146 PROFESSIONAL

OPERATIONS MANUAL

Just Flight

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146 PROFESSIONAL

Operations Manual

Please note that Microsoft Flight Simulator must be correctly installed on your PC prior to the installation and use of this 146 Professional simulation.

CONTENTS

INTRODUCTION

Just Flight are excited to bring you the 146 ‘Whisper Jet’ for Microsoft Flight Simulator, featuring the 100, 200 and 300 series of this classic British airliner.

The design process of what was to become the 146-100 began under Hawker Siddeley in 1973 when the iconic high T-tail, short undercarriage, four engines and distinctive airbrake were chosen for a regional airliner with short-field performance and quiet operation. The 146-100 first flew in 1981, followed by the stretched 200 series in 1982 and 300 series in 1988.

This Just Flight simulation is based on G-JEAO, which retired from service with British European Airways in 2000 and is now preserved at the de Havilland Aircraft Museum, and the recently retired CC.Mk2 and C.Mk3 aircraft of Royal Air Force, 32 (The Royal) Squadron.

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

146-100

Length	28.19 m (85.11”)
Wingspan	26.34 m (86.5”)
Height	8.61 m (28.3”)
Wing area	773 m^2 (832 ft^2)

146-200

Length	28.6 m (93.1”)
Wingspan	26.34 m (86.5”)
Height	8.61 m (28.3”)
Wing area	773 m^2 (832 ft^2)

146-300

Length	30.99 m (101.8”)
Wingspan	26.34 m (86.5”)
Height	8.61 m (28.3”)
Wing area	773 m^2 (832 ft^2)

Weights

146-100

Empty weight	52,510 lb (23,818 kg)
Maximum zero fuel weight	71,576 lb (32,466 kg)
Maximum take-off weight	84,000 lb (38,102 kg)
Maximum landing weight	77,500 lb (35,153 kg)

146-200

Empty weight	54,230 lb (24,598 kg)
Maximum zero fuel weight	79,067 lb (35,864 kg)
Maximum take-off weight	93,000 lb (42,184 kg)
Maximum landing weight	81,500 lb (36,741 kg)

146-300

Empty weight	56,530 lb (25,642 kg)
Maximum zero fuel weight	84,200 lb (38,192 kg)
Maximum take-off weight	97,500 lb (44,225 kg)
Maximum landing weight	86,000 lb (39,009 kg)

Performance

146-100

Economical cruise	383 TAS at 30,000 ft
Range with max. payload	935 NM / 1,077 M / 1,733 km
Take-off to 35 ft, surface level, ISA	4,000 ft (1,219 m)
FAR landing, surface level, ISA, max. landing weight	3,630 ft (1,106 m)

146-200

Economical cruise	383 TAS at 30,000 ft
Range with max. payload	1,176 NM / 1,355 M / 2,179 km
Take-off to 35 ft, surface level, ISA	4,950 ft (1,509 m)
FAR landing, surface level, ISA, max. landing weight	3,760 ft (1,146 m)

146-300

Economical cruise	383 TAS at 30,000 ft
Range with max. payload	1090 NM / 1,253 M / 2,020 km
Take-off to 35 ft, surface level, ISA	4,950 ft (1,509 m)
FAR landing, surface level, ISA, max. landing weight	4,030 ft (1,228 m)

Engines

Type	Four x Avco Lycoming ALF502R-5 turbofans
Thrust (sea-level, static)	6,970 lb (31 kN)
Bypass ratio	5.7:1
Length	1.44 m (56.8”)
Diameter	1.06 m (41.7”)
Dry weight	577 kg (1,270 lb)

Fuel

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

Liveries

The 146 is supplied in the following liveries:

146-100

- Air France Express (G-JEAT)
- AirUK (G-UKPC)
- British Aerospace demonstrator (G-SSSH)
- Dan-Air London (G-BKMN)
- Formula One Flight Operations – white (G-OFOM)
- Formula One Flight Operations – silver (G-OFOA)
- Jersey European (G-JEAO)
- Pacific Southwest Airlines (N246SS)
- United Express (N463AP)

146-200

- AirCal (N146AC)
- Air Canada Jazz (C-GRNZ)
- American Airlines (N699AA)
- Continental Express (N406XV)
- QantasLink (VH-NJJ)
- SN Brussels Airlines (OO-DJJ)
- USAir (N165US)
- Jota Aviation (G-SMLA)
- Cobham Aviation (VH-NJG)
- Cello Aviation (G-RAJJ)
- Crossair (HB-IXD)

146-200QC

- TNT Airways (OO-TAZ)
- Titan Airways (G-ZAPK)

146-200QT

- TNT Airways 1990s (G-TNTA)
- Ansett Australia Airlines Cargo (VH-JJZ)
- Titan Airways (G-ZAPR)

146-300

- Aer Lingus (EI-CTO)
- Air New Zealand (ZK-NZN)
- Ansett Australia (VH-EWM)
- Astra Airlines (SX-DIZ)
- British Airways (G-OINV)
- Eurowings (D-AQUA)
- Flybe (G-JEBC)
- KLM UK (G-UKAC)
- Cobham Aviation (VH-NJN)

146-300 QT

- ASL Airlines (EC-MID)
- Australian Air Express (VH-NJM)
- TNT Airways (OO-TAD)
- Jota Aviation (G-JOTE)

CC.Mk 2

- RAF Statesman modern (ZE701 – Queen’s Flight)
- RAF Statesman 1980s (ZE701 – Queen’s Flight)

C.Mk 3

- RAF (ZE708)

INSTALLATION, UPDATES AND SUPPORT

You can install this 146 software as often as you like on the same computer system:

1. Click on the Account tab on the Just Flight website.
2. Log in to your account.
3. 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 'BAe 146'.
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.

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SYSTEMS OVERVIEW

The BAe 146 is a short-range subsonic transport aircraft, powered by four Avco 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.

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 combined cabin altitude, vertical speed and cabin differential pressure indicator is on the First Officer's flight instrument panel. Each pilot has personal air distribution selector levers on his 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.

The electrical equipment bay, below the flight deck floor, is cooled by a fan drawing air from the forward galley and flight deck area. The fan runs continuously with either AC 1 or AC 2 busbar energised.

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 maintains the pressurised hull at sea level cabin altitude conditions up to 15,000 ft, with a maximum cabin altitude of 8,000 ft at 30,000 ft.

Cabin pressurisation is provided by engine bleed air through the air conditioning system. Pressure control is maintained by regulating the air flow from the cabin through two discharge valves to the atmosphere.

The discharge valves are controlled by a four-position rotary DISCHVALVES switch, located on the PRESSURIZATION sub-panel of the flight deck overhead panel, annotated DITCH/NORMAL/SHUT 1/SHUT 2. It is necessary to PULL the switch against a spring and turn it to the left to select DITCH.

The discharge valve position indicators show the relative position of each valve in both auto and manual operation.

In addition to their normal function, each discharge valve provides:

1. Outward relief in the event of over-pressurisation, to prevent a cabin pressure differential greater than 6.55 PSI.
2. Inward relief to limit the negative differential pressure to 0.3 PSI.
3. Protection against cabin altitude exceeding 15,000 ft by closing the valve following a major loss of pressurisation.

If the cabin altitude rises above 9,300 (+300) ft, the MWS CABIN HI ALT red caption is lit, the red alert lights flash, the triple-chime warning sounds and the air conditioning system automatically goes to the fresh air mode. If the cabin altitude subsequently falls to below 8,500 ft, the warning is automatically cancelled and the system reverts to RECIRC if previously selected.

The PRESSURE SELECTOR/CONTROLLER on the AIR CONDITIONING sub-panel of the flight deck overhead panel automatically controls the cabin altitude and cabin altitude rate of change via one or both discharge valves when the push-button MODE annunciator/switch is lit, showing the legend AUTO in green.

The lower right-hand RATE knob is used to vary the cabin pressure rate of change, which can be set within the range of 200-1,600 ft/min climb and 150-1,100 ft/min descent at sea level.

A detent provides a setting of 525 (±75) ft/min climb and 375 (±50) ft/min descent at sea level, with automatically increased ft/min changes at altitude. The ALT knob, to the left of the RATE knob, is used to select a cabin altitude within the range of -2,000 ft to +14,000 ft. The BARO knob, to the left of the ALT knob, is used to set the barometric pressure within a range of 930-1,100 mb or 27-32 inHg. The dial of the pressure selector/controller has a cabin altitude scale and an inner scale of flight altitude. A needle controlled by the altitude knob permits a flight altitude to be selected and indicates the cabin altitude attainable at maximum differential pressure.

Operation of the MODE annunciator/switch removes the power supply from the auto controller circuits and energizes the manual control circuitry. With this manual selection made, the MODE annunciator changes, AUTO green goes out and MAN white is lit. Manual control of the discharge valves is by the MAN – SHUT/OPEN rotary switch below the discharge valve position.

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

Cabin altimeter / cabin differential pressure and cabin VSI

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

1. Rate of change of 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 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.

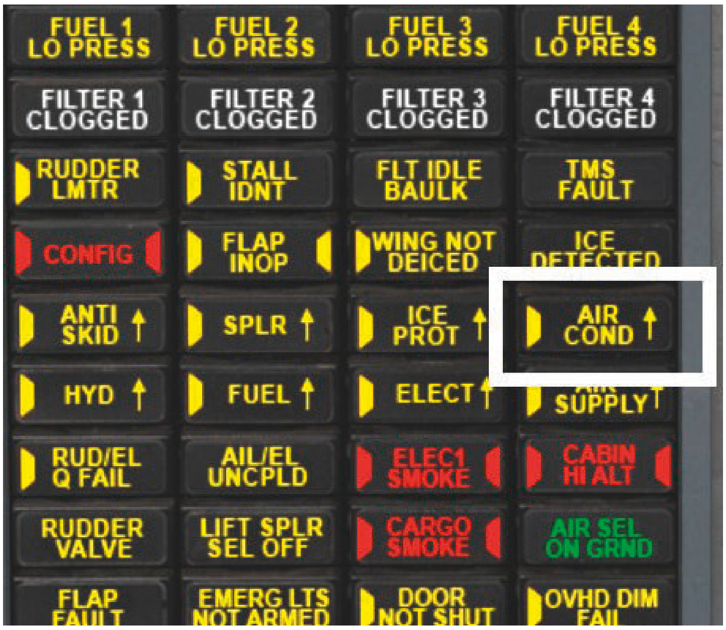
With the switch selected to MAN, the valve is controlled by a spring-loaded-to-centre switch labelled WARM/COOL, adjacent to the AUTO/MANUAL switch. Full-range movement of the valve from HOT to COLD or vice versa takes 20-30 seconds.

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

Cabin altimeter, differential pressure and VSI

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 the manual mode is selected and a green AUTO legend for the automatic mode.
- A rotary discharge valve position selector for use in the manual mode
- Two discharge valve position indicators
- A cabin rate selector. The normal position has a detent.
- A selected cabin altitude indicator. The indicator is a circular card with a pointer that indicates against two circular scales. The outer scale is the selected cabin altitude. The inner scale is the cruise altitude at which the differential pressure will be approximately 6.3 PSI at the selected cabin altitude. The dial has a barometric scale in a reference window.
- A combined cabin altitude and barometric datum selector. With the selector pushed in, the selector rotates the altitude pointer relative to the card. When pulled out (middle/wheel click), the selector controls the barometric scale.
- A four-position discharge valve rotary switch: DITCH, NORMAL, SHUT 1 and SHUT 2:

  NORMAL – control is via valve 1 and valve 2 in both the manual and the automatic mode.

  SHUT 1 – discharge valve 1 is closed and control is via valve 2.

  SHUT 2 – discharge valve 2 is closed and control is via valve 1.

  DITCH – both valves are closed when the aircraft ditches.

Note: *The DITCH switch is only intended for use when the aircraft is ditching. Pressure is dumped by selecting the manual mode and fully opening the discharge valves using the rotary valve position control.*

In the automatic mode the cabin rate is controlled to the set rate until the set cabin altitude is attained. The set cabin altitude is then held. The rate direction does not need to be set.The cabin will climb if the actual cabin altitude is below the set value and will descend if the actual cabin altitude Is above the set value.

In the manual mode, the pilot must manually position the discharge valves to achieve the required rate and cabin altitude.

Ground pressurisation switch

A GRND PRESSN push-button switch is on the overhead GRND TEST panel. The switch contains an amber lamp and enables the pressurisation to be tested on the ground in the AUTO mode.

At the test position, the switch bypasses the on-ground squat switch signal. The test position is indicated by illumination of the amber light. There is no direct indication of the normal position. If the switch is in the test position when the PACKS are ON, the aircraft could be inadvertently pressurised on the ground. To ensure that the switch is in the correct position, the switch is selected to test, illumination of the lamp is checked and then the switch is pressed once more to exit the test mode.

Ditch selection

If DITCH is selected with the packs supplying the cabin, the system opens the valves and dumps most of the pressure out then controls to a differential pressure of between 0.25-0.5 PSI. To dump cabin pressure, MAN mode is selected and the discharge valves manually selected to fully OPEN.

BARO datum setting

The BARO setting may be set to QFE, QNH or the standard pressure setting. For cruise at a flight level, it is set to the standard pressure setting. For cruise at a low altitude, it is set to the setting used lor landing on the main altimeters. For descent and landing it is set to the setting used for landing on the main altimeters.

Rate control

The selected rates are:

- At the detented position, a climb rate of 525 ft/min and a descent rate of 325 ft/min.
- At the minimum position, a rate of climb or descent of between 50 and 200 ft/min.
- At the maximum position, a rate of climb of between 1,200 and 2,000 ft/min and a rate of descent of between 1,000 and 2,000 ft/min.

Setting the pressurisation for take-off

The MODE switch is selected to AUTO. The green AUTO legend will be illuminated.

The discharge valve switch is set to NORM. The discharge valve indicators will move to the fully open position if an air supply is on.

The MAN rotary switch is set to the 11 o’clock position. This has no effect on the automatic mode but is a reasonable starting position for the manual mode.

The BARO setting is set for the cruise – normally the standard pressure setting.

For cruising altitudes of FL280 and below, the altitude pointer is set to the cruise altitude on the inner scale. The selected cabin altitude will be given on the outer scale and will be less than 8,000 ft. For cruising altitudes above FL280, the altitude pointer is set to 8,000 ft cabin altitude on the outer scale.

The RATE control is set to the detent.

Pressurisation in the descent

To allow the cabin differential pressure to reach its maximum value for the start of the descent, the pressurisation should be set a few minutes before the descent is started.

The BARO setting is normally QNH, but QFE or the standard pressure setting may be set.

If the PACKS are to be ON for the landing, set the altitude pointer to the landing field elevation if QNH is set, to zero if QFE is set and to the landing field pressure altitude if the standard pressure setting is set. Round the altitudes based on QNH and the standard pressure setting up to the nearest 100 ft. If the PACKS are to be OFF, increase the pointer setting by 500 ft.

At the rate detent, the controller controls to a fixed altitude rate of 325 ft/min. The system takes approximately 24 minutes to descend the cabin from an altitude of 8,000 ft. The rate may need to be adjusted during the descent to lower the pressure.

For the pressurisation, the overall time in the descent is the most important factor in descent planning. The descent must be started at a point such that this time is at least as long as the time needed to descend the cabin.

Monitoring pressurisation in the descent

Assessing the position of the cabin altitude pointer relative to the Δp pointer allows a quick assessment of the descent rate performance of the pressurisation to be made.

Both pointers move towards the 12 o'clock position; the altitude pointer to the landing field pressure altitude and Δp to zero. We want the altitude pointer to reach the 12 o'clock position first; that is, the cabin altitude to arrive at the landing field altitude before Δp gets to zero. If the altitude pointer stays between the landing field altitude and the Δp pointer ('cabin ahead of Δp'), there will be a satisfactory outcome.

From very high cruise altitudes the attitude pointer has first to overtake the Δp pointer. If the aircraft descent rate is too high relative to the set cabin rate, the aircraft altitude will catch the cabin altitude and the Δp will become zero. The cabin rate will then become the same as the aircraft rate. Do not use prolonged unnecessarily high aircraft rates of descent.

Manual control of the pressurisation

To enter the manual mode, press the MODE switch. The white MAN annunciator should illuminate. The MAN SHUT/OPEN switch directly controls the position of the discharge valves and thus, indirectly, the cabin rate.

It is not practical to control the cabin rate by reference to the valve position indicators. The easiest way to control the cabin rate is to move the MAN SHUT/OPEN control and look at the cabin rate pointer. Then turn the control in the direction that the pointer needs to move to achieve the desired rate. Small changes in control position can cause large changes in cabin rate. Make a small adjustment and assess the effect. Repeat the process until the required rate is established.

For a given control position, the rate depends on flight conditions, engine conditions and the pack/air supply status. Any change that reduces the flow into the cabin will require the valves to be moved towards closed to maintain the cabin rate. Increased flow into the cabin will require a move towards open. Try to anticipate the need to adjust the position of the discharge valves to compensate for changing conditions.

Try to minimise power changes in the descent and consider the use of airbrake. On landing, the discharge valves will not automatically open. Aim to equalise cabin and aircraft altitudes shortly before landing and then select the MAN control to OPEN. Take care when reading the cabin altimeter as there is a marked scale change at 10,000 ft.

Cabin over-pressure

In the AUTO mode, if the cabin differential pressure indicates above the leading edge of the red radial maximum pressure indication line, select MAN and reduce the differential pressure to the normal operating range.

Cabin high altitude

A CABIN HI ALT caption is on the MWP. The caption illuminates if the cabin altitude exceeds 9,300 ft. The maximum allowed airfield altitude is 8,000 ft.

AUTO FLIGHT SYSTEM

The Automatic Flight Guidance System (AFGS) is an integrated autopilot and flight director system and can be regarded as consisting of three sub-systems:

- Two-axis autopilot and auto-trim (pitch)
- Duplex yaw damper
- Flight director

The auto pitch trim signals are also derived within the autopilot and control the pitch trim through the pitch-trim actuator. Aircraft pitch is controlled through a different actuator, called the pitch actuator.

The flight director logic and computation are fully integrated within the autopilot. The flight director can be selected and used when the autopilot is not engaged, provided that the avionics master switch is ON.

Both the flight director and the autopilot commands are output by a single autopilot computer.

The autopilot computer accepts NAV information identical to that supplied to the Captain’s flight instruments. The source of this information is dependent on the NAV1/SPLIT/NAV2 switch on the navigation selector.

A full-time, limited authority, duplex yaw damper is fitted in series with the rudder control system. Each yaw damper can demand up to two degrees of rudder movement in either direction. Control of the system is through the yaw damper master switches (YAW DAMP MSTR 1 and 2) and the yaw damper engage button on the autopilot controller.

Under normal circumstances the yaw damper system must be engaged.

For Category 2 approaches the AFGS is supplemented by an Approach Monitoring System (AMS) with annunciators on each instrument panel.

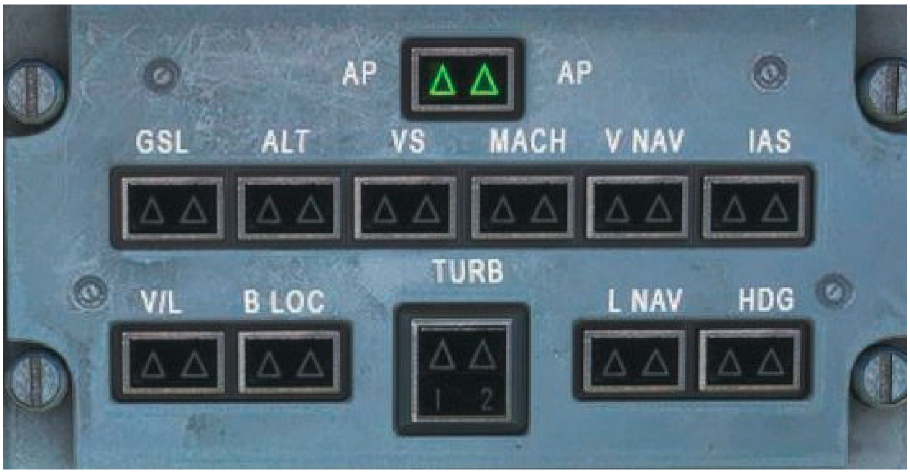
Control, selector and test panels

Mode selector

The mode selector is mounted on the glareshield and contains the push-button switches for the selected mode. Hidden legends are used so that the button appears blank until a mode is selected, at which point a white triangle is illuminated.

Engagement of the autopilot is indicated by a green triangle on the AP button at the top of the panel.

The bottom row selects lateral modes and the middle row selects vertical modes.



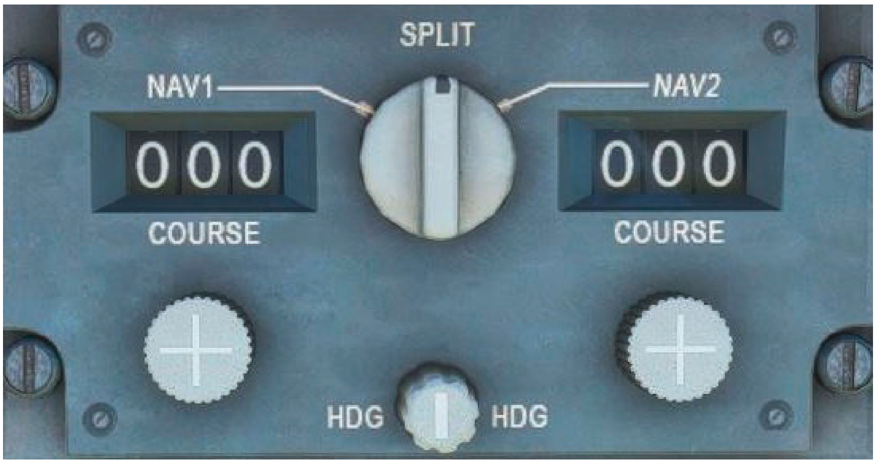
Navigation selector

The navigation selector is situated on the glareshield coaming and contains a large rotary switch labelled NAV 1–SPLIT–NAV 2. This selects the distribution of radio navigation information to the autopilot and to the pilot's instruments.

The autopilot and flight director use the information that is displayed on the Captain's HSI. With SPLIT selected, NAV 1 supplies HSI 1 and NAV 2 supplies HSI 2.

If NAV 1 is selected, both HSIs are supplied from NAV 1 and a NAV 2 selection supplies both HSIs from NAV 2.

The COURSE selector knobs allow rotation of the course pointer on the HSIs. An HDG knob provides remote selection of the heading bug on both HSIs.

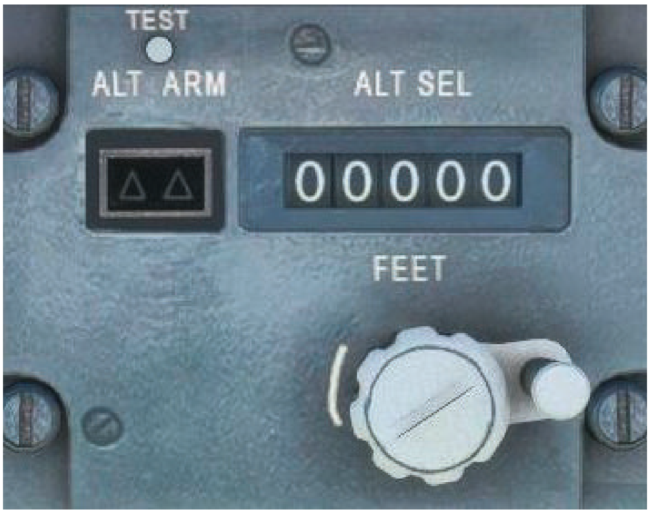


Altitude selector

The altitude selector is mounted on the glareshield and contains a five-figure read-out. The last two figures are fixed zeros.

A mode select button labelled ALT ARM allows arming of the selected altitude. The 'armed' state is indicated by a white triangle.

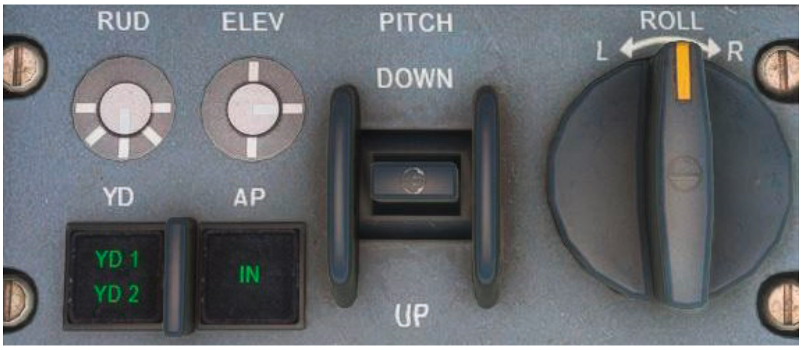
A press-to-test switch allows warning altitudes to be checked against the altitude set on the Captain's altimeter.



Autopilot controller

The autopilot controller is mounted on the centre console and contains the autopilot (AP) and the yaw damper (YD) engage buttons. These also indicate engagement by green illuminated IN for the AP, and YD1/YD2 for the yaw damper.

PITCH and ROLL controls and associated out-of-trim indicators (ELEV and RUD) are also found on the controller.



Master switches

All power to the AFGS is controlled by the two AVIONICS MASTER switches A and B. The AP MSTR controls the power to the autopilot pitch and roll servo motors. Yaw DAMP MSTR switches 1 and 2 are alongside.

Flight director switches

Labelled as FD BARS, these allow each pilot to select the flight director display onto his own ADI. The First Officer will see the same commands as the Captain. These are related to the navigation information selected to the Captain's HSI.

With the AP disengaged, initial selection of the flight director will be into basic PITCH and ROLL modes. All other modes, except for TURB, can be subsequently selected independently of the AP.

Sync/Go-around/Trim switches

A push-button (SYNC) fitted to each control wheel allows either pilot to temporarily disengage the autopilot servo motor clutches to carry out manually controlled adjustments to the aircraft attitude. This will re-datum the autopilot or flight director modes. Release of the button will re-engage the clutches. This is available in the basic modes of PITCH and ROLL and for IAS, MACH, VS and ALT. The SYNC button can be toggled with the 'TOGGLE AFTERBURNER' assignment or set with the 'SET ELT' assignment.

Two push-button switches allow either pilot to disengage the autopilot, cancel AP warning or select go-around on the flight director (providing flaps are not up).

A split thumb-operated switch controls the electric elevator trim.

Flight annunciator panels

Panels provide remote indication of the modes of engagement and visual annunciation warnings associated with the AFGS. These are blank until illuminated with associated white, green, blue, amber or red legends.

HSI/RMI switches

Adjacent to the left and right annunciator panels are two switches annotated HSI RNAV/NAV. These allow VOR/ ILS or RNAV information to be displayed on the respective HSIs for navigational purposes, and for subsequent input to the autopilot for tracking. Two green annunciators on each flight annunciator panel are labelled NAV and RNAV and indicate the current mode selection on the appropriate switch.

The switches can also be controlled with the 'TOGGLE GPS DRIVES NAV 1' control assignment.

Autopilot operation

Engagement

The autopilot is armed once the Avionics master switches and the A/P MSTR switch on the overhead panel have been switched ON. The only means of engaging the autopilot is by pushing the AP button on the autopilot controller. The button is a push on/off switch which reveals a green illuminated IN legend when the autopilot is engaged. Also, while the autopilot is engaged, the AP indicator on the mode selector will be illuminated by a green triangle unless either sync button is being depressed.

The autopilot may be engaged at a reasonable pitch attitude and at any bank angle less than 42°. If the flight director is switched off at engagement, the autopilot will maintain the pitch attitude existing at the moment of engagement and in roll the datum will depend on the bank angle at engagement.

Should the flight director be switched on prior to autopilot engagement, the autopilot will engage into the previously selected flight director mode. If the flight director is in go-around mode, however, engaging the autopilot will cause this mode to be cancelled.

Disengagement

Disengagement is normally effected by pressing either pilot's cut-out button. This causes an audio warning lasting one second. Disengagement by selecting the AP MSTR switch to OFF, removing electrical power from the system, pressing the AP engage button, operation of an internal safety device, operation of the pitch rate or stick position cut-out or operation of the stall warning system will result in a continuous warning which can only be cancelled by pressing either pilot's cut-out button.

In addition to the audio warning, a visual indication of autopilot disengagement is given by the illumination of the red AP annunciators on the pilot's flight annunciator panels. Both annunciators are illuminated for 1.5 seconds for a disengagement by a cut-out button or continuously until cancelled in the same way as the audio warning.

Synchronisation (SYNC)

The sync facility allows the pilot to adjust the datums of the PITCH, ROLL, ALT, MACH, IAS and VS modes without having to disengage and then re-engage the mode.

Operating either of the sync buttons when the autopilot is engaged illuminates the white SYNC annunciator on each pilot's mode panels, temporarily disengages the autopilot clutches and unlocks the datum chasers. The pilot may then manually manoeuvre the aircraft to establish a new datum. When this is achieved the sync switch is released. The datum chasers lock to their new value, the clutches re-engage and the sync annunciators are extinguished.

While the SYNC switch is operated, the autopilot IN legend on the autopilot controller remains lit and the AP green triangle on the mode selector is extinguished.

Under these circumstances the pitch monitor threshold (approx. 3°/sec) may be exceeded and the control column may be pushed forward more than 7 degrees, thus allowing the aircraft to be manoeuvred without disengaging the autopilot.

During SYNC manoeuvres the electric trim facility is available.

Pitch rate switch and turn controls

Apart from the sync button, the pilot may adjust the pitch and/or roll datum by use of the pitch rate switch and the turn control.

With the autopilot engaged, moving the pitch rate switch out of its central detent disengages any previously selected pitch mode except TURB. Moving this switch up or down will pitch the aircraft in the appropriate direction. Two pitch rates of 1 degree per second and 2 degrees per second at low airspeed (reduced with increasing airspeed to give approximately constant 'g') are available. The two switch positions have different spring pressures to differentiate between fast and slow rates. The new pitch attitude will be that existing 1.5 seconds after the pitch rate switch is allowed to return to its centre detent and the aircraft will remain in basic pitch attitude mode until another pitch mode is selected. Indication of pitch attitude mode is provided by the green PITCH annunciator on each pilot's mode panel.

Moving the turn control out of its central detent, with the autopilot engaged, causes any previously selected roll mode except TURB to be disengaged and the aircraft takes up a bank angle proportional to the amount the turn control is moved, up to a maximum of 28 degrees. The autopilot is then in basic roll mode, indicated by the green ROLL annunciator on the flight annunciator panels, and will remain so until a new roll mode is selected, at which time the turn control is returned automatically to its central detent.

The turn control may also be centred by use of the sync button or moving the turn control back to zero.

Category 2 Approach Monitoring System (AMS)

The CAT 2 AMS operates in conjunction with the autopilot to provide for a monitored approach down to a decision height of 100 ft. To ensure the independence of the AMS it is supplied from radio and gyro signals separate from those used by the AFGS. Similarly, the ADIs are also separately supplied to enable cross-flight instrument monitoring.

CAT 2 annunciator switch

The Captain's and First Officer's CAT 2 annunciators have an identical function. The CAT 2 annunciator switch indicates the armed status of the AMS. Pressing either of the CAT 2 annunciator switches will reverse the AMS status, for example an armed or inactive system will be inhibited.

Warnings

The amber localiser (LOC dev) and amber glideslope (GSL DEV) annunciators flash when the respective ILS beam deviation is excessive. With all conditions for a CAT 2 approach satisfied, but with neither CAT 2 annunciator illuminated amber, the system will be armed automatically at 600 ft 'rad alt' and the CAT 2 annunciator switch will be illuminated green. Pressing either of the CAT 2 annunciator switches will inhibit the AMS and illuminate both CAT 2 annunciators amber.

Operational description

To arm the AMS and illuminate the CAT 2 annunciator switch green requires the following inputs to be valid. If the inputs are incorrect at 600 ft 'rad alt', the AMS will not arm and no annunciation will be given. If any input fails after the AMS is armed and the CAT 2 annunciation illuminated green, the annunciation will change to amber.

- No.1 and No.2 glideslope and localiser valid
- No.1 and No.2 localisers tuned
- Radio altimeter valid
- Landing gear down

- Less than 600 ft radio height
- Greater than 100 ft ‘rad alt’
- NAV selector in SPLIT position
- Autopilot engaged
- Autopilot mode B.LOC not selected
- Attitude transfer switch to NORM position
- Compass transfer switch to NORM position

Note: *Disengagement of the autopilot will extinguish the amber and green CAT 2 annunciators.*

Autopilot control modes – general

Basic modes

The initial engagement of autopilot (AP) and FD is into the PITCH and ROLL modes.

Pitch and roll datums

Apart from the SYNC button, the pilot can adjust the pitch and/or roll datum by use of the pitch rate switch and turn control on the AP controller.

Roll attitude hold

This is a basic mode and a sub-mode of HDG.

With AP engagement and bank angles of 3 degrees or less, the AP will maintain a fixed heading.

With bank angles between 3 and 28 degrees, the AP will maintain the engaged bank angle.

At bank angles greater than 28 degrees, the bank will be reduced to and held at 28 degrees.

With bank angles greater than 42 degrees, the roll attitude cut-out will disengage the AP.

Preselection

No preselection of modes can be made unless a flight director is switched ON or the autopilot is engaged.

Modes selected with a FD ON will be engaged by the AP if subsequently selected.

If FD is switched off and AP is not engaged, any modes selected will be cancelled.

If AP is disengaged and an FD is ON, any modes selected will remain for the use of the FD.

If both FDs are OFF and AP is disengaged, all modes will be cancelled .

Flight director

With the avionics master switch selected ON, the FD on either ADI may be switched on by the associated FD BARS switch.

If the AP is not engaged, the FD will switch into PITCH and ROLL attitude holds and the pitch datum will be that existing at the time an FD is switched on. The roll datum will depend on the angle of bank at time of switch on and uses the same criteria as the AP (see ‘Roll attitude hold’ above). The existence of FD bars in the ADI is the indication that the FD is switched on.

If the AP is already engaged and an FD is switched on, the FD will take up the mode already in use, unless in TURB mode when the FD bars will remain parked. TURB mode is an AP mode only.

Both FD displays show demands in response to deviations indicated on the Captain's HSI.

Go-around

Available for flight director only. Selection is by use of the combined AP cut-out and GA mode select switches on the top of the outboard horn of each aileron control wheel. The AP will be disengaged on selection and all other modes will be cancelled, unless ALT ARM has been preselected.

Indication of GA mode is by green GA on the flight annunciator panels.

If AP is engaged, the first press on the GA select button will disengage the AP and a second press will cancel the AP disconnect warnings and select GA mode.

If AP is not engaged, a single press will select GA mode.

In GA the FD demands wings level and 10 degrees nose-up pitch. At this stage there is no HDG hold, but just a wings level command. HDG and ALT ARM can be selected subsequently.

Go-around may be cancelled by switching the FD OFF, by selecting IAS, by engaging AP or by using the SYNC button.

Autopilot control modes – vertical coupling

Altitude (ALT) mode

The ALT mode can be engaged at any time by pressing the ALT button, except in the TURB or Go-around modes. It is available to both AP and FD.

ALT mode is indicated by a white triangle and green ALT annunciators. The ALT mode is automatically engaged on completion of an altitude arm flare. The ALT datum is set at the moment of mode engage and may be adjusted by use of the SYNC button.

The ALT mode is disengaged by re-pressing the ALT button, by selecting IAS, MACH, VS, TURB or Go-around mode or, if AP is engaged, by moving the pitch trim switch out of detent.

ALT is automatically superseded at ILS glideslope capture.

Altitude arm (ALT ARM)

Altitude arm can be selected at any time except when in TURB mode by setting the desired altitude on the altitude selector and then pressing the ALT ARM button. This causes the white triangle to be illuminated within the button, together with white ALT on the flight annunciator panels to indicate the armed condition.

The barometric datum is that set on the Captain's altimeter.

At a variable vertical distance proportional to vertical speed and before the selected altitude, a computed flare to the selected altitude will begin. At this point any selected pitch mode will disengage and BOTH the green and the white ALT annunciators on the flight annunciator panels are illuminated.

When the selected altitude is reached, the white triangle on the mode selector and the white ALT on the flight annunciators will go out and ALT mode will automatically be engaged.

ALT ARM may be disengaged by selecting a new altitude on the altitude selector, by re-pressing ALT ARM or by selecting another pitch mode.

When in the armed state, ALT ARM will automatically be disarmed at glideslope capture if GSL is armed. After glideslope capture, a new altitude may be selected on the altitude selector together with ALT ARM.

Vertical speed (VS) mode

This mode is selected by pressing the VS button. Indications are a white triangle and green VS on the flight annunciators. The mode is available to both the FD and AP and the datum is that which exists at the time of engagement of the mode.

VS mode may be disengaged by re-pressing the VS button, selecting IAS, MACH, ALT or TURB modes or by selecting Go-around and, if AP is engaged, by moving the pitch trim out of detent on the autopilot controller.

VS mode is automatically superseded at ILS GS capture or ALT ARM flare.

The datum vertical speed may be adjusted using SYNC.

Since vertical speed is maintained by control of pitch attitude, the mode should be used with discretion.

Mach mode

This may be engaged at any time, except when in TURB or Go-around, and is available to both the AP and FD. Datum is set at time of engagement. Indications are by white triangle and green MACH on the flight annunciators.

The mode may be disengaged by re-pressing the VS button or by selecting IAS, MACH, ALT, TURB or Go-around modes and, if AP is engaged, by movement of the pitch trim switch from the centre detent.

The mode will be superseded at ILS GS capture or ALT ARM flare.

The datum Mach number may be adjusted by means of the SYNC button.

Vertical navigation (VNAV)

Not available in this aircraft.

Airspeed mode (IAS)

This mode is selected by pressing the IAS button and is not available in TURB mode. Datum speed is that which exists at the time of engagement.

Indications are a white triangle on the face of the mode button and green IAS flight annunciators.

Re-pressing the IAS button will cancel, as will the selection of MACH, ALT, VS, TURB or Go-around modes.

IAS mode is superseded at glideslope capture or ALT ARM flare.

Glideslope coupling mode (GSL)

This may be armed at any time except in B LOC, TURB or Go-around modes, providing the Captain's HSI is selected to an ILS frequency. The Captain's HSI change-over switch must be selected to NAV (and the appropriate navigation receiver tuned to an ILS frequency) prior to arming.

GSL is available for both the FD and AP.

Arming is accomplished by pressing the GSL button. A white triangle is displayed on the GSL button and the controlling pitch mode annunciator will also be illuminated (for example ALT, IAS).

A white (armed) GSL annunciator will show on both annunciator panels and will go out on glideslope capture to be replaced by the green (capture) flight annunciators.

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

At the capture point, the controlling pitch mode will be automatically terminated and the aircraft will pitch down smoothly.

At glideslope capture, the ALT ARM mode is disengaged but may be reselected for a subsequent altitude capture.

Selection of a new pitch mode or re-pressing the GSL button will disengage the GSL mode. Moving the Captain's HSI change-over switch from NAV will also disengage GSL mode.

GSL arm will disengage if TURB, B LOC or Go-around are selected. Changing frequency from ILS to VOR on the NAV set that is supplying the Captain's HSI will also disengage the mode.

When in GSL capture, selecting ALT, IAS, MACH, VS, TURB, B LOC, or Go-around will cause disengagement, as will changing frequency from ILS to VOR and, if AP is engaged, moving the pitch trim switch out of detent.

There is no adjustment to a glideslope datum and SYNC has no effect other than to declutch the AP.

Autopilot control modes – lateral coupling

Heading mode (HDG)

This mode is engaged by pressing the HDG button and is controlled by the HDG selector knob on the navigation selector. Roll angle is limited to 28 degrees.

Indications are white triangle and green HDG flight annunciators.

Changes of heading should be kept to less than 150 degrees, otherwise the turn could be made in the wrong direction.

Heading mode may be disengaged by re-pressing the HDG button and, if AP is engaged, by moving the turn control out of detent. Selection of L NAV or TURB modes will also disengage, as will selection of Go-around. The HDG mode can be reselected to give TURB plus HDG or Go-around plus HDG.

The use of the SYNC button will de-clutch the AP but the FD will continue to indicate demands to achieve datum heading and the AP will return to datums when the SYNC button is released.

VOR/LOC mode (V/L)

Provided the Captain's HSI is displaying radio information from a navigation receiver, indicated by the illumination of a NAV 1 or NAV 2 annunciator on the Captain's flight annunciator panel, coupling to a VOR radial or ILS localiser may be armed at any time, except when in TURB or Go-around modes.

The V/L mode is available for both the AP and FD.

The centre rotary switch on the navigation selector will determine which navigation receiver supplies the AFGS and the frequency selected will decide between VOR and ILS coupling.

If the Captain's HSI is not displaying NAV 1 or NAV 2 information, pressing the V/L mode button will be ineffective.

Indication of arming is by means of the white VOR or white LOC annunciators on the flight annunciator panels and a white triangle on the V/L button.

On arming V/L, Roll or HDG will remain engaged, allowing interceptions to be established (maximum 120 degrees for VOR and 90 degrees for ILS). During the interception the controlling mode may be changed without disarming V/L.

V/L may be disarmed by re-pressing the mode button, selecting TURB, B LOC or Go-around mode or by changing the selected navigation receiver to an incompatible frequency.

Changing the Captain's HSI change-over switch from NAV to R NAV will cause reversion to ROLL attitude hold.

At the capture point the controlling azimuth mode (roll or HDG) will disengage and the aircraft is turned to capture and track the centre line with automatic drift correction.

Once the ILS or VOR centre line is being tracked, the maximum bank angle is reduced from 28 to 10 degrees.

The use of SYNC in V/L mode has no effect other than to de-clutch the AP. The FO will continue to show demands and, on release of SYNC, the AP will attempt to meet them.

Indication of V/L capture is the white triangle in the mode button and the green VOR or LOC on the flight annunciators.

Disengagement from capture is similar to that given for disengagement from V/L arm.

Back localiser coupling mode (B LOC)

The criteria for B LOC are very similar to those of V/L mode. The front beam QDM should be set on the COURSE read-out of the navigation selector and the B LOC mode automatically reverses the sense of the deviation signals.

Maximum intercept angles of 90 degrees can be set up using roll or HDG modes.

B LOC is available for both AP and FD.

The Captain's HSI must be displaying ILS information. The Captain's HSI switch must be selected to NAV prior to coupling.

Indications are a white triangle on the B LOC button and a white or green B LOC (arm or capture) displayed on the flight annunciator panels.

Lateral navigation mode (L NAV)

The L NAV mode is available to both the AP and the FD. The mode is engaged by pressing the L NAV selector on the mode selector panel. The L NAV mode cannot be engaged when the AP is in TURB mode or the FD is in GA mode.

The L NAV mode couples the autopilot to the L NAV information on the course display of the left (Captain's) HSI. If the HSI change-over switch is not at R NAV, the L NAV mode cannot be engaged.

The AP and FD will give commands to satisfy a track error command from the L NAV.

The indication that L NAV is engaged is given by:

- Illumination of the L NAV selector button white triangle
- A green L NAV flight annunciator on each pilot's instrument panel

L NAV can be disengaged by:

- Re-pressing the L NAV selector button
- Selecting HDG mode
- Operating the turn control if the AP is engaged
- Selecting TURB when the AP is engaged
- Selecting the FD to GA mode
- Selecting the L HSI change-over switch to NAV

The use of the SYNC facility in L NAV mode has no effect other than to declutch the AP. The FD roll command will continue to show demands to achieve the L NAV demand; when the SYNC button is released, the AP will regain the L NAV track.

Turbulence mode (TURB)

An AP mode only, if the FD is ON the FD bars will be parked out of view.

The AP main channel gearings are attenuated to give a soft ride. The mode is one of PITCH and ROLL attitude hold, with the initial datums being those at the time of engagement. On selecting TURB, any other pitch or roll mode (or armed state) will disengage.

After TURB has been engaged, HDG mode may be subsequently engaged to give TURB plus HDG. Note that there is no ALT hold or ALT ARM.

Indications are a white triangle in the TURB button and green TURB annunciators. PITCH and ROLL annunciators will also illuminate on the flight annunciator panels. If HDG is selected, the green ROLL lights will be replaced by HDG annunciators.

TURB can be disengaged by re-pressing the mode button or by disengaging the AP.

On disengagement of TURB, the AP and FD (if switched on) will revert to pitch and roll attitude hold, or to HDG if selected.

Datum adjustment is by pitch trim switch and turn control or by SYNC, but the FD will remain parked throughout.

Altitude alerting

An altitude alerting system provides a visual warning of the approach to a pre-selected altitude, and once this altitude has been attained the system provides an audio and visual warning should a 300 ft deviation occur.

Audio warning is given by a dedicated altitude-alerting 1.5-second tone which sounds on departure from the selected altitude as the 300 ft point is crossed.

When the aircraft approaches to within 900 ft of the selected altitude, a steady visual warning will come on and remain on until 300 ft and then extinguish. If the aircraft deviates by more than 900 ft from the selected altitude, after passing 900 ft before the selected altitude and before reaching 300 ft, a flashing visual warning is given. This warning will continue to flash until height is reduced to less than 900 ft or a new height is selected on the altitude selector.

Whilst the aircraft remains within ±300 feet of the selected altitude, the altitude alerting system will be dormant. Should the aircraft deviate more than ±300 feet, a flashing visual warning and a 1.5-second audio warning will be given as the 300 feet point is crossed. The flashing visual warning remains on until the error is reduced below 300 feet or a new height is selected on the altitude selector.

Failure of the altitude alerting system is indicated by a red bar obscuring the digital read-out on the altitude selector. This failure bar will appear in the event of a power failure.

Trim operation

Automatic trimming of the pitch channel is provided whenever the autopilot is engaged and is used to maintain the long-term pitch trim.

The trim servo speed is electrically limited to either of two predetermined values which are governed by a switch on the flap selector between 18° and 24°.

The electric elevator trim can be used in the SYNC mode. This allows the pilot to re-trim the aircraft rapidly without removing his hands from the control column.

Safety features and warnings

Roll attitude cut-out

A roll attitude cut-out is incorporated to disengage the autopilot if a roll angle greater than 42 degrees or a roll rate greater than 32 degrees per second (or any equivalent intermediate combination) develops. These values are reduced, with LOC track mode or RAD ALT below 350 feet, to a 19˚ roll angle or a roll rate greater than 15° per second. Automatic disengagement of the autopilot illuminates the flashing red ‘AP’ caption in both flight annunciator panels and gives a continuous audio warning.

Stall warning

The autopilot is disengaged if a stall warning is sensed.

Pitch rate cut-out

An independent pitch rate cut-out is incorporated to disengage the autopilot if a pitch rate of 3 degrees per second or greater is sensed.

Stick position cut-out

The autopilot is disengaged whenever the control column travels farther than 6.5˚ forward of centre.

Trim warnings

A trim sense monitor within the autopilot computer protects against auto-trim failures by detecting any movements of the trim servo motor in the wrong direction. Operation of the monitor will disengage the auto-trim servo motor clutch and illuminate the amber EL TRIM annunciators. The EL TRIM annunciators will be extinguished when the autopilot is disengaged.

The autopilot computer also contains a detector to sense any out-of-trim load, being held by the roll servo motor. The out-of-trim load is indicated by the illumination of the amber AIL annunciator; this can be extinguished by reducing the out-of-trim load using the manual rudder or aileron trim systems.

Should the autopilot be disengaged while the EL TRIM and/or AIL annunciator are illuminated, the pilot must be prepared to accept any out-of-trim control force.

Yaw damper warning

If an asymmetry of 1.5 degrees or greater is sensed between the yaw damper actuators, both yaw dampers are frozen and an amber YD warning is given on the flight annunciator panels.

When the YAW DAMP 1 and 2 MASTER switches are selected ON and a yaw damper is disengaged, the amber YD caption will be illuminated on both flight annunciator panels.

Typical operation

For all flight phase descriptions in this manual, the aircraft is manoeuvred automatically by the flight control system. If the autopilot is disengaged, the aircraft may be manually flown to satisfy the flight director demands. With the exception of go-around, the same modes of operation and indicator settings are used.

Take-off and climb

Take-off is normally made by manually following the flight director commands, with the autopilot being engaged above 300 feet AGL.

1. Prior to take-off, set the heading bug on the HSI to the runway heading or the desired outbound heading. Set the course pointer to the radial of the first desired VOR course. Line up on the runway centreline, select PITCH and ROLL modes, (FD bars on) and arm the altitude pre-selector. The vertical command bar now provides runway heading guidance and the horizontal bar commands the pitch attitude after SYNCing. Apply power and keep the roll bar centred for low visibility runway guidance during the take-off roll.
2. After lift-off, rotate to the required pitch attitude, SYNC the pitch bar and maintain the roll bar centred. When stable flight conditions are achieved, engage the autopilot. IAS and HDG can be selected as safe climb modes.
3. After reaching a safe altitude, use SYNC to change the desired airspeed through the optimum noise abatement climb profile. Releasing the button puts the autopilot back in IAS hold and on the climb-out heading. Further heading changes may then be made, as directed by departure control, by moving the heading bug to a new heading.
4. The climb is continued in IAS or MACH until the ALT SEL capture point is reached. The aircraft is gently levelled off and the system automatically switches to ALT hold mode. Warning of the approaching altitude is given by an alert light at 900 feet to go. The light extinguishes at 300 feet from the selected altitude.

VOR capture and tracking

The VOR mode of operation features automatic capture of the radial. This is usually accomplished with the autopilot engaged and the flight director in the HDG mode. Any vertical mode can be selected, e.g. ALT hold.

1. Tune the navigation receiver to the desired VOR station. Set the course pointer to the desired course.
2. Check that HDG and V/L ARM modes are illuminated, indicating that the system is flying the intercept heading selected with the heading on the HSI and that the system is armed for VOR capture.
3. At VOR capture, the HDG light will go out and VOR will be annunciated, indicating that VOR capture has occurred. The aircraft will smoothly roll out and track the radial with crosswind correction.
4. If the VOR flag or the HDG flag comes into view while tracking the VOR radial, the flight director bars will bias out of view and the autopilot will remain coupled.

ILS approach

On an ILS approach the localiser and glideslope are automatically captured. The localiser is normally captured first but can be captured after glideslope capture and is captured from roll modes in the same manner as the VOR radial. The glideslope can be captured with any vertical mode previously selected and from either above or below the beam. To make an ILS approach, perform the following:

1. Tune the navigation receiver to the localiser frequency and set the course pointer to the published inbound course.
2. Set the heading bug to the desired intercept heading.

3. Select LOC and GSL modes, which arms both the localiser and the glideslope circuits. As the aircraft nears the localiser beam, the HDG light will go out and LOC (G) will annunciate localiser capture. The aircraft will smoothly roll out on the localiser. The expanded localiser pointer at the bottom of the ADI will appear when the localiser deviation is one dot or less. After localiser capture, select the published missed approach heading.
4. When the glideslope is captured, the GSL (W) light goes out and the GSL (G) annunciator lights up. Any previously selected vertical mode will automatically release at glideslope capture. The autopilot will track the centre of the localiser and glideslope beams with crosswind corrections if required. Select the missed approach altitude in the altitude selector and select ALT ARM (altitude alerts are inhibited in GSL mode).
5. When the decision height annunciator illuminates, the decision to land or go around must be made. To assume control of the aircraft for flare and touchdown, press the autopilot disengage button on the handwheel and land.
6. If either a localiser or glideslope flag comes into view while making an ILS approach, the respective axis will remain coupled on the autopilot, the flight director bars will bias from view and the mode light will not extinguish.

Go-around

The go-around mode can be selected at any time, with any mode previously selected, if FD is selected. If the autopilot is in use, however, the first button press will disengage the AP and the second button press will change to the GA mode. After AP disconnection, the flight director command bars will command a wings level, 10-degree pitch-up attitude.

After the flaps and gear are retracted, re-engage the autopilot. The missed approach departure is made using HDG with the climb being performed using PITCH SYNC or IAS hold.

Back course approach

Tune the localiser frequency and set the course pointer to the front course localiser course. Set the desired intercept heading on the heading bug on the HSI. Select B LOC to arm the system for automatic back course localiser capture. ALT hold may be selected to maintain approach altitude.

When the aircraft approaches the back localiser, automatic capture will occur. The lateral deviation bar as well as the expanded localiser have the proper sensing and present the proper indication. When B LOC is selected, the glideslope circuits are locked out.

After localiser tracking has begun, the descent phase of the approach should be initiated. The IAS, VS or PITCH modes may be used.

For missed approaches, go-around operation is as previously described.

Let-down to VOR approach

1. To fly a typical VOR let-down, track into the station in VOR mode with the NAV receiver tuned to a VOR frequency. After entering the cone of confusion, set the course to the published value. After station passage, the system will track the new outbound course.
2. If the VOR is approached from a heading that requires manoeuvring to the outbound leg, select HDG mode and use the heading bug on the HSI to alter course.
3. Adjust the heading bug 135 degrees or less in the direction of the 180-degree turn. Set the course pointer to the inbound radial. After completing 45 degrees of the turn, adjust the heading bug until the 180-degree turn is completed. While in the inbound turn, select VOR. You will automatically capture and track the inbound radial with automatic crosswind correction.

4. Use indicated airspeed (IAS) or vertical speed (VS) mode and altitude preselect to provide vertical guidance to the runway. First select the VOR crossing altitude on the altitude alert controller and press ALT ARM. The ALT ARM light will come on. Use airspeed (IAS) or vertical speed (VS) mode to fly your selected rate of descent. When the selected altitude is approached, the ALT light will indicate that you are levelling out until crossing the VOR. After crossing the VOR, select the MDA (Minimum Decision Altitude} as your next altitude and again use IAS to fly to the MDA. At the MDA the decision to land or go around must be made.

Holding

To establish a holding pattern over the outer marker or a VOR intersection, perform the following:

1. Select HDG and ALT modes. Tune the navigation receiver to the VOR or localiser and set the desired course. Maintain flight to the holding point by adjusting the HDG bug.
2. When the aircraft reaches the holding point, turn the heading bug 135 degrees in the direction of the outbound turn. After completing 45 degrees of the turn, continue moving the heading bug until the reciprocal heading of the inbound course is reached. If crosswind correction is needed, it must be set manually by adjusting the heading bug for the appropriate crab angle.
3. After the required time on the outbound heading, set the heading bug 135 degrees in the direction of the outbound turn.
4. After completing 45 degrees of the turn, continue moving the heading bug to the inbound course with crosswind correction.
5. If automatic capture and tracking of the inbound radial is desired, select V/L mode after the turn to the inbound radial has been initiated. Crosswind corrections are automatically computed in VOR mode.

COMMUNICATION SYSTEM

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

- Speech communication, utilising a dual VHF (Very High Frequency) system
- 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

VHF communication system

Two separate VHF COMM systems are provided. Each installation comprises a VHF transceiver, controller and antenna. Audio and keying facilities are provided by the audio integrating system.

Each transceiver is controlled by VHF COMM control units with dual frequency selection which are located on the centre console. Both controllers incorporate two pairs of concentric knobs for frequency selection of COMM A and COMM B respectively. The frequency range is 118.000-135.995 MHz in 8.33 kHz increments. The selected frequency is displayed through a viewing window located above the associated knobs.

Each controller has a separate power ON/OFF switch and a transfer TFR switch. The TFR switch enables the controlled transceiver to be switched to the COMM A or COMM B selected frequency as required. A green indicator light illuminates to indicate which frequency is in use.

Power supplies are MDC to VHF 1 and DC 2 to VHF 2.

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 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, a circuit is made via the squat switch and the fuselage upper pressure doors unsafe warning circuit to energise bulk erase in the CVR. The button must be held for at least 14 seconds to completely erase the recording.

When the AVIONICS MASTER switch A is selected to OFF, the CVR ceases to operate and, if the bulk erase procedure has not been applied, the last 30 minutes of recording will be held on the tape.

If power supplies to the CVR are interrupted for any reason, the recorder will stop recording, with the last 30 minutes of recorded information held on the tape.

In a ditching situation the underwater locating device (ULD) is activated by the water sensitive switch and radiates a pulsed acoustic signal to assist in location of the CVR.

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.

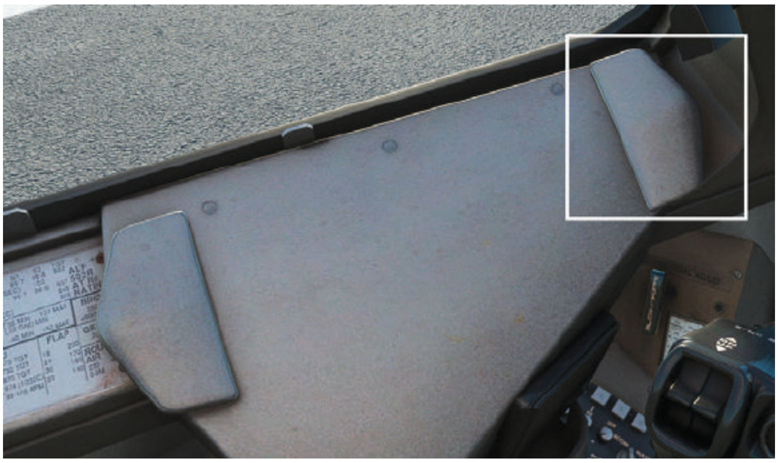
High, high/low and low chime tones are activated by corresponding signals when received from passenger and toilet call, cabin crew call, fasten seat belts and no smoking signs. All chime tones are fed to the cabin attendant's panels, passenger cabin and toilet speakers.

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 buttons are for reception; press to select and rotate to the right for increased volume.

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.



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 transformer rectifiers (TRs) which convert the AC (provided by the engine and APU generators or the external source) to DC. The aircraft battery provides an emergency DC supply and also, via a standby static inverter, an emergency AC supply.

The AC and DC supplies are distributed by a network of busbars classified as normal, essential and emergency. The normal busbars are duplicated to form the basis of a two-channel system: channels 1 and 2, both having AC and DC busbars.

Normal, essential and emergency AC busbar network

Channels 1 and 2 normal AC busbars are powered by three-phase, 115/200V, 400 Hz AC provided by the engine and APU generators or, on the ground, an external AC source. These power sources cannot be paralleled, and each channel is normally fed by a separate source. If only one source is available, it can power both channels, but in flight the APU generator will only power one channel.

The generator driven by engine No.1 (GEN 1) normally powers the AC 1 busbar in channel 1 and the generator driven by engine No.4 (GEN 4) normally powers the AC 2 busbar in channel 2. The APU generator or the external AC source, both in channel 2, can each power channel 1 and/or channel 2. If only one engine-driven generator is online and either external AC (EXT AC) or the APU generator (APU GEN) is available, the engine-driven generator will power its associated busbar and the other available source may be used to power the other busbar.

The essential and emergency AC busbars are in channel 1, therefore the AC 1 busbar normally feeds the essential AC busbar which, in tum, normally feeds the EMERGency AC busbar; the EMERG AC busbar is powered with single-phase 115V AC.

Normal, essential and emergency DC busbar network

The normal DC busbars, DC 1 in channel 1 and DC 2 in channel 2, are fed with 28V DC provided by TRs powered by the normal AC 1 and AC 2 busbars. AC 1 busbar feeds the TR powering the DC 1 busbar and AC 2 busbar feeds the TR powering the DC 2 busbar.

During normal operation the DC 1 and DC 2 busbars are paralleled and feed the EMERGency and essential DC busbars but, when the busbars are split, DC 1 feeds the EMERG DC and ESS DC busbars, both in channel 1. DC 2 alone remains 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

If there is a loss of 115/200V, 400 Hz AC to the AC 1 and AC 2 busbars, the hydraulically driven standby generator (STBY GEN) will operate automatically to provide three-phase, 115/200V, 400 Hz AC to the ESS AC busbar, and 28V DC to the ESS DC busbar. The AC 1, AC 2, DC 1 and DC 2 busbars will not be powered but the EMERG AC and EMERG DC busbars will normally each be fed by their ESSential busbar. The STBY GEN forms part of channel 1.

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.

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 TRs 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.

Location of electrical system equipment

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.

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

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.

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 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 – 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 – 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 system via the EXT AC switch on the flight deck.

The EXT AC switch has two effective positions, ON and OFF, and a neutral 'centre' position. The EXT AC switch and the GRD SERVICE POWER switch are spring-loaded from ON to the centre position.

If external AC power has been connected but is not switched on, the green EXT AC PWR AVAILABLE annunciator will be lit.

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 AUTO FLIGHT SYSTEM, COMMUNICATION 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 a single battery, BATT, with an ON/OFF switch and an associated BATT OFF LINE annunciator which lights if the battery is not connected to the EMERG DC BUSBAR, provided there is power on this busbar or DC 2 busbar.

When BATT is switched OFF, the EMERG DC busbar is isolated. The EMERG DC OFF and BATT OFF LINE annunciators will light, provided there is power on the DC 2 busbar.

Battery charging is from the EMERG DC busbar. The battery ‘floats’ on the busbar when fully charged. The battery has an individual busbar to which it is connected permanently.

When the STBY GEN is selected and signalled to operate, the distribution of emergency DC power is affected – see the Standby generator section.

If the battery overheats, initially a thermal switch operates the amber BATT HI TEMP annunciator on the overhead ELECTRIC panel and the amber ELECT annunciator on the Master Warning Panel. If the battery temperature falls below the setting of the thermal switch, the warnings will cancel, but if the battery temperature continues to rise to the higher setting of another thermal switch, the warning will persist and the battery will be automatically isolated from the EMERG DC busbar, causing the appropriate BATT OFF LINE annunciator to light until the battery temperature falls below the setting of the lower temperature thermal switch.

APU starting power

The APU has a DC starter motor which can be powered only from TR 1 or the battery. TR 1 can be powered from GEN 1, GEN 4 or EXT AC. For APU starting, TR 1 is selected automatically in preference to the battery if DC BUS 1 is energised. Thus, if TR 1 is not delivering power but DC BUS 2 is powered, the BUS-TIE DC switch must be selected OPEN to allow the battery to be used for an APU start.

Note: *If the DC BUS 1 OFF annunciator is on but the DC BUS 2 is energised and the BUS-TIE DC switch is at AUTO, the APU must not be started or a fuse will rupture.*

Main engine starting power

Each engine has a DC starter motor which may be powered by an external DC supply or two TRs. One TR alone is inadequate and cannot be connected to the starter motors.

The EXTernal DC supply, nominally 28V DC, is connected via a receptacle on the right side of the fuselage – just forward of the hydraulic equipment bay. The supply from the TRs is either the normal 28V DC for NORMal starts or 35V DC for COLD starts.

A START PWR switch on the ENGINES panel has three sections – EXT DC/NORM/COLD – to allow the required starting power mode to be selected.

When the START PWR switch is selected to NORM, the TRs may be powered by EXT AC, the APU GEN or, for ‘cross starting’, GEN 1 or GEN 4. During NORMal starts, in addition to powering the starter motors, the TRs power their normal DC busbars.

When COLD is selected the APU GEN must not be used. When COLD is selected the TRs are switched automatically to supply 35V DC to the engine starter only. The TRs’ auto cut-outs (ACOs) are held open so that the DC 1 and DC 2 busbars are not powered.

When using EXT DC for starting, if the APU is running it may be used to power the AC and DC busbar system.

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

1. The EMERG DC bus will be 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 online if:
    a. Either the START PWR switch is at EXT DC

    or

    b. The APU GEN is online

    or

    c. EXT AC is online
3. When using GEN 1 or GEN 4 for ‘cross-starting’, only one generator can stay online. Whichever generator is online first stays online, but if both generators are online when the START MASTER switch is selected ON, GEN 4 will drop offline.
4. All galley electrical supplies are automatically disconnected.

Further details of main engine starting are given in the Power Plant section.

Controls and indicators

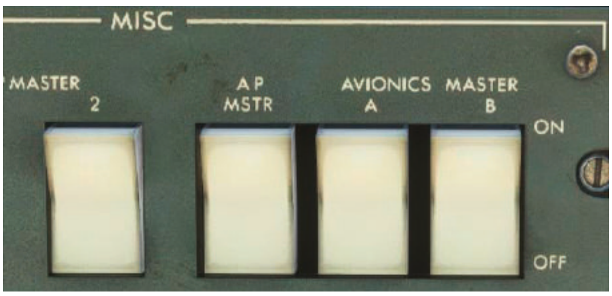
General

The indicators and controls in the following table are all on the overhead instrument panel on the flight deck unless otherwise specified. The letters A, G, and W (amber, green and white) indicate the colour of an annunciator or lamp.

When an amber annunciator (except EMERG DC OFF) lights on the ELECTRIC panel, the ELECT annunciator lights on the Master Warning Panel and the single-chime audio warning sounds.

Colour codes on the voltmeters, ammeters and frequency meter indicate appropriate operating range:

- Normal – green
- Cautionary – yellow
- Emergency – red



Item	Legend	Notes
Generator switches	GEN 1 & 4, ON, OFF LINE, OFF/RESET	
Generator offline ind.	GEN 1 & 4, OFF LINE	A – annunciator
Generator drive fault ind.	DRIVE 1 & 4, HI TEMP	A – annunciator
APU generator switch	APU GEN ON, OFF LINE, OFF/RESET	
APU generator offline ind.	APU GEN OFF LINE	A – annunciator
APU generator fault	APU DRIVE FAIL	A – annunciator
Ammeters, Gen 1, 4 and APU	AMPS 0-250	
External AC power switch	EXT AC, OFF, ON	
External AC power connected ind.	EXT AC POWER AVAILABLE	G – annunciator
Bus-tie switches	BUS-TIE AC & DC, AUTO, OPEN	
Primary AC bus fail ind.	AC BUS 1 & 2 OFF	A – annunciator
Primary DC bus fail ind.	DC BUS 1 & 2 OFF	A – annunciator
Standby inverter switch	STBY INV ARM, OFF, O/RIDE	
Emergency AC fail ind.	EMERG AC OFF	A – annunciator
Standby generator switch	STBY GEN ARM, O/RIDE	
Standby generator on ind.	STBY GEN ON	W – annunciator
Essential AC bus fail ind.	ESS AC OFF	A – annunciator
Essential DC bus fail ind.	ESS DC OFF	A – annunciator
Emergency DC bus fail ind.	EMERG DC OFF	A – annunciator
Battery offline ind.	BATT OFF LINE	A – annunciator
Battery overheat ind.	BATT HI TEMP	A – annunciator
AC voltmeter	AC VAC 0-250	
Battery power on ind.		
Rotary selector switch, AC volts and frequency		
Frequency meter	Hz 0-500	
DC voltmeter	DC VDC, 0-40	
Rotary selector switch, DC volts and amps	VOLT/AMP	
Battery switch	BATT ON/OFF	
DC amps ind.	AMPS, TR1, TR2, BATT	
Avionics supply switches	AVIONICS MASTER, A, B	MISC panel

Single failure warnings

INDICATIONS		FAILURE
PANEL	**ANNUNICATORS**	
MWS	ELECT ↑	LOSS OF GEN 1 OR 4 (BUS-TIE SWITCHES AUTO)
ELECTRIC	GEN 1 or 4 OFF LINE * AC BUS 1 or 2 OFF	* May light momentarily
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 ↑	APU GEN DRIVE-OIL TEMP OR PRESSURE FAULT
ELECTRIC	APU DRIVE FAIL	
MWS	ELECT ↑	BATTERY HIGH TEMPERATURE
ELECTRIC	BATT 1 HI TEMP * BATT 1 OFF LINE	* If overheat is severe
MWS	ELECT ↑	BATTERY OFF LINE
ELECTRIC	BATT 1	

AC failures – multiple system warnings

INDICATIONS		FAILURE
PANEL	**ANNUNICATORS**	
MWS	ELECT ↑ ICE PROT ↑ CABIN HI ALT * EMERG LTS ON	* May light LOSS OF ALL GENERATED POWER Note: GEN 1 and 4 OFFLINE not indicated
ELECTRIC	AC BUS 1 OFF AC BUS 2 OFF ESS AC OFF DC BUS 1 OFF DC BUS 2 OFF ESS DC OFF	
ICE PROTECTION	L PITOT HTR FAIL	

MWS	ELECT ↑ AIR SUPPLY ↑ AIR COND ↑ ICE PROT ↑ ANTI SKID ↑ HYD ↑ FLAP FAULT FUEL 1 LO PRESS FUEL 2 LO PRESS FUEL 3 LO PRESS FUEL 4 LO PRESS	LOSS OF GEN 1 AND 4
ELECTRIC	GEN 1 OFF LINE GEN 4 OFF LINE AC BUS1 OFF LINE AC BUS 2 OFF LINE STBY GEN ON DC BUS 1 OFF DC BUS 2 OFF BATTERY 1 OFF LINE	
ANTI-SKID & LIFT SPOILERS	ANTI-SKID INOP	
ICE PROTECTION	R PITOT HTR FAIL	
AIR SUPPLY	ENG 1 AIR VALVE ENG 4 AIR VALVE	
HYDRAULIC	GREEN LO PRESS GREEN LO QTY *	* May light
AIR CONDITIONING	RECIRC VALVE	
MWS	ELECT ↑ ICE PROT ↑ FUEL ↑ FUEL 1 LOW PRESS FUEL 3 LOW PRESS	
ELECTRIC	GEN 1 OFF LINE AC BUS 1 OFF ESS AC OFF	LOSS OF GEN 1 NO POWER TRANSFER TO AC 1 (BUS-TIE SWITCHES AUTO)
ICE PROTECTION	L PITOT HTR FAIL Q FEEL HTR FAIL AUX PITOT HTR FAIL	
FUEL	L OUTER LO PRESS R INNER LO PRESS L STBY LO PRESS R STBY LO PRESS	

MWS	ELECT ↑ FUEL ↑ CABIN HI ALT * ICE PROT ↑ EMERG LTS ON	* May light
ELECTRIC	AC BUS 1 OFF ESS AC OFF DC BUS 1 OFF ESS DC OFF	LOSS OF GEN 1 (BUS-TIE SWITCHES OPEN)
ICE PROTECTION	L PITOT HTR FAIL	Note: GEN 1 OFF LINE not indicated
FUEL	L OUTER LO PRESS R INNER LO PRESS	
MWS	ELECT ↑ ICE PROT ↑ FUEL ↑ FLAP FAULT FUEL 2 LO PRESS FUEL 4 LO PRESS	
ELECTRIC	GEN 4 OFF LINE AC BUS 2 OFF	LOSS OF GEN 4 NO POWER TRANSFER TO AC 2 (BUS-TIE SWITCHES AUTO)
ICE PROTECTION	R PITOT HTR FAIL	
FUEL	L INNER LO PRESS R OUTER LO PRESS L STBY LO PRESS R STBY LO PRESS	
MWS	ELECT ↑ AIR SUPPLY ↑ ICE PROT ↑ FUEL ↑ FLAP FAULT ANTI SKID ↑ FUEL 2 LO PRESS FUEL 4 LO PRESS ENG A-ICE ON	
ELECTRIC	GEN 4 OFF LINE AC BUS 2 OFF DC BUS 2 OFF	
ICE PROTECTION	R PITOT HTR FAIL ENG 2 VLV NOT SHUT ENG 4 VLV NOT SHUT	LOSS OF GEN 4 (BUS-TIE SWITCHES OPEN)
AIR SUPPLY	ENG 4 AIR VALVE	
FUEL	L INNER LO PRESS R OUTER LO PRESS L STBY LO PRESS	
ANTI-SKID & LIFT SPOILERS	ANTI-SKID INOP	

MWS	ELECT ↑ ICE PROT ↑ FLAP FAULT	LOSS OF ESS AC
ELECTRIC	ESS AC OFF	
ICE PROTECTION	L PITOT HTR FAIL Q FEEL HTR FAIL AUX PITOT HTR FAIL	
MWS	ELECT ↑ FLAP FAULT	LOSS OF EMERG AC
ELECTRIC	EMERG AC OFF	

DC failures – multiple system warnings

INDICATIONS		**FAILURE**
PANEL	**ANNUNCIATORS**	
MWS	ELECT ↑	LOSS OF DC 1 AND DC 2 (AC POWER NORMAL) Note: STBY GEN does not operate
ELECTRIC	DC BUS 1 OFF DC BUS 2 OFF ESS DC OFF	
MWS	ELECT ↑ AIR SUPPLY ↑ AIR COND ↑	LOSS OF DC 1 (BUS-TIE SWITCHES AUTO)
ELECTRIC	DC BUS 1 OFF	
AIR SUPPLY	ENG 1 AIR VALVE	
AIR CONDITIONING	RECIRC VALVE	
MWS	ELECT ↑ EMERG LTS ON	LOSS OF DC 1 (BUS-TIE SWITCHES OPEN)
ELECTRIC	DC BUS 1 OFF ESS DC OFF	
MWS	ELECT ↑ AIR SUPPLY ↑ ICE PROT ↑ ANTI SKID ↑ FLAP FAULT ↑ ENG A-ICE ON	LOSS OF DC 2
ELECTRIC	DC BUS 2 OFF	
ICE PROTECTION	ENG 2 VLV NOT SHUT ENG 4 VLV NOT SHUT	
AIR SUPPLY	ENG 4 AIR VALVE	
ANTI SKID & LIFT SPOILERS	ANTI SKID INOP	

MWS	ELECT ↑ EMERG LTS ON	LOSS OF ESSENTIAL DC
ELECTRIC	ESS DC OFF	
MWS	FLAP FAULT MWS FAULT	LOSS OF EMERG DC Note: No ELECT annunciator No Chime, Master Caution or Bright-up * May light
ELECTRIC	EMERG DC OFF STBY GEN ON *	
AIR SUPPLY	ENG 2 AIR SUPPLY	

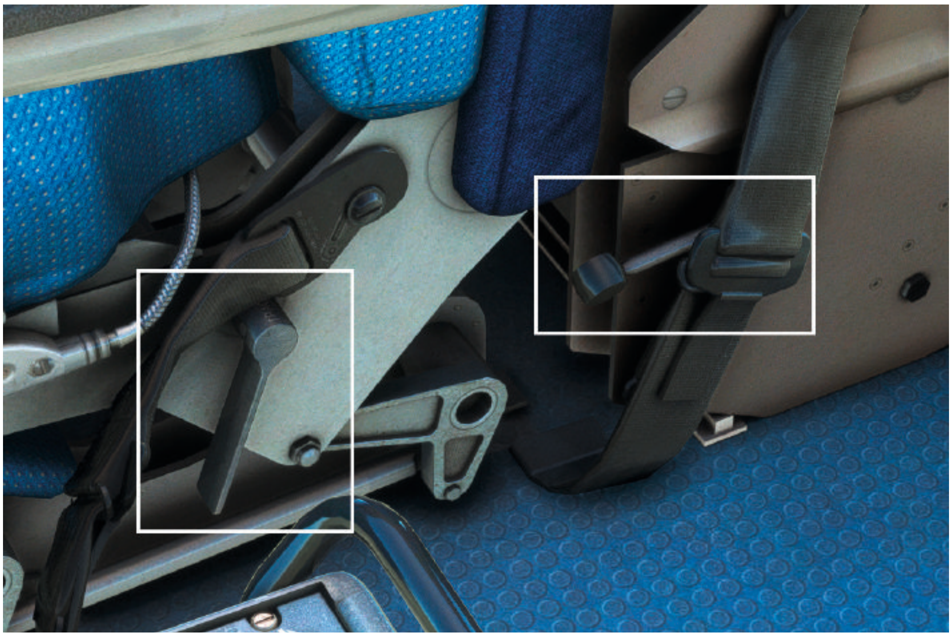
AIRCRAFT EQUIPMENT

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.

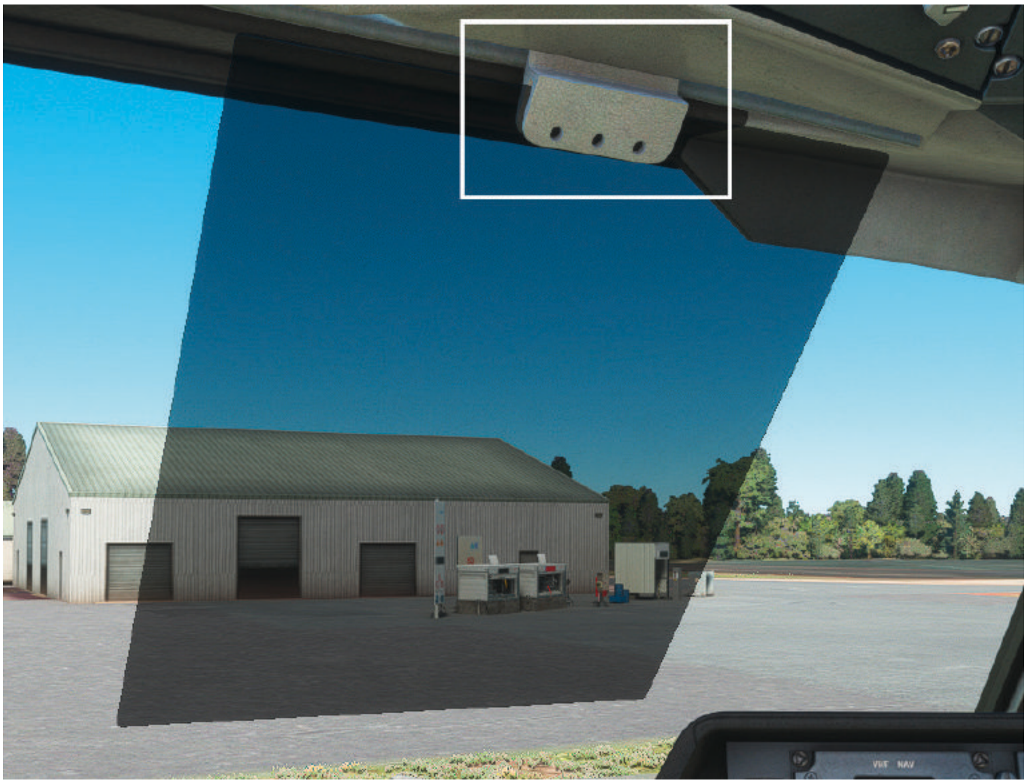


An airfield approach chart holder is located on each pilot's handwheel. Side consoles, situated outboard of the Captain's and First Officer's stations, contain ashtrays, stowable chart/cup holders and stowage for both flight and operations manuals, checklists, sun visors and blind flying screens. Headset 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.

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.

Passenger cabin

The passenger cabin will accommodate 70-112 seats (-100 to -300), mainly six abreast and at 31 inches seat pitch. Overhead stowage bins are provided on each side of the passenger cabin.

Rear galley

The rear galley provides accommodation for one cabin attendant.

A stowable cabin attendant seat is attached to the rear face of the main passenger cabin rear left-hand bulkhead.

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.

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.

The warning system comprises an amber flight deck presentation with associated audio warning.

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.

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)

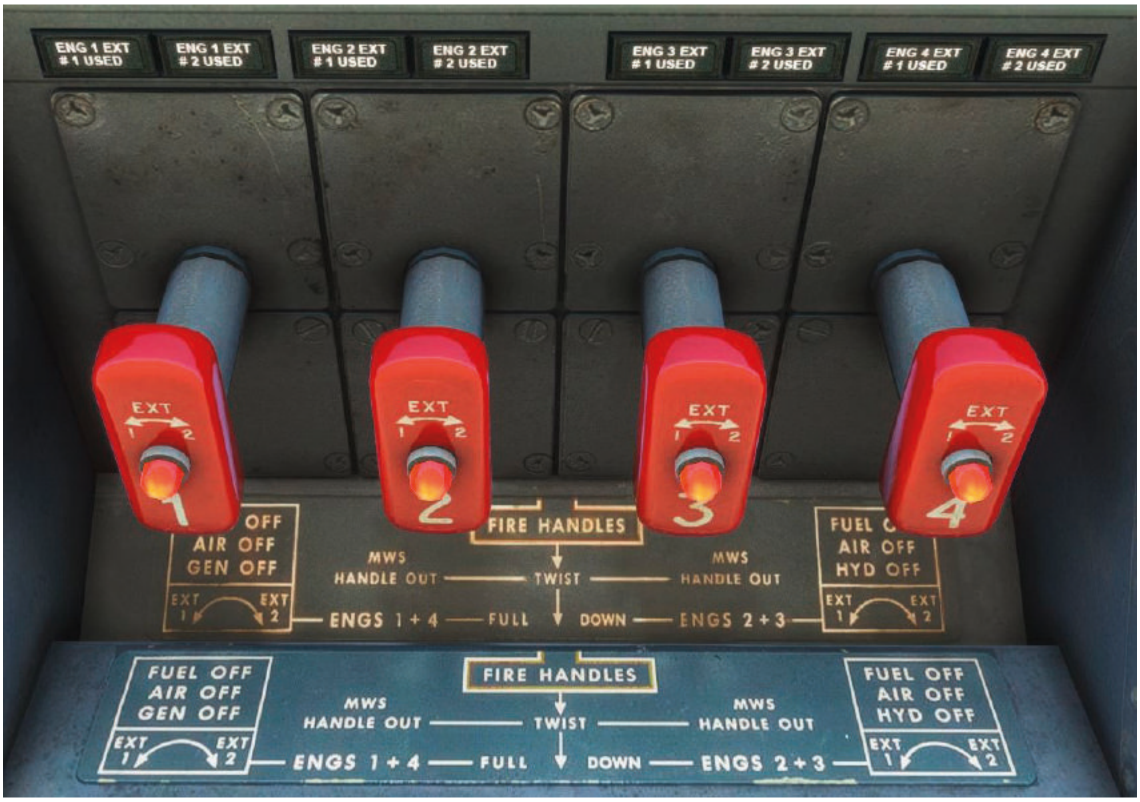
    During this phase the handle operates through a system of pulleys and cables to close the engine low-pressure fuel valve.
3. If the fire still persists after phase 2, turning the fire handle through 90 degrees to the left or right will operate a microswitch to discharge No.1 or No.2 bottle respectively.

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.


ENG 1 EXT #1 USED
ENG 1 EXT #2 USED
ENG 2 EXT #1 USED
ENG 2 EXT #2 USED
ENG 3 EXT #1 USED
ENG 3 EXT #2 USED
ENG 4 EXT #1 USED
ENG 4 EXT #2 USED
EXT
FIRE HANDLES
FUEL OFF
AIR OFF
GEN OFF
MWS
HANDLE OUT
TWIST
ENGS 1 + 4
FULL
DOWN
ENGS 2 + 3
FUEL OFF
AIR OFF
HYD OFF


GRND TEST
ENG OVSPD
ENG FIRE
APU FIRE
APU OVSPD
ENG + APU EXTING
SMOKE
STALL WARN
ZONE LOOPS
STALL IDNT
NOSE SQUAT SW
SPEED WARN
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 detection system

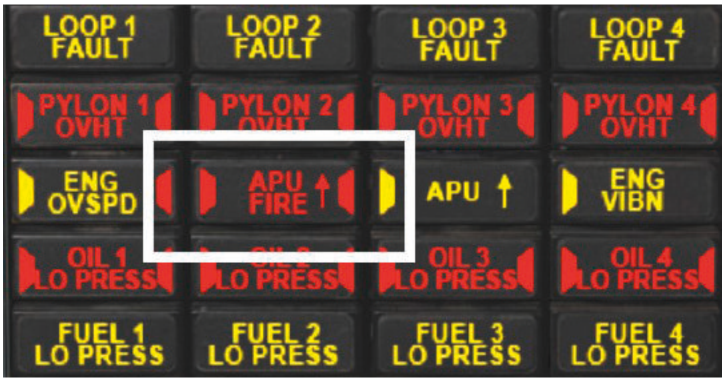
The APU fire detection system employs a continuous-length detector to sample temperature conditions in the APU bay and to activate visual and audible warnings on the flight deck if abnormal fire or overheat situations develop.

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.

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 and LOOP FAULT 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.

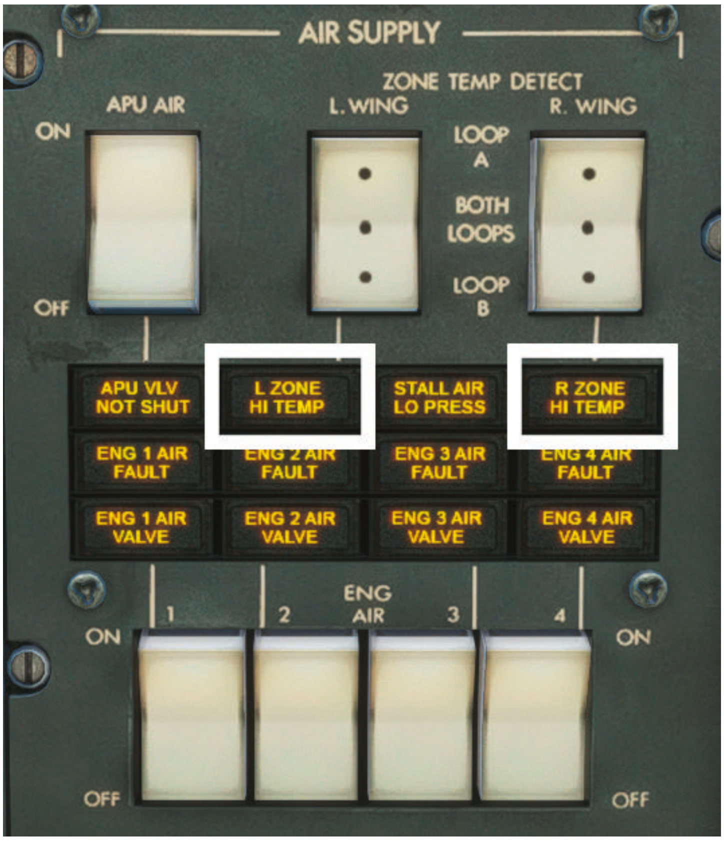
The pylon lower fairings are divided into zones to discriminate between leaks from the engine bleed air supply ducting upstream or downstream of the precooler. Leaks downstream (zone 2) can be controlled by closing the engine bleed isolation to shut off the air supply. Leaks from zone 1 could be at full 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.

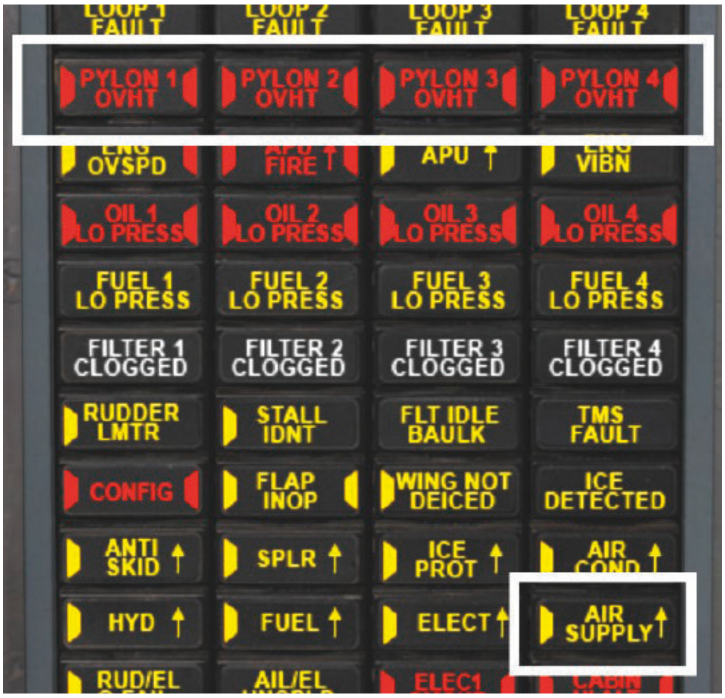
Alarm signals

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.

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.

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.

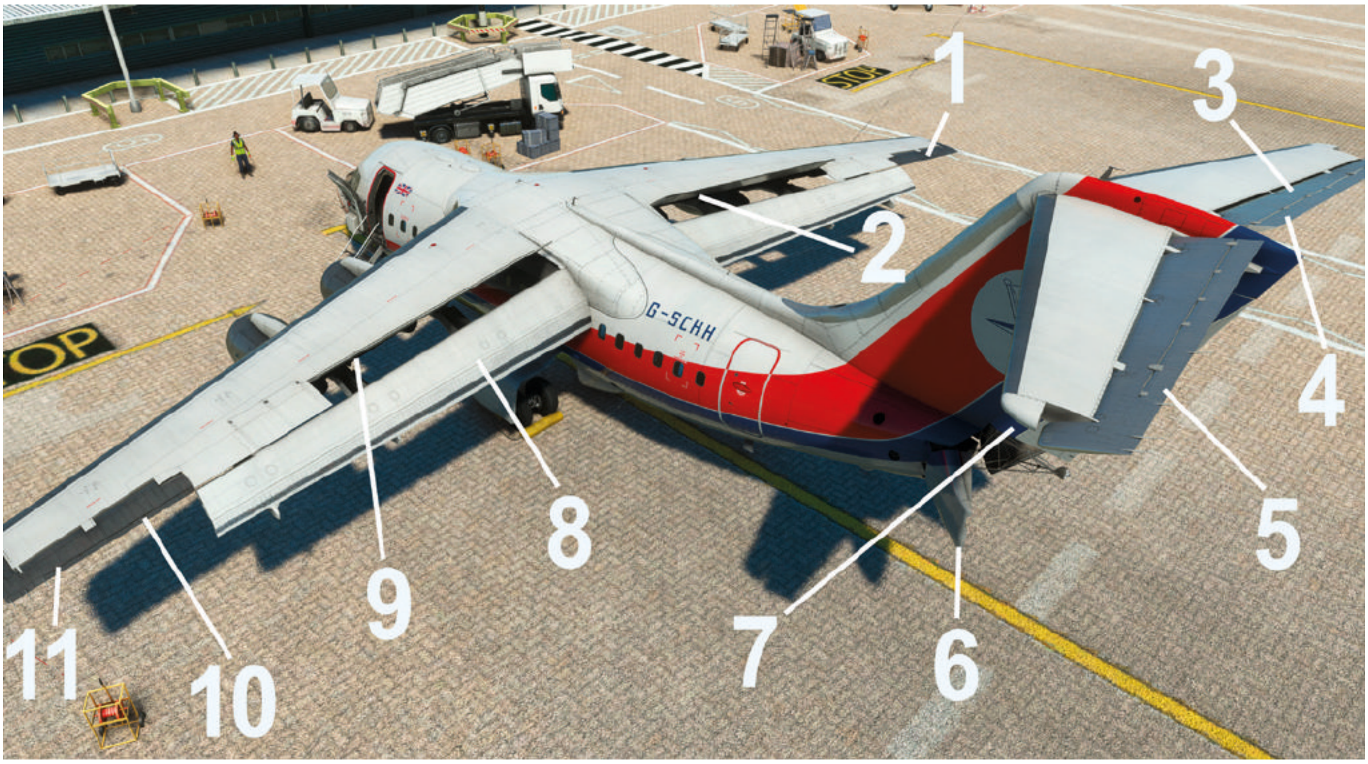
Pitch is controlled by servo tab-operated elevators.

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 knob 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.

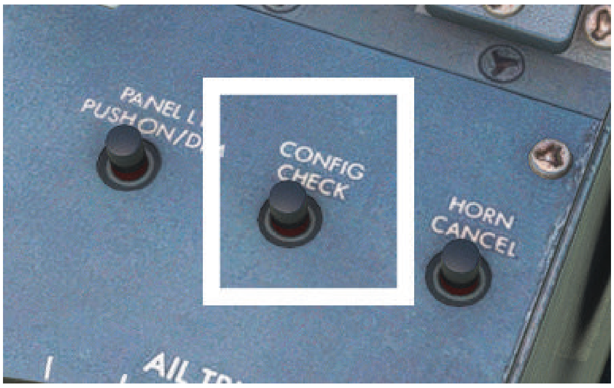
Four spoilers are provided on each wing, three lift spoilers and one roll spoiler, all powered hydraulically. The lift spoilers are selected manually and controlled electronically.

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.

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.

An autopilot servo is connected in parallel with the aileron servo tab circuit of the right wing so that autopilot inputs move the handwheels and tab circuits.

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.

Lift spoiler logic

Following selection, the lift spoilers will deploy if the following conditions are met:

1. Any three thrust levers are at or about flight idle and:
2. One main gear oleo and the nose gear oleo are compressed

   OR

   The nose gear oleo is compressed, and one main gear oleo has been compressed in the last 10 seconds

   OR

   Both the main gear oleos are compressed

The Yellow system spoilers (YLW SPLRS) will deploy immediately. 1.5 seconds after both of the main gear oleos have been continually compressed, the Green system spoilers (GRN SPLRS) will also deploy.

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.

An autopilot servo connected to the left servo tab control circuit applies inputs in parallel with the control column so that the autopilot moves the control columns in addition to the servo tab.

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 two sources of input:

1. Either one of the two pilots’ manually operated trim wheels.
2. An electric elevator trim motor controlled by either one of the pilots’ electric elevator trim switches or the autopilot.

Both the trimming inputs operate through a common clutch unit. Operation of either manual trim wheel overrides the electric trim input, allowing a 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.

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, one fitted on each side of the forward fuselage underneath the side screens, send vane angle signals to four summing units – two for the stall warning system and two for the stall identification system. The summing units also receive signals relating to the wing FLAP angle selected or, if the flaps are up, aircraft speed.

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 flight, operation of the stall warning system is accompanied by the automatic disengagement of the autopilot.

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.

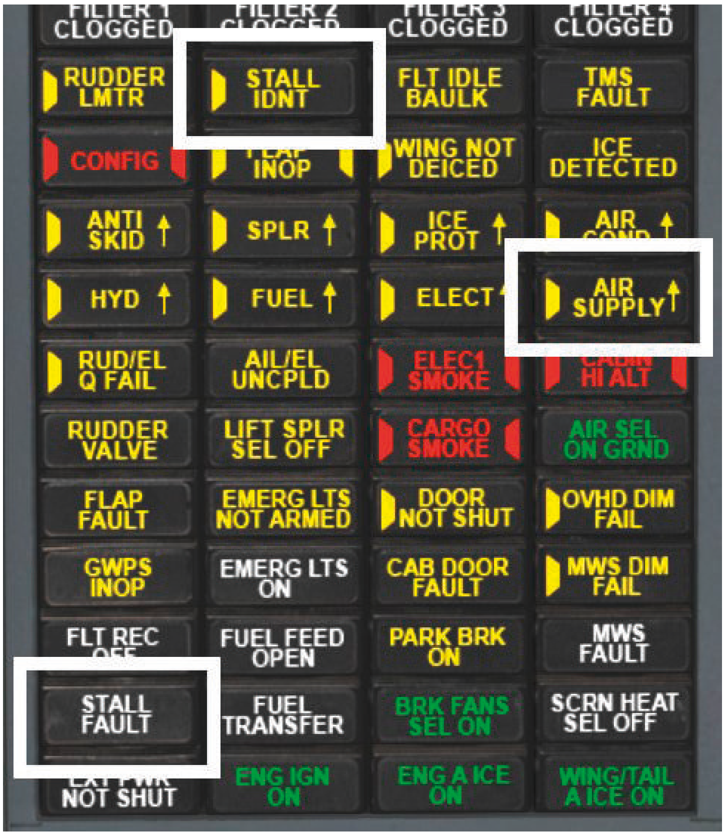
Operation of the stall warning and/or identification systems must always be accepted as indicative of a stall condition.

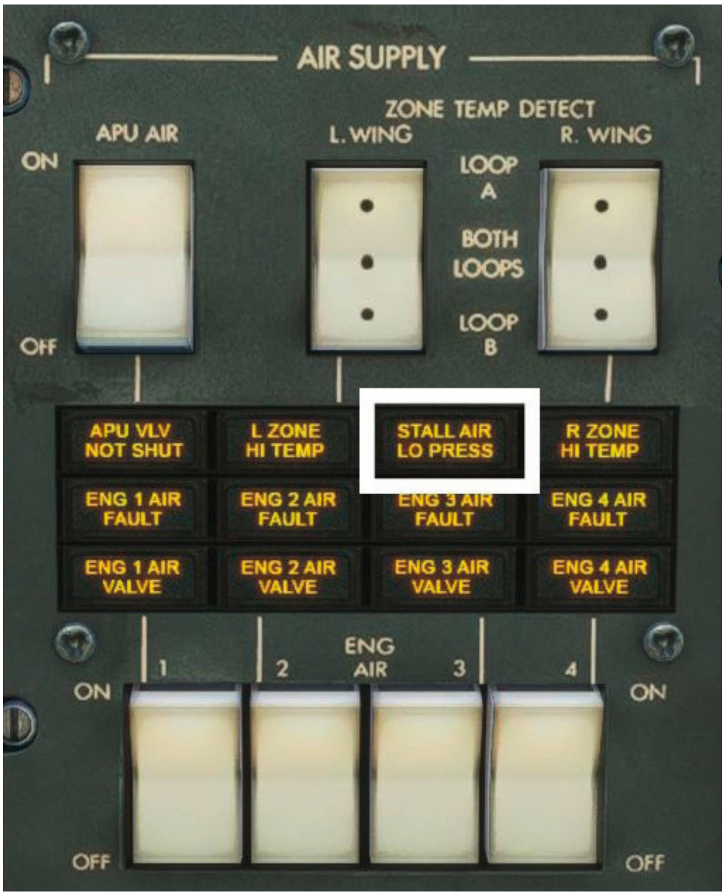
On the flight deck overhead GRND TEST panel, press-to-test buttons STALL WARN 1 & 2, and STALL IDENT 1 & 2 provide means of testing the systems. The stall warning system can be tested both on the ground and in the air, but the stall identification system can be tested on the ground only. The squat switch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

The white STALL FAULT caption on the MWS is only lit in the event of a fault in the system that will require remedial action on the ground; no in-flight action is necessary.

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.

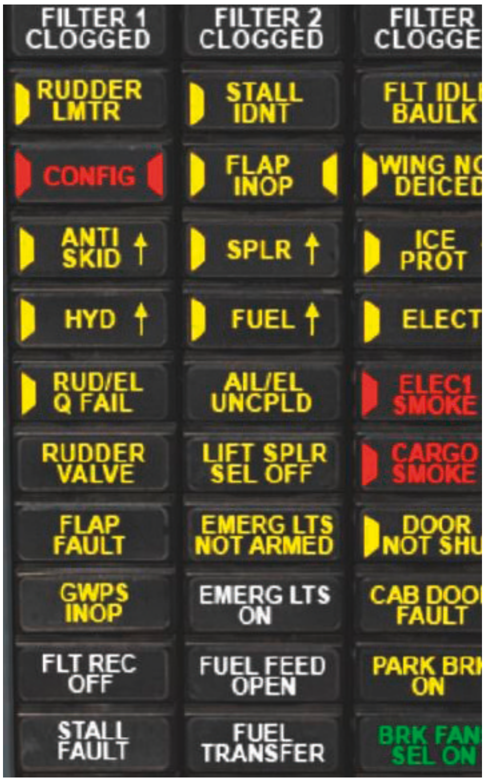
A rudder limiter limits the rudder pedal travel to prevent excessive sideslip and fin loads which could result in structural failure. The limiter is driven by a rudder Q-pot. At approach speeds and below, the pedal limit corresponds to a rudder surface deflection of ±30°; as speed increases, pedal travel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

Twin yaw dampers are fitted which act in series with the rudder servo units to constrain Dutch roll. The authority of the dampers is scheduled to increase with advancing flap selection from one degree either side of applied rudder position, when flaps are up, to a maximum of two degrees at full flap. There is no feedback from the dampers to the rudder pedals except when at low airspeed, with full rudder applied, a pulsating force can be felt. This force can be easily overridden and presents no control problem.

A T-handle, annotated PULL FOR PEDAL ADJUST, is situated on the side panel adjacent to each pilot.



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 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.

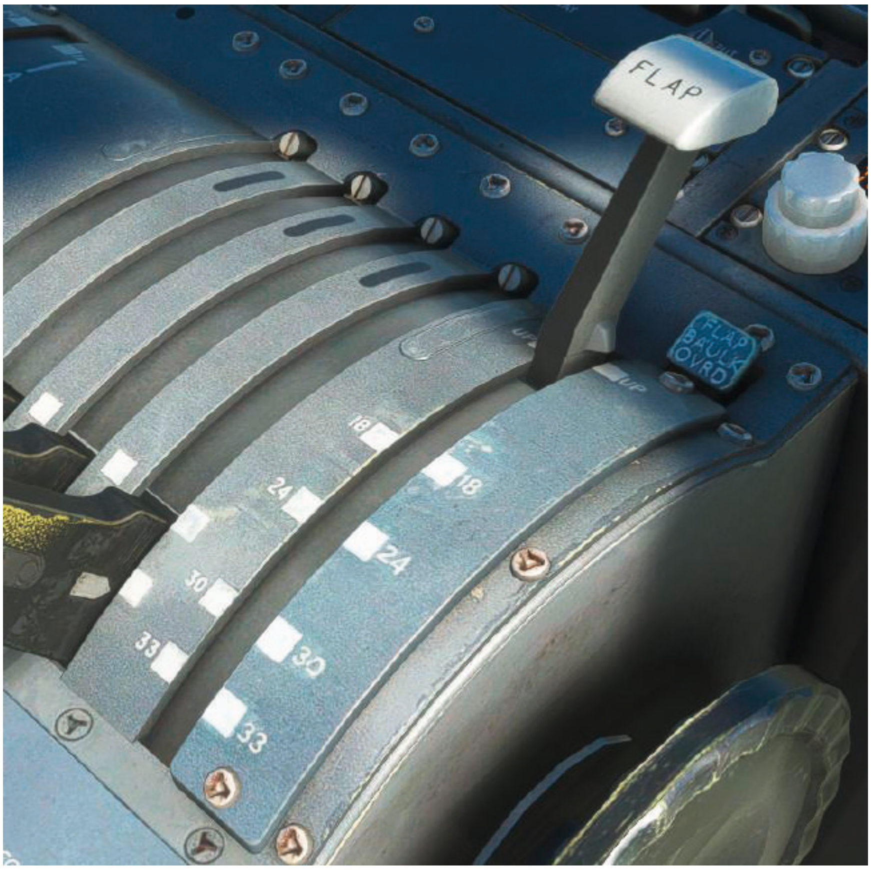
Electrical power supplies are segregated so that each Control Lane is powered by a separate source and a third source powers the Safety Lanes.

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.

The lift spoilers are for ground use only and are selected by the combined airbrake/lift spoiler selector lever. For lift spoiler deployment, two conditions must be satisfied:

1. Three of the four thrust levers must be retarded below flight idle, and
2. Two of the three landing gear oleos must be compressed as follows:
    - The Yellow spoilers deploy immediately on compression of both main oleos or one main oleo and the nose oleo. Either main oleo compression signal is retained for 10 seconds after compression. This permits the Yellow spoilers to deploy following a subsequent compression of the nose oleo, thus offering protection from a bounce or wing rock after initial touchdown.
    - The Green spoilers deploy 1.5 seconds after main oleo compression has been sensed. Nose oleo compression does not affect green spoiler deployment. The delay permits progressive deployment of the spoiler system.

If either condition is not satisfied, the lift spoilers will not extend.

The lift spoilers each have a separate jack with a lock mechanism to retain the spoiler retracted if the hydraulic power fails. Unselected unlocking of any jack is identified by an MWS amber SPLR ↑ caption and an amber SPLR UNLOCKED annunciator on the overhead instrument panel.

The supply of hydraulic fluid to the lift spoiler jacks is controlled by two selector valves, one for the Yellow channel and one for Green. Each selector valve has an ON/OFF control switch – LIFT SPLR YEL and GRN.

If there is a fault in a selector valve, an MWS amber caption SPLR and an amber YELLOW FAIL or GREEN FAIL annunciator, as appropriate on the overhead panel, will be lit to indicate a loss of safety in the associated valve. As airborne deployment of the affected channel could result from a further failure, selecting the respective LIFT SPLR switch to OFF will inhibit the channel, extinguish the YELLOW or GREEN FAIL annunciator and also, as a reminder that one or both channels are inoperative, an MWS amber caption LIFT SPLR SEL OFF will be lit.

Two pressure switches, one in the deploy line of each selector valve, cause green flight mode annunciators SPLR Y & SPLR G on both pilots' instrument panels to be lit when the spoilers are deployed.

A MAN SPLR FAULT annunciator on the overhead instrument panel and the amber MWS SPLR ↑ caption will be lit if there is a fault in one of the squat switch systems. When the annunciator is lit, none, some or all of the spoilers may deploy when they are selected on landing. Deployment will always be symmetrical.

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

Whenever a spoiler system fault is indicated by an amber annunciator in the overhead panel, an MWS amber caption SPLR ↑ will light on the MWS panel.

The lift spoilers may be selected and used on the ground after landing or during an aborted take-off.

On the ground, if any lift spoiler jack is unlocked and any thrust lever is moved towards a take-off setting, the CONFIGuration warning system will be activated.

Indications

ITEM	LEGEND	NOTE
Lift spoiler selector lever	IN/AIRBRAKE/OUT/LIFT SPLR	Centre pedestal
Spoiler unlocked ind.	SPLR UNLOCKED	A – Overhead inst panel
Squat switch disparity ind.	MAN SPLR FAULT	A – Overhead inst panel
Channel failure Yellow	YELLOW FAIL	A – Overhead inst panel
Channel failure Green	GREEN FAIL	A – Overhead inst panel
Channel inhibit switch Yellow	LIFT SPLR YEL	Overhead inst panel
Channel inhibit switch Green	LIFT SPLR GRN	Overhead inst panel
Channel inhibit ind.	LIFT SPLR SEL OFF	A – MWS main panel
Channel fault alert ind.	SPLR ↑	A – MWS main panel
Spoilers deployed Yellow	SPLR Y	G – L and R inst panels
Spoilers deployed Green	SPLR G	G – L and R inst panels

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

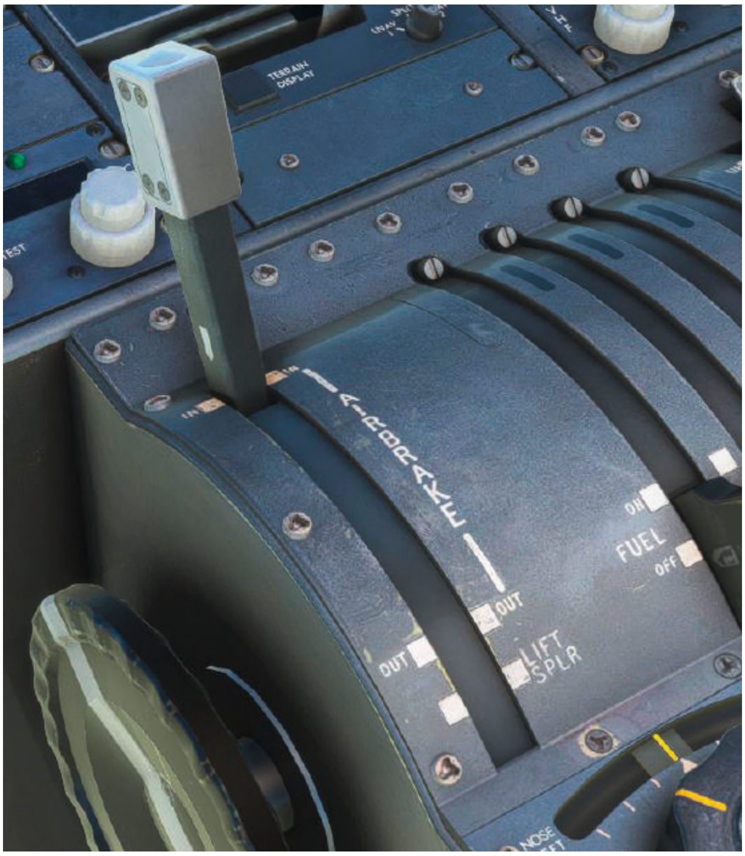
The combined AIR BRAKE/LIFT SPLR selector lever mounted on the centre pedestal enables the airbrake to be selected to any position between IN and OUT. Control is maintained by an electro-hydraulic system using command and response signals.

A thrust lever inhibit signal ensures that the airbrake cannot be opened when No.1 or 4 thrust lever is at a take-off setting.

In addition, if the airbrake is open with the airbrake selector lever left in the OUT position, advancing No.1 or No.4 thrust lever forward to the take-off setting will cause the airbrake to automatically close (at a slower rate than if an IN selection had been made). The airbrake will, however, open again when the thrust levers are retarded from the take-off setting, unless the airbrake selector lever has subsequently been moved to the IN position.

A white AIR BRK annunciator will light on the annunciator panel on each pilot's panel whenever the airbrake is not closed.

When the aircraft is on the ground, if the airbrake is not closed and any thrust lever is in the take-off sector, the CONFIGuration warning system will be activated.



Controls and indicators

Note: *The letters A, R and W in the following tables indicate the colour (amber, red or white) of the annunciator or caption.*

Roll control

Note: *Red CONFIG warnings are accompanied by the intermittent horn audio warning. Amber warnings are accompanied by the single-chime audio warning.*

ITEM	LEGEND	LOCATION
Aileron trim wheel	AIL TRIM, LEFT WD,	Centre pedestal
Aileron trim indicator	RIGHT WD	Centre pedestal
Aileron circuits disconnect	PULL DISCONNECT	Centre pedestal
Aileron uncoupled ind.	AIL AIL/EL UNCPLD	MWS main panel
Roll spoiler indicator	ROLL SPLR L & R (A)	Centre inst panel
Configuration warning horn		
Configuration warning	CONFIG (R)	MWS main panel
Yaw control		
Rudder trim wheel	RUD TRIM	Centre pedestal
Rudder trim indicator	NOSE LEFT, NOSE	Centre pedestal
Rudder servo stuck valve ind.	RIGHT RUDDER VALVE (A)	MWS main panel
‘Q’ pot system failure		MWS main panel
‘Q’ pot jam ind.	RUD/EL Q FAIL (A)	MWS main panel
Yaw damper switches	RUDDER LMTR	Overhead inst panel
	YAW DAMP MSTR 1,2	
Pitch control		
Elevator trim wheel	ELEV TRIM, NOSE UP,	Centre pedestal
Elevator trim indicator	NOSE DOWN	
Electric elevator trim switches	DN UP	Pilot’s handwheel
Configuration warning horn	CONFIG (R)	MWS main panel
Configuration warning		
Elevator circuit disconnect	PULL DISCONNECT	Centre pedestal
Elevator uncoupled indicator	ELEV	
‘Q’ pot system failure		MWS main panel
Stall warning stick shaker motor	AIL/ED UNCPLD (A)	MWS main panel
	RUD/EL ‘Q’ FAIL (A)	
		Pilot’s control column
Stall warning test buttons	STALL WARN 1,2	
		Overhead inst panel
Stall identification test buttons	STALL IDENT 1, 2	Overhead inst panel
	STALL VALVE A, B,	Pilot’s main panel
Stall ident annunciators	OPEN (R)	
Channel inhibit annunciators	IDNT 1, 2, INHIB (A)	Pilot’s main panel
Stall warn/ident system fault caption	STALL FAULT (W)	MWS main panel
Stall ident air reservoir low press.	STALL AIR (A)	Overhead inst panel
	LO PRESS	

Flaps

Note: *Amber FLAP INOP warnings are accompanied by the single-chime audio warning. Red CONFIG warnings are accompanied by the intermittent horn audio warning.*

ITEM	LEGEND	LOCATION
Selector lever	FLAP	Centre pedestal
Position indicator	FLAP °, 0, 18, 24, 30, 33	Centre inst panel
Flap fault indication	FLAP FAULT (A)	MWS main panel
Flaps inoperative ind.	FLAP INOP (A)	MWS main panel
Flap safety lanes test button	FLAP SAFETY	Overhead inst panel
Flap Yellow control lane test button	FLAP CTRL FAULT YEL	Overhead inst panel
Flap Green control lane test button	FLAP CTRL FAULT GRN	Overhead inst panel
Configuration warning horn	CONFIG (R)	MWS main panel
Configuration warning		
<u>Airbrake</u>		
Airbrake selector lever	AIRBRAKE	Central pedestal (R)
Airbrake out warning		
Configuration warning horn	AIR BRK OUT (W)	MWS main panel
Configuration warning	CONFIG (R)	MWS main panel

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. Additional annunciators are provided by the Master Warning Panel (MWP).

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.

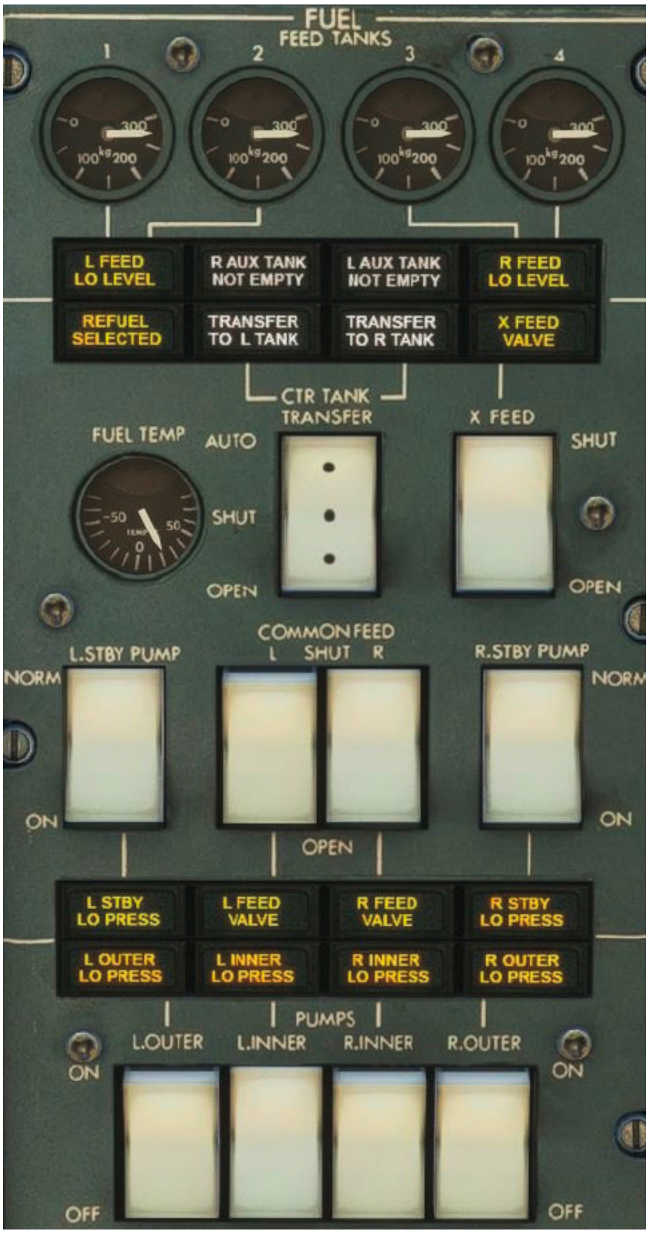
The contents of each wing and centre tank are displayed on the pilot's centre panel. The fuel in the feed tanks (approximately 600 lb / 272 kg in each) is included in the wing tank contents. The contents of each feed tank are displayed on the overhead fuel panel.

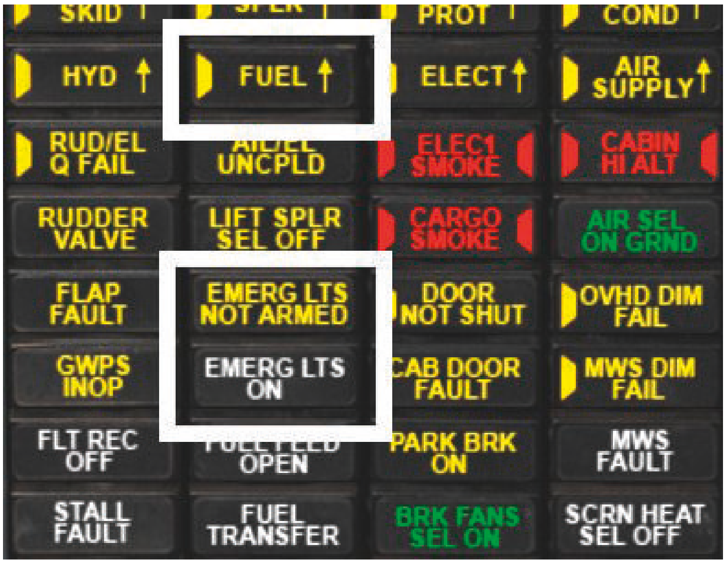
If auxiliary tanks are fitted, the left wing tank quantity indicator includes the left auxiliary tank contents and the right wing tank quantity indicator includes the quantity in the right auxiliary tank.

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.

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.

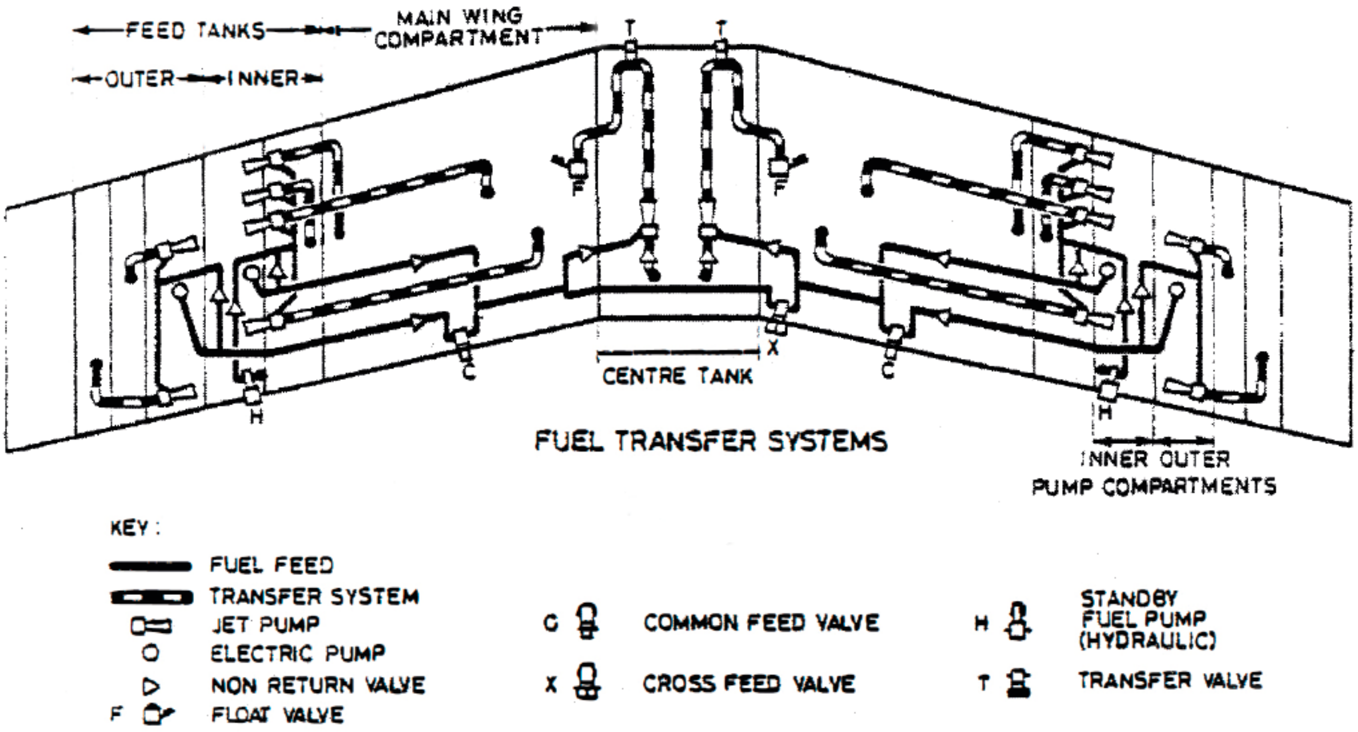
4 x AC fuel pumps & 'LO PRESS' (A)

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.

Without auxiliary tanks fitted

Tank	Gallons		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**

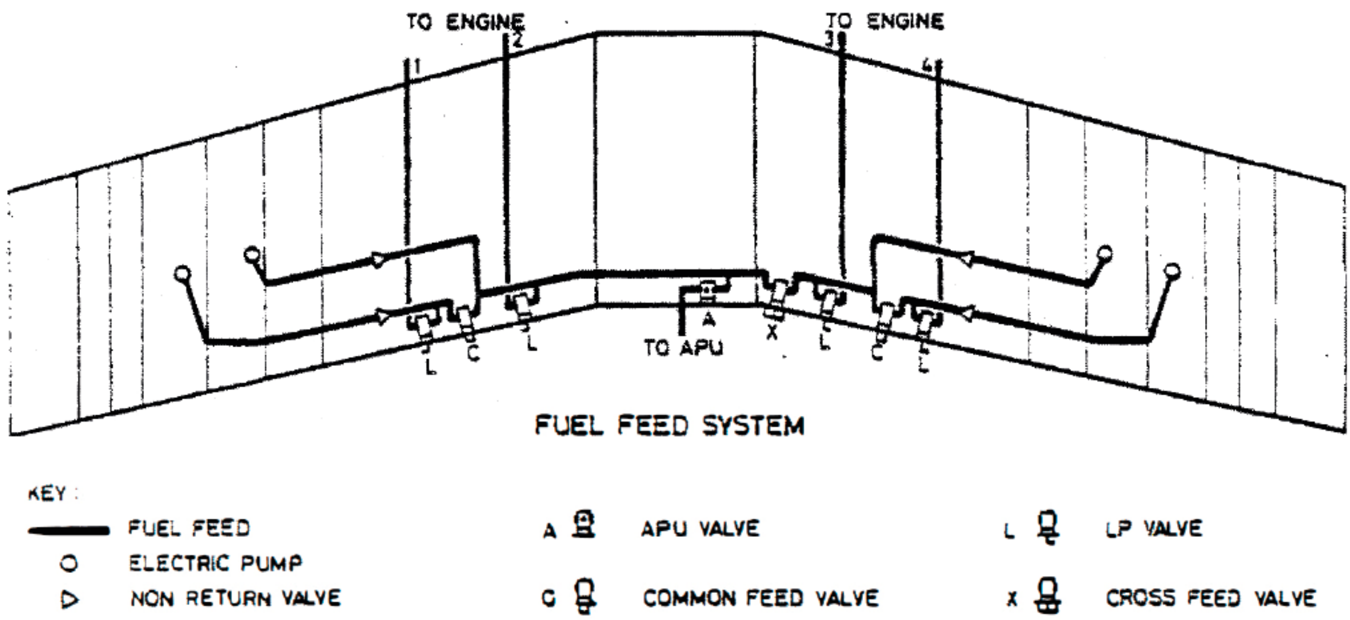
Note: *A specific gravity of 0.8 is assumed in conversions between volume and mass. These quantities represent usable fuel.*

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:

- 4 AC fuel pumps (0)
- 2 common feed valves (C)
- 1 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:

	HYDRAULIC SYSTEM		
SERVICE	**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 lit but the system pressure indicator will register the Green system operating pressure.

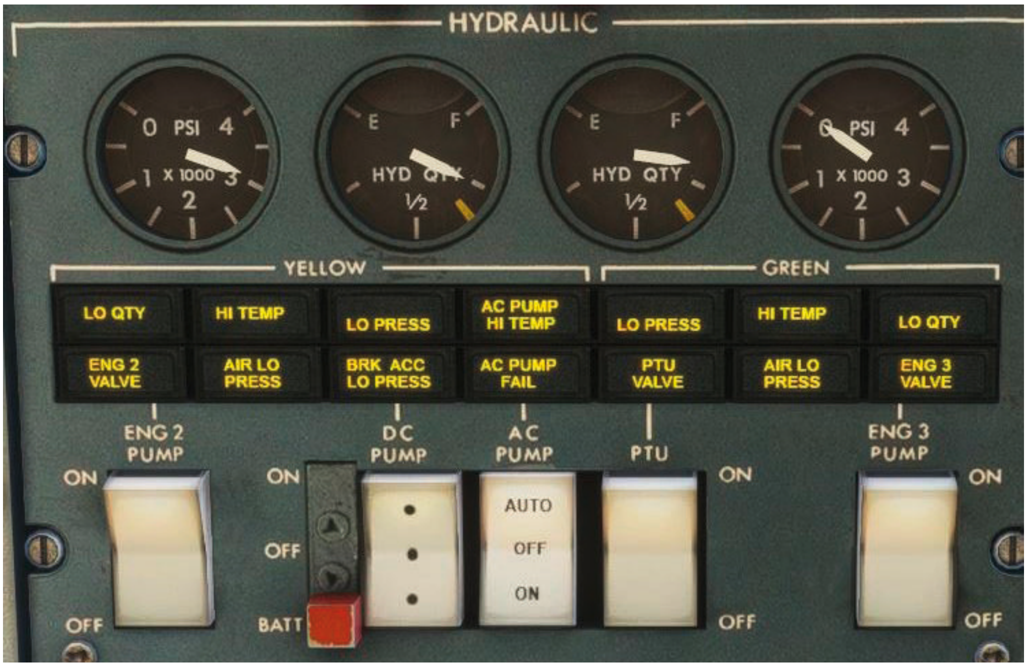
Controls and indicators

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
- Fails to operate when selected AUTO and signalled ON



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

The two outer engines supply hot air for anti-ice protection of their respective outer wings and also to maintain an anti-icing parting strip along the inner wing. Bleed air from the inner engines is used for de-icing the inner wings, a function which is used primarily for shedding accreted ice prior to landing.

If icing is encountered in flight, under normal circumstances only the outer wing is maintained ice free and ice is permitted to accrete on the inner wing leading edge. When the approach configuration is selected, de-icing must be initiated to shed this ice build-up, and if this action is not carried out an amber WING NOT DE-ICED warning illuminates on the MWS to remind the crew. This warning is triggered by the flap selection lever when 18° or more 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.

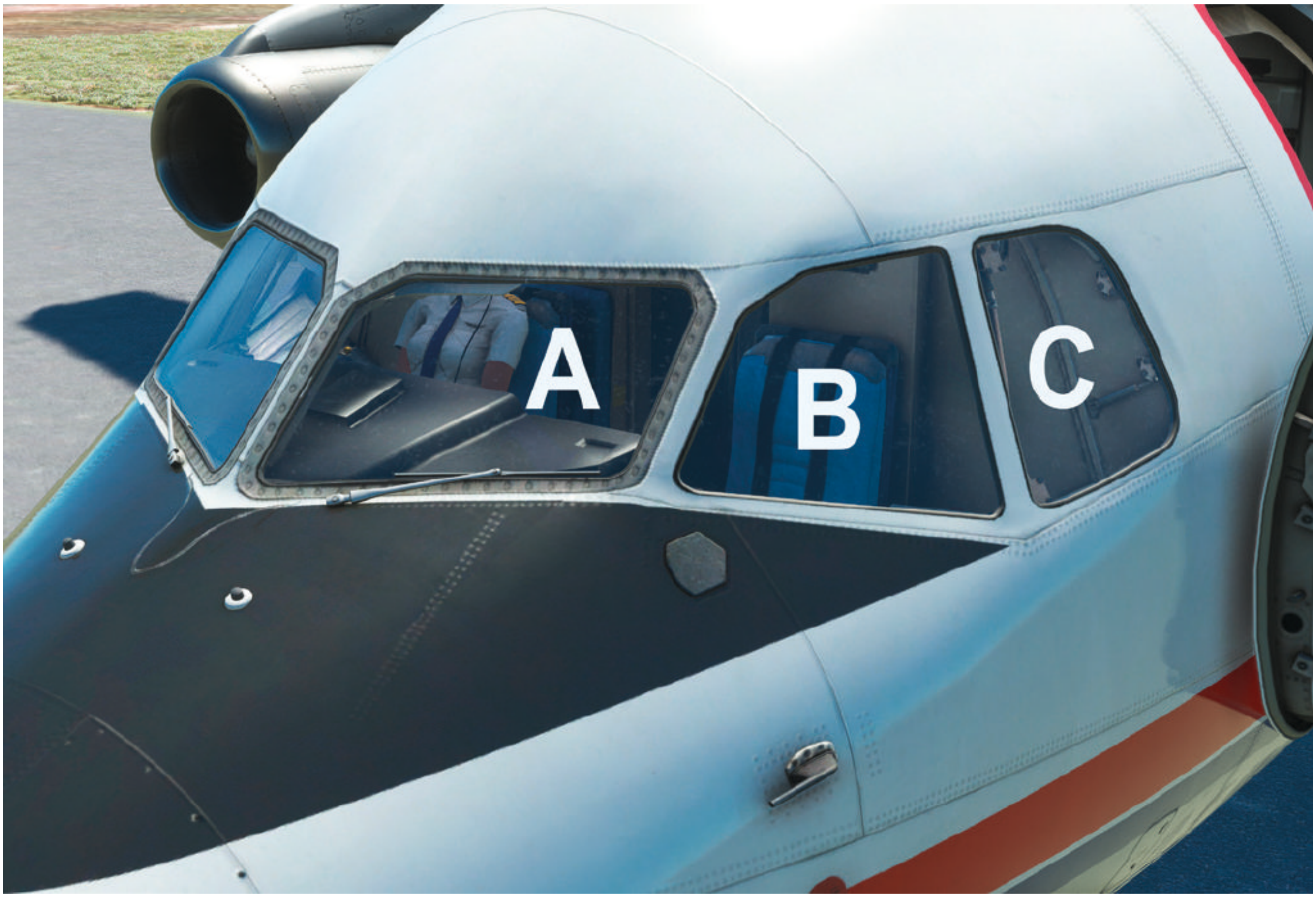
Annunciators give indication of high and low pressure in the air intake diffuser ring.

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 double-pole three-position switch annotated L PITOT HTRS, OFF, BATT, ON. The switch connects either the AC essential busbar or the DC emergency/battery 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.

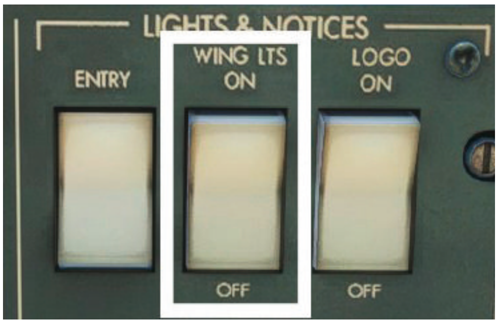
When selected, a single WING LTS ON/OFF switch on the flight deck overhead panel provides illumination of the inboard area of both wing leading edges.

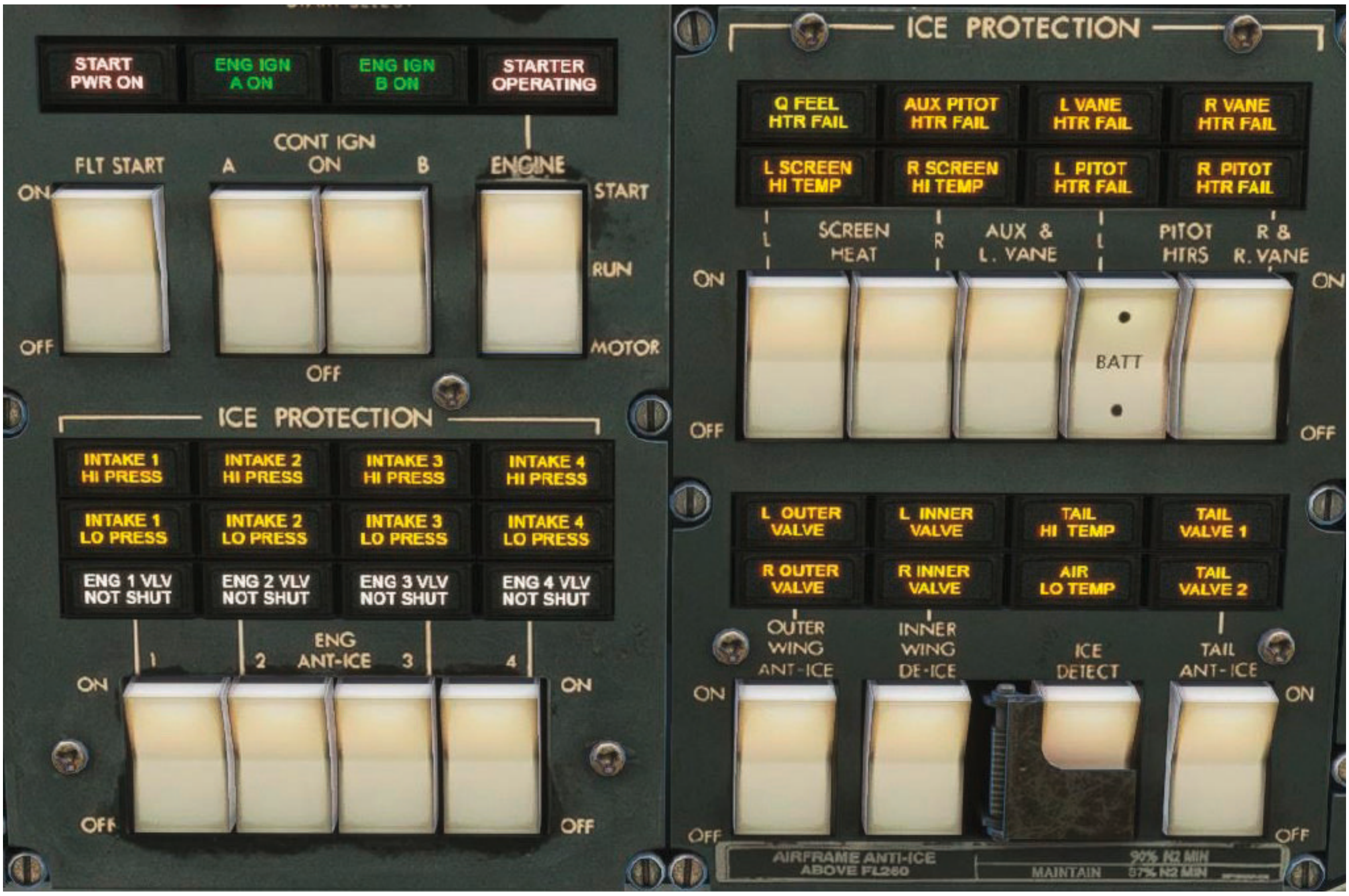
Drain mast heating

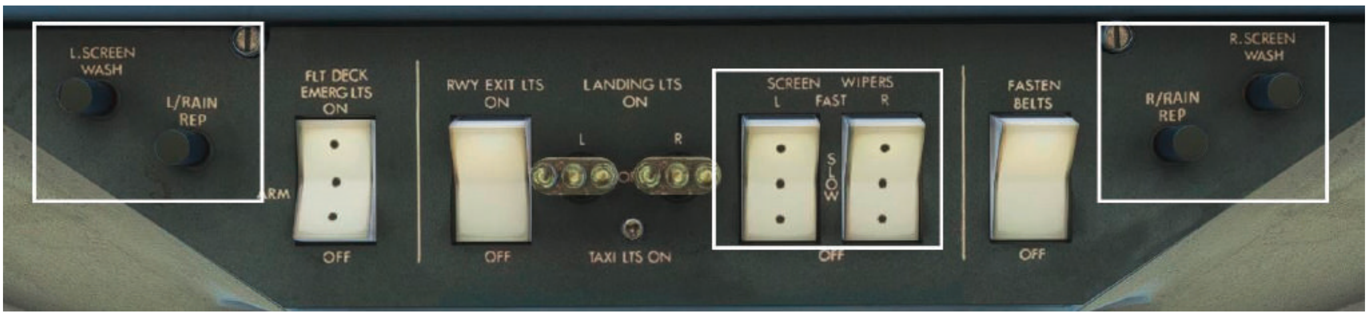
The water waste drain masts are electrically heated to prevent ice accretion restricting the free flow of waste water to the atmosphere.

Controls and indicators

The associated ice and rain protection controls and indicators are located on the flight deck overhead panel.







INDICATING AND RECORDING SYSTEMS

The flight data recorder (FDR) system records the mandatory flight parameters, and parameters for maintenance and performance monitoring can also be stored. An underwater acoustic beacon is fitted to the unit. A three-axis accelerometer provides acceleration measurements for flight data recording purposes.

A cockpit voice recorder 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 Panel (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. 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 station boxes.

The fire bell is the exception; its generated tone is electro-mechanical. Due to the small number of tones required, the possibility of simultaneous warnings is minimal.

Two clocks are fitted – one on the Captain's instrument panel and one on the First Officer's panel.

Flight data recording system

The flight data acquisition and recorder unit gets operational data from various aircraft systems and units. This data is programme-sequenced and then recorded by an accident-protected recycling recorder.

The flight data entry panel (FDEP) in the First Officer's side console provides the following switches and indicators:

Documentary data switches

Eight 10-position thumbwheel switches provide manual selection of individual digits for inserting the following into the recording:

- DAY (two digits)
- MONTH (two digits)
- FLIGHT LEG (one digit)
- FLIGHT NUMBER (three digits)

DDI button

Pressing the DDI button inserts a marker into the recording to call attention to a change of documentary data. A marker incorporates details of a particular day, month, flight leg and flight number. The documentary data sequence is interrupted while the button is pressed; when the button is released, the sequence recommences.

EVENT button

Pressing the EVENT button inserts a marker in the recording to call attention to any particular flight event.

Fault indicator

Fault indication is given by a lamp which lights when a fault condition is detected within the FDR.

Only those faults which would result in a loss of all, or a majority of, recorded parameters will cause a fault indication.

Pressing the indicator should light the lamp, thereby providing a check of presence of power (and validity of no fault indication when the lamp is unlit).

GROUND CHECK switch

The GROUND CHECK switch is normally ineffective while flight power is present. It provides an On/Off switch to facilitate ground testing of the FDR. The switch is biased to the Off position (up).

A ground check of the FDR system can be performed from the flight deck as follows:

1. Press the FAULT indicator front face, ensure that the lamp lights and then release, checking the lamp goes out.
2. Move the GROUND CHECK switch to the GROUND CHECK position and hold. If there is no fault in the system, the FAULT light will remain out. If, however, a fault exists, the light will illuminate. Release the GROUND CHECK switch.

Underwater locator

The underwater locator (pinger) is a small beacon transmitter. It is attached to the aircraft and designed to survive severe crash conditions and begin operating upon entry into water. The transmitter has a self-contained power supply enabling it to operate continuously for 30 days after water entry with a range of 2-3 miles.

Accelerometer

A three-axis accelerometer measures acceleration in each of three axes: vertical, lateral and longitudinal. The resulting measurements are routed to the flight data recorder.

Master Warning System (MWS)

The Master Warning System (MWS) provides the flight crew with indication of aircraft systems malfunction and status.

Indications are displayed by hidden legend annunciators on the Master Warning Panel (MWP) on the centre instrument panel and on the systems sub-panels on the overhead 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

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)	INTERMITTMENT HORN (steady 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 (flaps > 30°)	STEADY HORN	Horn cancel switch on centre console. Only by corrective action.	Test switch on overhead panel.
AUTOPILOT DISCONNECT	CAVALRY CHARGE	Manual A/P disconnect – automatic after one second. 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.	Test button on Altitude Selector.
RED WARNING	TRIPLE CHIME High tone repeated at five-second intervals	Pressing either red 'Alert' lamp on glareshield coaming.	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.	

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.

A tail bumper is incorporated in the air conditioning bay door.

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. Refer to the ELECTRONIC FLIGHT BAG (EFB) section for more information on controlling the tiller.

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.

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 ALERTS 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:

1. The flaps are selected to more than 30° down but the gear is not locked down. This warning cannot be cancelled.

   OR

2. 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

3. The test button is depressed.

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 Yellow or Green hydraulic system may be selected to power the wheelbrake system.

The brake units incorporate a self-adjusting wear mechanism and brake wear indicators.

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.

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.

The BRAKES selector has four settings; this enables the hydraulic pressure to be taken from either the Green or Yellow system. Automatic change from Green to Yellow will occur in the event of electrical power failure. The Yellow system supplies parking brake pressure from the Yellow system accumulator when BRAKES is selected to PULL TO PARK ON YELLOW. PUSH EMERG YEL provides an emergency braking system, but no anti-skid, from a DC pump and the reserve compartment of the Yellow system reservoir. Anti-skid is only available with BRAKE selected to GRN or YEL and ANTI-SKID selected to ON or BATT.

During towing, braking pressure can be maintained by use of the DC or AC pump.

As the landing gear is retracted, Green hydraulic system pressure is supplied to auxiliary pistons in each brake unit to brake the main wheels before the landing gear is locked up.

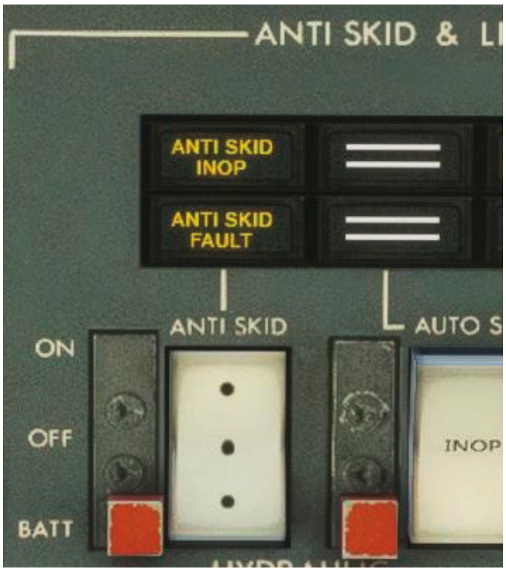
Anti-skid system

Wheelbrake anti-skid facilities are electronically controlled and receive speed signals from transducers fitted in each main wheel.

The anti-skid system modulates pilot-selected wheelbrake pressure to maintain optimum braking.

The skid control system comprises:

1. An anti-skid control box which receives wheel speed signals from the transducer in each wheel.
2. Two electronically actuated skid control valves for each wheel, one in the Yellow and one in the Green system.
3. An ANTI-SKID three-position master switch ON/OFF/BATT on the overhead ANTI-SKID panel.
4. ANTI-SKID FAULT and ANTI-SKID INOP amber annunciators on the anti-skid panel.



The anti-skid control box incorporates continuous monitoring of circuit integrity, provided that ANTI-SKID is selected on. It also provides an integral ground test facility.

Electrical power supply to the inboard and outboard wheelbrake control circuits is taken from DC 2. In the event of an electrical failure with GRN selected, solenoids will be de-energised and the brakes will fail/safe to the Yellow hydraulic system. An alternative supply (emergency DC) is available from the BATT position of the ANTI-SKID switch.

Anti-skid is selected ON prior to take-off. Selection of ANTI SKID prior to take-off is necessary to provide:

1. Full anti-skid protection in the event of a rejected take-off.
2. Continuous monitoring of the anti-skid system.

Anti-skid protection will be available for a rejected take-off when the wheel speed has increased above 33 knots and will remain operative until the wheel speed has fallen to below 15 knots, at which point direct braking is progressively transferred to the pilot.

A ground test facility is provided by the two ANTI-SKID FAULT buttons on the GRND-TEST overhead panel, marked YEL and GRN.

The continuous monitoring of the anti-skid system provides two amber warnings, which are combined with the ANTI-SKID ↑ annunciator on the MWP.

ANTI-SKID FAULT indicates reduced integrity of the system with no significant reduction in braking performance. No pilot action is required.

ANTI SKID INOP indicates a degradation of braking performance and some pilot action may clear the fault. If the INOP indication cannot be removed, the required landing distance must be increased and care should be exercised in braking.

Brake temperature indicator

The brake temperature indicating system comprises four sensor assemblies, one for each wheel. Power supply is from the DC 1 busbars.

A single brake temperature unit is situated on the centre console. A three-position ON/OFF/TEST switch controls the digital display screen.

At the first selection of the ON position the display will indicate the highest temperature and the MAX button will be illuminated.

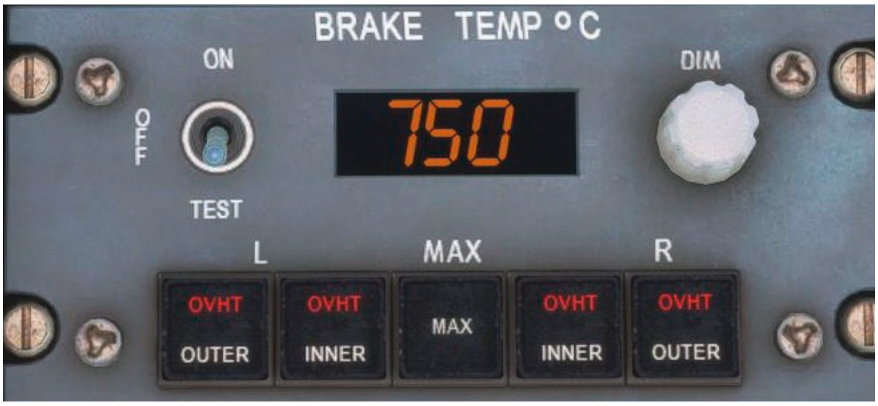
Selecting MAX at any time will cause the MAX button to illuminate and the highest of the four brake temperatures will be displayed. Any other selected button previously illuminated will go out at this point.

If a brake temperature is in excess of 650˚C, this will be displayed in conjunction with an illuminated red OVHT button for the associated brake. This can only be reset after the brake has cooled below 650˚C by switching the brake indicator OFF for approximately five seconds and then back ON.

Pushing any of the lower four buttons, marked OUTER or INNER, will cause the MAX light to go out and the selected button to light. The individual temperature for the corresponding brake will be displayed.

The TEST position will cause the display to indicate 750˚C and all four red overheat buttons will simultaneously illuminate. Any other selection of individual brakes will indicate different temperatures in the display, but they will be in the overheat range at an approximate value of 750˚C.

Returning the switch to ON will return the system back to the normal MAX selection.



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

These are located on the overhead instrument panel and the pilot's centre panel.

A brake temperature indicator is fitted on the centre console.

The BRAKES selector is on the pilot's centre pedestal and the brake pedals are integral with the rudder pedals. The BRAKES selector has four settings:

- GRN – closes a change-over microswitch to select the Green system and deselect the Yellow system.
- YEL – closes a change-over microswitch to select the Yellow system and deselect the Green system.
- PUSH EMERG YEL – starts the DC pump and switches off anti-skid.
- 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 a motorised brake valve and one to switch the flight recorder off. When the motorised brake valve fully closes, limit switches light the PARK BRAKE ON caption on the MWP and arm the CONFIG warning.

A three-position switch for the brake fans is provided on the overhead instrument panel. A green annunciator BRK FANS SEL ON is on the MWP.

Parking brakes are selected by PULL TO PARK ON YELLOW and the application of the Captain's brake pedals. The PARK BRK ON amber annunciator on the MWP will illuminate when the valve has fully closed and, conversely, on release of the parking brake the light will go out only when the valve has fully opened. Application of the parking brake will also switch off the flight data recorder and arm the red CONFIG on the MWP, which will operate if any thrust lever is moved into the take-off range.

A further BRK ACC LO PRESS amber annunciator is shown on the HYDRAULIC panel, which lights when pressure in the Yellow accumulator falls below 2,500 PSI. This can be topped up with the AC or DC hydraulic pumps.

Separate brake pressure indicators for the Yellow and Green systems are at the bottom of the Captain's instrument panel and show applied differential brake pressure. The available pressure from the brake control valve is 3,000 PSI.

Circuit breakers GEAR & BRAKES and ANTI SKID FAULT test buttons are on the overhead panel.

- ANTI-SKID INOP – indicates degradation of anti-skid. Check switch is ON. Select alternate hydraulic supply or select BATT.
- ANTI-SKID FAULT – indicates reduced integrity of system unlikely to affect braking
- BRAKE FANS switch:
    - o AUTO – fans ON with landing gear locked down and OFF with landing gear selected up
    - o ON – fans ON used on ground with brake temperature above 100˚C
    - o OFF – fans OFF
- ANTI-SKID switch:
    - o ON – anti-skid control energised from DC 2 provides continuous monitor
    - o OFF – anti-skid control de-energised. Direct braking.
    - o BATT – anti-skid control energised from MDC. No monitoring. Used with AC gen fail.
- BRAKE ACC LO PRESS – accumulator pressure below 2,500 PSI. Can top with AC, EDP or DC pump.
- DC PUMP switch:
    - o ON – momentary spring-loaded switch used to top up brake accumulator
    - o OFF – normal position
    - o BATT (guarded) – used for continuous operation to supply anti-skid system in the event of total hydraulic failure

Change in selections between systems should be made with brake pressures released.

Anti-skid only available on YEL or GRN selection.

Loss of DC 1 results in automatic change to YEL.

- YEL – brakes selected to the Yellow system. Opens change-over microswitch and de-energises Green and Yellow supply valves, allowing Yellow pressure to brake control valves.
- GRN – brakes selected to the Green system. Closes change-over micro-switch, energises solenoid in Green system to open and allows Green system pressure to brake control valves. Closes off Yellow system.
- PUSH EMERG YEL – no anti-skid. Direct braking. DC pump runs continuously. Accumulator pressure kept topped up on Yellow. ANTI SKID FAULT and ANTI SKID INOP will illuminate. De-energises skid control box.
- PULL TO PARK ON YELLOW – handle used in conjunction with Captain's brake pedals to apply parking brake. Effective parking maintained for a minimum of 2.5 hours. Accumulator can be topped up using AC or DC pump. Flight data recorder is switched off and a white annunciator FL REC OFF illuminates on MWP. Amber PARK BRK ON illuminates on MWP and configuration warning is armed, so that if any thrust lever is in the take-off range a red CONFIG will light on the MWP, together with a red flasher and intermittent warning horn.

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 symbolically on attitude director indicators (ADI) and horizontal situation indicators (HSI), which comprise part of the AFGS (see the AUTO FLIGHT SYSTEM section). Attitude and direction references are taken from vertical reference units and gyro compass units, which supply selected indicators on the Captain's and First Officer's flight instrument panels.

Standby navigation services include a standby attitude indicator, standby compass, standby altimeter and an outside air temperature indicator.

The air data system includes separate pitot heads and static vents from which pressure signals are fed to the servo altimeters, airspeed indicators and various other items including the air data unit (ADU). Electrical outputs from the ADU are fed to the AFGS and the servo altimeters, for static error correction. The true airspeed system, utilising the pitot and static pressure sources of the ADU, together with the total air temperature probes' input, provides outputs of static air temperature, true airspeed and total air temperature to any FMS.

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 radio altimeter system is fitted which provides accurate altitude information during low approach and aircraft landing manoeuvres.

Instrument displays

Altimeters

The altitude system consists of two primary altimeters and one standby altimeter. 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 is a barometric instrument with a servo-driven presentation. Altitude information is presented by a single pointer reading against a dial and by a four-drum counter. The pointer turns through one revolution for every 1,000 ft of altitude and the dial and first drum counter are calibrated in 20 ft increments. The selected barometric pressure setting in MB and inHg is shown along the lower portion of the altimeter. The setting is controlled by a knob on the bottom left corner of the bezel.

The operating range of the altimeter is from minus zero to 50,000 ft. The 10,000 ft counter drum presents red lines below zero altitude and black and white lines from zero to 10,000 ft.

Static source error signal failure is indicated by a red flag marked SSC (static source correction) being visible in the centre of the gauge.

Electrical or servo malfunction is indicated by a red and black striped warning bar which obscures the altitude read-out.

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.

Vertical speed indicator

The vertical speed indicator (VSI) provides indication of the aircraft’s rate of ascent or descent. The indication of vertical speed is shown by a pointer moving over a calibrated dial.

The traditional VSI was later replaced by a combined VSI and TCAS display. In addition to indicating the vertical speed, it displays any potential TCAS conflicts in the area surrounding the aircraft. The display range is controlled via the transponder.

You can toggle between the traditional VSI and the combined VSI/TCAS gauge via the EFB tablet.

Mach airspeed indicator

The Mach airspeed indicator provides simultaneous indication of airspeed, command airspeed and limit speed by means of pointers reading against a fixed dial and Mach number by means of an outer scale.

The striped limit speed pointer indicates the maximum safe operating speed (VMO and MMO) of the aircraft at all altitudes.

The command speed pointer is set by rotation of the knob on the lower left of the bezel. Its position is sent to a fast/slow indicator on the ADI.

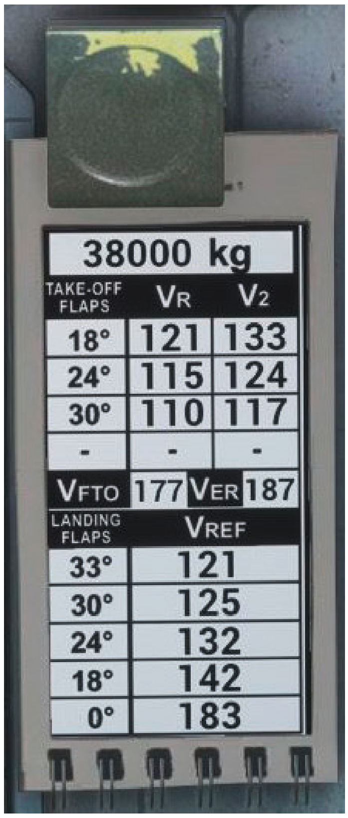
Overspeed switching is fitted and provides an output signal whenever the airspeed pointer exceeds the limit speed pointer.

Adjustable index marks are fitted on a track attached to the bezel.

The index marks and pointer (bugs) can be automatically configured by left-clicking on the speeds flipchart, which is located just below the landing gear lever.

There are cards for each 1,000kg of aircraft gross weight and the correct card will be automatically selected based on the current gross weight. Each card displays take-off, climb and approach speeds, based on the selected flap setting:

- VR – rotation speed
- V2 – take-off safety speed
- VFTO – final take-off speed
- VER – en route speed
- VREF – landing speed



The co-pilot will also call out some of these speeds if enabled via the EFB.

The speeds set by left-clicking the card will differ depending on whether you are on the ground (i.e. before take-off) or airborne (i.e. approach):

Bug	On ground	Airborne
Yellow speed pointer	V2	VREF + 5
Yellow index mark	VR	VREF
Orange index mark	VFTO	VFTO
White index mark	VER	VER

With ‘Flipchart Options’ enabled on the EFB, you can click on a specific row (e.g. TAKE-OFF 24°) to set the speeds for that flap setting. On approach, the co-pilot will only call for flap settings up to the configuration that you have selected using the flipchart (default is 33°).

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.

Attitude director indicator (ADI)

The attitude director indicator (ADI) provides a visual presentation of the pitch and roll attitude of the aircraft on a spherical display. The side scale shows glideslope, and localiser deviation is presented on the lower horizontal scale. An inclinometer is mounted on the lower front face of the instrument.

A cross-pointer flight director bar system displays the AFGS-computed commands (see the AUTO FLIGHT SYSTEM section). The bars are displayed when selected by the FD BARS switch.

The fast/slow speed display is on the left side of the ADI. The datum for the display is the internal bug on the Mach/ASI. The scale is composed of a white scale and an amber circular pointer. The scale has five horizontal white lines. The top of the scale is annotated F for fast and the bottom of the scale is annotated S for slow. The fast/slow pointer is an amber circle.

When the ASI pointer is against the ASI internal bug, the fast/slow pointer is over the centre of the scale. As speed increases above the ASI bug speed, the circle moves up the scale. As speed decreases below the ASI bug speed, the circle moves down the scale. When the speed is 10 knots above the bug speed, the circle is centred on the top line. When the speed is 10 knots below the bug speed, the circle is centred on the bottom line.

ATT, FD, GS, LOC and SPD warning flags are incorporated and appear due to electrical power failure or loss of a valid signal. A TEST switch causes the sphere to indicate a preset right bank and climb, while the flight director bars should indicate pitch up and roll right command. Both the FD and ATT flags should be visible.

The left ADI is powered by 26V SAC and the right ADI by 26V AC 2.

Standby attitude indicator

The standby attitude indicator displays pitch and bank attitude with horizon reference on a sphere against a fixed aircraft symbol. The upper part of the sphere is blue, representing the sky, and the lower part is black, representing the earth. A white line dividing the two colours represents the horizon. The horizon can be manually caged.

Should electrical power fail to the indicator, a warning flag is displayed.

Horizontal situation indicator (HSI)

Two HSIs are fitted, one on each flight instrument panel.

These provide a visual presentation of aircraft heading, direction to next waypoint, glideslope deviation, course deviation, selected course, reciprocal heading, to-from station indication and selected heading.

Distance to the next waypoint and ground speed are displayed in the upper windows. A Navigation Mode annunciator indicates VOR, ILS or RNAV, in conjunction with an RNAV bearing pointer.

The source of heading information is always magnetic and is indicated by MAG in the top central position.

A glideslope pointer and scale on the right-hand side give a conventional display and an invalid signal will cause a VERT failure flag to obscure the display. The glideslope pointer will display indications for both an ILS glideslope and RNAV/GPS pseudo-glideslope.

Selected heading is displayed by a white delta-shaped heading marker and is remotely controlled by means of the HDG selector on the centre of the glareshield panel.

Selected course is displayed on the azimuth card by a yellow course arrow. This is remotely set by the associated COURSE knob on the glareshield panel.

A HEADING failure flag will cover the heading index at the 12 o'clock position if the associated compass fails or if there is a power failure.

Distance bearing indicator (DBI)

The DBI displays magnetic heading, radio bearing and DME indications.

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.

Two digital read-outs display distances for DME 1 and DME 2.

Compass information for each DBI is a repeat of the opposite HSI. DBI 2 repeats HSI 1 and DBI 1 repeats HSI 2.

Failure flags are shown below for HDG. The DME has a red and white shutter that indicates a DME fault or power failure. The absence of computed data is indicated by a series of dashes.

A test function for the DME is provided on the associated VHF/DME control panel.

Transfer switching

A double switch on the Captain's lower instrument panel provides attitude (ATT) and compass (COMP) transfer switching.

The ATT switch is labelled BOTH 1, NORM and BOTH 2. The normal (NORM) selection is to the centre position. With BOTH 1 or BOTH 2 selections, both ADIs receive attitude information from either No.1 or No.2 VG according to selection.

Compass transfer switching is obtained by selection of the COMP transfer switch. With NORM selected, both systems operate independently. With BOTH 1 or BOTH 2 selected, the HSIs and DBIs will receive heading information from the No.1 or No.2 compass system respectively, according to selection.

Compass system

Two identical gyro-magnetically stabilised compass systems are installed. Only one is described, except where reference to both systems is necessary. A flux valve is situated in each wing.

Each system incorporates a flux valve and a directional gyro (DG) and is designated No.1 or No.2 compass system. The No.1 system normally supplies the heading information to the Captain's HSI and the No.2 compass system to the First Officer's HSI.

A COMP switch (C) on the Captain's lower instrument panel allows transfer to BOTH 1 or BOTH 2. With these selections, both HSIs will receive heading information from the same source.

The DBI heading displays are crossed over so that the Captain's HSI displays the same heading information as the F/O's DBI and vice versa.

Each HSI can receive heading information from either the combination of flux valve and DG, or from DG only, depending on the position of the COMPASS switch. Selection to SLAVED is the normal selection.

Compass-slaved indicators (A) are installed beside the compass selector on each of the instrument panels. They provide the normal 'dot/cross' indication to show direction of error, and with the correct alignment of gyro and detector the indicator will oscillate slightly about the centre position.

Rapid synchronisation is obtained by means of the HDG SLEW switch. A separate switch on the left and right instrument panel is provided for each compass system.

Standby compass system

As back-up heading information, a standby magnetic compass is provided on the centre strut of the front windscreens.

Instrument Comparator Monitor (ICM)

The ICM compares the Captain's and First Officer's primary attitude and heading displays, evaluates the difference and provides a warning whenever the difference exceeds a predetermined value. These warnings are displayed on the Captain's and First Officer's warning annunciator panels.

Pitot-static system

Three independent pitot-static systems are installed in the aircraft, numbered 1, 2 and 3.

Number 1 and 2 systems are duplicates and provide pressure inputs to the Captain's and First Officer's altimeter, vertical speed indicator and combined airspeed/Mach meter respectively.

Number 3 system provides pressure inputs to the combined cabin altimeter/vertical speed/differential pressure indicator situated on the First Officer's panel. In addition, Number 3 system also serves the AFGS and other ancillary equipment, including a barometric altitude rate computer.

Radio navigation

Dual VOR/ILS systems, designated NAV 1 and NAV 2, are provided. The instrumentation outputs of either system can be displayed on both pilots' HSI and DBI.

Dual distance measuring equipment (DME) systems are fitted which provide slant distance information from DME ground stations. Dual automatic direction-finding systems (ADF) are fitted, utilising fixed loop and sense aerials to provide bearing information to two distance-bearing indicators (DBI). Either DBI can be used with the very high frequency omni-range system (VOR), and switching is provided to enable either ADF or VOR signals to be represented.

Marker signals are detected by a single marker system and are fed as tones into the audio integrating system and appropriately coloured annunciator captions on both the Captain's and First Officer's panels.

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 flight deck ADI, HSI and DBI indicators.

The system comprises two glideslope antennae, one VOR/LOC antenna with dual output, two receivers, two controllers and a navigation selector.

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.

Deviation and bearing are presented on Horizontal Situation Indicators (HSIs) and Distance Bearing Indicators (DBIs).

Distance Measuring Equipment (DME)

Two DME systems provide 252-channel operation. Control of the DME, with HOLD and TEST facility, is integral with each VHF navigation control unit.

Power supply is via the AVIONICS MASTER switch and is essential AC/DC for DME 1 and AC 2 / DC 2 for DME 2.

If ON is selected, the DME transmitter is inhibited for approximately one minute to enable warm-up. The receiver is operative from switch on, so that if a ground station signal is received the identification code is fed to the audio integrating system. The indicator displays four dashes in this mode.

If STBY is selected, the receiver is immediately operative. Power is supplied to the transmitter circuits but operation is inhibited. Following a time delay, the system is held ready for immediate operation and four dashes are displayed.

When HOLD is selected:

- The DME frequency is held at the frequency in the active display at the time HOLD was selected. When the active frequency on the controller is changed, the VHF NAV receiver is tuned to the new selected frequency but the DME remains tuned to the held frequency. There is then no indication of the DME-tuned frequency on the controller.
- The green hold light illuminates on the bottom left of the controller.
- If the interrogator loses the held frequency, an amber alert light illuminates on the bottom right of the controller.

At ON and HOLD, the interrogator displays ranges up to 200 NM. At ORIDE, the interrogator displays ranges up to 400 NM.

As soon as the airborne DME transmits, the DME circuits start to search for reply pulses. The selection of ON (for 200 NM) or ORIDE (for 400 NM) determines the range. Four dashes are displayed until reply pulses are detected and distance is displayed.

During periods of self-test, a continued display of dashes confirms correct operation.

Operation of the DME TEST provides a functional test of the entire system. During the test the display on the DBI shows the shutter then four dashes followed by four zeros. These remain as long as the test switch is held. When the zeros appear, a tone is heard.

Automatic direction finder (ADF)

The system comprises two ADF receivers, two antennas and one ‘dual’ controller. The frequency range is 190 to 1749.5 kHz, selectable at 0.5 kHz intervals.

ADF bearing displays are presented to each pilot on a Distance/Bearing Indicator (DBI).

The aural ident of the selected non-directional beacon (NDB) is distributed via the aircraft audio integrating system.

The ADF system can operate in either of two modes selected on the controller:

- ANT mode – system operates as a non-directional MF receiver. Pointers will park in the 3 o’clock position.
- ADF mode – system operates as an ADF.

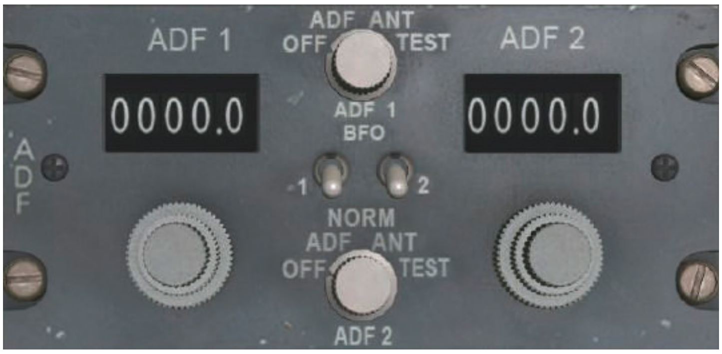
There is a TEST mode for each ADF which is activated from the control unit. With the test function selected, the pointer will move to the 8 o’clock position. During the test there is an audio tone.

There is a two-position switch labelled BFO/NORM:

- NORM – normal position used in conjunction with the majority of NDBs which have AM idents.
- BFO – a beat frequency oscillator allows identification of NDBs which employ interrupted carrier idents.

The bearing pointer switches on the DBI must be selected to ADF in order to obtain ADF bearings. If the ADF is operating but no useable signal is being received, the pointer moves to the 3 o’clock park position.

Power supplies for ADF 1 are from 26V emergency AC and emergency DC. ADF 2 is supplied from 26V AC 2 and DC 2.



Radar navigation

Radio altimeter

The radio altimeter system provides continuous accurate height (terrain clearance) information during low approach and landing manoeuvres from altitudes of 2,500 ft to touchdown, regardless of barometric pressure changes.

The radio altimeter comprises a transmitter/receiver, two identical antenna and one indicator. The display indicates aircraft height above the terrain during the approach phase of the flight. The display increment is 10 ft when below 1,000 ft, and 50 ft when above 1,000 ft. The display range is from 0 to 2,500 ft. Above 2,500 ft the display is blank.

A separate counter display is provided for decision height. DH is selected by turning the PUSH TEST knob until the DH display indicates the desired DH. During this time the DH is displayed in the RAD ALT window to the nearest foot. DH range is from 0 to 980 ft.

A red flag comes into view over the DH display if the radio altitude computations stop, or if electrical power falls below a preset tolerance. A warning appears on the DH annunciator panels when the aircraft descends below the selected DH.

The DH annunciators are inactive when aircraft height is less than 10 ft (aircraft on the ground). During climb out the annunciators will illuminate when the display switches to 10 ft and remain illuminated until the aircraft ascends to 50 ft above decision height.

Pressing the PUSH TEST knob on the indicator initiates a functional self-test of the system.

The following sequence occurs when the knob is pressed and held:

- Decision height, as selected by the DH display, is shown for two seconds in the RAD ALT window to the nearest foot and may be adjusted during this period.
- System self-test altitude is displayed for two seconds (100 ft), then the RAD ALT display lamp test (8888) is displayed until the knob is released.

Power supply for the radio altimeter is from AC essential and from DC 1 for the indicator.

Transponder

The transponder allows an ATC code and flight identification code to be entered.

1. ATC mode indicator – illuminates to indicate that ATC mode is active
2. Flight identification mode indicator – illuminates to indicate that FID mode is active
3. Transponder fail indicator – illuminates to indicate a transponder failure
4. LCD display
5. Identification button – used to initiate an identification squawk
6. Transponder select knob – used to select either transponder 1 or 2
7. Mode select knob – used to select transponder/TCAS mode
8. Test button – triggers a TCAS test
9. Traffic display range select buttons – used to increase or decrease the traffic display range
10. Alphanumeric keyboard
11. ATC/FID mode select button – used to switch the display between ATC and FID modes
12. ALT select button – used to switch between the two altimeter sources
13. Clear button – used to delete entries from the display
14. Enter button – used to enter an FID code

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.

Unfortunately Microsoft Flight Simulator does not currently supply reliable and realistic weather data for use on a weather radar, therefore we currently simulate only the test and map (ICAO) functions.

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 anti-clockwise 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.

MAP – toggles whether airport ICAO codes are displayed on the WXR display.

WX – toggles whether the unit displays the WXR return.

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. Location of an airport and its ICAO code (map mode only)
4. Current tilt angle
5. Range rings
6. 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. The system consists of a computer unit and various flight deck annunciators and controls. The computer receives inputs from the radio altimeter, barometric altitude rate computer, No.1 glideslope receiver and landing gear and flap position switches.

The inputs are continuously processed to provide aircraft flight path surveillance when between 50 and 2,450 ft AGL. No action from the flight crew is required unless a warning is activated. With the exception of glideslope mode violations, all warnings can be cancelled only by taking corrective action such as adding climb power and executing a positive pull-up. The GPWS is totally inhibited by operation of the stall warning system.

Mode 1 – excessive barometric sink rate

This mode, which is effective in all aircraft configurations, provides for flight over level ground when the aircraft is losing height at an excessive rate. The computer compares the barometric altitude sink rate with the available terrain clearance and determines whether a hazard exists. In general, the warning is given to allow time for a gentle recovery manoeuvre, thus the smaller the terrain clearance the smaller the sink rate which triggers a warning. Below 50 ft terrain clearance the GPWS is inhibited to avoid spurious warnings which would result from ground effect in the static pressure system.

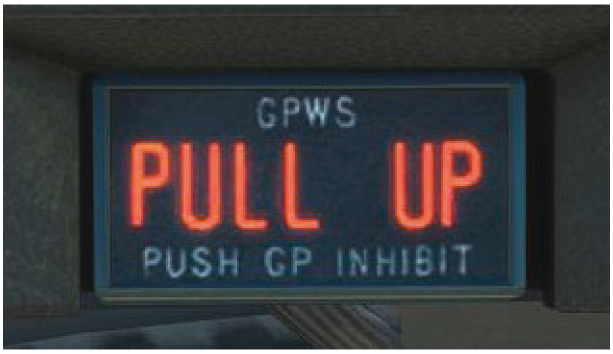
This mode has two unique boundaries. The outer boundary advises the pilot that the rate of descent for a given altitude is excessive and the condition should be adjusted. When the outer boundary is penetrated, flashing red GPWS PULL UP warning captions are activated and an audio warning of “Sink Rate, Sink Rate” is heard. If the rate of descent is not corrected and the second boundary is penetrated, a second message “Whoop, Whoop. Pull Up” is heard. This mode is independent of aircraft configuration.

Mode 2 – excessive terrain closure rate

This mode provides for level flight in which the terrain is rising to meet the aircraft. The radio altimeter signal is differentiated by the computer to obtain terrain closure rate, which is then compared with the available terrain clearance. Two sub-modes are provided to afford adequate protection in cruise while minimising nuisance warnings on final approach.

Mode 2A is effective between 1,800 and 50 ft terrain clearance with the flaps not selected to the Land position. Deliberate descent is assumed below 1,500 ft and the flight path slope profile becomes steeper to tolerate a higher terrain closure rate of a given terrain clearance. The mode has an inner and outer boundary, and if the outer boundary is penetrated the visual warning will be flashing red PULL UP captions, accompanied by an audible warning of “Terrain, Terrain”. If the inner boundary is penetrated, the warnings will be flashing red PULL UP captions accompanied by an audible “Whoop, Whoop, Pull Up” warning.

Mode 2B – with the flaps selected to land, this mode only operates between 790 to 220 ft and the slope of the flight path reflects a ground closure rate appropriate to landing. The warnings are flashing red PULL UP captions accompanied by an audible “Terrain, Terrain” warning.



Mode 3 – accumulated altitude loss before acquiring 700 ft terrain clearance after take-off or go-around

This mode provides a warning if the aircraft loses excessive height after take-off or go-around. It is initiated below 700 ft terrain clearance by the selection of flaps from land, coincident with an increase in barometric height. The GPWS computer integrates the barometric altitude rate signal to determine the actual height loss. At altitudes of between 375 and 700 ft, the smaller the available terrain clearance, the smaller the height loss which triggers the warning. This mode is available until 700 ft when Mode 4 is primed. The warnings are an audible “Don’t Sink, Don’t Sink” warning with flashing red GPWS PULL UP captions.

Mode 4 – flight into terrain with less than 500 ft terrain clearance and not in landing configuration

This mode provides for low rates of barometric sink (outside Mode 1) when the aircraft is close to the ground.

There are two sub-modes, each determined by the aircraft configuration:

Mode 4A – if the landing gear is up, warning is given when the terrain clearance is reduced to 500 ft. In this mode the warnings are flashing red GPWS PULL UP captions accompanied by an audible “Too Low, Gear” warning.

Mode 4B – if the landing gear is down, with land flap not selected, warning is given at 200 ft. At sink rates in excess of 1,385 ft per minute, however, the greater the sink rate, the greater the terrain clearance at which the warnings are given. The warnings are flashing red GPWS PULL UP captions accompanied by an audible “Too Low, Flaps” warning.

Mode 5 – glideslope deviation

This mode is primed by the selection of an ILS frequency on the No.1 navigation system. It becomes effective when the aircraft is below 500 ft terrain clearance, the landing gear is down and a good glideslope signal is received. Between 500 and 200 ft terrain clearance warning is given if the aircraft is two dots below the glideslope. Below 200 ft, to avoid nuisance warnings which could result from the increasing deviation sensitivity of the ILS system (with the approach of the glideslope transmitter antenna), the GPWS tolerates an increasing deviation signal up to 3.5 dots. At 50 ft, Mode 5 operation is inhibited.

The mode can be inhibited manually for operational purposes by pressing a switch lamp on the Captain’s flight systems mode annunciator panel. The lamp will then light to illuminate the white GSL ALT captions. The mode will automatically be re-armed by the aircraft flying below 500 ft terrain clearance, then by flying above 500 ft terrain clearance. The warning is an audible “Glideslope” with a steady amber illumination or GSL DEV captions.

Mode 6 – radio altimeter decision height

This mode is activated by the aircraft descending through the decision height set on the radio altimeter. It can be set to activate at any altitude between 50 and 1,000 ft and the warnings are an aural, “Minimums, Minimums”, given once, and a flashing amber annunciator DH light on the radio altimeter.

The alerts 1, 2, 3 and 4 have priority over alert Mode 5. If during a Mode 5 alert glideslope audio message a mode 1, 2, 3 or 4 alert is detected, the Mode 5 alert will be interrupted for transmission of the appropriate mode alert audio message. If the Mode 5 alert persists, the audio “Glideslope” warning will be transmitted on inhibition of the activated alert.

Steep approach mode

This mode is used for ILS approaches with glideslopes of 4.5 to 6 degrees to prevent nuisance SINK RATE warnings.

The S.APP button, located to the right side of the landing gear lever, illuminates white when the mode is selected and green when enabled. Engagement occurs when:

- Gear is down and locked
- Landing flaps are selected
- Weight is off-wheels (aircraft is airborne)

If at any time any of these criteria are no longer met, 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.

Flap warning override

The guarded FLAP WARN OVRD button, located on the right side of the landing gear lever, controls the flap warning override. It is used to prevent nuisance TOO LOW FLAP warnings when landing with abnormal flap settings.

GPWS test

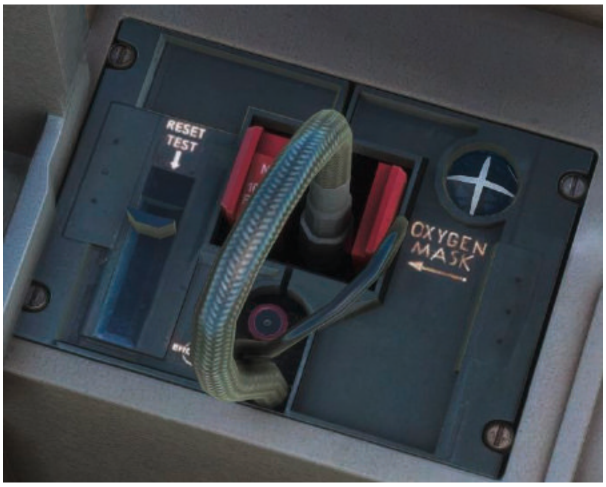
Pressing either GPWS PULL UP caption when on the ground initiates the manual test programme. The test programme checks the validity of the mode inputs from the radio altimeter, barometric rate computer and glideslope receiver. If they are satisfactory, the content of the computer memory programme is added to light the GPWS PULL UP, GSL DEV and GPWS INOP captions, and also to activate the relevant audio warnings.

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

Each engine supplies final-stage compressor bleed air for the following airframe systems:

- 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

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

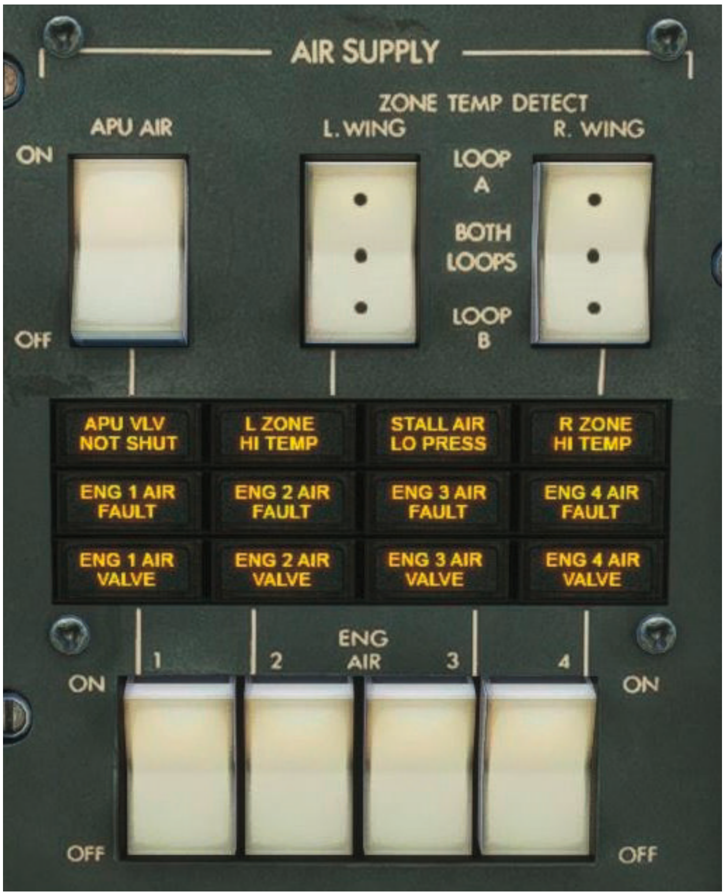
The air flows from the engine outlet to a combined isolation and pressure-regulating valve. The isolation valve is electro-pneumatic; it requires both electrical power and compressor delivery air pressure to open. From the isolation valve the air passes into a precooler; the precooler cooling medium 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.

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.

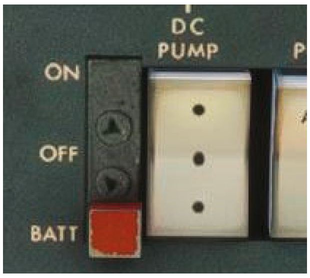
Controls and indicators

Controls and indicators associated with the pneumatic system are located on the flight deck overhead panel and the Master Warning Panel on the centre instrument panel. System caption annunciators on the MWP have an arrow pointing upwards to draw attention to an indication located on the overhead panel.

INSTRUMENT PANELS

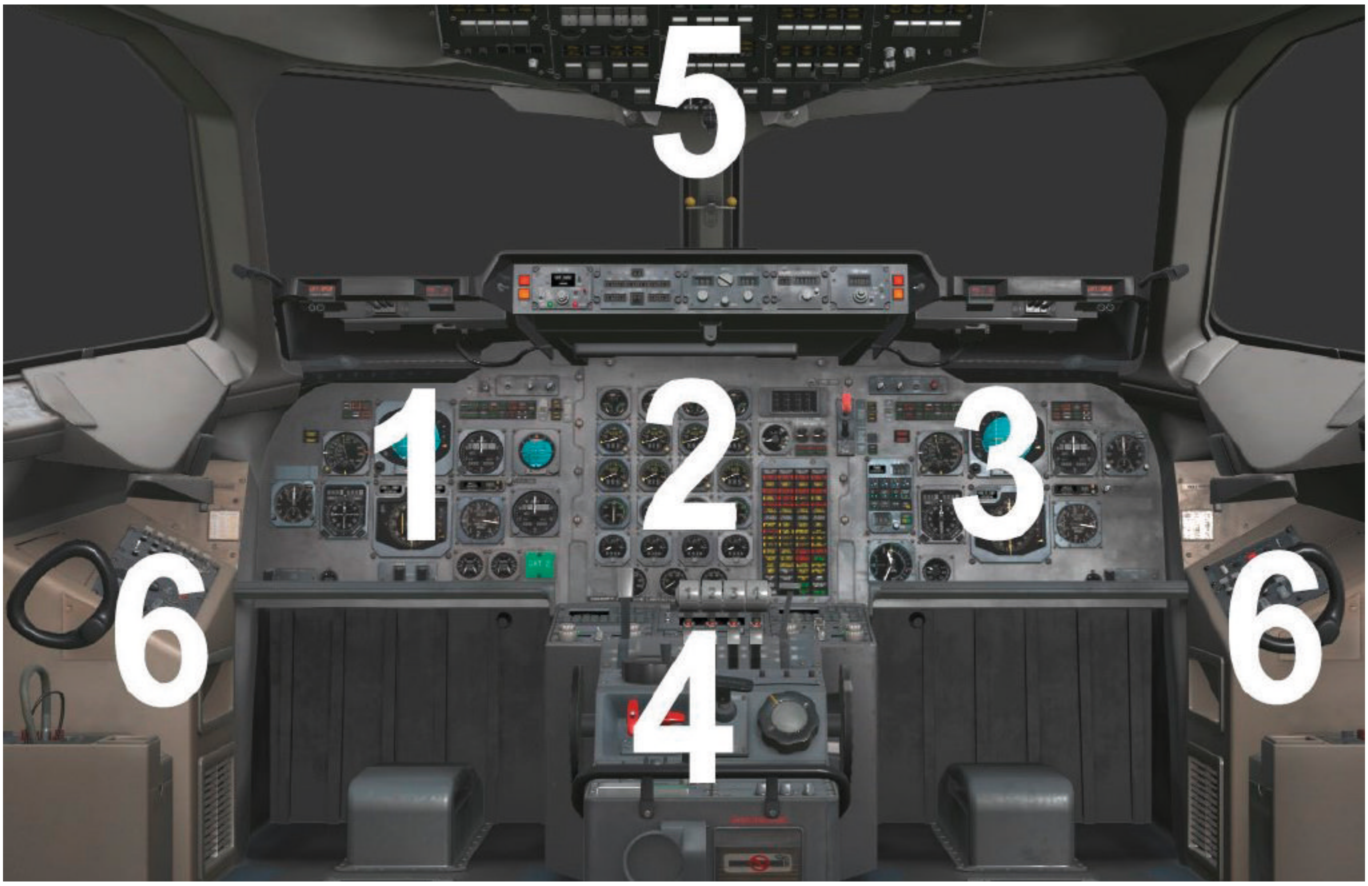
The location of the instrument panels on the flight deck are shown below. All instruments are integrally lit; panel inscriptions and selector switches are edge-lit.

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. Centre console
5. Overhead panel
6. Side consoles

Flight Management System (FMS)

The 146 was originally launched with only conventional navigation equipment, requiring the flight crew to navigate using a combination of VORs and NDBs. As technology advanced, the 146 was retrofitted with basic GPS navigation and then more capable FMS equipment. To provide the greatest flexibility and with consideration given to the retiring of VOR/NDBs and associated procedures in the real world, we have chosen to include a modern FMS unit which integrates with both the HSI and the autopilot.

The FMS distance and course indications will be shown on the HSI with the change-over switch selected to R NAV. The Captain's switch must be selected to R NAV in order for the autopilot L NAV mode to be available.

Documentation for the Working Title FMS can be found on their website:
https://www.workingtitle.aero/packages/cj4/

Note that some modifications have been made to the FMS for the sake of compatibility with the 146, notably the removal of radio, MFD and V NAV functionality.

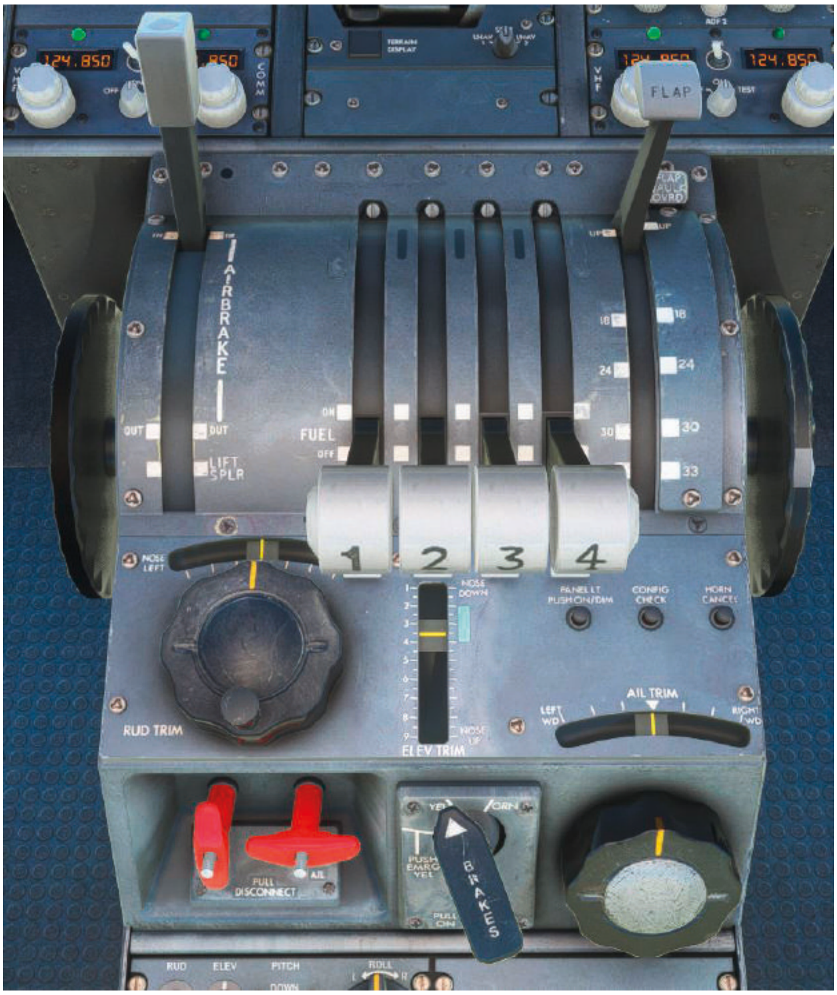
It is also possible to disable the FMS via the EFB if you would prefer to operate the aircraft in its original configuration. With the FMS disabled, the LNAV autopilot mode and HSI can be used with the default MSFS flight planner instead.

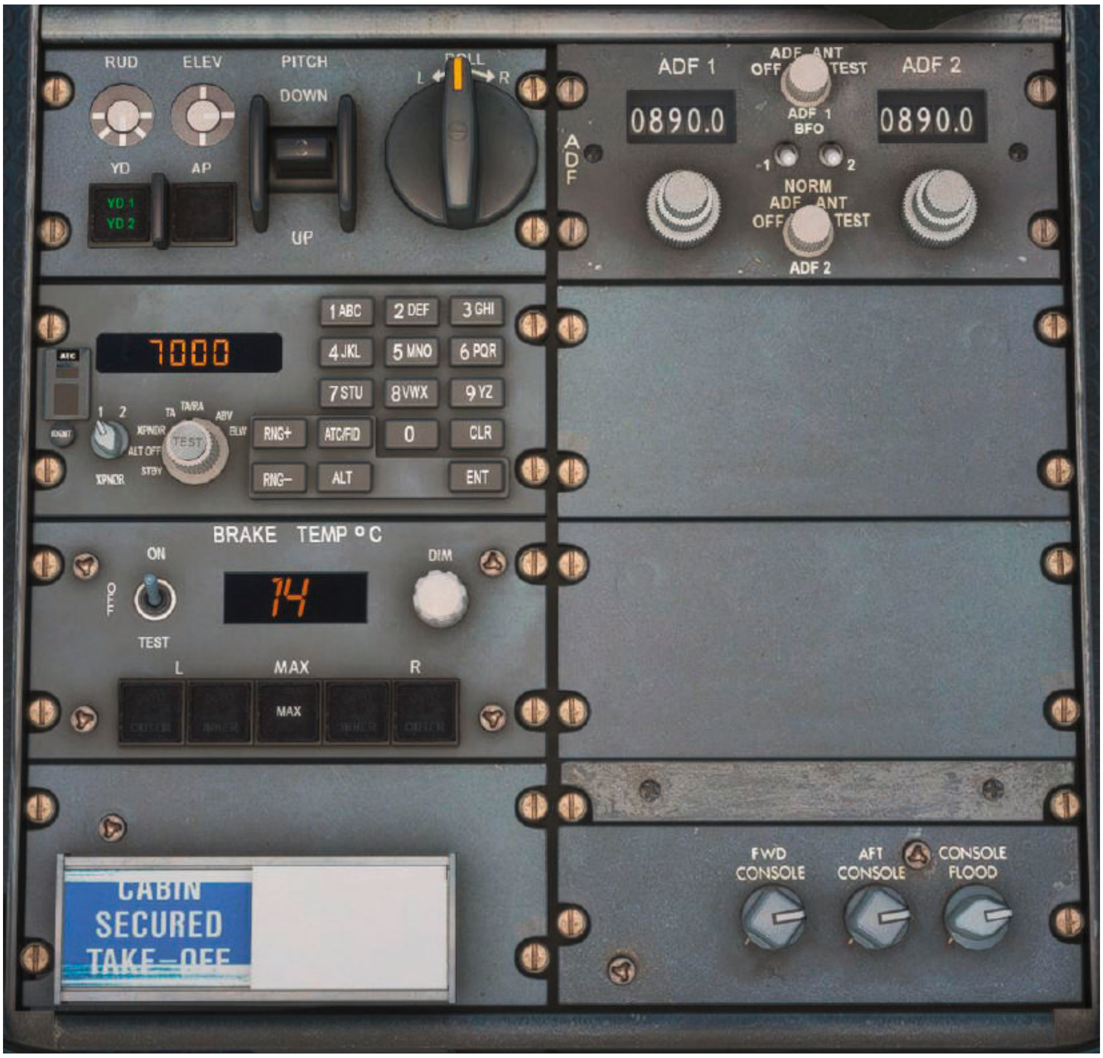
Captain's panel and First Officer's panel

Centre panel

Overhead panel


POS INIT 1/2
FMS POS
N52°28.0 W000°14.6
AIRPORT
PILOT/REF WPT
COMPLETE
N52°28.0 W000°14.6
SET POS
N52°28.0 W000°14.5
<INDEX
FPLN>
122.900
124.850
TFR
ON
OFF
TEST
VHF
COMM
RANGE
TILT
TERRAIN DISPLAY
SPLIT
LNAV
SPERRY


FLAP
AIRBRAKE
FUEL
LIFT SPLR
1
2
3
4
RUD TRIM
ELEV TRIM
AIL TRIM
FULL DISCONNECT
BRAKES


RUD
ELEV
PITCH
DOWN
UP
ROLL
L
R
YD
AP
YD 1
YD 2
ADF 1
ADF ANT
OFF
TEST
ADF 2
0890.0
0890.0
ADF 1
BFO
NORM
ADF ANT
OFF
TEST
ADF 2
ADF
7000
1 ABC
2 DEF
3 GHI
4 JKL
5 MNO
6 PQR
7 STU
8 VWX
9 YZ
RNG+
ATC/ID
0
CLR
RNG–
ALT
ENT
TEST
BRAKE TEMP °C
ON
OFF
TEST
DIM
14
L
MAX
R
MAX
FWD CONSOLE
AFT CONSOLE
CONSOLE FLOOD
CABIN
SECURED
TAKE-OFF

Side consoles

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.

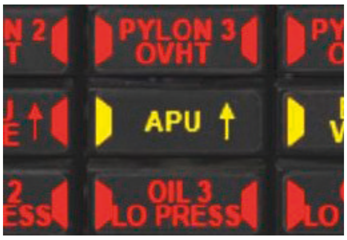
Bleed air and/or electrical power from the APU is available only when the APU is operating at speeds above 95% RPM.

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.

The APU control system incorporates ‘shaft priority’ load limiting. If the sum of the electrical and air loads causes the TGT to rise above the maximum limit, the air supply is automatically reduced to regulate the TGT to the maximum rating.

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.

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 the aircraft's main DC 1 busbar or, alternatively, from the aircraft battery. Battery starting is automatically selected when DC BUS 1 is not powered. Selecting the APU START/STOP switch to START initiates the starting sequence, which is completed in approximately one minute and indicated by the lighting of the APU PWR AVAILABLE annunciator.

When the speed reaches 95%, 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

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.

The doors and stairs are controlled 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 only be opened from outside. Each door can be opened in an emergency from within the compartment or bay.

The QC/QT freighter variants are equipped with a large fuselage cargo door, which requires Yellow hydraulic pressure to operate.

If the cargo door is not locked, the associated FREIGHT DOOR red annunciator will illuminate.

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.

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.

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.

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.

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.

POWER PLANT

General

The aircraft is powered by four Avco Lycoming ALF502R-5 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 thrust levers control the thrust of the four engines and also operate each engine's high-pressure fuel shut-off valve.

Thrust modulation system

A thrust modulation system (TMS) is used to control engine thrust by trimming, with limited authority, the engine power lever settings selected by the pilot.

The TMS provides for a selection of temperature references for either full (Tamb) or flexible (Tflex) take-off thrust.

The TMS trims the thrust settings selected by the pilot, utilising parameters of engine spool speeds, turbine gas temperature, ambient air temperature, static air pressure and engine air bleed configurations.

Starting

Starting is achieved by a DC electric starter motor which transmits its drive through the engine accessory gearbox to turn the HP shaft. Starting can be achieved by using the auxiliary power unit, cross-engine starting or with power supplied from an external source.

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.

Operating indicators

The N1 indicator shows the front fan speed as RPM percentage by a pointer over a graduated scale, together with a digital read-out allowing accurate monitoring at a glance. A command bug can be positioned anywhere around the graduated scale and has a digital read-out to allow accurate positioning.

The TGT indicator shows inter-turbine gas temperature, utilising voltage produced by thermocouple probes in the gas stream, by moving a pointer over a graduated scale together with a digital read-out allowing accurate monitoring at a glance. A command bug can be positioned anywhere around the graduated scale and has a digital read-out to allow accurate positioning.

The command bugs can be automatically configured by left-clicking on the speeds flipchart, which is located just below the landing gear lever. The positions that are selected differ depending on the active TMS mode and stage of flight:

TMS mode/stage of flight	**N1 bugs**	**TGT bugs**
Aircraft on approach	Go-around thrust setting	MCT (857°C)
TMS – TO or GA	Target N1% (as indicated on TMS)	MCT (857°C)
TMS – SYNC N1	Target N1% (as indicated on TMS)	MCT (857°C)
TMS – SYNC EGT	Go-around thrust setting	Target ˚C (as indicated on TMS)
TMS – MCT or TGT	Go-around thrust setting	Target ˚C (as indicated on TMS)
TMS powered off	Go-around thrust setting	MCT (857°C)

The N2 indicator shows the high-pressure shaft speed as RPM percentage by a pointer over a graduated scale.

All three indicators have colour bands incorporated on the graduated scale.

Engine vibration is shown on a monitor comprising four separate meter mechanisms presenting vertical indication displays for engines 1, 2, 3 and 4 from the left.

If a vibration level of 1.2 is exceeded, an ENG VIBN amber annunciator on the Master Warning System (MWS) panel lights, a single audio chime sounds at five-second intervals and flashing amber lights on the flight deck glareshield are activated. Operation of a VIBN TEST push-button on the centre panel activates the monitor display pointers in each meter to indicate 2 for all engines and, after three seconds, the amber ENG VIBN annunciator lights.

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 and, after ignition, through the secondary orifices in the nozzles.

Engine fuel flow and quantity used are provided by an indicator which shows fuel flow rate and incorporates a counter showing the amount of fuel used. A pull-to-reset knob allows the counter to be reset to 0000.

An amber FUEL LO PRESS annunciator on the Master Warning System (MWS) panel lights if the fuel booster pump feed pressure is inadequate.

An amber FILTER CLOGGED annunciator on the MWS panel lights if the 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 calibrated scale for pressure indication is colour-coded green for normal pressure range, amber for low or high oil pressure and red for pressure below 20 PSI. If the pressure should fall into the red sector, the appropriate red OIL LO PRESS annunciator on the MWS panel will illuminate, together with the two flashing red alert lights on the glareshield.

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 and control units through the thrust modulation system actuators and linkage. The first movement of each engine's thrust lever, from FUEL OFF to ON (ground idle stop position), opens the high-pressure fuel valve; the remaining forward movement controls the engine throttle valve.

When at ground idle, closure of the high-pressure fuel valve is prevented by a baulk mechanism, comprised of a detent roller and operating trigger, mounted on each thrust lever. Downward pressure on the operating trigger raises the detent roller clear of a ground idle stop, allowing rearward movement of the thrust lever to close the valve.

In the air, the flight idle baulk prevents a thrust lever from moving below the flight idle position if the associated trigger is up. If a thrust lever trigger is depressed, the associated thrust lever can be moved aft of the baulk.

On the ground, the thrust lever baulk provides a resistance to thrust lever movement, but the levers can be moved easily past the baulk without depressing the triggers. The baulk has two flight idle positions: a nominal 60% N2 and a nominal 67% N2.

The flight idle baulk is mounted on a carriage with two solenoids, a spring and a mechanical lock. The solenoids operate the lock and are energised via the squat switch system. If either solenoid is energised, the lock is broken. Each solenoid is operated by a different squat switch and a different power supply: squat switch 1 and EMERG DC for one, and squat switch 2 and DC 2 for the other.

When the lock is broken, the thrust lever roller stop pushes the baulk down against spring pressure as the thrust levers are moved past the baulk. A resistance to motion is felt at this point. The spring pushes the baulk back up once the thrust levers are clear of the baulk.

When the lock is made, the baulk becomes a hard stop; a thrust lever can be moved aft of the stop only when its trigger is depressed. The carriage can be rotated by a motor powered by EMERG DC.

The motor rotates the baulk to the 67% N2 position when:

the radio altitude is above 200 ft (250 ft on some aircraft)

AND

any one of the ENG ANT-ICE switches is at ON or either DC 1 or DC 2 fails.

The motor rotates the baulk to the 60% position when:

the radio altitude is less than 200 ft

OR

all the ENG ANT-ICE switches are at OFF and both main DC busbars are powered.

The flight idle baulk motor can move the thrust levers forward; it cannot move the thrust levers rearwards.

If enabled on the EFB, the co-pilot will automatically select the ground idle position upon touchdown; otherwise you need to manually select ground idle.

A red fire warning light is fitted into the rear face of each thrust lever. No.1 and No.4 thrust levers each incorporate a thrust modulation system disconnect (TMS DISC) push-button.

The thrust lever triggers can also be operated with the ‘ENGINE FUEL VALVE’ control assignments.

LP turbine overspeed

Should an LP turbine overspeed occur, an emergency shutdown system operates automatically.

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.

The overspeed trip is reset automatically during a subsequent engine start procedure.

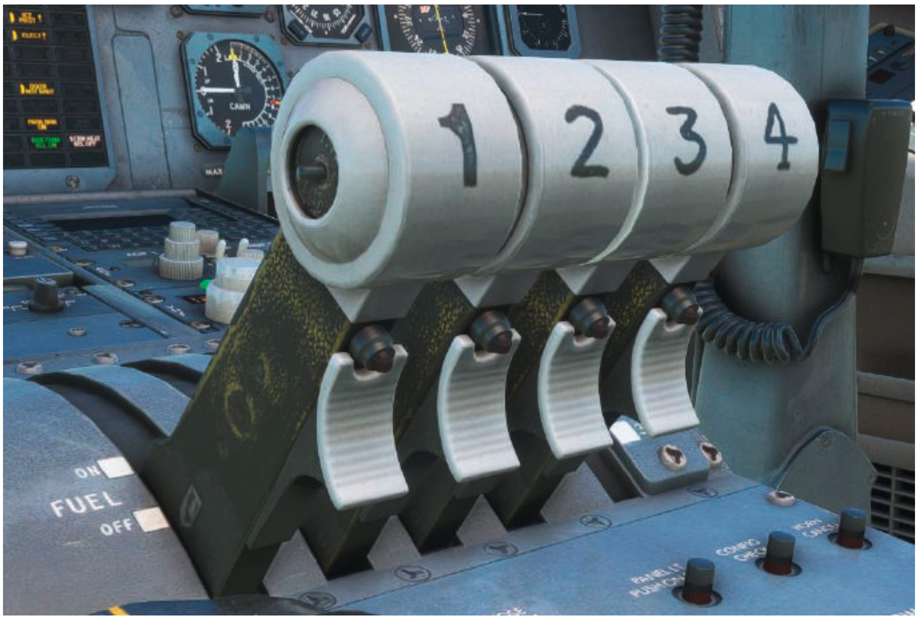
Controls and indicators – engine operating

The indicators and controls in the following table are on the centre instrument panel on the flight deck unless otherwise stated. The letters A and R (amber and red) indicate the colour of an annunciator.

Item	Legend	Notes
Engine fuel indicating		
Fuel flow and quantity used indicator	FF x100 FUEL USED	Reset knobs allow FUEL USED digital counter to be reset to 0000.
Low pressure ind.	FUEL 1 LO PRESS (A) FUEL 2 LO PRESS (A) FUEL 3 LO PRESS (A) FUEL 4 LO PRESS (A)	Captions (MWS)
High pressure fuel filter blocked ind.	FILTER 1 CLOGGED (A) FILTER 2 CLOGGED (A) FILTER 3 CLOGGED (A) FILTER 4 CLOGGED (A)	Captions (MWS)
Engine oil indicating		
Oil pressure, temperature and quantity indicator	OIL °C x 10 PSI x 10 qty x ¼	One for each engine. Calibrated scale with colour segments: Pressure scale Red (warning) – danger, take corrective action Amber (caution) – observe Green (normal) – satisfactory Temperature scale Green (normal) – satisfactory Amber (caution) – observe Red (warning) – danger, take corrective action
Low pressure ind.	OIL 1 LO PRESS (R) OIL 2 LO PRESS (R) OIL 3 LO PRESS (R) OIL 4 LO PRESS (R)	Captions (MWS)
Low pressure ind.		Annunciator – on glareshield

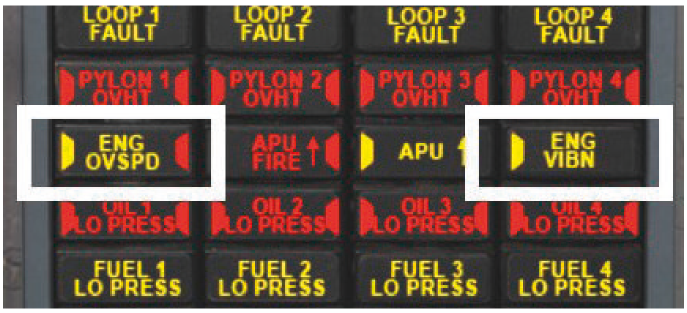
Fan speed indicator	N1	One for each engine. Calibrated scale has colour segments: Green (normal) – satisfactory Amber (caution) – observe Red flash (warning) – danger, take corrective action (emergency shut-down should operate) Reading also shown on 3-digit counter. A 2-digit counter and moving index can be preset by a knob.
High-pressure shaft speed indicator	N2	One for each engine. Calibrated scale has coloured segments: Green (normal) – satisfactory Amber (caution) – observe Red flash (warning) – danger, take corrective action
Turbine gas temperature	TGT	One for each engine. Calibrated scale has coloured segments: Green (normal) – satisfactory Amber (caution) – observe Red flash (warning) – danger, take corrective action Fine TGT also shown on 3-digit counter. A second 3-digit counter and moving index can be preset by a knob.
<u>Engine warning indication</u> Engine vibration monitor Engine vibration ind. Engine vibration ind. Engine vibration test push-button Engine emergency shutdown (LP turbine overspeed) ind.	 0123 ENG VIBN – VIBN TEST ENG OVSPD	 Four indicators (one for each engine, 1 to 4, left to right) (A) Caption MWS (A) Annunciator – on glareshield – (A) Annunciator MWS

Throttles – centre console



Triple display indicator – centre panel

MWS engine annunciators



Engine instruments (N1, TGT and N2)

Engine vibration indicators – centre panel

Thrust Modulation System (TMS)

General

The system operates in a variety of modes and consists of a control display unit (CDU), through which the pilot can select a required mode of operation, which is interfaced with a microprocessor-based computer (TMC) driving an actuator on each engine fuel control unit to provide limited trim authority about thrust lever settings. System disconnect push-buttons are located on No.1 and 4 engine thrust levers.

Each thrust lever trim actuator is motored to a centre (neutral) position when the TMS is in a non-controlling situation or selected off, thus allowing the pilot to maintain normal manual control of the engines through the thrust levers.

Principal modes of operation associated with the TMS functions are:

- Take-off (TO)
- TMS disconnect (GA)
- Maximum continuous thrust (MCT)
- Turbine gas temperature (TGT)
- Flight descent (DESC)

Synchronisation (SYNC) in N1 (fan speed) or N2 (core speed) with either engine 1 or 2 as master may be selected in TGT mode. It may also be selected as an alternative to TO, TMS disconnect, MCT, or DESC.

Control display unit (CDU)

The following controls and indicators are located on the display panel:

PWR

Pressing the push-button energises the TMS and applies electrical power to the engine actuators and the ON annunciator lights.

Any power supply failure in either the TMC or CDU extinguishes the ON annunciator and lights the adjacent yellow annunciator and also the TMS FAULT annunciator on the Master Warning System (MWS) panel.

TEST

Manual test is initiated by pressing the push-button with the system in the standby state, and both yellow and green annunciators light.

The N%/°C indicator displays 88.8 and all indicators on the CDU come on in sequence. If the green annunciator remains lit on completion of the test, the test has been successfully completed and the TMS is in the standby state ready for a mode selection. If the yellow annunciator remains lit, the test has failed and the MWS annunciator TMS FAULT also lights.

TO

Pressing the TO push-button causes the TMS to enter the take-off mode and the arrow beneath the legend shows green.

All other mode annunciators go out. N1 fan speed is shown on the N%/°C indicator if the mode is engaged below 75 knots air speed. Attempts to engage the mode above 75 knots result.in a blank N%/°C display and the TMS remains in, or enters, the standby state. The engines are driven to computed target N1 value by the TMS actuators.

If any air bleed selection other than engine anti-ice is made, the N%/°C display will flash twice per second.

The CDU displays the take-off target N1 calculated by the TMC and based on ambient pressure, sensed outside air temperature (OAT) and selected bleed conditions. Having set prevailing ambient temperature as a reference, sensed OAT may read high with the aircraft at rest and in direct sunlight, but with the aircraft taxiing the reading should stabilise at the correct value.

As thrust levers are advanced, all engines are controlled independently to seek target N1. Actuator authority is restricted to the limits of zero trim (centre) and full extend. All actuators trim fully up initially. As the engines reach target N1 the actuators begin to trim down against advancing levers to control engine speeds to target. While the engines are accelerating the blue arrows in the engine identifiers come on. As each engine attains target speed, its associated blue arrow goes out.

Should a thrust lever be advanced so far that its actuator has reached the limit of its trim-down authority (centre) when controlling to a target, a white arrow in the associated engine identifier lights, advising the pilot to retard that thrust lever.

At 75 knots IAS all actuators freeze at the trim position they have attained and remain so until an alternative mode is selected or thrust levers are retarded below flight idle when actuators centre.

GA

The TMS disconnect (TMS DISC) mode is selected by depressing either of the two TMS DISC buttons on the outer thrust levers and is indicated by the GA legend on the CDU illuminating white.

If the TMS is disconnected below 15,000 ft a target N1 will be displayed, provided the engine bleed configuration is appropriate to a go-around. The TMS actuators run to the centre (neutral) position and, on completion, the green mode arrow under the GA legend lights. Should any actuator fail to centre, the GA mode arrow will not light but the appropriate arrow under the engine ident associated with the actuator in question will flash. A second depression of either TMS DISC button causes the engine ident display to revert to a steady arrow.

MCT

Pressing the MCT push-button causes the TMS to enter the MCT mode and the green arrow beneath the MCT legend to light.

When the MCT mode is engaged the computed MCT target is continuously displayed in the N%/˚C display. The target will be 857˚C TGT except when an N1 schedule overrides. This N1 schedule prevents over-thrusting at low altitudes and ambient temperatures and the N1 value appropriate to the prevailing altitude and temperature will be initially seen in the CDU display each time the mode is selected. If the TMS decides to control to TGT, the N1 value (which may be the N1 limit or some lower value) will be replaced by 857˚C after approximately two seconds.

When climbing under N1 control, a point will often be reached when normal thrust reduction with altitude will cause control to change from N1 to TGT. In this case each engine will make the transition independently, but the CDU display will always show N1 unless all engines are TGT-controlled. Under some circumstances engines will reach, and be controlled to, the N1 limit.

The TMS controls each engine to the appropriate N1 or TGT by trimming its power lever up or down to maintain the datum stored in the computer's memory.

TGT

Pressing the TGT push-button causes the TMS to enter TGT mode and the green arrow beneath the TGT legend to light.

In the TGT mode the TMS controls each engine's TGT by trimming its power lever up or down to maintain the TGT selected by the CDU front panel thumbwheel control. A new value selected is automatically captured except when the hundreds digit is changed. When the hundreds digit is changed the actuators are frozen, the legend goes out and the TMS reverts to the standby state.

To re-engage TGT mode, the TGT push-button must be re-pressed and the new temperature will be captured. In the TGT mode the TGT target value in ˚C is selected by the CDU thumbwheel control. This, topping at the MCT limit value, is continuously displayed on the N%/˚C display. If the thumbwheel TGT is set too high, the MCT limit will be displayed. When a high TGT value is selected, for example when climbing, an N1 schedule may override (as with MCT mode). In this eventuality control and display are similar to the MCT mode, with scheduled N1 replacing 857˚C.

Control does not begin in TGT mode until 2.5 seconds after mode selection to enable SYNC also to be selected if desired without a double-engine disturbance.

DESC

Pressing the DESC push-button causes the TMS to enter DESC mode and the green arrow beneath the DESC legend to light.

In the descent mode the TMS computes and displays target core speed (N2) on the N%/˚C display. The engines are speed-controlled to the computed N2 target value by trimming up their power levers (trim down below actuator centre position is inhibited).

With air conditioning and/or engine anti-ice selected, the two inboard engines are advanced to satisfy bleed schedules and the two outboard engines are controlled to the appropriate flight idle N2. With airframe anti-ice or de-ice selected, all four engines are advanced as required.

SYNC

The SYNC push-button, when pressed, causes the TMS to enter SYNC mode and the arrow beneath the SYNC legend lights up green.

CTRL should be selected to either N1 or N2 and MSTR to either engine No.1 or 2.

SYNC may be used in the following two ways:

1. In SYNC mode only, the master engine actuator is in the centre position and that engine will be controlled to the speed selected by the flight deck thrust lever. The slave engines trim to the same spool speed by up or down trimming of their actuators.
2. In TGT SYNC mode the master engine is controlled to the selected thumbwheel temperature and the other engines are synchronised to the master engine N1 or N2 spool speed.

In cases 1 and 2 all engines are limited to the N1, N2 and TGT limits associated with the MCT mode.

If the master engine tends to exceed these limits, all engines are trimmed down to maintain SYNC, but if a slave engine exceeds limits only the appropriate slave engine will be trimmed down, thus not maintaining SYNC until the master engine thrust lever is retarded.

If TGT is pressed when in SYNC mode, SYNC drops out and TGT is engaged. When in TGT/SYNC mode:

- Pressing TGT causes SYNC to drop out and TGT to engage.
- Pressing SYNC causes the system to enter standby mode; a second press engages SYNC.

CTRL

The alternate action-type CTRL push-button switches the master engine speed control parameter between N1 and N2.

Latching/unlatching the switch causes control of the speed indicated with its legend N1 or N2 illuminated in white. N1 or N2 remains selected when power is cycled off and on, but the N1 and N2 legend lights go out when power is off.

When the controlling parameter is N1, control automatically switches to N2 at power settings below a nominal 70% N2. This improves mode stability at low power settings. The CDU continues to display N1 selected and control automatically reverts when thrust levers are advanced to give more than 70% N2.

Note: *CTRL is only operative when SYNC is selected.*

MSTR

The alternate action-type MSTR push-button changes the controlling master engine between engine 1 and engine 2.

Latching/unlatching the switch causes the engine indicated by the legend 1 or 2 illuminated in white to be master. The master engine selected remains selected when power is cycled off and on, but the 1 and 2 legend lights go out when power is off.

Note: *MSTR is only operative when SYNC is selected.*

TGT ˚C

The TGT ˚C thumbwheel is used only in TGT and TGT/SYNC mode to select the turbine gas temperature in ˚C.

In TGT mode the TMS maintains each engine's turbine gas temperature to the TGT thumbwheel-selected ˚C temperature. In the TGT/SYNC mode, the TMS maintains the master engine's (indicated on the MSTR push-button, 1 or 2) turbine gas temperature as above, and synchronises the three slave engines' spool speeds to the master engine's N1 or N2 speed (indicated on the CTRL push-button, N1 or N2). The temperature range selectable for TGT is 600-899˚C but is limited by the computed MCT value. A new value selected is automatically captured except when the hundreds digit is changed.

TREF ˚C

During normal full-power take-offs, the TREF ˚C thumbwheel control is set to the prevailing ambient temperature. The TREF thumbwheel can also be used to set a flexible take-off thrust when engine de-rating is required, by selecting a higher than ambient temperature.

For all modes other than take-off, TREF has no significance.

1/2/3/4

The annunciators in the engine identifiers 1 to 4 indicate:

1. Which actuators have been commanded beyond their limits of control.
2. Which actuators have failed to respond to a system centring command.

Actuators commanded beyond their limits of control

One of the arrows in the associated engine identifier comes on to indicate that the actuator has been commanded to move beyond its control limits. The sense of the arrow advises the direction of thrust lever movement required to allow the actuator to re-enter its authority limits. The up arrow (blue) or the down arrow (white) advises the necessity for thrust lever advance or retard respectively.

N% / ˚C

The N% / ˚C gas discharge indicator displays target engine speed TGT/temperature for the selected mode. The target engine speed is displayed as a percentage of spool speed. The target speed displayed is N1 for TO mode and N2 for DESC mode. In the TMS DISC mode the target is N1 and is for information only as the actuators are driven to centre in this mode.

In the TEST mode the N%/˚C indicator displays 88.8 to indicate all display functions are in operation. In the MCT mode the computed temperature set point or overriding N1 value is displayed. In the TGT mode the TGT ˚C thumbwheel setting or an overriding N1 value is displayed, until limited at the computed MCT value. In the TO mode the display freezes when the aircraft reaches an airspeed of 75 knots. If an incorrect bleed air selection has been made in the TO mode, the display flashes at a 0.5 Hz rate.

In TMS DISC mode the display remains blank if an incorrect bleed air selection has been made. The display also remains blank in TO and TMS DISC modes above 15,000 ft.

The TMS disconnect buttons can be triggered with the 'AUTO THROTTLE TO GA' control assignment.

Operational details of the TMS are given in the HANDLING NOTES – Power plant section.

Electrical supply

The thrust modulation system is powered from the Avionics B master switch on the flight deck overhead panel.

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% or 45% N2 RPM (as applicable). 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 35V DC is required (see the NORMAL PROCEDURES – Power plant section for details).

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 35V 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). Alternatively, an external DC supply capable of a 35V DC output may be used, if it is available. 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.

Ground starting and motoring

When starting power has been established and the START PWR switch has been selected to the appropriate source (EXT DC or NORM or COLD), selecting the START MASTER switch to ON will cause the annunciator START PWR ON to light, indicating that start power is available, for selection and distribution, to the starter motors.

A rotary START SELECT 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 the two ignition systems. Simultaneously, the annunciators STARTER OPERATING, ENG IGN A ON and ENG IGN B ON all light. As the engine accelerates, and after 'light off' has occurred, the ENG VLV NOT SHUT annunciator may light briefly. At self-sustaining speed (40% or 45% N2 as applicable) operation of the starter motor and ignition will be terminated and the annunciators STARTER OPERATING, ENG IGN A ON and ENG IGN B ON will all go out.

The engine then accelerates under its own power to the selected idle speed. The next engine to be started must be selected on the START SELECT switch and the starting cycle may then be repeated by re-selecting the ENGINE switch to START. On completion of all engine starting the START MASTER switch must be selected OFF (thus restoring the aircraft electrical power system to its normal operating mode) and the START SELECT switch must be set to OFF. The START PWR switch should be left selected to NORMal.

In the event of an aborted start, or for maintenance purposes, it may be desirable to perform an engine motoring cycle, during which the ignition system is inoperative. The procedure for a motoring cycle is as for a starting cycle except that the ENGINE switch is held to MOTOR for one second and then released; power is routed to operate the starter motor indefinitely. As there will be no ignition, the annunciators ENG IGN A & B ON will not light. To terminate a motoring cycle, select the START MASTER switch to OFF and the START PWR switch to NORMAL.

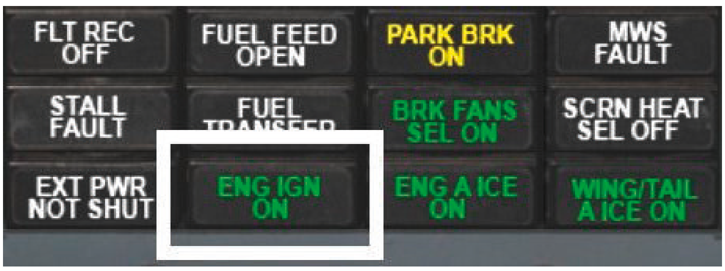
In-flight starting and relighting

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. On opening the thrust lever to flight idle, the engine should light up and accelerate to a stable speed appropriate to the aircraft altitude and airspeed. To complete the starting procedure, the FLT START and ENGINE SELECT switches must be selected OFF.

Should an engine 'flame out' in flight, it must be shut down. An in-flight start may be attempted if there are no indications of engine damage.

During take-off, when slush or water exists on the runway, or during flight when atmospheric or operating conditions have the potential to induce flame out, either one or both CONT IGN switches should be selected ON to provide an immediate relight facility.



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.

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.

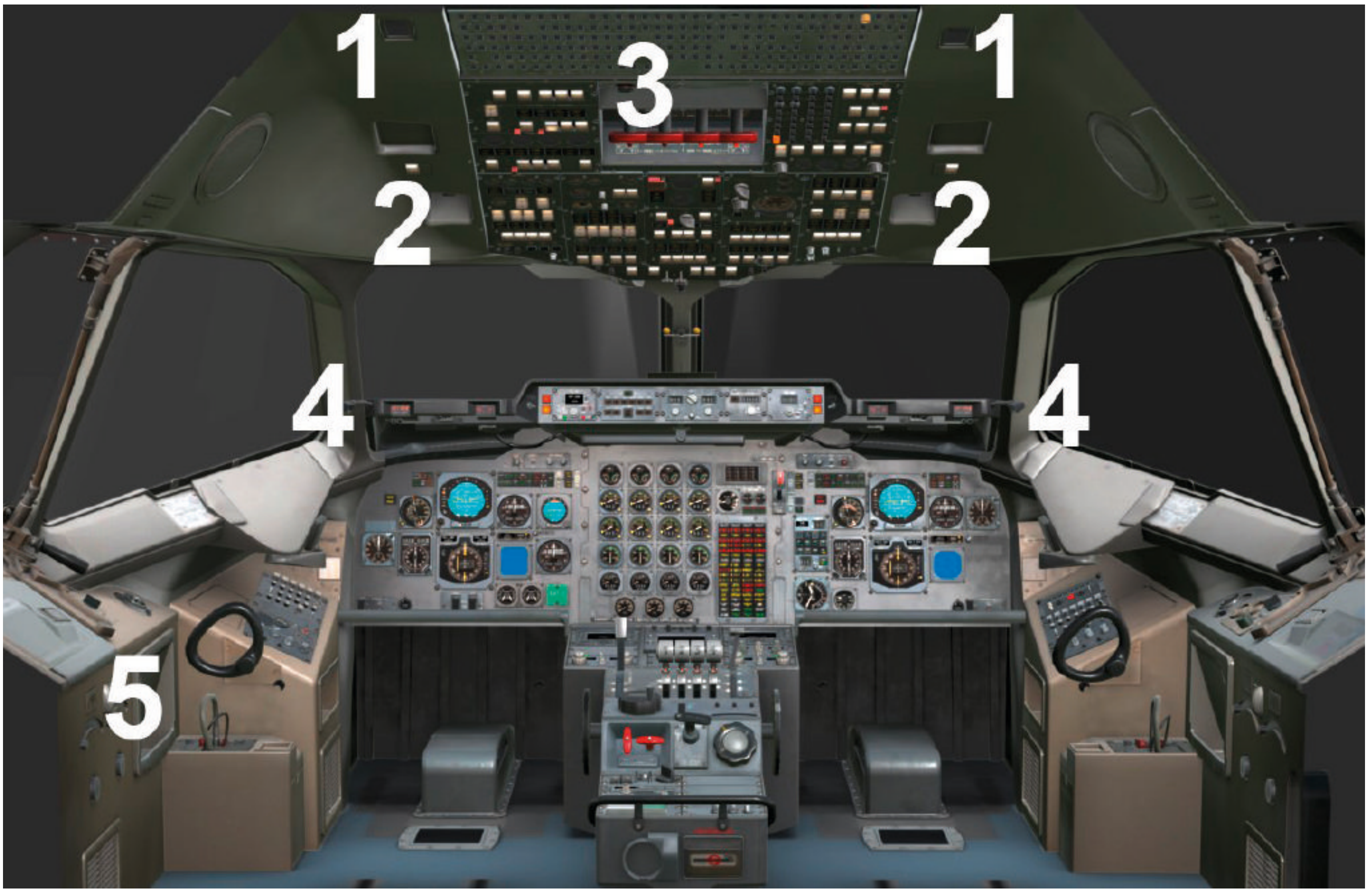
Call systems permit signalling between the ground crew and the flight crew, and between the flight crew and cabin crew.

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
5. Flight kit light

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.

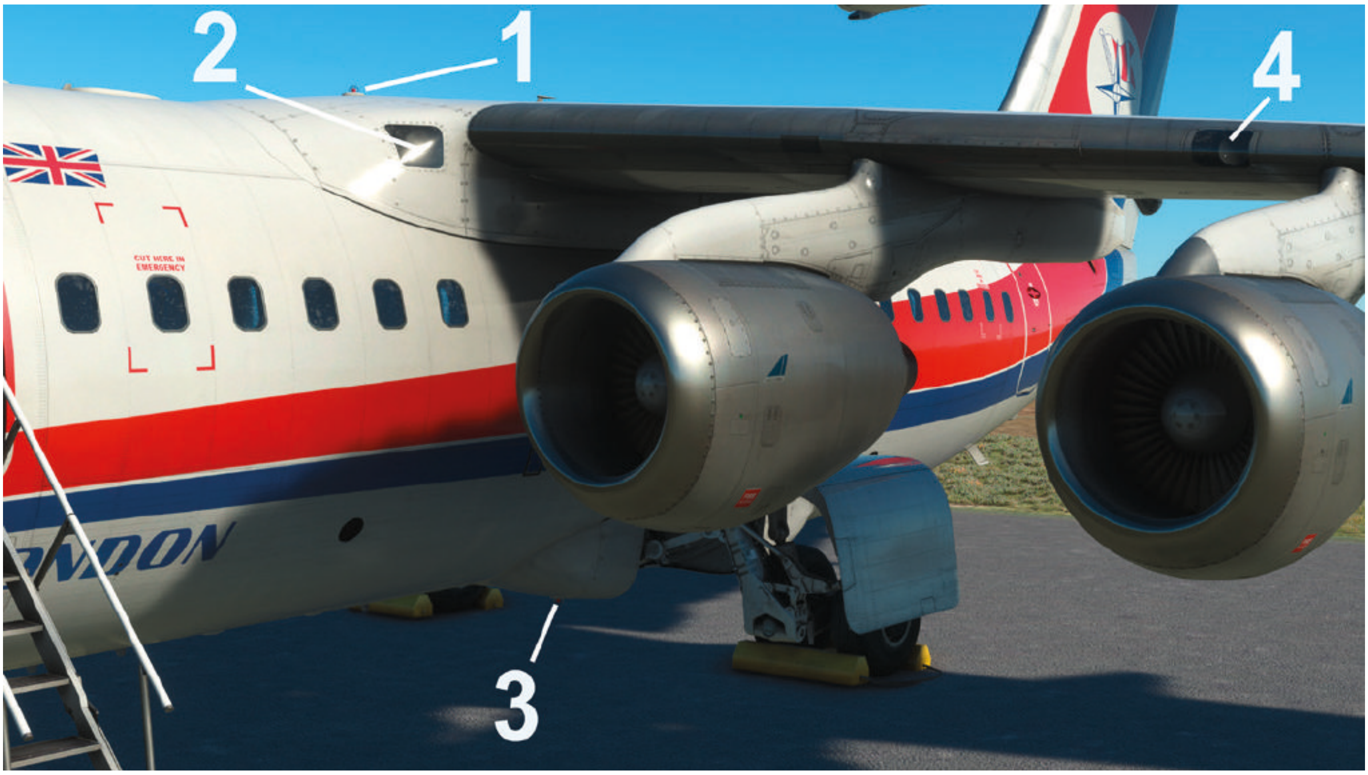
The EMERG CALL light module is lit by red filaments and cannot be dimmed. The CABIN CALL and GRND CALL light modules are lit by blue filaments and are dimmed by the flight deck overhead panel dim circuit.

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.

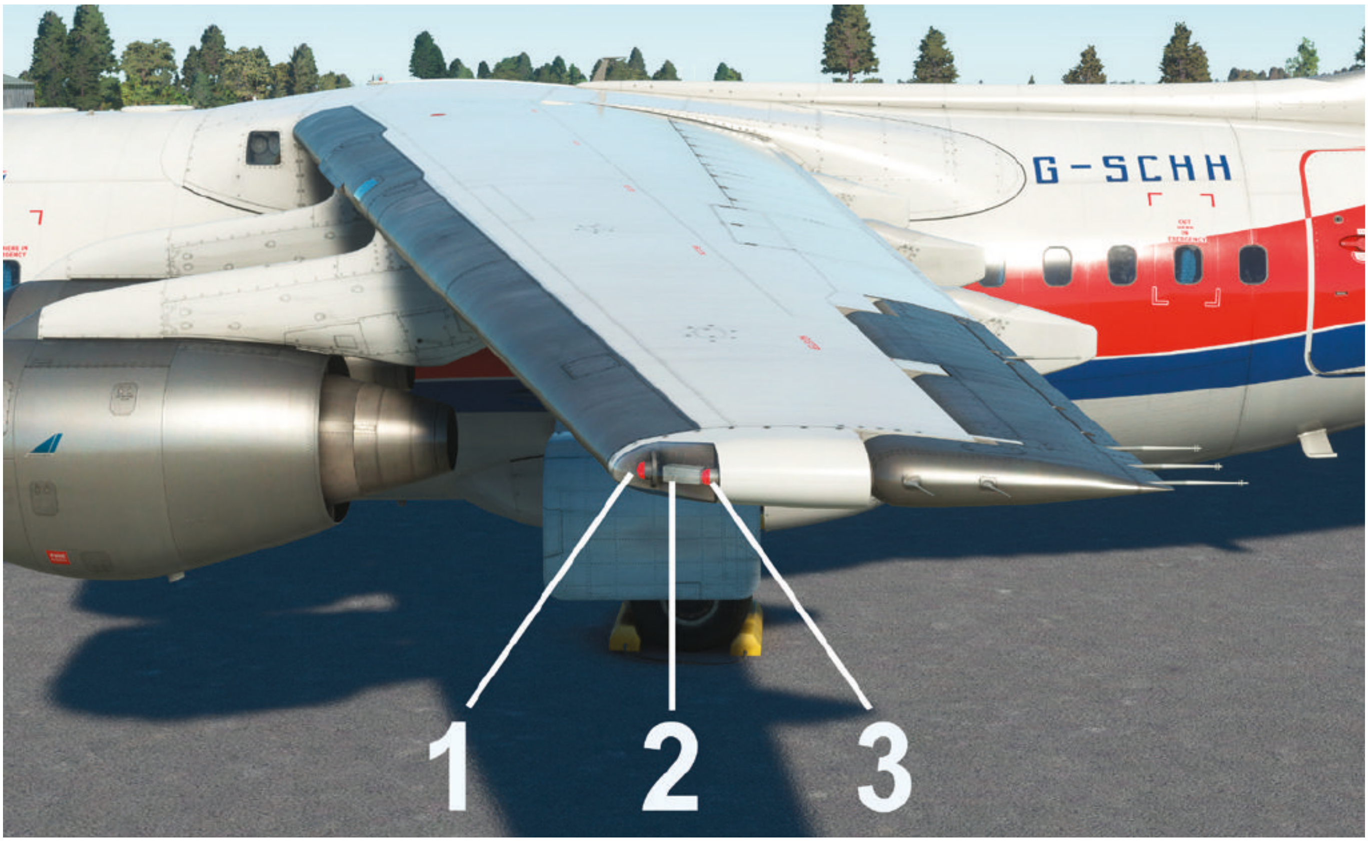
Audio tones over the intercom system accompany calls received on the flight deck. Calls from the cabin attendants' intercom panels are announced by a single chime and calls from the ground crew are announced by a gong.

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.

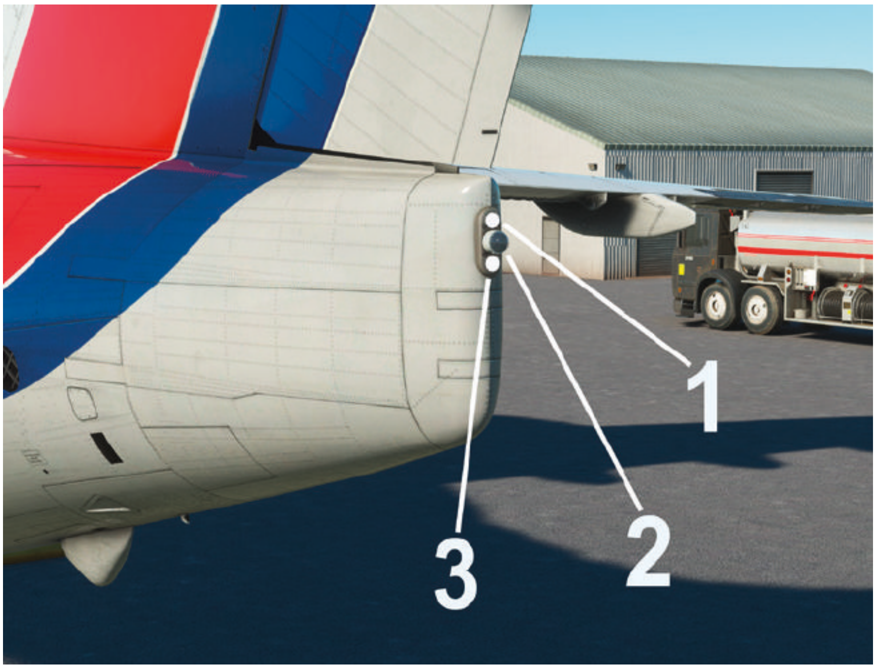
Exterior lighting



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 L.TS 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.

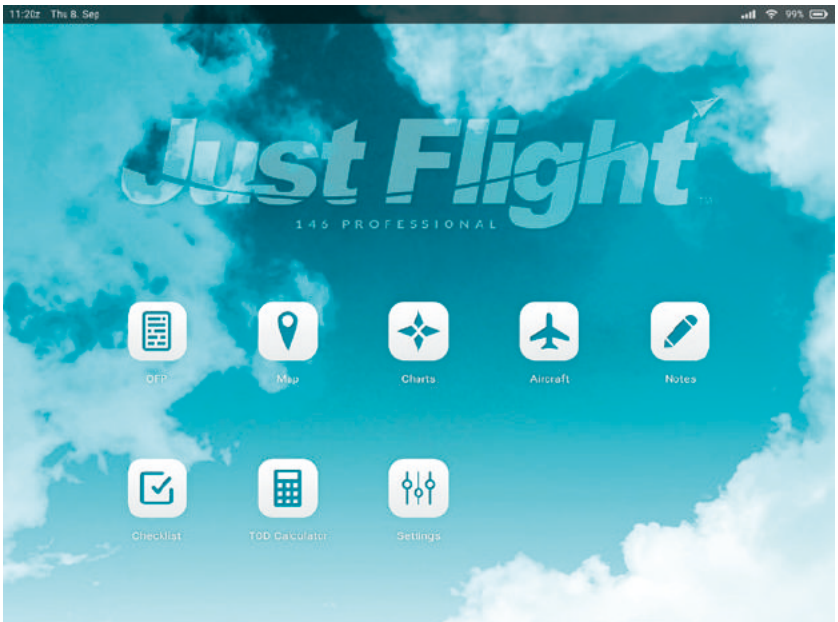
ELECTRONIC FLIGHT BAG (EFB)

The aircraft is equipped with a tablet computer which is divided into two main areas:

1. An ‘Electronic Flight Bag’ (EFB) which can be used for viewing your simBrief operational flight plan (OFP), monitoring your position on a moving map, viewing your Navigraph charts and making notes.
2. An aircraft screen for controlling various aircraft options and payload.

The tablet can be powered on/off with the physical ‘Home’ button on its right bezel. The ‘Home’ button can also be used to return to the EFB menu from the aircraft screen. The EFB can be hidden by using a click spot on each of the compass deviation cards.

The Home screen of the EFB shows the icons of the various applications that are available to use. Pressing one of these icons will open the respective application.



The top bar of the EFB shows the current simulator time and date in the top left corner, as well as the current battery status of the tablet in the top right corner. The battery will drain over time if the aircraft’s electrical power (ESS DC) is switched off and will recharge once it is powered on again.

The tablet will automatically move between the Captain and Co-pilot sills depending on the selected camera view. Both tablets can also be toggled on at the same time by clicking on both compass deviation cards.

The tablet can be rotated left/right and up/down using the clickspots on the outer edge (bezel) of the EFB tablet.

The background on the EFB can be changed to an image of your choice by replacing the wallpaper.jpg file in the following file directory: …Community\justflight-aircraft-146\html_ui\Pages\VCockpit\Instruments\Airliners\JF_146\EFB\img.

Operational Flight Plan (OFP)

The OFP app allows you to view your latest simBrief OFP and display its information conveniently within the simulator.

On selecting the simBrief screen you will be prompted to enter your simBrief pilot ID to access your data. Alternatively, you can choose to identify yourself via your simBrief username by enabling the ‘simBrief Username Login’ setting in the EFB settings.

Once you have entered your simBrief identification and pressed the ‘Continue’ button, you are presented with a summary of your active OFP, including airport codes, times, route information, fuel weight etc.

Pressing the ‘METAR’ button allows you to view the wind information for your origin, destination and alternate airports. This information is shown in both raw and simplified forms.

To view the full OFP, press the ‘Output’ button. Your entire flight plan will then be shown in text form, which can be scrolled as desired by using the scrollbar to the right of the OFP output area.

The OFP data can be refreshed at any time by pressing the ‘Refresh’ button in the left sidebar and this will update the data to your latest simBrief flight plan.

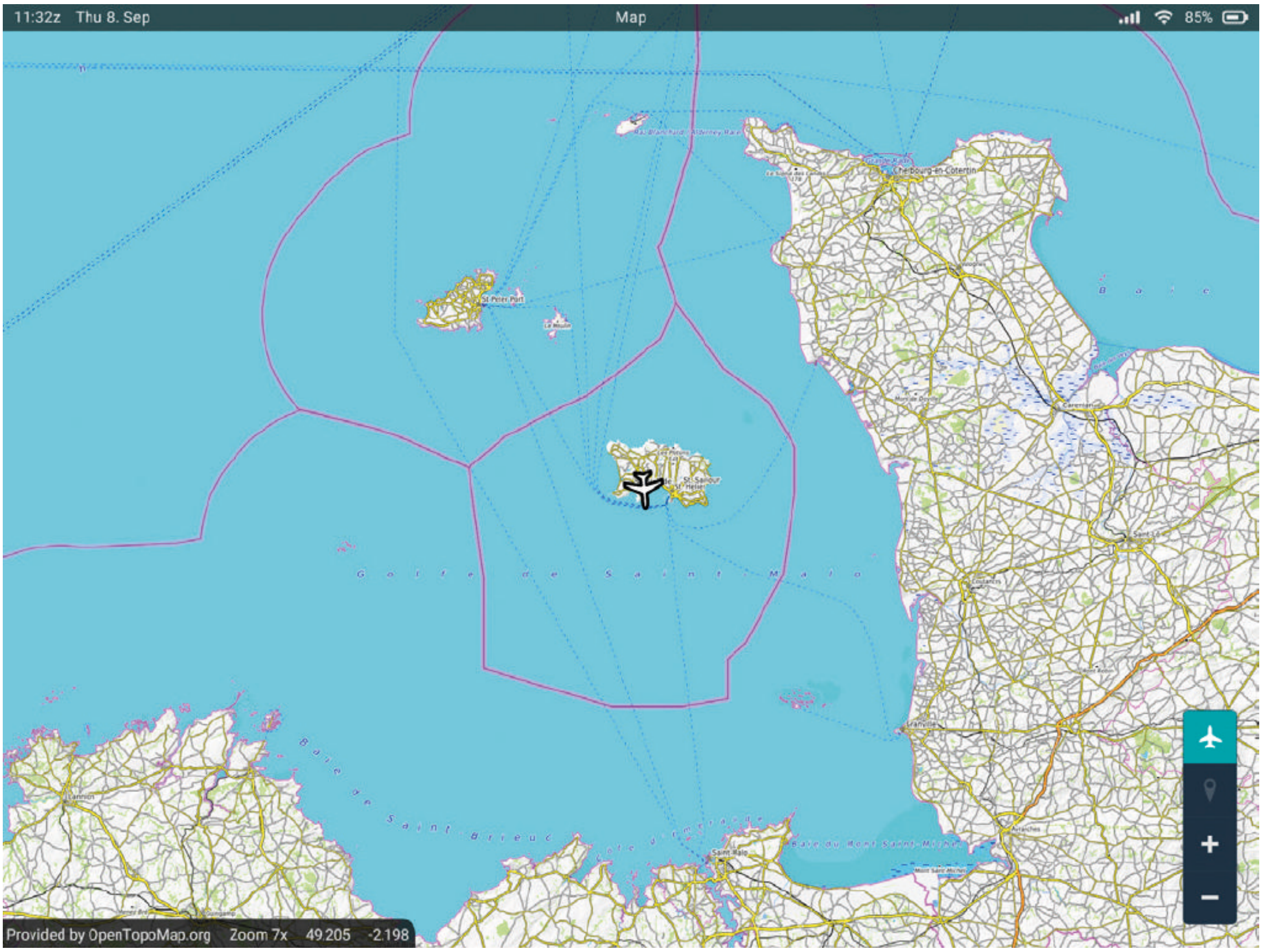
Note: *A simBrief account is required for this functionality.*

Map

The Map app provides you with a moving map based on visual data from OpenTopoMap.org.

By default, the map is set to track the aircraft's current position (displayed in the bottom right corner). It is also possible, however, to move the map manually by pressing the aircraft icon in the bottom right corner of the display and then simply clicking and dragging anywhere on the map. Pressing the location pointer icon will centre the view back to the aircraft's current position.

The map's zoom level can be adjusted via the '+' and '-' buttons.



Charts

The Charts app allows you to browse aviation charts provided by Navigraph as part of an active Navigraph subscription. A login (via external link or QR code) is required to link the EFB to your Navigraph account. Follow the instructions on the EFB and your external internet browser to complete the linking process.

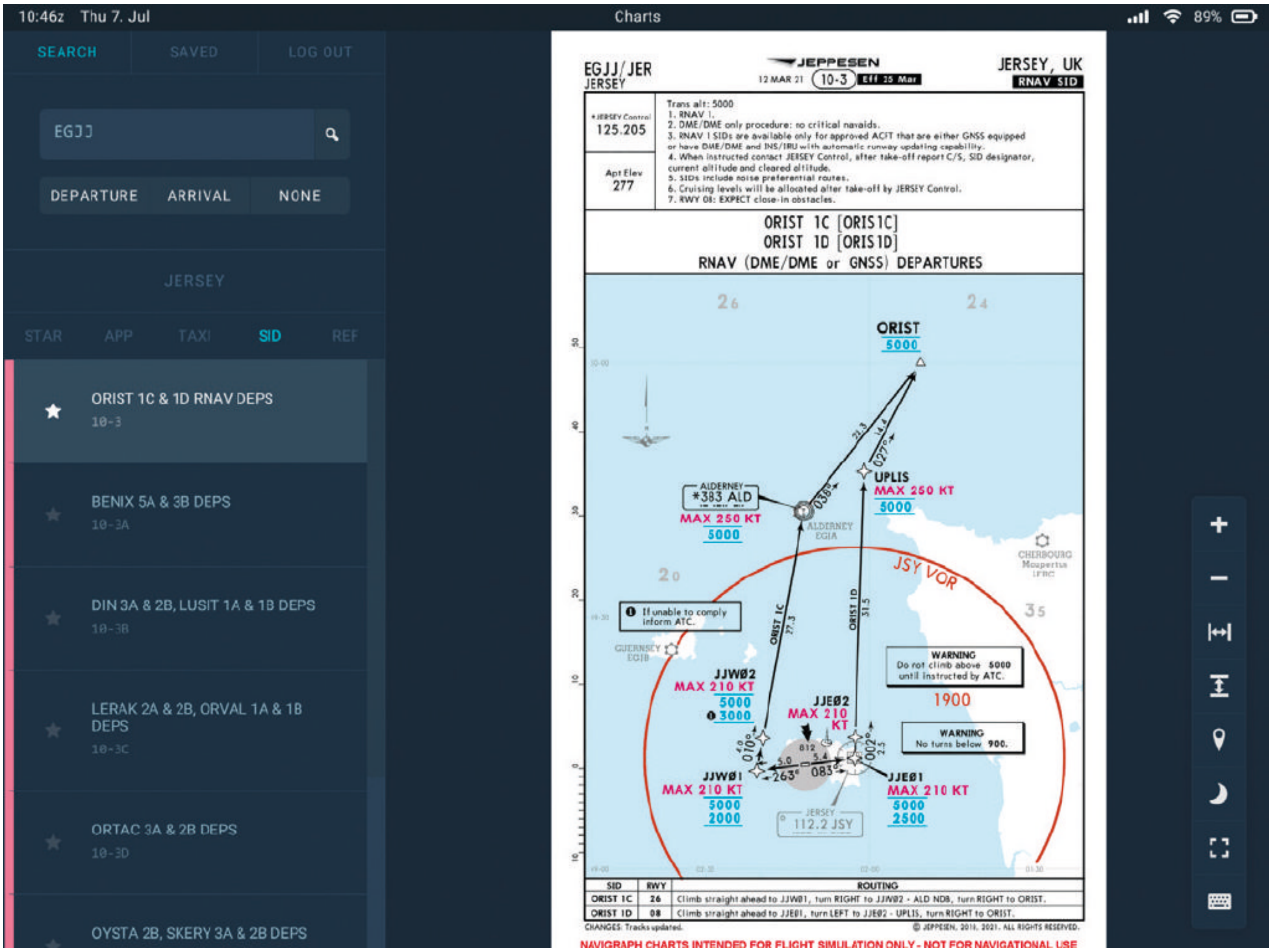
With your Navigraph account linked, you can then enter an ICAO code in the 'ICAO Code' search field to view the various associated STAR/APP/TAXI/SID/REF charts for that airport.

If you have a simBrief OFP loaded on the OFP page, you can quickly access the charts for the departure and arrival airports simply by pressing the respective 'Departure' and 'Arrival' tabs. This will list all relevant charts for that airport under the STAR/APP/TAXI/SID/REF headings.

To view a chart, simply press the relevant tab and the chart will appear on the right side of the page. The active chart can be moved/resized/fitted as needed by using the controls at the right of the document window. Charts that provide georeferenced data may additionally display the aircraft's current position as an overlay icon if applicable.

Charts can be saved for quick reference by pressing the star icon to the left of the chart's name. You can quickly access all of your saved charts by pressing the 'Saved' button at the top of the page.

To unlink your Navigraph account from the EFB, press the 'Log Out' button at the top of the page.



Note: *A Navigraph account is required for this functionality.*

Aircraft

Selecting the Aircraft app from the Home page will launch the aircraft screen, which allows you to control various aircraft options and payload.

Please refer to the sections below for further information on the individual functions of the Aircraft page. You can return to the EFB from the Aircraft screen by either clicking the 'Home' icon or the physical 'Home' button.

Configuration

With the Aircraft menu selected, pressing the Settings 'cog' icon enables or disables the Configuration menu.

This menu has the following options:

- **Sync Altimeters** – automatically synchronises standby and Co-pilot/Captain altimeter barometric settings ('master setting' is based on camera selection).
- **TCAS VSI** – toggles between traditional and TCAS vertical speed indicators.
- **State Saving** – enables/disables aircraft state saving. The aircraft state can be saved and reloaded automatically between flights, allowing you to always return to your cockpit in the same state that you last left it.
- **Pilot Callouts** – enables/disables pilot callouts ("V1", "Rotate" etc.).
- **Cabin Announcements** – enables/disables cabin announcements ("The seatbelt sign has been turned off" etc.).
- **FMS Navigation** – enables/disables the FMS CDUs. When disabled, the autopilot and HSI will take GPS information from the default MSFS flight planner.
- **Flipchart Options** – when enabled, you can click on the relevant row of the speeds flipchart (located below the landing gear lever) to specify which flap setting you would like the speed bugs to be set for. This allows you to pre-select your take-off or approach flap setting. When disabled, clicking anywhere on the flipchart will set the speed bugs based on your current flap setting.

- **Gauge Refresh Rate –** allows you to control the digital gauge refresh rates (lower refresh rate = higher FPS).
- **Cockpit Pilots –** enables/disables the visible Co-pilot and Captain with interior camera selected.
- **Interior Cabin –** enables/disables the cabin with interior camera selected (note that the cabin is low-poly for performance).
- **Aux Fuel Tanks –** enables/disables the auxiliary fuel tanks.
- **Auto Ground Idle –** enables/disables the automatic selection of throttles to ground idle from flight idle upon touchdown.
- **Cabin Ambient Sounds –** enables/disables the cabin ambient sounds.
- **HF Aerials–** enables/disables HF aerial wires on the exterior.
- **Auto Cabin Lights –** when enabled, the intensity of the cabin lights is automatically set depending on the time of day. When disabled, a slider provides control of the intensity.
- **Rudder Axis Steering –** when enabled, the rudder axis control assignment will also control the tiller for nose-wheel steering. When disabled, the 'STEERING INC/DEC' and 'NOSE WHEEL STEERING AXIS' assignments can be used to control the tiller without moving the rudder pedals. You can also click and drag the tillers to control only the steering.
- **Visible Cargo –** enables/disables the visibility of the cargo containers in the cargo variants of the 146 (200QC, 200QC and 300QT).
- **VHF Tail Aerial –** enables/disables the visibility of the VHF3 aerials on the tail of the aircraft.

Aircraft States

Three aircraft states can be selected:

- **Cold & Dark –** aircraft is fully cold and dark, chocks are fitted and all doors are closed.
- **Turnaround –** aircraft is configured in a turnaround state with the engines off, cargo and forward passenger doors open and stairs deployed, chocks fitted and ground power connected.
- **Ready For Takeoff –** aircraft is fully configured for take-off, with the parking brake on.

The aircraft will automatically be configured in the 'Cold & Dark' state when a flight is started at a parking/ramp/gate position, otherwise the 'Ready For Takeoff' state will be selected. Restoration of a saved stated, if enabled in the Configuration menu, will then occur.

Announcements

Five cabin announcements can be triggered:

- **Seats for take-off –** flight deck to cabin PA for crew to take seats for take-off. After a short time the crew will confirm that the cabin is secure and slide the CABIN SECURED sign on the aft pedestal to the take-off position.
- **Seats for landing –** flight deck to cabin PA for crew to take seats for landing. After a short time the crew will confirm that the cabin is secure and slide the CABIN SECURED sign on the aft pedestal to the landing position.
- **Release crew –** flight deck to cabin PA to release crew to begin their service.
- **Arm doors –** cabin PA to arm doors and cross-check.
- **Disarm doors –** cabin PA to disarm doors.

The announcement buttons will be disabled (greyed out) if they have already been triggered.

The "Seats for take-off", "Cabin crew released" and "Seats for landing" cabin announcements can also be triggered by pressing the CABIN CALL button on the overhead panel at the relevant stage of the flight (before take-off, during the climb and during the descent).

Doors and equipment

All passenger, service and cargo doors can be opened/closed by pressing the associated button:

- **FWD PAX** – door 1L, main passenger door. The stairs must be fully retracted before the door can be closed.
- **STAIRS** – door 1L, integrated airstairs. Door 1L must be fully open before the stairs can be extended. Extension is under gravity, but retraction requires yellow hydraulic pressure (supplied by the AC pump prior to engine start).
- **AFT PAX** – door 2L, rear passenger door.
- **FWD SERV** – door 1R, forward service door.
- **AFT SERV** – door 2R, rear service door.
- **FWD CARGO** – forward lower cargo door.
- **AFT CARGO** – aft lower cargo door.
- **FUSELAGE CARGO** – fuselage cargo door (QC/QT variants only).

The CHOCKS button enables/disables the wheel chocks.

The GRD PWR button enables/disables the ground power unit (GPU), which supplies external AC/DC power to the aircraft.

Fuel and payload

The EFB can be used to set:

- Fuel load in each of the tanks – left and right wing and auxiliary tanks (if equipped) and centre tank.
- Forward and aft cargo payload.
- Fuselage cargo payload (QC/QT variants only).
- Total passenger (PAX) load.
- Zero fuel weight (ZFW) – the selected weight will be automatically split into a suitable passenger quantity and cargo load.
- Total fuel weight – the selected weight will be automatically split between the tanks.

Fuel and cargo loads, ZFW and total fuel weight values can be increased/decreased by 5% using the plus/minus buttons or entered manually. Manual entry can be achieved by clicking on the relevant value field, inputting the value with the number keys on your keyboard and then pressing the Enter key, or by using the on-screen keyboard in the EFB. The Backspace key can also be used to delete an entry.

A Randomise icon is located immediately to the right of the PAX TOTAL field. Clicking this icon will set a random passenger and cargo load.

The auxiliary fuel tanks will only be shown if they are enabled in the EFB Configuration menu.

Units of measurement can be toggled between kilograms (kg) and pounds (lb).

Due to simulator limitations, any changes to the fuel load will only be shown on the FUEL/PAYLOAD window after a few seconds and no payload changes will be shown. We therefore advise you to only use the EFB for setting and reviewing fuel and payload.

The CG % SMC (Standard Mean Chord) is shown and the value can be left-clicked to automatically set the pitch trim to the correct position for take-off. The value will turn red if the CG is outside limits.

The gross weight value will turn red if the aircraft maximum take-off weight (MTOW) has been exceeded.

If you have imported a simBrief OFP, a window prompt will ask you whether you would also like to import the fuel and payload from the OFP data. This option will trigger the zero fuel weight and total weight to be automatically set to the OFP values.

Failures

The FAILURES menu can be accessed by clicking on the two-spanner icon in the top right corner of the Aircraft page.

Over 90 system failures are simulated, with each failure accurately simulating a failure of the respective system as well as producing the correct visual and aural alerts.

FAIL – a tick indicates a failure in the respective system is active.

ARM – a tick indicates that a failure in the respective system is armed and the system will fail at the time specified in the MINS field.

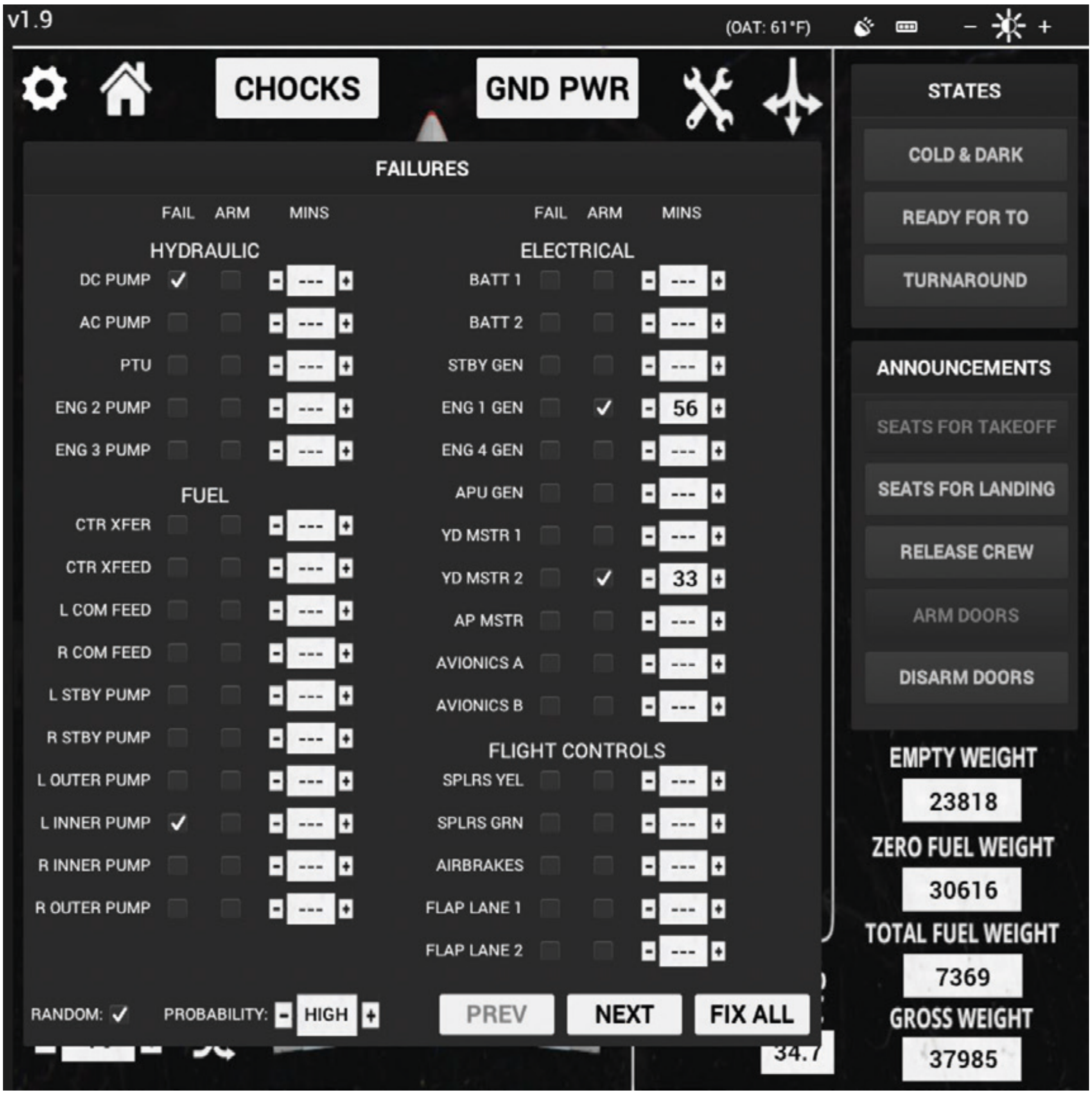
MINS – if a failure is armed, the value in this field will indicate how long until the failure becomes active. The default value is 60 mins, indicating that a failure will occur 60 minutes after being armed. The time can be adjusted by clicking the + (plus) and - (minus) buttons either side of the MINS field.

RANDOM – enables/disables random system failures.

PROBABILITY – determines the rate at which random system failures occur. This field has four settings which can be cycled using the + (plus) and - (minus) buttons on either side of the field: REAL, LOW, MED and HIGH, with REAL being the lowest probability of failure and HIGH being the highest probability of failure.

NEXT/PREV – cycles through the various system failure pages.

FIX ALL – fixes all active and armed failures and returns the aircraft to a fully functional state.



Pushback controls

Pushback controls can be accessed by clicking on the three-arrow icon in the top right corner of the Aircraft page.

A pop-out PUSHBACK menu will open, providing controls for manoeuvring the aircraft on the ground with a pushback tug.

- **CONNECT**– connects the pushback tug to the aircraft. Pushback will begin once a direction is chosen via the arrow buttons. Text will change to CANCEL once a button is pressed.
- **CANCEL** – stops the pushback and disconnects the pushback tug. Text will revert back to CONNECT once button is pressed.
- **ARROW BUTTONS** – provide control of the aircraft in four directions. An arrow will change to green once that direction is selected. Multiple directions can be selected at the same time (e.g. reverse and left). The pushback direction can also be controlled with MSFS rudder axis control assignments.
- **SPEED** – provides control over the pushback tug speed. The greater the value, the higher the speed.
- **STEER ANGLE** – displays the current steering angle of the pushback tug.
- **STATUS** – displays the current status of pushback.

Note: *Due to simulator limitations you may experience a slight jolt when the pushback tug connects to the aircraft, as well as some jittering when the aircraft speed varies between speeds 0 and 2.*

Notes

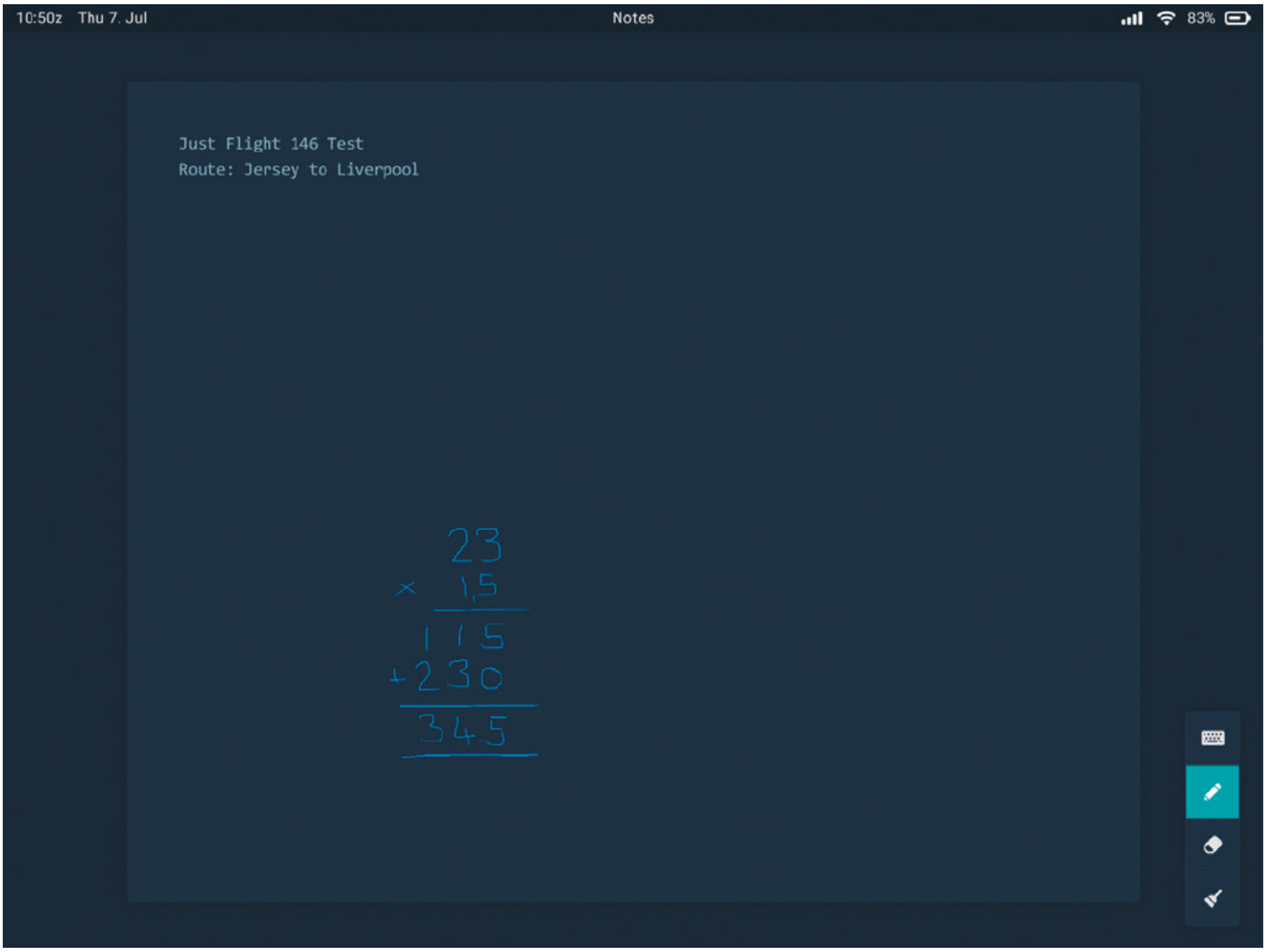
The Notes app acts as a virtual notepad for the pilot, allowing you to take text-based and handwritten notes on the fly (particularly useful for noting clearances and taxi instructions).

The Notes app supports standard keyboard inputs and will automatically display a scrollbar once the content exceeds the height of the input area.

An on-screen keyboard is also available. This can be toggled on/off by pressing the keyboard icon at the bottom right of the page. Once open, the keyboard can be moved freely to any position on the display by pressing and holding the top bar of the keyboard. To hide the keyboard, simply press the keyboard icon again. (This feature is particularly useful for VR users.)

To write handwritten notes, press the pen icon at the bottom right of the page and then left-click with your mouse and drag the pen to write on the screen. To erase text, press the eraser icon and, again with your mouse, left-click and drag to erase what you have written.

To erase all handwritten notes from the page, simply press the paintbrush icon at the bottom right of the page.



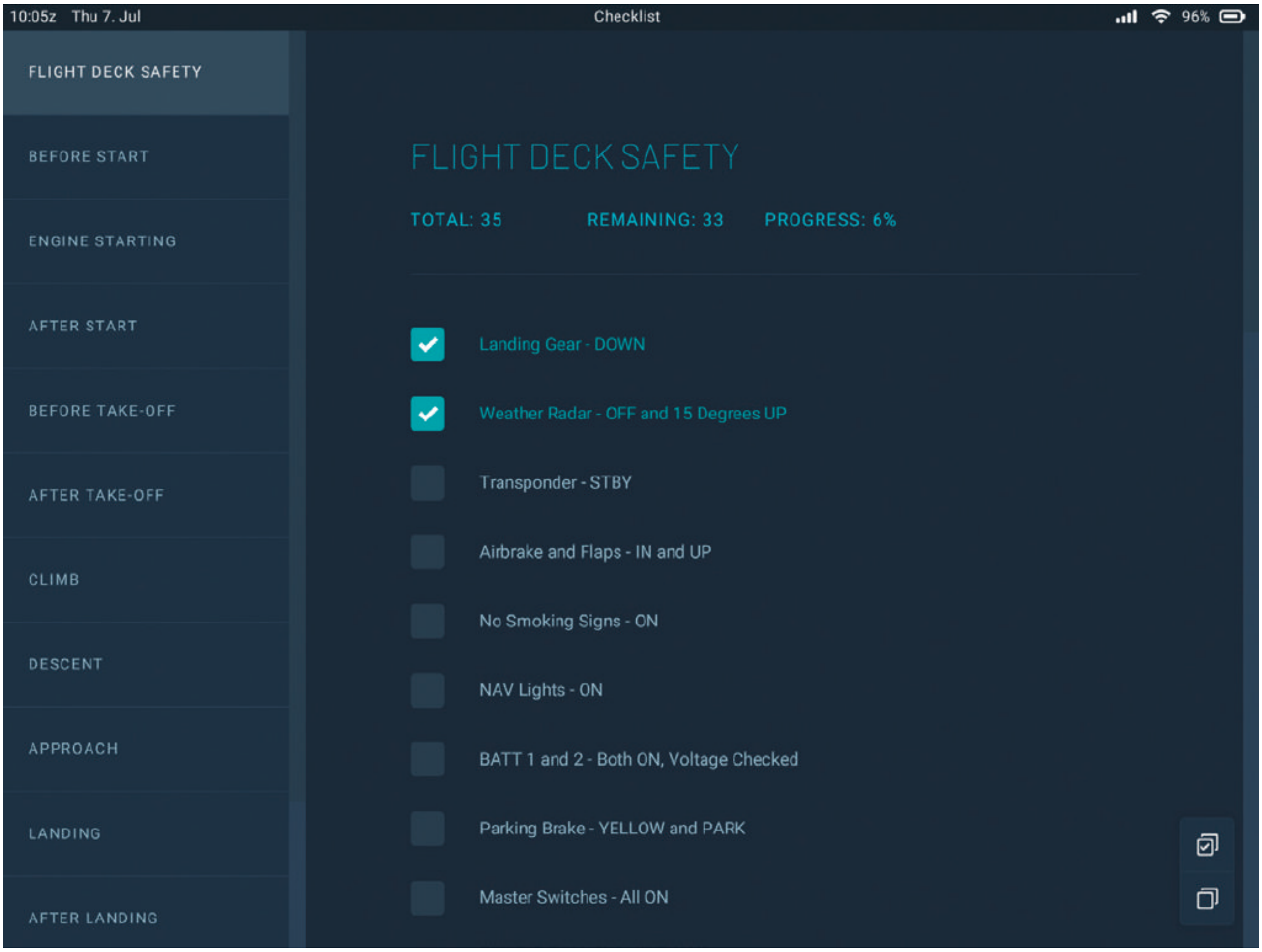
Checklist

The Checklist app allows you to view all the aircraft's checklists on one easy-to-navigate page. The title of each checklist is shown on the left side of the page. Pressing the title of a checklist will open the respective checklist on the right side of the page.

Each step of a checklist has an item, action, and a tickbox which can be manually ticked to allow you to keep track of your progress. You can see your progress through the checklist at the top of the page.

Two controls at the bottom right of the page allow you to tick all boxes on the page or to untick all boxes.

Note: *The Checklist page on the EFB is intended to be used as a guide only. For automated checklists please use the interactive checklist menu within MSFS.*



TOD Calculator

The Top Of Descent Calculator is a useful tool which allows you to calculate and view the exact point at which you should begin your descent.

The distance of your descent can be calculated based on the following four factors:

- Current altitude (feet)
- Ground speed (knots)
- Target altitude (feet)
- Desired angle (degrees)

Each of these factors is shown on this page, where text can be entered into each of these fields either via an external keyboard or via the on-screen keyboard which can be toggled from the lower right corner of the page.

Once values have been entered into each of these four fields, the calculator will then produce two outputs:

- Desired TOD distance – the ground distance covered between the start of your descent and your target altitude.
- Desired vertical speed – the vertical speed that the aircraft will have to descend at to meet the distance stated.

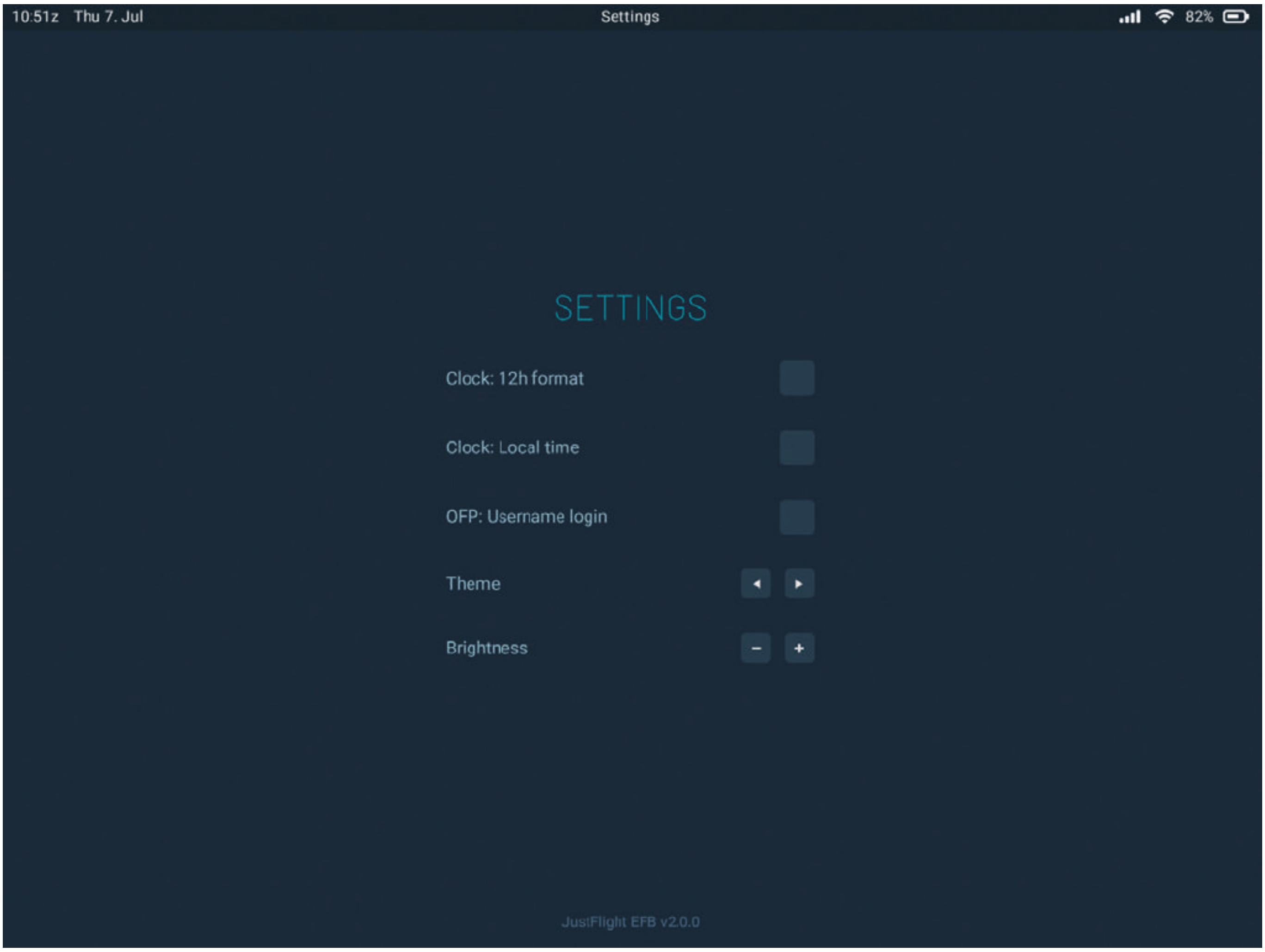
Note: *Desired distance, Desired vertical speed, and Desired angle are all interchangeable values and can be toggled by pressing the arrows in the fourth field.*

For ease of use, the 'Current altitude' and 'Ground speed' fields both have a 'SYNC' feature; once active, this continuously inputs the aircraft's current altitude and ground speed into their respective fields. With this feature active, the calculator's outputs will be constantly updated as the aircraft's altitude and speed change during its descent.

Settings

The Settings screen offers several options to adjust the look and behaviour of the EFB:

- **Clock: 12h format** – toggles the 12/24-hour format of the top bar clock.
- **Clock: Local time** – toggles between UTC and local time on the top bar clock.
- **OFP: Username login** – allows simBrief identification via username instead of pilot ID.
- **Theme** – switches the EFB's colour scheme.
- **Brightness** – increases/decreases the EFB's brightness.



FLYING THE 146

In this tutorial flight we will be departing from Jersey Airport, located in the Channel Islands and 87 nautical miles south of mainland England. We will depart to the west before flying north over the English Channel, crossing the south coast of England at Southampton and passing just to the east of Birmingham before starting our approach into Liverpool John Lennon Airport on the banks of the River Mersey.

Covering approximately 285 nautical miles, this regional flight is the ideal length for learning about the important systems on board the 146.

Here are the details for today's flight:

EGJJ > JW (329.0) > GUR (109.40) > SAM (113.35) > HON (113.65) > LPL (349.5) > EGGP

Estimated time en route: 70 minutes

Route distance: 285 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 146 tutorial flight, follow these steps:

1. Start Microsoft Flight Simulator.
2. Click **World Map**.
3. Click **More** and then click **Load/Save**.
4. Choose **Load From This PC**.
5. Select **Just Flight 146 tutorial flight** from the list of saved flights.
6. Click on **OK**.
7. Click **Fly**.

You should now find yourself sitting in the cockpit on Stand 4 at Jersey Airport. As we have started the flight at the gate, the aircraft has automatically loaded in a 'cold and dark' state, with all the cockpit systems switched off, 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 you to learn a considerable amount about the features and functions on board the 146.

If you wish to skip ahead and start this tutorial flight with more systems already set up, then you can load the aircraft in a 'COLD & DARK', 'READY FOR TAKEOFF' or 'TURNAROUND' state via the EFB.

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 details of each system.

For today's flight we will be navigating using the 'traditional' methods on which the 146 cockpit was developed – VOR, ADF and ILS – to acquaint you with their use. The cockpit has been retrofitted with an FMS in more recent years and guidance on using the FMS for every stage of flight can be found in the Flight Management System (FMS) section of this manual.

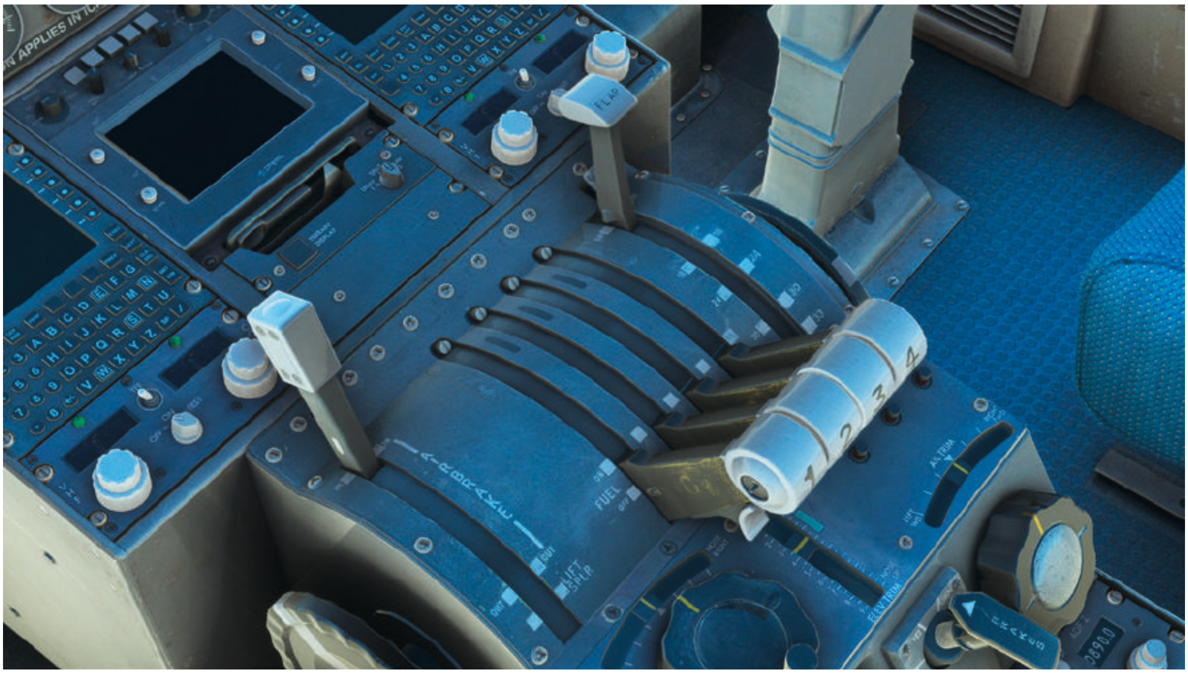
Pre-flight checks

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, confirm that the weather radar is **OFF** 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**.



We can now power up the electrical system.

On the electrical section of the overhead panel, set BATT 1 and BATT 2 to **ON**.

Confirm that the battery ammeter is showing a discharge and rotate the DC selector in turn to the **BATT 1** and **BATT 2** positions to check for a minimum of 24 volts.

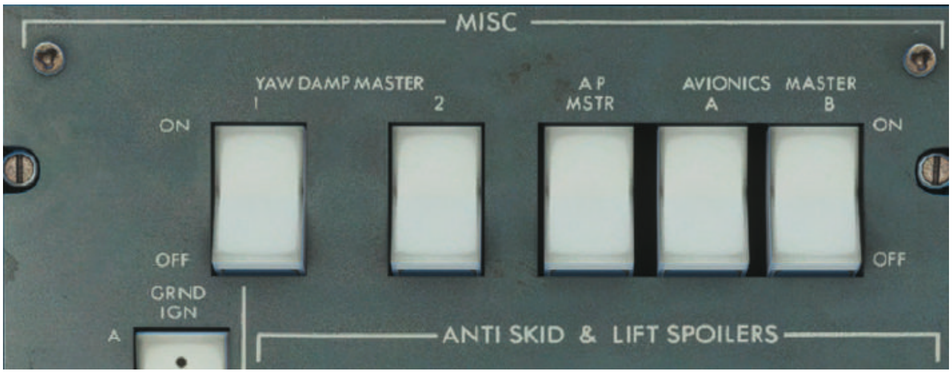
With electrical power now supplied to the aircraft, MWS cautions can be triggered at various stages of the flight. This is normal as we make selections in the cockpit and they can be cancelled by pressing the MWS amber or red buttons on the glareshield.

On the upper lights panel, set the navigation lights to **HI INT**, the no smoking signs to **AUTO** and the cabin emergency lighting to **ARM**.

Moving down to the centre panel, confirm that the landing gear is selected **DOWN** and the indicators show three greens.

On the centre console, confirm that the brake selector is set to **YEL** (Yellow hydraulic system) and pulled for parking brakes.

Returning to the very top of the overhead, on the MISC panel switch **ON** the YAW DAMP MASTER 1 and 2, AP MSTR and AVIONICS MASTER 1 and 2.



Moving down the overhead, switch **ON** the ANTI-SKID and YEL and GRN LIFT SPLRS.

Moving to the ELECTRICAL panel, set both BUS-TIE switches to **AUTO**.

Set the standby inverter (STBY INV) and generator (STBY GEN) 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 L INNER fuel pump to ensure sufficient fuel flow to the APU.

We will be using APU power to start the engines today so, moving across to the APU panel, start the APU by moving the master switch to **START**. Monitor the APU RPM and TGT as it spools 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 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 even days of the month.

We can now test the MWS by fully pushing in the MWS CTRL switch on the First Officer's side. 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 back to its middle position with the red light extinguished.

Ground tests of the Smoke, Stall, Fire Loops, Speed, Anti-Skid, Rear Bay Temperature, Flap and Horn can also be carried out using the GRND TEST section of the overhead.

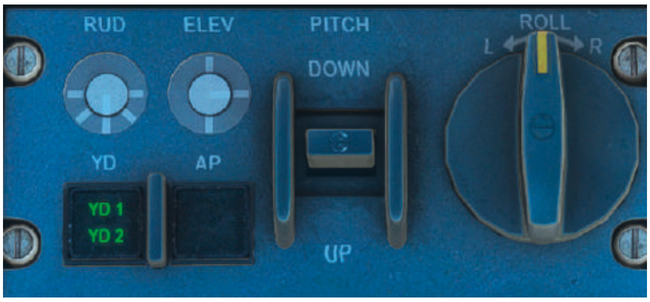
On the hydraulic panel, set the DC PUMP to **ON** and check for a rise in the YELLOW brake pressure. Once a pressure rise has been confirmed, move the DC PUMP back to the **OFF** position.

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. Once checked, set 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.

On the aft centre console, press the YD button on the autopilot controller to engage both yaw dampers. YD 1 and YD 2 annunciators illuminate to confirm engagement.



Finally, on the left and right side panels, open the oxygen main valve and confirm supply using the test feature on both pilot regulators.

We can now get the aircraft ready for passenger boarding and baggage loading.

Use the EFB tablet to open the forward passenger door and both cargo doors and extend the airstairs. The EFB can be toggled by clicking on the relevant compass deviation card on the Captain's or First Officer's panel.

The cabin crew and ground handlers can now begin their preparations for passenger boarding and the loading of baggage while we continue setting up the aircraft ready for the flight ahead.

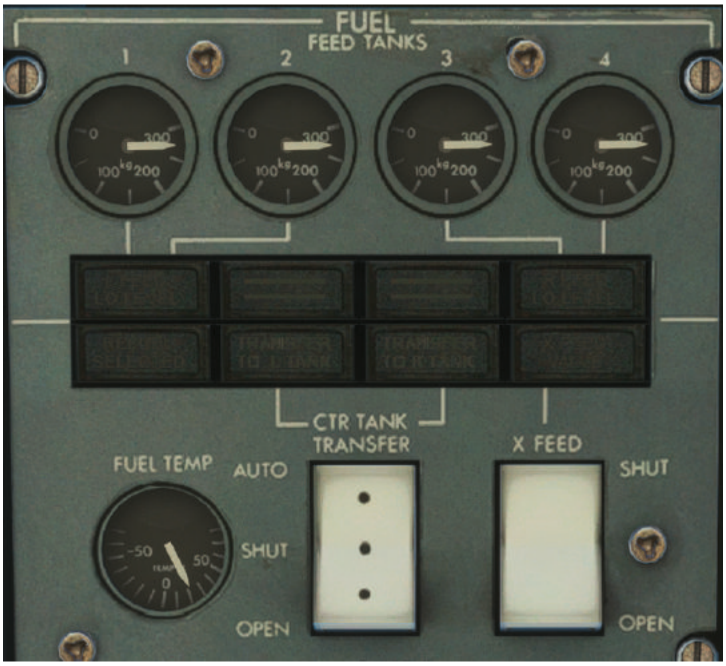
We will now work through the Before Start checklist.

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 until the pressure has risen sufficiently.

Confirm that the thrust levers are in the **FUEL OFF** position.

On the overhead, confirm that all the hydraulics are **OFF**.

On the fuel panel, set the CTR TANK TRANSFER switch to **AUTO**. Once airborne, the fuel in the centre tank will be automatically transferred out to each wing.



On the pressurisation panel, confirm that the mode selector is set to **AUTO** and the discharge valves to **NORMAL**. Use the ALT SET knob to set a flight altitude of **24,000 ft**, which corresponds to a cabin altitude target of approximately 5,500 ft.

Moving down to the ice protection panel, set the ICE DETECT switch to **ON**.

On the centre panel, confirm that we have sufficient fuel for the flight. We are carrying 3,700 kg of fuel in each of the wing tanks today and 0 kg in the centre tank.

Over on the First Officer's side panel, confirm that today's date is set on the Flight Data Recorder (this is initialised automatically each time the aircraft is loaded) and that the flight leg is set to 1. You can also use the thumb-wheel selectors to set your own flight number.

On the transponder panel, press the ATC/FID button to switch from ATC mode to FID mode. You can now input your flight ID, for example JF123, using the keypad. Press **ENTER** to confirm your input.

Press the ATC/FID button again to return to ATC mode.

We can now configure the TMS (Thrust Modulation System) for take-off. This is an unusual and interesting system that requires a bit of study.

Press the **PWR** button to power up the TMS and press **TEST** to start the built-in test.

Once the test is complete, set the TREF to the outside air temperature: **+15°C**.

Press the **TO** button to arm Take-off mode. The N% display will now show the N1 setting for the current pressure altitude, selected ambient temperature and engine anti-ice setting.

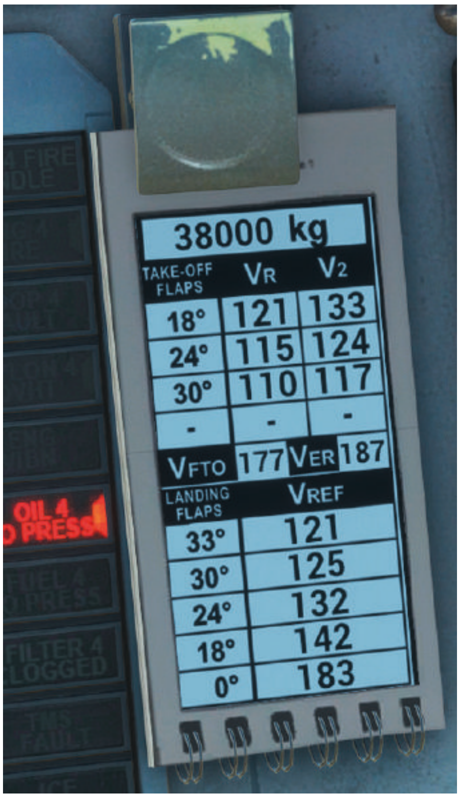
Set the TGT to our maximum climb temperature: **840°C**.

On the centre panel, set the N1 and TGT bugs to the values shown on the TMS.

The final step when reviewing our take-off performance is to look at the take-off speeds. A handy flipchart of speeds is mounted below the landing gear lever. In the real aircraft you would have to flip to the page that corresponds to the nearest aircraft weight, but we have automated that process and the appropriate page will be shown based on the aircraft weight.

The current aircraft weight is approximately 38,000 kg, which has been rounded up on the flipchart to the nearest thousand.

We will be using flaps 18 for take-off, giving us a VR of **121 KIAS** and V2 of **133 KIAS**. VFTO (final take-off speed) is **177 KIAS**, which is the speed we will climb at in the event of an engine failure.



Set the reference speeds on the ASI using the coloured bugs.

Note: *N1, TGT and V-speed bugs can be set automatically by clicking on the flipchart. V-speed bugs are set based on the current flap position, with flaps 0 also setting the flaps 18 speeds for convenience.*

With all bugs set, we will now turn **OFF** the TMS so it doesn't interfere with our engine start.

We can now configure the navigation instruments for our departure.

Switch **ON** the flight director bars.

Switch on the VHF NAV 1 radio by pushing in the central ON button and rotating the DME knob to **ON**. It will go through a warm-up process before displaying the current active and pre-selected frequencies.

Tune the first VOR on our flight plan, GUR (**109.40**), into the active slot.

Rotate the NAV 1 course selector to set **332 degrees**, which is our course inbound to the VOR.

For the initial climb we are going to maintain the runway heading, so rotate the HDG knob to set the heading bug to **263 degrees**. Press the **HDG** button on the glareshield to arm the autopilot's heading mode.

As we won't be using ATC today, select our cruise altitude of **24,000 ft** and press **ALT ARM**.

On the aft centre console, tune ADF 2 to **329.0**, the frequency for the JW NDB. Rotate the ADF 2 mode knob to the **ADF** position. We will use the NDB for guidance following take-off as it is 1 NM straight ahead during the initial climb.

On the RMI/DBI, select the left button to VOR and the right button to ADF. In this configuration the distance and bearing to the GUR VOR will be shown by the left button, and the bearing to the JW NDB by the right.

Confirm that the HSI source is set to NAV, allowing the NAV 1 radio to supply the HSI.

Finally, although we won't be using ATC today, switch **ON** the VHF COMM 1 and 2 radios.

Starting the engines

Once all the passengers have boarded, we need to retract the airstairs. However, as the retraction of the airstairs is powered by the YELLOW hydraulic system, and as we currently have no engines running, we will need to use the AC pump to pressurise the YELLOW hydraulic system. On the overhead panel, set the AC PUMP switch to **ON**, retract the airstairs via the EFB and return the switch back to **OFF**.

Close all passenger and cargo doors and remove the chocks.

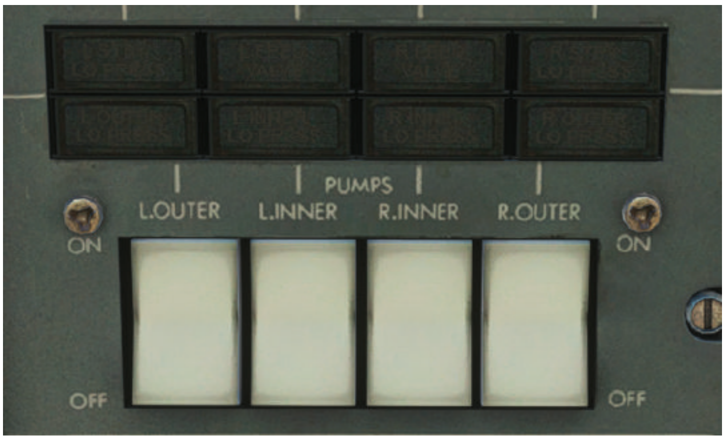
Set the FASTEN BELTS switch to **ON**.

Switch **ON** the beacon lights.

Set the APU AIR switch to **OFF** and confirm that both PACK switches are **OFF**.

Release the parking brake and begin pushback so the aircraft is facing to the east, ready for engine start. Set the parking brake once pushback is complete.

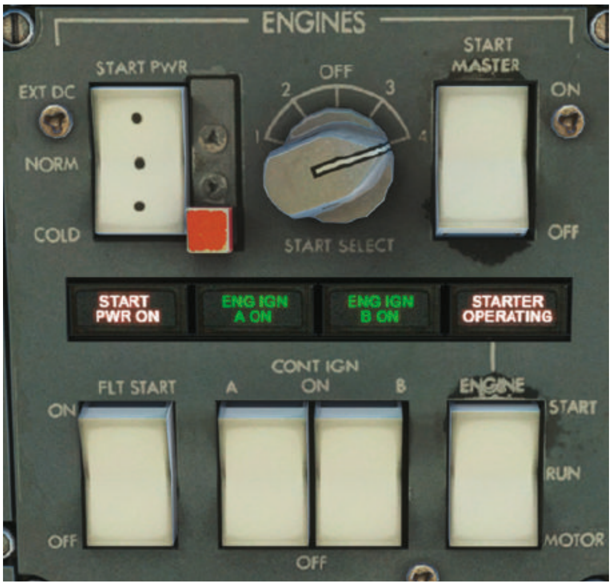
On the overhead panel, switch **ON** all four fuel pumps.



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 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, TGT and N2 values. Once N2 reaches approximately 10%, advance the thrust lever from FUEL OFF to **FUEL ON**. Confirm fuel flow and that N1/TGT/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 to **OFF**.

As we are not expecting any icing conditions on our flight today, we can now turn **OFF** the engine anti-ice.

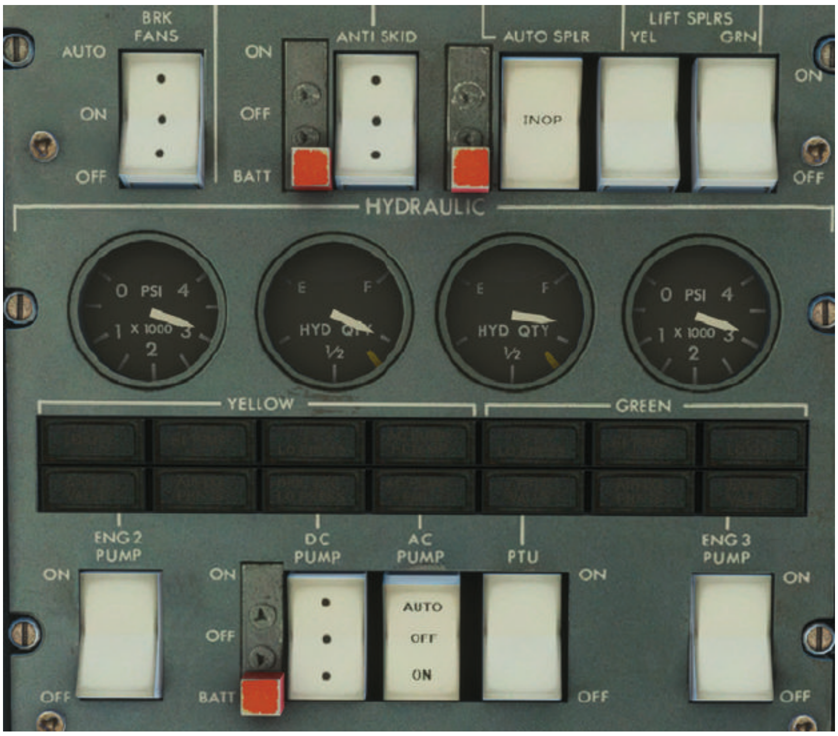
On the electrical panel, set GEN 1 and GEN 4 to **ON**. The generators on engines 1 and 4 are now supplying electrical power.

Switch the APU AIR back **ON** to supply air conditioning to the cabin during taxi and take-off.

Switch **ON** both PACK switches.

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, turn **ON** both the AC PUMP and PTU to supplement hydraulic power in the event of failure during take-off.



On the ICE PROTECTION panel, switch **ON** all the heaters.

The TMS can now be switched **ON** again with TO mode armed in preparation for take-off.

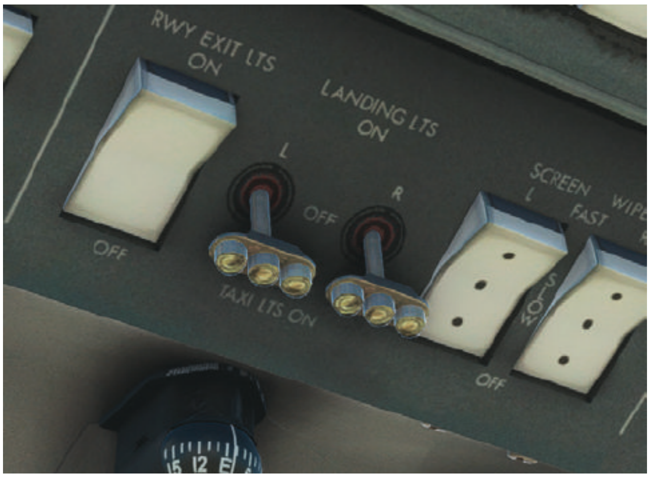
Finally, rotate the transponder mode knob to **TA**.

Taxi

We can now begin the short taxi to runway 26 via taxiway A.

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 26 and hold short so we can run through the Before Take-off checklist.



Confirm that the flaps have extended to **18 degrees**.

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.

If there is standing water present on the runway or heavy precipitation in the area, switch **ON** the CONT IGN A & B switches on the overhead panel for continuous ignition in the event of engine failure during take-off and climb.

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 and then move the Cabin Secured slider to the correct position at the rear of the centre console.

Switch **ON** the landing and strobe lights.

Confirm that the TMS is on, TO mode is engaged and N1 REF is shown.

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 them to approximately N1 according to the bugs that you set previously. With TO mode engaged on the TMS, it will more precisely set the N1 thrust on all engines to the computed N1 REF value.

Once N1 thrust has been achieved, release the brakes and keep the aircraft running down the centre line with small rudder inputs. As you approach **121 knots**, start to raise the nose of the aircraft. Slowly bring the nose up 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 undercarriage using the **[G]** key and adjust the elevator trim as required to maintain the V2 + 10 speed of **143 knots**, manually holding the runway heading (263 degrees) and retracting the flaps as you climb through VFTO speed and 1,500 ft AGL.

Once stable in the climb, adjust your pitch to maintain a climb speed of **190 knots** and maintain your westerly heading.

Climb

As you climb through 2,000 ft AGL, engage the autopilot and **VS mode**. The autopilot will hold the easterly heading and this vertical speed.

Start reducing thrust to maintain a climb speed of approximately **220 KIAS**. The base line climb thrust in the 146 is 88% N1, increasing 1% for every 5,000 ft of altitude.

Press the SYNC button on the TMS to engage SYNC mode and press the MSTR (master) button to select engine 1 as the master engine. The TMS will now adjust the engine 2, 3 and 4 thrust settings to match that selected by engine 1.

We can now begin a right turn towards the GUR VOR, using the heading bug to set an initial heading of **300 degrees**. On the glareshield, engage V/L (VOR LOC) mode. This will be pre-selected so that as we intercept the 332-degree inbound course to the VOR, the autopilot will switch from maintaining our selected heading to the inbound course.

With VS (vertical speed) mode engaged you can use the autopilot SYNC feature to adjust the selected vertical speed (this can be assigned to the ‘TOGGLE AFTERBURNER’ assignment in MSFS). With SYNC mode enabled you can manually pitch the aircraft to command a new vertical speed. Disabling SYNC mode will then trigger the autopilot to hold the newly selected vertical speed. Alternatively, you can use IAS mode for pitch control in the climb.

We can now carry out the After Take-off and Climb checks.

Confirm that the gear and flaps are **UP/RETRACTED**.

Set all four engine air switches to **ON** and then switch **OFF** the APU air. Confirm that the aircraft is pressurising.

Switch **OFF** the AC pump and PTU.

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.

Passing through 10,000 ft, switch **OFF** the landing lights and Fasten Seatbelts signs and increase the climb speed to **250 KIAS** using either VS or IAS mode.

We can now pre-select the next VOR on the VHF NAV 1 radio. Move the ACT/PRE switch to **PRE** and then use the frequency selector knobs to select **113.35** for the SAM VOR.

Once within 5 NM of the GUR VOR, as indicated on the HSI, synchronise the heading bug to your current heading and engage **HDG** mode.

Select the inbound course to the SAM VOR, **030 degrees**, using the NAV 1 selector on the glareshield.

Use the flip button on the VHF NAV 1 radio to flip the SAM frequency into the active slot and then pre-select V/L (VOR LOC) mode. The autopilot will now intercept and then hold the course to SAM.

Returning briefly to the TMS, when using higher thrust settings in the climb you can engage MCT mode. This mode allows you to set maximum continuous thrust by advancing the thrust levers and letting the TMS actuators adjust them to maintain MCT. However, to preserve engine life, it is recommended that you climb in SYNC mode with the lower N1 values as discussed earlier.

We will continue to climb in IAS mode at 250 knots until reaching 24,000 ft. If we were to climb above 24,000 ft, we would switch to Mach mode and hold Mach 0.6 until reaching our cruising altitude.

Cruise

On reaching the pre-selected cruise altitude of 24,000 ft, the autopilot will level off and hold the altitude.

The 146 is not fitted with an autothrottle, only the TMS, so as the airspeed increases you will need to reduce thrust to maintain the desired cruise speed of **280 KIAS** or **Mach 0.68**.

You will shortly need to repeat the VOR change process from SAM to HON (113.65 on a course of 352 degrees) and again once overflying the HON VOR (113.65 on a course of 338 degrees).

Over on the First Officer's side, confirm that the cabin altitude has stabilised at the selected value, with a differential pressure within limits.

This indicator is the primary source of information for the pressurisation system during flight, but the overhead panel can also be referred to for the position of the outflow valves.

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.

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 146 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 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 for the currently selected VOR. 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!

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.

This would also be a good time to get acquainted with the FMS CDUs, referring to the FMS manual for information on each page. Don't worry – the FMS will have no effect on our navigation with the HSI source selector set to NAV.

Descent

To reduce the workload in the descent and approach phases, we can tune the ILS frequency for the approach into the pre-select slot now: **111.75**.

We can also tune an NDB that will be used for the approach. Tune LPL (349.5) into the ADF 2 radio and confirm that the RMI/DBI right selector is still set to **ADF**.

Set your Decision Height at **200 ft** on the RAD ALT panel.

We will begin our descent when we are **10 NM** outbound of the HON VOR, as indicated by the HSI and RMI/DBI.

Reduce your speed to **250 KIAS** and select a new altitude of **2,000 ft** before arming it. Engage **VS** hold mode and use the autopilot SYNC mode to pitch down to **-2,000 ft/min** before deselecting the autopilot SYNC mode to maintain that descent rate. The autopilot SYNC mode is very useful for fine-tuning a vertical speed.

Remember to reduce thrust to maintain 250 KIAS during the descent and use the airbrake if required.

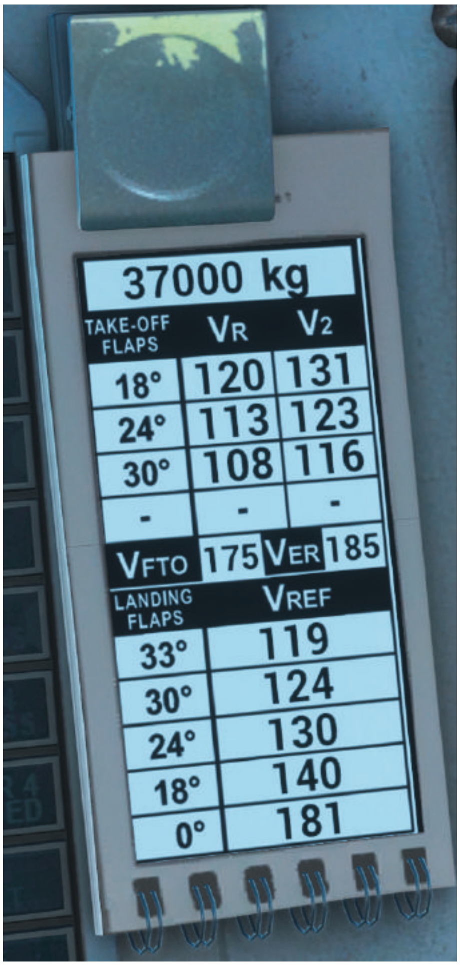
Engage **DESC** mode on the TMS. This will ensure that there is sufficient supply to the air conditioning and engine anti-ice systems by computing and maintaining a minimum N2 thrust setting if we select flight idle.

We can now work through the Descent checklist.

Switch **ON** the PTU.

Liverpool John Lennon Airport is situated at 60 ft above sea level, so reduce the cabin altitude target on the overhead to approximately **60 ft** to allow the pressurisation system to automatically handle the descent.

Check the flipcharts for our VREF speed for the approach. We will be using **33 degrees** of flap today.



Approach and landing

We will continue to fly outbound from the HON VOR on a course of 338 degrees to intercept the ILS 27 approach.

When we are **55 NM** outbound of the HON VOR, we will use the previously tuned NDB to guide us onto the ILS approach in the absence of ATC vectors.

Using either HDG mode or by hand-flying the aircraft, use the RMI/DBI needle to set a course towards the LPL NDB.

Now flip the VHF 1 NAV frequency so that the ILS frequency (111.75) is in the active slot and set the NAV 1 course to the ILS course: **266 degrees**.

Passing through 10,000 ft, switch **ON** the landing lights and reduce speed to **220 KIAS**.

We can now carry out the Approach checks.

Switch **ON** the fasten seatbelts sign.

When passing through 5,000 ft, select the APU master to **START** and confirm that the RPM and TGT rise.

Keep monitoring the altitude and speed. On reaching 2,000 ft the autopilot will level off the aircraft and the speed will quickly decrease, especially if the airbrake is deployed. Increase thrust to maintain **220 KIAS**.

Continue to reduce your airspeed to **200 KIAS**.

Once you are stabilised on a direct course to the NDB, engage **V/L** (VOR LOC) mode to arm localiser hold mode and **GSL** (glideslope) mode to arm glideslope hold mode.

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. Once confirmation is received, move the Cabin Secured slider at the rear of the centre console to the correct position for landing.

Once the ILS has been intercepted, the autopilot will turn and descend onto the approach.

Check that your airspeed is below 205 KIAS and then select **flaps 18**.

Lower the landing gear and confirm three greens.

Reduce your airspeed further towards **VREF + 10** and extend the flaps to **33 degrees**.

With landing flaps set, we can now click on the V-speeds flipchart again, to automatically set our landing speed bugs.

We can now carry out the Landing checks.

Set the AC pump to **AUTO**.

Switch **ON** the APU air and switch **OFF** the engine air.

Confirm that the brakes are selected to **YEL** (Yellow).

Confirm that the flaps are indicating **33 degrees**.

The TMS will automatically disconnect when passing 200 ft, but you may also manually disconnect the TMS now by pressing the TMS disconnect switch on the Engine 1 thrust lever (this can be assigned to the ‘AUTO THROTTLE TO GA’ control assignment in MSFS).

Passing through 500 ft, disconnect the autopilot and begin reducing speed to VREF.

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, gently lower the nose-wheel onto the runway and extend the lift spoilers by moving the airbrake handle fully aft. Apply gentle braking and, once the aircraft has slowed, turn onto the first available taxiway to the right.

We can carry out the After Landing checks once you are safely off the runway.

Retract the flaps, airbrakes and lift spoilers.

Switch **ON** the taxi lights and switch **OFF** the strobe lights.

Switch **OFF** the TMS.

Set the transponder back to **STBY**.

Check both CONT IGN A & B switches are **OFF**.

Shutdown

Begin your taxi to the nearest available stand.

Switch **OFF** the taxi lights as you turn onto the stand.

Once you have come to a stop on the stand, engage the parking brake.

Confirm that the aircraft is depressurised – the cabin altitude should match the airfield elevation.

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.

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** all heaters.

Switch **OFF** ice detection.

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.

Leaving the aircraft

Switch **OFF** the Yaw Damper Master 1 and 2 switches.

Switch **OFF** the AP Master switch.

Switch **OFF** the Avionics Master A and B switches.

Once the brakes are sufficiently cool, as shown on the brake temperature gauge on the centre console, the brake fans can be switched **OFF**.

Switch **OFF** Anti-Skid.

Switch **OFF** both the YEL and GRN lift spoilers.

Switch **OFF** the cabin emergency lights and confirm 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 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.

Switch **OFF** all the 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 146 Professional tutorial flight!

LIMITS

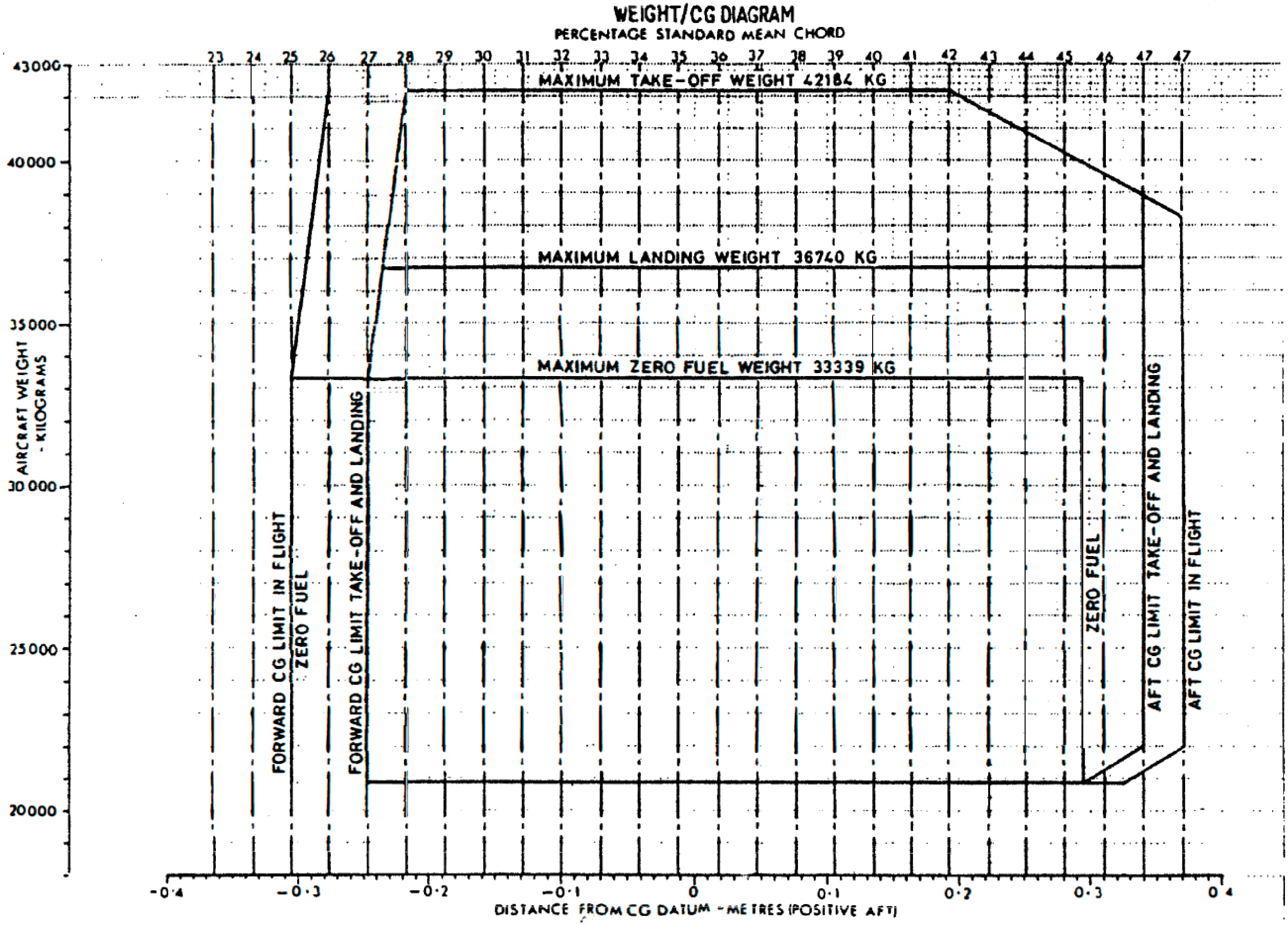
Weight and loading limits

Maximum total weight	93,500 lb (42,411 kg)
Maximum take-off weight	93,000 lb (42,184 kg)
Maximum landing weight	81,000 lb (36,740 kg)
Maximum zero fuel weight	73,500 lb (33,339 kg)

The centre of gravity of the aircraft should always lie between the forward and aft limits defined in the envelope in the chart on the following page.

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 1,249.2 cm (491.81 inches). This is 1.219 m (4.0 feet) forward of the reference point which is indicated by two plates at the rear end of the landing gear wheel well pressure floor.



WEIGHT/CG DIAGRAM
PERCENTAGE STANDARD MEAN CHORD
23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 47
MAXIMUM TAKE-OFF WEIGHT 42184 KG
MAXIMUM LANDING WEIGHT 36740 KG
MAXIMUM ZERO FUEL WEIGHT 33339 KG
43000
40000
35000
30000
25000
20000
AIRCRAFT WEIGHT - KILOGRAMS
FORWARD CG LIMIT IN FLIGHT
ZERO FUEL
FORWARD CG LIMIT TAKE-OFF AND LANDING
ZERO FUEL
AFT CG LIMIT TAKE-OFF AND LANDING
AFT CG LIMIT IN FLIGHT
-0·4 -0·3 -0·2 -0·1 0 0·1 0·2 0·3 0·4
DISTANCE FROM CG DATUM - METRES (POSITIVE AFT)

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	–	–

Airspeed limitations

Maximum operating speed (VMO)	295 KIAS
Maximum operating Mach number (MMO)	M0.70
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:

Setting	Intended usage	Max. speed (KIAS)
UP	En route and normal hold	VMO
18°	Take-off and approach	210
18°	Low speed hold	175
24°	Take-off, approach, climb	180
30°	Take-off	170
33°	Landing	145

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

Maximum operating altitude

Flaps up 30,000 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 14,000 ft.

Maximum operating temperature

The maximum air temperature for take-off and landing is +50˚C at altitudes below 2,525 ft and ISA +40˚C at altitudes from 2,525-8,000 ft.

The maximum en route temperature is ISA +35˚C.

Maximum ground temperature soak

The aircraft must not be dispatched in ground ambient temperatures less than -40˚C.

Maximum airfield altitude for take-off and landing

The maximum airfield altitude for take-off and landing is 8,000 ft.

Cabin pressure

The maximum normal pressure differential is 6.55 lb/sq.in.

The cabin shall be at zero differential pressure during take-off and landing.

Precision approach and landing

The aircraft is approved only for the following kinds of ILS approach and landing:

- Category 1
    - Manual approach with or without flight director
    - Automatic coupled approach and manual landing
- Category 2
    - Automatic coupled approach and manual landing

Autopilot

General

The autopilot may be engaged in pitch, IAS or VS modes at not less than 300 ft AGL after take-off.

The autopilot must not remain engaged when descending below 1,000 ft AGL except in accordance with the following paragraphs.

The localiser may be intercepted with flaps at 0° or 18° but it is recommended that if the localiser intercept range is less than 10 nautical miles, the intercept should be made with flaps 18°.

Non-precision approach

The autopilot may remain engaged down to 500 ft AGL provided that pitch, IAS or VS modes are used and that the rate of descent is less than 1,000 ft/min. The LNAV mode must not be used for an IFR approach.

Category 1 ILS approach

The autopilot may remain engaged down to 50 ft if coupled to an ILS localiser and glideslope.

Category 2 ILS approach

The autopilot may remain engaged down to 50 ft if coupled to an ILS localiser and glideslope.

- The decision height must be identified by reference to radio altitude and must not be less than 100 ft or the Obstacle Clearance Altitude/Height (OCA/H).
- The autopilot must be coupled to an ILS which conforms to the requirements for Category 2 operation.
- All four engines must be operating.
- The yaw damper must be serviceable and engaged.
- Both CAT 2 green annunciators must be lit at 500 ft and remain so until the autopilot is disengaged.
- The following displays must be serviceable throughout the approach:
    - All three attitude displays
    - Both heading displays
    - All primary air data displays
    - Both radio altimeter displays

The maximum wind components in which the ILS coupling performance has been demonstrated to meet Category 2 requirements are:

Head: 25 kts

Tail: 10 kts

Cross: 15 kts

Flight director

General

Use of the approach modes V/L and GSL must be monitored by the non-controlling pilot using raw radio information.

Use of the go-around mode (GA) must be monitored by the non-controlling pilot using raw attitude information. If a go-around is carried out with a comparator ATT warning or with an ADI ATT flag displayed, pitch attitude must be controlled by reference to the Standby Attitude Indicator.

Yaw damper

If the system will not remain engaged in flight, airspeed should be limited to 240 KIAS.

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.

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.

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 selected ON, the following limitations apply:

- Non-icing conditions:
  - The maximum airspeed above 21,000 ft is 230 KIAS.
  - The maximum altitude is 25,000 ft.
- Icing conditions:
  - The maximum airspeed above 19,000 ft is 230 KIAS.
  - The maximum altitude is 22,000 ft.

Bleed air may not be used in flight above an altitude of 15,000 ft.

Operating limitations

Maximum TGT during running	732°C
Maximum TGT during starts	870°C (974°C for 10 secs)
Overspeed shutdown	110% RPM
Starting envelope	Max. altitude – 15,000 ft
	Max. speed – 250 KIAS to 10,000 ft, reducing to 200 KIAS at 15,000 ft

Engines

Operating limitations

Condition	N1 (%)	N2 (%)	TGT (°C)	Duration	Oil pressure (PSIG)	Oil temp (°C)	Vibration
Start and relight	–	–	824	Max. 10 secs above 799	–	-40 to 133°C	–
Normal take-off	96.7	98.8	882	5 mins	87 to 107		Max. 1.2
Max. continuous	96.7	96.9	857	–	87 to 107		Max. 1.2
Flight idle	–	Min. 60.0	–	–	35 mins		–
Ground idle	–	Min. 50.0 to 51.0	–	–	25 mins		–

Flexible thrust operation

Flexible thrust (reduced thrust) must not be used for take-off unless the following conditions are met:

1. Runways must not be wet or contaminated with snow or ice.
2. The availability of the rated thrust must be periodically checked to ensure no excessive engine deterioration.

When flexible thrust is used, the following must be observed:

1. N1 flex must not be greater than N1 ref.
2. N1 flex must not be less than 78% N1.
3. N1 flex must not be less than N1 ref minus 8.0%.

NORMAL PROCEDURES

This simulation includes fully interactive checklists for each stage of the flight, using the built-in MSFS checklist system. These can be carried out manually or by using the automated Co-pilot option.

Air conditioning

Flight deck safety

Note: *It is assumed that the APU is running.*

Ground test

REAR BAY HI TEMP button	Press and hold
MWS audio	Single chime
MWS amber caution lights	Flashing
REAR BAY HI TEMP annunciator	Lit
MWS AIR COND caption	Lit
REAR BAY HI TEMP button	Release
MWS caution lights, caption and annunciators	OFF

Ground pressurisation

GRND PRESSN button	Press and hold
GRND PRESSN button	Lit
GRND PRESSN button	Release

Air conditioning

DISCH VALVES	Normal
Manual rotary control	Mid position
Mode selector	Confirm AUTO
Packs 1 and 2 switches	OFF
Ram air switch	SHUT
APU air	ON, APU TGT stabilised
DISCH VALVE indicators	Check OPEN
Pack 1 switch	ON, APU TGT stabilised
Pack 2 switch	ON, APU TGT stabilised
FLT DECK and CABIN TEMP CTRLS	AUTO
AUTO TEMP rotary controls	As required
CABIN FAN switch	ON
FLT DECK FAN switch	As required

Pressurisation

DISCH VALVES rotary selector	NORMAL
Discharge valves indicators	OPEN if AIR SUPPLY ON, otherwise SHUT
MAN SHUT-OPEN rotary selector	Set mid position
MODE selector button annunciator	Out, if lit press mode selector button
ALT/BARO SET rotary	PULL BARO SET 1013.2 mb (29.92 inHg) then depress and set FLIGHT ALT as required

For cruise altitudes up to 28,000 ft set FLIGHT ALT to the planned cruise altitude. The cabin differential pressure will then be approximately 6.3 PSI at the cruising altitude. For a cruise altitude of 28,000 ft or above, set the CABIN altitude to 8,000 ft.

Air conditioning

FLT DECK/CABIN TEMP CTRL AUTO/MAN switches	AUTO
AUTO rotary selectors	Mid position
FLT DECK/CABIN FAN switches	As required
CABIN AIR switch	FRESH or RECIRC if required
PACK 1/2 switches	OFF, unless required for A/C
RAM AIR switch	As required
APU AIR switch	OFF, unless required for A/C
APU VLV NOT SHUT annunciator	Out
ZONE TEMP DETECT L/R WING	BOTH LOOPS
ENG AIR switches	OFF

Starting

PACK 1/2 switches	OFF
APU AIR switches	OFF

After start

APU AIR switch	ON. Check APU TGT stabilises.
DISCH VALVES	Check OPEN
PACK 1 switch	ON
PACK 2 switch	ON
RAM AIR switch	As required

Descent

Cabin RATE of change	Set control to detent position (300 ft/min)
CABIN altitude	Set destination pressure altitude

Shutdown

PACK 1 & 2 switches	OFF
FLT DECK & CABIN FAN switches	OFF
APU VLV NOT SHUT & NRV LEAK annunciators	Check out
APU TGT	Stabilised

Autoflight

Flight deck safety

YAW DAMP MASTER 1 & 2	ON
AP MSTR	ON
AVIONICS MASTER A & B	ON
FD BARS switches (left and right)	ON. AFGS pitch and roll panel legends lit.
ALERTS BRT/DIM switch	Checked and set as required
FLT ANNUN TEST button	Press and hold
FLT annunciators	All panels and AFGS mode selector panel legends lit
FLT ANNUN DIM knob	Release. Panel legends out, except pitch and roll.
YD mode flight annunciators	Lit
YD engage/disengage button	Press
YD1/YD2	Lit
YD mode flight annunciators	Out
AP engage/disengage button	Depress, check IN lit
AFGS MCP green AP annunciator	Lit
Captain's AP cut-out button	Press and release
Autopilot	Disengaged, checked, elevator and aileron controls free
Audio warning	Operates for two cycles
AP red mode annunciator	Lit for approx. one second
AP engage/disengage button	Depress, check IN indication is lit
AFGS MCP green AP annunciator	Lit
Control handwheel	Move aft then forward
Elevator trim wheel	Rotate and check indicator
AP engage/disengage button	Press and release, check IN indication goes out
Audio warning	Operates continuously
AP red mode annunciator	Lit
AP cut-out button	Press twice
AP mode annunciator	Out
Audio warning	Cancelled

Flight Director display	GA mode. FD bars wings level, pitch nose up.
GA green mode annunciators	Lit
FD BARS switches	OFF

Leaving aircraft

YAW DAMP MASTER 1 & 2	OFF
AP MSTR	OFF
AVIONICS MASTER A & B	OFF

Communications

Flight deck safety

AVIONICS MASTER A & B	ON
VHF COMM 1 & 2	ON
Rotary selector	Confirm audio
Squelch button	As required
Frequency selector	As required
Audio selector panels	As required
CVR Test button	Press, check indicator shows ‘good’, release button

Leaving aircraft

AVIONICS MASTER A & B	OFF

Electrical power

Flight deck safety

BATT switch	ON
VOLT/AMP rotary selector	BATT
Voltage	Min. 23 volts
MWS amber caution light	Press to cancel
AC & DC switches	AUTO
STBY INV & GEN	ARM
EMERG AC OFF annunciator	Out
Left HSI	Fail flag not in view
Altimeter	Fail flag not in view

Standby attitude indicator	Fail flag not in view
TGT indicators	Fail flag not in view
Brake indicators	Reading (yellow system only)

Generator control switches 1 & 4	OFF/RESET
APU generator control switch	ON

EXT AC (if required)	Check ON (green EXT AC PWR AVAILABLE annunciator lit

Rotary selector	EXT AC, volts and frequency in green sectors
EXT AC switch	ON
MWS red alert light	Press to cancel

GEN 4 control switch	OFFLINE
AC rotary selector switch	ENG 4 GEN
Volts and frequency	In green band
GEN 4 control switch	ON
Repeat for GEN 1	Checked and ON
EXT AC switch	OFF

If ENG 1 & 4 to be shut down for taxi in:

Flaps	Indicating zero
APU GEN	ON. Check output.
GEN 1 & 4	Select OFF/RESET

Before shutdown

GEN 1 & 4	OFF/RESET

Select GEN 1 and GEN 4 to OFF/RESET before engines 1 and 4 respectively are shut down.

Leaving aircraft

BATT switches 1 & 2	OFF

Fire protection

Flight deck safety

ENG FIRE 1 test button	Press and hold
FIRE EXT HANDLE red lamp	Lit
MWS audio	Firebell
MWS red alert lights	Flashing

MWS amber caution lights	Flashing
ENG 1 FIRE red caption	Lit
LOOP 1 FAULT amber caption	Lit
ENG 1 red thrust lever lamp	Lit
MWS red alert light	Press and release
MWS audio, alert and caution lights	Cancelled
ENG FIRE 1 test button	Release
FIRE EXT HANDLE lamp	Out
ENG 1 FIRE caption	Out
LOOP 1 FAULT amber caption	Out
ENG 1 thrust lever lamp	Out

Repeat for other engines.

APU FIRE test button	Press and hold
MWS audio	Firebell
APU FIRE red caption	Lit
APU amber caption	Lit
MWS red alert lights	Flashing
MWS amber caution lights	Flashing
APU FIRE red annunciator	Lit
APU LOOP FAULT amber annunciator	Lit
MWS alert light	Press and release
MWS audio, alert and caution lights	Cancelled

APU FIRE test button	Release
APU FIRE red caption	Out
APU amber caption	Out
APU FIRE red annunciator	Out
APU LOOP FAULT amber annunciator	Out

ENG + APU EXT test button	Press and hold
ENG EXT USED white annunciators	Lit
APU EXT USED white annunciators	Lit
ENG + APU EXT test button	Release
ENG EXT USED white annunciators	Out
APU EXT USED white annunciators	Out

SMOKE test button	Press and hold
MWS audio	Triple chime
MWS red alert lights	Flashing
ELECT SMOKE red caption	Lit

SMOKE test button	Release
MWS audio, alert lights and caption	Cancelled
FIRE HANDLES 1, 2, 3, 4	Fully in

Flight controls

Flight deck safety

Airbrake lever	Full forward
Flap lever	Agrees with flap position ind.
AVIONICS MASTER A & B	ON
ANTI SKID switch	ON
LIFT SPLRS, YEL, GRN switches	ON
STALL IDNT 1 button	Press and hold
MWS audio	Single chime
MWS amber caution lights	Lit
IDNT 1 amber annunciators	Lit
STALL IDNT caption	Lit
STALL IDNT 1 button	Release
MWS caution lights, caption and annunciators	Cancelled
STALL IDNT 2 button	Check as STALL IDNT 1
STALL WARN 1 button	Press and release, check No.1 stick shaker operates
STALL WARN 2 button	Check as STALL WARN 1
FLAP SAFETY button	Press and release
MWS audio	Single chime
MWS amber caution lights	Flashing
MWS FLAP INOP amber caption	Lit for 12-15 seconds
MWS caution lights and caption	Cancelled

Note: *If MWS FLAP FAULT amber caption was lit before initiating test, caption should go out after 12-15 seconds.*

FLAP CTRL FAULT YEL button	Press and release
MWS amber caution lights	Flashing
MWS FLAP FAULT amber caption	Lit for 12-15 seconds
MWS caution lights and caption	Cancelled
FLAP CTRL FAULT GRN button	Check as for FLAP CTRL FAULT YEL

Note: *Both YEL and GRN systems must be pressurised before the rudder trim check.*

RUD TRIM	Check full movement and indication. Set neutral.
AIL TRIM	Check full movement and indication. Set neutral.
ELEV TRIM	Check full movement
ELECTRIC TRIM	Check operation and sense
ELEV and AIL DISCONNECT handles	Fully in
MWS amber AIL/EL UNCPLD caption	Out

Before take-off

FLAP lever	Select and confirm take-off setting with flap indicator
ELEV TRIM indicator	Set to appropriate value for aircraft CG
RUDDER TRIM indicator	Neutral
AIL TRIM indicator	Neutral
CONFIG CHECK button	Press and hold
MWS red CONFIG caption	Out
Audio	No intermittent horn
CONFIG CHECK button	Release
Controls	Checked full and free

After take-off

FLAP lever	UP
Flap indicators	Show flaps up

Note: *When at or above 400 ft and clear of obstacles, allow aircraft to accelerate through the standard flap retraction airspeed schedule.*

Landing

Flaps	Set for landing

After landing

Airbrake and lift spoilers	IN
Flaps	UP

Leaving aircraft

AVIONICS MASTER A and B	OFF
LIFT SPLRS, YEL, GRN switches	OFF

Fuel

Flight deck safety

FUEL FLOW indicators	Pull to zero totalizers
FUEL QUANTITY indicators	Check reading

Before start

FEED TANKS indicators (x4)	FULL
L/R FEED LO LEVEL annunciators	Out
CTR TANK TRANSFER switch	AUTO if fuel in centre tank, otherwise shut

Note: *With CTR TANK TRANSFER selected at AUTO, fuel transfer will commence automatically after take-off. With AUTO selected a small quantity of fuel will remain in the centre tank when transfer ceases. Select OPEN to transfer this fuel. Select SHUT on completion of transfer.*

X FEED	SHUT

Note: *During normal conditions, each engine is fed directly from its respective feed tank; use common and cross-feed valves only as required.*

L & R STBY PUMPS switches	NORM
COMMON FEED, L & R switches	SHUT
FUEL PUMP switches (x4)	ON
Panel annunciators (x16)	Out

Note: *The recommended minimum amount of fuel per wing for take-off is 317 kg (700 lb).*

FUEL USED reset knobs (x4)	ZERO
Fuel flow indicators	Pull, check 0000
Fuel indicators	Left and right balanced

Approach

Fuel quantity	Check
X FEED, COMMON FEED L & R	Shut

Note: *The recommended minimum amount of fuel per wing for go-around is 159 kg (350 lb).*

Shutdown

FUEL PUMP switches (x4)	OFF

Hydraulic power

Flight deck safety

Content indicators	Not below amber mark
DC PUMP switch	Hold ON
YELLOW brake pressure	Check pressure is increasing
DC PUMP switch	Release to OFF
AC PUMP	ON
LO PRESS amber annunciator	Out (above 1,750 PSI)
YELLOW system pressure	3,000 ± 50 PSI
AC PUMP FAIL annunciator	Out
PTU switch	ON
PTU VALVE annunciator	Out
LO PRESS amber annunciator	Out
Green system pressure	2,600 ± 200 PSI
AC PUMP	OFF
PTU switch	OFF

Before start

ENG 2 PUMP switch	OFF
DC PUMP switch	OFF
AC PUMP switch	OFF
PTU switch	OFF
ENG 3 PUMP switch	OFF

Starting

AC PUMP switch	OFF

After start

ENG 2 PUMP switch	ON, check YELLOW system pressure rises to 3,100 ± 50 PSI
ENG 3 PUMP switch	ON, check GREEN system pressure rises to 3,100 ± 50 PSI
HYDRAULIC annunciators and MWS amber HYD caption	Check out
PTU	ON

Note: *If aircraft is to be pushed back, ENG 3 PUMP and PTU should not be selected ON until the towbar has been disconnected. If an AIR LO PRESS annunciator remains lit, increase the relevant engine RPM until annunciator goes out and then return to ground idle – annunciator should remain out.*

Before take-off

AC PUMP switch	ON

Climb

AC PUMP switch	OFF

After landing

If ENG 2 to be shut down for taxi in:

AC PUMP switch	ON
ENG 2 PUMP switch	OFF

Shutdown

ENG 2 & 3 PUMP switches	OFF
DC PUMP switch	OFF
AC PUMP switch	OFF
PTU switch	OFF

Ice and rain protection

Note: *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 (41°F) or below during ground operation, take-off, initial climb or go-around, or the TAT is 10°C (50°F) or below in flight.*

Flight deck safety

CONT IGN A & B switches	OFF
ENG IGN A & B green annunciators	Out
MWS ENG IGN ON green caption	Out
ENG ANTI-ICE switches (1, 2, 3, 4)	OFF
ENG 1, 2, 3, 4 VLV NOT SHUT white annunciators	Out
SCREEN HEAT L & R switches	OFF
AUX and L VANE switch	OFF

PITOT HTRS L, R VANE switches	OFF
MWS SCRN HEAT SEL OFF white caption	Lit
Remaining associated annunciators (6)	Out

OUTER WING ANTI-ICE switch	OFF
INNER WING DE-ICE switch	OFF
ICE DETECT switch	OFF
TAIL ANTI-ICE switch	OFF
Associated WING & TAIL annunciators (8)	Out

Before start

ICE DETECT switch	ON

After start

ENG ANTI-ICE 1, 2, 3, 4	As required

Note: *Select ON if OAT +5°C or below and visible moisture exists, reducing visibility to less than 1,000 metres.*

ENG ANTI-ICE switches (4)	ON
ENG VLV NOT SHUT annunciators (4)	Out
SCREEN HEAT L & R switches	ON
MWS SCRN HEAT SEL OFF white caption	Out
PITOT HTRS L, R VANE switches	ON
Associated annunciators (8)	Out

Before take-off

CONT IGN A & B	As required

Note: *Select CONT IGN A & B to ON if ENG ANTI-ICE is ON, or if standing water or snow is present on the runway.*

After take-off

Note: *If icing conditions prevail and/or ICE DETECTED caption is lit, select ice protection ON and ensure N2 RPM 67% minimum.*

ENG ANTI-ICE 1, 2, 3, 4	ON
CONT IGN A & B	As required
OUTER WING ANTI-ICE	ON

TAIL ANTI-ICE	ON
INNER WING DE-ICE	When clear of icing conditions, ON for 1 minute

Climb

If icing conditions prevail, select as for AFTER TAKE-OFF.

Descent

Note: *If icing conditions are anticipated, select as above prior to entering icing. Descend through icing layer. Adjust engine speed to maintain a minimum of 67% N2.*

Holding

If holding in icing conditions, maintain 0 degrees flap and add 7 knots to the normal holding speeds of 180 KIAS or VFTO + 15 kts if greater.

Select as for AFTER TAKE-OFF. For prolonged holding in icing conditions select INNER WING DE-ICE ON for one minute at 8-10 minute intervals and when altitude is reduced for the approach and landing.

Approach and landing in icing conditions

ENG ANTI-ICE 1, 2, 3, 4	ON
CONT IGN A & B	As required
OUTER WING ANTI-ICE	ON
TAIL ANTI-ICE	ON

Prior to selecting flaps:

INNER WING DE-ICE	Select ON

At 200 ft:

OUTER WING ANTI-ICE	OFF
INNER WING DE-ICE	OFF
TAIL ANTI-ICE	OFF
ENG ANTI-ICE 1, 2, 3, 4	OFF
CONT IGN A & B	As required

After landing

CONT IGN A & B	OFF
ENG ANTI-ICE 1, 2, 3, 4	As required

Shutdown

ENG ANTI-ICE 1, 2, 3, 4	OFF

ENG VLV NOT SHUT annunciators (4)	Out
SCREEN HEAT L & R switches	OFF
AUX and L VANE switch	OFF
PITOT HTRS L, R VANE switches	OFF
ICE DETECT switch	OFF

Indicating/recording systems

Flight deck safety

AVIONICS MASTER A	ON
MWS CTRL switch	NORM
MWS DIM knob	Check control dims lit captions
MWS PUSH TEST button	Press and hold
MWS audio	Triple chime
MWS red alert lights	Flashing
MWS amber caution lights	Flashing
MWS red alert light	Press and release
MWS audio alert & caution lights	Cancelled
MWS red alert & amber caution captions	Dim, except MWS DIM FAIL & OVHD DIM FAIL
MWS PUSH TEST button	Release
MWS CTRL switch	Select O/RIDE, check lit captions increase to full bright
MWS CTRL switch	NORM, lights dim
MWS DIM knob	Set as required
ANNUN CTRL switch	NORM
ANNUN TEST button	Press and hold
Overhead panel annunciators	All light and bright
ANNUN TEST button	Release
ANNUN DIM knob	Control dims lit annunciators
ANNUN control	Select O/RIDE, check lit captions increase to full bright
ANNUN control	NORM, lights dim
ANNUN DIM knob	Set as required
GRND TEST SPEED WARN 1	Press and check intermittent horn sounds, then release
GRND TEST SPEED WARN 2	Press and check intermittent horn sounds, then release
Clock	Check correct time is set

Before start

Flight data recorder	Enter – day/month/flight leg/flight number

Note: *MWS FLT REC OFF caption will remain lit when BRAKES lever is selected to PARK.*

Landing gear

Flight deck safety

Gear lever	DOWN
Override lever	Normal
AC busbars	Check powered
Gear indicators	Confirm three greens

ANTI SKID INOP & FAULT annunciators	Out
ANTI SKID FAULT YEL test button	Press and hold
MWS audio	Single chime
MWS amber caution lights	Flashing
MWS ANTI SKID amber caption	Lit
ANTI SKID INOP & FAULT annunciators	Lit
ANTI SKID FAULT annunciator	Out after approx. 4 seconds
ANTI SKID FAULT YEL test button	Release
MWS caution lights, caption and annunciator	Cancelled after 10 seconds
ANTI SKID FAULT GRN	Repeat as for YEL

Before start

Brakes lever	YEL and PARK (minimum pressure 2,200 PSI)
MWS amber PARK BRAKE ON caption	Lit

After start

BRK FAN switch	AUTO

Before take-off

Brakes	YEL and GRN checked, select YEL

Note: *Press brake pedals to release parking brake and gently apply even pressure to both pedals. Check YELLOW pressure indicated and confirm drop. When clear of obstacles select BRAKES to GRN and repeat check. Reselect BRAKES to YEL.*

Brake and tyre cooling period	Check adequate

After take-off

Gear lever	UP
Gear indicators	All out

Climb

BRK FAN switch	AUTO

Approach

BRK FAN switch	AUTO

Landing

Gear lever	DOWN
Gear indicators	Confirm three greens
Brake lever	GRN, checked
Brake pedals	Press and release brake pedals, check GREEN pressure is indicated and exhausted

After landing

Brakes	YEL

Shutdown

Brakes	PARK, pressure checked
MWS amber PARK BRK ON caption	Lit

Leaving aircraft

ANTI-SKID switch	OFF

Navigation

Flight deck safety

AVIONICS MASTER A & B	ON

GPWS PULL UP warning	Press and hold
GPWS red PULL UP warning	Lit
MWS GPWS INOP amber caption	Lit
GPWS audio	“WHOOP WHOOP, PULL UP”
GPWS PULL UP warning	Release – warnings, caption and audio cancelled

Note: *Audible “GLIDESLOPE” warning is only activated when an ILS frequency is selected on NAV 1 and a valid glideslope signal is received.*

NAV 1 and 2 COURSE selectors	Set 180°
VHF NAV 1 and 2 switches	ON
ILS frequency	Select
ADI and HSI LOC, and G/S flags	In view
ILS TEST switch	Hold up-left and down-right in turn. Check flags removed from view, LOC and G/S indications follow, course mask shows yellow/blue.
ILS TEST switch	Release
VOR frequency	Select
VOR switch	Hold. Check HSI NAV flag removed from view and lateral deviation, beam bar centres. Course mask displays white and ‘to’. RMI flag removed and pointer positions to 180 degrees magnetic.
VOR TEST switch	Release
DME TEST switch	Hold. Shutter removed from view when reading of 000 NM indicated.
DME TEST switch	Release
ALT SEL rotary selector	Set to Captain’s altimeter indicated height
TEST button	Press and hold
ALT SEL rotary selector	Increase by more than 300 ft
Amber ALERT light and annunciator	Lit
Audio tone	Activated
TEST button	Release, alert and annunciator light out
FD BARS switches	ON, check bars centred
Airspeed indicators	Read zero
Attitude director indicators	Press and hold TEST, check 10° climb, 20° right turn indicated
ATT and FD flags	In view
FD bars	Show full fly up and right
TEST button	Release
Altimeters	Power failure flag not in view, set QFE/QNH, cross-check with standby altimeter

Standby attitude indicator	Failure flag not in view, press fast erection knob
RMIs	HDG flag not in view, cross-check heading with standby compass
HSIs	Cross-check heading with standby compass and RMIs, HDG flag not in view
Radio altimeter	Failure flag not in view, press and hold TEST button, check digits at 8888 and lamp lit, then release
COMPASS switch	SLAVED, synchronised
Weather radar	Checked and set as required
Transponder mode	ON, allow 60 seconds for warm-up
Transponder test button	Press, confirm reply light is lit, release
Transponder mode	STBY
Audio panel MKR receive button	Press
Rotary selector switch	TEST
Marker annunciator lights	Lit in sequence
Audio tone	Activated
Rotary selector switch	LOW
Audio panel ADF receive button	Press
Rotary selector switch	TEST, check audio tone
ADF bearing pointers	Positioned at 225°
Rotary selector switch	ADF
Audio panel ADF receive button	Press

Before take-off

During turns, each pilot checks:

Attitude director indicator	Erect
Standby attitude indicator	Erect
Inclinometer	Correct operation
Horizontal situation indicator	Correct orientation
ADF needles	Maintaining correct bearing
RMI/DBI	Correct orientation
VOR needles	Maintaining correct bearing
Standby compass	Correct orientation
YD indicator	Opposing turn
VHF NAV/DME	Frequencies set
ADF	Frequencies set
Transponder	ON (or as required)

Climb

Altimeters	Reset to standard

Descent

Airspeed indicators	Cross-checked
Altimeters	Set, cross-checked
Radio altimeter	Set decision height
Compasses	Cross-checked

Approach

Altimeters	Set QNH, cross-checked

Landing

Altimeters	Set QNH, cross-checked

After landing

Weather radar	STBY
Transponder	STBY

Leaving aircraft

Weather radar	OFF
AVIONICS MASTER A and B	OFF

Oxygen

Flight deck safety

Oxygen passenger valves	Both OFF
Oxygen main valve	Full ON
Main supply	1,450-1,850 PSI
Oxygen masks	Test supply, check flow blinker

Leaving aircraft

Oxygen valves	Fully OFF

Pneumatics

Flight deck safety

APU AIR switch	OFF
PACK 1 & 2 switches	OFF
ZONE TEMP DETECT, L.WING & R.WING switches	BOTH LOOPS
ZONE LOOPS A & B buttons	Press and release each in turn
L & R ZONE HI TEMP annunciators	Out
ZONE LOOPS A & B buttons	Press and hold
MWS audio	Single chime
MWS amber caution lights	Flashing
MWS AIR SUPPLY amber caption	Lit
L & R ZONE HI TEMP annunciators	Lit
ZONE LOOPS A & B buttons	Release
MWS caution lights, caption and annunciators	Cancelled
APU AIR switch	ON if air conditioning required
ENG AIR switches	All OFF
ENG AIR FAULT annunciators	Out
ENG AIR VALVE annunciators	Out

Starting

APU AIR switch	OFF if using APU GEN for start

After start

APU AIR switch	ON. Check APU TGT stabilises.

After take-off

ENG AIR switches	All ON
APU AIR switch	OFF
APU VLV NOT SHUT and NRV LEAK annunciators	Out

Note: *APU AIR should be selected OFF immediately after selecting ENG AIR to ON.*

Landing

APU AIR switch	ON
ANTI-ICE and DE-ICE switches	OFF
ENG AIR switches	All OFF by decision height

Note: *APU AIR should be selected ON immediately prior to selecting ENG AIR to OFF.*

Leaving aircraft

APU AIR switch	OFF
APU VLV NOT SHUT and NRV LEAK annunciators	Out
APU TGT	Stabilised

Auxiliary Power Unit (APU)

Flight deck safety

BATT switch	ON
VOLT/AMP rotary selector	BATT
Voltage	Minimum 23 volts
MWS amber caution light	Press to cancel

APU GEN switch	ON
APU FIRE test button	Press and hold
MWS audio	Fire bell
APU FIRE red caption	Lit
APU amber caption	Lit
MWS red alert lights	Flashing
MWS amber caution lights	Flashing
APU FIRE red annunciator	Lit
APU LOOP FAULT amber annunciator	Lit
MWS alert light	Press and release
MWS audio, alert and caution lights	Cancelled
APU FIRE test button	Release
APU FIRE red caption	Out
APU amber caption	Out
APU FIRE red annunciator	Out
APU LOOP FAULT amber annunciator	Out

APU AIR switch	OFF
APU VLV NOT SHUT annunciator	Out
APU START/STOP	START
START PWR ON annunciator	Lit
APU OIL LO PRESS & FUEL VALVE annunciators	Lit and then out
APU RPM	Check RPM increases smoothly
START PWR ON annunciator	Out above 60% RPM
APU TGT	Does not exceed limits
APU OIL LO PRESS annunciator	Out
APU PWR AVAILABLE annunciator	Lit after RPM reaches 95% RPM
APU GEN OFFLINE annunciator	Out
APU AIR	As required

Note: *APU FUEL LO PRESS annunciator will remain ON until FUEL PUMP L INNER is selected ON.*

Starting main engines

APU AIR switch	OFF (if starting from APU GEN)

After starting main engines

APU AIR switch	ON. Check APU TGT stabilises.

After take-off

APU AIR switch	OFF (after ENG AIR is ON)
APU VLV NOT SHUT & NRV LEAK annunciators	Out

Climb

APU START/STOP switch	STOP
RPM and TGT indicators	Decreasing

Approach

APU	START (follow procedure above)

Landing

APU AIR switch	ON (prior to selecting ENG AIR to OFF)
ANTI-ICE and DE-ICE	OFF

Leaving aircraft

APU air switch	OFF
APU VLV NOT SHUT & NRV LEAK annunciators	Out
APU TGT	Stabilised
APU START/STOP switch	STOP

Doors and stairs

Before start

External stairs	Clear of aircraft
Airstairs	Retracted
Doors	Closed

After start

MWS door captions	Out

Shutdown

External area	Clear
Doors	Open
Airstairs	Extended

Power plant

Note: *The procedure given here is applicable when an AC power source is available either from the APU GEN or EXT AC.*

Flight deck safety check

BATT switch	ON
VOLT/AMP rotary selector	BATT
Voltage	Minimum of 23 volts
MWS amber caution light	Press to cancel

GEN 1 & 4	OFF/RESET
APU	Start
APU GEN	ON
GRND TEST, ENG FIRE warning	Test

EXT AC	ON if required, check volts/frequency in green sector

***Note:** At temperatures outside the range -10°C to +30°C at altitudes above 2,000 ft AMSL, use of an external power supply is recommended. If the APU is used for engine starting, monitor APU TGT for indications of APU surge. Do not select COLD with APU as power source.*

Fire handles	Fully IN
CONT IGN A & B switches	OFF
ENG IGN A & B green annunciators	Out
MWS ENG IGN ON green caption	Out
ENG ANTI-ICE switches	OFF
ENG VLV NOT SHUT annunciators	Out
ENG AIR switches	OFF
ENG AIR FAULT annunciators	Out
ENG AIR VALVE annunciators	Out
Engine instruments	Fail flags not in view
FUEL FLOW indicators	Pull to zero totalizers
VIBN TEST button	Press and hold
ENG VIBN indicators	‘2’ units on all engines
MWS ENG VIBN amber caption	Lit
MWS audio	Single chime
MWS amber caution lights	Flashing
VIBN TEST button	Release
ENG VIBN indicators	Zero
MWS caution light and caption	Cancelled
Thrust levers	Advance until CONFIG warning initiated
MWS audio	Intermittent horn
MWS red ALERT lights	Flashing
MWS red CONFIG caption	Lit
Thrust lever	FUEL OFF. Warnings cancelled.

Before start

TMS PWR ON button	Press
TMS lighting	BRIGHT
ON annunciator	Lit
TMS TEST button	Press
TMS green TEST annunciator	Lit
TMS temperature selector	Set T/Amb or T/Flex

TO button	Press
N1REF / N1FLEX	Confirm and bug on N1 indicators
TO button	Press
Take-off speeds	V1, VR, V2, VFTO; check AUW and take-off flap setting and bug on both airspeed indicators.

Starting

Beacon	ON
PACK 1 and 2	As required
APU AIR	As required

Note: *Select PACK 1 and 2 APU AIR OFF if starting from APU GEN.*

APU GEN	As required

Note: *Select APU GEN OFF/RESET if starting using EXT AC.*

START PWR switch	NORM when using APU GEN, NORM or COLD when using EXT AC
START MASTER switch	ON
White START PWR ON annunciator	Lit
START SELECT rotary switch	Select engine (normal sequence is 4, 3, 2, 1)
ENGINE	Push to START for 1 sec and then release to RUN
White STARTER OPERATING annunciator	Lit
Green ENG IGN A and B ON annunciators	Lit
Relevant thrust lever	At 10% N2 RPM, select to FUEL ON, ground idle

Note: *Monitor engine instruments during start and observe TGT limitations (max. 824°C for 10 seconds above 799°C).*

TGT	Rising normally
N2 and N1 RPM	Rising normally
Oil pressure	Rising normally
Fuel flow	Normal indication
ENG IGN A and B ON annunciators	Out at 45% N2 RPM
Ground idle N2 RPM	50%
STARTER OPERATING light	Out within 10 seconds
Oil pressure indication	In green band
MWS OIL LO PRESS caption	Out

Note: *Do not move the thrust lever above ground idle until the STARTER OPERATING light is out.*

Start remaining engines in turn	START SELECT to next engine, repeat starting procedure by reselecting ENGINE switch to START.

Note: *Do not move the START SELECT switch to the next engine position until the STARTER OPERATING and ENG IGN A & B ON annunciators are checked OUT for the engine being started.*

After start

START PWR switch	NORM
START SELECT rotary switch	OFF
START MASTER switch	OFF
START PWR ON annunciator	Out

Before take-off

If TMS required for take-off:

TREF °C	Set T/Amb or T/Flex °C
T/O button	Press, green arrow lit
%N / °C indicator	N1REF / N1FLEX displayed and confirmed
V1/VR/V2/VFTO	Checked

Climb

Climb power may be set in either of two ways:

1. N1 SYNC mode
2. TGT and TGT/SYNC modes

Descent

VREF/VFTO	Checked and set bugs
N1 GA	Set N1 bugs

After landing

If ENG 2 & 4 to be shut down for taxi in:

FLAPS	Indicating zero
GEN 4	OFF/RESET
AC PUMP	ON
ENG 2 PUMP	OFF
Thrust levers	ENG 2 & 4 FUEL OFF

Shutdown

Thrust levers	FUEL OFF

HANDLING NOTES

Take-off and landing

Maximum crosswind

The maximum crosswind component in which the aircraft has been demonstrated to be satisfactory is 30 knots for take-off and 35 knots for landing, at 90° to the flight path.

Critical engine

The critical engine is the outer engine on the upwind side.

Take-off procedure

Select the take-off flap setting appropriate to the prevailing airfield conditions and the scheduled performance data.

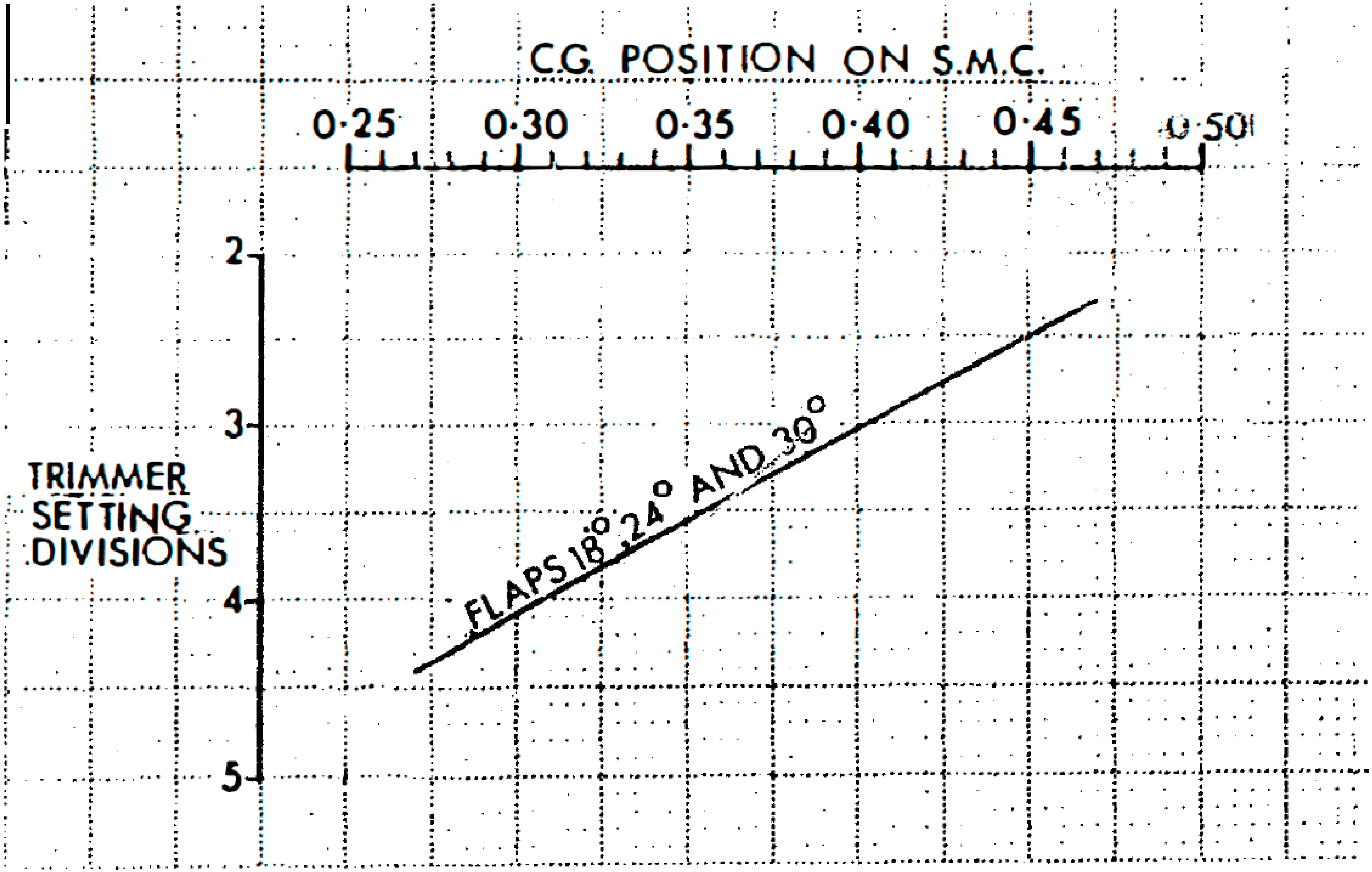
Set the elevator trim appropriate to the aircraft centre of gravity. Determine and display the relevant scheduled speeds and take-off power setting(s).

When all other take-off preparations are complete, advance the thrust levers to achieve take-off N1 setting in accordance with the procedures given in the HANDLING NOTES – Power plant section.

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.

Start the elapsed time clock and release the brakes. 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.



Elevator trimmer setting for take-off

Monitor engine indications throughout the take-off.

Up to 80 knots, abandon the take-off if achieved N1 falls more than 1% below target or if engine limitations are exceeded. If these conditions occur between 80 knots and V1, the take-off may be continued unless actual engine failure is suspected.

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.

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.

FLAP RETRACTION AIRSPEED SCHEDULE			
	Take-off flap setting		
	30°	**24°**	**18°**
Select 24°	V2 + 10 KIAS		
Select 18°	V2 + 20 KIAS	V2 + 10 KIAS	
Select 0°	VFTO	VFTO	VFTO

When flaps are retracted, set climb power and continue acceleration to the required en route climb speed.

If additional thrust is desired during a flexible power take-off, advance the thrust levers to give N1ref.

Noise abatement climb

Maintain the initial climb with take-off flap at V2 + 10 knots until the power cut-back point (1,000 ft above airfield level unless otherwise specified in airport procedures).

Reduce to climb power and increase the pitch attitude to continue the climb at V2 + 10 knots.

On reaching the upper limit altitude of noise abatement restrictions, accelerate through the flap retraction airspeed schedule to the required en route climb speed.

During the initial climb it is recommended that pitch attitude should not be allowed to exceed 20°. If this attitude is reached, allow speed to increase.

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. If autopilot is engaged, select TURB or PITCH mode in a level attitude and monitor autopilot performance. 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.

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 to 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 change-over 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.

Approach, landing and missed approach

Prior to commencing a landing approach, determine the target threshold speed for 33° flap (VREF33) appropriate to the landing weight and set the airspeed bug to this speed.

Determine the go-around N1 setting appropriate to the reported conditions at the destination airfield and set the N1 bugs to this setting.

The recommended minimum manoeuvre speeds in the approach and landing pattern are given below:

Flap Setting	Minimum Manoeuvring Speed
0°	VFTO + 15 KIAS
18°	VREF33 + 30 KIAS
24°	VREF33 + 20 KIAS
30/33°	VREF33 + 10 KIAS

Approach and landing

Aim to be downwind in the visual pattern or inbound on an instrument approach at 160 knots, with 18° flap selected and airbrake IN. Just before turning base or reaching the instrument descent point, select landing gear DOWN and 24° flap.

Reduce speed to VREF33 + 20 knots. Select 33° flap and further reduce the speed to VREF33 + 5 knots.

Select the ENG AIR switches to OFF by 200 ft on final approach.

When approaching the runway, reduce speed to cross the threshold at VREF.

When gusts are reported, increase approach and threshold speeds by the gust factor, up to a maximum increment of 10 knots.

During the landing flare reduce power to flight idle.

After touchdown

Retard the thrust levers to ground idle and lower the nose-wheel gently to the runway. Select the airbrake lever to the LIFT SPLR position and commence wheel braking.

The airbrakes may be deployed at any time on the approach or after touchdown, but landing distance is reduced by deployment before crossing the runway threshold.

Missed approach

In the event of a decision to carry out a missed approach, advance the thrust levers to give go-around N1 in accordance with the procedures given in the HANDLING NOTES – Power plant section and at the same time smoothly rotate the aircraft nose-up to an initial 10° pitch attitude.

Select 24° flap and airbrake IN. Although auto-airbrake retract is available, the airbrake should be selected IN to prevent subsequent deployment when the thrust levers are retarded.

When no longer descending, select landing gear UP.

Adjust the pitch attitude to climb at a speed not below VREF33 + 5 knots. It is recommended that the pitch attitude should not be allowed to exceed 20°. If this attitude is reached, allow speed to increase.

Tyre and brake cooling periods

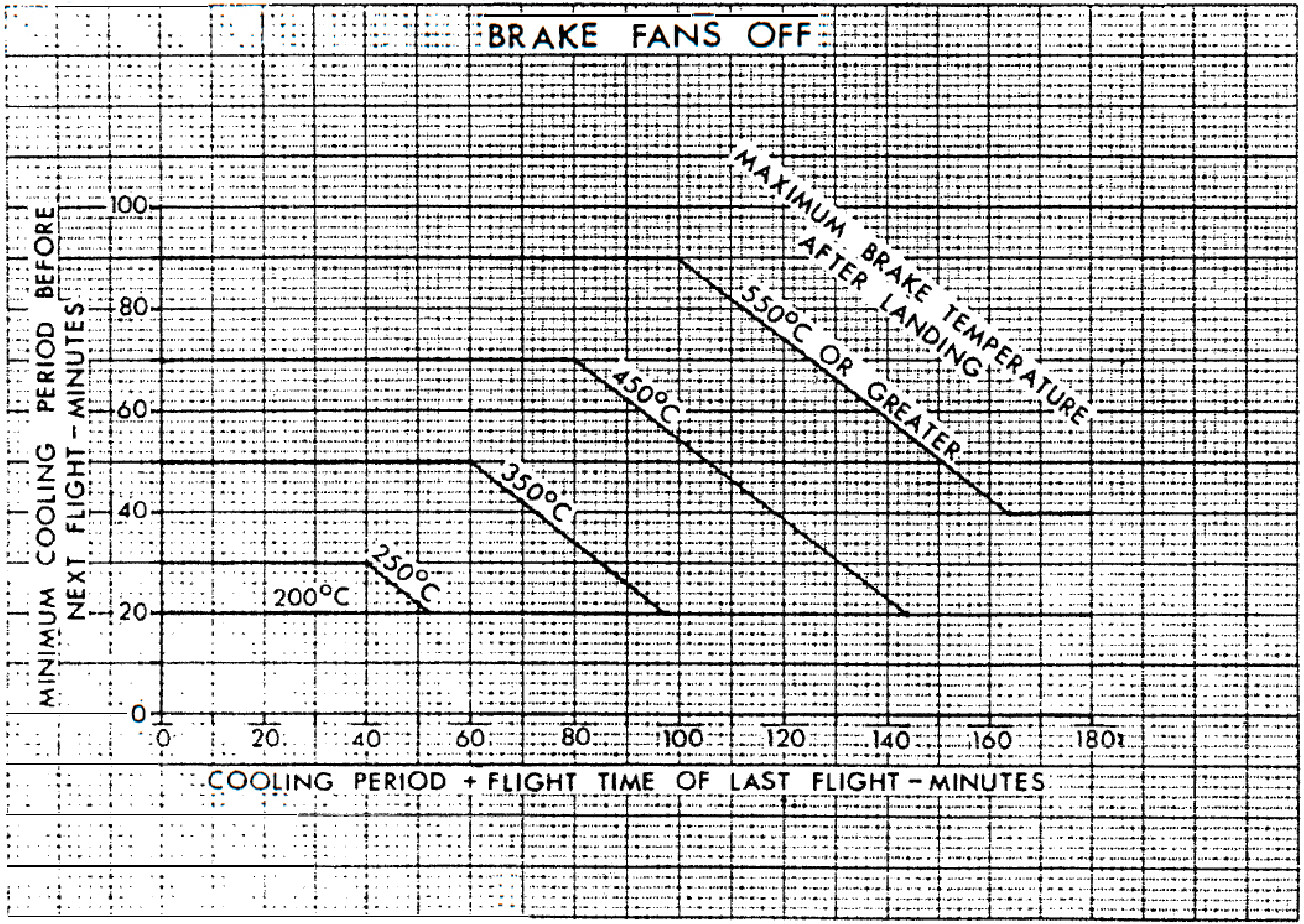
Use brake fans during landing and taxiing as required. Brake fan operation is not indicated on the flight deck.

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 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, except that it may be less than 15 minutes but not less than 5 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.

TYRE AND BRAKE COOLING PERIOD



Power plant

Thrust ratings

The ALF 502 is rated to produce a nominal take-off thrust of 6,970 lb at temperatures up to 15°C at sea level. Take-off and go-around thrust is defined by an N1 schedule referenced to air temperature and pressure altitude which must be achieved within the maximum take-off TGT and N2 limits.

Two methods of setting take-off thrust may be used. Normal take-off thrust is always available and, when take-off performance conditions are not limiting, reduced thrust – using the assumed temperature method of calculation – may be used.

Take-off performance is scheduled on the assumption that the thrust levers are not moved during the first and second segment climbs. To ensure that thrust levels are maintained throughout the take-off when using TMS, the TMS actuators are inhibited at 75 kts in the TO mode.

Maximum continuous thrust (MCT) is defined by a TGT limit of 857°C, except where this TGT requires an N1 in excess of the take-off/go-around N1 schedule for the appropriate altitude and ambient temperature conditions, in which case MCT is defined by the N1 schedule. To maximise engine life, use of this power setting should be restricted to occasions of emergency or operational necessity.

Maximum climb and cruise thrust are defined by the MCT schedule except that 840°C should not be exceeded. To maximise engine life, TGTs lower than 840°C should be used when practicable.

Flight idle setting

The ALF 502 has two idle settings. On the ground, with weight on wheels, the ground idle baulk (GI) is set at approximately 50% N2, permitting any thrust level above GI to be set. After take-off, a flight idle (FI) baulk is engaged at approximately 60% N2 to ensure that the engine is always able to accelerate rapidly to achieve TO/GA thrust following a slam acceleration.

Note: *To ensure that an adequate supply of bleed air is available for engine and intake anti-icing, only transient operation below 67% N2 is permitted in icing conditions.*

Throttle Modulation System (TMS)

The TMS permits thrust ratings to be set accurately and rapidly. The TMS contains thrust rating schedules for take-off, maximum continuous thrust and descent, and trims each engine to the selected parameter. In addition, TMS displays the go-around thrust rating but provides no control in the GA mode. Synchronisation of N1 or N2 is also provided.

The authority of the TMS actuators is limited, therefore some movement of the thrust levers by the pilot is required. If an actuator reaches the limit of its authority without the required power setting being achieved, the appropriate actuator arrow will light, indicating the direction in which the thrust lever should be moved to achieve the target value. A blue arrow indicates that the thrust lever should be advanced and a white arrow indicates that the thrust lever should be retarded.

In all TMS modes except GA, limit logic is provided to maintain the appropriate N1, N2 and TGT limits, within the control authority of the TMS actuators. The N1 limiting function will, in some cases, permit a slightly higher indicated N1 value. Since TMS authority is limited, engine limits can be exceeded by manual thrust lever movements. Consequently, it is important to monitor engine instruments and the TMS actuator arrows at all times. With GA selected or the TMS selected OFF, it is possible to exceed the take-off thrust rating. However, engine response is good throughout the operating range, with little lag or over-swing resulting from smooth thrust lever movements, thus allowing thrust levels to be accurately set.

When TO mode is selected, the TMS displays the rated thrust N1 relevant to the sensed pressure altitude, the ambient temperature value set on the CDU and the engine anti-ice bleed condition. If any other bleed selection is made, the display flashes to indicate an invalid configuration for take-off. In the GA mode, the TMS displays the rated thrust N1 relevant to the sensed pressure altitude, the sensed temperature and the engine anti-ice bleed condition. If any other bleed selection is made the display remains blank. In both the TO mode and the GA mode the display also remains blank at pressure altitudes above 15,000 ft.

The TMS TO mode also permits reduced thrust take-off N1 targets to be calculated using the 'assumed temperature' procedure. A temperature (Tflex) which is higher than the true ambient temperature is set on the CDU. The TMS displays the reduced thrust N1 target.

In the temperature control modes (MCT and TGT) the TMS controls to either 857°C (MCT) or the selected TGT value (TGT). The temperature value is displayed on the TMS CDU. When the thrust limit in either temperature mode is defined by an overriding N1 limit, the TMS CDU display will indicate the overriding N1 value.

When the DESC mode is selected, the TMS CDU will display the minimum N2 required to provide an adequate supply of bleed air to those systems in use, at the sensed pressure altitude. The bleed air requirements, as selected by the pilot, are automatically signalled to the TMS.

When airframe anti-ice/de-ice is not selected ON, the inboard engine N2 is controlled to provide sufficient bleed air for the ECS while the outboard engines are controlled to the relevant flight idle N2 for the engine anti-ice condition. In this situation (termed '2 UP – 2 DOWN') the TMS CDU will display the N2 target for the inboard engines. When airframe anti/de-ice is selected ON, all engines are controlled to the N2 value displayed in the TMS CDU.

In the SYNC mode the engines are synchronised in the selected control parameter (N1 or N2). Either engine 1 or engine 2 may be selected as the master (MSTR) engine. In the SYNC mode no minimum N2 protection is provided for air bleed selections other than engine anti-ice. The SYNC mode may be selected in conjunction with the TGT mode. When TGT is selected, followed by SYNC, the master engine is controlled to the selected TGT value and the remaining engines are speed-synchronised to the master engine in the selected control parameter, which is normally N1.

Procedures – TMS operative

Before start

Obtain Tamb (actual outside air temperature). Determine N1 ref by using this value as the starting point in Fig.1 (ENG ANT-ICE OFF) or Fig.2 (ENG ANT-ICE ON) with Tamb and airfield pressure altitude.

Figure 1

ALF 502R-5 RATING	TAKE-OFF OR GO-AROUND % N1 SETTING (ENG A-ICE OFF)	AIRFRAME ANTI-ICE OFF AIRCRAFT BLEED AIR OFF

TAKE-OFF: TFLEX OR TAMB (DEG C) — GO AROUND: IOAT (DEG C)

ALT FT x1000	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	55	60	ALT FT x1000
15		96.7	96.7	96.7	96.7	96.7	96.3	95.7	95.1	94.7	94.3	93.9	93.5	92.6	91.7	90.8	90.0	89.1						15
14		96.7	96.7	96.7	96.7	96.7	96.4	95.8	95.1	94.8	94.3	94.0	93.6	92.8	91.9	91.0	90.2	89.3						14
13			96.7	96.7	96.7	96.7	96.5	95.9	95.2	94.9	94.4	94.1	93.7	92.9	92.0	91.1	90.3	89.5	88.4					13
12			96.7	96.7	96.7	96.7	96.5	96.0	95.3	94.9	94.5	94.1	93.8	93.0	92.2	91.3	90.5	89.6	88.6					12
11			96.7	96.7	96.7	96.7	96.6	96.1	95.3	95.0	94.6	94.2	93.9	93.1	92.3	91.4	90.6	89.8	88.7	88.2				11
10				96.7	96.7	96.7	96.6	96.1	95.3	95.1	94.7	94.3	94.0	93.3	92.4	91.5	90.7	89.9	88.9	88.3				10
9				96.7	96.7	96.7	96.6	96.2	95.4	95.2	94.7	94.4	94.0	93.4	92.5	91.7	90.8	90.1	89.1	88.4				9
8				95.5	96.4	96.7	96.6	96.2	95.5	95.2	94.7	94.4	94.1	93.5	92.6	91.8	90.9	90.2	89.2	88.5	88.0			8
7				94.3	95.2	96.1	96.7	96.2	95.5	95.2	94.7	94.4	94.1	93.6	92.8	91.9	91.0	90.3	89.3	88.6	88.1			7
6				93.0	93.9	94.8	95.7	96.2	95.5	95.2	94.8	94.4	94.1	93.6	92.8	92.0	91.1	90.4	89.5	88.6	88.2	87.7		6
5			90.9	91.3	92.7	93.6	94.6	95.5	95.5	95.2	94.8	94.5	94.2	93.6	92.9	92.0	91.2	90.5	89.6	88.7	88.3	87.8		5
4		88.6	89.6	90.5	91.4	92.3	93.2	94.1	95.0	95.2	94.8	94.5	94.2	93.7	92.9	92.1	91.1	90.6	89.3	88.8	88.4	87.9		4
3		87.5	88.4	89.3	90.3	91.1	92.1	92.9	93.8	94.7	94.8	94.5	94.2	93.7	92.9	92.1	91.2	90.6	89.8	88.9	88.5	88.0	87.6	3
2	85.3	86.2	87.1	88.0	88.9	89.8	90.7	91.6	92.5	93.3	94.1	94.5	94.2	93.7	92.9	92.1	91.3	90.7	89.9	88.9	88.5	88.0	87.6	2
1	84.0	84.9	85.8	86.7	87.5	88.4	89.3	90.2	91.1	91.9	92.7	93.6	94.2	93.7	92.9	92.1	91.4	90.7	89.9	88.9	88.5	88.1	87.7	1
0	82.8	83.6	84.5	85.4	86.2	87.1	87.9	88.8	89.7	90.5	91.3	92.1	92.9	93.7	93.0	92.2	91.4	90.7	89.9	88.9	88.6	88.1	87.7	0
-1	81.7	82.5	83.3	84.1	84.9	85.7	86.6	87.4	88.2	89.0	89.9	90.7	91.5	92.3	93.0	92.2	91.4	90.7	89.9	89.0	88.6	88.2	87.8	-1

FLAT RATED RANGE ◄—|—► FULL RATED RANGE

RATING	TAKE-OFF
TIME LIMIT	5 MIN
TGT LIMIT	882°C
N1 LIMIT	96.7%
N2 LIMIT	98.8%
N1 COMPENSATION	FITTED
IAS (SETTING)	UP TO 75KT

FLEXIBLE THRUST

1. IF TFLEX IS WITHIN FLAT RATED RANGE, DO NOT DERATE
2. WITH AIRFIELD ALT / TAMB, ESTABLISH N1REF
3. WITH AIRFIELD ALT / TFLEX, ESTABLISH FULL RATED N1
4. SUBTRACT △N1FLEX FROM FULL RATED N1 TO ESTABLISH N1FLEX

TFLEX - TAMB °C	0	5	10	15	20	25	30	35	40	45	50
△ N1FLEX %	0	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0

NOTE: DO NOT USE N1FLEX GREATER THAN N1REF
DO NOT USE N1FLEX LESS THAN 78.0%
DO NOT USE N1FLEX LESS THAN (N1REF-8.0%)

Figure 2

ALF 502R-5 RATING	TAKE-OFF OR GO-AROUND % N1 SETTING (ENG A-ICE ON)	AIRFRAME ANTI-ICE OFF AIRCRAFT BLEED AIR OFF

TAKE-OFF: TFLEX OR TAMB (DEG C)—GO AROUND: IOAT (DEG C)

ALT FT x1000	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	55	60	ALT FT x1000
15		96.5	96.0	95.4	94.7	94.5	94.0	93.2	92.8	92.4	92.0	91.6	90.7	89.7	88.7	87.9	86.8	86.0						15
14		96.6	96.0	95.5	94.9	94.6	94.1	93.3	93.0	92.5	92.1	91.8	90.9	89.9	88.9	88.1	87.1	86.2						14
13			96.0	95.5	95.0	94.7	94.2	93.4	93.1	92.6	92.2	91.9	91.0	90.1	89.2	88.3	87.3	86.4	85.9					13
12			96.1	95.6	95.1	94.8	94.4	93.5	93.2	92.7	92.4	92.0	91.2	90.3	89.4	88.5	87.5	86.5	86.0					12
11			96.1	95.5	95.1	94.8	94.4	93.7	93.3	92.8	92.5	92.1	91.4	90.4	89.6	88.7	87.7	86.6	86.1	85.6				11
10				95.6	95.2	94.9	94.5	93.8	93.4	92.9	92.6	92.2	91.5	90.6	89.7	88.8	87.9	86.8	86.3	85.8				10
9				95.5	95.2	94.9	94.5	93.9	93.4	93.0	92.7	92.3	91.7	90.8	89.9	89.0	88.1	87.0	86.4	85.9				9
8				95.5	95.3	95.0	94.6	93.9	93.5	93.1	92.7	92.4	91.9	91.0	90.0	89.1	88.3	87.2	86.6	86.1				8
7				94.3	95.2	95.1	94.7	94.0	93.5	93.1	92.7	92.4	92.0	91.1	90.2	89.2	88.5	87.4	86.7	86.2				7
6				93.0	93.9	94.8	94.7	94.0	93.6	93.2	92.8	92.5	92.0	91.2	90.3	89.4	88.6	87.6	86.8	86.3				6
5			90.3	91.8	92.7	93.7	94.6	94.1	93.6	93.2	92.8	92.5	92.1	91.2	90.4	89.5	88.8	87.8	86.9	86.4				5
4		88.7	89.6	90.5	91.5	92.4	93.3	94.1	93.7	93.2	92.9	92.5	92.2	91.3	90.4	89.6	88.9	88.0	87.0	86.6				4
3		87.6	88.5	89.4	90.3	91.2	92.1	93.0	93.8	93.3	92.9	92.6	92.2	91.4	90.5	89.6	88.9	88.0	87.1	86.7				3
2	85.3	86.3	87.2	88.1	89.0	89.9	90.8	91.6	92.5	93.3	92.9	92.6	92.2	91.4	90.6	89.7	89.0	88.1	87.2	86.7				2
1	84.1	85.0	85.9	86.9	87.7	88.5	89.4	90.3	91.1	92.0	92.8	92.6	92.3	91.4	90.6	89.7	89.1	88.2	87.2	86.8				1
0	82.9	83.7	84.5	85.4	86.3	87.2	88.0	88.9	89.7	90.4	91.3	92.1	92.3	91.5	90.6	89.8	89.1	88.2	87.2	86.8				0
-1	81.7	82.5	83.3	84.2	85.1	85.8	86.6	87.4	88.3	89.1	90.0	90.8	91.5	91.6	90.7	89.8	89.1	88.3	87.3	86.9				-1

FLAT RATED RANGE ◄—|—► FULL RATED RANGE

RATING	TAKE-OFF
TIME LIMIT	5 MIN
TGT LIMIT	882°C
N1 LIMIT	96·7%
N2 LIMIT	98·8%
N1 COMPENSATION	FITTED
IAS (SETTING)	UP TO 75 KT

FLEXIBLE THRUST

1. IF TFLEX IS WITHIN FLAT RATED RANGE, DO NOT DERATE
2. WITH AIRFIELD ALT / TAMB, ESTABLISH N1REF
3. WITH AIRFIELD ALT / TFLEX, ESTABLISH FULL RATED N1
4. SUBTRACT △N1FLEX FROM FULL RATED N1 TO ESTABLISH N1FLEX

TFLEX – TAMB °C	0	5	10	15	20	25	30	35	40	45	50
△ N1FLEX %	0	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0

NOTE
DO NOT USE N1FLEX GREATER THAN N1REF
DO NOT USE N1FLEX LESS THAN 78.0%
DO NOT USE N1FLEX LESS THAN (N1REF-8.0%)

NOTE: AT VREF IOAT IS APPROXIMATELY 2 DEG C HIGHER THAN TAMB

N1 bugs	Set N1 ref
TGT bugs	Set 882°C

If required for the climb, set the TGT thumbwheel to the recommended value for climb, up to a maximum of 840°C.

TMS PWR switch	ON
TEST button	PUSH

CDU display shows 88.8 and CDU annunciators light sequentially. Green and Amber lower quadrants in the test button illuminate while test is in progress. The green light remaining on indicates no failures detected. The amber light remaining on indicates TMS system fault – do not use.

Full thrust take-off

Set Tref thumbwheel to Tamb.

TO mode button	PRESS – confirm TO green annunciator lit and TMS CDU displays N1 ref.

Check that the N1 ref displayed on CDU is within 0.2% of the value obtained from Fig.1 (ENG ANT-ICE OFF) or Fig.2 (ENG ANT-ICE ON).

Flexible thrust take-off

Determine Tflex from Flight Manual Scheduled Take-Off Performance or Airport Analysis charts.

Determine full rated N1 from Fig.1 (ENG ANT-ICE OFF) or Fig.2 (ENG ANT-ICE ON).

Calculate N1 flex in accordance with the instructions under Fig.1 or Fig.2 as appropriate.

Adjust Tref thumbwheel to Tflex and check that the value of N1 displayed on the CDU is within 0.2% of the calculated N1 flex. It is recommended that the N1 bug nearest to the pilot flying is reset to the N1 flex. The remaining N1 bugs should remain set at N1 ref.

Take-off procedures

Advance thrust levers until the blue actuator lights go out. Confirm target N1 captured. Release brakes.

Up to 75 knots, adjust thrust levers in appropriate direction to extinguish any actuator arrow that lights. Monitor engine performance.

At 75 knots the actuators will freeze and will remain frozen until another TMS mode is selected, the PWR switch is selected OFF or the associated thrust lever is retarded below Flight Idle.

Climb

Climb power may be set in either of two ways:

1. N1 SYNC mode

CTRL button	N1
MSTR button	As required. No.2 engine is normally selected as the master engine to minimise directional trim changes during power adjustments and to enhance synchronisation of the inboard engines.
SYNC button	Press – confirm SYNC mode lit

Note: *If TGT mode was in use prior to the selection of SYNC mode, deselect TGT mode before engaging SYNC mode.*

Adjust master engine thrust lever to climb N1, maintaining all TGTs at or below the climb thrust target value.

Note: *In SYNC mode all engines are automatically constrained to the MCT limits within the limit of actuator authority. If a slave engine reaches a limiting value it will fall out of synchronisation.*

2. **TGT and TGT/SYNC modes**

TGT mode is selected by:

TGT thumbwheel	Confirm set to required value
TGT button	Press – confirm TGT mode lit and selected TGT displayed on CDU

If actuator arrow(s) light, adjust relevant thrust lever(s) in appropriate direction to extinguish lights.

Monitor engine performance. TGT values should remain within 10°C of selected value.

TMS also provides a TGT/SYNC mode, where the master engine is controlled to the selected TGT value and the slave engines are speed-synchronised in the appropriate mode. Depending on engine and bleed characteristics, slave engine TGTs may be above the selected TGT value. To maintain all engines within the climb thrust TGT limits, reduce the selected TGT value by rotating the TGT thumbwheel until the highest TGT is not greater than the climb thrust TGT limit.

TGT/SYNC mode is selected by:

CTRL button	N1
MSTR button	As required
TGT button	Press. Confirm TGT mode lit and selected TGT displayed on CDU.
SYNC button	Press. Confirm SYNC mode lit and TGT mode remains lit.
TGT thumbwheel	Adjust to maintain hottest engine within climb thrust TGT limit.

Notes:

To enter a SYNC mode from a TGT/SYNC mode, the TGT button must be pressed to deselect TGT/SYNC before the SYNC button is pressed to select SYNC. Pressing the SYNC button alone will leave the TMS controlling in a TGT mode.

In TGT/SYNC modes all engines are automatically constrained to the MCT limits within the limit of actuator authority. If a slave engine reaches a limiting value it will fall out of synchronisation.

There is a two-second delay between selecting TGT and engagement of the mode. This allows the selection of TGT/SYNC mode, if required, without additional engine disturbance.

Cruise

TMS operating procedures for cruise are the same as for the climb. Either N1 SYNC mode may be used and the master engine N1 adjusted to maintain required speed, or TGT mode with/without SYNC may be used and the TGT thumbwheel adjusted to provide the required thrust.

Maximum cruise thrust TGT is the same value as maximum climb thrust TGT.

Note: *When operating in TGT or TGT/SYNC modes, if the hundreds digit of the TGT thumbwheel is changed the system will enter the standby state. TGT or TGT/SYNC control to the new value can be regained by selecting as for an initial selection.*

Descent

These recommended descent procedures using TMS depend on the bleed air requirements during descent.

When airframe anti/de-ice is not required it is recommended that the N1 SYNC mode is retained throughout the descent and approach. In N1 SYNC mode use of engine anti-ice is monitored by the TMS. When descending in the N1 SYNC mode, the pilot must maintain the following minimum N2 values to provide adequate cabin ventilation during descent:

FL 300 to 250:	70% N2 minimum
FL 250 to 200:	65% N2 minimum
Below FL 200:	Flight idle

When airframe anti/de-ice is required during descent it is recommended that the DESC mode is used to ensure adequate bleed air is available for ice protection. The DESC mode may also be used when airframe anti/de-ice is not required. When airframe anti/de-ice is selected ON, all engines are controlled to the N2 target value displayed on the CDU. When airframe anti/de-ice is selected OFF, the inboard engines are controlled to the N2 target value displayed on the CDU and the outboard engines are controlled to 60% N2.

DESC button	Press – confirm DESC mode lit and target N2 for inboard engines displayed on CDU.
Inboard thrust levers	Adjust to extinguish actuator arrows. Confirm N2 as displayed on CDU.
Outboard thrust levers	Adjust as required. Confirm actuator arrow lights out.

Approach/missed approach

Before starting the approach, determine Go Around N1 (Fig.1, ENG ANT-ICE OFF or Fig.2 ENG ANT-ICE ON) and set N1 bugs.

It is recommended that N1 SYNC mode is used for the approach.

At 200-250 ft AGL on the approach, the TMS is signalled automatically to the Go-Around (GA) mode. The actuators centre and the green GA chevron illuminates, provided that the engine air switches are selected OFF and the GA N1 value for the sensed pressure altitude and temperature is displayed on the CDU.

If a missed approach is commenced prior to 200 ft AGL:

TMS DISC BUTTON(s)	Press either button on the outboard thrust levers. Confirm green GA chevron lit and GA N1 target displayed on CDU.
Thrust levers	Advance to achieve N1 target

Note: *No TMS control is provided by the GA mode. The thrust levers are manually controlled throughout the missed approach until a subsequent TMS mode selection is made.*

Procedures – manual control

Before start

Obtain Tamb from the tower.

Determine N1 ref by using Fig.1 (ENG ANT-ICE OFF) or Fig.2 (ENG ANT-ICE ON) with Tamb and airfield pressure altitude.

Full thrust take-off

N1 bugs	Set N1 ref
TGT bugs	Set 882˚C

Flexible thrust take-off

Determine Tflex from Flight Manual Scheduled Take-Off Performance or Airport Analysis charts.

Determine full rated N1 from Fig.1 (ENG ANT-ICE OFF) or Fig.2 (ENG ANT-ICE ON).

Calculate N1 flex in accordance with the instructions under Fig.1 or Fig.2 as appropriate.

It is recommended that the N1 bug nearest to the pilot flying is reset to the N1 flex. The remaining N1 bugs should be set to N1 ref.

TGT bugs	Set 882˚C

Take-off procedures

Advance all thrust levers and adjust to achieve target N1. Release brakes.

Up to 75 knots, adjust thrust levers as required to achieve target N1. Monitor engine performance. Up to 80 knots, abandon the take-off if N1 falls more than 1% below the target N1 or engine limitations are exceeded.

Climb

Climb thrust may be set to a common TGT value up to the maximum climb TGT of 840˚C, or all engines may be set to a common N1 value with the hottest engine running at the desired TGT. If climb performance permits, the latter method is preferred for passenger comfort and ease of directional trim.

The recommended normal climb procedure is to set 88% N1 for the initial climb (90% N1 at gross weights above 75,000 lb), provided that N1 ref + 1%/1,000 ft above airfield altitude is not exceeded. Retain this thrust lever position up to 15,000 ft which will normally result in a 1-2% increase in N1, provided that a TGT of 820˚C is not exceeded. At 15,000 ft, adjust the thrust levers to maintain 820˚C on the hottest engine until reaching cruising level.

If maximum climb performance is required, after take-off advance the thrust levers to increase the N1 ref/N1 GA value by 1% N1/1,000 ft above airfield altitude until the appropriate TGT/N1 limit is reached. Thereafter, adjust the thrust levers to maintain the selected TGT or N1 limit as applicable.

Cruise

Adjust thrust levers to achieve and maintain selected cruise airspeed. Do not exceed maximum cruise thrust (840˚C).

Descent

The recommended descent procedures depend on the bleed air requirements during descent.

When airframe anti/de-ice is not required, maintain the following minimum N2 values to provide adequate cabin ventilation during descent:

FL 300 to 250	70% N2 minimum
FL 250 to 200	65% N2 minimum
Below FL 200	Flight idle

When engine anti-ice is selected ON in addition to air-conditioning, observe the above minimum N2 schedule but maintain a minimum of 67% N2 for adequate engine anti-ice protection.

When airframe anti/de-ice is required during descent, maintain all engines at or above a schedule of 72% N2 + 2% per 5,000 ft above sea level.

Approach/missed approach

Before starting the approach, determine go-around N1 (Fig.1 ENG ANT-ICE OFF or Fig.2 ENG ANT-ICE ON) and set N1 bugs.

On commencing a missed approach:

Thrust levers	Advance to achieve N1 target

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 146 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
Autopilot Engage/Disengage (aft centre console)	TOGGLE AUTOPILOT MASTER
Autopilot SYNC mode (Hold)	SET ELT
Autopilot SYNC mode (Toggle)	TOGGLE AFTERNBURNER
Autopilot Pitch Selector (aft centre console)	ELEVATOR TRIM UP (NOSE UP) ELEVATOR TRIM DOWN (NOSE DOWN)
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 Directors Adjust Down	INCREASE AP PITCH HOLD REFERENCE
Flight Directors Adjust Up	DECREASE AP PITCH HOLD REFERENCE
HSI/RMI Switch	TOGGLE GPS DRIVES NAV 1
MWS Red and Amber Warning Cancel	TOGGLE GPWS
Nose Wheel Steering Tiller	NOSE WHEEL STEERING AXIS
Throttles to Ground Idle	THROTTLE 1 DECREASE THROTTLE 2 DECREASE THROTTLE 3 DECREASE THROTTLE 4 DECREASE
TMS Disconnect	AUTO THROTTLE TO GA

Note: *This list is not a complete list of all the MSFS control assignments that work with the 146 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**.

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