AVRO VULCAN

B MK. 2, K.2 & MRR

OPERATIONS MANUAL

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Operations Manual

Please note that X-Plane 11 must be correctly installed on your PC prior to the installation and use of this Vulcan B Mk. 2 simulation.

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INTRODUCTION

The Vulcan B Mk. 2 is a four-engine, delta-wing strategic bomber which saw service in the UK during the Cold War. XM655, on which this product is based, was the third-from-last Vulcan to be produced for the Royal Air Force. It was delivered in 1964 and was part of the UK's nuclear deterrent force throughout the 60s and 70s. It is now being preserved by a team of volunteers at Wellesbourne Airfield.

The Vulcan was the second of the V-bombers to enter service, preceded by the Vickers Valiant and followed by the Handley Page Victor. The B.2 was the successor to the earlier B.1, featuring more powerful engines, a larger wing area and improved systems including electronic countermeasures (ECM) and in-flight refuelling capability.

The Vulcan gained fame when it took part in Operation Black Buck, a series of long-range bombing missions during the Falklands War. It was considered the most technologically advanced of the three V-bombers and served with the RAF until its retirement in 1984.

Aircraft specifications

Dimensions

Length	32.3 m (106 ft)
Wingspan	33.8 m (111 ft)
Height (to top of tail)	8.3 m (27 ft)
Wing area	368.4 m^2 (3,965 ft^2)

Engine

Type	4 x Bristol Siddeley Olympus 301 turbojets
Power	Each rated at 20,000lb static thrust

Weights and fuel

Empty weight	99,630 lb (45,191 kg)
Normal maximum all-up weight	205,000 lb (92,986 kg)
Fuel capacity (without bomb bay tanks)	74,080 lb (9,260 gallons)

Performance

Maximum level speed (sea level)	Mach 0.75 (528 MPH)
Maximum cruising speed (55,000 ft)	Mach 0.95 (627 MPH)
Service ceiling	64,960 ft
Range (internal fuel)	1,710-2,300 miles
Range (ferry)	4,750 miles

Paint schemes

The Vulcan is supplied with eleven paint schemes:

- XM655 (XM655 Maintenance and Preservation Society)
- XL426 (Vulcan Restoration Trust)
- XH562 (Kiwi roundels)
- XL361 (anti-flash white)
- XH538 (white belly)
- XM607 (Red Flag)
- XH534 (No.230 OCU, RAF Coltishall)
- XM600 (No.9 Squadron, RAF Cottesmore)
- XM607 (Black Buck)
- XL426 (anti-flash white)
- XH558 (RAF Vulcan Display Flight, 1992)

The Vulcan K.2 is supplied with four paint schemes:

- XM571 (50 Squadron)
- XL445 (50 Squadron)
- XJ825 (50 Squadron)
- XH558 (50 Squadron)

The Vulcan MRR is supplied with two paint schemes:

- XH560 (27 Squadron)
- XH534 (27 Squadron)

INSTALLATION, UPDATES AND SUPPORT

You can install this Vulcan 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.

Installing the aircraft

To install the aircraft in X-Plane 11:

1. Download the Vulcan from your Just Flight account.
2. Unzip the downloaded .zip file. The resulting folder will be named 'JF_Avro_Vulcan'.
3. Copy the 'JF_Avro_Vulcan' folder into the 'X-Plane 11/Aircraft' folder.

Accessing the aircraft

To access the aircraft in X-Plane 11:

1. From the Main Menu, click 'New Flight' or go to the Flight Configuration window.
2. Click on the 'JF_Avro_Vulcan' in the aircraft selection screen.
3. Click 'Customize' and choose a livery from the drop-down menu in the top right.
4. Click 'Start Flight'.

Uninstalling

To uninstall this software from your system:

1. Go to your X-Plane 11 folder.
2. Open the 'Aircraft' folder.
3. Delete the 'JF_Avro_Vulcan' folder.

Recommended X-Plane Settings

Joystick/yoke

For maximum enjoyment of this aircraft in X-Plane we recommend setting your joystick 'Stability Augmentation' sliders to 0. This will help prevent control issues, such as running out of pitch trim, and results in more realistic flight behaviour.

To turn off Stability Augmentation, follow these steps:

1. Launch X-Plane and go to the ‘Settings’ window.
2. Go to the ‘Joystick’ tab.
3. Click on the ‘Control Sensitivity’ button along the bottom of the window.
4. Set all three of the ‘Stability Augmentation’ sliders to 0% to disable them.
5. The Control Response sliders can be set as desired.
6. Press ‘Done’.

Rain effects

This aircraft includes support for Librain, a windshield rain effect library developed by Saso Kiselkov for X-Plane 11. To install Librain, please follow these steps:

1. Download the latest ‘librain.plugin.zip’ file from https://github.com/skiselkov/librain/releases/
2. Extract the ‘librain.plugin’ folder from inside the downloaded zip file
3. Copy the extracted ‘librain.plugin’ folder into the aircraft’s ‘plugins’ folder, which can be found in \X-Plane 11\Aircraft\

The Librain effects will now be visible whenever precipitation is enabled in X-Plane 11.

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 our Newsletter and emails.

Regular News

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

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SYSTEMS GUIDE

General

The Vulcan B Mk. 2 is a delta-wing, all-metal aircraft. It is powered by four Olympus 301 engines, each developing 20,000lb static thrust at sea level in ISA conditions. The aircraft is capable of air-to-air refuelling and is fitted with a ram air turbine (RAT) and an airborne auxiliary power plant (AAPP) for emergency electrical supplies.

The aircraft is operated by a crew of five:

- Captain
- Co-pilot
- Air electronics officer (AEO)
- Navigator/plotter
- Navigator/radar

The two pilots are seated side by side on ejection seats on a raised platform at the front of the cabin, referred to as the cockpit. The rear crew members are behind the two pilots, facing aft. This simulation features only the cockpit area.

Air conditioning

General

The cabin air conditioning and pressurisation system provides a means of maintaining comfortable temperatures and pressures within the crew compartment. Hot pressurised air is fed from the engine compressors, cooled by cold ram air and a cooling turbine, and then distributed throughout the cabin via ducting.

The temperature of the conditioned air is controlled by varying the proportion of hot air which flows through or bypasses the air cooler or the cooling turbine. The cabin pressure is determined by the amount of air allowed to flow out of the crew compartment. Pressurisation can be at two alternative levels: cruise or combat. The controls for the cabin heating and pressurisation are grouped together on the right console.

Cabin pressurisation

Two alternative pressurisation settings can be obtained:

- CRUISE – cabin altitude is maintained at 8,000ft until the maximum differential pressure of 9 PSI is reached at approximately 47,000ft, after which cabin altitude increases proportionally.
- COMBAT – cabin altitude is maintained at 8,000ft until the maximum differential pressure of 4 PSI is reached at approximately 19,500ft, after which cabin altitude increases proportionally.

An EMERGENCY DECOMPRESSION switch on the left console allows for decompression of the cabin in an emergency.

Cabin pressure is controlled by the three-position CABIN PRESSURE COMBAT/CRUISE/NO PRESSURE switch. With the switch at NO PRESSURE, pressurisation does not take place or, if the cabin is already pressurised, moving the switch to NO PRESSURE decompresses the cabin.

Cabin air conditioning and controls

The four ENGINE AIR OPEN/SHUT switches on the right console control the supply of engine air to the flow control valves. They also control the supply of engine air to the anti-icing systems and bomb bay heating.

The two CABIN AIR OPEN/SHUT switches open the shut-off valves, allowing the engine air to pass to the air conditioning unit. One switch controls the starboard supply and the other the port supply. When a switch is at OPEN, the flow valve automatically regulates the volume of air passing to the system.

Cabin temperature can be controlled automatically or manually. Selection of auto or manual is made by a four-position switch. When the switch is moved to the AUTO position, the temperature is automatically controlled according to the setting of the AUTO TEMP SELECTOR rotary control. If manual control is required, the switch is moved to the down position and then moved either forward to the COLD position (left-click) or aft to the HOT position (right-click) until the desired temperature is obtained. The switch is spring-loaded from both of these positions to the centre (neutral) position. An indicator shows the position of the temperature control valve.

The ram air valve is controlled by a three-position guarded SHUT/OPEN switch, spring-loaded to the central (neutral) position. An indicator shows the position of the valve.

An AAPP BLEED FOR CONDITION SHUT/OPEN switch is used to provide cabin ventilation on the ground. An override device, operated by an undercarriage microswitch, prevents the use of AAPP bleed in flight. A magnetic indicator is provided beside the switch, showing OPEN, SHUT, or cross-hatch when no electrical power is available.

The air-ventilated suits are supplied from an air conditioning unit which is similar to that used for cabin conditioning. The main cock in the hot air supply is controlled by an OPEN/CLOSE switch at the rear of the right console. Temperature and flow controls are provided for each suit on each console.

Operation of cabin air system

Before starting the engines, set the controls as follows:

- Cabin pressure selector – CRUISE
- Auto temperature selector – NORMAL
- Engine air switches – ALL SHUT
- Cabin air switches – BOTH SHUT
- Cabin temperature control switch – NEUTRAL (centre)
- Ram air switch – as required
- Emergency decompression switch – NORMAL (forward)
- Abandon aircraft switch – NORMAL (forward)
- Canopy unlocked indicator – black
- AAPP bleed switch – SHUT

If opened on the ground, the ram air switch should be SHUT before take-off unless the extra cooling is required.

After starting the engines, set all engine air switches OPEN and leave them open for the duration of the flight. Set the port cabin air switch OPEN after starting and for taxiing. OPEN the starboard switch at cruise altitude and SHUT it for descent and landing.

In an emergency, cabin pressure can be released by:

- Rearward movement of the EMERGENCY DECOMPRESSION switch
- Rearward movement of the ABANDON AIRCRAFT switch
- Selecting NO PRESSURE on the pressure selector switch

Windscreen thermal demisting

To demist the inside of the windscreen, hot air is supplied from a duct on each side of the centre panel. Windscreen demisting is controlled by an ON/OFF switch on the co-pilot's instrument panel. When switched ON, current is supplied to the blower and the heater.

Oxygen system

Oxygen is carried in twelve 2,250-litre bottles which are housed in the power compartment and bomb bay. High pressure lines supply the oxygen to the cabin.

The oxygen regulators are at the forward end of the left and right consoles. A mixture of oxygen and air is supplied according to cabin altitude.100% oxygen is provided automatically above 34,000ft or can be selected at any height.

The regulators have the following controls:

- OXYGEN FLOW INDICATOR magnetic indicator – displays white when oxygen is flowing through the regulator and black when no oxygen is flowing through the regulator.
- NORMAL/100% OXYGEN (air inlet control) – controls the ratio of oxygen to air that is delivered through the regulator. If NORMAL is selected the regulator will automatically vary the ratio to supply the proper mixture to the pilot, dependent on altitude. If 100% is selected the regulator will supply pure oxygen.
- ON/OFF valve – controls the flow of oxygen to the regulator.
- Regulator pressure gauge – displays the current oxygen supply pressure.
- Emergency test button – used to test the supply of oxygen to the mask.

Electrical system

General

The main electrical system is AC-operated. 200-volt, 3-phase, 400Hz power is supplied by four 40 kVA alternators, one on each engine.

Current is fed from each alternator to an individual busbar which can be connected to a synchronising ring main busbar for load sharing purposes. From the individual busbars, a number of transformer-rectifier units (TRUs), transformers and frequency changers provide the secondary power supplies.

Provision is made for standby supplies in the event of a major AC failure. A ram air turbine (RAT) supplies power primarily at high altitude and an airborne auxiliary power plant (AAPP) supplies power at lower altitudes.

The controls for the electrical system are grouped on the alternator control panel, the secondary supplies panel and the AAPP panel. These are provided as 2D pop-up panels.

Alternators

Each alternator provides 200-volt, 3-phase, 400Hz power.

Alternator supplies are controlled by two circuit breakers. With the alternator (A) breaker closed, the alternator feeds its own busbar. With the synchronising (S) breaker and the A breaker closed, the alternator supplies its own busbar and the synchronising busbar. The A and S breakers are arranged so that if the A breaker is opened, the S breaker is normally closed, thus ensuring an alternative power supply to the individual busbar via the synchronising busbar. The S breaker normally opens before the A breaker is closed. S breakers can be closed in order to parallel two or more alternators on the synchronising busbar.

Each load busbar supplies approximately a quarter of the total loads, and the PFC loads are divided between the four busbars.

The alternator control panel features the following controls and indicators:

- Voltmeter and frequency meter for the selected incoming alternator.
- RAT and AAPP test push-buttons, used to obtain the readings for these supplies on the meters.
- Alternator selector switch, incorporating a push-button to facilitate synchronisation of alternators. Use the mouse scroll wheel to rotate it and left-click to push in on the centre push-button.
- EXTRA SUPPLIES TRIP push-button, used to trip any extra supply (RAT, AAPP, 200-volt ground supply) from the synchronising busbar.
- Mimic diagram of the 200-volt system. The diagram incorporates a voltmeter and a frequency meter to show supplies at the synchronising busbar, magnetic indicators which show continuity when an S breaker is closed and amber lights to show when an alternator is not connected to its own busbar.
- Magnetic indicators for the RAT and AAPP show continuity when they are connected to the synchronising busbar.
- Centrally positioned red alternator failure warning light (duplicated on the centre instrument panel) which illuminates steadily if one alternator fails and flashes if two or more fail.
- AAPP ON push-button.
- Beside each S breaker indicator is an alternator ISOLATE button.
- Beside each amber light is an alternator RESET button.
- NON-ESSENTIAL SUPPLIES TRIP/RESET switch, spring-loaded to the central (guarded) position. This switch can be used to trip non-essential supplies without releasing the RAT and to reset non-essential supplies once power has been restored. Left-click the switch to move it up to TRIP; right-click to move it down to RESET.
- Four KW/KVAR meters, one for each alternator; normally read KW with a centrally positioned button labelled PUSH FOR KVAR to read KVAR.
- Four ON/OFF switches, one for each alternator.

When an engine is running, its alternator is brought online as follows:

1. Check, by means of the alternator selector switch, that the alternator voltage and frequency are within 115 ±5 volts, 400 ±4 Hz.
2. When the alternator is running correctly, set its alternator switch ON. Check that the S breaker opens, the A breaker closes (amber light out) and the KW/KVAR meter registers the load, indicating that the alternator is feeding its busbar.
3. Whenever there is no supply on the synchronising busbar, it is arranged by means of a voltage pick-up unit that the No.2 alternator S breaker closes automatically.
4. To connect an alternator to the synchronising busbar, select the appropriate alternator on the selector switch with the mouse wheel and then press in the switch with a left-click until the magnetic indicator shows continuity. To take an alternator off the synchronising busbar, press its ISOLATE button.
5. For take-off, the AAPP is connected to the synchronising busbar and is normally closed down at 20,000ft. If the climb is continued, No.4 alternator is connected to the synchronising busbar. For low-level flight or descent below 20,000ft, No.3 alternator is substituted for No.4 on the synchronising busbar. After landing, the AAPP is connected to the synchronising busbar at 5,000ft.

Ram air turbine (RAT)

A ram air turbine, housed in the underside of the port air intake, can be lowered into the airstream to provide power for electrical services in an emergency. The RAT drives a 22 KVA alternator which supplies 200-volt, 3-phase, 400Hz power to the synchronising busbar. The electrical supplies should not be used below 20,000ft.

When the pilot pulls the RAT release toggle, the RAT releases into the airstream and all non-essential loads are shed automatically, resulting in a cartridge start of the AAPP. The RAT is ready to supply loads within two seconds. Speed should be maintained above M 0.85 or 250 knots. The output can be checked on the alternator control panel either by pressing the RAT TEST push-button or, if the RAT is on the synchronising busbar, by reading the voltage and frequency from the synchronising busbar meters.

The RAT output cannot be connected to the synchronising busbar unless No.2 alternator A breaker is open, the RAT voltage is above 180 volts and there is no supply on the synchronising busbar. The RAT is automatically disconnected from the synchronising busbar if No.2 alternator or the AAPP is brought on line.

Once the RAT has been released, it cannot be retracted again in flight. Reload the aircraft or restart the flight to return the RAT to the stowed position.

Airborne auxiliary power plant (AAPP)

General

The AAPP consists of a gas turbine driving a 40 KVA alternator in a bay aft of the starboard wheel bay. It can provide a 200-volt supply for use in emergency or for use on the ground when an external power unit is not available. On the ground it can provide bleed air to the cabin conditioning and air-ventilated suits.

The AAPP supplies 200-volt, 3-phase, 400Hz power. It is used as a standby electrical supply and can be connected to any individual busbar via the synchronising busbar.

The AAPP may be started electrically or by a cartridge. Whenever the non-essential services are tripped, either by operation of the RAT release or by selection of the NON-ESSENTIAL SUPPLIES TRIP/RESET switch to TRIP, a cartridge start is triggered. Following RAT release, the non-essential services may be RESET, in which case the electrical method of starting the AAPP is restored. Cartridge starting of the AAPP should not be used on the ground.

Controls

The AAPP controls are on the alternator control panel and the AAPP panel.

Alternator control panel:

- AAPP TEST push-button for checking incoming voltage and frequency
- AAPP ON push-button for bringing the AAPP alternator onto the synchronising busbar. The AAPP is prevented from being connected to the synchronising busbar when No.1, 3 or 4 alternators are connected. If the No.2 alternator, the GPU or the RAT are supplying the busbar, pressing the AAPP ON button disconnects them and allows the AAPP alternator to be connected.

AAPP panel:

- JPT gauge
- Oil pressure gauge
- Fuel level magnetic indicator, which shows HIGH when the AAPP tank contains 8 gallons or more, LOW when the tank contains less than 2 gallons and black when the fuel is at an intermediate level or when no electrical power is available.
- Start push-button, embodying an amber light to indicate that the oxygen valve is open.
- LP COCK OPEN/SHUT switch
- HP COCK OVERRIDE switch, spring-loaded to OPEN
- IGNITION ISOLATION switch, spring-loaded to ON
- Fire warning light and test push-button
- OXYGEN & RELIGHT ON/OFF switch to provide oxygen enrichment for an electrical start above 15,000ft, to override a selected cartridge and achieve an electrical start to provide a relight facility.
- Split two-pole ON/OFF master switch

Operation

Cartridge starting:

1. When the RAT release toggle is pulled, or the NON-ESSENTIAL SUPPLIES switch is selected to TRIP, the AAPP start circuit is selected to cartridge.
2. Switch ON the master switch.
3. Press the start button.
4. Confirm that the oxygen light illuminates.
5. Check that the JPT, oil pressure, voltage and frequency are within limits.

Electrical starting:

1. If the non-essential busbars are live, indicated by the load shedding indicators showing a horizontal line, or if the non-essential busbars have been RESET following RAT release, when the indicators show a horizontal line superimposed on cross-hatch indication, then electrical starting of the AAPP is selected.
2. Switch ON the master switch.
3. Set oxygen and relight switch to ON (if above 15,000ft).
4. Confirm that the oxygen light illuminates.
5. Press the start button.
6. Check that the JPT, oil pressure, voltage and frequency are within limits.

An electrical start will also be achieved when the non-essential loads have been shed, by selecting the oxygen and relight switch ON, switching the master switch ON and pressing the start button.

Shutdown:

1. Switch OFF the master switch.
2. Monitor the JPT, oil pressure, voltage and frequency.

Secondary power supplies

General

The secondary power supplies required to operate the aircraft equipment are provided by transformer rectifier units (TRUs), transformers and frequency changers, all fed from the primary 200-volt AC busbars.

The controls and indicators for the main secondary supplies are grouped on the secondary supplies panel.

Transformers

Four transformers supply 115-volt, 3-phase, 400Hz power: two main (each 3 KVA), one NBS (1 KVA) and a Green Satin (1 KVA).

Each main transformer normally supplies its own services but if one transformer fails, its loads are automatically transferred to the other transformer. Two ON/OFF/COUPLE switches on the secondary supplies panel control the transformers, and indications are provided by two three-position magnetic indicators adjacent to the switches. When the transformers are ON, the indicators show line continuity. If one transformer fails and automatic coupling takes place, or if COUPLE is selected, its indicator shows discontinuity. When OFF is selected, the loads have no supply and the indicator shows cross-hatch.

28-volt DC

Four interconnected busbars are used to distribute the 28-volt power from two TRUs whose outputs are paralleled, either one being capable of supplying the total 28-volt system load.

The 28-volt loads are supplied from battery, vital, essential and non-essential busbars. The battery busbar is connected directly to the battery. The vital busbar is connected to both the battery and essential busbars. The essential busbar obtains its supply from either the battery, via the battery isolation contactor, the GPU or the TRUs. The non-essential busbars are fed via the port and starboard load shedding contactors from the essential busbars.

A 24-volt, 40 amp-hour battery is connected to the battery busbar and supplies the vital busbar at all times. When the battery switch is set to ON, the battery busbar is connected to the essential busbar for general use and for battery charging.

The controls for the 28-volt system are on the secondary supplies panel, consisting of two guarded ON/OFF/RESET switches for the TRUs and a guarded ON/OFF switch, spring-loaded to the centre position, for the battery. Ammeters show the input to the TRUs. A magneto indicator shows the continuity of input between the battery and essential busbars. Three-position indicators between the essential and non-essential busbars normally show continuity between these busbars, show discontinuity when automatic load shedding (either by release of RAT or operation of the TEST/RESET switch) has taken place and show override (continuity on background of cross-hatch) when RESET is selected after RAT release. The non-essential supplies TRIP/RESET switch sheds and restores the non-essential loads independently of RAT operation.

External power supply

A 28-volt ground supply can be plugged into the port wing. This supply feeds all normal 28-volt services and, if the battery switch is on, charges the battery.

Engines

General

The aircraft is powered by Olympus Mk. 301 engines. Engine control is provided by a combined throttle and HP cock. Limitations on engine output are controlled by the position of a Take-off/Cruise switch. A jet-pipe temperature limiter is installed which controls the engine speed to prevent the jet-pipe temperature limit being exceeded.

Throttle and HP cock controls

The four throttle levers, which also control the HP cocks, are forward of the retractable centre console in a quadrant marked OPEN/IDLING. The quadrant is gated at the IDLING position and the part of the quadrant below this, which controls the HP cock position, is marked OPEN/HP COCKS/SHUT and has a further gate at the SHUT position.

Left-click on the throttle levers to move them forward from the HP cocks SHUT gate. With the throttle levers at the IDLING gate, left-click on them to move them aft to SHUT.

Although the aircraft is fitted with auto-throttle controls, these are inoperative.

RPM governor

Each engine RPM governor has a double datum selector, allowing it to control RPM to take-off or cruise limits with the throttle at OPEN. The four selectors are controlled by a single TAKE-OFF/CRUISE switch on the left side of the throttle levers. In addition to selecting the required RPM datum, the switch also selects the corresponding temperature datum for each engine JPT limiter.

JPT limiter

The JPT limiter works to prevent the jet-pipe temperature limit being exceeded. It is controlled by the ON/OFF switch located aft of the TAKE-OFF/CRUISE switch. With the switch on, jet pipe temperatures are controlled automatically. With the switch off, the limiter is overridden and the JPTs must be controlled by throttle movement.

Engine starting system

Each engine has its own starter motor, which requires its respective engine air switch on the starboard console to be set to OPEN. Air can be supplied from a ground air starter unit, feeding through a connection on the underside of the starboard wing, or from the rapid start system. The ground air supply feeds into the main lines of the engine air system and then to the starter motors through electrically actuated valves. Compressed air from a running engine can be used to start the others, singly or simultaneously, provided that the appropriate engine air switches on the starboard console are set to OPEN.

The rapid starting system is arranged so that the powered flying controls (PFCs) and artificial feel are switched on automatically when the simultaneous rapid start button is pressed. Because of the peak loads involved, electrical power during starting must be supplied by a ground power unit and not from the AAPP.

A gyro hold-off system is fitted which de-energises the MFS, JPT limiters, contents gauges, auto-stabilisers and artificial horizons until the engine start master switch is selected ON.

Controls

The starting control panel on the left console features the following controls:

- Four push-buttons for individual engine starting, each containing a light
- GYRO HOLD OFF push-button
- RAPID START push-button for starting all engines simultaneously
- NORMAL/RAPID lock-toggle selector switch for selecting Palouste or high-pressure air
- Ignition ON/OFF switch
- AIR CROSS FEED three-position magnetic indicator
- ON/OFF master switch

An air cross-feed indicator shows OPEN whenever the master start switch is ON. When the air selector is set to NORMAL, engines can only be started by the individual push-buttons, using an external air supply or cross-feed. When the air selector is set to RAPID and the master switch is ON, all engines can be started simultaneously using the RAPID START push-button or separately, using the individual buttons. With the air selector switch set to RAPID and the master switch OFF, the gyro hold-off system is effective when the hold-off button is pressed.

A relight button on each throttle lever provides a means of relighting the engines in flight. When one of the buttons is pressed, 28-volt vital busbar power energises the igniter plugs regardless of throttle position or switch selections on the engine start panel.

Operation – normal

With the IGNITION switch ON, MASTER switch ON and air selector switch set to NORMAL, pressing the starter button energises three circuits:

- Solenoid to open position on starter air control valve
- Engine igniter plugs
- Palouste air bleed valve

The increase in Palouste air opens the air control valve and a pressure switch illuminates the start button. The air rotates the starter turbine which drives the HP compressor. Fuel from the HP pump is directed to the burners where the igniters initiate combustion. The engine accelerates and, once above self-sustaining speed, de-energises the engine igniters. The starter button light extinguishes.

Operation – rapid

With the IGNITION switch ON, MASTER switch ON and air selector switch set to RAPID, pressing the RAPID start button will start all four engines or pressing an individual starter button will start the corresponding engine.

The rapid start facility uses a mixture of bottled air and fuel from the booster pumps. When this mixture is ignited, the resulting hot gases turn the starter turbine. A pressure switch operates and makes the starter light come on. The engine accelerates and, once above self-sustaining speed, de-energises the engine igniters. The starter button light extinguishes.

Engine instruments

The following engine instruments are grouped together on the centre instrument panel:

- Four JPT gauges
- Four fuel pressure magnetic indicators which show white when there is sufficient pressure
- Four RPM indicators
- Four oil pressure gauges
- Engine control magnetic indicator (inoperative)

Fire protection system

There are four guarded fire extinguisher push-buttons, one for each engine, on the coaming above the centre instrument panel. Each button incorporates a red warning light which illuminates to indicate a fire. Pressing the button fires the extinguisher into the corresponding engine.

Similar controls are available on the co-pilot's instrument panel for the wings and fuselage, and a red warning light illuminates to indicate a bomb bay fire.

Flying controls

Powered flying controls (PFCs)

General

The flying controls in the cockpit are conventional in operation. Dual interconnected control columns and rudder pedals are provided, operating powered controls through a series of linkages.

The controls for the powered flying controls, artificial feel, auto-stabilisers and Mach trimmer are grouped together on the left console. The elevator and aileron trim and feel relief switches are duplicated on the two control columns. Those for the rudder are on the fuel contents panel. The emergency trim control is on the forward end of the retractable console.

Elevons

Control of the aircraft in the pitch and roll axis is achieved by eight elevons hinged into the wing trailing edge, four on each side. Each group of four is divided into two outboard and two inboard elevons. They are numbered 1 to 8 from port to starboard. Each surface is operated by a separate electro-hydraulically powered flying control unit (PFCU).

If the control column is moved fore or aft, all eight elevons move down or up. If it is moved to the left, the port elevons move up while the starboard ones move down. If it is moved rearwards and to the right, all eight elevons move up but the starboard elevons move up to a greater degree than the port elevons. Full elevator and aileron travel cannot be obtained at the same time.

Rudder

The single rudder is controlled by two powered flying control units, one main and one auxiliary. Normal control is by the main unit with the auxiliary unit idling. Change-over occurs automatically if the main unit fails.

Powered flying controls (PFCs)

Each PFC unit consists of an electrically driven hydraulic pump, a servo-valve and a hydraulic jack to move the control surface. Movement of the cockpit control operates the assembly to supply fluid to the appropriate side of the jack, thus moving the control surface. When the control surface position coincides with the new position of the cockpit control, jack movement ceases and the control surface remains in the selected position until further control movements are made.

Incorporated in the assembly is a surface lock valve. As long as servo pressure is available, the valve is held open to allow fluid to pass to either side of the jack. If this pressure is not available, the valve closes under a spring load and no further fluid can pass to or from either side of the jack. This triggers the illumination of a warning light on the instrument panel. Control surface lock valves form a ground lock for the aircraft surfaces.

A 200-volt, 400Hz AC supply is required to operate the PFC motors. This is supplied from the main busbars:

Elevons:

- No.1 and No.8 – No.1 busbar
- No.3 and No.6 – No.2 busbar
- No.4 and No.5 – No.3 busbar
- No.2 and No.7 – No.4 busbar

Rudder:

- Main – No.3 busbar
- Auxiliary – No.2 busbar

Artificial feel units

As the flying control system is irreversible, aerodynamic loads are not transmitted to the pilots' controls. To compensate for this lack of feel, artificial feel units are provided in the elevator, aileron and rudder control systems.

Elevator and rudder feel can be reduced to a minimum by use of feel relief switches, which also allow full range of control movement.

If any part of the artificial system malfunctions, or in an emergency, the artificial feel may be relieved by using the switch on the control column which relieves both the aileron and elevator systems. The system in which relief is not required may be restarted by pressing the A start button for aileron feel or the E start button for elevator feel. Feel relief on the rudder is achieved by pressing the button on the fuel contents panel. To retain normal feel, the R start button should be pressed.

To prevent possible feel unit runaway while at low level at speeds greater than 250 knots, a locking facility is provided for all three channels and is controlled by a single switch. No further movement of normal or relief actuators can take place until NORMAL has been selected, although failure warning is given if the speed is altered by 30 knots from that speed at which LOCK was selected.

The actuators for the artificial feel are operated by 28-volt DC.

Trimmers

Control forces felt by the pilot in flight are produced by compression or extension of the feel mechanism in response to control movement or change of airspeed. Trim adjustment is made by varying the length of the control run between the pilots' controls and the feel unit. This is done by an electrically operated actuator, which removes the load by resetting the feel actuator.

Electrical supplies for the system are 28-volt DC.

Auto-stabilisers and Mach trimmer

Pitch and yaw dampers (auto-stabilisers) are installed in the elevon and rudder circuits to improve the natural damping of aircraft oscillations. In addition, a Mach trimmer is installed to counteract the nose-down trim change at high Mach numbers.

The yaw damper system is duplicated, with the circuit in use being selected by the pilot. The actuators are in the rudder control circuit between the feel unit and the PFC. The system is airspeed-monitored – rudder displacement is constant up to 200 knots and then decreases as the airspeed increases.

Pitch dampers are provided to improve longitudinal stability at high altitudes and high Mach numbers (above M0.9). There are four channels in the system, each one feeding to one of the inboard elevon PFCs. The system is height-monitored and is inoperative below 20,000ft. Above this altitude the amplitude of control movement increases with increase of altitude.

The Mach trimmer system is duplicated and operates on the elevator control run, thus controlling all eight elevons. The system is brought into operation by a height switch at 20,000ft. The system applies up-elevon as the Mach number increases above M0.87. The amount of up-elevon applied is always the sum of the movement of two actuators. Full extension of both actuators represents a total up-elevon movement of 12° (6° for each) but this is only achieved at a Mach number of approximately M0.96.

The gyros and amplifiers in the systems are operated by 115-volt, 3-phase, 400Hz AC, while the servos, motors and relays are operated by 28-volt DC.

Controls and indicators

The controls for the PFCs, auto-stabilisers, Mach trimmer and artificial feel are grouped together on a panel on the port console. Controls for trim and feel relief are on each pilot's control column and on the fuel contents panel. The PFC motor controls, pitch damper and Mach trimmer control buttons embody warning lights.

At the top of the centre instrument panel is a bank of warning lights and magnetic indicators. The three left-hand magnetic indicators are for the PFC units, the artificial feel and the auto-stabilisers respectively. There is a control surfaces position indicator below the warning lights and indicators.

The 10 push (off) spring-loaded stop buttons for the individual PFC units are arranged along the inboard edge of the panel, those for the elevons being grouped in pairs to indicate outboard and inboard pairs of elevons. The inboard button of the rudder pair controls the main unit. Each button incorporates a warning light which illuminates if the unit malfunctions. Three PFC START push-buttons, which also engage the feel systems, are at the rear of the panel and are marked A, R and E. A signifies the outboard elevons and aileron feel, R the rudder and rudder feel, and E the inboard elevons and elevator feel.

The three push (off) / pull (on) buttons for the artificial feel warning systems are at the forward end of the panel and are marked FEEL A, R, E. In this case the letters are for aileron, rudder and elevator feel. Each button embodies a warning light. When the button is pushed in, the main warning on the pilots' centre instrument panel is cancelled.

At the outboard side of the panel are the controls for the auto-stabilisers and Mach trimmer. These consist of:

- YAW DAMPERS NO.1/OFF/NO.2 switch
- RESET COMPARATOR spring-loaded push-button for the pitch dampers and Mach trim
- Four PITCH DAMPERS push (off) / pull (on) buttons, each embodying a warning light
- Two AUTO-TRIM ON/OFF spring-loaded push-buttons, each embodying an extension indicator light
- AUTO-TRIM ON/OFF push-pull button, embodying a warning light

Each pilot's control column carries the following feel and trim switches:

- Four-way aileron and elevator trim button
- Guarded artificial feel relief switch for the aileron and elevator feel

The throttle quadrant and retractable console have the following controls:

- Twin rudder trim switches on the fuel contents panel, spring-loaded to the centre (off) position. They are marked RUDDER TRIM, PORT/STBD.
- RUDDER ART. FEEL RELIEF push-button on the fuel contents panel
- Emergency trim switch for all the trim circuits on the retractable console

The centre instrument panel has the following indicators:

- At the top of the centre instrument panel is a bank of warning indicators. The three left-hand magnetic indicators are for the PFC units, the artificial feel and auto-stabilisers respectively.
- The auto-stabiliser indicator shows white if any channel is switched off or fails.
- The artificial feel indicator is a three-position indicator which shows black, white or ILS. It shows black during normal flight conditions, ILS during approach conditions (with TRACK and LOC & GP selected) and white if any of the relays fail or if the aileron or rudder channels disengage.
- The PFC indicators only show white if any PFC stop button is pressed, or when servo pressure falls below 35-50 PSI and if a 28-volt supply is available.
- The amber MAIN WARNING lights at either end of the group come on if a fault develops in any of the systems (except the yaw damper). This warning is cancelled by pushing in the button of the channel concerned. The appropriate magnetic indicator shows white as a reminder that a channel is unserviceable. The main warning lights are then available for any subsequent failure.
- Below this group is the control surfaces position indicator, representing a view of the aircraft from the rear. There is a separate indicator for each of the control surfaces, with datum lines to show the surface position relative to the take-off position.

Operation

Starting the PFCs

With electrical power available and the PFC and artificial feel buttons out, the PFC motors and the artificial feel are started by pressing the START push-buttons. Check that the two left-hand magnetic indictors show black and that the lights in the buttons are out. After flight and before turning off the secondary power supplies, push in all the control buttons. Those for the PFCs are spring-loaded to the out position.

Artificial feel lock

When flying at speeds above 250 knots at low altitude, set the feel lock switch to LOCK when the desired speed has been reached and check that the light illuminates.

If the speed is changed by more than approximately 30 knots from the locking speed, the main warning lights and the lights in the feel indicator buttons illuminate and the magnetic indicator goes white. To prevent the main warnings coming on, push in the feel indicator buttons. The lights in the indicator buttons come on and the magnetic indicator shows white.

Before the feel is unlocked, reduce speed to below 250 knots, trim out the control forces and then raise the feel indicator buttons. The main warning lights will illuminate. Unlock the feel and ensure that all failure warnings disappear.

Trim controls

Aileron and elevator trimming are achieved by using the appropriate control assignments. This will cause the trim button on the control column to move.

Rudder trimming is achieved by using the appropriate control assignments or by moving the rudder switches on the throttle quadrant in the required direction.

The emergency trimmer on the retractable console can also be used. This is pressed in on the centre to activate it, then moved fore and aft for longitudinal trim, sideways for lateral trim and rotated for rudder trim.

Yaw dampers

To switch on the yaw dampers, the selector switch is put to No.1 or No.2 as required. The yaw damping will always be in operation and at all heights when either motor is selected. The magnetic indicator shows white when the switch is off. A power supply failure to the selected yaw damper does not necessarily give a white indication. The switch must be put to the off (centre) position after flight.

Pitch dampers

The pitch dampers are energised by pulling out the selector buttons on the left console. The buttons may be pulled out at any stage in the flight, but the dampers are inoperative until the height switch permits their operation at 20,000ft. The buttons must be pushed in after flight.

Mach trimmer

Both Mach trim servos are energised by pulling out the single ON/OFF button on the left console. The system does not operate at heights below 20,000ft and only starts applying nose-up trim at speeds above M0.88. The blue lights in the reset buttons are illuminated whenever the servos are extended.

Airbrakes

The slat-type airbrakes in the mainplane, located above and below the engine air intakes, are electrically operated by two motors using 200-volt, 3-phase AC. The port motor is supplied by No.2 busbar and the starboard motor by No.3 busbar. The supplies to the airbrakes are disconnected if load shedding occurs.

The airbrakes have three extended positions:

- Medium drag – 35°
- High drag (undercarriage up) – 55°
- High drag (undercarriage down) – 80°

The transition from 55° to 80° is automatic when the undercarriage is lowered.

The airbrakes are controlled by the speedbrakes toggle, speedbrake up or down assignments, or by a ganged switch on the rear face of the throttle quadrant. The switch has three positions: IN, MEDIUM DRAG and HIGH DRAG.

The airbrakes are operated by two electric motors. If one motors fails, the other can be brought into operation by selecting the NORMAL/EMERGENCY switch on the throttle quadrant to EMERGENCY.

The three-position magnetic indicator for the airbrakes is at the top of the centre instrument panel. It shows white when no power is available or when selected out, and black when power is on and the airbrakes are in.

Brake parachute

A brake parachute is installed in the tail cone, aft of the rudder, to provide additional braking during the landing run.

Parachute operation is electrically controlled by a JETTISON/STREAM switch on the centre instrument panel. Left-click the switch to select STREAM to deploy the parachute and right-click to select JETTISON to jettison the parachute. The switch can also be operated using the 'Spoiler arm' control assignment.

The brake parachute operation uses 28-volt DC.

Reload the aircraft or restart the flight to return the brake parachute to the stowed position.

Fuel system

General

Fuel is carried in fourteen pressurised tanks, five in each wing and four in the fuselage, above and to the rear of the nose-wheel bay. The tanks are divided into four groups, each group normally feeding its own engine. A cross-feed system enables the various groups to be interconnected. Automatic fuel proportioning is normally used to control the fuel CG position.

Provision is made for carrying either saddle-shaped or cylindrical fuel tanks in the bomb bay. Fuel from these tanks passes into the main system through two delivery lines to each side of a centre cross-feed cock.

An air-to-air refuelling system is fitted. The nose probe is in the nose and pipes from it join the normal refuelling lines.

The majority of the controls and indicators for the fuel system are grouped in the form of a mimic diagram on the retractable console. The air-to-air refuelling controls are on the starboard console.

Fuel tanks

The tanks on each side of the aircraft are numbered from 1 to 7. No.1 and No.2 are fuselage tanks and the remainder are wing tanks. The tank numbers correspond to the CG position of each tank, with No.1 having the furthest forward CG and No.7 the furthest aft. No.1, 4, 5 and 7 tanks comprise the outboard tank group in each wing (No.1 group port, No.4 group starboard). No.2, 3 and 6 tanks comprise the inner tank groups (No.2 group port, No.3 group starboard). Each group normally feeds its associated engine.

For this simulation, tanks 4, 5, and 7 on each side are grouped together as a single tank, as are tanks 3 and 6. This leaves two fuel tanks per tank group: a forward tank and an aft tank.

The outboard engines' fuel tanks are shown in yellow on the fuel diagram. The inboard tanks are shown in white.

Two fuel tanks can be carried in the bomb bay, one at the forward end and one at the rear end.

The fuel tank for the airborne auxiliary power plant (AAPP), located in the starboard wing to the rear of the AAPP, has a capacity of 10 gallons. The tank is filled from the main fuel system via a line from the wing tanks of No.4 group whenever the No.4 group wing booster pumps are running.

Tank	Imperial gallons	Pounds (AVTUR – 8lb/gal)	Pounds (AVTAG – 7.7lbs/gal)
Saddle tank (forward position)	718	5,744	5,529
Saddle tank (rear position)	721	5,768	5,552
Cylindrical (any position)	995	7,960	7,662

Tank group	Tank number	AVTUR – 8lb/gal		AVTAG – 7.7lbs/gal	
		Gallons	Pounds	Gallons	Pounds
1 and 4 (outboard – port and starboard)	1	2x 610	2x 4,880	2x 620	2x 4,774
	4	2x 630	2x 5,040	2x 640	2x 4,928
	5	2x 515	2x 4,120	2x 525	2x 4,042.5
	7	2x 565	2x 4,520	2x 575	2x 4,427.5
	Total each group	2x 2,320	2x 18,560	2x 2,360	2x 18,172
	Total both groups	4,640	37,120	4,720	36,344
2 and 3 (inboard – port and starboard)	2	2x 935	2x 7,480	2x 945	2x 7,276.5
	3	2x 630	2x 5,040	2x 640	2x 4,928
	6	2x 745	2x 5,960	2x 755	2x 5,813.5
	Total each group	2x 2,310	2x 18,480	2x 2,340	2x 18,018
	Total both groups	4,620	36,960	4,680	36,036
	Total fuel	9,260	74,080	9,400	72,380

Each tank group can be pressurised with air from its associated engine. Pressurisation of the main tanks is controlled by a switch on the air-to-air refuelling panel. Below the switch are four magnetic indicators, one for each tank group, which show black when the tanks are pressurised. A switch on the centre console is provided for bomb bay tank pressurisation but it is inoperative.

Controls and indicators

Retractable console

The fuel panel on the retractable console carries a mimic diagram of the system, including the bomb bay tanks.

Forward of the diagram are three CG control switches, two FWD/AFT transfer pump switches (one for each side of the system) and one PORT/STBD switch for use during air-to-air refuelling.

On each side of the diagram are two AUTO/MANUAL switches, one for each group. These switches control sequence timing.

In each tank on the diagram is an OFF/ON pump switch, which controls both the main and auxiliary pumps, and a CONT push-button for reading the contents.

The cross-feed cocks are represented in the diagram by three magnetic indicators, with OPEN/CLOSE cock switches to the rear of them.

Four push-buttons marked NO.X ENG are provided for flow meter selection. The bomb bay system diagram has two BOMB-BAY/MAIN switches, two ON/OFF pump switches for each tank and a pressurisation switch (inoperative).

Starboard console

The air-to-air refuelling controls are grouped on a panel on the right console and consist of:

- Two probe lighting dimmer switches
- Nitrogen switch
- Main tanks pressurisation switch
- Four tank pressurisation magnetic indicators
- ON/OFF master switch
- Refuelling indicator
- Refuelling gallery pressure gauge

Fuel cocks

The four HP cocks are opened by the initial movement of the throttle levers forward from the fully closed position. Left-click and drag on the throttle levers to pull them out and forward from the HP cocks SHUT gate. With the throttle levers at the IDLING gate, left-click and drag them out to move them aft to SHUT.

The four LP cocks are electrically controlled by four guarded ON/OFF switches on the underside of the coaming above the centre instrument panel.

Cross-feed cocks and indicators

There are two wing cross-feed cocks, each connecting the tank groups on that side, and a centre cross-feed cock between No.2 and No.3 groups. The cocks are electrically operated.

Three three-position magnetic indicators show continuity with the diagram lines when the cocks are open, discontinuity when the cocks are shut, and cross-hatch when the cocks are at an intermediate position or when no power is available.

Fuel pumps

Each wing tank contains both a booster pump and an auxiliary pump. The fuselage tanks have a single booster pump.

Each saddle-type bomb bay tank has four booster pumps, with one pair supplying each feed from the tank. The pumps run in parallel and each pump switch controls one port and one starboard pump in its tank.

Each cylindrical tank has three booster pumps. The same controls are provided, with the right-hand pump switch for each tank controlling the forward pump and the left-hand switch controlling the other two pumps.

Transfer pumps in No.1 and No.7 tanks on each side allow fuel to be transferred in either direction between these tanks if it is necessary to adjust the fuel CG position. As both tanks are in the same group, transfer does not affect the group contents.

With a transfer pump switch at FW, the refuelling valve of No.1 tank opens and No.7 tank pump starts and transfers fuel to No.1 tank. Placing a switch to AFT opens the refuelling valve of No.7 tank and starts the No.1 tank pump.

Four magnetic indicators on the centre instrument panel, below the JPT gauges, show black when the fuel pressure to the engine is satisfactory, white when the pressure falls below 5 PSI and black when there is no power supply.

The two bomb bay fuel indicators show black when the fuel pressure is sufficient and the cocks are open. They show white if the fuel pressure falls below 10 PSI.

Sequence timers

Because of the configuration of the aircraft, the fuel tanks are located forward and aft of the aircraft's centre of gravity. It is therefore essential that fuel is used at approximately the same rate from all tanks in order to maintain the fuel CG position. An electrically operated sequence timer on each side of the aircraft ensures even fuel distribution by sequentially drawing fuel from each of the tanks to feed the engine.

With all booster pumps ON and the AUTO/MANUAL switches at AUTO, sequence timing is in operation. To interrupt the sequence timing in any group, put the appropriate switch to MANUAL. If you wish to use fuel from any particular tank in the group, switch OFF all booster pumps which are not required. The AUTO/MANUAL switches should be set to MANUAL after flight.

Fuel contents gauges

Four main tank contents gauges, one for each tank group, are on a panel forward of the throttle levers. Each gauge is calibrated with two concentric scales and they read in pounds x 1,000. Normally each gauge reads the contents of its appropriate group on the inner scale. An individual tank reading is obtained on the outer scale by pressing the push-button in the appropriate tank position on the mimic diagram. The gauges are powered by the 28-volt DC supply.

Flow meters

A flow meter is provided to give the following indications:

- Fuel consumption by individual engines (lb/min)
- Total fuel consumption by all four engines (lb/min)
- Total amount of fuel gone (lb)

Two indicators, one giving total flow/pounds used and the other giving instantaneous flow for individual engines, are on the co-pilot's instrument panel, together with a FUEL FLOW/RESET/NORMAL switch for resetting the total flow indicator. Selection of an individual engine flow is obtained by pressing the appropriate engine push-button on the fuel system mimic diagram. The instrument continues to indicate the flow to that engine until another engine is selected.

CG indicator

A fuel CG position indicator on the centre instrument panel indicates the CG of the fuel system. Readings can be taken by pressing the CG CHECK button.

The instrument face has two arcs, one for each side of the fuel system. Each arc is divided into three sectors: a central green sector to indicate the safe range and red outer sectors marked NOSE HEAVY and TAIL HEAVY. The needles should be on or near the zero position.

Air-to-air refuelling controls

The air-to-air refuelling indicator consists of the outline of the aircraft with numbered lights in the position of each tank. The lights illuminate when the valves open and go out individually as the tanks fill.

The master switch must be set to ON before refuelling starts. This opens the refuelling valves, depressurises the tanks and isolates the fuel contents gauges, resulting in them reading zero. All lights in the indicator illuminate and extinguish again as the associated tank is filled.

After refuelling is complete, the master switch must be set to OFF and the nitrogen purge switch set to ON to force any fuel from the probe lines.

The aircraft CG can be controlled during air-to-air refuelling by three switches on the fuel control panel – the two switches which normally control the transfer pumps, for fore and aft control, and the PORT/STARBOARD switch at the top of the panel, marked FR RECEIVER CG CONTROL, for lateral control.

When the refuelling master switch is ON, the transfer pump switches are disconnected from the transfer pumps. Setting them to FWD closes the refuelling valves in tanks 6 and 7, while setting them to AFT closes the refuelling valves in tanks 1 and 2. The refuelling valves remain open in all other tanks. If the lateral control switch is moved to PORT or STBD, the refuelling valves in the No.6 and No.7 tanks on the opposite side are closed.

Fuel system management

General

Before starting engines:

1. Set the AUTO/MANUAL switches to MANUAL.
2. Check fuel contents and booster pump and cross-feed operation.
3. Switch on one booster pump in each group and confirm that the magnetic indicator is black.
4. Confirm that the LP cocks are open.
5. After starting, switch on all booster pumps and put the AUTO/START switches to AUTO.

Before take-off:

1. Confirm all booster pumps are on.
2. Move all transfer switches to the centre position.
3. Confirm that the cross-feed cocks are closed.
4. Set the AUTO/MANUAL switches to AUTO.
5. Set tank pressurisation ON.

After shutdown:

1. Set all booster pumps to OFF.
2. Set AUTO/MANUAL switches to MANUAL.
3. Move all transfer switches to the centre position.
4. The LP cocks are normally left open.

In flight

With the AUTO/MANUAL switches at AUTO and all booster pumps ON, fuel balancing is maintained automatically, ensuring that the fuel CG remains approximately constant.

Make systematic checks of all tank contents at frequent intervals. The contents for corresponding tanks on opposite sides of the aircraft should be approximately the same.

When the contents of any tank in a group has fallen to 400lb, set the AUTO/MANUAL switch for that group to MANUAL and switch off the booster pump for that tank when the fuel level falls to 150lb.

Cross-feeding

If an engine fails or is shut down for a long period, or if the fuel feeds unevenly for any reason, cross-feeding is necessary to maintain a lateral fuel balance. The appropriate cross-feed cocks must be opened and the system can be left at AUTO. Switch off the booster pumps on the side containing less fuel until lateral balance has been restored.

Landing fuel

Although all the fuel indicated on the fuel contents gauges is usable, the recommended minimum fuel for final landing is 8,000lb total.

Bomb bay fuel tanks

Use the fuel in the bomb bay tanks as soon as possible after take-off. Before selecting the bomb bay tanks, the main tank AUTO/MANUAL switches must be set to AUTO and all booster pumps must be ON.

When established in the climb:

1. Open the wing cross-feed cocks.
2. Set both pump switches ON for each tank in use.
3. Set both BOMB-BAY/MAIN switches to BOMB-BAY.
4. Check that the bomb bay magnetic indicators change to white when the pump switches are set to ON and then revert to black as the pressure builds up.
5. When the magnetic indicators show white, or the tank contents have fallen to 150lb, set the BOMB-BAY/MAIN switches to MAIN.
6. Switch OFF the booster pumps and close the wing cross-feed cocks.

General equipment

Entrance door

The aircraft is entered by the door on the underside of the fuselage, below the crew compartment, which is fitted with a folding ladder. The door is hinged at the forward end and opens downwards. To open and close the door, click the corresponding button on the Side Menu.

A magnetic indicator on the centre instrument panel shows white when the door is unlocked.

Ejection seats

The cockpit is fitted with ejection seats for the Captain and co-pilot. The seats have adjustable armrests to improve visibility of the consoles.

The seat pins can be fitted or stowed by clicking on any one of the pins. They are automatically fitted or stowed when selecting either of the two panel states.

Ejection can be initiated by assigning a key or joystick button in X-Plane to 'Flight Controls / Deployment / Eject'. After ejection a new flight must be started in order to fly again.

Windscreen wipers

Windscreen wipers are provided for each pilot's windscreen panel and for the centre panel. The wipers are electro-hydraulically operated. The wipers for the Captain's and centre windscreen share a common motor, while the co-pilot's has an independent system.

The wipers are controlled by two three-position OFF/FAST/SLOW switches, one for the Captain and centre windscreen and one for the co-pilot's wiper.

The wipers are operated by 28-volt DC.

Visors

Sun visors are provided for the windscreen and side panels. The side visors slide down and the front ones are hinged at the top.

Anti-flash screens are provided for the windscreen, side screens and crew windows. The screens for the side windows are sliding shutters.

Lighting

Internal lighting

The pilot's instrument panels and consoles are lit by white floodlighting which is controlled by two switches, one on the outboard side of each instrument panel.

The lighting uses 115-volt, 3-phase AC from the main transformers.

External lighting

Before any of the external lighting can be used, the EXTERNAL LIGHT master switch must be set ON. The switch is located on the inboard side of the right console.

Steady navigation lights are provided, with rotating beacon lights on the top and bottom of the fuselage. The control is marked NAV LIGHTS – STDY/FLASH. When FLASH is selected, the navigation lights are steady and the rotating beacon lights operate.

A downward identification light is controlled by a STEADY/OFF/MORSE switch on the inboard side of the right console. The switch is spring-loaded from MORSE to OFF.

There is a combined landing/taxi lamp under each wing. The lamp extends further for the taxi position than for landing. The lamps are individually controlled by two three-position RETRACT/LANDING/TAXI switches on the inboard side of the right console. The lamps incorporate a mechanism that allows them to retract if the airspeed exceeds 180 knots. Once the lamps have retracted, the control switches must be reselected to RETRACT and then to LANDING before the lamps will re-extend.

Hydraulic system

General

The main hydraulic system provides pressure for operating the following:

- Undercarriage raising/lowering
- Nose-wheel centring/steering
- Bomb doors opening/closing
- AAPP air scoop

An electrically operated hydraulic power pack unit (EHPP) is installed for operation on the ground of the bomb doors and wheel brakes. It may also be used for in-flight operation.

An emergency air system is provided for lowering the undercarriage, and separate self-contained electro-hydraulic systems are provided for the PFCs and the windscreen wipers.

Main system supplies

Engine-driven pumps

Three engine-driven pumps, one on each of No.1, 2 and 3 engines, draw fluid from a reservoir. From the pumps, fluid is delivered to the main gallery at a pressure of 3,600-4,000 PSI. In addition to supplying the various services, this pressure is used to charge the wheel brake accumulators.

Hydraulic pressure gauge

A triple pressure gauge is on the centre instrument panel. The left-hand arc shows the pressure in the main gallery, while the two right-hand arcs show the pressure in the two brake accumulators.

Operation

When the engines are running, check that the main and accumulator pressures are between 3,600-4,250 PSI.

The main pressure drops when a hydraulic service is operated. Check that it does not exceed 4,400 PSI after the operation and that it stabilises back in the normal range.

To check that all pumps are working, use the normal selector to open the bomb doors and confirm that they don’t take longer than seven seconds to reach the open position.

Hydraulic power pack

An electrically operated hydraulic power pack unit (EHPP) provides emergency pressure for operating the bomb doors and for recharging the brake accumulators.

The unit consists of a 3-phase electric motor driving a pump in a reservoir. This is pressurised by engine air. The power pack is filled from the main reservoir. The pump delivers fluid at a pressure of 4,000 PSI and uses 200-volt AC from No.2 busbar.

The hydraulic power pack is energised to supply the bomb doors when the bomb doors emergency switch is set to the OPEN or CLOSED position.

Undercarriage system

General

The undercarriage main-wheel units are four-wheel, eight-tyre bogies. The nose-wheel unit is a steerable twin-tyre.

Hydraulic pressure operates the undercarriage doors, extension mechanism, bogie trimmers and down locks, through electrically controlled selector valves.

Normal control and operation

Undercarriage raising and lowering is controlled by an UP and a DOWN button on the centre instrument panel. When the weight of the aircraft is on its wheels, a safety device prevents the undercarriage from being raised.

Undercarriage position indicator

The undercarriage position indicator is on the centre instrument panel and indicates as follows:

- All wheels up and doors locked closed – no lights
- Wheels unlocked – three red lights
- Wheels locked down – three green lights

Undercarriage emergency air system

The emergency air supply for the main wheels and nose-wheels is contained in two separate bottles. The two controlling valves are mechanically linked and are operated by a handle on the right of the throttle quadrant. When the handle is pulled to its full extent, the undercarriage lowers regardless of the position of the normal selector.

Wheel brakes

The brake units are hydraulically operated. Two accumulators provide a reserve of pressure for brake operation and can be recharged by the hydraulic power pack. The pressure at the brakes is shown on the triple pressure gauge on the centre instrument panel.

A parking brake is provided, which operates through a cable to open simultaneously all the hydraulic valves in the brakes control valve.

The parking brake is applied by turning and pulling the lever on the left of the throttle quadrant.

If it is necessary to recharge the accumulators in flight or on the ground when the engines are not running, this can be done by the hydraulic power pack.

The brake accumulators can be charged from the power pack by operation of the START/STOP switch on the centre instrument panel. The switch is spring-loaded to the central position. With the switch moved to START and released, the power pack charges the accumulators in approximately six seconds and switches off automatically when the line pressure reaches 4,000 PSI, unless it has already been stopped by selecting STOP. While the brake accumulators are being charged, both normal and emergency bomb door selection is inhibited by an automatic shut-off valve. To ensure that the hold-off device is reset, select STOP after each operation.

Bomb doors

The bomb doors are hydraulically operated. For normal operations, supplies from the main system are fed through dual selector valves to door jacks. If the normal supply fails, the doors can be operated through a separate system from the hydraulic power pack.

The Captain has two switches on the left console, labelled BOMB DOOR CONTROL NORMAL and EMERGENCY. The NORMAL switch is a rotary type selector with three positions: OPEN/AUTO/CLOSE. When OPEN or CLOSE is selected, the bomb doors operate at the time of selection.

The EMERGENCY switch is a guarded three-position switch labelled OPEN/NORMAL/CLOSE. When this switch is operated, the doors are opened or closed by supplies from the hydraulic power pack and the electrical supplies are cut off from the normal selector. This switch is inoperative if the power pack is being used to charge the brakes accumulator.

The three-position magnetic indicator for the bomb doors is located on the centre instrument panel. It shows black when the doors are closed, white when they are open and cross-hatch when they are moving or when there is no electrical supply.

Ice protection

General

A thermal anti-icing system provides protection for the leading edges of the wings and fin and for the engine air intakes. Hot air from the engines and cold air from individual intakes are mixed, pass along the inside of the skin and are then exhausted.

In the engine, thermal anti-icing is provided by means of hot air from the HP compressor through an on/off electrically operated valve.

The anti-icing system can be controlled either manually or automatically. The compressor anti-icing valves can be controlled either by the wing anti-icing controls or by separate on/off switches.

Gold film heating is provided for the pilots' windscreen.

The anti-icing system uses 115-volt AC from port and starboard main transformers and also 28-volt DC. The de-icing systems use 28-volt DC and 200-volt AC from No.2 busbar.

Controls

The controls are grouped on a panel at the rear of the right console. One group of controls is for the port wing and engines, one for the fin and one for the starboard wing and engines. The controls for fin anti-icing also control the anti-icing of the ECM air intake. The controls for each group consist of the following:

- AUTO/OFF/MANUAL switch
- Temperature gauge, reading from 0-200˚C
- Manual heat control switch, labelled INC/DEC, spring-loaded to the central neutral position

In addition to these controls, the engine air switches must also be OPEN before hot air can be supplied to the systems.

When the AUTO/OFF/MANUAL switch is put to AUTO, the opening and closing of the hot air valve and the cold air supply are controlled by sensing elements to maintain a skin temperature of approximately 10˚C and leading-edge duct air temperature at 150˚C.

When MANUAL is selected, the manual heat control switch must first be held to INC until the temperature reaches 140˚C and can then be adjusted as required to maintain the required temperature.

When either AUTO or MANUAL is selected, the compressor anti-icing is also switched on. It is switched off when OFF is selected. This applies whether the engine air switches are OPEN or SHUT and, if necessary, compressor anti-icing without wing and air intake anti-icing can be selected with engine air switches SHUT.

Two separate guarded switches are provided to enable engine anti-icing to be used when the wing anti-icing is not in use. These are ON/OFF switches, one on either side of the manual heat control switches.

The windscreen heating will be operational when the entrance door is closed and the pressure-head heaters are on. Three three-position magnetic indicators for the windscreens show NORMAL when the windscreen heating is operated satisfactorily and cross-hatch when windscreen heating is off or isolated.

A HIGH/MEDIUM/LOW heat switch is located on the co-pilot's instrument panel.

Flight instruments

Military Flight System (MFS)

The Military Flight System (MFS) consists of:

- Twin aircraft attitude systems
- Twin compass systems
- Autopilot

Basic information is displayed on the director horizon and the beam compass at each pilot's station. These two instruments, which replace the normal artificial horizon, gyro-magnetic compass, ILS indicator, PDI and selector and autopilot heading selector, provide flight director signals for the pilots.

ILS signals can be fed into the system, the ILS localiser information being presented on the beam compass and the ILS glidepath information on the director horizon.

Flight director signals are fed into the director horizon, telling the pilot the attitude required to achieve the desired condition of flight. If the autopilot is in use, it is supplied with heading signals from the system.

Director horizon

Each director horizon is an artificial horizon on which the pitch and roll elements have been separated.

The various components consist of:

1. Attitude failure flag
2. BEAM and glidepath (GP) flags and a pitch director indicator (P) flag
3. Horizon bar
4. Pitch scale (glide path)
5. Pitch scale (attitude)
6. Pitch pointer
7. Glidepath pointer
8. Bank ringsight pointer and bank scale
9. Azimuth director pointer
10. Pitch scale setting knob

Roll signals are fed to the horizon bar which rotates in a conventional sense to indicate bank angle. The bank ringsight, operating at right angles to the horizon bar, moves over a scale to indicate the precise angle of bank. The scale is marked in 10˚ intervals up to 30˚ and then to 60˚. The azimuth director pointer moves over the same scale to indicate the difference between the current heading and the selected heading index on the beam compass. When ILS is selected, the pointer indicates deviation from the localiser.

Pitch signals are fed to the pitch pointer, which moves vertically over the pitch scale. The instrument has a linear pitch scale movement. It is calibrated against two scales ranging from 20˚ nose-up to 10˚ nose-down.

The glidepath pointer, which moves relative to the pitch scale, is controlled by ILS glidepath (glideslope) signals. When there are no glidepath signals, the needle remains over the centre dot on the pitch scale. When the pitch scale is being servo-driven and/or a selection other than central is made on the pitch selector switch, the P flag shows.

The BEAM flag is permanently in view while valid ILS localiser signals are being received. The GP flag shows when valid ILS glidepath signals are being received.

Beam compass

Each beam compass is driven by the gyro-magnetic compass system. The beam compass:

- Acts as the heading monitor for the autopilot
- Acts as the heading selector for both director horizons and for the autopilot
- Shows the displacement from a selected radio beam and the aircraft heading relative to that beam
- Can provide directional gyro information

The various components consist of:

1. Sense switch
2. Rotatable compass scale
3. Heading pointer, with a miniature aircraft in the centre and a ringsight pointer at the tip
4. Heading index
5. Top and bottom datum marks
6. Radio-coupled range marks
7. Radio beam displacement bar and scale
8. DG flag
9. Compass warning light
10. Setting knob

Any movement of the aircraft in azimuth is shown by the heading pointer moving over the compass card. The compass card can be rotated by clicking on the setting knob to pull it out and then rotating it to bring the desired heading against the datum mark at the top or bottom of the dial. The heading pointer moves with the card to indicate aircraft heading. The heading index can be moved round the compass card by clicking on the setting knob to push it in and then rotating it.

The radio beam displacement bar travels horizontally over a scale on the face of the dial to indicate deviation from the beam signals.

The sense switch is used to control the coupling of localiser radio signals to the azimuth director pointer and autopilot.

MFS selector

An MFS selector is provided on the centre instrument panel. It has the following switches:

- COMP switch for compass selection
- Navigational selector switch
- Pitch selector switch

The COMP switch is marked with an arrow to indicate which compass system (port or starboard) has been selected to supply heading control signals to the azimuth director pointers and to the autopilot.

The navigational selector has five positions:

- BOMB – non-functional
- REMOTE – the heading information is controlled by the default GPS
- Central (normal) – all heading indications by the heading pointer are magnetic
- LOC – ILS localiser beam or NAV 1 signals are fed into the system. The BEAM flag on the director horizon shows and the beam bar on the beam compasses indicates the aircraft position relative to the beam.
- GP – both localiser and glidepath signals are fed into the system. Both the BEAM and the GP flag show on the director horizons and the glidepath pointer moves relative to the centre dot to show the relative position of the glidepath to the aircraft.

The pitch selector switch controls the servo-driven functions of the director horizon pitch scales and has five positions:

- MACH – non-functional
- HEIGHT – pitch directions are given to maintain the aircraft at the altitude at which it was flying at the time of selection
- Central (normal) – no pitch director signals are fed to the director horizons and the pitch scale can be adjusted to any required attitude datum using the pitch scale setting knob
- APPROACH – pitch directions are given to maintain the glidepath
- DATUM – non-functional

Power supplies

The main system is operated by 115-volt AC at 400Hz. All control switches are operated by 28-volt DC.

Power failure is indicated by:

- Failure warning flags on both director horizons
- No compass annunciation
- No ILS BEAM or GP flag indications
- MFS pitch selector reverting to the central position

Autopilot

A Mk.10 autopilot is installed as part of the Military Flight System. The autopilot uses 115-volt AC and 28-volt DC. Power to the autopilot is controlled by a switch on the right console.

The autopilot control panel is located at the rear of the retractable console and carries the following controls:

- TRACK – this two-position pull-push switch can be operated using left-click to move it between OFF (down) and ON (up). With the autopilot engaged and the TRACK switch pulled up, the aircraft will track the heading set by the heading index or the ILS localiser beam, depending on the position of the navigational selector.
- GLIDE – this two-position pull-push switch can be operated using left-click to move it between OFF (down) and ON (up). With the autopilot engaged and the GLIDE switch pulled up, the aircraft will alter the pitch in accordance with the glidepath beam.
- POWER – this two-position pull-push switch can be operated using left-click to move it between OFF (down) and ON (up). When the POWER switch is pulled ON, electrical power is supplied to the autopilot system, provided that the power switch on the right console is on; this is indicated by the READY magnetic indicator changing from black to white.
- ENGAGE – this two-position pull-push switch can be operated using left-click to move it between OFF (down) and ON (up). When the ENGAGE switch is pulled ON, the autopilot will couple to the control surfaces; this is indicated by the IN magnetic indicator changing from black to white.
- BOMB – non-functional
- IAS/ALT – this three-position pull/push switch can be operated using the mouse scroll wheel to rotate it between IAS (up), OFF (middle) and ALT (down) positions; left-click to pull/push the switch from the IAS or ALT position to engage the selected mode. When ALT is selected, the autopilot will level off and maintain the current altitude. When IAS is selected, the autopilot will pitch the aircraft to maintain airspeed. The autopilot POWER and ENGAGE switches must be pulled ON before the altitude lock mode will function.
- Rudder, aileron and elevator channel switches – these two-position switches can be operated using left-click to move them between OUT (down) and IN (up). These switches control whether a particular control surface is coupled to the autopilot. Moving all three switches to the OUT (down) position will disengage the autopilot.
- READY magnetic indicator – this magnetic indicator displays black if power is not available to the autopilot system and displays white if electrical power is connected to the autopilot system.
- IN magnetic indicator – this magnetic indicator displays black if the autopilot is disengaged and white when it is engaged.
- A/L PRIME – non-functional

The turn and pitch controls are at the forward end of the retractable console.

A rotary switch turns over a scale marked from 0˚ to 40˚ on either side of a neutral detent to provide turn control. To turn the aircraft, move the turn control to the desired bank angle. The control remains at the selected position and the aircraft maintains that angle of bank until the control is moved to a new position. The control is disconnected when the TRACK switch is pulled.

A DIVE/CLIMB switch provides pitch control. The switch is spring-loaded to the central (neutral) position and is moved forward to produce nose-down pitch change and rearwards to produce nose-up pitch change.

The trim indicator on the centre instrument panel is in the form of a side view of the aircraft and indicates any out-of-trim condition in pitch. The indicator also contains flags to show when the autopilot is ready and engaged.

The artificial feel indicator on the centre instrument panel shows white if any of the autopilot aileron or rudder channels disengage.

Pressure heads

The two pressure (pitot) heads are located below and on either side of the nose of the aircraft and are electrically heated. The heaters use 115-volt AC from one phase of the 200-volt supply (No.2 busbar port, No.4 busbar starboard). The supply is controlled by a switch on the right console. A magnetic indicator at the top of the centre panel shows white when the heater is switched off.

Pressure-operated instruments

Each pilot has the following pressure-operated instruments on their instrument panel:

- Airspeed indicator (ASI)
- Mach meter
- Vertical speed indicator (VSI)
- Altimeter

The Captain's panel features a standby artificial horizon.

Miscellaneous instruments

An accelerometer is fitted on the left of the centre instrument panel. The maximum and minimum readings can be reset by pressing the PUSH TO SET knob.

Each pilot has a bubble-type slip indicator at the bottom of their instrument panel.

A hinged arm is fitted underneath the aircraft tail cone and two red tail clearance lights are fitted to the coaming. If the arm touches the ground, during a landing for example, the lights will illuminate to warn that the tail is too close to the ground.

Radios

V/UHF

A UHF radio is fitted on the left console. As the simulator does not provide support for UHF radios, it has been repurposed as a VHF radio which controls COM 1 and NAV 1.

The radio has the following controls:

1. A 20-position rotary switch giving a selection of 18 preset channels, the guard frequency (G – 121.50) and MANUAL
2. Four digit selectors – only operative when MANUAL is selected on the 20-position rotary switch. Rotate each selector to set a COM 1 frequency. As only four digit selectors are available, the first digit (which is always 1) in the COM 1 frequency is not selectable. For example, set 2830 to tune 128.30.
3. Volume control
4. Function switch
5. Two selectors for setting a NAV 1 frequency (in the real aircraft this would be set by the rear crew)

A small pop-up will appear when you adjust one of the NAV 1 selectors, showing the currently tuned NAV 1 frequency.

The 18 preset channel COM 1 frequencies are set to 118.00 by default but can be changed by editing the 'RadioConfig.json' file. They are formatted without decimal points, so entering a value of '12345' in the file equates to a frequency of '123.45' MHz in X-Plane.

There are entries for all 18 channel presets, plus the Guard preset.

Radio compass (ADF)

A radio compass is fitted to the co-pilot's instrument panel, showing the relative bearing to the selected NDB. As the radio compass controller is fitted to the rear crew compartment in the real aircraft, in this simulation the frequency can be set using the HF, CONF I/C and WARN RX knobs on the co-pilot's station box.

A small pop-up will appear when you adjust one of the ADF selectors, showing the currently tuned ADF frequency.

TACAN indicator

A TACAN indicator is fitted to the centre instrument panel, showing the bearing and distance to the selected beacon. As the simulator does not provide support for TACAN frequencies, the indicator is fed by NAV 1, which can be tuned on the V/UHF radio.

Radio altimeter

A radio altimeter is installed on the Captain's instrument panel. It can measure the height of the aircraft above the surface up to a maximum of 5,000ft. Height measurement is in two ranges: 0-500ft and 0-5,000ft. A limit indicator consisting of three coloured lights is located on the co-pilot's panel. The controller is located on the left console. Power is supplied by 115-volt AC and 28-volt DC.

The controller has the following controls:

- ON/OFF switch
- Range selector
- Limit lights selector
- Spring-loaded test switch

The altimeter is ready for use after being switched on. When the test switch is operated, the needle moves to 65 feet.

PANEL GUIDE

The Vulcan's cockpit can be divided into several areas:

- Left (Captain) and right (co-pilot) instrument panels
- Centre instrument panel
- Left (Captain) and right (co-pilot) console panels
- Throttle quadrant
- Retractable console

We have also included 2D pop-up panels to cover important electrical system panels that are located in the rear crew compartment in the real aircraft:

- Alternator control panel
- Secondary supplies panel
- AAPP control panel

Magnetic indicators and warning lights for the critical systems are grouped across the top of the centre instrument panel.

Side Menu

The Side Menu arrow appears on the left side of the screen every time you load the Vulcan:

Left-click on this arrow to open the Side Menu:

You can use the Side Menu to open the 2D panels:

- Checklist
- Flight computer
- Payload menu
- Alternator control panel
- Secondary supplies panel/AAPP control panel
- Autopilot control panel

Simply place your mouse cursor over the panel that you want to open and then left-click on it. It will illuminate to indicate that it is open and the relevant 2D panel will appear.

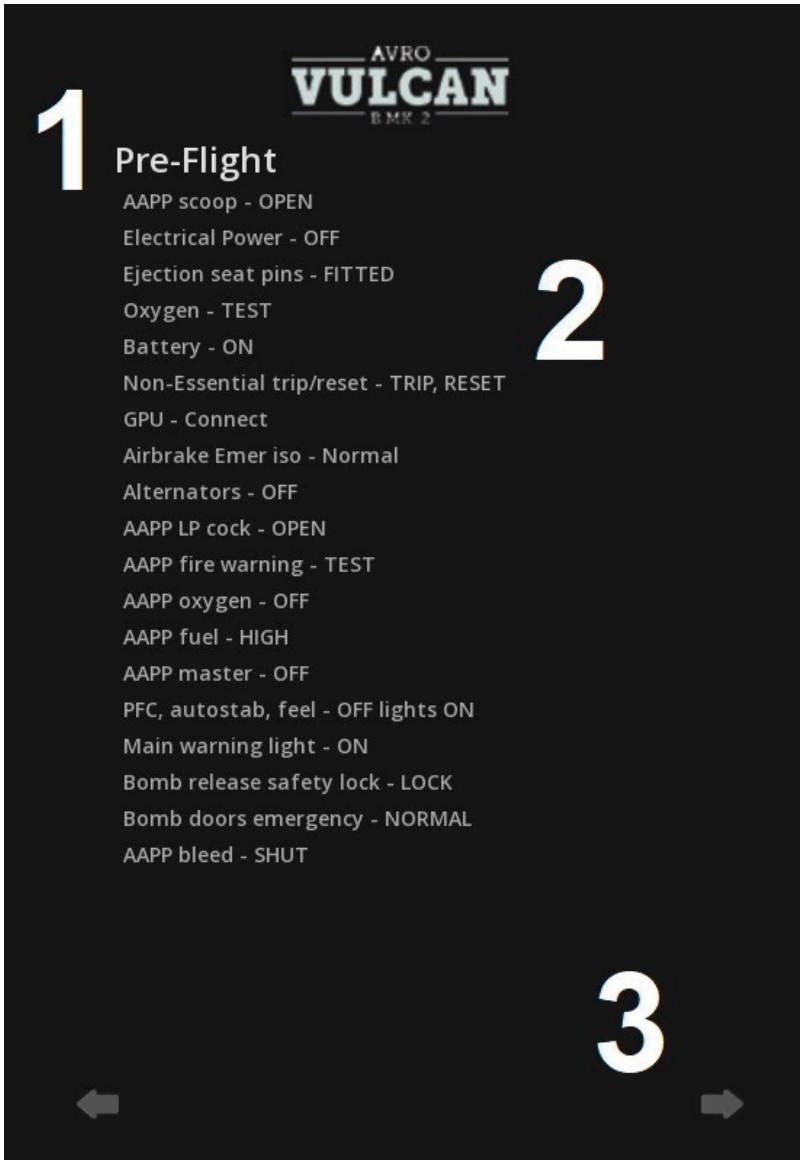
The cross in the top right corner closes the Side Menu.

Additionally, there are buttons for the following functions:

- Toggle cold and dark, or engines running (resets the flight)
- Air refuelling hose (K2 variant only)
- Pilot's helmet sun visor
- RAT deployment
- Autopilot 2D pop-up panel
- Show/hide ground equipment
- Show/hide the control sticks
- Deploy drag parachute
- Instrument reflections
- Window reflections
- Show/hide the co-pilot
- Bomb bay doors
- Crew access door

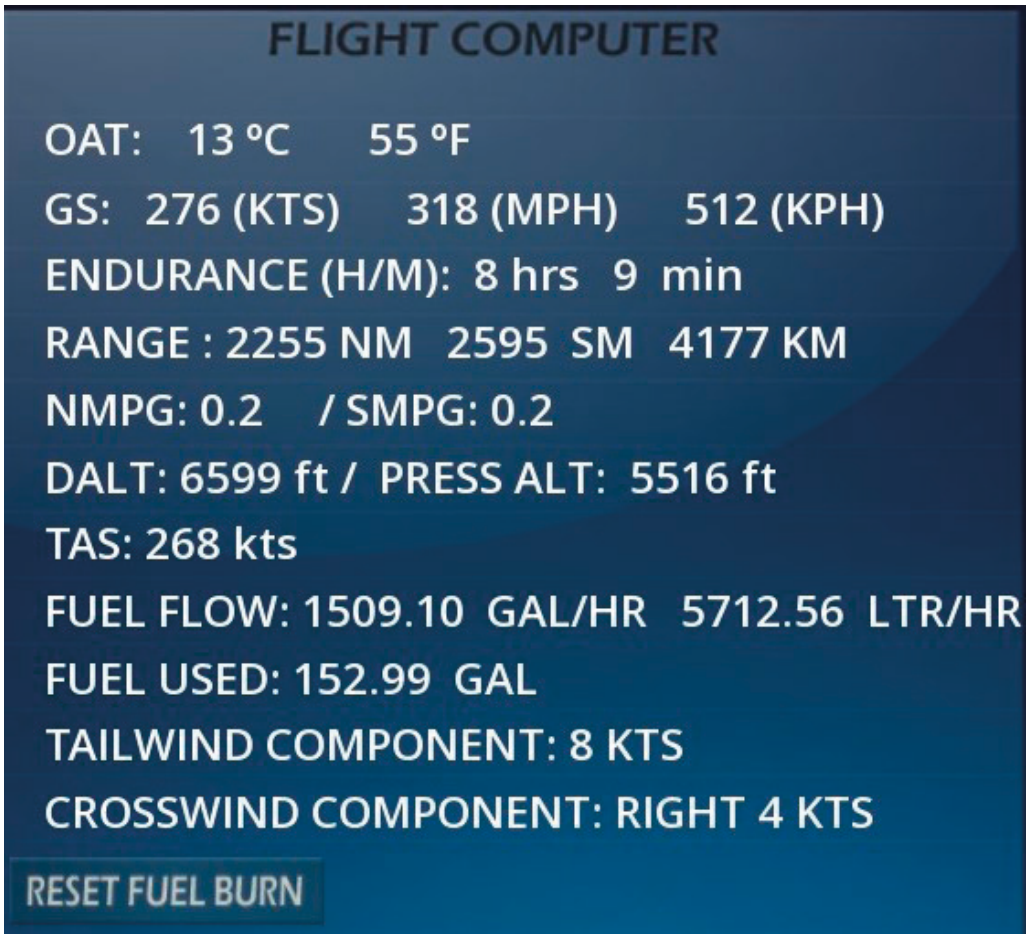
Checklist panel

In addition to the checklists in this manual, an interactive checklist is included in the aircraft as a 2D pop-up panel which can be accessed by clicking on the appropriate symbol on the Side Menu.



1. Checklist name – in the top left corner of the panel is the name of the currently selected checklist, for example ‘Pre-Flight’.
2. Checklist items – the checklist items are displayed in the centre of the panel. When the panel is first opened, or when a new checklist is selected, the items will appear in red text. Click on the checklist item when you have completed the relevant action/check and the item text will turn green to indicate that the item is complete. Hover over longer checklist items to see all of the text.
3. Checklist navigation buttons – at the bottom of the panel are four buttons. These allow you to cycle through the available checklists and select the previous/next page of the selected checklist. The button will be greyed out if it is not active.

Flight computer



The flight computer provides a variety of information:

- Outside air temperature (OAT) – Celsius and Fahrenheit
- Groundspeed (GS) – nautical miles per hour, statute miles per hour and kilometres per hour
- Endurance – hours and minutes
- Range – nautical miles, statute miles, kilometres
- Nautical miles per gallon and statute miles per gallon
- Density altitude and pressure altitude (feet)
- True airspeed (knots), track (degrees) and drift (degrees)
- Fuel flow – gallons and litres
- Fuel used – total fuel burn (gallons)
- Crosswind component (knots)
- Headwind/tailwind component (knots)

The total fuel burn can be reset by clicking on the RESET FUEL BURN button.

Left instrument panel

1. MFS annunciator
2. Oxygen flow indicator
3. White floodlighting switch
4. Windscreen wiper switch (left and centre wipers)
5. Airspeed indicator
6. Auto-throttle comparator lights (inoperative)
7. TFR video light
8. Mach meter
9. TFR warning light
10. ILS marker light
11. Radio altimeter
12. Director horizon
13. TFR failure light
14. Vertical speed indicator (VSI)
15. Altimeter
16. Crew escape lights
17. Beam compass
18. Standby artificial horizon and slip indicator
19. DME distance indicator (NAV 1)

Centre instrument panel

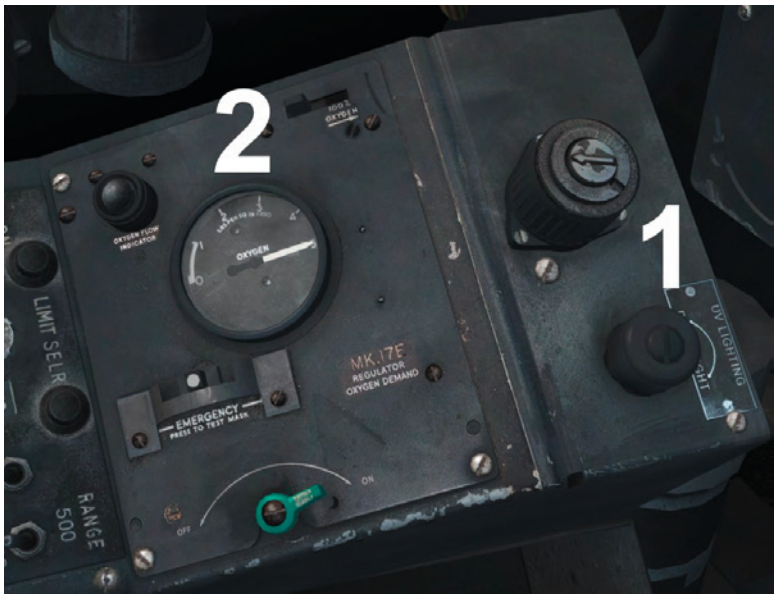
1. LP cocks
2. Main warning light (x2) – illuminate when any of the PFCs, feel units or auto-stabilisers fail
3. PFC warning indicator
4. Artificial feel indicator
5. Auto-stabiliser indicator
6. Airbrakes position indicator
7. Alternator failure warning light
8. Bomb doors position indicator
9. Canopy unlocked indicator
10. Entrance door unlocked indicator
11. Pressure-head (pitot) heater indicator
12. Accelerometer (G-meter)
13. Control surfaces position indicator
14. MFS selector
15. Jet pipe temperature (JPT) gauges
16. Tail parachute switches – move down to stream (deploy) the parachute; move up to jettison the parachute
17. Autopilot trim indicator
18. Fuel pressure indicators
19. Engine governor control indicator (inoperative)

20. RPM gauges
21. TACAN indicator (shows bearing to NAV 1 VOR)
22. Oil pressure gauges
23. Hydraulic power pack switch
24. Undercarriage control buttons
25. Hydraulic triple pressure gauge
26. Undercarriage position indicator
27. CG indicator
28. CG check button

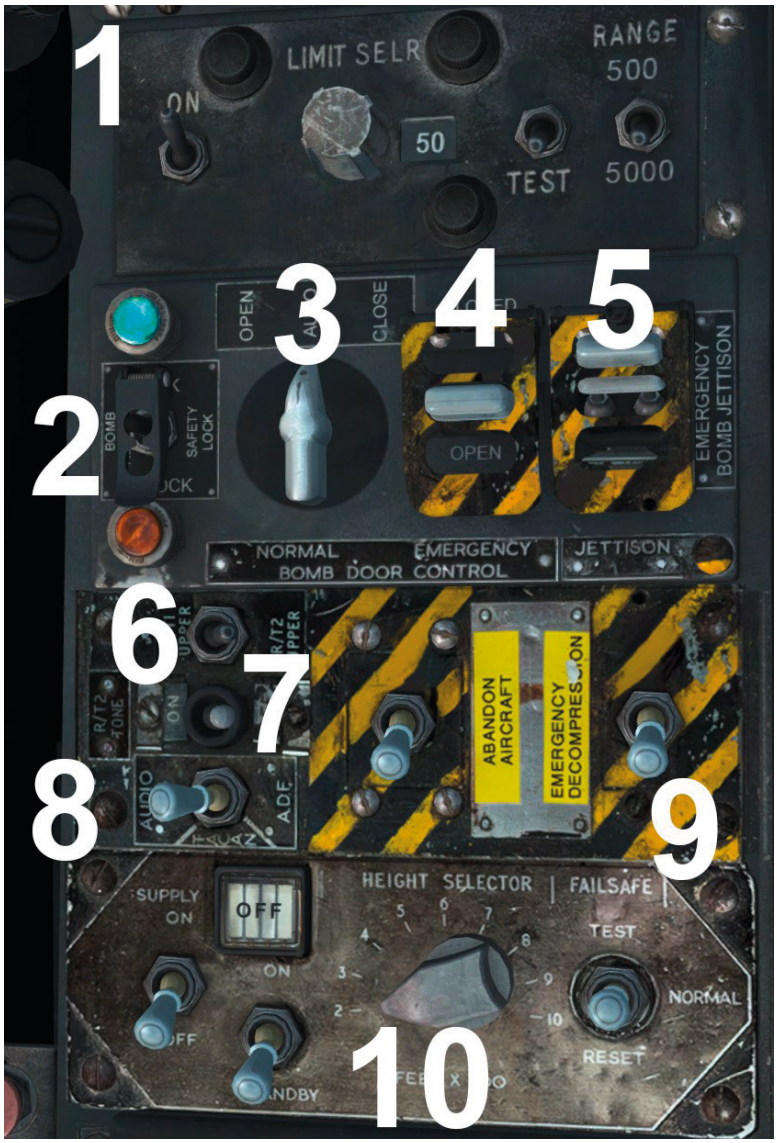
Right instrument panel

1. Bomb bay tanks fire warning light
2. TFR warning light
3. Wing/fuselage tank fire warning lights and extinguisher buttons
4. ILS marker light
5. Radio altimeter limit lights
6. MFS/TFR switch
7. TFR video light
8. Mach meter
9. Airspeed indicator
10. Director horizon
11. TFR failure light
12. Windscreen overheat warning light
13. Windscreen de-ice switch
14. Windscreen demist switch
15. Windscreen wiper switch (right wipers)
16. Altimeter
17. Vertical speed indicator (VSI)
18. Fuel flow indicator – indications for individual engines can be obtained by pressing the fuel flow engine selector push-buttons on the retractable console
19. ADF indicator
20. Beam compass
21. Flow meter total flow indicator
22. Slip indicator
23. MFS annunciator
24. Flow meter reset switch
25. Oxygen flow indicator
26. White floodlighting switch
27. Co-pilot's station box

Left console

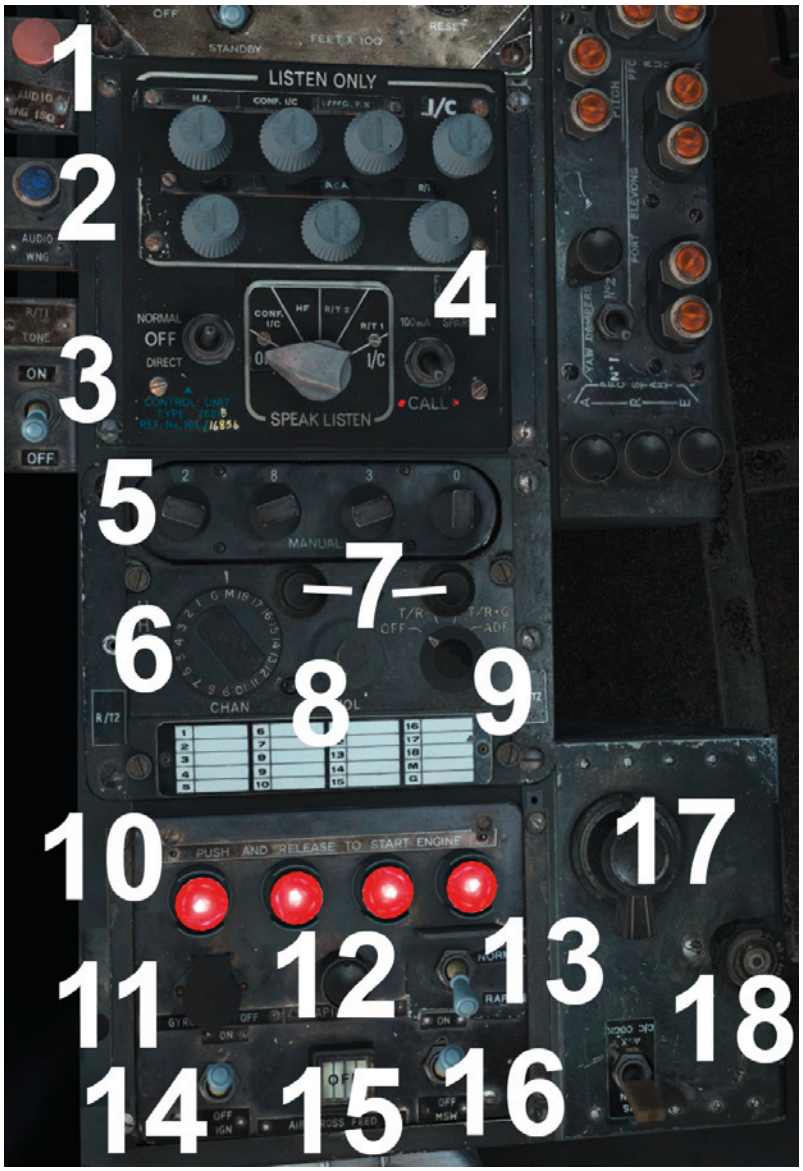


1. UV lighting dimmer switch
2. Oxygen regulator



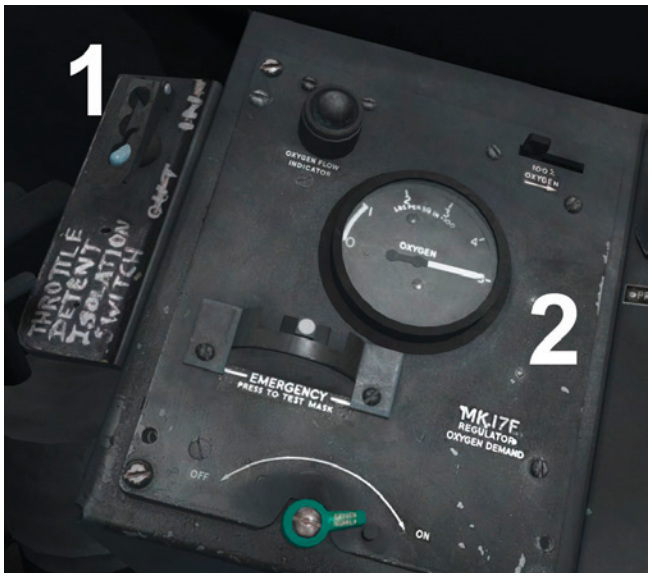
1. Radio altimeter controller
2. Store safety lock and warning lights
3. Bomb doors normal control
4. Bomb doors emergency control
5. Bomb jettison switch
6. Aerial change-over switch
7. RT2 tone switch
8. ILS/TACAN/ADF audio switch
9. Abandon aircraft and emergency decompression switches
10. TFR controller

1. PFC and artificial feel start buttons (x3)
2. Yaw damper selector switch
3. Comparator reset button
4. PFC stop buttons (x10)
5. Pitch damper control buttons (x4)
6. Mach trimmer reset (x2) and master control buttons
7. Artificial feel warning cancel buttons (x3)
8. Artificial feel lock switch and indicator light

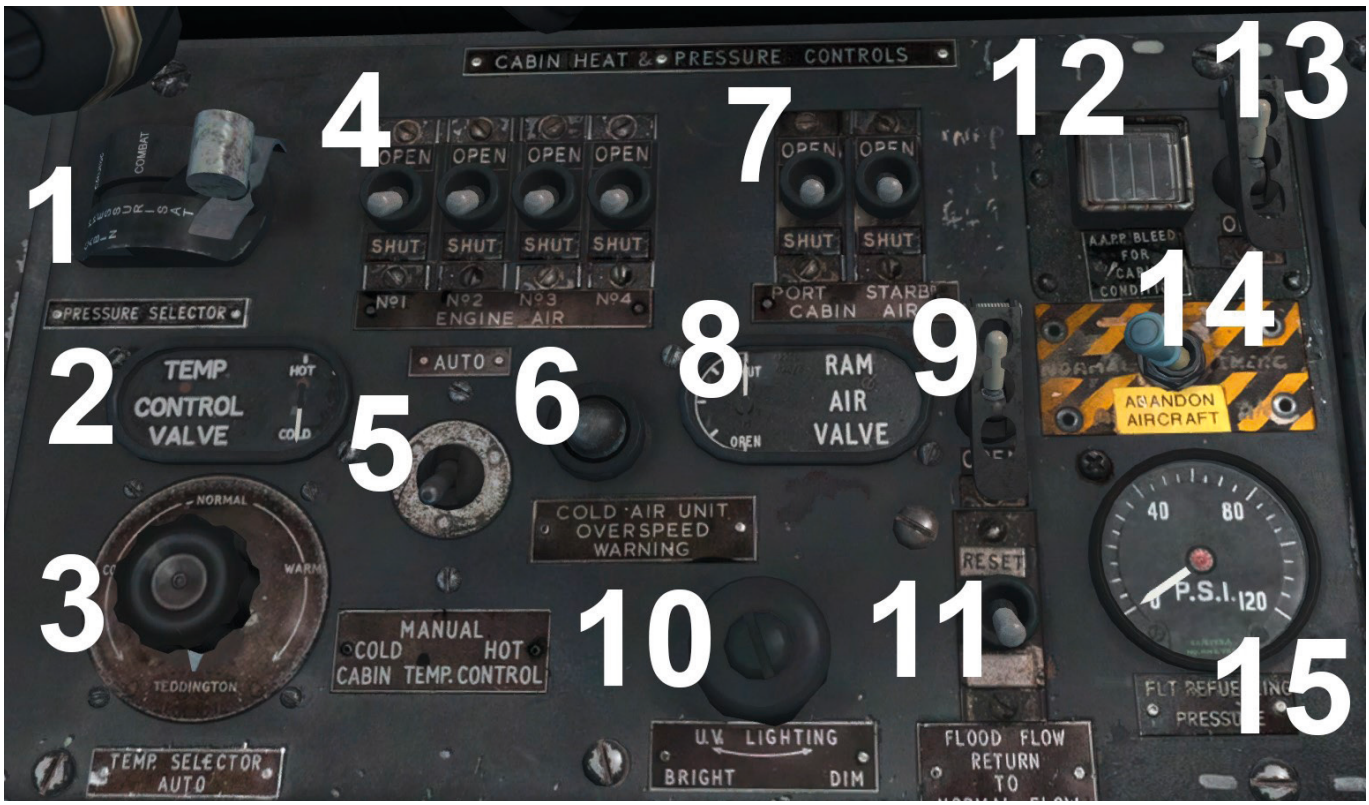


1. Audio warning isolation button
2. Audio warning test button
3. RT1 tone switch
4. Captain's station box
5. V/UHF radio COM frequency selectors
6. V/UHF radio COM channel selector
7. V/UHF radio NAV frequency selectors
8. V/UHF radio volume knob
9. V/UHF radio mode selector
10. Individual start push-buttons
11. Gyro hold-off push-button
12. Rapid start push-button
13. Rapid/normal start selector switch
14. Ignition switch
15. Air cross-feed indicator
16. Start master switch
17. Air-ventilated suits temperature control
18. Air-ventilated suits flow control

Right console



1. Throttle detent isolation switch
2. Oxygen regulator



1. Cabin pressure selector
2. Temperature control valve position indicator
3. Cabin temperature selector
4. Engine air switches
5. Cabin temperature control switch
6. Cold air unit overspeed indicator
7. Cabin air switches
8. Ram air valve position indicator
9. Ram air valve switch
10. UV lighting dimmer switch
11. Flood flow switch (inoperative)
12. AAPP air bleed indicator
13. AAPP cabin air bleed switch
14. Abandon aircraft switch
15. Air-to-air refuelling pressure gauge

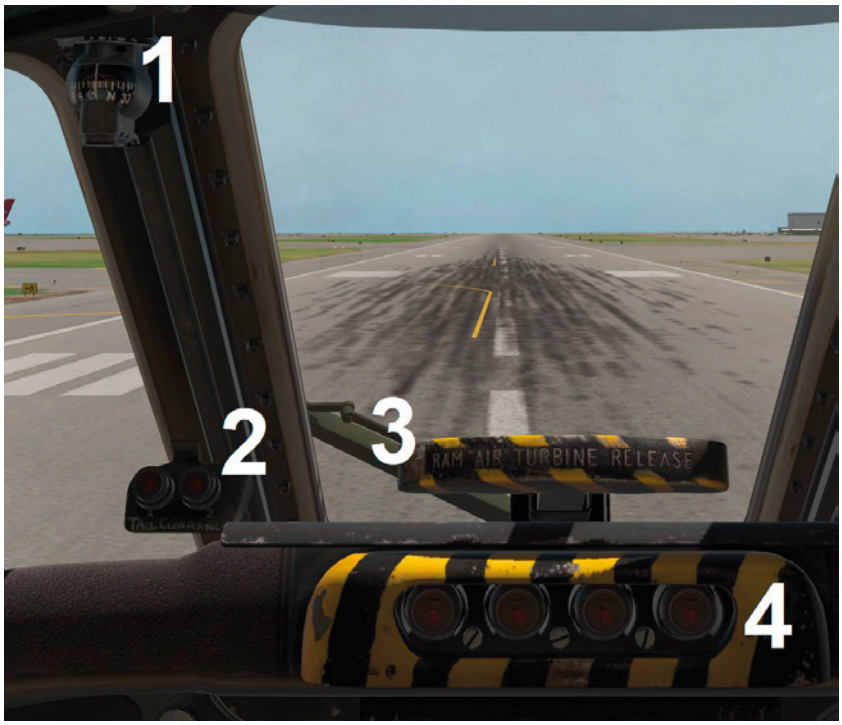
1. Refuelling probe lighting dimmer switches
2. Nitrogen purge switch
3. Tank pressurisation switch
4. Tank pressurisation indicators
5. Air-to-air refuelling indicator
6. Air-to-air refuelling master switches
7. Airframe anti-icing auto/manual switches
8. Anti-icing temperature gauges
9. Engine anti-icing switches
10. Anti-icing manual heat control switches

1. Pressure head (pitot) heater switch
2. Autopilot power switch
3. External lights master switch
4. Identification light steady/Morse switch
5. Landing/taxi lamp switches
6. Navigation lights steady/flash switch
7. ECM monitor/alarm control
8. Air-ventilated suits flow control
9. Air-ventilated suits temperature control
10. Air-ventilated suits master switch
11. Windscreen overheat indicators

Control column

1. Nose-wheel steering engage button
2. Elevator and aileron feel relief switch
3. Aileron and elevator trim switch
4. Press-to-transmit switch

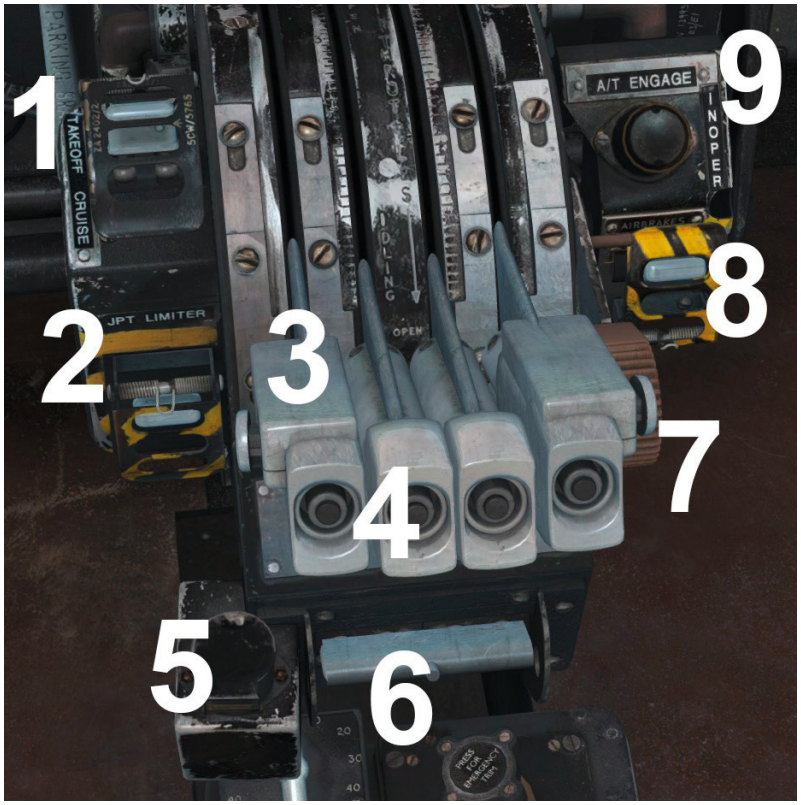
Upper cockpit



1. E2B compass
2. Tail clearance warning lights
3. RAT release handle
4. Engine fire warning lights and extinguisher buttons

Throttle quadrant

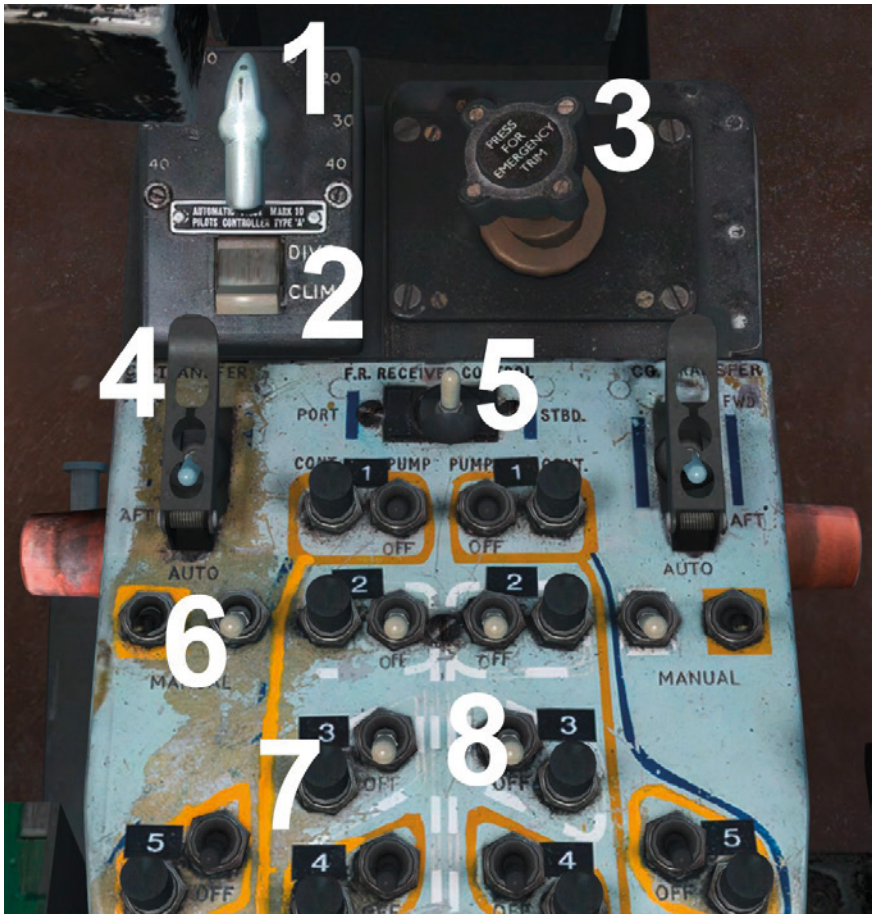
1. Anti-dazzle lamp switch
2. No.1 engine group fuel contents gauge
3. Parking brake lever
4. No.2 engine group fuel contents gauge
5. Cabin altimeter
6. Rudder feel relief push-button
7. Rudder trim switch
8. No.3 engine group fuel contents gauge
9. No.4 engine group fuel contents gauge
10. HRS/MFS switch



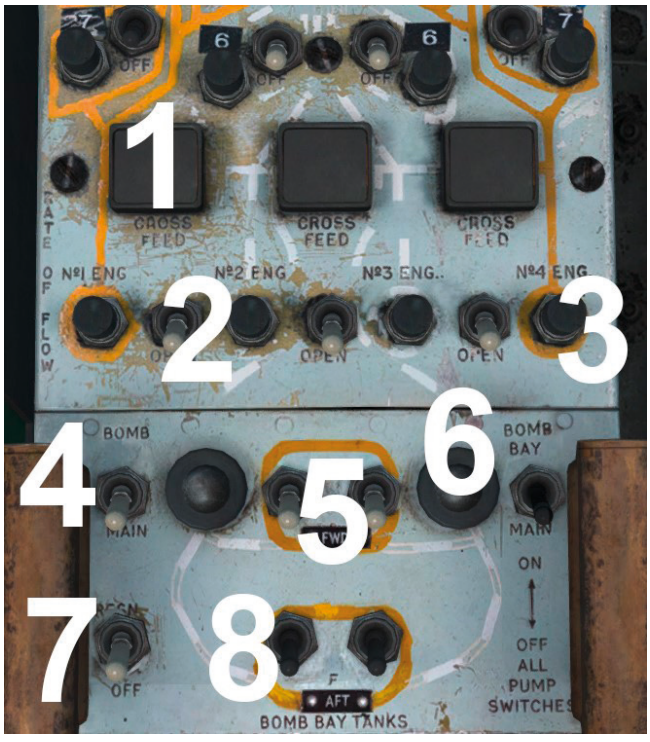
1. RPM governor switch
2. JPT limiter switch
3. Throttle levers
4. Engine relight buttons
5. Pilot's bomb release control
6. Airbrakes selector switch
7. Undercarriage emergency lowering control
8. Airbrakes normal/emergency switch
9. Auto-throttle engage push-button (inoperative)

Retractable console

The console can be retracted and extended by clicking on the handle at the rear.



1. Autopilot turn control
2. Autopilot pitch control
3. Emergency trim control
4. Fuel CG/transfer switches
5. Flight refuelling lateral CG control switch
6. Auto/manual switches
7. Tank contents push-buttons
8. Tank pump switches



1. Cross-feed cock position indicators
2. Cross-feed cock switches
3. Fuel flow engine selector push-buttons
4. Bomb bay/main tank selector switches
5. Pump switches for forward bomb bay tank
6. Bomb bay fuel pressure indicators
7. Bomb bay tanks pressurisation switch (inoperative)
8. Pump switches for rear bomb bay tank

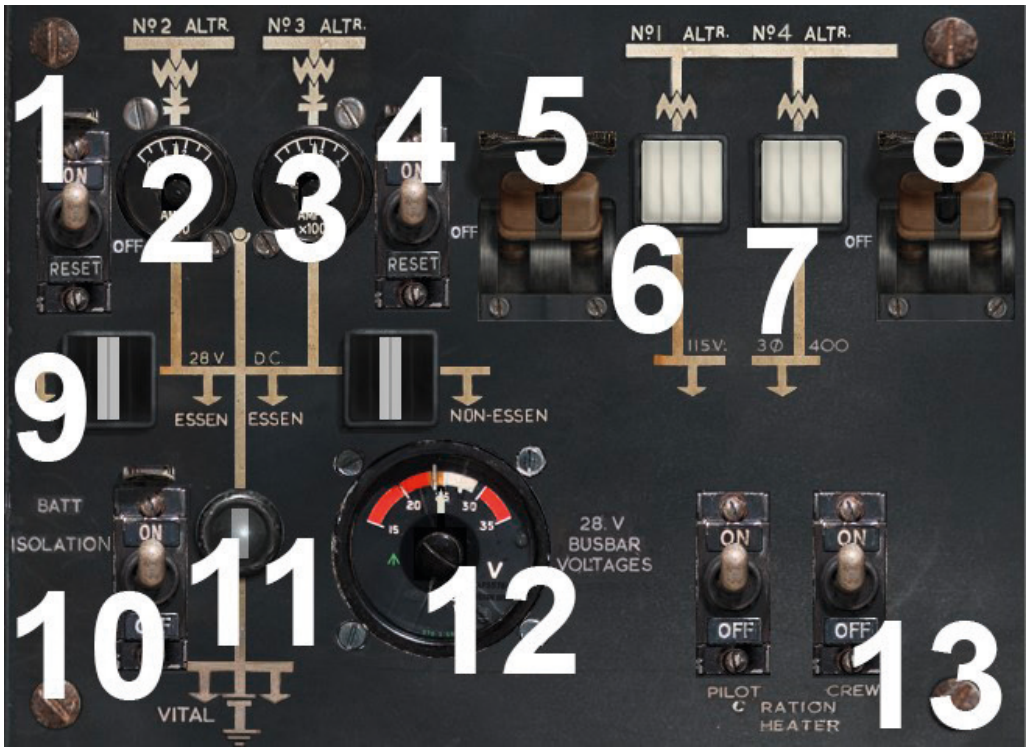
1. Autopilot track switch
2. Autopilot glide switch
3. Autopilot power switch
4. Autopilot channel engage switches (aileron, rudder and elevator)
5. Autopilot READY indicator
6. Autopilot Autoland switch (inoperative)
7. Autopilot IN indicator
8. Autopilot bomb switch
9. Autopilot IAS/altitude switch
10. Autopilot engage switch

Alternator control panel

1. Incoming alternator voltmeter
2. RAT field switch
3. Extra supplies trip button
4. RAT test push-button
5. Alternator selector switch
6. AAPP test button
7. Incoming alternator frequency meter
8. Synchronising busbar voltmeter
9. RAT synchronising magnetic indicator
10. Alternator failure red warning light
11. AAPP synchronising magnetic indicator
12. Synchronising busbar frequency meter
13. AAPP synchronising button

1. Alternator synchronising magnetic indicators (x4)
2. Non-essential supplies reset switch
3. Alternator isolating buttons (x4)
4. Alternator warning lights (x4)
5. Alternator reset buttons (x4)
6. Alternator KW/KVAR meters (x4)
7. KVAR reading selector button
8. Alternator on/off switches (x4)

Secondary supplies panel



1. Port TRU switch
2. Port TRU ammeter
3. Starboard TRU ammeter
4. Starboard TRU switch
5. Port main transformer switch
6. Port main transformer magnetic indicator
7. Starboard main transformer magnetic indicator
8. Starboard main transformer switch
9. Load-shed magnetic indicators
10. Battery isolation switch
11. Battery magnetic indicator
12. DC voltmeter
13. Ration heater switches

AAPP control panel

1. JPT gauge
2. Fuel level magnetic indicator
3. Oil pressure gauge
4. Starter button
5. LP cock switch
6. HP cock override switch
7. Ignition isolation switch
8. Fire warning light and extinguisher button
9. Fire warning light test button
10. Oxygen and relight switch
11. Master switch

MODEL OPTIONS

The external model can be equipped with a variety of optional equipment:

- In-flight refuelling probe
- Olympus 201 or 301 engines
- TFR nose dome
- Modern aerials
- ECM tail cone
- K.2 Hose Drum Unit
- MRR air sampling pods and nose blade aerials

The options can be configured using values in the 'config.json' file, allowing you to realistically configure repaints. These files are found inside the individual livery folders, within the Vulcan's 'liveries' folder. A value of '1' will enable the corresponding option:

[parts]

hasProbe=1 *// In-flight refuelling probe fitted?*

has201=1 *// Olympus 201 engines fitted?*

hasTFR=0 *// TFR dome fitted to nose?*

hasModernAerials=0 *// Modern aerials fitted?*

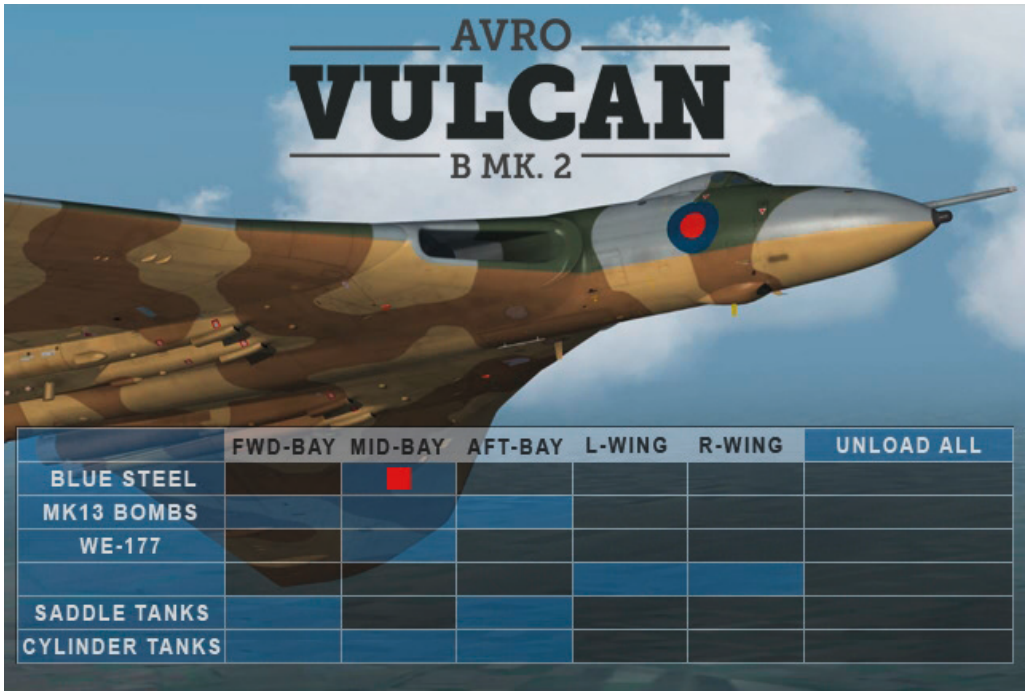
hasFinECM=1 *// ECM fitted to tail?*

isK2=0 *// Is a K2 variant?*

isMRR=1 *// Is an MRR variant?*

Payload

The Vulcan can carry a variety of conventional and nuclear payloads. A 2D payload manager allows you to select your payload.



The payload manager shows the available options in the left column and the available positions along the top row. Cells that are shaded blue are valid positions for the associated payload.

Click on a blue cell to enable the payload on that position. A red square will appear to indicate which payloads are active. Click on the UNLOAD ALL button to remove all payloads.

Engine nozzles

Although this simulation is based on a Vulcan B.2 fitted with Olympus 301 turbojet engines, we have included this option to toggle between Olympus 301 and 201 engine nozzle types to provide a more realistic experience when flying paint schemes belonging to aircraft fitted with the Olympus 201s.

Ground equipment

This option allows you to toggle a variety of ground equipment.

The Houchin ground power unit (GPU) can be used to provide electrical power to the aircraft whilst on the ground. The GPU is parked underneath the port wing and is plugged into the aircraft just aft of the bomb bay.

The Palouste compressor is used to provide compressed air to the engine air starter motors, facilitating engine starting whilst on the ground. The Palouste is parked underneath the starboard wing and the air supply hose is connected to the aircraft just aft of the starboard landing gear.

The aircraft can be fitted with chocks and engine covers whilst on the ground.

The ground equipment will only appear if the aircraft is on the ground with the parking brake applied.

FLYING THE VULCAN

In this tutorial flight we will be departing from RAF Cottesmore, located to the north-west of the city of Peterborough in the UK. We will be flying south-west, around the eastern edge of the East Midlands and Birmingham airspace, and overhead RAF Brize Norton before approaching RAF Fairford from the east to land on runway 09. Covering approximately 80 nautical miles, this short flight is the ideal length for learning about the essential systems on board the Vulcan.

Here are the details for today's flight:

EGXJ – DTY (116.40) – EGVA

Estimated time en route: 25 minutes

Route distance: 80 nautical miles

Departure time: 1200 (local time)

Weather: Clear

Now that we are prepared for the flight, we can proceed to the cockpit to begin our pre-flight checks. To load up the Vulcan tutorial flight, follow these steps:

1. Start X-Plane 11.
2. From the Main Menu click **New Flight** or go to the Flight Configuration window.
3. Click on the Vulcan in the Aircraft Selection Screen.
4. Click **Customize** and choose the XM655 livery from the drop-down menu in the top right. Uncheck the box labelled **Start with engines running**.
5. Under the Location box, type **EGXJ** and select **RAF Cottesmore**. Click the **Customize** button.
6. Under 'Starts', select **Ramp** and choose a ramp start location. Press **Confirm** when done.
7. Click **Start Flight**.

You should now find yourself sitting in the cockpit at RAF Cottesmore. The aircraft is configured 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 this aircraft.

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.

Getting started

The first step is to open the crew entrance door to allow entry into the cockpit. Use the Side Menu pop-up menu to open the door and confirm that the entrance door magnetic indicator is showing white (open).

We can now start working through the pre-flight inspections.

On the secondary supplies (SSP) 2D panel, switch **ON** the battery and two transformers.

Confirm that the parking brake is set **ON**.

Confirm that the landing gear is selected **DOWN** and that three green lights are shown on the position indicator.

Using the Side Menu pop-up, enable the ground equipment to connect the GPU and Palouste to the aircraft.

Switch to the external (Chase) view and carry out a visual inspection of the aircraft. The wheel chocks, engine covers and ground equipment should be visible. The ground power and air are connected to the underside of the aircraft.

Returning to the cockpit, confirm that the ejection seat pins are fitted.

On the left console, press and hold the oxygen regulator test button and check for the white flow magnetic indicator to confirm the flow of oxygen.

Moving aft along the console, make sure that the bomb release safety lock is set to **LOCK** and that the associated green light is illuminated. Move the bomb doors emergency switch to **NORMAL** (centre) and rotate the normal selector to **AUTO**.

Moving over to the right console, move the autopilot master switch to the **ON** (up) position.

On the centre console, confirm that the three channel switches – R (rudder), A (aileron) and E (elevator) – are selected **IN** (up) and then pull the POWER switch. After a short delay the READY magnetic indicator will show white to indicate that the autopilot is powered up and ready for use.

On the underside of the coaming, above the centre instruments, open the four LP fuel cock switch guards and move the switches to the **OPEN** (forward) position.

Back over to the right console, move the cabin pressure selector to the **CRUISE** (fully forward) position and then rotate the guard to prevent any inadvertent selections.

Moving aft, confirm that the ENGINE AIR and CABIN AIR switches are set to **SHUT**.

Set the EXTERNAL LIGHT master switch to **ON** and the NAV LIGHT switch to **STEADY** to illuminate the navigation lights.

Starting the engines

We are now ready to start the four mighty Bristol Siddeley Olympus 301 turbojets, using the iconic rapid start system that is fitted to this aircraft.

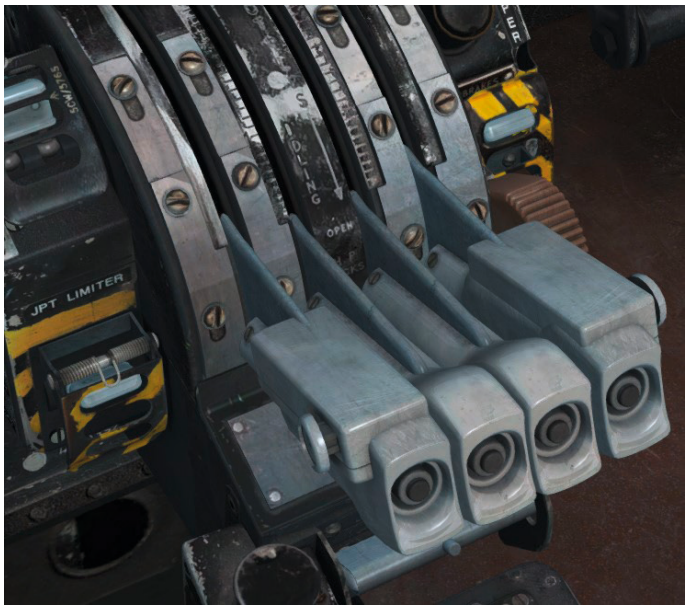
Close the entrance door by using the Side Menu pop-up and confirm that the magnetic indicator shows black.

Check that the area surrounding the aircraft is clear of obstructions and then move the NAV LIGHT switch to **FLASH** to illuminate the beacon lights.

Set all four ENGINE AIR switches to **OPEN** on the starboard console to enable the starter motors.

On the centre console, switch **ON** all the fuel tank pumps and confirm that the AUTO/MANUAL switches are set to **AUTO** and the CROSS-FEED switches are set to **CLOSED** (up).

Left-click and drag on all four throttle levers to move them aft then up to the HP COCKS **OPEN/IDLING** position. Advance the throttle levers to approximately 50%.



We can now move over to the engine start panel at the aft end of the left console. You can raise the ejection seat armrests for a clearer view of the consoles by left-clicking and dragging on them.

Switch **ON** the ignition and engine master (MSW) switches and set the air selector switch to **RAPID**.

We are now ready to initiate the rapid start sequence. Press the RAPID START button and confirm that all four engine start lights illuminate.

On the centre instrument panel, monitor the oil pressure, JPT and RPM gauges to confirm that all four engines are spooling up.

Confirmation of four successful engine starts is shown by the four engine start lights extinguishing. Once this occurs, switch **OFF** the ignition and engine master (MSW) switches and bring the throttle levers back to the idle position.

Configuring the aircraft

With the engines started, we can now proceed with the remainder of the before taxi checks.

On the alternator control 2D panel, switch **ON** the four alternators and confirm that the four amber lights extinguish.

On the secondary supplies (SSP) 2D panel, switch **ON** the two TRUs.

On the left console, switch **ON** the PFCs, auto-stabilisers and artificial feel.

Using the airbrakes selector on the throttle quadrant or the speedbrakes control assignment, extend the airbrakes and confirm the magnetic indicator shows white.

Using the normal operation selector on the left console, **OPEN** the bomb doors and confirm the magnetic indicator shows cross-hatch while the doors are in motion and then white when they are fully open. Retract the doors by rotating the selector back to **CLOSE**.

Using the Side Menu pop-up, remove the ground equipment and perform a quick visual inspection to confirm that it has all been removed.

On the alternator control 2D panel, synchronise all the alternators, confirm successful load sharing and then isolate alternators 1, 3 and 4.

The Vulcan is a joy to fly by hand under visual flight rules so we won't be making extensive use of the radio navigation equipment or autopilot on this flight. We will, however, be using the Daventry VOR (116.40) to keep us clear of busy airspace around Birmingham. Tune the VOR using the two selectors on the left console radio unit.

Switch **ON** the radio altimeter and use the test switch to confirm that it is operational. The radio altimeter can be set to one of two different ranges (scales) and we will use the default 0-5,000ft range.

On the right console, switch **ON** the pressure head (pitot) heaters and extend the left and right taxi lights (full down position).

Taxi

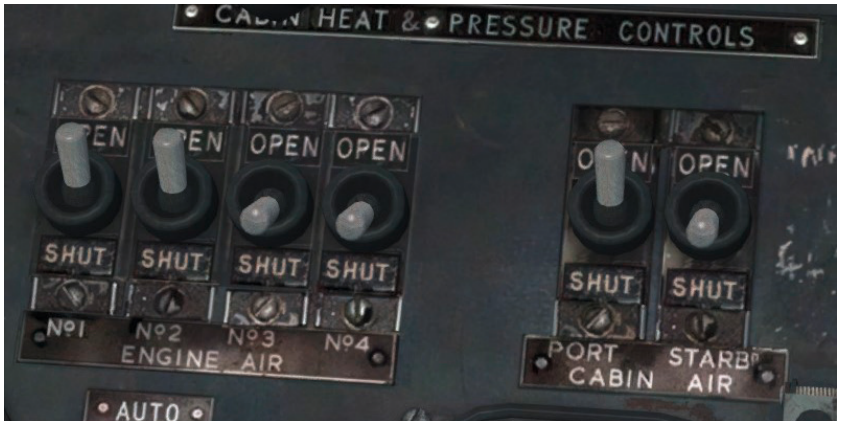
We can now taxi to the runway. As the wind is calm, we will be departing from runway 23 and then turning left to approximately 207 degrees to fly towards Daventry VOR.

Check that the area around the aircraft is clear of obstacles and then release the parking brake. Apply power slowly to get the aircraft rolling and then start your taxi to the threshold of runway 23.

Steering the aircraft with the rudder pedals only is generally sufficient. Combined use of the rudder pedals and the brakes permits, if necessary, tight turns. Differential engine power can also be used.

Check the operation of gyroscopic instruments by means of alternate turns.

Stop at the holding point just short of runway 23. Extend the landing lamps to the **LANDING** position, set the No.1 and No.2 ENGINE AIR and PORT CABIN AIR switches to **OPEN** and set the No.3 and No.4 ENGINE AIR and STARBOARD CABIN AIR switches to **SHUT**.



You can now stow the ejection seat pins by left-clicking on any one of them. They will all be stowed in a holder above the left and right console.

With the before take-off checks complete, have a look left and right, verify that nothing is on approach and that the runway is clear, and then taxi onto the runway.

Take-off

Line up with the runway centre line and then come to a stop. Smoothly apply full power and, as the aircraft starts to gather speed, keep it running down the centre line with rudder inputs. Depending on the aircraft weight, you may need to hold some nose-down stick input to keep the nose wheel firmly on the runway. As you approach **155 knots**, start to raise the nose of the aircraft.

The aircraft will begin to climb away from the runway and once you are safely airborne, tap the brakes and then raise the landing gear using the **[G]** key.

Make elevator inputs as required to maintain an initial climb speed of approximately **170 knots**, holding the runway heading (225 degrees).

The Vulcan has strong adverse yaw at low airspeeds, so generous use of the rudder while applying roll inputs will be necessary to maintain coordinated flight.

Climb

Retract the landing lamps and then start a turn towards Daventry VOR. The bearing to the VOR is shown on the TACAN indicator on the centre instrument panel.

Continue the climb at **250 knots** to produce an aircraft pitch that provides sufficient forward visibility.

For high-altitude operations the climb profile would be to maintain 250 knots indicated until 25,000 feet. Then accelerate to 300 knots and maintain that until reaching Mach 0.86. This is maintained until the final cruise altitude, which was often 40,000-50,000 feet.

For this flight we will level the aircraft off at **3,000ft** and throttle back to maintain **300 knots**. The aircraft is great fun to fly at low level, but we'll give ourselves some altitude to ease the workload on this first flight.

Cruise

Rotate the heading index on the beam compass to match your current heading towards the VOR, as indicated by the heading pointer.

We will now reduce our workload by utilising the autopilot. Pull the **ENGAGE** switch on the autopilot unit, confirm that the IN magnetic indicator is showing white, and then pull the **TRACK** switch and rotate the IAS/ALT selector to **ALT**.

The autopilot will now hold the selected track (heading) and altitude.

On the right console, move the remaining ENGINE AIR and CABIN AIR switches to the **OPEN** position.

On the left and right consoles, switch **ON** the oxygen regulators. The flow indicators on the regulators are duplicated on the left and right instrument panels for improved visibility.

This is the ideal opportunity to explore the cockpit using the PANEL GUIDE for reference or to practise opening and closing the bomb doors.

As we overfly the Daventry VOR, as indicated by the TACAN indicator needle swinging around to face aft, rotate the heading index to set a new heading of **221 degrees**. This heading will take us directly to RAF Fairford.

Although not fitted to the real aircraft, we have included the default GPS pop-up which can be used to track your progress – a useful substitute for the rear crew navigator!

This can be accessed by assigning a keyboard or joystick button to 'GNS NAV 1 toggle popup' in 'Navigation & Radios → GPS → G430/530 #1 (pilot)' in X-Plane's keyboard or joystick assignments window.

With an airspeed of 300 knots, it won't take long to reach RAF Fairford from overhead Daventry VOR. Maintain a careful lookout for RAF Brize Norton, which should be in your 10 o'clock position as we approach our destination.

Descent

As we are flying a high-performance aircraft at a relatively low level, our descent into the circuit will be a quick affair.

Once visual with RAF Brize Norton, set the ENGINE AIR and CABIN AIR switches to **SHUT**.

Disengage the autopilot by pushing in the ENGAGE switch, slow the aircraft to **180 knots** and extend the landing lights.

Begin a descent down to a circuit height of **1,000ft**.

Approach and landing

As RAF Fairford comes into view, position the aircraft to fly south over RAF Brize Norton towards a base leg for the extended centreline of runway 27.

Once established on the base leg, extend the landing gear and check for three green lights.

Continue descending and make a right turn from base to final, using the PAPI lights to guide your descent rate.

Once established on final for runway 27, begin to reduce your airspeed to **170 knots**.

Passing through 500ft, extend the airbrakes, if necessary, to provide greater control of your airspeed as you begin to slow to a touchdown speed of approximately **155 knots**.

As the aircraft arrives over the runway, start to bring the aircraft into a flare, gently raising the nose just above the horizon. Reduce the throttles to idle and the aircraft should touch down smoothly.

Deploy the brake parachute using the switches on the centre instrument panel or the 'Deploy/jettison chute' control assignment.

Apply gentle braking and, once the aircraft has slowed to a fast walking pace, jettison the parachute and turn left off the runway. When you are safely off the runway, switch **ON** the taxi lights and retract the airbrakes.

Shutdown

Begin your taxi to the nearest available parking spot.

As you taxi, switch **OFF** the autopilot power and master switches and the radio altimeter.

Switch **OFF** the PFCs, auto-stabilisers and artificial feel, but leave on the auxiliary rudder and re-fit the ejection seat pins.

Once you have come to a stop at your chosen parking spot, engage the parking brake and switch **OFF** the auxilliary rudder.

Retract the taxi lights and switch **OFF** the pressure head heaters.

Confirm that the four throttle levers are at the **IDLE** position and then left-click and drag on each of them to move them aft and down to **SHUT** the HP cocks.

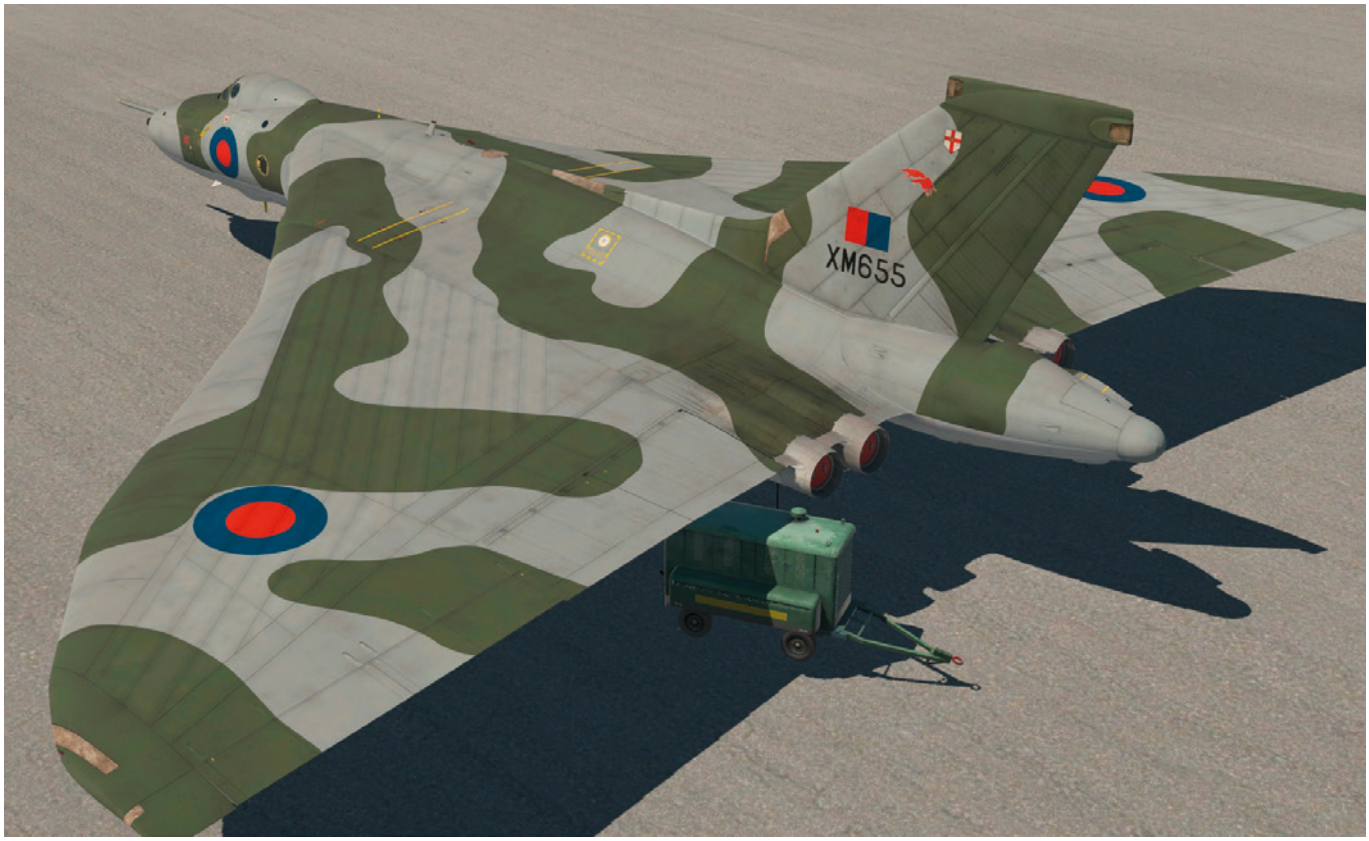
On the centre console, switch **OFF** all the fuel pumps.

On the alternator control 2D panel, switch **OFF** all four alternators.

On the secondary supplies (SSP) 2D panel, switch **OFF** the battery, two TRUs and transformers.

Using the menu bar, enable the ground equipment and then use the Side Menu pop-up to open the entrance door.

Congratulations – you have completed the Vulcan tutorial flight!



PROCEDURES

Limitations

G limitations:

Up to 160,000lb	+2G up to M0.89
	+1.8G up to M0.93
160,000lb to 190,000lb	+1.8G up to M0.89
	+1.5G up to M0.93
Above 190,000lb	+1.5G up to M0.93

Weight limitations:

Max. take-off (with ordnance)	210,000lb
Max. for normal take-off	204,000lb
Normal landing	140,000lb
Overload landing	204,000lb

Speeds for safe operations

Maximum speeds for operation of services:

Airbrakes	No restriction
Bomb doors	Up to normal limiting speed of aircraft
Undercarriage	270 KIAS (M0.9 above 40,000ft)
RAT	330 KIAS or M0.92
Tail parachute	145 KIAS (jettison at 60 KIAS)
Maximum demonstrated crosswind	20 KIAS

Rotation and initial climb speeds:

AUW (lb)	Rotation speed (KIAS)	Initial climb speed (KIAS)
150,000lb and below	135	148
160,000lb	139	148
165,000lb	141	149
170,000lb	143	151
180,000lb	148	156
190,000lb	153	160
195,000lb	155	163
200,000lb	157	165
210,000lb	162	169

Recommended climb speed:

250 KIAS to 20,000ft

300 KIAS up to M0.86

Circuit speeds:

AUW (lb)	Pattern speed (KIAS)	Approach speed (KIAS)	Threshold speed (KIAS)
120,000lb and below	155	135	125
130,000lb	160	140	130
140,000lb	165	145	135
150,000lb	169	149	139
160,000lb	173	158	143
170,000lb	177	162	147
180,000lb	181	166	151
190,000lb	185	170	155
200,000lb	189	174	159
210,000lb	193	178	163

Pre-flight

AAPP scoop	**OPEN**
Electrical power	**OFF**
Ejection seat pins	**Fitted**
Oxygen	**TEST**
Battery	**ON**
Non-essentials trip/reset	**TRIP, check MI (x2)**
	RESET, check MI (x2)
GPU	**CONNECT**
Airbrake emergency isolate switch	**NORMAL**
Alternators	**Four OFF, four ambers**
AAPP	**LP cock open**
	Fire warning test
	Oxygen switch OFF
	Fuel HIGH
	Master switch OFF
PFC, autostabilisers and feel	**All OFF, lights on**
	Yaw dampers off
	Pitch dampers off, four amber lights
	Mach trimmers off, blue lights off, amber lights on
Main warning lights	**Both on**

Bomb release safety lock	**LOCK, green light on**
Bomb doors emergency switch	**NORMAL**
AAPP bleed switch	**SHUT/indicating**
AVS master switch	**CLOSED**
200v supply	**External on or start AAPP**
115v transformers	**ON, check MI (x2)**
	Check auto coupling
	Check manual coupling
	ON, check MI (x2)
Autopilot	**Power ON, three channels IN**
MFS/TFR switch	**MFS**
Fire warning lights	**Checked**
LP cocks	**OPEN, guarded**
HP cocks	**SHUT**
Throttle detent isolation switch	**IN**
Pressure selector	**CRUISE**
Cabin air switches	**SHUT**
Ram air valve	**SHUT**
Temperature selector	**COLD**
Cold air turbine MI	**Black**
External lights master switch	**ON**
Navigation lights	**FLASH**
Tank pressurisation	**OFF, four white MIs**
Air-to-air refuelling panel	**All OFF**
Engine/airframe anti-icing	**OFF**

Engine starting

The air for engine starting can be supplied by an external source (the Palouste), by cross-bleed from a running engine or by the rapid start air system.

When using the Palouste, the engines can be started in any order. If cross-bleed is going to be used, engine No.1 or 4 must be started first.

The three remaining engines can be started individually in the same manner, using the external supply, or the external supply can be removed and cross-bleed used. The running engine must be set to 70% RPM to provide enough cross-bleed air to start the remaining engines.

If the first engine started is No.1 or 4, the three remaining engines can be started simultaneously using cross-bleed with the running engine set to 90% RPM.

To use cross-bleed, the engine air switches for the running engine and the engine to be started must both be set to OPEN.

Once two engines are running, the remaining two may be started with the two running engines set to 60% RPM.

If the rapid start air system is going to be used, all engines can be started simultaneously using the rapid start button, or the engines can be started individually using the individual start buttons.

Rapid start

Throttles	**Set to 50%**
Air selector switch	**RAPID**
Ignition switch	**ON**
Engine master switch	**ON**
Engine air switches	**All SHUT**
Rapid start button	**Press**

Normal start

Air selector switch	**NORMAL**
Ignition switch	**ON**
Engine master switch	**ON**
Air cross-feed MI	**OPEN**
Engine RPM	**70%**
Or Palouste	**Connected, ready**
Appropriate engine air switch(es)	**OPEN, remainder SHUT**
Individual start button	**Press**
Throttle	**Idling**

Checks during engine starting

Oil pressure	**Rising**
Fuel flow	**Checked**
JPT	**Less than 700°C**
Fire warnings	**Out**
Start indicator light	**Out above 22% RPM**

After start

Alternators	**Four switches ON**
	Amber lights out
	S breaker MI horizontal
	KW/KVAR meters reading
	Alternator failure warning light out
Engine master switch	**OFF**
Ignition switch	**OFF**
Air cross-feed MI	**SHUT**
Fuel console	**As required**
Engine air switches	**All SHUT**
Cabin air switches	**Both SHUT**

Airbrakes	**Test then IN, black MI**
Hydraulic pressure	**Checked, normal**
Bomb door normal operation	**Check clear**
	Select OPEN, MI white
	Select CLOSE, MI black
PFC, autostabilisers and feel	**All ON, lights out**
	Autostabilisers, yaw dampers, pitch dampers and Mach trimmers all on
	Blue and amber lights off
	Artificial feel amber lights out
Feel lock switch	**NORMAL, green light off**
Main warning lights	**OFF**
Controls	**Check**
External power	**OFF**
28v TRUs	**ON**
AAPP	**Master switch ON**
	Press start button
	JPT/oil pressure within limits
	Fire warning off
	ON button pressed
Extra supplies trip	**Press**
External power	**Removed**
Alternators	**Synchronise all alternators**
	Check load sharing
	Isolate No.1, 3 and 4
AVS master switch	**OPEN**

Taxi checks

Ejection seat pins	**Removed**
Pressure head heaters	**ON**
Entrance door	**Closed, MI black**
Chocks, ground equipment	**Removed**
Landing lamps	**As required**
Brakes	**Check**
Hydraulic pressures	**Check, in the green**
Instruments	**Check**

System checks

PFCs	**Check**
Emergency trims	**Check full range**

Normal trims	**Check**
Feel relief	**Check**
Instrument flags	**Clear**
NAV selector	**Central**
Autopilot	**Ready MI white**

Before take-off

Electrics	**Alternators all ON**
	AAPP on sync bar
	115v transformers ON
	28v TRUs ON
	Indications normal
PFC/stabiliser panel	**All lights off**
Red/amber lights	**All off**
Magnetic indicators	**Black**
Hydraulic pressures	**Check, in the green**
Transfer switches	**AFT selected, lights on**
Fuel console	**AUTO/MANUAL switches to AUTO**
	14 booster pumps ON
	Cross-feed cocks SHUT
	BOMB-BAY/MAIN to MAIN
Transfer switches	**CENTRE/GUARDED, lights off**
De-ice switch	**MEDIUM**
Tank pressurisation switch	**ON**
Altimeters	**Set**
Radio altimeter	**ON**
Cabin air switches	**Port or starboard OPEN**
Engine air switches	**1 and 2, or 3 and 4 OPEN**

After take-off

Undercarriage	**UP**
Take-off/cruise selector	**CRUISE**
Landing lamps	**Retracted**
Tank pressurisations	**MIs black (x4)**
Cabin air switches	**Port or starboard OPEN**
Engine air switches	**1 and 2, or 3 and 4 OPEN**
Anti-icing	**As required**
Bomb bay tanks	**As required**

Climb

Oxygen	**ON, check flow**
Altimeters	**Set**
Electrics	**Press extra supplies trip**
	Check No.2 on sync busbar
	Sync No.4 with No.2
	Isolate No.2
	AAPP master switch OFF

Cruise

Oxygen	**Check flow**
De-ice switch	**MEDIUM**
Engine air switches	**All OPEN**
Cabin air switches	**Both OPEN**
Anti-icing	**As required**

Descent

Altimeters	**Set**
Take-off/cruise selector	**As required**
Engine air switches	**1 and 2, or 3 and 4 SHUT**
Cabin air switches	**Port or starboard SHUT**
Alternators	**Sync No.3 with No.4 alternator**
	Isolate No.4
Below 5,000ft:	
AAPP	**Start electrically and connect to sync bar**
NAV selector	**Central**

Before landing

Undercarriage	**DOWN, three green lights**
Brakes	**Parking brake off, pressures in green**
Fuel	**Contents checked**
	AUTO/MANUAL switches to AUTO
	All pumps ON except empty tanks
Landing lamps	**As required**
Engine air switches	**All SHUT**

After landing

Brake parachute	**Jettisoned**
Anti-icing	**OFF**
Engine air switches	**All SHUT**
Tank pressurisation switch	**OFF**
De-ice switch	**LOW**
No.3 alternator	**On sync busbar**
AAPP	**OFF**
PFC and autostabilisers	**OFF except aux rudder**
Airbrakes	**IN**
AUTO/MANUAL switches	**MANUAL**
Autopilot	**OFF**
Radio altimeter	**OFF**
Alternators	**No.1 and No.4 OFF**
HP cocks	**No.1 and No.4 SHUT**
Fuel pumps	**One on per running engine**
Ejection seat pins	**Fitted**

Shutdown

Parking brake	**ON**
Auxiliary rudder	**Stop, all PFC lights on**
Bomb doors	**As required**
Engine master switch	**OFF**
Landing lamps	**Retracted**
De-ice switch	**OFF**
Entrance door	**Open**
115v transformers	**OFF**
28v TRUs	**Both OFF**
HP cocks	**SHUT**
Fuel pumps	**All OFF**
External lighting	**All OFF, master OFF**
Alternators	**All OFF**
Pressure-head heaters	**OFF**
Engine air switches	**All SHUT**
Cabin air switches	**Both SHUT**
AVS master switch	**CLOSED**
Chocks	**In position**
Battery	**OFF**

CREDITS

Just Flight

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Aircraft liveries	David Sweetman
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Manual	Martyn Northall, Mark Embleton
Design	Fink Creative

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Robin DR400

PA-28-181 Archer TX/LX

PA-38 Tomahawk

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C152

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