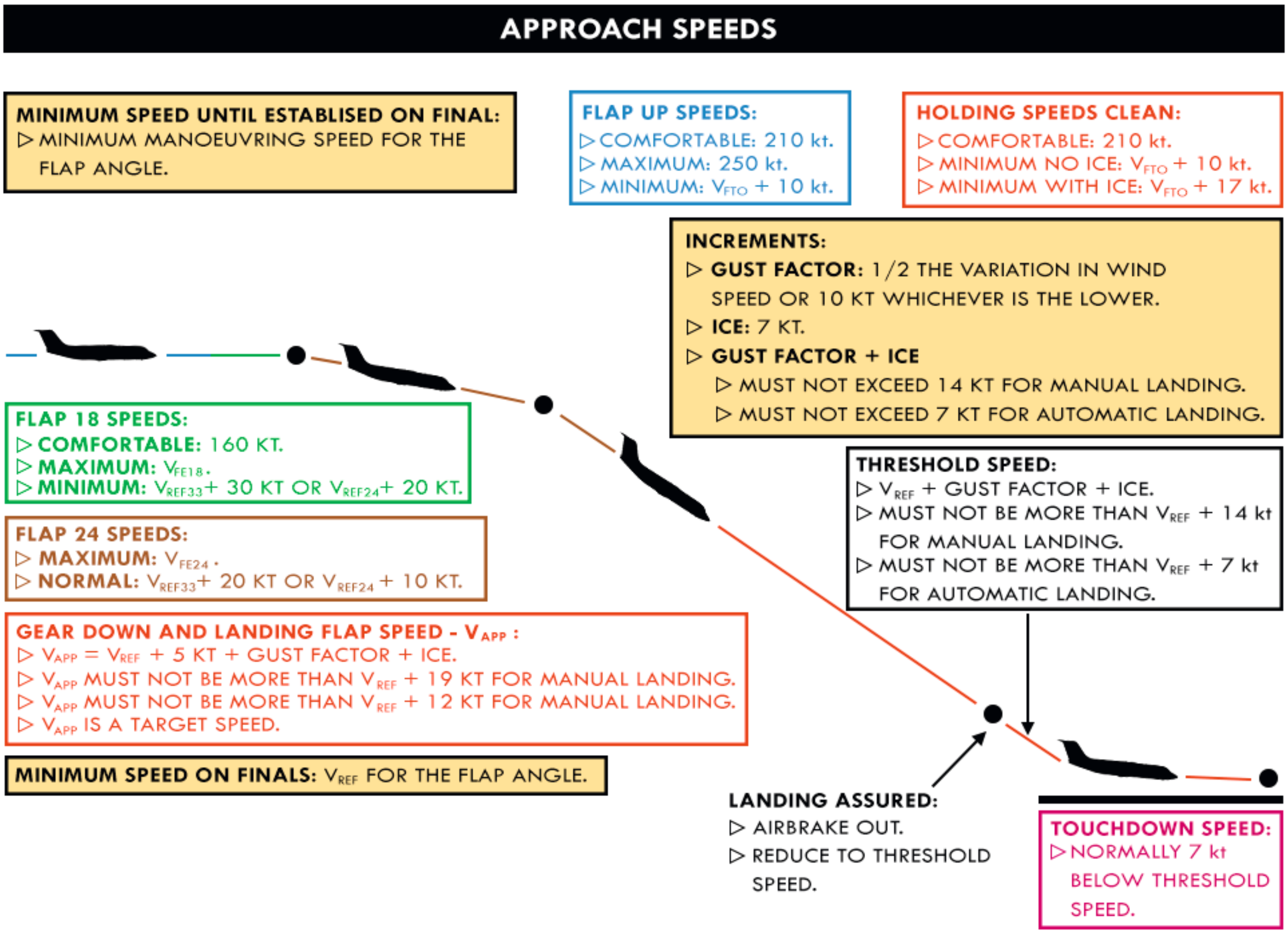
From about 200 ft, progressively reduce speed from Vapp to cross the threshold at the threshold speed. During the flare reduce thrust to flight idle. For Category 2, Category 3 and automatic landings, the airbrakes must be OUT by 500 ft. For all other approaches they may be left in until below 200 ft.

Selecting the airbrakes at 100 ft generally gives the speed reduction to cross the threshold at the target threshold speed. If speed is high, select the airbrakes earlier; if speed is low, delay the airbrake selection.

Do not prolong the flare; a better stopping distance is achieved by touching down a little fast rather than by floating down the runway, especially with a tailwind. A high attitude on touchdown, combined with a high sink rate, could lead to a tail strike in the RJ100.

The spoilers should automatically deploy on touchdown. As a back-up, a manual selection to LIFT SPLR should still be made. After main-wheel touch, select ground idle. When the nose-wheel is on the ground, select LIFT SPLR.

Immediately all three gear units are on the ground, apply balanced braking commensurate with the distance to the runway exit.



After touchdown

If the thrust levers are at IDLE, N2 should automatically reduce from 60% to 50% on touchdown. If the spoilers automatically deploy, counter the nose-down change of trim with elevator. If the spoilers do not automatically deploy, lower the nose-wheel to the ground.

After nose-wheel touchdown, the column should not be moved significantly forward of neutral. Excessive forward movement of the column can result in ‘wheelbarrowing’, i.e. both main wheels airborne. Rearward movement of the column, once the spoilers are deployed, improves deceleration even when wheel braking is not being applied.

The braking applied should be proportionate to the distance remaining on the runway, but the brakes must be applied such that speed is comfortably under control before the end of the runway. It is important to brake for effect and not for comfort.

After arrival on the runway, it is essential that the lift is dumped. Dumping the lift transfers the weight to the wheels, which allows the brakes to work more effectively.

Go-around

The go-around can be flown manually or automatically.

The go-around is initiated by applying N1GA smoothly, rotating towards a pitch attitude of 10° and selecting the GA flap. The GA flap is 24° if the approach is made with 33°, and 18° if the approach is made with 24°. The initial climb is made at a speed not below Vref for the landing flap plus 5 kt, with the airbrake selected IN.

Once a positive rate of climb has been achieved, the gear is selected up and the climb continued at a speed not below VREF for the landing flap plus 5 kt. At the acceleration altitude, the aircraft is accelerated through the flap retraction schedule.

A level acceleration is made at the acceleration altitude if one or more engines are inoperative; a climbing acceleration is initiated at the acceleration altitude in an all-engines case.

The go-around procedure may be continued all the way to a climb to altitude using the climb procedures. On the other hand, it may be necessary to exit the procedure before completion; for example, a go-around to a visual circuit where remaining at 18° of flap and making an early thrust reduction may be more appropriate. Flap 18° may be appropriate to a short radar circuit but flap zero should be used if the pattern is likely to be prolonged or holding is expected.

It is recommended that the pitch attitude should not exceed 20° nose up. If this attitude is reached, allow the speed to increase.

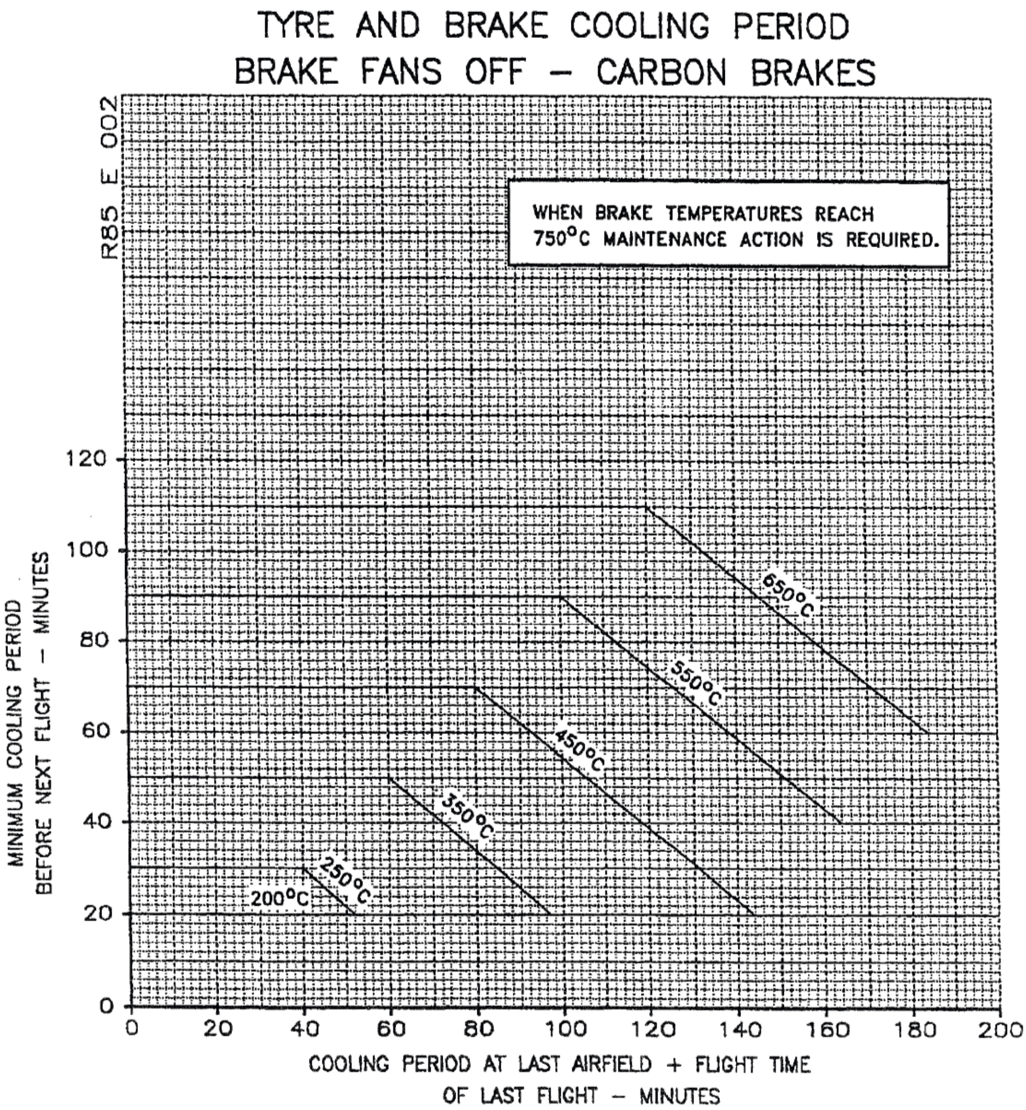
Tyre and brake cooling periods

Use brake fans during landing and taxiing as required. Brake fan operation is not indicated on the flight deck.

Following a landing or rejected take-off (RTO), before the aircraft taxis out for another take-off a waiting period is required with the aircraft parked. This is to ensure that the brakes are cool enough to absorb the energy in an RTO and that the tyres will not overheat during the take-off roll.

The minimum cooling period with all brake fans operative is 15 minutes. It may be less than 15 minutes, but not less than five minutes provided that:

1. No more than three flights are completed in any two-hour period which includes cooling periods of less than 15 minutes.
2. In such a two-hour period, cooling periods of less than 15 minute may occur on consecutive flights only once.



MSFS CONTROL ASSIGNMENTS

MSFS allows users to greatly customise the controller scheme of their external hardware, which can allow for a much more immersive experience. You can set up these controls within MSFS by navigating to: Options > Controls Options.

The following table shows a list of non-normal MSFS control assignments that can be used in conjunction with the Just Flight RJ Professional:

Aircraft control	MSFS control assignment
APU Master Switch to START	APU STARTER
APU Master Switch to STOP	APU OFF
Autopilot Disconnect (Yoke)	TOGGLE DISENGAGE AUTOPILOT TOGGLE AUTOPILOT MASTER
Autopilot Engage (MCP)	TOGGLE AUTOPILOT MASTER
Autopilot SYNC mode (Hold)	SET ELT
Autopilot SYNC mode (Toggle)	TOGGLE AFTERBURNER
Autopilot LNAV mode	AUTOPILOT NAV1 HOLD
Autopilot VOR LOC mode	TOGGLE GPS DRIVES NAV 1
Engine Fuel Cut Off Latches	SET ENGINE 1 FUEL VALVE SET ENGINE 2 FUEL VALVE SET ENGINE 3 FUEL VALVE SET ENGINE 4 FUEL VALVE
Flight Director Switches	TOGGLE FLIGHT DIRECTOR
MWS Red and Amber Warning Cancel	TOGGLE GPWS TOGGLE MASTER CAUTION TOGGLE MASTER WARNING
Nose Wheel Steering Tiller	NOSE WHEEL STEERING AXIS
TOGA buttons	AUTO THROTTLE TO GA

Note: *This list is not a complete list of all the MSFS control assignments that work with the RJ Professional and does not include the basic control assignments for controls such as Pitch, Roll, Yaw, Throttles etc. which are shared between all aircraft.*

Home cockpit users who require the use of LVARs to set up external hardware can find a complete list of LVARs used in the simulator by enabling Developer mode, then on the bar at the top of the screen navigate to: Windows > Behaviours > Local Variables.

Entering instrument names or abbreviations into the ‘Filter’ box will vastly speed up the process of finding LVARs. For example, if you are trying to find the LVARs used for the landing lights, you can search for ‘LdgLts’ and you will find the following LVARs: **OVHD_CTR_LWR_L_Ldg_Lts** and **OVHD_CTR_LWR_L_Ldg_Lts**.

CREDITS

Project management	Martyn Northall
Aircraft modelling and design	Mark Griffiths
Aircraft systems and cockpit programming	Martyn Northall, Tomas Aguilo
Cockpit display programming	Tomas Aguilo, Ernie Alston, Richard Slater, Eric Marciano
FMS programming	Ernie Alston
Aircraft liveries	David Sweetman, Mark Griffiths, SeventhMoon
Flight dynamics	Martyn Becker
Sounds	SimAcoustics
Development assistant	Mark Allison, John Hodgson
Manual	Mark Allison, Mark Embleton
Installer	Richard Slater
Design	Fink Creative

Many thanks to all the testers.

COPYRIGHT

More Just Flight add-ons for Microsoft Flight Simulator

PA-38 TOMAHAWK

AVRO
VULCAN
B MK. 2, K.2 & MRR

F28
PROFESSIONAL

FS Traffic

146
PROFESSIONAL

HAWK T1/A
ADVANCED TRAINER

Just Flight

www.justflight.com