

747 Classic

**Flight Handbook
&
Reference Manual**

**Section 1
Air Conditioning &
Pressurization to GPWS**

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Air Conditioning and Pressurization



Introduction

Air conditioning and pressurization is accomplished using compressed air routed either directly from the pneumatic manifold for heating or through air conditioning (packs) for cooling. The conditioned air is distributed through ducting to five temperature-controlled areas:

- Zone 1 flight deck
- Zone 2 forward main cabin
- Zone 3 mid main cabin
- Zone 4 aft main cabin
- Upper deck left and right sides

Ventilation uses mostly fresh air from the pneumatic supply. The remainder is recirculated air supplied by 4 electric recirculating fans. The aircraft is fitted with two external connections for ground air conditioning units.

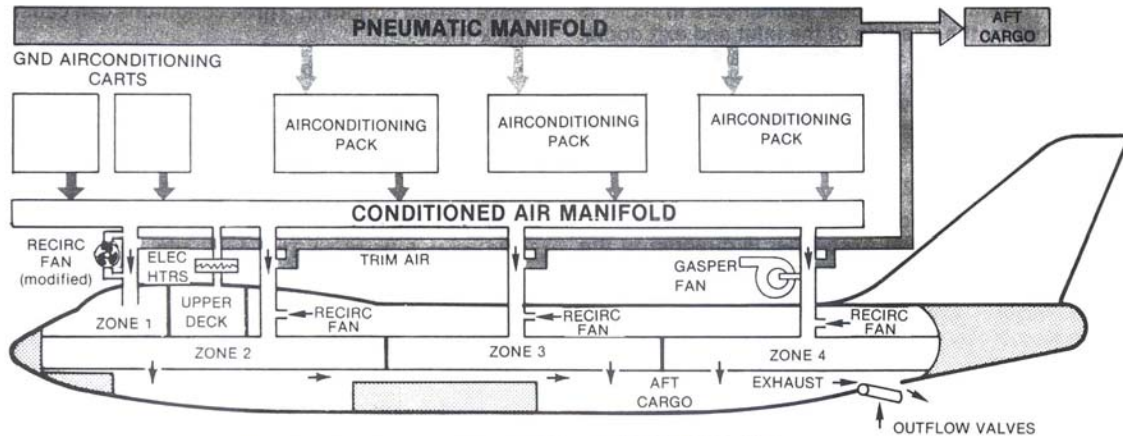
Pressurization control is achieved by varying the flow of exhaust air, using two controllable outflow valves.

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Air Distribution

Air from the pneumatic manifold is conditioned by the three air conditioning packs and collected in a conditioned air manifold. The manifold has a spring-loaded pressure relief door to protect the ducting from over pressure. Vertical risers in the sidewalls carry the air to the area above the main cabin ceiling for distribution. Recirculated air is added to the ducting of zones 1, 2, 3 and 4. Conditioned air enters the main cabin through nozzles located beneath the luggage bins. Upper deck air enters through nozzles on the centerline of the ceiling. The flight deck has controllable outlets in the ceiling, along the window ledges, and at the foot level of each crew position.



AIRCONDITIONING AND PRESSURIZATION SYSTEM

The temperature of the conditioned air is maintained at a level that satisfies the zone requiring the lowest duct temperature. Since the conditioned air is supplied to all the compartments at the same temperature, the remaining zones, as well as the upper deck, must add supplemental heat to satisfy their local requirements. Supplemental heating is accomplished as follows.

- The upper deck areas (left and right side) use electric heaters to heat the conditioned air.
- Zones 1, 2, 3 and 4 use hot air (trim air) directly from the pneumatic manifold mixed with the conditioned air.

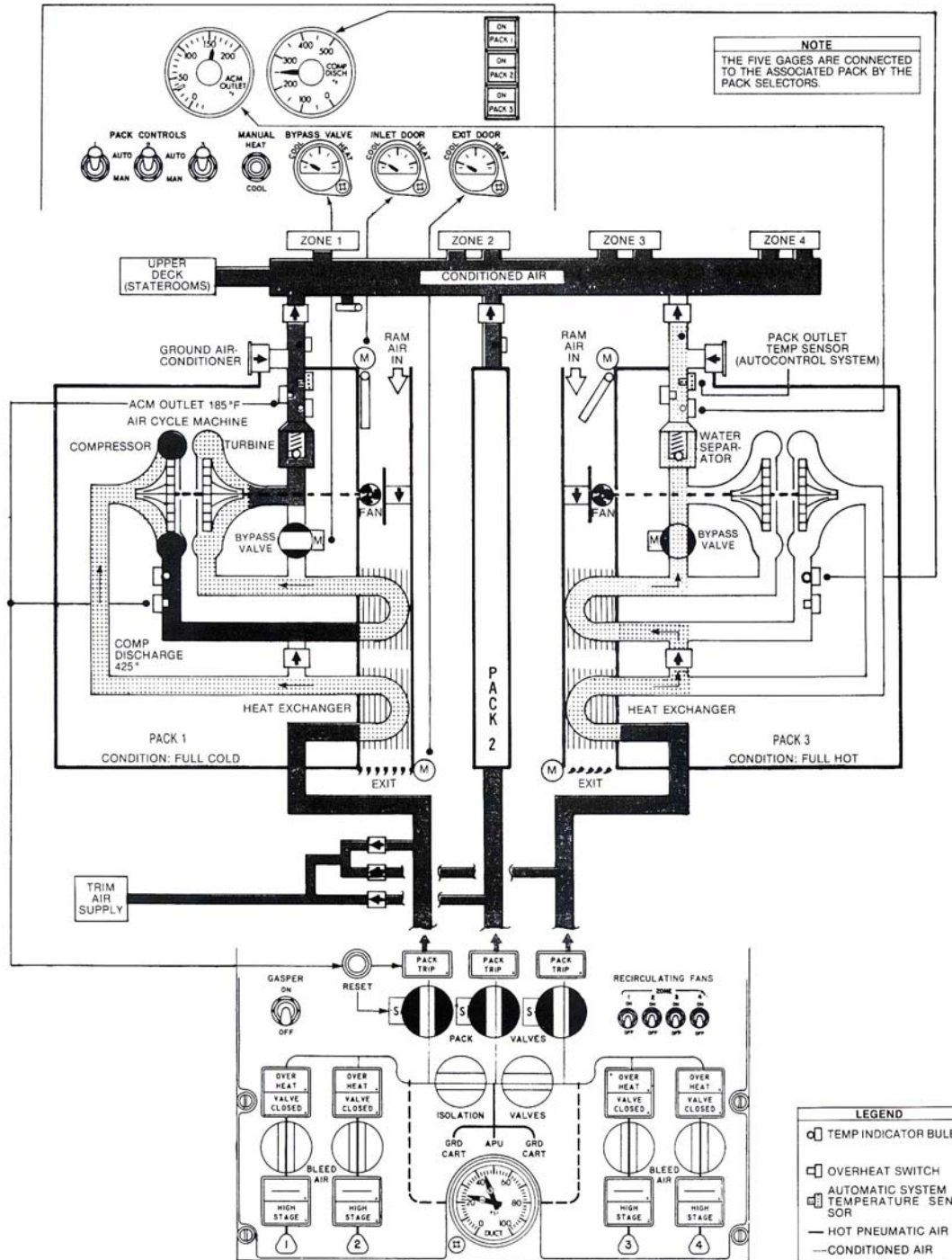
A single electric fan located above the main cabin ceiling supplies gasper air. The air source is the zone 4 distribution system.

The aft cargo compartment uses hot air from the pneumatic manifold bled directly into the aft cargo compartment. The forward cargo compartment is heated by equipment cooling fan exhaust.

Air leaves the main cabin through floor-level grills and spills behind the sidewall liners of the cargo compartments to aid in keeping the cargo areas above freezing. The air moves rearward, behind the liners, and is exhausted overboard through two outflow valves located behind the aft cargo compartment.

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AIRCONDITIONING PACKS

Hot air from the pneumatic manifold is cooled by three identical air conditioning packs pictured above. The hot air enters each pack through a pack valve. Initial cooling takes place in an air-to-air heat exchanger. If additional cooling is required, a bypass valve can be closed to direct airflow through an air cycle machine (ACM). The air then passes through a water separator and into the conditioned air plenum.

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Pack Valves

Three air conditioning pack valves control the flow of air to the packs and to the zone trim system. The valves are pneumatically opened and can be overridden and closed electrically by the PACK VALVES switches on the flight engineer's panel. Each PACK VALVES switch energizes a solenoid to close the valve. This is the same solenoid used by a pack trip. In the switch open position, power is removed from the close solenoid and the valve is free to open pneumatically. The pack valves modulate automatically to control mass airflow into each pack. These valves begin to close if duct pressure is less than 12 psi and are fully closed below 8 psi. When the pack valve is open, a position switch on the valve arms the auto-control for its respective pack and for all four zones.



Heat Exchangers

Cooling of the hot air takes place in the air-to-air heat exchangers. Cool air is provided by ram air in flight and by an ACM-driven fan on the ground. A check valve in the ram air duct prevents the fan air from reversing out the inlet.

Inlet and Exit Doors

Ram airflow across the heat exchangers in flight is regulated by the position of the inlet and exit doors. The doors are fully modulated and are operated by electric motors. Each door has a position indicator. In AUTO mode when the aircraft is on the ground, the gear tilt switch actuates both the inlet and exit doors to full COOL (open).



Air Cycle Machine (ACM)

When additional cooling is required, air leaving the first stage of the heat exchanger is directed to the ACM by closing an ACM bypass valve. The ACM is a cooling device incorporating a compressor driven by an expansion turbine on a common shaft. The turbine also drives an ACM fan for pack cooling airflow on the ground. The ACM enables the pack to produce conditioned air that is colder than ambient cooling air. This is accomplished by temporarily raising the temperature of the air through compression, so that the cooling air can extract more heat in the heat exchanger.

Bypass Valve

The bypass valve controls the speed of the ACM by regulating pressure drop across the turbine. It is motor operated and has a position indicator. When the valve is:

- OPEN, all the air bypasses the ACM, rendering it inoperative,
- CLOSED, all the air is routed through the ACM compressor and turbine for maximum cooling.
- In an intermediate position, the position determines the ACM contribution to total pack cooling.

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Pack Indicators

A pack selector is pressed to connect the desired pack to the following six indicators:

- BYPASS VALVE COOL (closed) HEAT (open)
- INLET DOOR COOL (open) HEAT (closed)
- EXIT DOOR COOL (open) HEAT (closed)
- ACM OUTLET to monitor pack outlet temperature and thermal switch setting;
- COMP DISCH to monitor ACM compressor outlet temperature and thermal switch setting



Pack Trip Protection

A pack trip automatically closes the pack valve and illuminates the PACK TRIP light. The bypass valve, inlet door, and exit door are sequenced to their pack valve closed condition. Three conditions can cause a pack trip:

- A COMP DISCH temperature of over 425F. The pack trip prevents ACM overspeed.
- An ACM OUTLET temperature of over 185F. The pack trip prevents excessive temperatures in the distribution ducts.
- System out of sequence (when the bypass valve is near full COOL and the INLET DOOR or EXIT DOOR is near full HEAT) The pack trip prevents ACM surging.

If a pack valve closes for any reason, the doors assume a pack-valve closed position.

Reset of a pack trip can only be accomplished after the fault is corrected. A single RESET switch is used for all three packs.



Air Conditioning Zones 1, 2, 3, and 4

The Air Conditioning Zones schematic (on the next page) illustrates the four zones and the upper deck.. All zones receive conditioned air, gasper air, and recirculated air. All zones depend on conditioned air for cooling. Heat can be added to each zone by modulating a zone trim air valve. The conditions depicted in the schematic are:

- All compartments under automatic control; ZONE 1, requiring the coldest duct temperature, is controlling the ACM OUTLET temperature of the three packs.
- The other zones have stable COMPT temperatures, but each requires a higher DUCT temperature.

Trim Air

Trim air is hot air taken directly from each pack supply duct. At least one pack valve must be open for the system to be operative.

Zone Trim Air Valves

Each zone trim air valve regulates the flow of trim air into the distribution system of the respective zone. The valves are motor operated and are fully modulated within a position transmitter.

Master Trim Air Valves

The master trim air valve provides protection when a zone trim air valve has failed in the open position. Then closed, it shuts off trim air to all zones. It does not modulate.

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Zone Temperature Indicators

Each of the temperature zones, 1, 2, 3, 4 and Upper Deck, have individual temperature gauges.

The gauges provide two temperature indications:

COMPT, (compartment) which is the ambient temperature of the zone, and

DUCT, which is the temperature of the zone supply duct.



The DUCT temperature indication is also used to verify the setting of the overheat thermal switches.

Overheat Protection

Thermal switches are used to provide warning if temperature in any zone distribution duct exceeds 185F. When operating in the AUTO mode, excessive temperature:

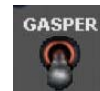
- closes the ZONE trim air valve (COOL),
- illuminates the OVERHEAT light, and
- locks out the affected zone.

When operating in MANUAL mode, excessive temperature only illuminates the OVERHEAT light.

When duct temperature cools to 160F, the system may be reset by pressing the RESET switch.

Gaspar Fan

The gaspar fan is electrically driven and is located above the main cabin ceiling. It uses Zone-4 supply duct air.



Recirculating Fans

The four recirculating fans are identical and are electrically driven. The zone 1 is located in the forward cargo compartment and uses main cabin exhaust air.



Air Conditioning Controls and Indicators

Each zone and each pack has an automatic and manual control system. They may be used in any combination with one exception; if all five zones are under manual control, the three packs must also be controlled manually, or they will go to a full-cold condition and all ACM outlet temperatures are maintained at 35F.



For automatic operation, each zone and each pack uses an electronic temperature controller.

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Zone Control

Zone Temperature Selector

Each zone temperature selector has an AUTO and MANUAL operating position. The AUTO position has a variable control range of from 65F to 85F. The vertical position of the selector is approximately 75F.



For automatic operation, in addition to having the temperature selector in AUTO, one pack valve must be physically open. The controller compares the setting of the temperature selector to the existing COMPT temperature, and signals all three packs for the required temperature if cooling is required. If more heat is required it modulates the trim air valve toward open.

Placing the temperature selector in MANUAL deenergizes a relay in the temperature controller and removes the signals to the packs. Positioning the selector to COOL or WARM directly modulates the trim air valve. In MANUAL, the selector is spring-loaded to the center (off) position.

Overheat Protection

In AUTO, the temperature sensor limits DUCT temperature to 160F. A backup thermal switch, set at 185F, functions as follows in the AUTO mode:

- illuminates the OVERHEAT light,
- closes the trim air valve, and
- locks out the system.



In MANUAL mode, the thermal switch only illuminates the OVERHEAT light.

Reset Switch

A single RESET switch, common to all zones and the upper deck, is used to reset overheat lockouts. Zone temperature be below 160F to reset an overheat lockout.

Pack Control

Pack Control Switches

Each pack has a separate PACK CONTROLS switch to select either the AUTO or MAN mode of operation.

Pack Temperature Control (Auto Control)

For automatic operation, a PACK CONTROLS switch must be in AUTO and a PACK VALVES switch for that pack must be open. Indicated ACM OUTLET temperature varies from 35 to 160F.

The temperature controller receives a temperature signal from each zone that is in the AUTO mode. The zone requiring the coolest duct temperature is the master, and is compared to the existing ACM OUTLET temperature. If warmer air is required, it modulates the bypass valve toward HEAT (open). If this is insufficient, it modulates the inlet and exit doors toward HEAT

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(closed). If cooler air is required, the sequence is reversed. If all four zones are in MANUAL mode, the controller maintains ACM OUTLET temperature at 35F.

Logic in the controller assures that the INLET DOOR is at full COOL limit before it closes the bypass valve. In reverse the bypass valve must be at full HEAT before the inlet and exit doors can leave the full COOL limit. The in-flight full COOL limit for the "save ram" controller is INLET DOOR at 10 o'clock, EXIT DOOR at 2 o'clock. On the ground, the inlet and exit doors are opened by the gear tilt switch, and temperature is regulated exclusively with the bypass valve.

Manual Control

For manual operation the desired PACK CONTROLS switch must be in MAN to:

- open the exit door
- arm the MANUAL temperature switch, and
- deenergize the automatic functions of the controller.

The MANUAL temperature switch is shared by all three packs, with selection through the pack selectors. Holding the MANUAL temperature switch to HEAT or COOL modulates the bypass valve or inlet door direction. Limit switches in each motor assure proper sequence operation.



Pressurization System

Introduction

The pressurization system controls the fuselage pressure by controlling the rate at which air is exhausted overboard. Controllable outflow valves regulate this exhaust rate. A continuous exhaust is provided for each lavatory and galley compartment to carry offensive odors overboard.

Then the aircraft is depressurized, an electric fan draws air through the system and exhausts in the vicinity of the main outflow valves. As cabin pressure increases, the fan is turned off and an overboard valve is opened automatically. Manual override for the fan is provided on the Flight engineers panel. (This switch is NOT modeled in this implementation)

Pressurization Control

Two outflow valves are located on the bottom of the fuselage behind the aft cargo compartment. Each valve has

- an AC motor for automatic operation,
- a DC motor for automatic operation and manual rate limiting, and
- a valve position transmitter.

An auto-manual relay prevents the ac to dc motors from operating simultaneously.

Autocontroller

Automatic pressurization control is accomplished through the pressure autocontroller. The controller senses outside pressure and cabin pressure and receives signals from the cabin pressure selector panel. It electrically positions the two outflow valves through their ac motors.

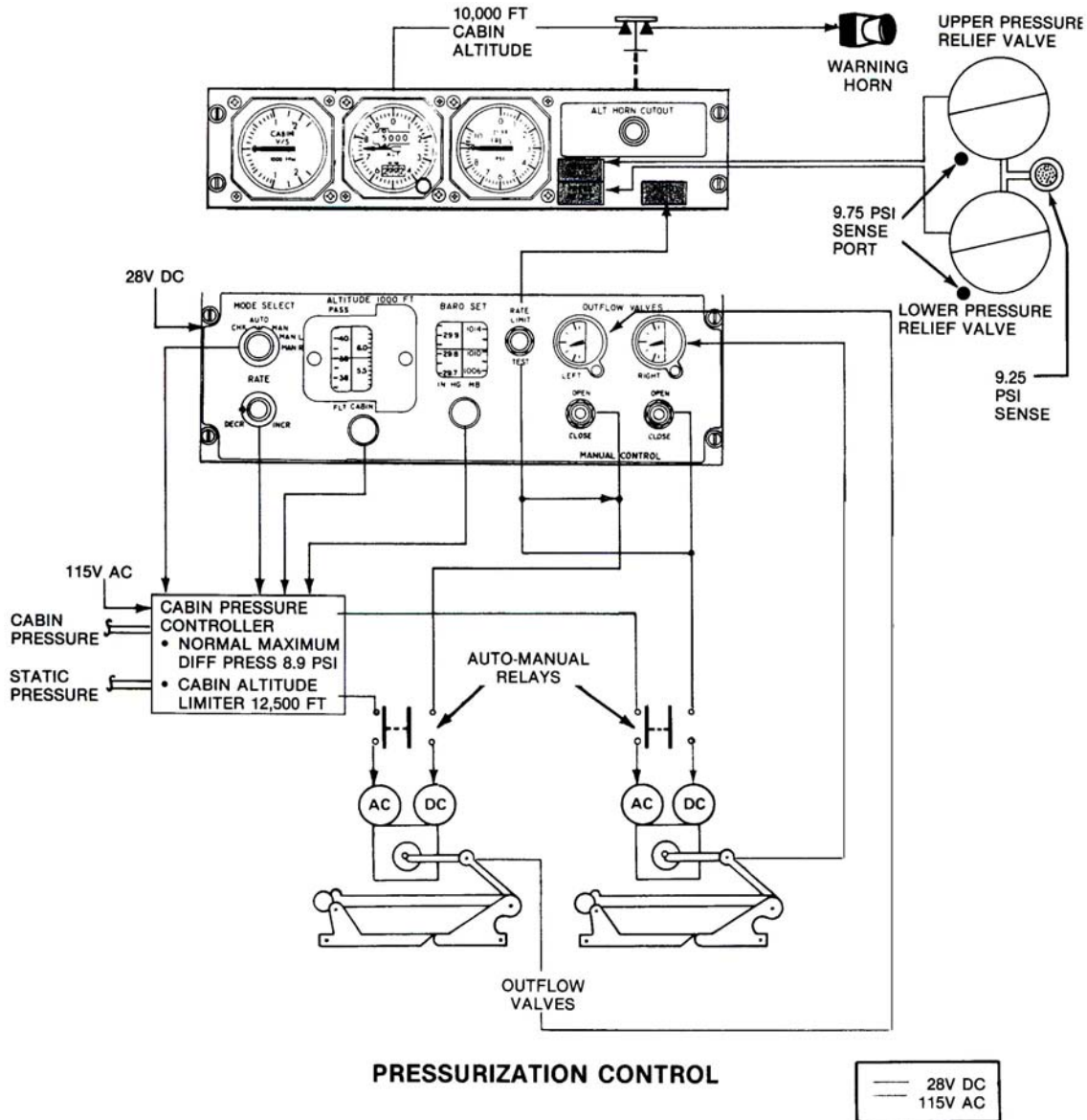
Control Panel

This panel is located on the flight engineers panel. It operates electrically to provide command signals for automatic and manual control of the outflow valves to maintain the desired cabin pressure.



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Protection

System protection consists of:

- The autocontroller, which maintains 8.9 psi maximum
- The autocontroller closing both outflow valves if the cabin altitude exceeds 10,500 feet to 13,000 feet.
- Two pressure relief valves, which limit pressure at 9.25 psi. Each valve also has a backup sensing to relieve at 9.75 psi.
- A rate limit system, which in automatic mode takes control of both outflow valves whenever the cabin rate of change exceeds approximately 2000 to 3000 fpm. The rate system is deactivated above 10,000 ft cabin altitude.

Two small doors in each lower cargo compartment door provide negative pressure relief.

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Pack Controls

Pack Selectors

Interlocked for single selection; each, when pressed ON, connects

- All six adjacent indicators to that pack
- The MANUAL temperature switch to that pack if related PACK CONTROLS switch is in MAN

Pack Control Switches

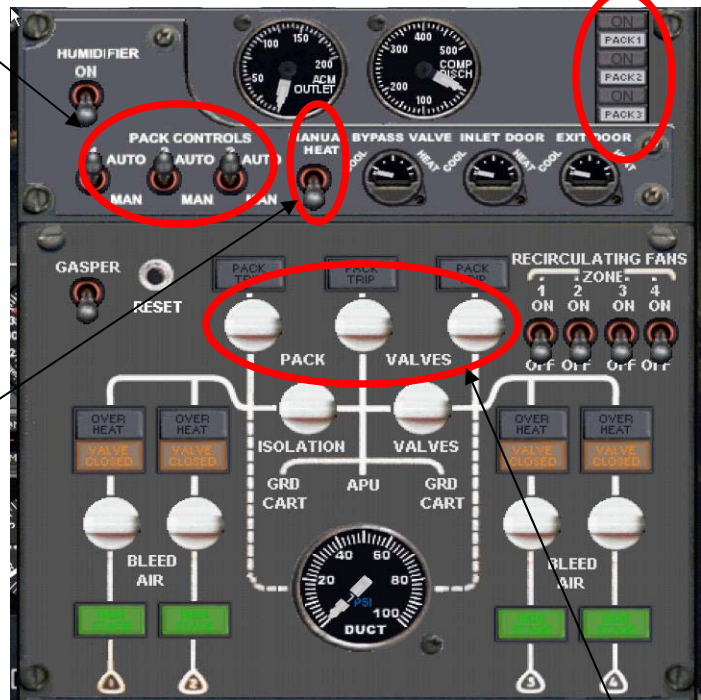
Each switch selects a pack-operating mode.

- AUTO: ACM outlet temperature automatically adjusted by zone requiring coolest duct temperature. If all ZONE temperature controls are in MANUAL, the ACM OUTLET temperature is automatically maintained at 35F.
- MAN: ACM OUTLET temperature for pack is adjusted with MANUAL temperature switch provided pack has been selected by PACK selector.

Manual Temperature Switch

Controls ACM OUTLET temperature on ground or in flight with related

- PACK CONTROLS switch in MAN, and
- PACK selector on
 - HEAT: increases ACM outlet temperature as shown by BYPASS VALVE indication to HEAT. If already at full HEAT, INLET DOOR indication is sequenced toward HEAT. The EXIT DOOR indication remains at full COOL
 - COOL: Decreases ACM OUTLET temperature as shown by INLET DOOR indication toward COOL. If already at full COOL, BYPASS VALVE indication is sequenced toward COOL. The EXIT DOOR indication remains at full COOL.



Pack Valves Switches

Arm each pack valve. Once armed, control and positioning is automatic.

- Each pack valve closed with duct pressure below 8 psi and required 12 psi to be fully open.
- Max flow to pack and zone trim system is regulated automatically
 - Open: Pack valve is armed to open. Control solenoid is de-energized
 - Closed: Control solenoid is energized and pneumatic air or spring pressure closes pack valve.

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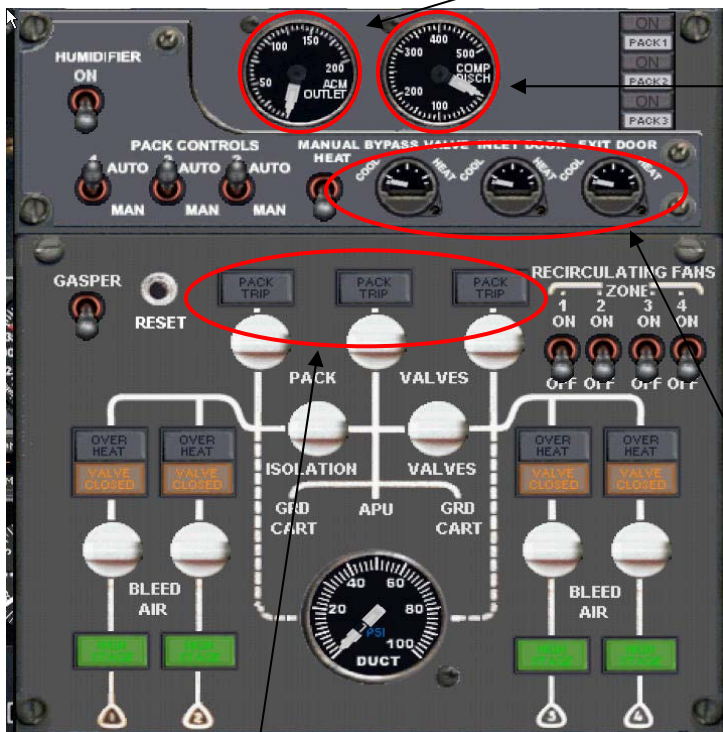
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Pack Indicators

ACM Outlet Temperature Gauge

Indicates temperature of air being supplied by the respective pack.

- Normally varies from 34-135F
- Pack trip occurs above 185F
- Selected to each pack by PACK selectors



Comp Disch Temperature Gauge

Indicates operating condition of ACM and heat exchangers.

- Temperature increases as cooling demand increases.
- Pack trip occurs above 425F
- Selected to each pack by PACK selectors

Bypass Valve, Inlet Door, Exit Door Indicators

Indicate position of bypass valve, inlet door and exit door in terms of HEAT or COOL function

- COOL is open position for inlet and exit doors
- Selected to each pack by PACK selectors

Pack Trip Lights

When on, indicate that related pack valve has closed or locked out pack because:

- ACM OUTLET temperature is over 185F
- COMP DISCH temperature is over 425F
- Bypass valve is out of sequence with inlet or exit door position

Recirculation and Ventilation Controls

Recirculating Fans Switches

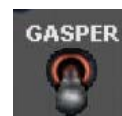
Will give a click sound and also you will hear the sound of the fans running. The fan sound is not loud and sounds much as it would in cockpit area. Number 1 fan increases conditioned airflow to the cockpit area and is seldom used. No's 2, 3 & 4 Fans recirculate conditioned air to the passenger cabin and 4



the

Gaspar Fan Switch

ON: Applies power to gaspar fan to increase airflow through various "eyeball" outlets.



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Zone and Upper Deck Temperature Controls and Indicators

Trim Air Switch

OPEN: Trim air is supplied

CLOSED: Trim air is shut off

Reset Switch

Used to reset overheat lockout in any zone or upper deck



Zone Temperature Selectors

Adjust temperature in respective zones

AUTO: Maintains selected zone temperature automatically between 65 and 85F, vertical position is approx 75F.

MANUAL: WARM setting adds trim air; COOL reduces trim air. With all some temperature controls in MANUAL, the ACM outlet temperature is automatically maintained at 35F.

Comp and Duct Temperature Gauges

COMPT: Indicates temperature in respective compartment (zone).

DUCT: Indicates temperature in the distribution ducts.

- With trim valve at full COOL duct temperature should be same as pack outlet temperature (ACM OUTLET gauge)
- With trim air valve at full HEAT, duct temperature should read higher than ACM OUTLET temperature.



Zone Overheat Lights

Light on when respective distribution duct temperature exceeds 185F.

ON: Overtemperature condition. The trim air valve closes immediately to COOL.. If related zone temperature is in AUTO.

Trim Valve Position Indicators

Indicate position of individual zone trim valves

COOL: Valve is closed

HEAT: Valve is open.

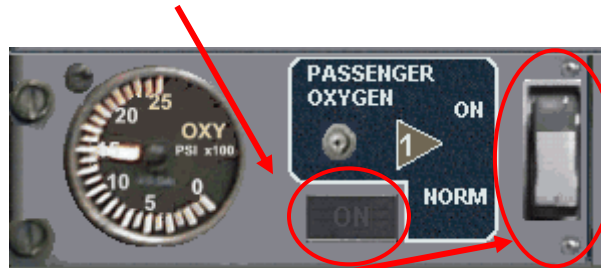
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Passenger Oxygen Control

Passenger Oxygen Indicator

Light (Amber) Illuminated indicates system is activated



Passenger Oxygen Switch

NORM: Three flow control units are pneumatically open when cabin altitude is at or above 14,000 feet passenger oxygen system is activated

ON: Two flow control units are opened electrically - passenger oxygen system activated.

Normal Operations

General

For passenger comfort, aircraft air conditioning should be initiated at least 15 minutes before passengers board. Normally the APU provides the required air for heating and cooling.

Air Conditioning Packs

- Use all packs for three and four engine taxi, descent, landing, and (if required) during meal service. At the blocks and during climb and cruise, use two packs after cabin temperature has stabilized.
- Use one less pack than allowable bleeds for landing or with anti-ice on; otherwise one pack per bleed is permitted.
- Use PACK CONTROLS switch AUTO mode. When switching from MAN (manual) to AUTO a 15 to 20 second delay will occur before AUTO takes over.

Before Opening a Pack Valve

- Select the indicators to that pack and check:
 - INLET DOOR at full COOL, and
 - BYPASS VALVE at 11 o'clock or warmer for AUTO mode, 11 o'clock for MAN mode
- Open or close the pack valves one at a time; allow several seconds between packs to stabilize APU loads or prevent engine stall.

Basic Monitoring

- Check that ACM OUTLET temperature is the same for all packs. Auto pack control maximum ACM OUTLET temperature is 135F or 165F. On the ground, any pack with its bypass valve full COOL should have a maximum ACM OUTLET temperature of 50F.
- Pack efficiency in flight is indicated by INLET DOOR position. The pack with an inlet door closest to COOL is the least efficient and is causing increased drag.
- At TOD, when the engines are reduced to idle thrust, the HIGH STAGE should come on.

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Air Conditioning Zones

- Except for flight deck, use AUTO
- If two or three zone trim valves are positioned near full heat, set the zone temperature selector for the trim valve that's indicating full COOL to MANUAL until the cabin warms up. When transitioning from MANUAL to AUTO, a delay of 5 to 10 seconds occurs before AUTO takes over.
- If control is poor, cycle zone temperature selector to MANUAL for 5 seconds to zero signals.
- If complaints of cold feet are received, hold the temperature to 78 to 80F.

Basic Monitoring

- Check that all compartment (zone) temperatures are the same.
- Check that duct temperatures are higher on zones with the trim air valve open (to verify that the master trim air valve is open).

Recirculating and Gasper Fans

Recirc Fans

Except as noted above, zone 2, 3, and 4 recirculating fans must be ON at all times on all passenger flights and off for cargo only flights. Zone 1, the flight deck is optional.

NOTE: for maximum cooling on the ground and during initial climb in hot and humid conditions, turn the recirculating fans off at all blocks arrival and leave off until at FL100

Gasper Fan

To maximize cooling and airflow to zone 4 when zone 4 is hot (on the ground or in flight), the gasper fan should be turned off. When zone 4 temperatures are normal, the gasper fan should be on when at or below FL250 and off above FL250.

Pre Flight

Temperature Controls (Upper Deck, and Zones)

Set all zone controls approximately vertical in the AUTO mode. Check that all OVERHEAT lights are out.

Trim Air

Select Trim Air Switch to OPEN



Bleed Air Switches and Isolation Valves



Open the four engine bleed air valves and two wing ISOLATION valves. The HIGH STAGE and VALVE CLOSED lights may be illuminated or out; all other lights should be out.

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Recirculating Fans and Gasper Fan

Normally zone 2,3, and 4 RECIRC fans and GASPER fan should be on for all passenger operations; off for cargo operations. The flight deck recirc fan is optional.



Pack Controls

Set all PACK CONTROL switches to AUTO



Inlet and Exit Doors

Check that each pack INLET and EXIT door indicates full COOL.



Bypass Valves

The bypass valve can indicate full COOL, 11 o'clock, 1 o'clock, or full HEAT.

(Pack Valves Closed) APU Bleed Air

Close all pack valves to minimize initial load on the APU. Open APU BLEED AIR valve; check that duct pressure is 40 to 45.



Pack Valves (one at a time)

Open the pack valves one at a time. Use three packs only if duct pressure is above 14 psi and APU EGT is 520F or less. To save fuel, reduce to two packs when cabin temperature has stabilized.



Starting

When using APU air, leave one pack on if the duct pressure remains above 30 psi with the start valve open.

- When using ground air or engine cross bleed, turn all packs and ADPs off.

Taxi

- Select the PACK selectors to each pack before opening the pack valve. If a bypass valve indicates cooler than 11 o'clock, position the bypass valve to the 11 o'clock position. Open the PACK VALVES switches one at a time.
- Check that the BYPASS VALVE indicator starts to respond before going to the next pack.
- If any HIGH STAGE light is out, cycle the related engine BLEED AIR switch off, then on
- Use all packs with three or four engines operating or two packs with two engines operating on the ground for passenger comfort and to provide maximum stall margin for the engines.
- Monitor the zone trim indicators occasionally during taxi. If zones 2,3, or 4 indicate neat full HEAT, place zone 2 temperature control to MANUAL..
- Check zone temperatures at least once during taxi, more often, if temperature adjustments are required. If temperatures are stable at approximately 76 to 80 F, further monitoring is not required.



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Takeoff

- Normally, make all reduced thrust takeoffs with two packs on. However, with high outside air temperatures, and depending on cabin temperatures, reduced thrust takeoffs may be made with one pack on or all packs off.
- Make full thrust takeoffs with one pack on, using the all packs on EPR setting.
- Leave the packs on as long as possible for passenger comfort and to improve the stall margin.
- Before entering the takeoff runway, turn the packs off one at a time, allowing several seconds between each pack. The rapid shutdown of more than one pack at a time may cause an engine surge.

After Takeoff

- If a packs-off takeoff was used, and the number 2 pack was not used for takeoff, between 400 and 2000 feet and when clear of obstructions, turn on one pack.
- If one pack is on, turn the second pack on after the first thrust reduction as workload permits.
- If two packs are on, turn on the third after the aircraft is clean if it is necessary to achieve cabin temperature.

Recheck Air Conditioning System Operation

- If zone 2, 3 and 4 trim valves indicate near full heat, place the flightdeck (zone 1) control to manual and allow one of the main cabin zones to become master. A warm flightdeck can drive the pack outlet temperature so cold that trim air will be insufficient to keep the main cabin warm.
- Observe that DUCT temperatures are reasonable.
- Turn gasper fan off above FL250.

Cruise

When established in cruise, if three packs were being used, continue to operate all three packs if passenger load is greater than 300. If passenger load is less than 300, reduce to two-pack operation by turning off the least efficient pack. The pack with its INLET DOOR closest to COOL is the least efficient. Return to three pack operation during meal service, or when requested by the purser.

Descent

Turn the gasper fan ON below FL250.

At the Gate (Blocks)

Use a maximum of two packs unless cooling is inadequate

APU Inoperative

Turn all three PACK VALVES switches off before engine shutdown to preclude overbleeding the last engine.

External Power Connected

Shut down the APU if air conditioning is not needed

External Power Not Connected

Set the BLEED AIR switch to CLOSE if air conditioning is not needed.

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APU

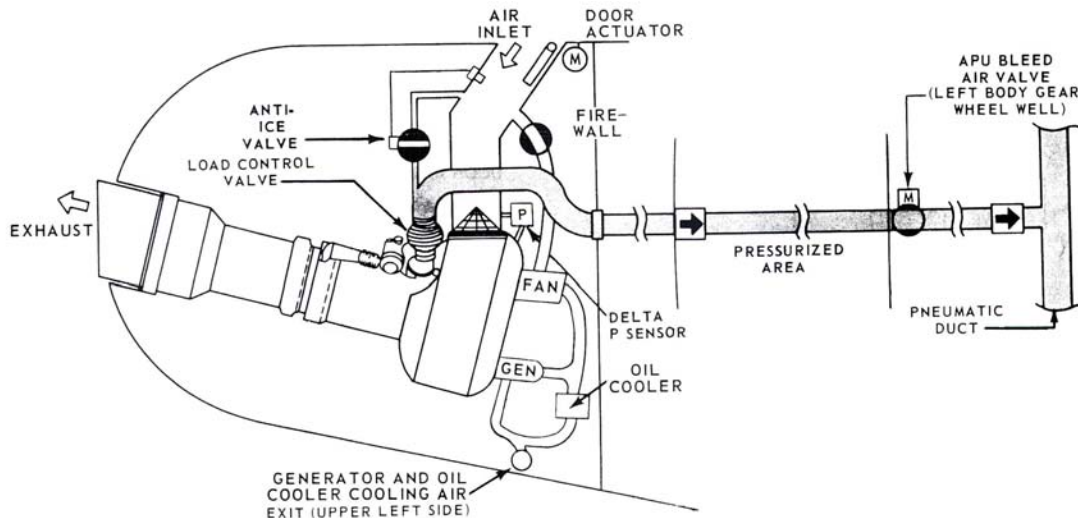


Introduction

The auxillary power unit can be used to:

- power the electrical system,
- pressurize the pneumatic system,
- supply air conditioning,
- provide bleed air for engine starting,
- supply power for the L.E. Flap drive motors,
- provide bleed air for the air drive hydraulic pumps (ADP),
- provide water tank pressure, and
- provide forward and cargo compartment heat.

The APU is a single spool 4-stage axial flow gas turbine engine isolated from the aircraft by a firewall. .



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The APU is installed in the unpressurized tailcone and isolated by means of a firewall. It is capable of driving two standard engine generators at the same time and provide sufficient air to operate three air conditioning packs. Automatic load control reduces air output to favor electrical loads. Operation is completely automatic so it can run unattended. Air is drawn in through an electrically operated door in the upper right side of the tail cone. Exhaust gasses exit at the rear of the tail cone. Compressed fresh air is supplied to the pneumatic duct through a load control valve and a bleed air valve.

A fan driven by the APU provides cooling air for the generator and oil cooler. The air is drawn in through a valve in the APU inlet duct. It then passes across the generator and oil cooler and is exhausted overboard on the upper left side of the tail cone.

APU control is through a master switch on the flight engineer's panel. Fire detection and extinguishing are provided. An APU remote fire control and shutdown panel is located in the right body gear wheel well.

APU Systems

Control

The control system is contained in an electronic turbine control unit (ETC), which regulates fuel flow as a function of EGT and/or RPM.

- During start and acceleration, the fuel flow is scheduled to a preset EGT-rpm schedule.
- During steady-state operation, an rpm sensor regulates fuel flow to maintain a constant 100% rpm regardless of load. With a normally operating system, APU overload is impossible. When EGT reaches 620 degrees, an EGT sensor throttles a load control valve to maintain the existing airflow constant. Increasing pneumatic loads merely result in a loss of duct pressure.

Anti-Ice

Hot air from the APU discharge duct is used for inlet screen anti-ice. A temperature sensor in the APU inlet duct automatically opens the anti-ice valve with the OAT between -7 to +4 degrees C, provided the BLEED AIR switch is on.

If the Anti-ice system fails and the inlet screen ices over, a Delta P sensor will cause an auto-shutdown.

Fuel

The primary source of fuel is the No 2 main tank. Fuel can also be supplied from any other tank through the No 2 crossfeed valve. Normally, fuel is supplied to the APU by the No 2 aft boost pump. However, when making a battery start, a dc pump located in the No 2 main tank supplies fuel. A green DC PUMP on light illuminates when this pump is operating. The APU control system arms the dc pump and the No 2 AFT BOOST PUMP switch does not have to be ON. A pressure switch prevents the dc pump from operating when the fuel line is pressurized from another source. A motor-operated shutoff valve is located on the rear spar, aft of the No 2 main tank. From this valve, a shrouded fuel line passes through the floor beams to the APU metering valve. The shroud has a flush-type drain fitting located on the bottom of the fuselage between the body gear.

Electrical

The APU is equipped with an electric starter, battery and battery charger. During the cranking cycle, APU battery voltage is very low. To ensure adequate voltage, the ETC and control relays are transferred to the main airplane battery. During the starting cycle the battery charger is disconnected until the starter cuts out.

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Oil

The APU has its own oil system with a tank capacity of four quarts. If oil pressure drops below a preset minimum, the APU shuts down automatically. It also shuts down if oil temperature rises above a preset minimum.

Controls and Indicators

The APU is controlled from the second officer's panel. Keep in mind that once an **APU start is initiated, further control is fully automatic**. APU operation will be discussed later but for now we will discuss controls and indicators.



RPM Gauge

Indicates APU rpm in percent

EGT Gauge

Indicates APU exhaust gas temperature in degrees centigrade (C)

Oil Quantity Gauge

Indicates quantity in one quart increments

APU Fuel Valve— (Blue)

- Extinguished – APU Valve is closed or open
- Illuminated – Valve is in transit

DC Pump On Light – (Green)

- ON – APU DC Fuel pump operating. DC pump will only operate when there is no power on the ground service bus. When the ground service bus is powered, No. 2 main fuel tank aft boost pump will be operating and the DC Fuel Pump will be shutdown.
- OUT – DC pump is off or pressure is low.

APU Fault Light – (Amber)

- Illuminated – APU Auto Shutdown
- Normal Shutdown – Fault light will illuminate until APU door reaches closed position.

APU Door Light (Blue)

- Illuminated – Door in transit
- During Shutdown – APU Door closes at 50% RPM and light illuminates while door is in transit.

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Bleed Air Switch

- Controls APU bleed air flow to the pneumatic system.
- OPEN:
 - Opens APU bleed air valve
 - Arms APU load control valve to open above 95%
- CLOSE:
 - Closes APU bleed air valve
 - Closes APU load control valve

APU Master Switch

Initiates automatic operation of manual shutdown:

- ON:
 - Opens main fuel valve and APU door
 - Arms ac and dc fuel pumps
 - Arms all running circuits if APU door is full open (in flight: one-half open)
- START:
 - Initiates starter cranking
 - Spring loaded to ON when released
- STOP:
 - Closes main fuel valve and disarms ac and dc fuel pumps
 - Sends simulated 110% rpm signal to ETC to test the auto-shutdown circuit and shuts down the APU.

DC Meters Module

The DC Meters Module will be covered in detail in the electrical power systems. The importance of the **battery switch** will be discussed in the APU start portion.

DC Volt Meter

- Indicates voltage at the selected DC power source

Battery Switch

- ON – Battery serves as backup to supply battery bus, DC standby bus and static inverted in event of essential power failure
- OFF – Battery isolated from all loads except hot battery bus. Battery will continue to receive charge. If running, APU will be shutdown.



DC Amps

- Indicates DC current output of selected source

DC Meter Switches (White – Blue)

- Depress to read voltage and amperage on DC meters. Light will illuminate in depressed switch.

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APU Normal Procedures

Exterior Safety Check

- Check that the APU exhaust area is clear of personnel, work stands, etc.
- Check APU fire bottle and disk in place

Battery Check

- Turn the BATTERY switch to ON to check the main battery and APU battery

With no power on the airplane:

- Battery voltage should not be below 24V

With power on the airplane:

- Battery voltage should be above 27V

APU Start

Arriving at the airplane, let's assume that external power is not available and we intend to use the APU to energize the aircraft's systems. Anytime we board a "cold" airplane, we move the **BATTERY SWITCH ON** to provide a limited number of lights, controls, **Oil Quantity Indication** and indicators. It should be remembered that the APU can not be started unless the **BATTERY SWITCH** is in the **ON** position.

If the Oil Quantity indication is below 2 ¼ quarts, DO NOT start the APU.

The next step in the APU start procedure is to make sure the **BLEED AIR SWITCH is in the Close position**. This action prevents undesired pressurization of the pneumatic ducts.

If the switch is left in the OPEN position, the bleed air valve will open prior to 100% RPM. This will result in a high EGT during the start, giving the appearance of a hot start, due to the additional load.



The key light that gives a signal to complete the APU start procedure is the APU door light.



When the APU Master switch is moved to ON, the Fuel Valve Light will illuminate for about 2 seconds indicating it is in transit and the APU door will start to move and the APU door light will illuminate for about 30 seconds to indicate the door is in transit.

Do not attempt to start the APU until the APU DOOR is fully open and the APU DOOR light is off.

Once the APU Master switch is moved to the START position, the sequence is fully automatic.

- When the APU RPM begins rotation, APU battery voltage will drop.
- When APU RPM reaches 7%, EGT will begin to rise.
- When APU RPM reaches 50%, the starter cuts out. The APU Start switch will move to ON position. DC Voltage Normal returns to normal.
- When APU RPM reaches 95%, electrical and pneumatic loading is possible.
- When APU RPM is 95% to 100%, it is normal

With **APU BATT** selected on the DC Panel, the ammeter will only indicate APU charging. Therefore, the ammeter indication at starter cut-out could be from 0 – 70 amps.

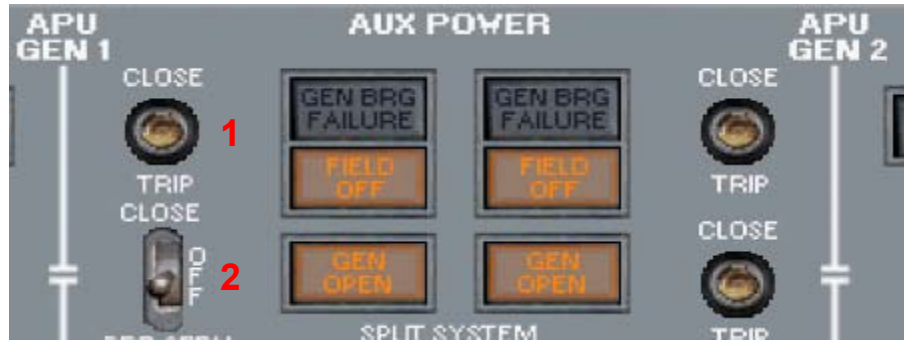
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Electrical Loading

The APU Generator loads to not affect control of maximum EGT. Use as required, but monitor generator load.

When you begin the APU start sequence by switching the APU START switch to ON, these four lights will illuminate on the AUX POWER PANEL



Once the APU start sequence has been completed, you may now put both APU generators “on-line” or on the SYNC BUS.

First: using the AC METERS module, check the frequency and voltage on each generator by pressing the appropriate ON button over the APU PWR 1 or APU PWR 2 lights on the AC METERS module. Click ON to activate the meter, off to deactivate. If the APU is started and ready to supply power to the bus, there will be reading of approximately 400hz frequency, and approximately 115 volts.



Second: once you are sure that the generators are actually set and ready to provide power to the bus, starting with APU GEN 1, click the switch labelled “1” above to turn on the APU 1 Generator Field ... note that the FIELD OFF light extinguishes.

Third: once the FIELD OFF light is extinguished, click the switch labelled “2” above to apply power to the SYNC BUS.

Fourth: click the switch labelled “3” to apply APU generated power to the AC1 BUS, then to the AC2 BUS.

Fifth and lastly, repeat 1 to 4 for the APU GEN 2 side.



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Pneumatic Loading

Without engines running:

- Close all pack valves before selecting the AU BLEED AIR switch to OPEN or CLOSED. This is done to reduce shock loads which can cause surge and fault shutdown if the air is shut off too rapidly

If EGT exceeds 620 degrees C while operating three packs:

- Turn one pack off

When ready to start the engines:

- Close required pack valves one at a time, allowing several seconds between each pack. This prevents surge and fault shutdown.

With engines running (on the ground):

- The APU BLEED AIR switch may be selected to OPEN or CLOSED at any time

Shutdown

When shutting down the APU prior to takeoff:

- Close APU BLEED AIR valve to cool the APU before shutdown. Always keep the APU BLEED AIR valve during taxi to permit maximum engine bleed for improved stall margin.

When the APU has cooled sufficiently (APU BLEED AIR off for a minimum of one minute):

- Place the APU master switch to STOP.
- Check that the FUEL VALVE light illuminates and then goes out.
- Check that the APU DOOR and FAULT lights illuminate.

After Landing

At airports where external power is available and routinely used, do not start the APU unless it is required for air conditioning during longer transits.

If the APU is required, it should be started early enough to ascertain that it is operating prior to arrival at the blocks; do not start too early and waste fuel.

Except for the APU fire test, use normal starting procedures.

Set the APU BLEED AIR switch to OPEN upon arrival in the terminal area (to assure normal operation with an air load)

Blocks

Transfer power from engine generators to the APU generator only after the parking brakes are set.

To conserve fuel:

- If air conditioning is required use a maximum of two packs
- If air conditioning is not required, turn off the packs and set the APU BLEED AIR switch to CLOSE.
- If external power is connected, use EXT PWR instead of APU GEN
- If both air conditioning and APU electrical power are not required, shut down the APU.

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Recap of APU Start

1. Battery Switch ON
2. Oil Qty above 2 ¼ Qts
3. Bleed Air Switch in Close position
4. Select APU Batt ON DC Meters
5. Place Master Switch to ON
6. Gen Open Lights ON (Located on AUX Panel)
7. Fuel Valve light ON
8. DC Pump Light ON
9. APU Door light ON
10. When APU Door light is OFF
11. Place Master Switch to Start
12. RPM will start to increase
13. DC Volts are low
14. At 7% RPM, EGT will start to rise. It will rise to about 800.
15. At 50% RPM, DC Volts will be normal (28 Volts). This is the starter cut-out point and EGT will now drop to about 450
16. At 95% RPM, Start is complete.

APU Shutdown

1. Bleed Air Switch CLOSE
2. Remove Electrical Load
3. GEN OPEN Lights ON
4. EGT Decrease to Idle temp
5. Place Master Switch to STOP
6. Fault Light ON
7. Fuel Valve Light – Bright OFF
8. RPM Decrease
9. At 50% RPM – APU Door Light ON
10. Fault light OFF
11. APU Door light OFF
12. RPM Zero

IMPORTANT ADDITIONAL NOTES:

The fuel supply for the APU is taken from Main Tank No. 2 and **does** affect the fuel quantity in the tank. The amount of fuel that will be used by the APU is between 1,300 and 1,400 lbs per hour so this should be taken into account when doing your fuel planning.

You **can not** start the engines without first starting and correctly configuring the APU. The systems we have designed into this aircraft prevent you from using the FS2004 <CTRL E> auto start function. Start the aircraft as per instructions in the AOM.

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Autoflight System



Introduction

Autopilot

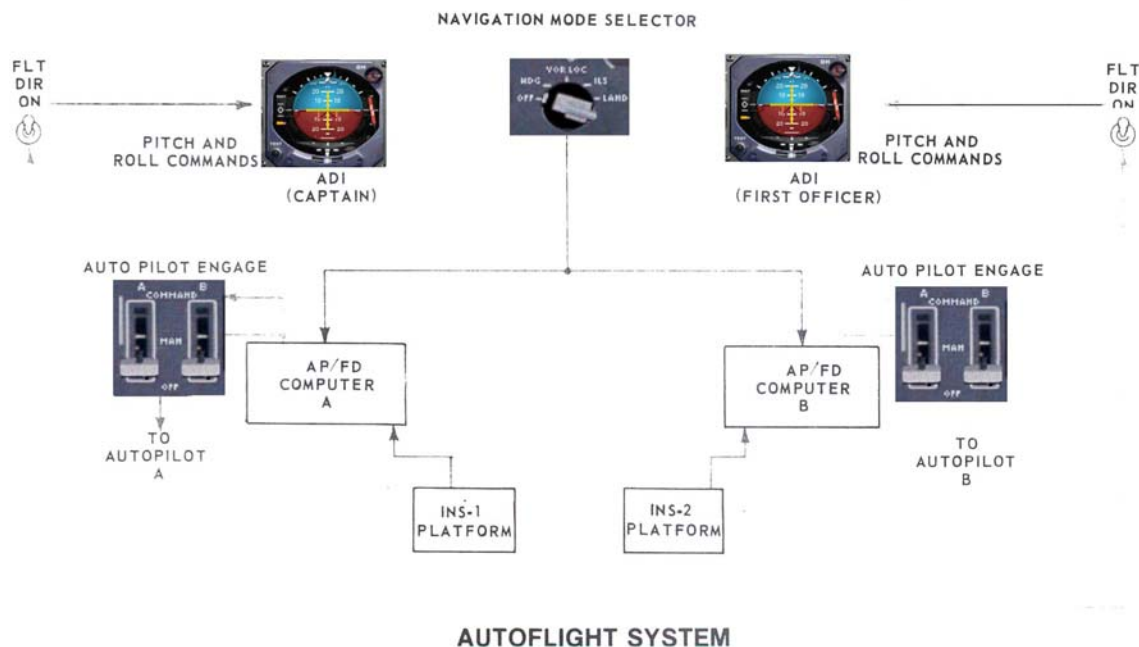
Two autopilots (channels A and B) provide automatic pitch and roll control. Separate engage switches select manual (MAN) or command (COMMAND) modes of operation.

Flight Director

The flight director system displays pitch and roll commands for the same navigation modes as the autopilot. Separate flight director (FLT DIR) switches activate the ADI command bars with signals from the selected flight director computer.

Autothrottle

The original 747-200s did not have a full regime autothrottle system. During the -200 model production run, a Full Flight Regime Auto Throttle (FFRATS) was developed and made available as an option. This simulation includes the FFRATS.



Computers

The autoflight system uses two independent computers. Computers A and B function in both autopilot and flight director systems

Airspeed and Altitude Inputs

The two central air data computers (CADC, see Flight Instruments section) supply altitude and airspeed signals. CADC-1 supplies AP/FD computer A with

- Calibrated airspeed,
- True Airspeed
- Altitude

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CADC-2 supplies the same information to AP/FD computer B.

Radio Altimeter Inputs

Two low range radio altimeters (LRRAs) provide altitude data for ILS attenuation. At altitudes below 1500 feet, the LRRAs permit dual autopilot operation in the LAND mode. The LRRAs also provides

- Rate of descent for the flare maneuver (initiates flare at 53 FT radio altitude)
- Altitude data to the autothrottle system for speed control during flare.
- Altitude data to inhibit the use of the performance management system (PMS) below 2300ft radio altitude.

Navigation Inputs

The Navigation Mode Selector selects the source of the navigation information to be used by the AP and FD computers:

- **INS:** commands to capture and track the selected INS track when the INS is set to RMT and the navigation mode switch is set to HDG. (NOTE: If the INS is in RMT and the Nav mode switch is in HDG, you will NOT be able to change course ... the INS is in CONTROL!!!!)
- **HDG:** commands to capture and maintain the selected heading
- **VOR LOC:** Commands to capture and track the VOR or localizer course selected
- **ILS:** 1. commands to capture and track the localizer and glideslope with NAV/GPS switch in NAV
2. commands to follow the flight path indicated in the MSFS Flight plan with the NAV/GPS switch in GPS.
- **LAND:** commands to capture and track the localizer and glideslope and to flare the aircraft.



Autopilot Controller

When the autopilot is engaged in manual (MAN) mode, an autopilot controller on the control pedestal can be used to control pitch and roll.



AP/FD Modes of Operation

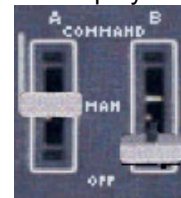
MODE	Autopilot: MANUAL	Autopilot: COMMAND	Flight Director
Alt Hold	*	*	*
TURB	*		
ALT SEL		*	*
IAS		*	*
VS		*	*
HDG		*	*
INS		*	*
VOR LOC		*	*
ILS		*	*
LAND			*

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Autopilot Engage Switches

- This is a two-channel system, which permits you to fly using the autopilot in A or B modes.
- Autopilot A is the one that would be used and autopilot B would be your backup system in case of a failure
- **CMD** – This position engages the autopilot in a COMMAND Mode where it has full control over steering and pitch as defined by the information you have set into the system. Only one engage switch can be in the CMD mode at one time with the exception of LAND mode is specified.
- **MAN** – This is the MANUAL mode, which allows limited Autopilot control plus manual steering and pitch controls. Only one engage switch may be in the MAN mode at one time.
- **In the manual mode**
 - Pitch Attitude Hold is available
 - Pitch wheel attitude select is available
 - Wing leveling is available (Roll knob in center detent)
 - Heading Hold is available via the Roll Knob in center detent
 - Altitude hold is available
 - Turbulence is available
 - Turn knob-roll is available



OFF – This position disconnects the autopilot when the aircraft is being hand flown

Autopilot Manual Modes

Engagement

Placing the Autopilot Engage switch to MAN will maintain the pitch attitude existing at the time of engagement. If MAN is engaged during a turn, the wings will be leveled. Heading hold begins when the bank angle is reduced to three degrees.

Altitude Hold

ALT HLD – (ALT HLD light on) Provides for airplane to maintain the barometric altitude reference existing at the time of selection. Can be selected with the navigation mode switch in any position, but cannot be engaged after glideslope capture. Speed Mode switch will trip to OFF when ALT HLD is selected.

Summary of Manual Mode as Implemented

TURN knob

- When in single channel operation (i.e. COMMAND); moving the knob out of the detent (centered) position will disengage the autopilot from command to MAN. Also, if the knob is not in the detent position the autopilot will not engage in CMD or MAN. This is a preflight item to make certain that the knob is indeed centered; this obviously prepares the A/P for future engagement. The turn knob has a light that illuminates when it is in the center detent and wing leveler engaged.
- When in Dual channel operation (LAND), moving the knob out of the detent will disengage one channel to OFF (you should get the aural warning and light warnings) and the other channel switches to MAN.
- With an A/P ENGAGE switch in the MAN position, the knob controls the roll of the aircraft.
- DESCEND/CLIMB wheels – Pitch the aircraft and are connected in parallel.



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NOTE: The Flight Director Roll and Pitch bars have been disabled when the Autopilot is being used in the MANUAL Modes. When steering the aircraft in the manual mode using the turn knob, the aileron roll method is employed. Setting the knob to a fixed position is not the same as a controlled bank angle. The aircraft will continue to increase the bank rate, as it would using a yoke. It will be necessary to change the amount of aileron roll to compensate for the roll rate that will be increasing. Centering the turn knob will engage the wing leveler and can be identified by the illuminated lamp above the turn knob.

Manual Operations

- When you move the Autopilot Engage switch to “**A**” or “**B**” to **MAN**, the autopilot will maintain the existing pitch attitude and will roll the wings level (remember that the knob has to be in the detent) since the wings are level the heading of the aircraft at that moment is maintained.
- Maneuver the airplane using the pitch and/or turn controls on the autopilot manual control panel.
- **THERE ARE NO NAVIGATION MODES AVAILABLE** (i.e. the AP/FD navigation mode selector) ...**in MAN position**
- **ALT HOLD mode is available in MAN** (but not ALT SEL)
- the Altitude green light will come ON. The autopilot will vary pitch to maintain the barometric altitude at the time of engagement



Speed Mode Switch (TURB mode available in MAN only)

When **TURB** mode selected,

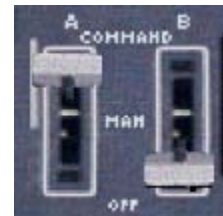
- The altitude mode switch will trip to OFF if engaged, since 2 pitch modes cannot command the autopilot at the same time; the last pitch mode selected has priority.
- Also the autopilot response rates are reduced, heading hold would be inoperative as the wings level position is maintained
- Lastly when the Autopilot Engage switch is placed to CMD the Speed Mode switch moves to OFF
- Selecting TURB Mode will automatically trip the autopilot from CMD to MAN mode.



Autopilot Command Modes

Engagement

Placing an AUTOPILOT ENGAGE switch to COMMAND automatically couples the autopilot roll channel to the mode set on the navigation mode selector. Pitch control will be referenced to the mode set on the altitude or speed mode selectors.



Altitude Mode Switch

ALT HLD – (ALT HLD light on) Provides for airplane to maintain the barometric altitude reference existing at the time of selection. Can be selected with the navigation mode switch in any position, but cannot be engaged after glideslope capture. Speed Mode switch will trip to OFF when ALT HLD is selected.



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ALT SEL – (ALT SEL light on) Provides for intercept and capture of a selected altitude. Flight path may be setup by using pitch wheel control or indicated airspeed mode. Speed Mode Switch will return to OFF when altitude is captured.

ALT SEL NOTES:

(Altitude may be dialed in when in any of the 3 positions)



The altitude mode selector is a 3 position switch (ALT SEL, ALT HOLD, OFF)

In the ALT HOLD position the associated green light above the selector illuminates and the A/P-F/D computer provides pitch inputs to maintain the altitude existing at the time of engagement.

The Altitude Mode selector trips to the OFF position when:

- GS captured (remains inhibited)
- A speed mode is selected
- Selecting TURB on speed mode switch

In the ALT SEL position the associated green light below the selector illuminates and the A/P-F/D computer arms to capture the altitude in the ALT SEL window. The FMA ALT SEL annunciation is amber when armed and green when captured. The ALTITUDE Mode trips to OFF position when:

- GS captured (remains inhibited)
- Selecting TURB on the speed mode switch
- Moving the A/P engagement switch from COMMAND to MANUAL

In the OFF position with the A/P or F/D engaged, pitch inputs are provided by another source such as the PMS or IAS position on the speed mode selector.

VS Mode

- **V/S** – Vertical speed – used in conjunction with vertical speed wheel to set a fixed vertical speed over a range of +4000 to –6000 FPM. Can be selected with NAV selector in any position.
- **Vertical Speed Wheel** – Used with vertical speed mode to set a desired vertical speed. When V/S is not selected the wheel is synchronized to follow the airplanes vertical speed.



VS-MODE NOTES:

In the V/S position the V/S A/P-F/D mode allows the VERT SPEED wheel to control the aircraft rate of climb-descent.

- +4000 to -8000 fpm range
- can be selected with the NAV Mode selector in any position

NOTE: When the SPED mode is not in V/S the adjacent VERT SPEED wheel is synchronized with the aircraft rate of climb/descent to indicate the existing vertical speed

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IAS Mode

IAS (Indicated Air Speed) mode provides for automatic pitch control referenced to the indicated airspeed at the time of engagement

Step by Step: doing an IAS Climb

Example of a climb from 4,000 feet to 10,000 feet using manual throttle control

- Set A/T speed to 250 knots
- Set altitude to 10,000 feet
- Increase power slowly until the Fast/Slow Indicator reaches the bottom of the diamond on the ADI. (Use an EPR setting of approximately 1.30 as power changes should be gradual and not noticed by the passengers)
- Select the Altitude switch to the ALT SEL Position
- Move the Speed Mode Switch to the IAS Position
- The IAS Mode will capture the speed that was in effect at the moment of engagement and should hold a speed of 250 knots
- Adjust the power to obtain the desired rate of climb (Normally between 1,500 and 2,000 FPM)
- At 9,100 feet, you will hear the Altitude horn and see the Alt Alert light illuminate.
- Move the Speed Mode switch to the V/S position
- At 9,500 feet rotate the Vertical Speed thumbwheel to obtain a climb rate of 500 FPM
- Monitor the Fast/Slow indicator to ensure you do not exceed the 250-knot limit. Adjust power as required
- When the aircraft levels off at 10,000 feet, the Speed Mode switch will move to the OFF position automatically. Move the Altitude switch to the ALT HLD Position.



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Step by Step: A Descent using IAS Mode

Example of a descent from 19,000 feet to 10,000 feet (assumes you are at cruise speed)

- Set A/T speed to 290 knots
- Set altitude to 10,000 feet
- Decrease power slowly to idle and wait until the Fast/Slow Indicator reaches the top of the diamond on the ADI. Select the Altitude switch to the ALT SEL Position
- Move the Speed Mode Switch to the IAS Position
- The IAS Mode will capture the speed that was in effect at the moment of engagement and should hold a speed of 250 knots
- At 10,900 feet, you will hear the Altitude horn and see the Alt Alert light illuminate.
- Move the Speed Mode switch to the V/S position
- At 10,500 feet rotate the Vertical Speed thumbwheel to obtain a descent rate of 500 FPM
- When the aircraft levels off at 10,000 feet, the Speed Mode switch will move to the OFF position automatically. Move the Altitude switch to the ALT HLD Position.
- Set A/T speed to 250 knots. Monitor the Fast/Slow Indicator and reduce speed to 250 knots

IAS ADDITIONAL NOTES:

IAS

In the IAS position pitch inputs are provided to the autopilot/flight director to maintain airspeed at the time of engagement. It trips off when:

- GS captures
- ALT HOLD is selected
- SPEED or MACH is selected on the TAT/EPR limit panel.

IAS Engagement

The engagement of the IAS climb mode has been refined and is now smooth in all tests we have run. Keeping in mind that in the real world this mode is not selected until the optimum climb speed has been reached in FFRATS EPR Limiter mode you should experience no oscillations. It has even been tested in non-real world conditions and it performed correctly. Climbing turns while below Optimum climb speed may generate some small pitching which is a problem within FS2004 and not RFP.

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FFRATS provides protection for:

- Minimum airspeed (ALPHA)
- Flap overspeed (FLAP LIM)

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A/T MODE SELECT pushbuttons allow selection of fixed or variable thrust. The following selections may be made:

- **EPR** – a fixed thrust selection used during takeoff or climb which provides overboost protection.
- **MACH** – a variable thrust selection used for high altitude cruise. It will maintain the existing mach at the time of engagement. Slow/Fast indicator is not functional.
- **SPEED** – a variable thrust selection that references the salmon bug on the Captains ASI for low altitude cruise and approach. Speed can be selected from 100-400 knots. Enables slow/fast indicator on ADI.

When pushed, a white light within the pushbutton illuminates. Pressing the **SELECT MACH** or **SELECT SPEED** pushbutton with speed mode selector in IAS causes the speed mode selector and A/T to trip to OFF. Selecting **IAS** on the speed mode selector with **SELECT SPEED** or **SELECT MACH** pushbutton pressed, the A/T switch trips to off.

NOTE: With the rotary EPRL MODE selector in TOD, SELECT EPR is the only A/T mode available. With A/T engaged and EPRL MODE not in TOD, select a new A/T mode by pressing the desired A/T MODE SELECT pushbuttons.

FULL	I	II
7Q	7F	3A

These engines are derated as indicated above by pressing the “I” or “II” pushbutton, illuminating a green light within the pushbutton. Pressing the button a second time removes the derate selection. Derate to a **3A** is normally only used for a runway with heavy slush or other items that would require a lower thrust setting.

It is possible to further derate the engines by slewing the EPR down/up in .01 increments using the RTRN/DECR switch.

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FFRATS ENGAGEMENT

FIRST:

Select A/T mode on the TAT/EPR Limit Computer To TOD and press EPR button



THEN

Move the A/T switch on the left side of the Autopilot to ON. (A green light will illuminate to indicate that the A/T is ON).

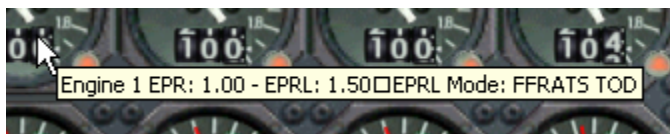


THEN

Push the FOUR FRATTS Activation buttons on three EPR Gauges, Note the EPR limit is set as specified by TAT/EPRL Indicator. #3 engine does not have the button pushed so you can see the difference in location of the EPR Limit set.



Placing cursor over EPR Gauge, brings up a tool tip indicating current EPR, EPRL (EPR Limit) and FFRATs Mode



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OR

press



THEN

Increase your throttles to 1.2 EPR using the F3 Key or your throttle and FFRATS Takes over

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Using the Full Flight Regime Autothrottle System (FFRATS)



EPR Modes can be set for automatic implementation by engaging the AUTO EPR switch on the ERP Gauge (Center Panel).

TOD Mode (Takeoff Dry) – When this mode is selected, the EPR Limit Computer sets the correct EPR for the temperature. The selected EPR is displayed on the TAT/EPRL Display. This EPR setting may be decreased by the pilot by slewing the numbers in increments of .01 EPR. You would slew to a lower number to use less power and fuel depending on the runway length and your load. Appropriate charts must be used. Once the TOD Mode has been selected and you are ready for your takeoff roll, you would press the EPR A/T Mode button. The Selected mode will illuminate in white.

CON Mode (Max Continuous Thrust) – This is an EPR Mode. The EPR Limiter sets an EPR that the aircraft could use on a prolonged basis without harm coming to the engines. The Selected mode will illuminate in white.

CLB Mode (Climb) – This is an EPR Mode. This mode would be used with the autopilot in the IAS Climb mode and the AUTO EPR engaged on the EPR Gauge. Power will be increased automatically as required with overboost protection. The Selected mode will illuminate in white.

CRZ Mode (Cruise) – This is a MACH function for high altitude cruise levels. This mode will set a MACH HOLD and maintain the MACH that the aircraft was at when the MACH mode was selected. The Selected mode will illuminate in white.

GA Mode (Go-Around) – This is an EPR function that arms the GA Button on the main panel.

Glareshield - The 3 Mode buttons are also enunciated and may be selected from the left side of the Captains Panel.



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ALPHA LIMIT Protection

ALPHA annunciation when:

- Aircraft is below minimum maneuvering speed with A/T in Speed or Mach mode.
- When approaching minimum maneuvering speed and in danger of a stall, the throttle will move forward as required to prevent stalling.
- All flap positions are taken into consideration.

FLAP LIMIT Protection

With the A/T engaged and the placard flap speeds are exceeded, FLAP LIM will be enunciated on the FMA. When Flap limits are exceeded throttle corrections will be attempted by the FFRATS.

Note:

There is no substitute for manual corrections and proper flying. The ALPHA and FLAP LIM protection will not save you from certain disaster caused by improper flying procedures. The enunciation for these modes is your cue to problems arising and you should take the required action to correct the situations before any FFRATS intervention is taken.

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A Typical Scenario: FFRATS with the Analog Panel



Takeoff – Select the **TOD** mode on the rotary switch and press the **EPR** button. The EPR button will be illuminated in White. On the left side of the autopilot panel, move the A/T switch to ON and the light will illuminate. On the main panel, engage the auto EPR by clicking on four knobs at the lower right of three EPR gauges. The red pointers will move to indicate the maximum EPR that will be used for this takeoff. The TAT/EPRL gauge to the right of the EPR gauges will also display the maximum EPR that will be used and the Mode you have selected on the FFRATS EPR Computer.



As you increase the throttles and the EPR exceeds 1.15 the auto mode kicks in. Continue to increase your hardware throttle(s) to maximum. The amount of EPR that will be attained will depend on several factors during your takeoff roll. Total Air Temperature, pressure, airport location and other items will all have an effect on the limits of the EPR during this phase of the flight. If your EPR does not quite reach the computed value or goes slightly above, this is not a reason for alarm and a small difference of say .03 EPR is less than 1% of your total thrust. Remember to hold V2 + 10 during this phase of the flight using pitch.

When you have reached your transition altitude, which will normally be between 2,400 and 3,000 feet, you will move the rotary switch to the CLB position. Of course at this time you will lower the nose so you can start to accelerate through your flap retraction speeds and on up to your assigned speed while flying below 10,000 feet. You adjust and hold speed by changing pitch/Vertical Speed and by no other method.

Note:

The EPR section of the FFRATS does not have anything to do with controlling your speed but is taking the place of the First Officers hands on the throttles and doing the work for him. You as the Captain are solely responsible for controlling the speed by altering the Rate of Climb with pitch.

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Time to climb to altitude

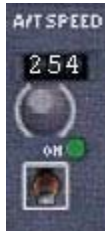
At 10,000 feet you will be cleared for a higher speed. Classic S-Combo will give you this number or you could opt to look it up on a chart. You would now set that speed in the A/T speed window and lower the nose/rate of climb so the aircraft can accelerate to the new speed. Keep an eye on the Fast/Slow indicator located on the left side of the ADI and when getting close start increasing your rate of climb so you will not over run the maximum speed.

When the moving line on the Fast Slow indicator just passes the bottom of the triangle, select the IAS Climb mode on the autopilot. In case you have forgotten the correct procedure to engage the climb modes here it is again. Have the maximum or target altitude preset in the altitude window. Move the switch to the ALT SEL position and lastly, move the rotary switch to the IAS position. You are still using the FFRATS in the CLB and EPR modes.

When the IAS mode is selected, the aircraft may lose or gain a little altitude for a few seconds while the computer makes adjustments to the rate of climb that will be used to maintain the speed at the time of engagement.

Reaching Cruise Altitude:

When you have reached your cruise altitude, the climb mode will move to off and you would manually select ALT HOLD. The maximum cruise speed for this aircraft is Mach 0.84 and just shortly before reaching that speed as indicated in the digital window of the Air Speed Indicator, you will move the rotary switch on the EPR Computer to the CRZ position and press the **MACH** button. Now on the left side of the autopilot panel you will engage the A/T switch and the green lamp should be illuminated. The Mach number that you were at when it was engaged is the Mach number that will be held. It may take 2 or 3 minutes for the speed to stabilize (takes up to 10 minutes on the real aircraft) but it will settle down. The Slow/Fast indicator will not give a true indication in this mode.



Step climbs are done at Mach .82 and Mach .84 is only used for maximum high level cruise.

You are finally at a point where you can settle back and relax a little as navigation, fuel burn, weather and other things are your only concerns.

The Descent:

When the time comes to start your descent you will be reducing your speed a little and this will be first on the list. In the speed window dial in the target speed and on the EPRL Computer panel select the **SPEED** mode button. The aircraft will now start slowing down. The mode for the descent that I will discuss is the V/S and you will have to adjust the rate of descent manually after you have engaged the V/S mode.

You can keep the SPEED mode for the FFRATS active during all phases of the flight through descent, holding patterns and approaches as you see fit.

Convenience:

The real aircraft usually just contains annunciator lights and only for PMS equipped units on the glareshield but to add more function and better ease of use, we have included working mode selectors along with annunciation.



Pressing one of these 3 buttons will active the appropriate A/T Mode (if available) and the lamp will light. Pressing the button a second time will extinguish the lamp and cancel the A/T mode.

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A Typical Scenario: FFRATS with the Tape Panel



Takeoff – Select the **TOD** mode on the rotary switch and press the **EPR** button. The EPR button will be illuminated in White. On the left side of the autopilot panel, move the A/T switch to ON and the light will illuminate. On the main panel, engage the auto EPR by clicking on the knob at the bottom of the EPR Tape gauge. A light will illuminate at the top of the EPR Tape gauge to indicate that the auto mode is engaged and the red pointers will have moved up to indicate the maximum EPR that will be used for this takeoff. The TAT/EPRL gauge to the left of the EPR Tape gauge will also display the maximum EPR that will be used and the Mode you have selected on the FFRATS EPR Computer.



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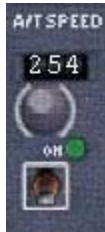
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Unravelling the mysteries of the FFRATS using the Analog Panel:

Hopefully this has solved some of your problems in learning how the **Full Flight Regime Autothrottle System** works and that you understand now that what was supplied in FS2004 was a very simple system that was a far stretch from the real world. Although some will see similarities to modern aircraft such as the 747-400 and 767's they are still vastly different in their operation even though the end result may be the same. What you learned in other more modern systems will be of little help in using the **FFRATS** other than understanding the outcome.

The only way to become accustomed to the **FFRATS** or any other part of this aircraft is through reading and practice. If you ask us for assistance regarding the use of the **FFRATS** or other items that we feel have been covered thoroughly in the documentation, don't be surprised to find us referring you back to the appropriate pages of the manual.

FFRATS Takeoff – Abridged Version: Just the facts

Step 1: You have preflighted correctly, all the buttons in the correct place, gauges all read correctly, switches are all in correct positions, RIGHT? Takeoff Checklist Completed, RIGHT? Clearance received from ATC to Take-Off ... RIGHT? OK, now Line up on the centerline,

Step 2:

TOD set,

EPR Mode Set,



EPR Light illuminated on main panel,



A/T on and light Green

FOUR Buttons Pushed on EPR Gauges, One left to push here



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Step 3: Landing lights on, strobes on, start the clock. While holding the brake on, advance throttles to 1.10 EPR, when stable, foot off brakes, advance throttle smoothly (if you have a hardware throttle on you joystick, or on your Flight Sim Yoke, Etc ... advance the throttle smoothly to the end) to 1.15 EPR. At 1.15 EPR the autothrottle system will take over.

Step 4: At your rotate speed, lift off gently to a 12-14 degree angle. At positive climb retract gear. Hold your V2 + 15 speed as set on A/T dial using trim adjustments. Retract flaps one step at a time. Double check altitude set in altitude window, speed set in A/T speed window and heading in the heading window.

Step 5: At 2500 – 3000 feet, trim nose slightly down, Set FFRATS to CLB, switch AP on, switch on ALT SEL, switch on HDG SEL, switch on VS mode, speed set to 250, now use VS wheel to maintain 250. Set your next cleared altitude .. say cruise at 31,000.

Step 6: Climb at 250 to 10,000 feet. After passing 10,000 feet, use the VS wheel to lower the nose and set the new speed to 320 in the A/T speed window. As the speed increases, and the orange/yellow marker touches the bottom of the speed diamond on the H S I, move the speed mode switch from V/S to IAS. The aircraft will settle into a nice climb to cruise at 320kts with the AP controlling pitch for you to maintain the 320kts.

Step 7: When you hear the ALT horn, get ready to make the final adjustments. At cruise, set ALT HOLD and observe green light, Set MACH and CRZ on FFRATS gauge, observe MACH light on main panel. Speed will settle into a steady .83 -.84 mach cruise, depending on weights, temps etc.

There ... you have done it!!!! Congratulations!!!!

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Unravelling the mysteries of the FFRATS using the Tape Panel:

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Step 2:

TOD set,

EPR Mode Set,



EPR Light illuminated on main panel,



EPRL switched on, light is green,

A/T on and light Green



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Navigation Modes

All navigation modes are available in COMMAND autopilot operation.



INS Mode (does not appear on Navigation Mode Selector)

The INS mode is used to couple the INS system to the AP/FD systems. The aircraft will follow the flight plan. In this simulation, to engage the INS navigation mode,

- The INS must have a set of waypoints entered, which are the next 8 waypoints on your route
- The INS must be in REM or remote mode
- Navigation mode is set to HDG
- NAV/GPS switch is in NAV

Heading Mode (HDG)

In the HDG mode, the autopilot and/or flight director is coupled to a selected heading set in the window of the heading selector. The NAV/GPS switch must be in NAV.

VOR LOC

Either VOR or LOC (localizer) signals will arm the autopilot and/or flight director for roll control, depending on the selected frequency. Prior to course capture, aircraft control is referenced to the selected heading. The NAV/GPS switch must be in NAV.

ILS Mode

Selection of the ILS mode will arm the autopilot and/or flight director. Prior to course capture, aircraft control is referenced to the selected heading. Glideslope intercept can be from above or below the glideslope. The NAV/GPS switch must be in NAV when you intend to capture and use the glideslope. If the NAV/GPS switch is in GPS, and Navigation mode switch is in GPS, the aircraft will follow the GPS flight plan.

Land Mode

The LAND mode is used for dual autopilot autoland operation with a flare mode. Dual autopilot operation requires the aircraft to be on a localizer and glideslope beams below 1500ft radio altitude, and both autopilot switches to be in the command position. Do not attempt autoland with a crosswind component of greater than 22 knots. The NAV/GPS switch must be in NAV.

NAV/GPS

With the switch in NAV mode, the 5 modes described above work as indicated. With the switch in GPS mode, AND the Navigation Mode Switch in ILS Mode, aircraft lateral direction will be controlled by the GPS system and the flight plan prepared and saved for the flight.



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Controls and Indications

Autopilot Controller

Turn Control

Maneuvers aircraft roll with AUTOPILOT engage switch in MAN. If autopilot is in COMMAND mode, movement out of center detent automatically trips the autopilot to manual mode



Pitch Control

Maneuvers aircraft in pitch with AUTO PILOT ENGAGE switch in MAN. If autopilot is in COMMAND mode, pitch controls are active unless autopilot is providing pitch commands.

Glareshield Panel Left Side

Flight Director Switch

- **Switch** – Controls output of autopilot flight director computer to Captain's attitude director indicator (ADI)
- **Pitch Wheel**– Provides pitch trim signal outputs to pitch command bar on the ADI



Autopilot Engage Switches:

Permit selection of A or B autopilot for MANUAL or COMMAND operation, or permits selection of both A and B for COMMAND operation after specific interlock conditions have been satisfied.

Autothrottle Engage Switch and Speed Selector

- **Speed Selector Indicator**– Rotation of the selector sets desired autothrottle airspeed on digital indicator, also sets command airspeed bug on airspeed indicators. Click on the left side to decrease (-), Click on the right to increase (+)
- **Switch/Light (Green)** – When switch is ON the light is illuminated and the throttles automatically maintain speed.

Glareshield Panel Center

Course Selector #1 and #2

- Rotation of the selector sets the desired course on the digital display and sets the course on the Captain's HSI. Course signals from the number 1 navigation radio go to the autopilot/FD computers as determined by the position of the course transfer switch.
- Tunes the No. 2 Navigational Radio



Course Transfer Switch

- **No. 1** – Autopilot/Flight Director Computers, A, B are referenced to No. 1 VHF Nav Radio.
- **No. 2** - Autopilot/Flight Director Computers, A, B are referenced to No. 2 VHF Nav Radio.

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- **DUAL** - Autopilot/Flight Director Computers, A, B are referenced to No. 1 VHF Nav Radio. Will move to DUAL automatically when in ILS or LAND Mode.

Back Beam Switch

- For use with back course of a localizer (B/B light ON)

Heading Selector

- Provides heading select signals to the HSI's and heading error signals to the autopilot and flight director computers.

Navigation Mode Switch

- **OFF** – This position on the real airplane is designated for the INS. On this simulation it is an OFF position and no navigational modes are active.
- **HDG** – Autopilot or flight director coupled to the selected heading reference, as set by the heading selector. Also INS steering commands are transferred to this mode if INS is in the RMT position. The NAV/GPS switch must be in NAV.
- **VOR LOC** – Either VOR or LOC signals will arm the autopilot and/or flight director for roll control, depending on selected frequency. Prior to course capture, control is reference to the selected heading. Actual capture begins at a radio beam deviation angle that varies with the intercept angle. The NAV/GPS switch must be in NAV.
- **ILS** – When the NAV/GPS switch is in NAV, election of the ILS position will arm the autopilot (single channel only) and/or flight director. Capture of the localizer course is a function of beam displacement and intercept angle. Prior to course capture, control is referenced to the selected heading. Course transfer switch moves to DUAL position when ILS is selected. When the NAV/GPS switch is in GPS, the aircraft will follow the flight path indicated in the flight plan.
- **LAND** – For dual channel autoland operation with flare mode. Dual channel operation requires airplane to be on a localizer and glideslope beam below 1500 feet radio altitude, and both (A and B) autopilot engage switches to be in the COMMAND position. Course transfer switch moves to DUAL when LAND is selected. The NAV/GPS switch must be in NAV.

NOTE ABOUT Glideslope Capture and Lock

Real World procedures must be followed. If the mode selector is in the OFF position you are expected to be holding and controlling altitude manually and the MCP will not be giving altitude inputs.

The capture of the Glideslope must be done from the ALT HOLD position if you are planning a coupled approach. Immediately following the capture the mode switch will trip to the OFF position which is normal and correct. Intercept the Glideslope from below and after a Glidepath has been locked. Coupled short finals are not for a 742 and should be flown manually.

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Glareshield Panel Right Side

Vertical Speed Selector

Used with vertical speed mode to set a desired vertical speed. When V/S is not selected the wheel is synchronized to follow the airplanes vertical speed.

Click here to descend, click here to climb



Speed Mode Switch

- **IAS** – Captures and retains the airspeed at the moment the IAS mode is selected. This is a pitch mode where the pitch is controlled by the amount of power you apply. Applying more power will not increase airspeed significantly but will increase the rate of climb. Decreasing the power will allow the aircraft to descend without losing airspeed. If the autothrottle is engaged while the IAS Mode is engaged, the IAS Mode will trip to OFF.
- **V/S** – This mode captures the vertical speed at the moment of engagement. Again this is a pitch mode but instead of the pitch being controlled by the power level, it is controlled by turning the Vertical Speed Wheel.
- **TUTORIALS** – Read and practice the tutorials for full practical instruction on the use of these modes.

Altitude Select

- Rotation of the control sets the desired altitude in the indicator for altitude select reference. Click on the left side to decrease (-), Click on the right to increase (+)

Altitude Mode Switch and Lights

- **ALT HLD** – (ALT HLD light on) Provides for airplane to maintain the barometric altitude reference existing at the time of selection. Can be selected with the navigation mode switch in any position, but cannot be engaged after glideslope capture. Speed Mode switch will trip to OFF when ALT HLD is selected.
- **ALT SEL** – (ALT SEL light on) Provides for intercept and capture of a selected altitude. Flight path may be setup by using pitch wheel control or indicated airspeed mode. Speed Mode Switch will return to OFF when altitude is captured.

Flight Mode Annunciators

Flight Director Approach Progress Display Autopilot Approach Progress Display



For both FD and AP lights have the following

- **ALT SEL**: Amber selected, green when captured
- **NAV**: Amber when navigation mode switch is selected to VOR LOC, ILS or LAND, green upon capture
- **GS**: Amber when navigation mode switch is selected to ILS or LAND,
- **FLARE**: Amber when navigation mode switch is in LAND and dual channel operation begins. Green at 53ft radio altitude.
- **NAV and GS** on the right side are lit when in GPS mode (i.e. NAV/GPS = GPS and Nave Mode switch is ILS>

approach annunciators, the indications:

when mode is selected
altitude is

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Electrical



Introduction

The electrical system provides the power to operate and control various aircraft systems. The primary electrical power is alternating current (ac) that is provided by:

- Four engine driven generators,
- An auxiliary power unit, or
- Two external power units.

Each engine driven generator can power its respective bus through its generator breaker (GB), and other busses through bus-tie breakers (BTB) and the synchronizing (sync) bus.

A split system breaker (SSB) allows the sync bus to function as a single bus or two independent buses.

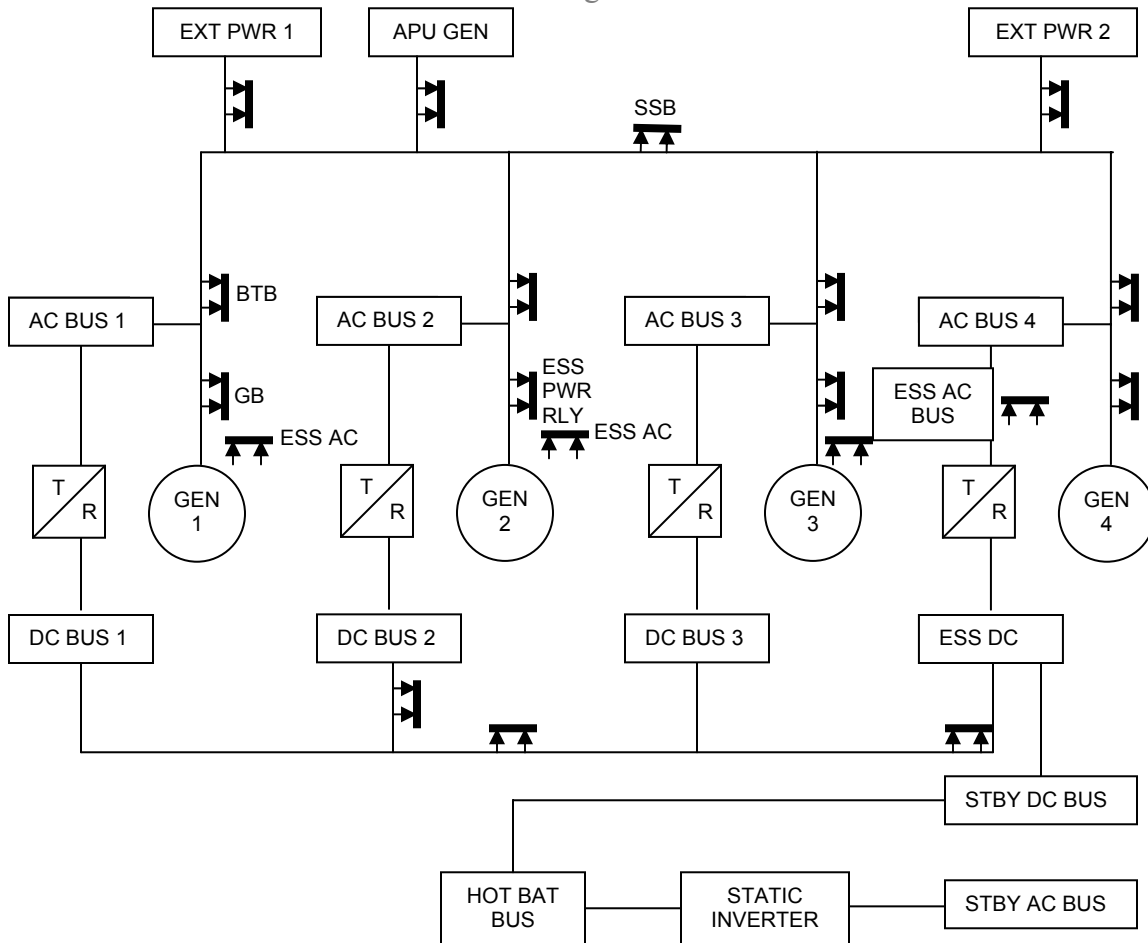
AC BUS 4 normally supplies essential ac power. However, it may be obtained directly from generators 1, 2 or 3.

Direct current (dc) requirements are supplied by transformer-rectifiers (TRs) that convert ac to dc. Essential dc power is normally supplied by the essential TR and may be supplied by the other TR buses through a dc bus tie.

Standby ac bus power is normally supplied by the essential ac bus (AC ESS). However, it may be obtained from a static inverter. Standby dc bus power is normally supplied by the essential dc (DC ESS); however, it may also be obtained from the HOT BATTERY BUS.

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Electrical Power Sources

AC Electrical Power

Generators

Identical generators on each engine or the APU power the airplane's electrical system. Engine-driven generators are rated at 60 kVa. The APU generator is rated at 90 kVa due to more efficient cooling. Meters on the flight engineer's panel permit monitoring generator frequency, voltage and current.

Each generator has a permanent magnet generator (PMG) which provides the only source of power for the generator field. PMG voltage (65-90V ac) may be read on the AC VOLTS meter.

Constant Speed Drive

Each generator is driven by its respective engine via a constant speed drive (CSD) transmission, that maintains generator output at 400Hz by compensating for changing engine speeds and generator loads. CSD oil OUT temperature and oil temperature RISE may be read on a CSD OIL TEMP gauge, and CSD RPM may be read on the FREQ meter. The CSD can be disconnected.

The APU Generator required no CSD because the APU RPM is controlled.

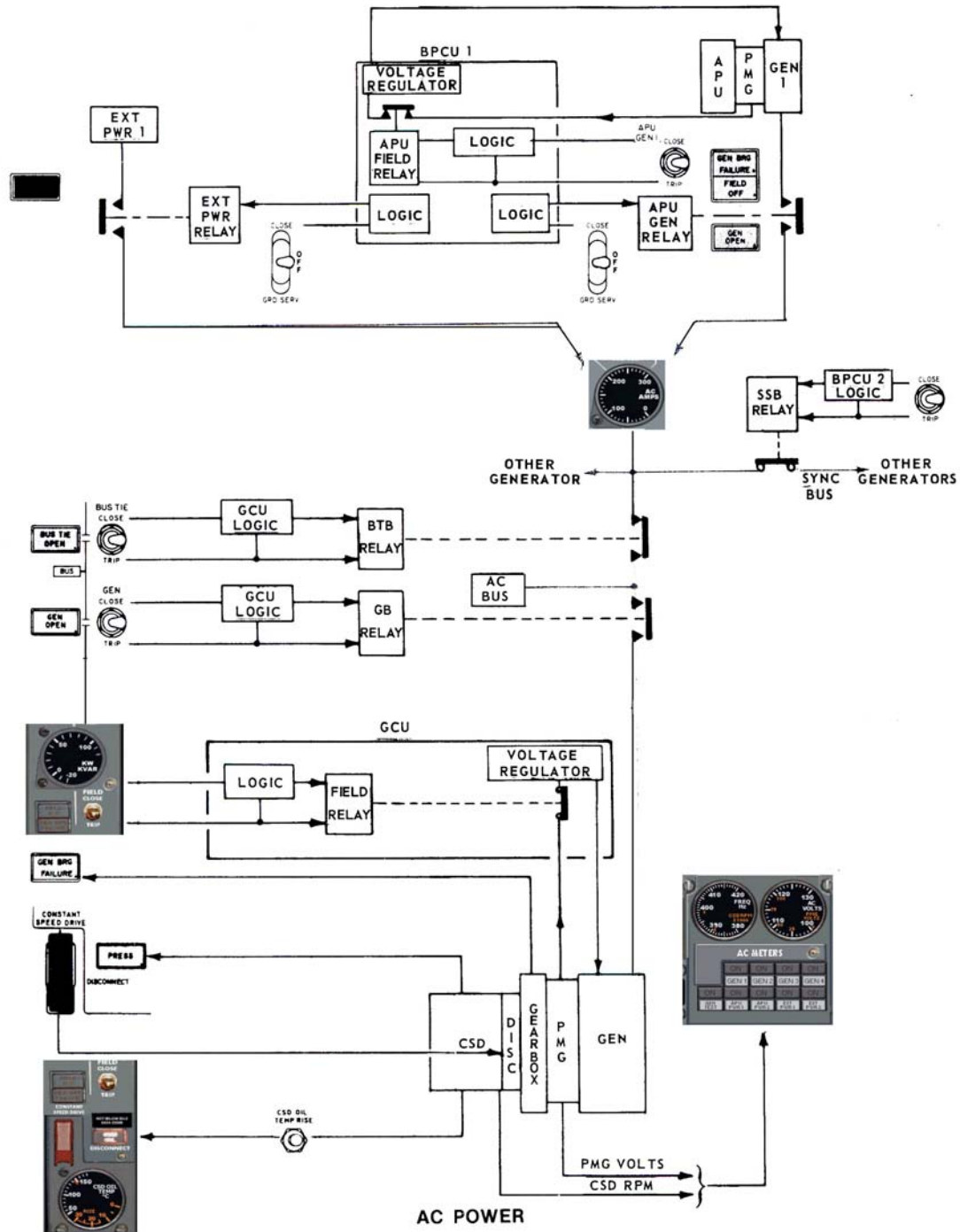
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Load Controller

Each engine generator system has a load controller that:

- Jogs the frequency when autoperalleling with the GB and SSB, and
- Adjusts CSDs whose generators are paralleled, to balance real load (KW) output.



Generator Control Unit

Each engine generator system has a generator control unit (GCU) that includes a field relay and a voltage regulator.

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The GCU contains circuits that

- Control the generator voltage
- Prevent the GB from closing during autoparalleling unless frequency and voltage are within limits.
- Adjust voltages between paralleled generators to balance the reactive load (KVAR)
- Trip the GB on engine shutdown
- Provide automatic fault protection
- Automatically reclose the BTB after a voltage fault or broken feeder wire is isolated, and
- Trip the generator field relay to deactivate the generator when the respective fire handle is pulled.

Fault Protection

Automatic fault protection circuits within the GCUs protect the electrical system from

- Overvoltage, undervoltage, or overload
- Feeder wires broken or short circuited, and
- CSD overspeed, underspeed, or KW hogging.

Whenever any abnormal condition is sensed, the fault protection circuits isolate the affected sections of the ac electrical system and illuminate the appropriate amber trip lights on the flight engineer's panel.

Auxiliary Power

The auxiliary power system (AUX POWER) utilizes external power (EXT PWR) and APU generator (APU GEN 1) power.

External Power

External ac power can be connected to the airplane's electrical system through two external power receptacles located on the lower forward right side of the fuselage. With the SSB closed, one external power source can power all airplane load buses. Lights on the flight engineer's panel provide visual indication of external power status.



APU Generator

APU generator power may be used to power all airplane load buses with the SSB closed. (See the APU section for all the details)

Bus Power Control Unit

The auxiliary power system contains two bus power control units (BPCU's) that

- Prevent connecting external power unless frequency and voltage are within limits,
- Control the APU generator voltage, and
- Provide automatic fault protection for external; power, APU generator, and the respective side of the synch bus.

Split System Breaker

The SSB allows the synch bus to function as a single bus or as two independent buses. It also permits faults to be automatically isolated to one side, so that the other side is still usable.

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With the SSB closed, the synch bus may be powered by external power, APU generator or engine generators.

Fault Protection

Automatic fault protection circuits within the BPCUs protect the ac electrical system from:

- External power voltage or frequency out of limits, overload or wrong phase rotation, and
- APU generator voltage frequency out of limits, overload, and short-circuited generator wires.

DC Electrical Power

Generation

The primary source of dc power is provided by five transformer-rectifiers (TRs). They are identified as the essential TR, TR No. 1, 2, 3, and the external power TR. TRs 1, 2, and 3 and the essential TR are located on a rack behind the flight engineer's panel. A battery, located on the floor behind the flight engineer's panel is used as a standby source of dc power. A separate battery is used for APU starting and APU control circuits. Dc voltage and amps may be read on the DC VOLT and DC AMP meters.

The essential TR receives power from the essential ac bus and delivers dc power to the essential dc bus. The essential dc bus delivers power to the standby dc bus and battery bus.

TRs 1, 2, and 3 receive power from the respectively number ac busses and deliver dc power to the respectively numbered dc buses.

The external power TR receives power from the ground handling bus and delivers dc power to the 28V dc ground handling bus.

Standby Power

If the battery switch is ON, ac and dc power sources are available in the event of loss of the normal power to the essential ac and dc buses.

Standby AC

Standby ac is provided by the battery from the hot battery bus. The dc power from the hot battery bus is delivered to the static inverter, which changes 28V dc to 115V ac. This ac power is delivered to the standby ac bus. When normal power is available, the standby ac bus receives power from the essential ac bus.

Standby DC

Standby dc is provided by the battery from the hot battery bus. When normal power is available, the standby dc bus receives power from the essential dc bus.

Power Distribution

Power is distributed to all the ac and dc systems on the aircraft through a number of distribution circuit breaker panels located in the equipment bay below the cockpit and on the cockpit ceiling. Further discussion of the distribution system is way beyond the scope of this manual.

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Controls and Indicators

Generator

Bus Tie Breaker (BTB) Open Light

ON: BTB tripped

OUT: BTB closed

Bus Tie Breaker (BTB) Switch

CLOSE: connects respective generator and bus to the synch bus.

TRIP: isolates respective generator and bus from the synch bus

Generator Breaker (GB) Open Light

ON: GB tripped

OUT: GB closed

Generator Breaker (GB) Switch

CLOSE:

- trips EXT PWR or APU GEN supplying that side of the synch bus
- Connects that generator to its bus and synch bus through BTRB

TRIP: isolates generator from its bus and synch bus

KW, KVAR Meter

Displays generator:

- KW Load, or
- KVARs, when KVARs switch is pressed

Field Off Light

ON: generator field relay tripped

OUT: generator field relay closed

Field Switch

CLOSE: closes generator field

TRIP:

- Opens generator field relay
- Trips respective GB

Generator Bearing Failure Light

ON: indicates main bearing is worn, generator is being supported by auxiliary bearing

Constant Speed Drive (CSD) Disconnect Switch

Disconnects CSD

Trips GB

Constant Speed Drive Oil Pressure Light

ON: CSD oil pressure below minimum or oil OUT temperature is in the caution range.

OUT: CSD oil pressure is normal and oil OUT temperature is normal

CSD Oil Temperature Gauge

OUT Scale: indicates temperature of oil leaving the CSD

RISE SCALE: indicates temperature rise through CSD (oil out minus oil in) if CSD OIL RISE TEMP RISE switch is pressed.



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Auxiliary Power

EXT PWR 1 and 2 AC Connected Lights

ON: External power is connected and voltage and frequency are within limits.
Ground handling bus is powered.
OUT: External power is disconnected or not within limits

APU GEN Breaker Open Light

ON: APU Generator is isolated from sync bus
OUT: APU generator powers the sync bus

APU GEN Field Switch

CLOSE: closes APU field relay
TRIP: Opens APU field relay and trips APU GEN breaker.

Power On Bus Lights (2)

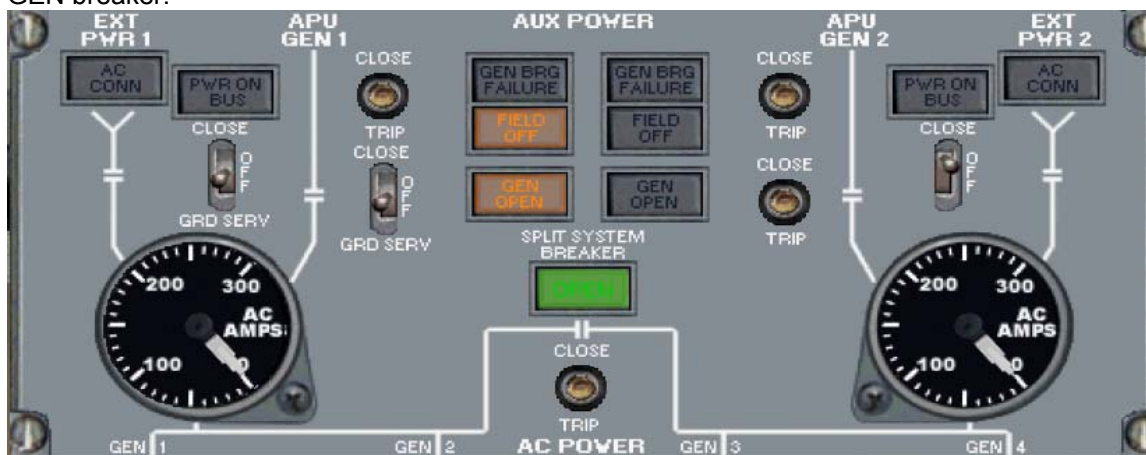
ON: respective external power is on the the sync bus.
OUT: respective external power is not on the sync bus.

Field Off Light

ON: APU generator field relay tripped
OFF: APU generator field relay closed

Generator Bearing Failure Light

ON: main bearing is worn and generator operating on auxiliary bearing.



EXT PWR 1 and 2 Switches

OFF: EXT PWR 1 and 2 isolated from the sync bus and GRD SERV bus
GRD SERV: EXT PWR 1 & 2 powers the GRD SERV bus and ground handling buses.
CLOSE: EXT PWR powers the sync and the ground handling buses (trips other sources).

Split System Breaker Switch

CLOSE: allows the sync bus to function as a single bus.
TRIP: splits the sync bus so each side operates independently.

APU GEN 1 and 2 Switches

OFF: APU GEN 1 and 2 isolated from the sync bus and GRD SERV bus
GRD SERV: APU GEN 1 & 2 powers the GRD SERV bus and ground handling if EXT PWR is unplugged.
CLOSE: APU GEN powers the sync bus (trips other sources) and ground handling is EXT PWR 1 is unplugged.

Split System Breaker Open Light

ON: SSB is tripped
OUT: SSB is closed

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AC and DC Meters, Standby and Essential AC

Standby Power On Light

ON: Standby buses are powered from the hot battery bus and static inverter.

OUT: Essential buses are supplying standby buses, or STANDBY PWR switch is off

Standby Power Switch

- NORMAL:** If essential power fails, standby buses automatically powered by hot battery bus (dc) and static inverter (dc)
- OFF:** Standby buses deenergized
- MANUAL ON:** Selects power for standby buses from hot battery bus and static inverter



ESS AC Bus Selector

- NORMAL:** No. 4 AC bus powers AC ESS bus.
- GEN 3, 2, 1:** Selected Generator Powers ESS bus directly

Essential Bus Off Light

ON: AC ESS bus not powered

OFF: AC ESS bus is powered

DC Voltmeter

Displays voltage of selected TR bus or battery.

DC Ammeter

Displays current output of selected TR unit (+ indication), battery output (- indication) or battery charge, (+ indication)

DC Meters Switches

Connects selected power source to DC meters

Battery Switch

ON: Permits battery to power the battery bus.

OFF: Prevents battery from powering the battery bus and shuts down the APU.



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AC Voltmeter

Displays:

- Voltage of selected ac power source
- PMG voltage of selected APU or engine-driven generator when GEN TEST switch is pressed

Frequency Meter

Displays:

- Frequency (Hz) of selected ac power source, or
- CSD rpm of selected engine-driven generator when GEN TEST switch is pressed.

Generator Test Switch

When pressed, displays:

- PMG voltage on voltmeter when engine-driven or APU generator is selected, and
- CSD rpm on FREQ meter when engine-driven generator is selected.



AC Meters Switches

Connects selected power source to ac meters and GEN TEST switch

DC Bus Isolation



Bus Isolation Open Lights

ON: When corresponding isolation switch is placed to the OPEN position

OUT: When corresponding isolation switch is placed to the CLOSE position

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Galley Power

Galley Power Switches (4)

ON: Connects each galley to an ac bus (provided TRIP light is out) and arms trip lockout.

OFF: Removes power from the respective galley and resets trip-off lockout

Trip Off Lights

ON: Indicates excessive galley current, feeder wire to galley short circuited, or external power or APU generator overloaded

OUT: Galley is receiving power if the switch is ON. Turning switch OFF puts light out.



Radio Bus Master Switches (located on overhead)

Essential Radio Switch

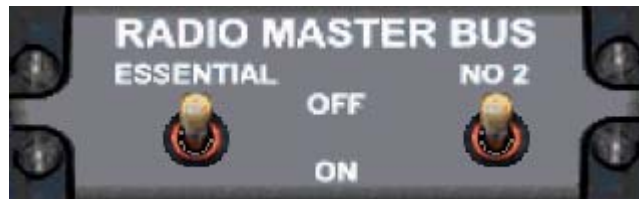
ON: Connects essential ac and dc to the ESS RADIO BUS

OFF: Deactivates the ESS RADIO BUS

No. 2 Radio Switch

ON: Connects AC BUS 2 and DC BUS 2 to RADIO BUS No. 2

OFF: Deactivates RADIO BUS No. 2



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Normal Operations

(Refer also to the Cold and Dark procedures section)

Preflight

Establishing External Power

The Battery Switch must be on and the main battery and the APU battery must be checked for proper voltage.



The SSB – Split System Breaker is normally closed with the OPEN light out for all ground and flight operations.



Using External Power

Check that the clear AC CONN light is illuminated. The light indicates that external power is connected to the aircraft, and that the voltage and frequency are within limits. The light will remain out if the power is not acceptable. Always use EXT PWR 1 so that the lower cargo loading system is operative. Close the EXT PWR switch and see that the PWR ON BUS light illuminates. The GRD SRV position of the EXT PWR 1 switch is primarily for maintenance. Monitor the load on the ammeter.



Special Feature

How External Power is implemented on the Classic, What you have to do:

If your aircraft is sitting on the tarmac with no power established, you have two choices:

1. Start the APU and power the aircraft from the two electrical generators driven by the APU (please see APU section for detailed description of APU operation). If there is no source of external power, this is your only choice, because battery power will eventually become exhausted.
2. If external power is available either via an external ground cart, or from the airport facility's external power source, you can hook up external power to the aircraft by following this procedure.

NOTE: In this simulation, EXTERNAL POWER is ALWAYS available.

Step 1: Turn on the battery as described above.

Step 2: On the overhead panel, click on the GRD CREW CALL "ON" button found in the cluster of buttons including the Seat Belt and No Smoking sign button. Clicking on the ON button will result in the following:



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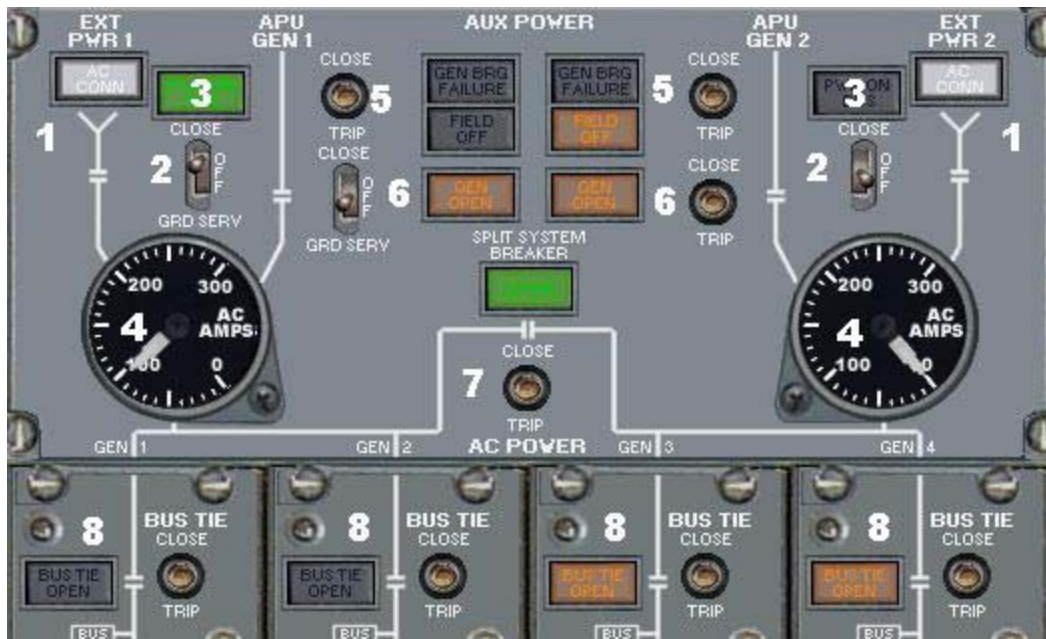
Note that the REQUEST EXTERNAL POWER and CANCEL EXTERNAL POWER areas are clickable.

Clicking on the REQUEST EXTERNAL POWER area, results in the following:



And, of course virtually notifies the ground crew to hook up BOTH External Power 1 and External Power 2 cables to the aircraft. The ground crew will comply with your request and connect External Power 1 first, then External Power 2.

The result is shown on the following graphic. After 60 seconds (approximately) the EXT PWR 1 light will illuminate (Number 1 on the graphic.) After another 60 or so seconds, the EXT PWR 2 light will illuminate.



Step 3: Move the EXT PWR 1 switch (labeled 2, on the left side of the graphic) to CLOSE. When you have done this, the green PWR ON BUS light (labeled 3) will illuminate and you will see that the left Ammeter is registering power..

Step 4 Click both left BUS TIE switches to CLOSE. You will note that the BUS TIE OPEN lights are extinguished.

Since the SSB (Split System Breaker) is OPEN, you are now powering the left side of the synch bus with EXT PWR 1. If you note the schematic at the beginning of this section, you will see that AC BUS 1, AC BUS 2, and DC BUS 1, DC BUS 2 (via transformer/rectifiers) are now powered.

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To power the right side of the Synch Bus, repeat steps 1 through 4 above, this time with EXT PWR 2, and EXT PWR 2 switch, and BUS TIE switches on the right side of the panel.

OK ... you now have EXTERNAL Power to the aircraft.

Using the APU Generator

Refer to the APU section for a complete description and use instructions.

Once the APU has started and stabilized, set the APU field switch to CLOSE and check that the FIELD OFF light goes out.



Next, check the voltage and the frequency before putting the APU generator on the synch bus. You do this by using the AC Meters. Once the APU is started, both APU FIELD OFF and GEN OPEN lights are illuminated. When the APU is stable, simply press the "ON" button over the APU PWR 1 light on the AC METER and observe the Frequency and Voltage. You can check both APU generators in this in this manner before bring each on line. Note that if the APU had been shut down with either APU PWR 1 or 2 button pushes, you will have to toggle the button of and then on again to make the meter reading.



Now you may close the APU GEN switch and check that the GEN OPEN light goes out. As a reminder, note that if EXT PWR 1 and/or 2 is CLOSED, bring the APU generator on line will automatically trip the EXT PWR 1 or EXT PWR 2 switch to CLOSE.

Now you may monitor the load on the ammeter.

Remember, never turn the BATTERY switch OFF with the APU running, since it will cause the APU to shutdown.

Also ... Remember to request the ground crew to disconnect the EXT PWR 1 and EXT PWR 2 cables before pushback.

This is done by going to the overhead, pushing the button over the GRD CREW CALL light to on, and clicking on the CANCEL EXTERNAL POWER area. It will take a minute or two for the power to be disconnected. You will note that once the external power cables have been disconnected, the AC CONN lights (labeled 1 in the graphic above) will be extinguished.



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Prestart

Before starting the engines, be sure the electrical panel is set for the following display with 8 lights illuminated:

- Four GEN OPEN lights illuminated.
- Four CSD LOW PRESS lights illuminated.
- Four BUS TIE OPEN lights out.
- Four FIELD OFF lights out.
- Four GEN BRG FAILURE lights out.

Check standby power as follows:

- Place the ESS AC BUS selector to OFF and the STANDBY POWER switch to NORMAL. Note that the ESS BUS OFF light illuminates. No flags on the N1 Gauges and standby horizon indicate that the standby ac and dc busses are powered.
- Place the ESS AC BUS selector to NORMAL and note that the ESS BUS OFF light is out.
- Leave the STANDBY POWER and ESS AC BUS switches in NORMAL

Check the Transformer/Rectifiers (TRs) for positive current on the dc ammeter and 2-30V on the dc voltmeter for each dc bus. Leave the dc meters selected to BATT. Check the DC BUS ISOLATION switches are on CLOSE and that the OPEN lights are out.

Galley power should be provided whenever possible. GALLEY POWER switches control power from each ac bus to the galley system. If a load reduction is required, use the BUS 1 switch to reduce the load on AC BUS 1, the BUS 2 switch for AC BUS 2, etc.



On the overhead panel place both RADIO MASTER BUS switches ON.



Transitioning From External Power or APU Power to Main Engine Power

After starting each engine, check that the CSD LOW OIL PRESS light goes out. Normally voltage and frequency checks are completed on all four generators before any one generator is put on the sync bus. Close the Generator Breaker switches in as 1, 2, 3 then 4 sequence, making sure that each respective GEN OPEN light extinguishes.

Leave the AC METERS selected at GEN 3.

Monitoring

During routine scan of the electrical panel, note the following:

- All amber lights are out.
- CSD oil out temperatures approximately equal and below the caution band.
- Generator KW meters approximately equal and within tolerances.
- Main Battery (BATT) above 27V.

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At least once during cruise and at top-of-descent check that:

- CSD RISE oil temperatures are approximately equal and below the caution band.
- APU battery is above 27V.
- TR dc lamps are above zero. Leave the dc meters selected to BATT.

After Landing

Transfer from the engine generators to the APU generators after the parking brakes are set.

Blocks

The STANDBY POWER and BATTERY switches should be OFF unless external or APU power is available.

If external power is connected and air conditioning is not required, shut down the APU.

If external power is connected and air conditioning is required, use the APU for air conditioning and external power for electrical requirements.

NOTE ABOUT: Charging the main Battery

When the main ships battery switch is on, the aircrafts electrical systems place a heavy load on the battery. If left in this condition without the engines and generators running you will soon end up with a dead battery.

The many systems set-ups that must be done to prepare the aircraft for pushback can take anywhere from 30 minutes to 45 minutes prior to and asking for permission to pushback. This is where the Ground Power Cart and the APU come into play.

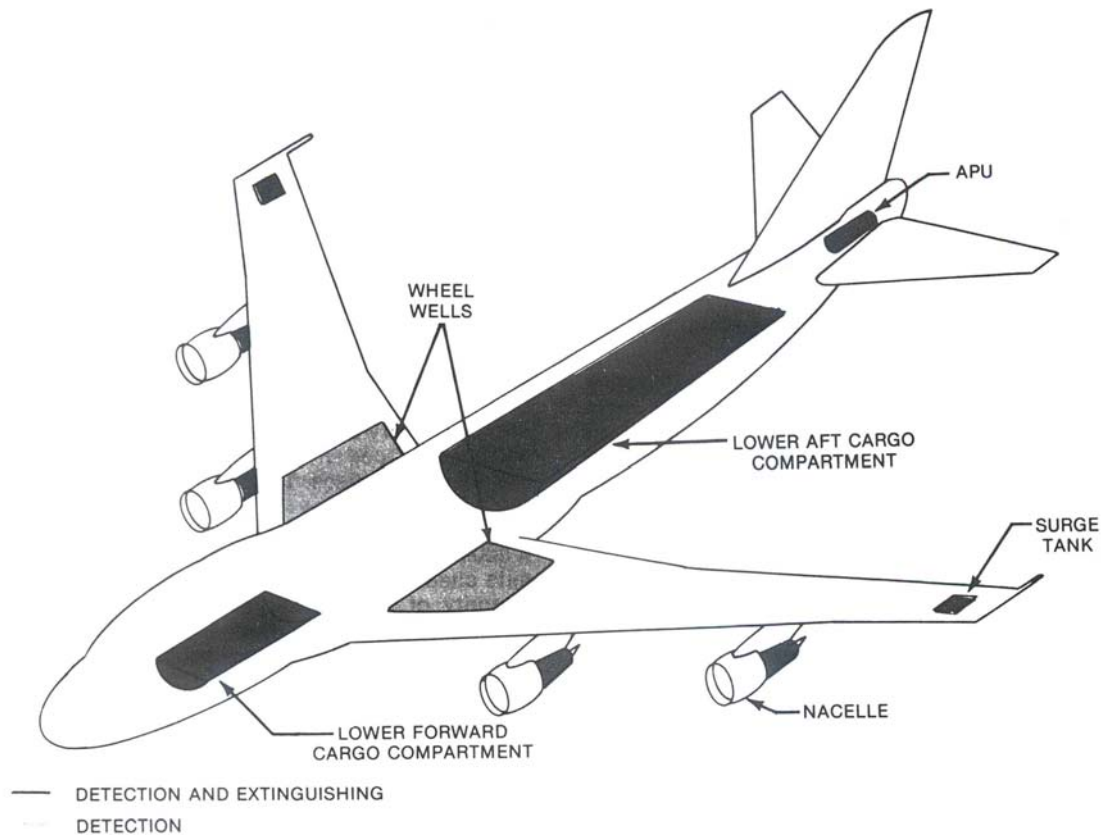
Normally if a Ground Cart is available and it normally is at most airports, it will be requested first. About 15 minutes before pushback the crew will start the APU and ask to have the Ground Cart be disconnected. Both the Ground Power Cart and the APU have the ability to charge the ships battery. The DC Meters on the electrical panel will assist in monitoring the battery state.

Check the AOM for details on configuring the electrics so that the battery will be charged by the Ground Power Cart and the APU.

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Fire Protection



FIRE PROTECTION AREAS

General Information

The fire protection system includes provisions for detection and extinguishing in the following areas:

- Engine nacelles
- APU compartment
- Lower cargo compartment
- Fuel vent surge tanks

Fire detection only is provided for the main wheel well.

Smoke detectors and automatic waste container fire extinguishers are installed in all the lavatories.

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Fire Protection In this Sim

Fire Detection and Protection is not Implemented in this simulation in general. However, in the event you DO encounter an engine fire, the fire warning light will be illuminated. Ralph and Chris have included the possibility of an engine fire should you pass through certain LAT/LON coordinates. (I can't even show you the graphic with the light "ON" because I do not know the secret locations that will create an engine fire.



If an engine fire should occur, you are in good hands. Simply follow the instructions below to extinguish the fire. You can safely fly the Whale with three engines to the closest airport.

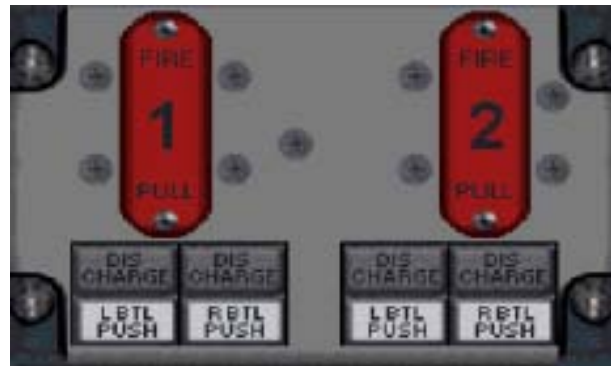
Extinguishing

Primary fire control is to shut off fuel, hydraulic fluid, bleed air, and generator with the fire handle. Secondary control is to discharge a fire bottle to combat any remaining fire.

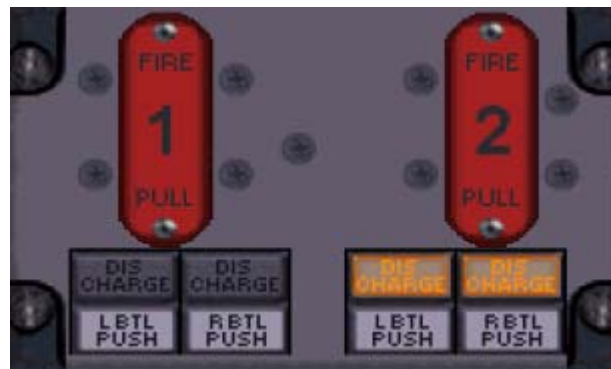
Fire bottles containing an extinguishing agent under pressure provide a means of combating engine nacelle fires. Two fire bottles are located in each pylon and are equipped with discharge squibs and red thermal discharge discs. The discs are visible from the ground.

Pulling an engine fire handle: (click on the fire handle that is illuminated)

- Arms two fire bottle DISCHARGE switches.
- Closes the engine fuel shutoff valve and deactivates the ENG VALVE on switch on the fuel panel.
- Closes the hydraulic supply valve to the engine driven pump (EDP).
- Energizes the depressurizing solenoid on the EDP.
- Trips the generator field and generator breaker in 10 seconds. (not implemented)
- Closes the engine bleed air valve. (not Implemented)



Pressing an armed DISCHARGE squib ignites the discharge squib for that bottle, releasing the extinguishing agent into the discharge manifold. A pressure switch in the manifold causes the DISCHARGE light to illuminate. Pressing the second DISCHARGE switch for the selected engine will discharge the other fire bottle in the nacelle. The discharge lights will remain on until reset by interrupting battery power.



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Flight Controls

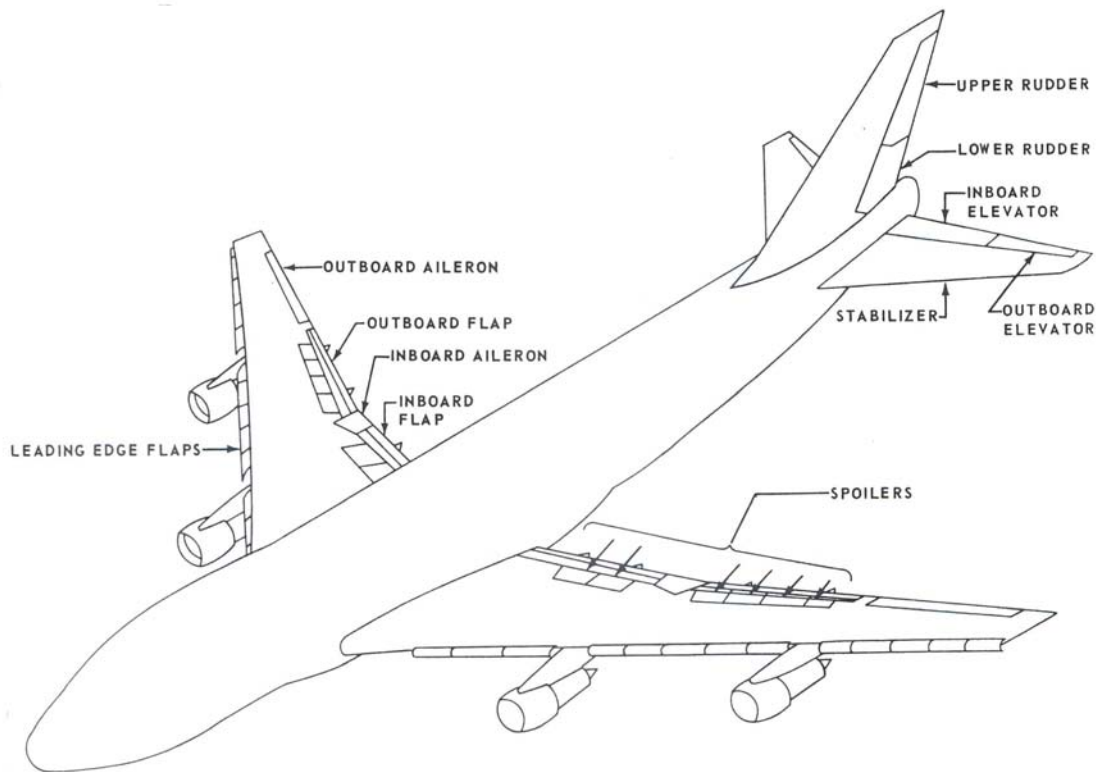
General

The basic flight controls are the:

- Inboard and outboard ailerons,
- Elevators, and
- Rudders.

Additional flight controls consist of:

- Inboard and outboard spoilers
- A moveable horizontal stabilizer, and
- Leading and trailing edge flaps



Control-feel forces are generated artificially in all axes. Feel systems are redundant in each axis so that equal forces will remain following any reasonable feel-system malfunction.

Manual or electric inputs from the flight deck controls determine hydraulic input to the actuator for each control surface. The actuators for most control surfaces contain two pistons in tandem. Any failure that makes either piston inoperative does not preclude operation of the other and, therefore does not prevent actuation of the control surface. Spoilers and outboard elevators have single-piston actuators.

The leading edge flaps (LE flaps) are powered by pneumatic motors that are controlled by flap lever operated switches in the control pedestal and on both trailing edge flap drive units.

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Hydraulic motors drive the trailing edge flaps. Electric motors are provided as a backup for extension and retraction of the leading edge and trailing edge flaps.

Lateral Control

Ailerons and Spoilers

Two ailerons on each wing, operating with spoilers, provide lateral control

The lateral control system comprises conventional control wheels that are bussed together by cables. Aileron trim is accomplished by repositioning the lateral control systems natural point.

The Ailerons are augmented with flight spoilers when control wheel movement exceeds 10 degrees. When flaps are retracted, the outboard ailerons are locked in faired position.

In addition to ailerons and spoilers, the lateral control system consists of two:

- Central control actuators,
- Aileron programmers, and
- Spoiler mixers.

Control wheel movement actuates the central control actuators (CCAs) by cable to provide a hydraulic power output that positions the aileron programmers and spoiler mixers. Autopilot inputs are supplied to the CCAs electrically. The aileron programmers position the ailerons in proportion to control wheel movement. The spoiler mixers allow proportional spoiler operation when control wheel movement exceeds 10 degrees.

In the event of cable bind or failure, each control wheel can operate independently of the other through a lost motion device; however, a substantially greater force than normal must be applied to the affected control wheel.

Aileron Trim

Aileron trim is provided by two AILERON TRIM located on the aft control pedestal. The forward switch arms the aft switch; therefore they must be operated simultaneously. Actuating the switches operates an electric motor on the aileron trim and feel mechanism, causing it to reposition, and thereby reposition the aileron control wheels.

Spoilers and Speedbrakes

Six spoilers are provided on each wing. The five outboard spoilers on each wing are used to assist the ailerons in lateral control.

The four inboard spoilers on each wing will function as flight Speedbrakes, while all six spoilers on each wing will act as ground Speedbrakes.

The hydraulic actuators that position the spoilers are designed to:

- Prevent "spoiler float" in the event of hydraulic power loss, and
- Permit spoiler "blowdown" at high speeds.

The spoilers may be operated as speedbrakes if manually selected in flight and after landing, or automatically after landing.

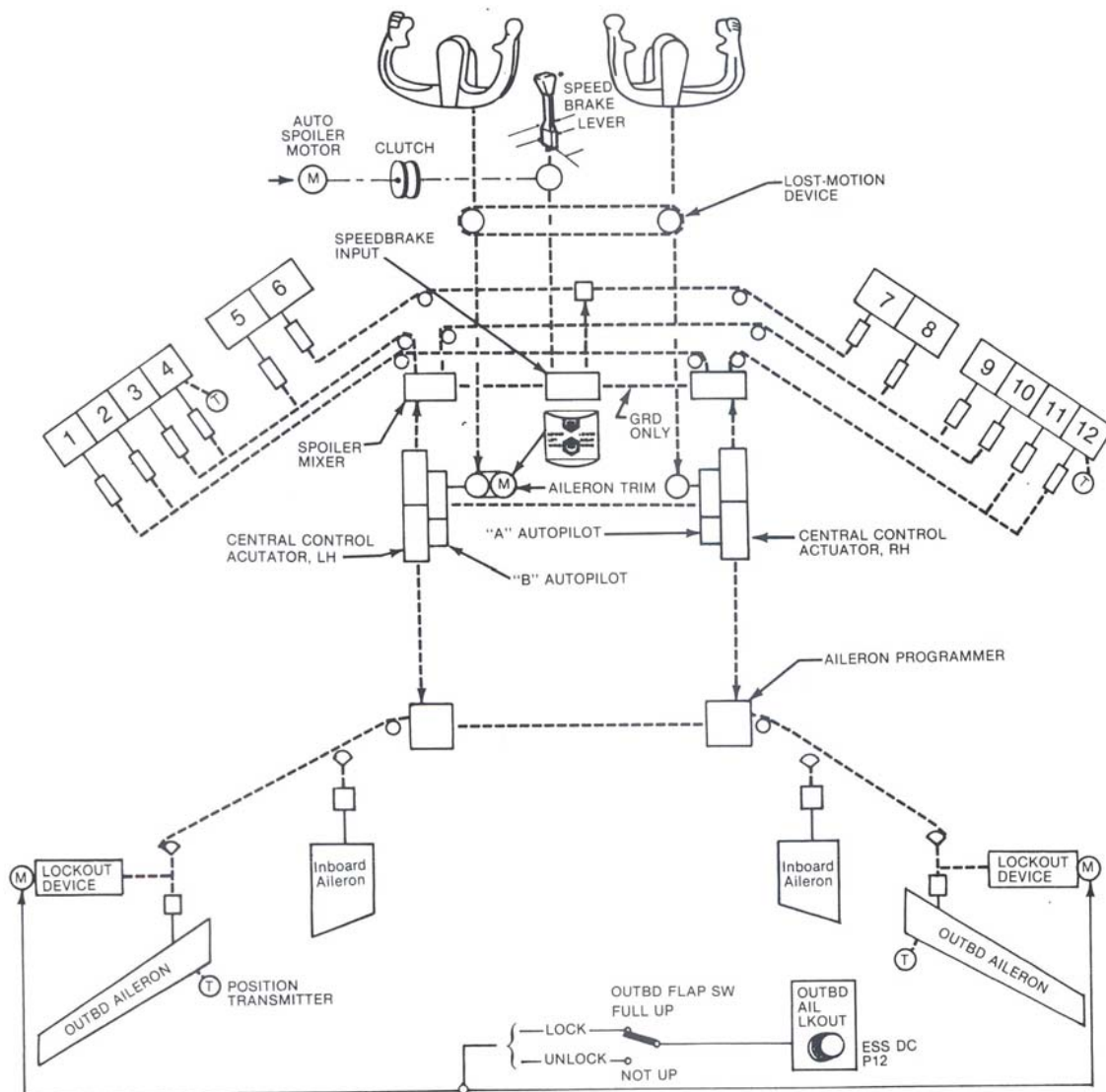
The speedbrake lever can be set to four basic positions:

- DOWN
- ARMED
- FLIGHT DETENT
- UP

Or any position in between.

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Lateral Control Systems Schematic

Placing the speedbrake lever in the DOWN detent retracts the spoilers. In FLIGHT DETENT, the flight speedbrakes are extended. A lock prevents moving the lever to the UP detent while in flight. The UP detent can only be selected on the ground to extend all the spoilers as speedbrakes.

Placing the speedbrake lever in the ARMED detent arms the autospoiler system for grouped operation.

Autospoilers

When on the ground, the autospoiler system will automatically extend the spoilers whenever reverse thrust is used. Regardless of whether the speedbrake handle has been placed in ARMED detent. This ensures that spoilers are extended for every landing and aborted takeoff.

If the speedbrake is placed in the ARMED detent before landing, the autospoiler system will automatically extend the spoilers when the airplane is firmly on the ground and the throttles are

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retarded. The spoilers will automatically retract if the throttles are advanced for a go-around. To protect against a bounce, spoiler extension is delayed for 0.6 seconds after the airplane is on the ground. If the spoilers start to extend and the airplane leaves the ground, they will automatically retract.

The autospoiler system includes a motor that will, on signal, drive the speedbrake lever to the UP or DOWN position. System operation is confirmed by observing speedbrake lever movement.

The autospoiler can be overridden manually at any time.

Pitch Control

General

Inboard and outboard elevators on each side of the airplane provide pitch control. Hydraulic actuators position the elevators in response to control column or autopilot inputs.

The actuators also limit elevator travel and provide snubbing action on the ground to prevent the elevators from wind damage. An elevator feel unit provides elevator-feel.

Elevator Control

When the control column is moved, it mechanically controls the hydraulic actuators on the inboard elevators. Inboard elevator movement mechanically controls the hydraulic actuator on the outboard elevator.

Elevator Feel

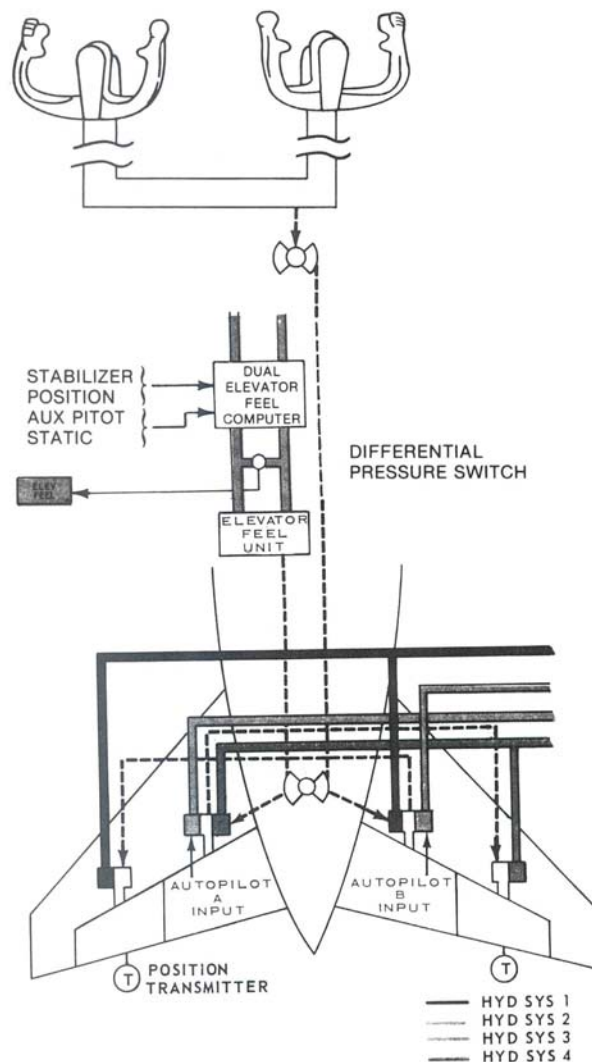
Because the actuators prevent aerodynamic forces from being fed back to the control column, feel forces are synthesized in the feel unit.

The two elevator feel system are powered by the No. 2 and No. 3 hydraulic systems, respectively.

Feel is a function of dynamic air pressure and stabilizer position. In the event of a single feel system failure, an amber ELEV FEEL light will illuminate in the forward caution panel, however, no changes in control forces will occur.

Autopilot Inputs

Electrical control signals from autopilots A and B are used to position the inboard hydraulic actuators to drive the elevators.



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Stabilizer Trim

The stabilizer trim system trims the airplane longitudinally by varying the horizontal stabilizer angle. It pivots the stabilizer about its rear attach point by driving hydraulically powered, trim-drive mechanism. The mechanism consists of two stabilizer control modules, A and B, and a bail screw actuator driven by two hydraulic motors. The two motors are identical but independent; one is powered by No. 2 hydraulic system, the other by the No. 3 hydraulic system. Should either motor fail, the remaining motor is capable of trimming the stabilizer by itself. Even with airloads from full elevator deflection. One hydraulic motor operates the stabilizer in one-half speed. Hydraulic flow to the motors is automatically reduced as airspeed increases. This prevents excessive trim rates in cruise.

A mechanical brake is provided on the jack screw. In addition, each hydraulic motor has a hydraulically operated brake. When the stabilizer is stationary, the brakes prevent it from creeping.

The trim system may be operated electrically by dual thumb switches on each control wheel or by inputs from the autopilot system. Control levers located on the control pedestal also may be used to operate the trim system manually.

Dual Thumb Switches

Pilot command signals originate through either of two sets of dual thumb switches on the control wheels. Operating both switches in the same direction, at either control wheel, energizes each control module. Hydraulic power is then directed to run both trim drive motors. Both switches must be operated simultaneously. This prevents inadvertent trim due to single switch failure.

Electric trim is available from 1.8 units nose up to 12 units nose up.

Manual Control Levers

Manual control is available from zero units to 15 units nose up. Neutral position is three units nose up.

Two manual stab trim levers are located on the left side of the center control pedestal. Both levers must be moved in order to operate the stabilizer. The levers operate cables that command both control modules and override any other inputs.

Stabilizer Trim Cutout Switches

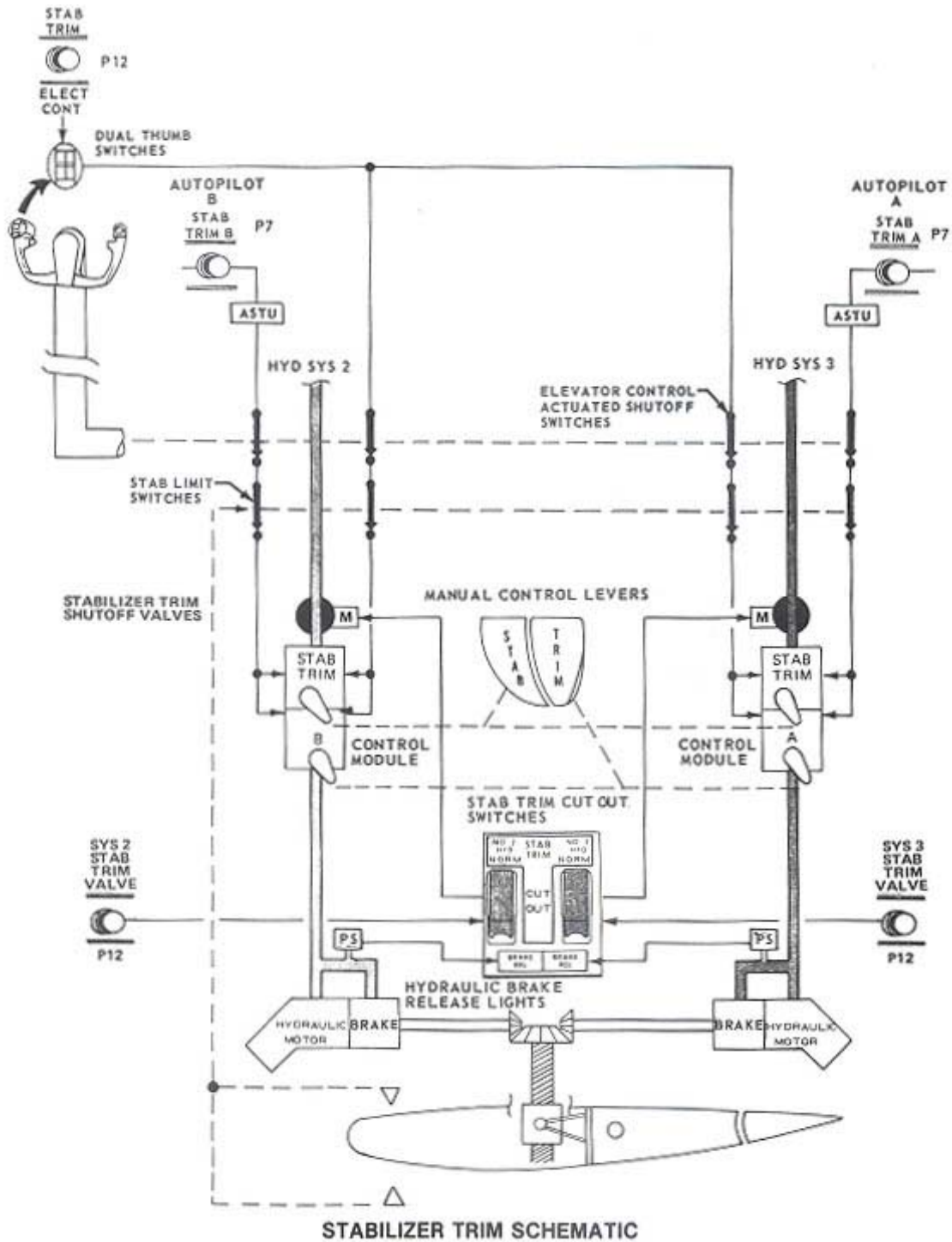
Two stabilizer trim (STAB TRIM) cutout switches are located on the central control pedestal adjacent to BRAKE REL lights. They are provided to electrically cut out hydraulic power from No. 2 and No. 3 hydraulic systems. The associated trim system is then completely inoperative.

Autopilot Stabilizer Trim

Dual automatic stabilizer trim units (ASTU) are provided to remove elevator loading whenever the autopilot is in operation by trimming the stabilizer to zero elevator load. Trim commands from the ASTU (initiated by a predetermined difference between the elevator and horizontal stabilizer) drive the stabilizer until the difference (standoff) is reduced below a predetermined amount. In dual autopilot operation (LAND mode) both stabilizer trim units are available; the unit associated with the first autopilot engaged does the trimming. If the operating unit fails, its AUTO STAB TRIM light (A or B) illuminates and the other unit automatically assumes the trimming function.

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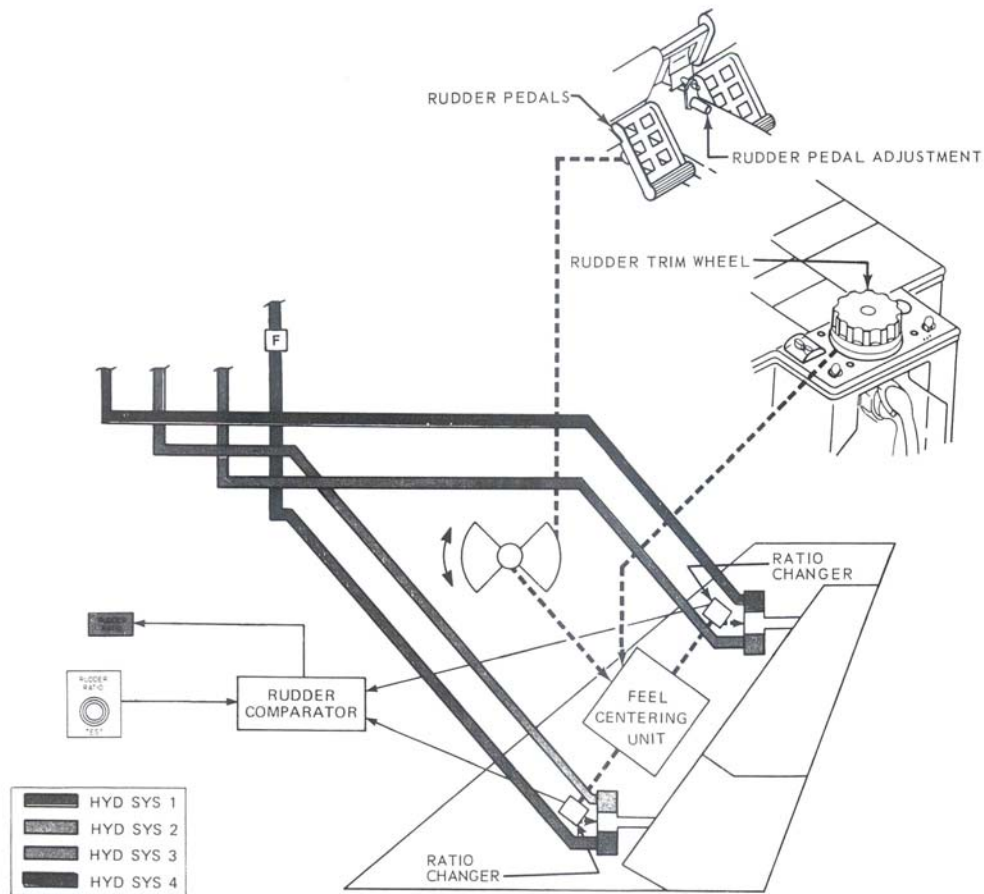
Rudder Control

Two rudders, each having about equal aerodynamic authority, provide yaw control. Each rudder is powered by two separate hydraulic systems.

Conventional rudder pedals control the rudders manually. Pedal movement is transmitted by means of cables to a feel-centering unit in the tail. Motion is transmitted mechanically through separate ratio changers to each rudder's hydraulic control unit.

Ratio Changers

The ratio changers vary the amount of rudder deflection for a given pedal position in proportion to airspeed. Full rudder pedal deflection gives 25 degree rudder at low speed. At approximately 170 knots, ratio change begins and full rudder pedal deflection gives about 4 degrees. Each rudder has a separate ratio changer.. The ratios selected provide structural safety at high speed and adequate control at low speed.



Rudder Trim

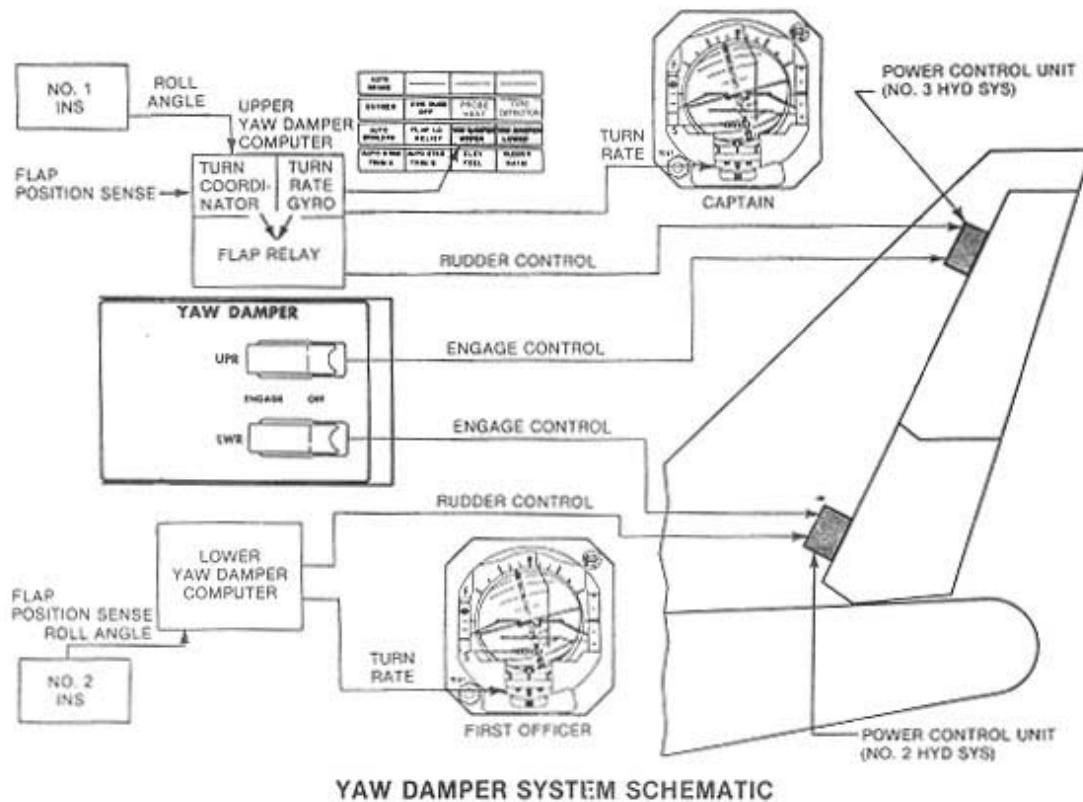
Rotation of the rudder trim control wheel on the center pedestal actuates a separate cable system to the feel-centering unit. This movement changes the neutral point, thus moving the rudder pedals and, through the ratio changer to the hydraulic power units, the rudder.

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Yaw Damper

Each hydraulic power control unit receives a separate yaw damper signal that is in series with pilot inputs, but is not felt at the rudder pedals. The yaw damper has approximately 4 degrees of authority. Hydraulic system 2 is the power source for the lower rudder and system provides power to the upper rudder. Yaw damper control switches are located on the pilots' overhead panel.



Turn coordinator

The yaw damper system provides turn coordination when the flaps are extended. Roll angle from INS 1 (upper rudder control) and INS 2 (lower rudder control) is transmitted to the yaw damper computers. Each hydraulic power control unit receives a signal from the computer to move the rudder in proportion to the roll angle signal. In addition, yaw damper inputs are integrated with the turn coordination inputs. The movement is not felt at the rudder pedals.

Trailing Edge Flaps

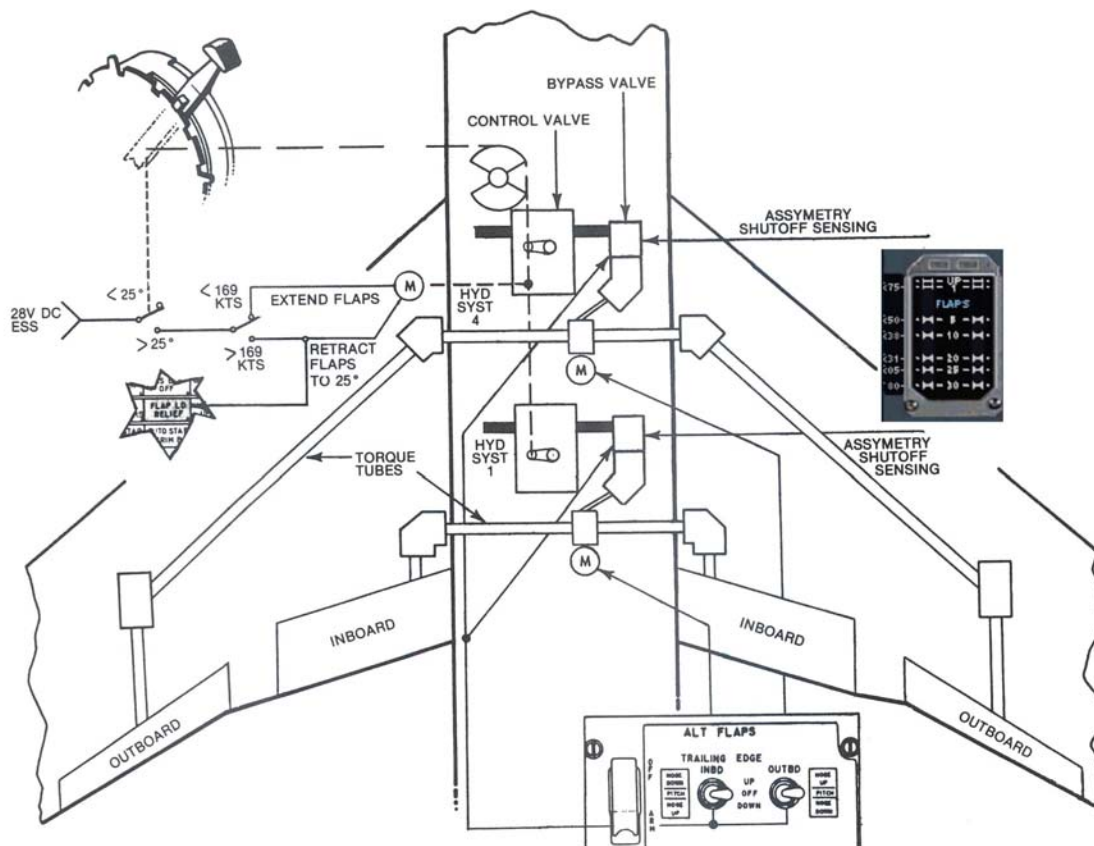
The trailing edge flaps are positioned by moving the flap lever that is accessible to both pilots. Flap lever movement operates cables that provide input to two control valves. One control valve, using pressure from the No. 4 hydraulic system, is for the outboard flap drive, the other using pressure from the No. 1 hydraulic system, is for the inboard flap drive.

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Hydraulic fluid passing through the control valve operates a hydraulic motor that is coupled through gears to a torque tube system. Each torque tube system extends laterally along both wings to two transmissions. Each transmission drives a ball screw actuator to move the respective flap. Each transmission has a torque limiter, in event of a jammed flap, it locks the drive system to prevent flap damage, and the motor stalls. Operation of the flaps in the reverse direction will release the torque limiter.

A load relief device, sensed by a “q” switch, is installed to provide automatic partial retraction of the trailing edge flaps. When the flaps are fully extended (flaps 30) and the airspeed exceeds 169 kt, the flaps are automatically driven back to the flaps 25 position. Trailing edge flap position is displayed on a flap position indicator tape located on the center instrument panel.



TRAILING EDGE FLAPS SCHEMATIC

Alternate Trailing Edge Flaps System

Alternate operation of the trailing edge flaps is accomplished electrically, using the ALT FLAPS switched on the overhead panel. The switches control two electric motors which drive the same torque tube system as the hydraulic motors. There is no load relief protection using the electric motors.

Alternate Flaps Switches (Non functional, except lights and switches.)

The ALT FLAPS switches consist of:

- An alternate flap arming switch, with an OFF and ARM position



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- Two directional switches labeled TRAILING EDGE INBD and OUTBD
- The directional switches have an OFF, UP and DOWN position

Placing the alternate flap arming switch to the ARM position

- Actuates a bypass valve in each trailing edge flap hydraulic system
- Arms the two directional switches

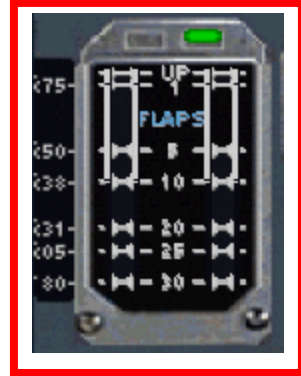
Protective torque limiter clutches in the electric drive units protect against overload.

The outboard flaps will only extend to flaps 25 position using the alternate system.

Flap Position Indicators

The trailing edge flap position indicators provide visual indication of the position of the trailing edge flaps.

The system consists of a position transmitter on each flap and two dual position indicators. One indicator on each side of the gauge indicated the position of the two outboard trailing edge flaps, while the other indicates the position of the inboard trailing edge flaps.

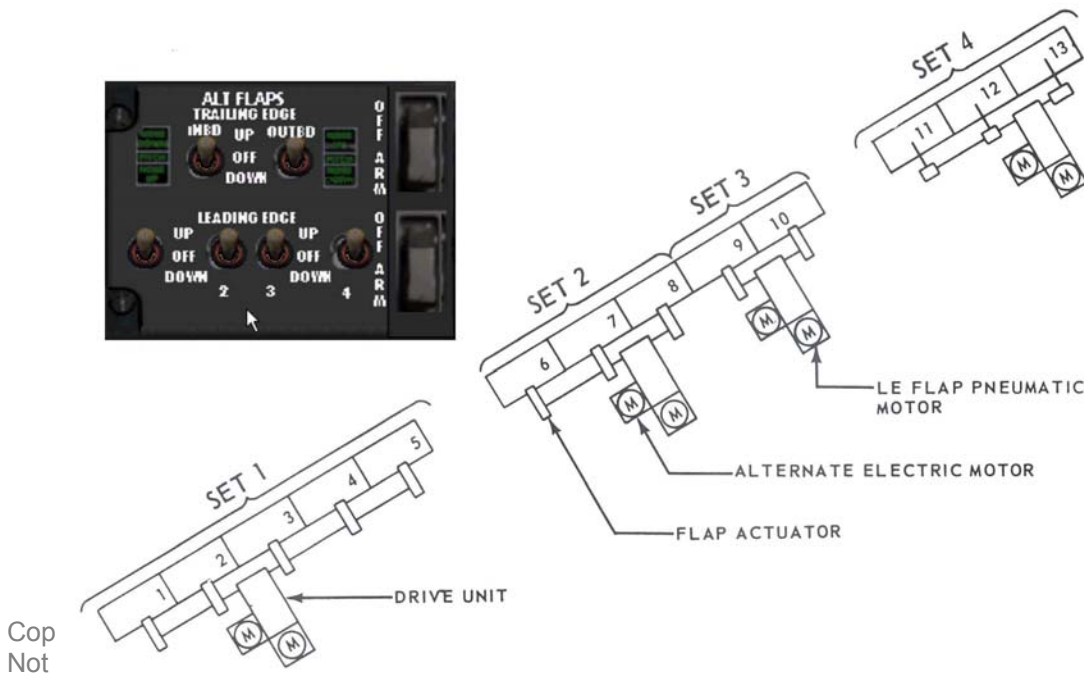


An amber light illuminates during flap transit, either up or down. A green light illuminates indicating flaps locked at indicated position. The scale provides an indication of the relative time needed for the flaps to move from one position to another, i.e. flaps 1 to flaps 5 takes relatively longer than flaps up to flaps 1.

Leading Edge Flaps

There are 13 leading edge flaps on each wing, ten of which are of variable camber design. The remaining three are Kruguer flaps.

The flaps on each wing are divided into four sets. In sequence of operation, symmetrical sets 2 and 4 extend when the flap lever is placed to the flaps 1 or greater position and the outboard trailing edge flaps have extended from their full up position. Sets 1 and three extend when the flap lever is moved to the flaps 5 or greater position and the inboard trailing edge flaps have extended past one degree.



LEADING EDGE FLAPS SCHEMATIC

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During normal operation the power to position the flaps is provided by pneumatically operated motors. Air is supplied from the airplane pneumatic system. Pneumatic extension or retraction time is 8 seconds.

Alternate Leading Edge Flap System

Each symmetrical pair of motors can be deactivated and the corresponding pair of flaps operated by electric motors that are coupled to the same mechanical drive units as the pneumatic motors.

Alternate Flaps Switches (Non Functional except switches)

The ALT FLAPS switches consist of:

- An alternate flap arming switch, with an OFF and an ARM position, and
- Four leading edge directional switches labeled UP, OFF and DOWN.



Placing the alternate flap arming switch to the ARM position, arms the LEADING EDGE directional switches for alternate extension or retraction. The normal pneumatic system is still capable of operating the leading edge flaps with the switch in the ARM position if the LEADING EDGE switches are in the OFF position.

Controls and Indicators

Flight Controls Hydraulic Power Panel (Non Functional except switches)

Empennage Placard

Indicates hydraulic power sources to the rudder and elevators.

Hydraulic Power Switches

Control hydraulic shutoff valves for the rudder and elevator systems.

OFF: valve closed

ON: valve open

Lateral Placard

Indicates hydraulic power sources to the spoilers, ailerons and central control actuators.

Hydraulic Pump Switches

Control the hydraulic shutoff valves for the Spoiler, aileron, and central control actuator systems.

OFF: valve closed

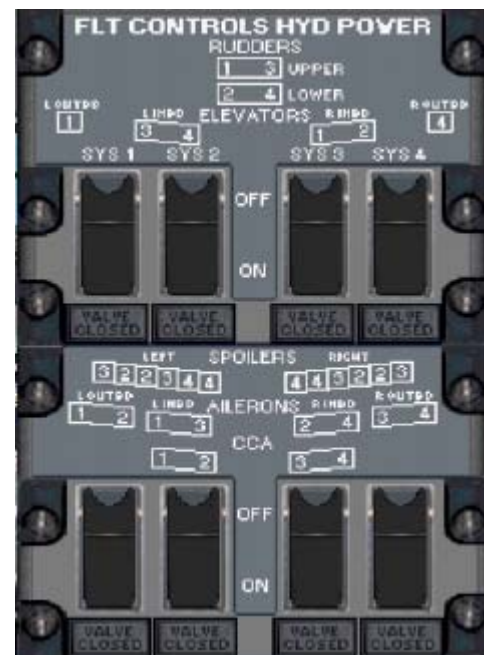
ON: valve open

Valve Closed Lights

Indicates the hydraulic valve shutoff position

OFF: valve is not in full open position

ON: valve open



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Elevators and Stabilizer



Stabilizer Trim Cutout Switches

Control No. 2 and No. 3 hydraulic system shutoff valves for the STAB TRIM system.

NORM: normal position of switches, both shutoff valves are open

CUTOUT: shutoff valves are closed

Manual Stabilizer Trim Levers

Mechanically perform the same function as the Stabilizer Trim Switches (Keypad 7 & 1).



Autospoilers and Speedbrakes

Speed Brake Lever

Selects speedbrake mode of operation

DOWN: Spoilers are retracted

ARMED: Extends spoilers when airplane is firmly on the ground and the throttles are retarded.

FLIGHT DETENT: Spoilers are extended in flight to reduce lift and slow the airplane.

UP: Raises all the spoilers.

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Flaps



Flap Lever

Selects flap settings

- Leading edge sets 2 and 4 extend when FLAP handle is moved out of FLAP UP detent.
- Leading edge flap sets 1 and 3 extend when FLAP handle is moved between position 1 and position 5.
- Takeoff range is either position 10 or position 20
- Landing range is either position 25 or position 30

Flap Position Indicator

Indicator Gauges: Two indicator gauges indicate the position of the flaps.

Flap Indicator Lights: An amber light illuminates during flap transit, either up or down. A green light illuminates indicating flaps locked at indicated position. The scale provides an indication of the relative time needed for the flaps to move from one position to another, i.e. flaps 1 to flaps 5 takes relatively longer than flaps up to flaps 1.

Flaps Limit Placard: identifies IAS limits for various flap settings



up



Flight Instruments



Introduction

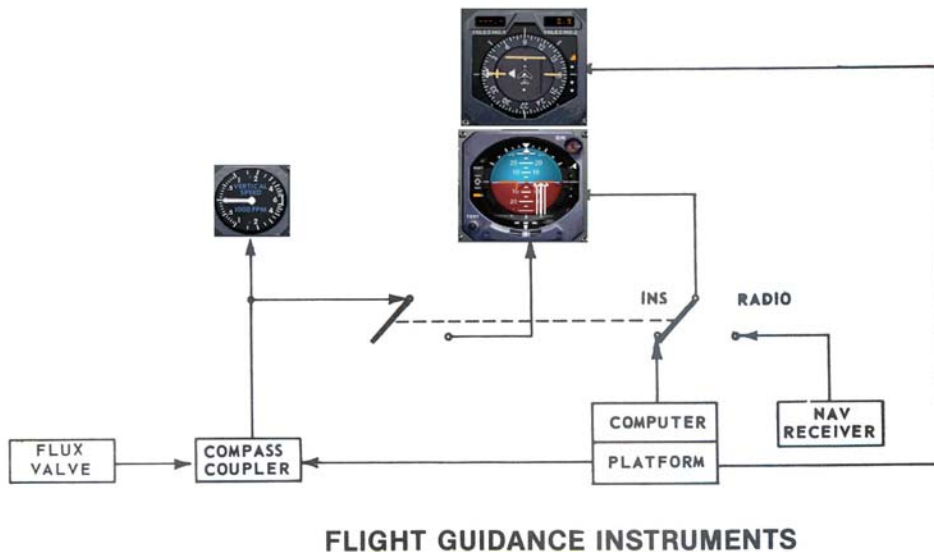
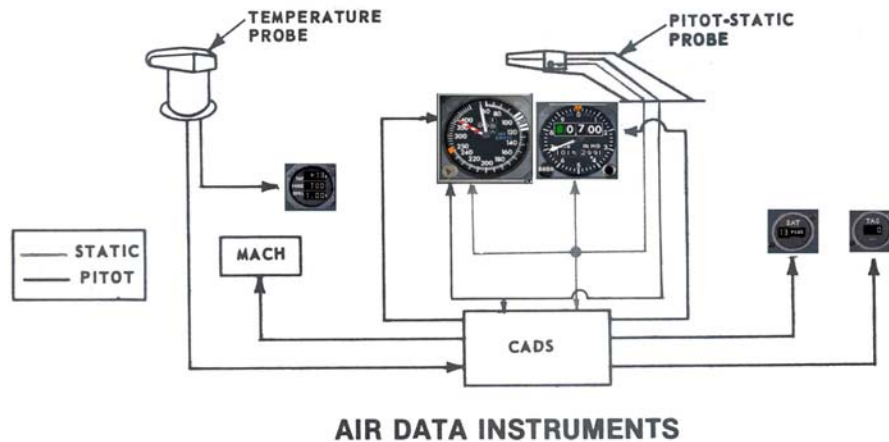
The flight instruments are the primary source of flight reference information for the pilots. This section describes:

- The air data system instruments that relate the airplane to the local air mass in terms of speed, altitude and temperature
- The flight guidance instruments that relate the airplane to its path over the earth in terms of altitude, turn rate, heading, radio altitude, and airplane position relative to a selected radio course or inertial navigation track
- The central instrument warning system that monitors the flight guidance instruments to bring discrepancies and failures to the crews' attention.
- The standby altitude indicator and clocks.
- The flight recorder that permanently records specific flight information.

To relate the airplane to the local air mass in terms of speed, altitude, and temperature, the air data system senses external air pressure and temperatures, translates and corrects the information, and then displays it.

The system directly measures the following air properties:

- Total or pitot air pressure (Pt)
- Static air pressure (Ps)
- Total air temperature (TAT)

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Pitot Static System

The pitot static system senses the dynamic or total pressure (pitot) and ambient pressure (static) outside the airplane to determine and display the vertical speed, airspeed and altitude.

The pitot-static system comprises:

- Four independent pitot systems
- Four independent static systems
- One alternate static system

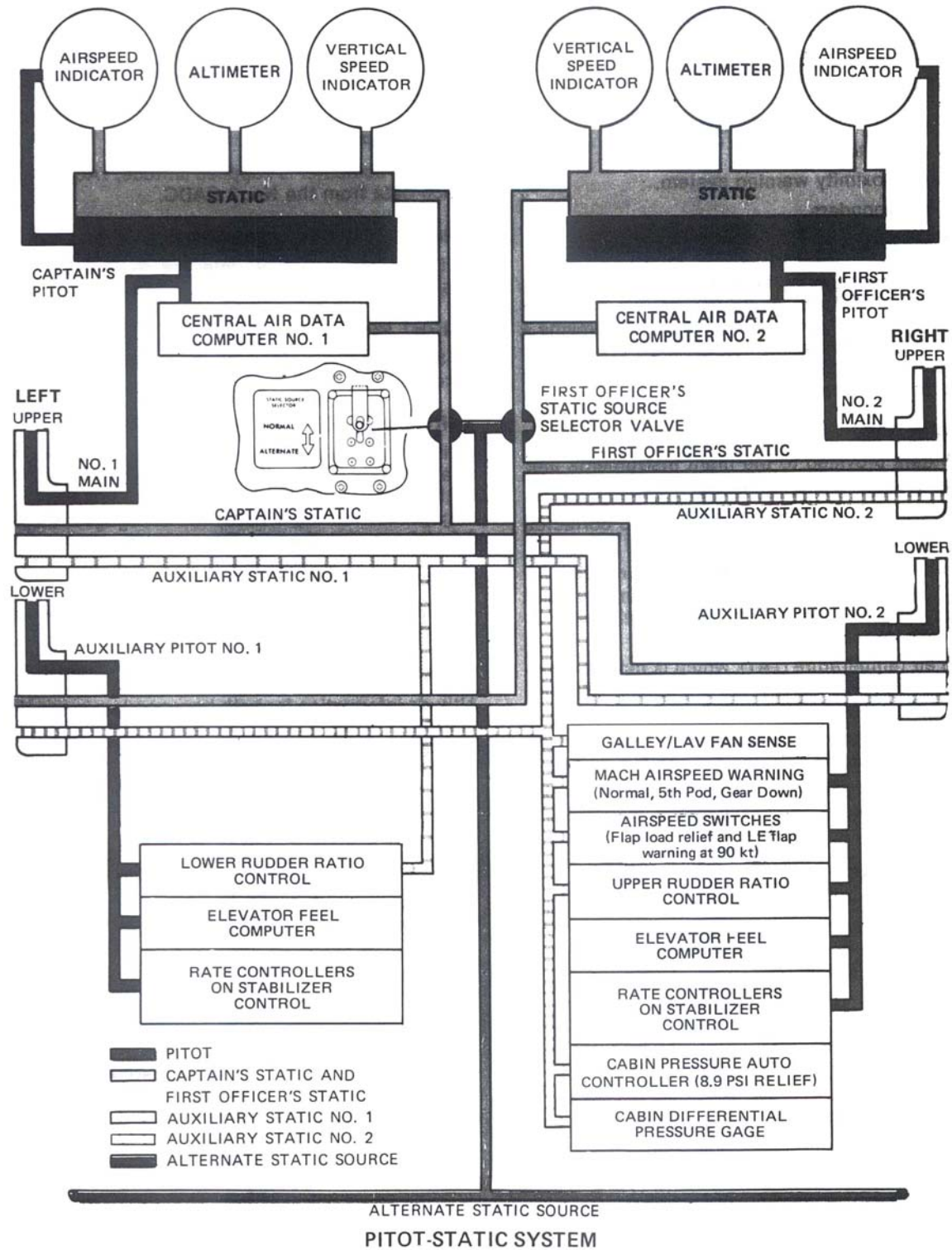
The pitot-static pressures of the four independent pitot and static systems are sensed at four probes, one upper and one lower on each side of the forward fuselage. The upper probes are the main probes, and the lower probes are the auxiliary probes. All probes are of the combination type, each providing one pitot and two static inputs to the various subsystems.

The alternate static pressure system has one flush-mounted sensing port on each side of the fuselage, just aft of the forward cargo door.

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The only electrical power required by the pitot-static system is for heater circuits that provide anti-icing of the pitot-static probes. The alternate static ports do not have anti-ice provisions.



Pitot System

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The captain's pitot pressure is supplied by the upper left (No 1 main) pitot probe. The first officer's pitot pressure is supplied by the upper right (No 2 main) pitot probe. Each pitot supplies pressure to the corresponding pilot's airspeed indicator and central air data computer (CADC). The lower left (No 1 auxiliary) and lower right (No 2 auxiliary) pitot probes supply pressure to control surface units: the rudder ratio control, the elevator feel computer, and the rate controllers on the stabilize control. In addition, the No 2 auxiliary pitot supplies pressure to the mach-airspeed warning and the airspeed switches.

Static System

Each static system has a balanced pressure source from a left and right interconnecting line. The captain's static pressure is supplied from the upper left and lower right probes; the first officer's from the upper right and lower left probes. The static pressure for each pitot passes through a corresponding static source selector which, when in normal position, routes the pressure to that pilot's airspeed indicator, altimeter, vertical speed indicator and CADC.

Auxiliary static pressure No 1 is supplied from a port in the upper left and lower right probes, auxiliary static pressure No 2, from upper right and lower left probes. Auxiliary static pressure No 1 is applied to the the lower rudder ratio control, whereas No 2 supplies pressure to the galley/lavatory fan sense, mach-airspeed warning, airspeed switches, cabin pressure Autocontroller, upper rudder ratio control, and the cabin differential pressure gauge.

Central Air Data System

The central air data system (CADC) uses two computers to provide corrected data to the following:

- Air data instruments
- INS Computers
- Autopilot and flight director computers
- PMS computer
- Ground proximity warning system (GWPS)
- ATC transponders
- Flight Recorder

Each of the central air data computers uses the same pitot static pressure as the flight instruments of the corresponding pilot. To provide a temperature sense for the direct reading of Total Air Temperature (TAT) and to compute Total Air Speed (TAS) and Static Air Temperature (SAT), a temperature sensing probe is mounted just forward of each pilot's No 1 window.

Air Data Instruments

- The air data provided to the flight instruments are:
- Mach number computed by the respective CADC
- Calibrated airspeed (CAS) which is IAS corrected for the static-source position error.
- Altitude, (ALT) which is normally corrected for static source position error by the computer.
- Total air temperature (TAT) which is ram air temperature sensed directly at the probe and not corrected by the CADC.
- Static Air Temperature (SAT) which is TAT corrected for compressibility (temperature rise)
- True air speed (TAS), which is computed by the No 1 CADC

INS Computers

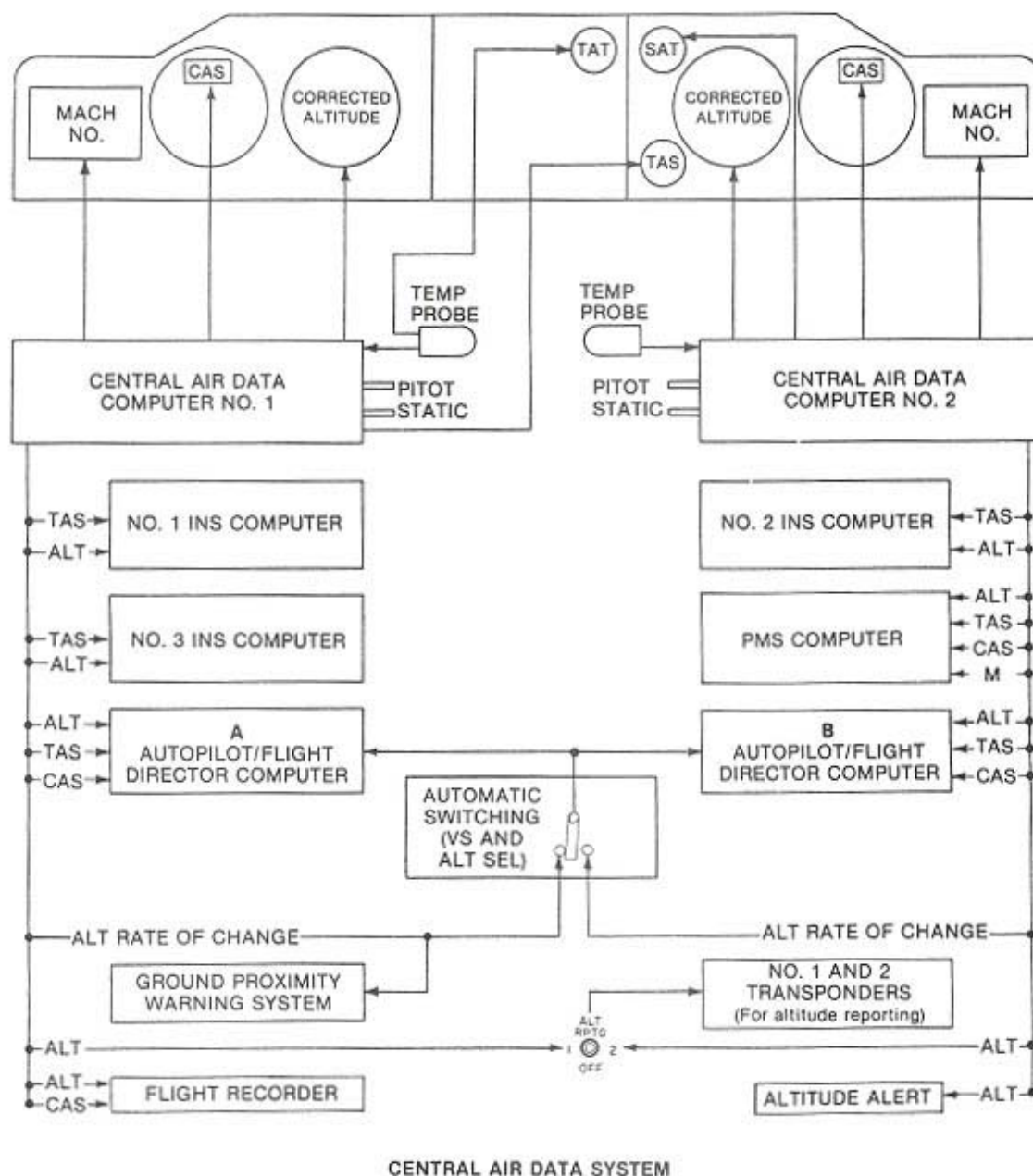
TAS is applied to each INS (Inertial Navigation System, discussed in another section) computer for wind data. If the CADC becomes inoperative, the INS CDU wind display will indicate zero. Altitude data is also supplied to the INS Computers.

Auto Pilot and Flight Director Computers

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These computers supply altitude data, TAS, and CAS. Altitude is supplied for altitude hold and altitude select. TAS is required to limit the maximum bank angle when flying on autopilot in heading mode. CAS is required when operating in the IAS mode (Discussed in the AUTOPILOT section).



Ground Proximity Warning System

Altitude rate of change data are supplied to the GPWS system from the No 1 CADC

Flight Recorder

CAS and altitude data are supplied to the flight recorder from the No 1 CADC

Vertical Speed and Altitude Select

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Altitude rate of change data are supplied to the vertical speed and altitude select by the No 1 CADC if both autopilots are off or when the A autopilot is engaged. When the B autopilot is engaged, the No 2 CADC supplies the data. Switching is automatic.

Altitude Alert

Altitude information is supplied to the altitude alerting system from the No 2 CADC.

Transponders

Altitude information for both transponders is supplied from No 1 or No 2 CADC.

Controls and Indicators

Altimeter

Altitude Window

Displays altitude in hundreds and thousands of feet. Below 10,000 feet the far left number is barred by the green flag.

Barometric (BARO) Set Control

Displays barometric setting in

- Inches of mercury (IN HG), or
- Millibars of mercury (MB)



Click on the left side to decrease (-)

Click on the right to increase (+)

29.92 IN HG or 1013 MD is called STANDARD and set at the "transition" altitude in the airspace through which you are flying. It is 18,000 feet in the US. Varies from country to country.



Altitude Bug

Manually positioned reference bug

Click on the left side to decrease (-)

Click on the right to increase (+)

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Airspeed Indicator

Mach Number Window

Displays Mach Number as computed by CADS.

Max Operating Airspeed Pointer

Commonly known as the “barber-pole”

- Indicates V_{mo} for existing altitude
- Positioned by static pressure

Command Airspeed Bug

Indicates command airspeed, as selected by either the autothrottle speed selector (on the glareshield panel) or by the command airspeed control on the indicator.

Command Airspeed Control

- Manual backup for autothrottle speed (A/T SPEED) selector on glareshield
- Click on the left side to decrease (-)
- Click on the right side to increase (+)



Airspeed Bugs

Five manually positioned reference bugs

- The 5 white bugs represent V₁, V_r, V₂, V_F and V_{ZF} during takeoff and V_{ZF}, V_{MA}, V_{GA} and V_{REF} during landings.
- Airspeed bug system as implemented in this software package is describe in detail below

Vertical Speed Indicator

- Indicates the airplane's rate of climb or descent
- Scale is 0 to 6000 feet per minute



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Total Air Temperature Gauge

- Displays true total (ram) air temperature



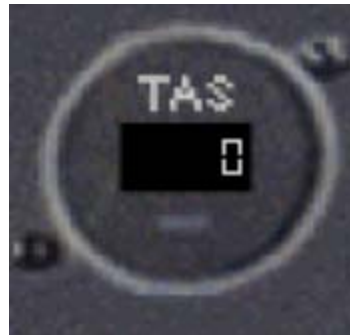
Static Air Temperature Gauge

- Displays true static air temperature



True Airspeed Gauge

- Displays true airspeed as computed by No 1 CAD/C



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SPECIAL FEATURE: Using the Airspeed Bugs for Takeoff and Landing

Operating Speeds

The bugs on the airspeed indicator are movable to provide reference speeds for aircraft configuration. The bug settings are used for takeoff, approach and landing. The five bugs are used for takeoff and four of the bugs are used for landings. The extra bug that is not being used on landing is set to the reference target speed for reverse thrust to be applied after landing.

Takeoff Bugs

- **V1** – This is the speed at which an engine can fail and you can either continue the takeoff and clear 35 feet height requirements or abort the takeoff and stop within the remaining available runway without reverse thrust.
- **VR** – This defines the rotation speed. The speed at which the rotation to an initial climbout altitude is initiated.
- **V2** – This is the engine out initial climb speed. The speed used for initial climb following an engine failure on takeoff.
- **VF** – Flap retraction speed. This is the speed at which flap retraction commences after takeoff.
- **VZF** – This is the zero flap Maneuver Speed. This is the minimum speed used for maneuvering the aircraft with the wing in a clean configuration. This speed is based on 1.5 VS for the clean configuration.



The chart on the next page shows the bug settings for each takeoff weight.

Flap Settings

The Flap Quadrant has detents at 0, 1, 5, 10, 20, 25 and 30-degree positions.

0 - Flaps Up

1 - A transition setting used when retracting flaps after takeoff and when initially slowing from zero flap maneuver speed. The proper speed to fly at this setting is halfway between the **VF** and the **VZF** bugs when accelerating and halfway between the **VZF** and **VMA** bugs when decelerating.

5 - A transition setting not included as a procedural position.

10 - Primary takeoff setting. Also used for maneuver and initial go-around.

20 - Alternate takeoff setting. Also used as a transition setting during approach.

25 - Primary landing setting.

30 - Alternate landing setting.

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Flaps 10 Takeoff and Climb Numbers					
Bug Settings					
Weight	V1	VR	V2	VF	VZF
820	166	178	186	230	266
814	165	177	184	229	265
800	163	175	182	226	263
780	160	172	180	222	260
760	158	169	177	219	257
740	155	166	174	215	254
720	150	162	171	212	252
700	146	159	168	208	248
680	143	155	166	205	246
660	139	152	163	201	243
640	135	148	160	198	239
620	131	145	157	194	237
600	127	140	154	190	233
580	125	136	151	187	230
560	123	133	148	183	227
540	123	130	147	180	223
520	123	126	144	177	219
500	123	123	142	173	214
480	123	123	142	170	210
460	123	123	142	166	205
440	123	123	142	163	201
Calls	V1	Rotate		Flaps 1	Flaps Up

The columns represent the speed bug settings. The column shown in green represent where you will not hear a call. This is just a reference point for a speed bug.

Flap Operation for the real aircraft. The time for the total end-to-end movement on the Vmax Classic is 49 seconds but is linear.

0 - 1 = 2 seconds

1 - 10 = 35 seconds

10 - 20 = 6 seconds

20 - 25 = 3 seconds

25 - 30 = 3 seconds

Flap Retraction

Flaps can always be retracted to 10 degrees as long as the existing speed is at or above **VREF**.

The **VF** bug always marks the speed at which flap retraction from 10 degrees is initiated.

When retracting flaps, aircraft speed must be at the appropriate speed for the selected flap setting and increasing.

Takeoff and initial climb performance depend on rotating at the correct airspeed and proper rate, to the rotation target attitude.

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Early, rapid or over rotation may cause aft fuselage contact with the runway. Late, slow or under rotation increases takeoff ground roll. Any improper rotation decreases initial climb performance. For optimum takeoff and initial climb performance, initiate a smooth continuous rotation at VR to the rotation target attitude. The rate of rotation is related to the airplane acceleration rate. At light gross weights, the airplane acceleration rate is higher and the rotation rate will be faster than at heavy gross weights. The total time to rotate from VR to the rotation target attitude will vary from eight seconds at light gross weights to eleven seconds at maximum gross weights. Lift-off should occur at approximately 10 degrees pitch attitude. After lift off continue the rotation to the rotation target attitude. Immediately after reaching the rotation target attitude, note the airspeed and adjust the pitch attitude to maintain the desired airspeed. Only slight adjustments are required to the rotation target attitude to maintain the desired initial climb airspeed. If large changes in pitch attitude are required, cross check pitot static instruments for possible erroneous indications.

The initial climb attitude is a function of gross weight, flap position, ambient conditions and thrust available. It will vary from 11 to 18 degrees; however, it is limited to 15 degrees maximum due to cabin floor angle and flight deck visibility.

Normal Climbout Procedure

The speeds specified in this procedure will be exceeded whenever 15 degrees pitch up attitude is limiting.

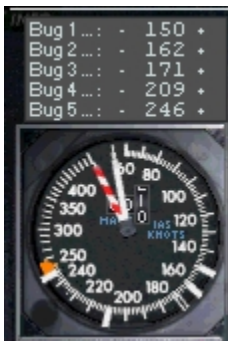
- When the aircraft is airborne in a positive climb, the PNF calls "Positive Rate". The PF calls "gear up" at the same time signally with his hand, thumb up. The PNF raises the gear and checks for normal indications and after the red gear door open light extinguishes, slowly and smoothly selects the landing gear lever to OFF.
- Accelerate to and climb at V2 + 10 knots (15 degree pitch MAX.) to TOCA.
- Provided there are no speed restrictions, at TOCA (min 600 feet AGL) reduce the pitch to about 7 to 9 degrees initially. Accelerate to the flap retraction speeds while maintaining a shallow but positive rate of climb of about 500 fpm.

Noise Abatement Climb-out Procedure

- At TOCA (min 600 feet AGL) accelerate and select Flaps on schedule.
- Climb thrust is set at 1,500 feet AGL
- At 3,000 feet AGL, reduce pitch, accelerate and retract flaps on schedule.

Possibly the hardest part for you to adapt to is the lack of a Flaps 5 call on takeoff. This call is omitted due to the very long time it takes for the flaps to get from Flaps 10 to Flaps 1. This is an area where proper timing is important.

Takeoff Diagram



The area at the top of the ASI is where you set the speed bugs. This is a popup area that is not normally visible. Use your mouse and left click on the upper right hand corner of the ASI to access the speed bug settings. This menu will remain visible for 10 seconds when not being used and will hide itself. Always start setting the bugs from Bug 1 and set each on in succession.

For takeoff, set Bug 1 at **V1** speed, Bug 2 at **VR**, Bug 3 at **V2**, Bug 4 at **VZ** and Bug 5 at **VZF**.

You will get your Flaps 1 call at **VF** and you will select Flaps 1, not flaps 5 by clicking the flaps key two times.

Ready for Pushback ... 2nd Generation

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When your speed is halfway between **VF** and **VZF** your flaps should be passing through Flaps 5 position and on their way to Flaps 1. Again, timing is the key to all this. You will get your Flaps Up call at **VZF**, which is your zero Flap Maneuver Speed.

Landing Bugs

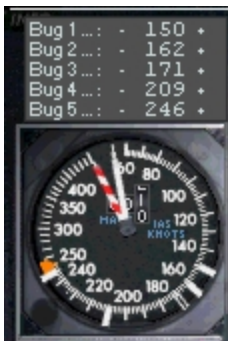
- **VZF** – Zero Flap maneuver speed
- **VMA** – This is the minimum speed for maneuvering in the terminal area at the maneuver flap setting.
- **VGA** – This is the Go-Around Speed. The speed used for a climbout on a missed approach.
- **VREF** – This is the Landing Reference Speed. The target speed for touchdown with landing flaps set. **VREF** should be padded with Plus 5 Knots.
- As you noticed, only 4 bugs have been mentioned for the landing. The first bug should be set to the Reverse thrust target speed.

The number 3 bug is always set to **V2** for takeoff and **VGA** for the approach. This will reference the proper speed to be used when an optimal climb gradient is needed whether on takeoff or a Go-Around.

The **VF** or **VMA** bug references the speed at which normal flap retraction commences after takeoff or after a Go-Around.

The **VZF** bug marks the speed for maneuvering with zero flaps.

The airspeed indicator also has an airspeed bug "**Speed bug**" controlled by the autothrottle (**A/T**) Speed Knob. For takeoff, set the bug to 250 knots or **VZF** whichever is higher. Set bug to optimum climb, cruise and descent speeds. For final approach set the bug to **VREF + 5** Knots.



Bug 1 should be set to the Reverse Thrust Target Speed. The reverse thrust target speed should be **80 knots** and a minimum of 60 knots.

Bug 2 should be set to **VREF**, **Bug 3** set at **VGA**, **Bug 4** set to **VMA** and **Bug 5** set to the **VZF** speed.

VZF is Clean Speed. You cannot go below **VZF** without calling "**Flaps 1**". If you go 1 knot below **VZF** the "**Flap 1**" call must be made.

You can slow to halfway between **VZF** and **VMA** with **Flaps 1** but any slower you must -

Halfway between **VZF** and **VMA** you must call "**Flaps 10**"

That is the last Flap Call based on Speed

You can now slow to **VMA**. You do not go below **VMA** speed.

At **2,100 feet (AGL)** which is **FAF + 600** feet call **Gear Down - "Flaps 20"**

Start slowing down

At **1,800 feet AGL** or when **Flaps 20** has been reached call "**Flaps 25**"

Ready for Pushback ... 2nd Generation

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Must be in full landing configuration before **FAF** (normally outer Marker) **1,500 AGL**

You should now be at **VREF + 5 knots** for landing. The extra 5 knots is just padding that they use in case of wind changes etc.

Flap Extension

- Flap extension from Flaps 1 to Flaps 10 takes six times longer than between other selections when lowering flaps. Extra time must be planned.
- When slowing from Flaps 1 to Flaps 10 bug speed, speed reduction must be slow and proportional to flap movement. **DO NOT** allow speed to reach the **VMA** bug until flaps have extended beyond the 5-degree position. The proper speed for flaps at 5 degrees remains at halfway between **VMA** and **VZF** as in the flaps 1 position.

On the next page you will see the Approach settings for the speed bugs.

The columns highlighted in yellow represent the speed bug settings and the columns in green, represent the point you will get the flap calls.

NOTE ABOUT: Speed Bugs

The manual speed bugs on the ASI gauge will be saved and reloaded on your next flight. They will reload the last position that the bugs were set to.

We have found in very rare cases that some computers will not save and reload this data and this is computer specific and not a Ready for Pushback issue. The problem has been traced to Win XP and Microsoft updates and in at least one case a video driver change corrected the problem.

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Landing Numbers Table						
Four and Three Engines						
	VZF	Flaps 1	Flap 10	VMA	VGA	VREF
Flaps	0	1	10	10	25	25
Gear	UP	UP	UP	UP	DN	DN
Weight	IAS					
820	266	265	248	229	202	185
800	262	261	244	226	199	183
780	259	258	241	222	196	180
760	257	256	238	219	193	177
750	256	255	237	218	192	176
740	254	253	235	215	190	174
730	253	252	233	213	189	173
720	252	251	232	212	187	172
710	250	249	230	210	186	170
700	249	248	229	208	184	169
690	248	247	227	206	182	167
680	246	245	226	205	181	166
670	245	244	224	203	179	165
660	243	242	222	201	178	163
650	242	241	221	199	176	162
640	240	239	219	198	175	160
Overweight numbers are above this line						
630	238	237	217	196	173	159
620	237	236	216	194	172	158
610	235	234	214	193	170	156
600	233	232	212	191	169	154
590	232	231	211	189	167	153
580	230	229	209	187	165	151
570	229	228	207	185	164	149
560	227	226	206	184	162	148
550	225	224	203	181	161	147
540	223	222	202	180	159	145
530	221	220	200	178	158	143
520	219	218	198	177	156	142
510	217	216	196	175	155	140
500	214	213	194	173	153	139
490	212	211	192	171	152	137
480	210	209	190	170	150	136
470	208	207	188	168	148	134
460	205	204	187	168	147	132
450	203	202	184	164	145	131
440	201	200	182	163	144	129
430	198	197	180	161	142	128
420	196	195	178	159	140	126
410	193	192	180	167	139	125
400	191	190	173	155	137	123

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Note: Using with Classic S-Combo supplied with this software.

In the real world, there are three scenarios for getting the aircraft into a landing configuration. Although we may not have duplicated all three perfectly with **Classic S-Combo**, we have come very close. The three real life scenario's are:

1st) Well, when the glide slope becomes active we call for gear down and flaps 20. When the glide slope is 1 dot from centered we call for flaps 25 or 30 as appropriate.

2nd) When descending on the glide slope at V_{ma} (that's the maneuver speed with flaps 10) extend the gear and call for flaps 20 when 600 feet above the intercept altitude. That's the feather altitude depicted on an approach chart. It's also the marker crossing altitude. Then when 300 feet above that altitude call for flaps 25. That's how we cross the marker completely configured and on speed.

3rd) If on a non-precision approach when inbound to the marker call for flaps 20 and gear down when 3 miles from the FAF (final approach fix), when 2 miles from the marker or final approach fix call for flaps 25. That's how we cross the marker on a non-precision approach in the proper configuration and on speed.

Magnetic Heading and Reference System

Description

A magnetic heading reference system (MHRS) is installed for each pilot, in conjunction with the INS (Inertial Navigation System... to be discussed in a later section), which provides a platform heading input, the MHRS produces a stabilized magnetic heading to the

- RMI's (Radio Magnetic Indicator)
- HSI's (in RADIO) mode only (Horizontal Situation Indicator)
- Autopilot and Flight Director computers
- Flight Recorder

To produce the stable magnetic inputs, a compass coupler for each system processes the unstable, but accurate, flux valve signals with the stable INS platform heading output.

RMI and HSI

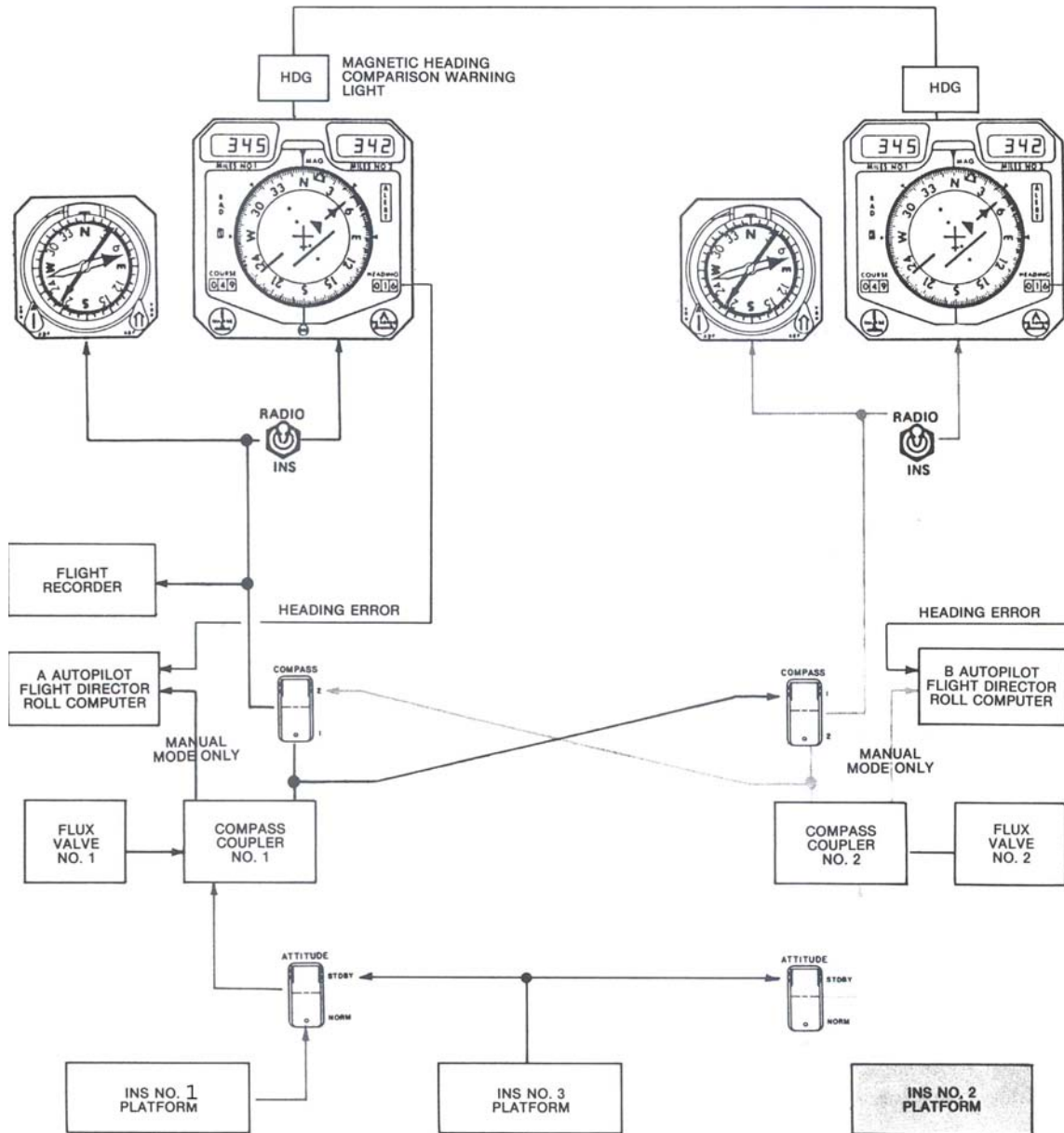
Each pilots RMI and HIS receives magnetic heading inputs from the MHRS selected on the pilots COMPASS transfer switch (Located on the overhead)



Autopilot and Flight Director

With the captain's COMPASS transfer switch to 2, the A autopilot/flight director computers receive inputs from the No 2 MHRS. With the first officer's COMPASS transfer switch set to 1, the B autopilot/flight director computers receive inputs from the No 1 MHRS.

Irrespective of the position of the compass transfer switches, autopilot/flight director roll computers receive inputs from their respective MHRS when the associated autopilot is in MAN.

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INS Function (Platform Heading)

The INS supplies platform heading signals to the compass coupler to stabilize the flux valve signal. Normally, INS No 1 supplies compass coupler No 1 and INS No 2 supplies compass coupler No 2 with respective attitude switches selected to normal. The standard source for either compass coupler is INS No 3.

A compass comparator compares the magnetic heading indication on the HIS azimuth cards when both HSIs are selected to display radio information.

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Horizontal Situation Indicator

The Horizontal Situation indicator (HSI) displays airplane position in relation to a selected VOR or ILS course, or INS track. The indications on the HSI are dependent on the current flight mode:



NAV Radio: When tuned to a VOR station or tuned to an ILS, and the Navigation mode switch set to VOR/LOC, the HSI will show the Magnetic Heading on the lubber line, and the VOR/LOC deviation on the course deviation bar. Note, the NAV/GPS switch must be set to NAV.



NAV Radio: When tuned to an ILS, and the Navigation mode switch is set to ILS or LAND, the HSI will indicate the aircraft magnetic heading on lubber line, the localizer deviation on the course deviation bar, and the glide slope deviation on the glideslope deviation scale



the



INS: When the INS is set to RMT and the Navigation mode switch is set to HDG, the desired track is shown by the course indicator. NOTE: If the INS is in RMT and the Nav mode switch is in HDG, you will NOT be able to change course ... the INS is in CONTROL!!!!



HDG and FD: When in HDG or HDG/FD mode, the HSI indicates the heading of the aircraft.



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HSI Controls and Indicators

Heading Bug

Indicated the heading selected by the Pilot on the Glare Panel Heading Selector



Course Indicator

Indicates the selected course, in this case 140

Course Deviation Bar

As a reference on the course deviation scale that indicates deviation from the selected course

Course Deviation Scale

Each dot equals 5 degrees on a VOR and 1¼ degree on the localizer

To-From Arrow

Points toward a line through the VOR station perpendicular to the selected course. The arrow is out of view if:

- The VOR signal is lost,
- The aircraft is directly over the ground station
- The Nav radio is tuned to an ILS frequency



Courses and headings are set on the glare shield (details are in the AUTOFLIGHT section).



Mileage Indicators - The left side display mileage to DME1 or the next waypoint. The right side displays mileage to DME2

Glideslope Deviation Scale

- Displays vertical position relative to the glideslope. Each dot indicates ¼ degree
- Masked as indicated here when a VOR is selected or no ILS signal is available

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Radio Magnetic Indicator (RMI)

LUBBER Line - Rotating compass card is read against lumber line

VOR 1 Pointer - Indicates bearing to VOR station -INOP in ILS mode

ROTATING Compass Card

VOR 2/ADF Pointer - Indicates bearing to VOR 2 or ADF facility.

VOR Selector Knob 1 - (INOP as on most of the real aircraft)

VOR Selector Knob 2 -

- In VOR Mode pointer displays bearing to VOR 2
- ADF - mode displays bearing to ADF facility

The needles are damped on this gauge as they are in real life. The movement is slower and may reflect the instantaneous loss of a signal that would not normally be seen in FS2000.

Above the RMI are digital readouts for DME 1 and DME 2



Radio Altimeter

This is a very accurate Radio altimeter.

- The knob in the lower right sets the decision height, referred to also as Decision Altitude (DA)
- At 2,500 feet the light at the top illuminates. This light can be extinguished by pressing on the light.
- The same lamp illuminates at your preset decision height and the "Minimums" call sounds.

The decision Height lamp is also coupled to the Decision Light on the ADI.

Decision Altitude Pointer

Indicates DA altitude set

Decision Altitude Numeric Window

Numeric guide for setting DA

DA/DH set knob

- Click on the left side to decrease (-)
- Click on the right side to increase (+)



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Attitude Director Indicator - Flight Director

The attitude director indicator **ADI** is installed on each pilot's panel. Conventional pitch and roll attitude information supplied by INS platforms, is displayed by the horizontal sphere. Pitch and roll command bars on the sphere are positioned by the flight director computer. The ADI also displays:

- Glideslope deviation
- Expanded localizer course deviation
- Turn and slip indications
- Speed Deviations relative to command airspeed bug.

The Bank Angle Scale

displays bank angle in response to attitude signals from the inertia navigation system.

The Fixed Airplane Reference



is a fixed symbol, rear view of the airplane. Attitude reference when related to horizon and bank angle.

Glideslope Pointer

displays vertical position relative to the glideslope. When signal is not valid a warning flag covers the display.

The Roll Command Bar

displays computed roll correction which the airplane must make to track a desired course.

The Pitch Command Bar

displays computed pitch attitude which the airplane must assume to maintain a desired altitude, or to track a glideslope beam or to fly

the go-around attitude.

Airspeed Fast-Slow Indicator Scale

Indicates the amount of airspeed error; referenced to airspeed bug indicator (set by auto throttle speed).

Runway Symbol

displays localizer deviation. Lateral movement shows displacement from o-course.



Test Switch when pressed, the attitude sphere will indicate a 20° right bank and a 10° pitch up attitude.



Decision Height Indicator light

Automatically illuminates when descent reaches decision height set on radio altimeter

Flight Director Switch

- Found on glareshield
- One for each pilot
- Controls output of selected AP/FD computer to the ADI
- ON: Activates roll and pitch command bars on the ADI
- OFF: Deactivates roll and pitch command bars on the ADI



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Standby ADI



Accurate warning flags are included in both of these instruments. To test these functions, kill the electrics by pressing <Shift – M>

NOTE ABOUT: Standby ADI



The knob in the lower right corner performs two functions:

- Right Click performs the cage/uncage
- Left click on the - / + symbols allows a 5° pitch to be set

Illustration shows it in the caged mode.

Clock

This is a DUAL function clock with the features of the real one plus added features for FS2000. It will require that you spend some time to learn how to use it properly.

The Readouts -

- Top window - Dual Function. This window gives the time and the simulation rate
- Bottom window - Shows the Elapsed time



Using the DUALple functions

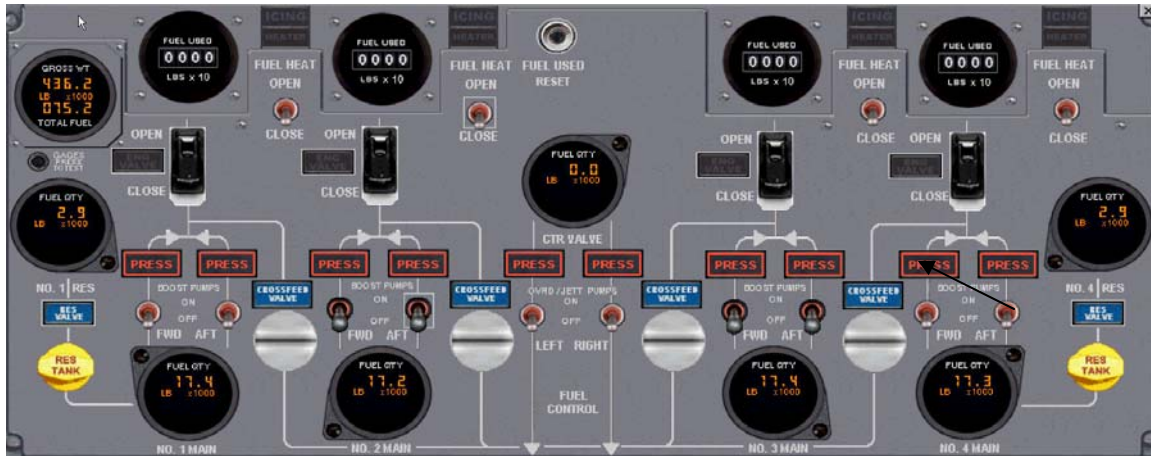
- **Top left button** - Toggles between LOCAL and ZULU TIME
- **Bottom Left button** - First click turns on the 24 ELAPSED TIME timer. Second click stops the timer. Third click resets the timer to zero. The timer records HOURS and MINUTES. When you first activate it, you will not see it working until 1 minute has elapsed.
- **Bottom right button** - First click activates the 12 minute EVENT TIMER. The large hand counts off the seconds and the smaller hand keeps track of minutes. The second click stops the event timer and the third click resets the event timer.
- **Top right button** - There are a total of 5 mouse spots on or around this small button. Top center is a plain hand and toggles between the time being displayed and the sim rate display. On the Left side, upper portion is to decrease the hours and sim rate. Lower left is to decrease the minutes. On the right side of the button, the top portion increases the hours and sim rate. Slightly down you increase the hours.

NOTE: The event timer stops when the main panel is not in view

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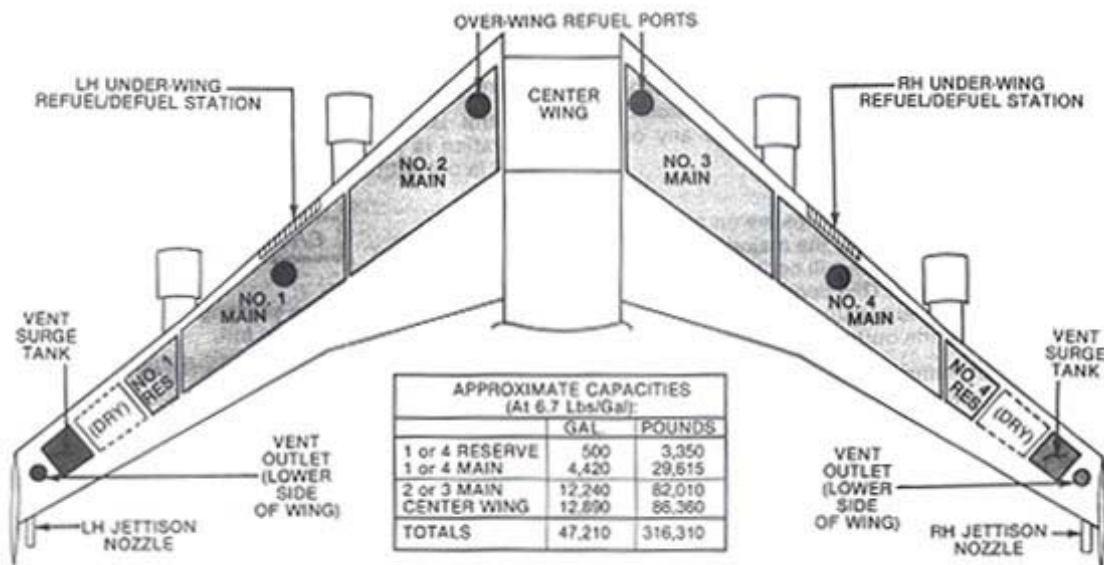
Fuel System



Introduction

- The fuel system consists of:
- Seven fuel tanks: four main, one center and two reserve.
- Four identical main tank-to-engine supply systems.
- An interconnecting manifold providing crossfeed from all tanks (except the reserves) to any or all engines.
- A combination fuel jettison/pressure refueling system.

Fuel Tanks



The tanks are formed by sealed sections of the basic wing and center section structure. Main-tank fuel is normally pumped to its respective engine, but at lower altitudes can flow by gravity. Reserve-tank fuel is transferred by gravity to the adjacent outboard main tank. Center tank fuel must be pumped to any engine; it will not flow by gravity. APU fuel is normally supplied by the number 2 main tank, but can be supplied from any tank except reserve tanks.

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Vent System

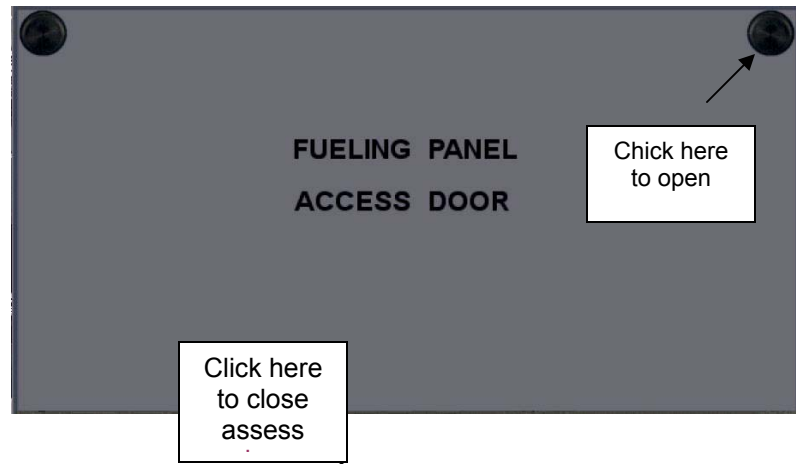
All tanks are connected (vented) to vent surge tanks, one in each wing tip. The vent surge tanks are connected to an overboard scoop vent under each wing tip which slightly pressurize the tanks during flight and permits excess fuel collected in the vent surge tanks to drain overboard.

Normally fuel collected in the vent surge tanks automatically drains into the inboard main tank on that side.

Refueling

Two refueling stations, one in each wing leading edge provide under wing refueling of all tanks. Either station is capable of supplying fuel to all tanks; however the refuel controls and gauges are located at the left hand station.

Electric quantity gauges control full tank shutoff. Each station is equipped with two fuel hose connections.



Overwing refueling ports are provided for each of the main tanks only. It is possible to transfer fuel from the inboard main tanks to any other tank on the ground, using the jettison pumps and normal refueling valves.

Defueling

Provision for defueling the aircraft is provided through the refueling system.

Quantity Measurement

Electrical gauges on the flight engineer's panel and at the left hand refueling station indicate tank quantities. The gauges at the refueling station are repeaters of the gauges at the flight engineer's panel. The maximum fuel gauge tolerances for level unaccelerated flight are as follows:

- Reserve tanks 1 or 4: +/- 52 lb each.
- Reserve tanks 2 or 3: +/- 90 lb each.
- Main tanks 1 or 4: +/- 525 lb each.
- Main tanks 2 or 3: +/- 1425 lb each.
- Center Tank: +/- 1950 lb.

Jettison

Fuel is jettisoned through a fixed jettison nozzle at each wingtip. The fuel is pumped overboard by means of electric pumps.

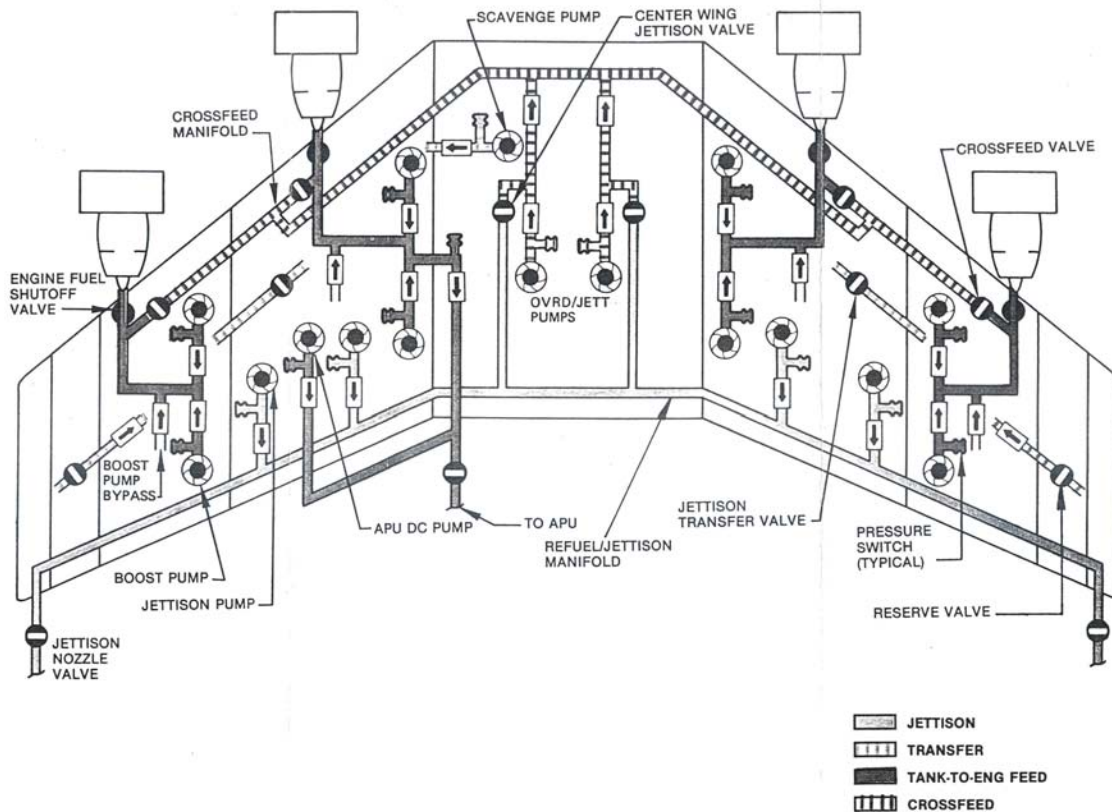
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Fuel Feed

Two boost pumps in each main and center tank normally provide fuel pressure for all operations. After being sensed by a low-pressure switch, each boost pump output flows through a check valve and into a line common to both pumps.

Main tank fuel flows through the engine fuel shutoff valve to the engine and, if selected, into the crossfeed manifold. Center tank fuel, having passed the check valves, flows into the crossfeed manifold and can supply fuel to any or all engines.



The basic fuel management configuration is main tanks to their respective engine, with one crossfeed valve open to pressurize the manifold. Reserve tank fuel is drained into the adjacent main tank when weight restrictions are met. When center tank fuel is being fed, its higher pump pressure gives it priority over main tank fuel.

Pumps

Main Tank Pumps

Two boost pumps are located in each main tank. One pump is located forward and the other pump is located aft in each tank to provide positive pressure during all flight altitudes. Separate 115V ac buses power pumps in the same tank; failure of any one bus affects only one pump in any tank.

Control is through FWD and AFT Pump switches.

The aft pump in the No. 2 main tank can also be turned on by the APU system, regardless of pump switch position. Low-pressure lights indicate pump operation.



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A boost pump bypass check valve is located in each main tank. It opens to minimize flow restrictions when operating on gravity feed.

Center Tank Pumps



The center tank pumps are called override/jettison (OVRD/JETT) pumps. Their output pressure is approximately twice that of the main tank boost pumps. These pumps are also used for fuel jettison.

Control is through LEFT and RIGHT pump switches and low-pressure lights indicate operation.

Fuel Valves

Engine Fuel Shutoff Valves

Each engine has an electrically operated shutoff valve located at the top of the engine pylon, in the associated tank. The valve controls fuel feed to the engine regardless of the source. Primary control is through an engine valve (ENG VALVE) switch. In addition, the valve will close when the:

- Start lever is in the CUTOFF position
- Engine fire handle is pulled



Crossfeed Valves

Each main tank/engine combination has an electrically operated crossfeed valve to connect it to the crossfeed manifold. Control of the valves is through individual rotary type switches. A CROSFEEED VALVE light indicates valve position.



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Fuel Jettison System



The jettison system provides a means to rapidly reduce gross weight. Fuel is pumped overboard through two nozzles, one located on each wingtip. A total of 6 pumps are used; the OTBD and INBD in each of the No. 2 and No. 3 main tanks, and the LEFT and RIGHT OVRD/JETT pumps in the center wing tank.

Fuel in the No. 1 and No. 4 main tanks is transferred into the No. 2 and No. 3 main tanks by gravity and from there is pumped to the center tank,

and then overboard. Reserve tank fuel is transferred into the respective main tank. Standpipes in each main tank assure a minimum reserve.

The average jettison rate is approximately 1000 pounds per minute per pump. A fuel jettison panel on the flight engineer's panel provides controls and indicators for jettison system operation.



Fuel System Controls and Indications (Upper Panel)



Fuel used Reset Switch

When pressed, resets FUEL USED gauges to zero



Fuel Used Gauge

Totalizes the pounds of fuel used by the respective engine.



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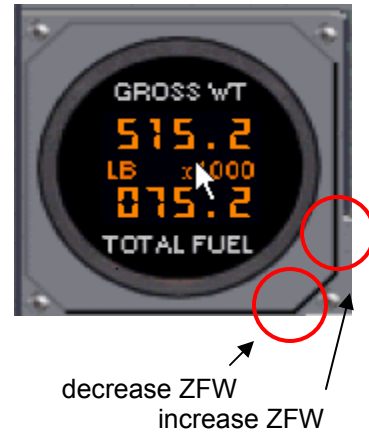
Gross Weight and Total Fuel Gauge

GROSS WT: is set clicking hidden spot on lower right of gauge block. (GROSS WT = ZFW (zero fuel weight) plus weight of fuel.)

Clicking momentarily indicates the increasing/decreasing ZFW. The longer the click is held, the more the ZFW increases or decreases. There is a “+” hidden click zone and “-” hidden click zone to increase or decrease the value, as noted.

Within 10 seconds after releasing the increase or decrease click action, the GROSS WT is again indicated (ZFW + Total Fuel).

GW decreases as fuel is used



Note: ZFW is the weight of the empty aircraft, plus the weight of the passengers and crew, plus the weight of the cargo and baggage. The ZFW plus Total Fuel Weight together are the Gross Weight of the Aircraft, an indication of MTOW, the mean takeoff weight for purposes of setting V speeds.

Fuel Heat Switch

Controls engine bleed air to the fuel heater

OPEN: opens fuel heat valve

CLOSED: closes fuel heat valve

Icing/Fuel Heat Light

Indicates condition of fuel filter and Fuel Heating operation

ICING ON: filter is clogging

HEATER ON: if heater switch is on



Engine Valve Switch

Controls engine fuel shutoff valve. In series with fire handle and start lever switches.

- Valve opens when all three are positioned to open the valve, i.e. fire handle closed, start lever switch to RICH or IDLE
- Valve closes when any of the three is positioned to close the valve, i.e. fire handle is pulled, start lever switch to CUTOFF



Engine Valve Light

Indicates valve position:

ON: valve is closed

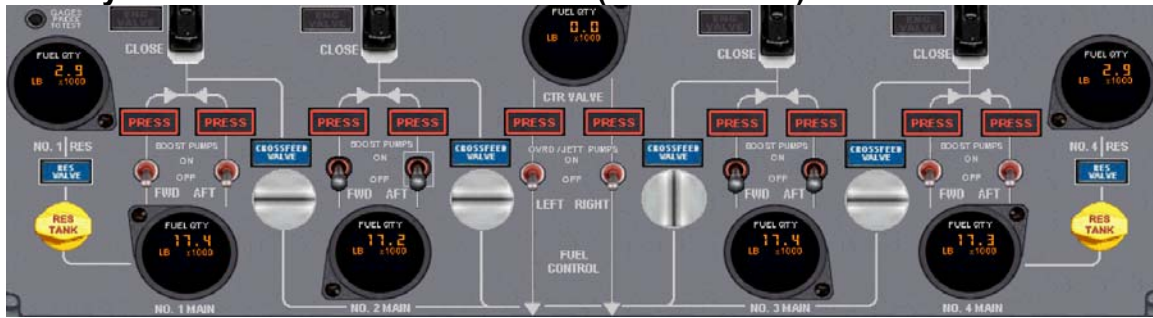
OUT: valve is open



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Fuel System Controls and Indications (Lower Panel)



Fuel Quantity Gauge

Indicates actual pounds of fuel in that tank, digital display is in pounds x 1000.



Reserve Valve Switch

Controls reserve valve. Orientation of switch indicates position
Vertical: Reserve valve open to drain reserve tank
Horizontal: Reserve valve closed



Reserve Valve Light

On: lights momentarily while valve is in transit (shown opening here)
Off: valve is fully open (vertical) or fully closed (horizontal)



Crossfeed Valve Switch

Controls crossfeed valve
Vertical: Crossfeed valve is open.
Horizontal: Crossfeed valve is closed.



Crossfeed Valve Light

On: Valve in transit. (shown opening here)
Out: Valve fully open or closed



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Gauges Press-to-Test Switch

Tests amplifiers and motors on all quantity gauges. When pressed all Fuel Quantity Gauges are set to 888.8 and when released, return to the value actually in the respective tank.



Boost Pump Switches

Control respective (FWD and AFT) pump.

Pump Pressure Lights

On: Pump pressure is low. (Pump may be off)
Out: Pump pressure is normal.



Override/Jettison Pump Switches

Control respective (LEFT or RIGHT) pump.

Pump Pressure Lights

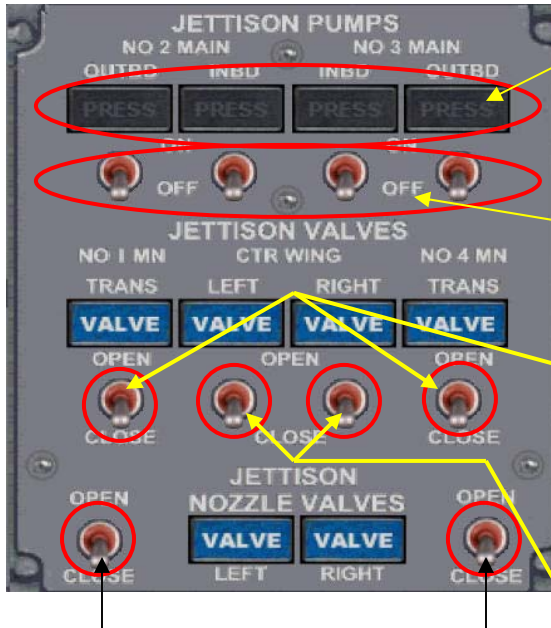
On: Pump pressure is low. (Pump may be off)
Out: Pump pressure is normal



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Fuel Jettison Panel



Pump Pressure lights

On: pump pressure is low. If dumping above 15,000 feet, may come on with normal pumping.
Out: Pump pressure is normal or pump switch is off

Jettison Pump Switches

Switches control ac pumps and PRESS lights
ON: Pump running and PRESS light is armed
OFF: Pump off and PRESS light disarmed.

No. 1 and No. 4 Main Jettison Transfer Valve Switches

Control the transfer valves for No. 1 and 4 main tanks.

OPEN: Outboard main drains into adjacent inboard tank.

Jettison Nozzle Valve Switches

One switch for each valve, left and right.
All tanks can dump through either nozzle valve.

OPEN: Opens the respective jettison nozzle valve.

CLOSE: Closes the respective jettison nozzle valve

Center Wing Jettison Valve Switches

One switch for each valve, left and right.
OPEN: Connects the respective left or right override pump to the jettison manifold.
Also connects inboard tank jettison pumps to the crossfeed manifold.

Jettison and Nozzle Valve Lights

On: Valve is in transit.

Out: Valve is fully opened or closed



Operations

Preflight

- Check that all jettison switches are in the OFF or CLOSE position, and that all amber and blue lights are out
- Close the reserve valves so the tanks do not drain during refueling. Check that the RES VALVE lights are out.
- Set the crossfeed valves. Normally number one and four should be open, number two and three closed. Check the crossfeed lights are out.
- Check that the ten BOOST PUMP switches are off and the ten PRESS lights are on. If the APU is running, No. 2 AFT light will be out.
- Check that the four engine valve switches are set to OPEN. All ENG VALVE lights should be out.
- Check that the four FUEL HEAT switches are set to CLOSE and that the ICING lights are out. The HEATER light should also be out.
- Press FUEL USED RESET switch until all four gauges read zero.
- Verify your fuel load, record the quantities and test the gauges.

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There are many configurations of the fuel system depending on the various phases of flight and the actual loading of the tanks based upon flight and load requirements.

Engine Start



- All Crossfeed Valves OPEN
- Number 2 Main Tank Boost Pumps ON.

Taxi and Takeoff

With less than 10,000 lbs of Center Fuel



- Number 1 and number 4 crossfeed valves OPEN
- Number 2 and number 3 crossfeed valves CLOSED
- Main number 1, number 2, number 3 and number 4 Boost pumps ON
- Center Wing Over/Jett Pumps OFF

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More than 10,000 lbs. of center fuel



- Center Wing Over/Jett Pumps ON
- Number 1 and number 4 crossfeed valves OPEN
- Number 2 and number 3 crossfeed valves CLOSED
- Main Number 1, number 2, number 3 and number 4 Boost pumps ON

Climb and Cruise

With less than 10,000 lbs. of Center Fuel

Do not use more than 16,000 lbs. total of main tank fuel before using all center tank fuel.

Use center tank fuel to all engines until wing tank fuel, if any, is consumed.

More than 10,000 lbs. of center wing fuel



- Maintain takeoff fuel configuration until setting climb power. Use center tank fuel to all engines until center tank fuel is consumed.
- Continue flight using main tanks No. 2 and No. 3 to all engines until the fuel quantity in main tanks No. 2 and No. 3 equals the quantity in main tanks No. 1 and No. 4 plus adjacent reserve tanks.
- When center tank is empty as indicated by the pump low-pressure lights being illuminated, turn OVERRIDE/JETTISON pumps OFF.

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Center Tank Empty, No. 2 and 3 Main Greater than No. 1 and 4



- Leave all other pumps ON until the quantity in main tanks No. 1 and No. 4 reach 23,500 pounds. At this time turn the booster pumps OFF for tanks No. 1 and No. 4.
- Keep all crossfeed valves OPEN.
- Continue this configuration until the inboard main tanks No. 2 and No. 3 quantities equal No. 1 and No. 4 plus adjacent reserves tanks.

Center Tank Empty, No. 2 and 3 Main equal 2 than No. 1 and 4 plus reserves



When this occurs, turn the boost pumps ON for No. 1 and No. 4, and then CLOSE crossfeed valves 2, 3, and 4. Leave No. 1 crossfeed valve OPEN, this ensures the crossfeed manifold will remain pressurized.

This configuration is known as TANK to ENGINE.

Descent and Landing

Fuel feed configuration should be set to TANK to ENGINE as above.

Routine System Monitoring

During routine panel scan, always compare fuel quantity gauges between outboards, between inboards and between reserves. This will ensure that crossfeed is progressing normally and provides early recognition of fuel transfer between tanks

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Fuel Heat

Open - Opens fuel heater valve, which permits flow of engine bleed air through the fuel heater.
Close - Closes fuel heater valve, to prevent the flow of engine bleed air through the fuel heater.

In real life it takes about 2 hours for fuel icing to occur at high altitudes and very cold conditions. Many trans Atlantic pilots will fly at lower altitudes just to avoid the fuel icing but if you insist on being up there, icing will occur. We have reduced the time from 2 hours to about 1 hour. This timer is not effected by the simulation rate.

Icing Parameters: - -37° C TAT and above 36,000 feet, otherwise the timer stops now,
General reset will be below 30000 feet - that's the "melting"

- 1 will ice after 58 min.
- 2 will ice after 57 min.
- 3 will ice after 59 min.
- 4 will ice after 60 min.

Heater will reset the Icing after 2 minutes

Fuel Jettison

In the unlikely event that mechanical difficulties are encountered during or after the takeoff, it might be necessary to either return to the airfield from which you just took off, or you might need to land at an en-route airport to rectify the problem. Main Tank Boost Pumps - ON



- Crossfeed Valves - CLOSED
- Center Wing Ovrdr/Jett Pumps - ON if fuel in tank
- No's 2 and 3 Main Jettison Pumps -ON
- Center Wing Jettison Valves - OPEN if fuel in tank
- Jettison Nozzle Valves -OPEN
- Normal jettison rate is at least 4,000 lbs. per minute
- When total of Main Tanks No. 2 and No. 3 equals 40,000 lbs. or less:
 - No. 1 & 4 Main Jettison Transfer Valves - OPEN
- **To Stop Fuel Jettison:**
 - Center Wing Ovrdr/Jett Pumps - OFF
 - No. 2 & 3 Main Jettison Pumps - OFF
 - Jettison Transfer Valves - CLOSE
 - Center Wing Jettison Valves - CLOSE
 - Jettison Nozzle Valves - CLOSE

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Fuel Loading

NOTE ABOUT: FUEL LOADING

The Pressure Refueling Panel may only be accessed when the engines are COMPLETELY shutdown. A complete spool down of the engines may take up to 2 minutes.

- **Refueling the Ready for Pushback aircraft MUST be done from the Pressure Refueling Panel and at no time should it be attempted from the FS2004 Aircraft Menu.**

Fuel Loading Tolerances and Limitations

All tank limitations are in-flight limitations. Loading errors in excess of the limitations are acceptable provided all excess fuel can be consumed during taxi and distribution is correct for takeoff.

Reserve Tanks

May be empty only if TOGW is 600,400 lb or less.

Filling reserve tanks for every flight is a standard procedure for many airlines with the intention of improving wing structural loading.

Main Tanks

Quantities in symmetrical tanks should be equal. Main tank fuel should be distributed in the following sequence:

- Load main tanks so that inboards equal outboards plus reserves until each outboard tank is 24,600 maximum.
- Load inboards until full

Center Tank

- Main tanks should be full before center tank fuel is loaded

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Fill'er up

Fuel loading is a Ground Maintenance function in real life, but the left wing fueling panel (both wings have fueling input, but only the left has the control panel as depicted below) has been included in this software model.



There is a manual and automatic process to load fuel using the fueling panel. We will review the automatic process first.

Automatic Fuel Loading

For this example, assume we are at the gate, and currently there are 57,200 pounds of fuel aboard. For our next flight we have determined that we need 158,000 pounds of fuel on board, so we need to load approximately 100,000 pounds. Here is a view of our current fuel panel:



The Automatic fuel loader will load the fuel in the following manner:

- No 1 and No 4 outboard tanks to capacity first (29,615 pounds each)
- No 2 and No 3 inboard tanks, next up to capacity or to the total required. (82,010 pounds each)
- Center tank to capacity, or the amount required ... or NONE at all if appropriate. (86,360)

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As you can see from the fuel panel depicted above, No 1 and No 4 have 14.8 thousand pounds each, while No 2 and No 3 have 8.1 thousand pounds of fuel. The center tank has 5.5 thousand pounds. The total fuel on board, as indicated in the fuel gauge located in the upper left of the panel is 57.2 thousand pounds. So, if we want to have a fuel load of 158,000 pounds, we need to load approximately 100,000 pounds.

To do this, open up the fueling panel, by clicking in the upper right, then

1. switch on the panel
2. dial in the amount of fuel you want using the SELECT QUANTITY dials 158.0
3. toggle the ACTUAL/PRESELECT switch to the left. This calculates the amounts to load to each tan. The switch is a momentary switch, returning to the starting point automatically.
4. Switch the ALL VALVES PRESELECT to OPEN .. watch the tanks filling.



When the fueling is complete, switch off the ALL VALVES PRESELECT switch and note that the tanks indeed have been "topped-off".



Switch the PRESSURE FUELING PANEL power switch to OFF and close the door by again clicking in the upper right of the fueling panel.

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Manual Fuel Loading

In addition to automated fuel loading, there is also a manual procedure available. Using the manual procedure means that you will need to plan not only the TOTAL fuel load required, but you will need to load each of the tanks correctly and as noted in this sequence:

- Outer mains 1 and 4
- Inner mains 2 and 3
- Once outer and inner are at capacity, then center tank

We will start this example with the same initial conditions as the “automatic” procedure above.



The aircraft currently has 57,200 pounds of fuel, No 1 and No 4 have 14.8 thousand pounds each, while No 2 and No 3 have 8.1 thousand pounds of fuel. The center tank has 5.5 thousand pounds.

The dispatch office tells we will need 200,000 pounds for our next flight, so we need to load 143,000 pounds, distributed correctly, according to the rules listed above. Remember the capacities of the tanks are:

- No 1 and No 4 outboard tanks - 29,615 pounds each
- No 2 and No 3 inboard tanks, 82,010 pounds each
- Center tank capacity, 86,360 pounds

You have to do some arithmetic to figure out how much to load in each tank.

	Res 1	Main 1	Main 2	Center	Main 3	Main 4	Res 2	Total
Capacity	3350	29615	82010	86360	82010	29615	3350	316310
Current	2900	14800	8100	5500	8100	14800	2900	57100
Available	450	14815	73910	80860	73910	14815	450	259210
Fill	0	14815	56685	0	56685	14815	0	143000
Current	2900	14800	8100	5500	8100	14800	2900	57100
	2900	29615	64785	5500	64785	29615	2900	200100

The table above indicates the capacity of the 7 tanks, the distribution of current fuel and the amount remaining to be loaded to each tank to fill it.

The green striped line is the amount to add, the yellow represents the resulting load for each of the tanks when we are complete.

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Manual loading is now simply a process of

1. Opening the fueling door by clicking on the upper right of the door
2. Power on the fuel panel
3. Selecting the Main 1 switch to ON and watching the tank fill, while filling the blue light is on
4. Selecting the Main 4 switch to ON and watching the tank fill, while filling the blue light is on
5. Selecting the Main 2 switch and filling until the meter reads 64785, then switch off, while filling the blue light is on
6. Selecting the Main 3 switch and filling until the meter reads 64785, then switch off, while filling the blue light is on

Here is what you will see while fueling Main 1, note the blue light on.



The total quantity gauge increases as you load fuel. In the case of Main 1 and 4, loading will stop when the tanks reach capacity

IMPORTANT NOTE:

Why should you not use the FS2004 Fuel Menu to change fuel quantities?

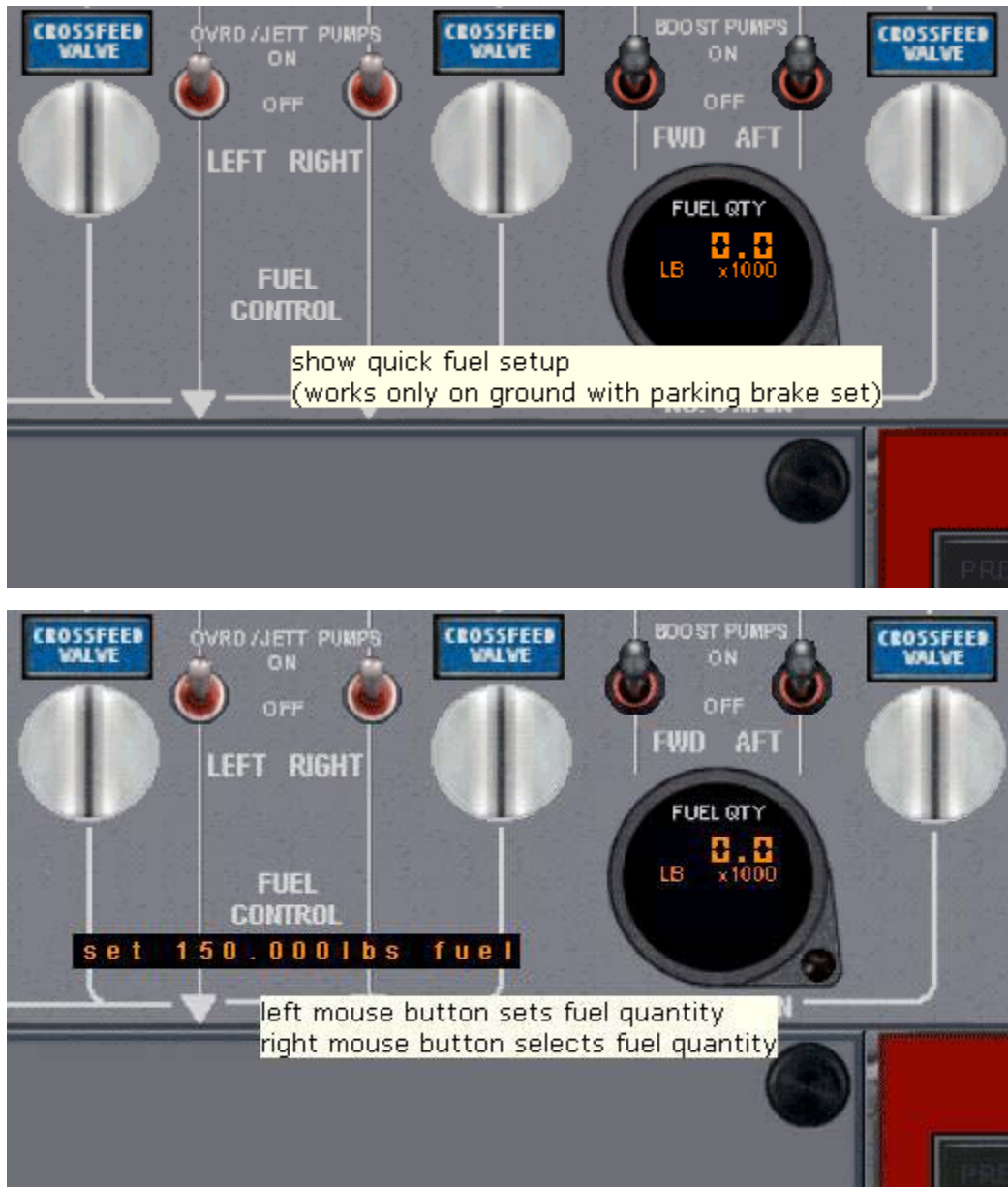
It is VERY important that tanks be fueled in the correct order. Fuel goes to the reserves first, then to No. 1 & No. 4 Mains and then to N0.2 and No. 3 Mains and lastly fuel added to the center tank if required. Working in the order stated, tanks must be FILLED before moving on to the next set of fuel tanks. It is not uncommon for the center tank to be empty or at standpipe level.

If you put fuel in the center tank and not in the other tanks you are looking for trouble and will surely get it. We offer no support to anyone who uses the FS2004 fuel menu to adjust fuel tank values. The FS2004 Fuel Menu is for other add-ons but is not for Ready for Pushback. Our systems and procedures are too complex and realistic for this primitive method to be used

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HOT TIP: Quick Fuel Menu



You can select 25.000, 50.000, 100.000, 150.000, 200.000, 250.000, 300.000 and max. lbs fuel.

Left mouse click on the words **FUEL CONTROL** will show the line with the quick setup settings. This will only work if we are on ground and have the parking brake set.

The line pops up, and we can toggle the settings with the right mouse button, and we can set the displayed fuel quantity with the left mouse button. After 10 seconds with no action the line disappears.

This method will place the correct amount of fuel in the proper tanks in the proper order to keep the aircraft in balance.

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ADDITIONAL FUEL SYSTEM NOTES AND USAGE HINTS:

BASIC INFORMATION YOU SHOULD KNOW

- A crossfeed valve in the vertical position (OPEN) means that the tank is connected directly to the fuel manifold.
- The fuel manifold is a pipe that runs across the leading edge of the wing and receives fuel from tanks and feed engines.
- A crossfeed valve in the horizontal position (CLOSED) means that a tank is feeding fuel directly to the associated engine.
 - Tank No. 1 feeds Engine No.1
 - Tank No. 2 feeds Engine No.2
 - Tank No. 3 feeds Engine No.3
 - Tank No. 4 feeds Engine No.4
- The Center Wing Tank can only feed the fuel manifold and can never feed directly to a specific engine.
- Mains No. 1, 2, 3 and 4 can be configured to feed direct to the associated engine (Tank-to-Engine) or to the Fuel Manifold.
- Here is a twist to it:
 - The Boost pumps in the center tank are much more powerful than the boost pumps in the mains. This means that they will override the main that are also connected to the manifold. This is why they are called OVRD/JET pumps. The JET part refers to them also being used to jettison fuel.
 - If Main No. 1 were configured to feed the manifold and the Center Wing tank had fuel and the Boost OVRD pumps were on, Engine No. 1 would receive it's fuel from the center tank and not from Tank No. 1 even though it is connected to the manifold along with the center. No. 1 Boost pumps would be used to help pressurize the manifold but can not supply enough boost on it's own to overcome the pressure from the center tank.
- Reserve Tanks can never feed an engine or the fuel manifold but can only be transferred to their respective Main Tanks.
- A Main Tank supplying fuel directly to an engine (tank-to-engine) would normally have its Boost Pumps ON but can also be used as gravity feed. The center tank does not gravity feed the manifold as the manifold needs to be pressurized.
- Main tanks connected to the manifold require Boost Pumps to be ON before any fuel is fed to the manifold. If all of the main tanks are connected to the manifold and no Boost Pumps are ON, all 4 engines will stall. If one set (fore and aft) of pumps are on, all 4 engines will be fed from the Boost Pump associated tank.

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Fuel Tank Sequence and Set-up

Engine Start

- All Crossfeed Valves OPEN
- Number 2 Main Tank Boost Pumps ON.



In this configuration, Main No. 2 is feeding fuel to and is pressurizing the Fuel Manifold. All engines and the APU are receiving their fuel from No.2 Main Tank through the Fuel Manifold.

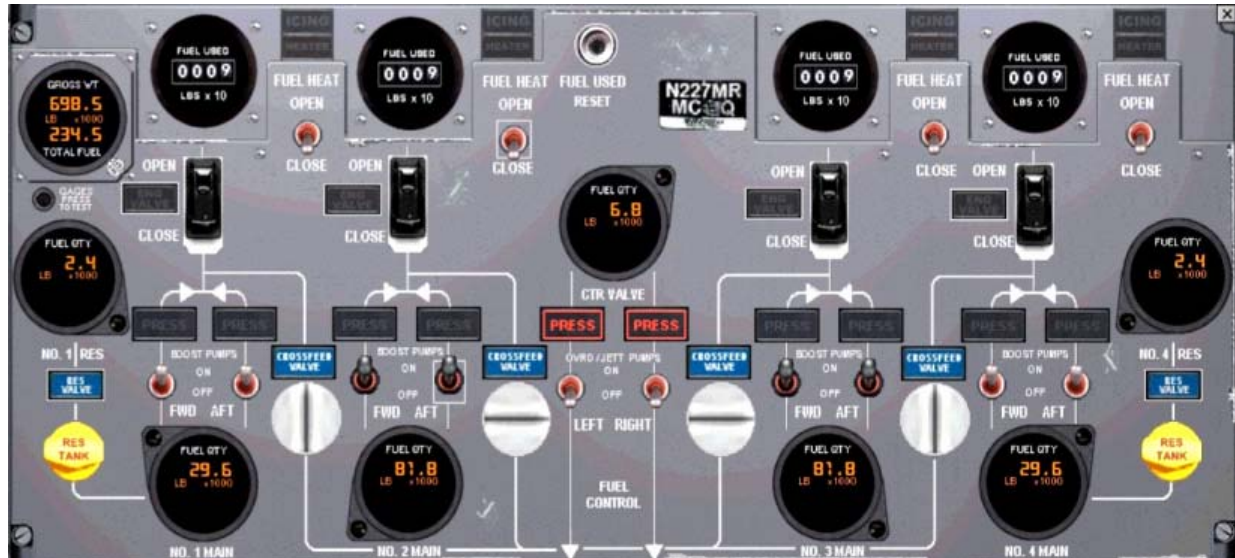
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Taxi and Takeoff

With less than 10,000 lbs. Of Center Wing Fuel

- Number 1 and number 4 crossfeed valves OPEN
- Number 2 and number 3 crossfeed valves CLOSED
- Main Number 1, number 2, number 3 and number 4 Boost pumps ON
- Center Wing Over/Jett Pumps OFF



In this configuration, Mains No. 1 and No. 4 are feeding fuel to the Fuel Manifold and are pressurizing the manifold. Main No. 2 and No. 3 are in a tank to engine configuration. The center tank is not being used.

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Climb

With less than 10,000 lbs. Of Center Wing Fuel

- Do not use more than 16,000 lbs. total of main tank fuel before using all center wing tank fuel.
- Use center wing tank fuel to all engines until center wing tank fuel, if any, is consumed.

More than 10,000 lbs. Of center wing fuel

- Maintain takeoff fuel configuration until setting climb power. Use center tank fuel to all engines until center tank fuel is consumed.
- Continue flight using main tanks No. 2 and No. 3 to all engines until the fuel quantity in main tanks No. 2 and No. 3 equals the quantity in main tanks No. 1 and No. 4 plus adjacent reserve tanks.
- When center tank is empty as indicated by the pump low pressure lights being illuminated, turn OVERRIDE/JETTISON pumps OFF.
- Leave all other pumps ON until the quantity in main tanks No. 1 and No. 4 reach 23,500 pounds. At this time turn the booster pumps OFF for tanks No. 1 and No. 4.
- Keep all crossfeed valves OPEN.
- Continue this configuration until the inboard main tanks No. 2 and No. 3 quantities equal No. 1 and No. 4 plus adjacent reserves tanks.
- When this occurs, turn the boost pumps ON for No. 1 and No. 4, and then CLOSE crossfeed valves 2, 3, and 4. Leave No. 1 crossfeed valve OPEN, this ensures the crossfeed manifold will remain pressurized.



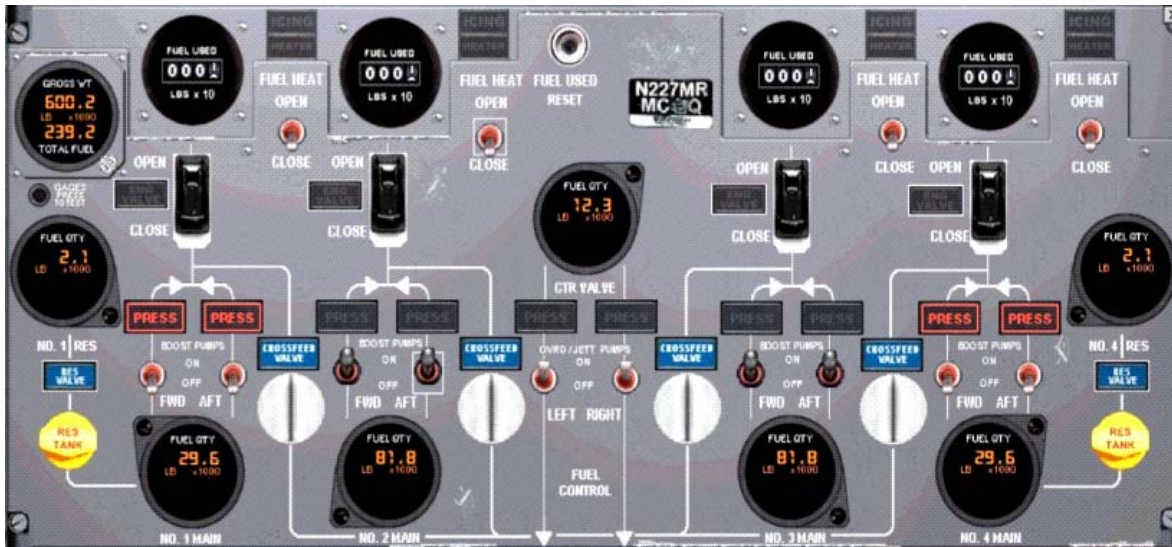
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Cruise

Usable Fuel in Center Wing Tank

- Center Wing tank to all engines UNTIL: Empty
- All crossfeed Valves OPEN
- No. 2 and No. 3 Main Tank Boost Pumps ON
- Center Wing Tank OVR/JETT Pumps ON
- No. 1 and No. 4 Main Tank Boost Pumps OFF



This configuration shows all tanks connected to the fuel manifold. Since the center tank has usable fuel and the OVRD/JET pumps are on, why would we bother with Boost Pumps for Mains No. 2 and No. 3?

Answer: Redundancy. Assist in pressurizing the Fuel Manifold. When the center tank does run out of fuel we still want pressure on the manifold and the larger Mains No. 2 and No. 3 now take over automatically.

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No Usable Fuel in Center Wing Tank

- All crossfeed Valves OPEN
- No. 2 and No. 3 Main Tank Boost Pumps ON
- Center Wing Tank OVR/JETT Pumps OFF
- No. 1 and No. 4 Main Tank Boost Pumps OFF



When an unusable fuel level has been reached the PRESS lights will illuminate as a warning when the Boost Pump switches are ON. This level for this to occur is approximately:

- **Center = 2,000 lbs**
- **Mains = 00 lbs**

Another term for this low level is "Standpipe Level".

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Scavenge Pump



When the center tank has reached stand pipe level of 2,000 lbs the center tank low pressure lights will be illuminated. Turn the OVRD/JET pumps OFF. At the top center of the fuel panel you will find the Scavenge Pump. Turn the Scavenge Pump ON. The Scavenge Pump will transfer the remaining 2,000 lbs. of fuel from the center tank to Main No. 2 and this process will take approximately 30 minutes.

Reserve Fuel Transfer

Initiate transfer of reserve tank fuel at start of descent or when the fuel quantity in the main tanks No. 1 or No. 4 reaches 5,000 pounds should that condition occur prior to descent.

If a transfer must be made for some reason before the above conditions are met, follow the guide lines below.

Reserve Fuel May be Transferred When:

- All Center Wing Tank fuel has been used.
- Fuel Quantity in main tanks No. 1 or No. 4 is less than 23,500 pounds per side.
- Gross weight of aircraft is 703,000 lbs or less.

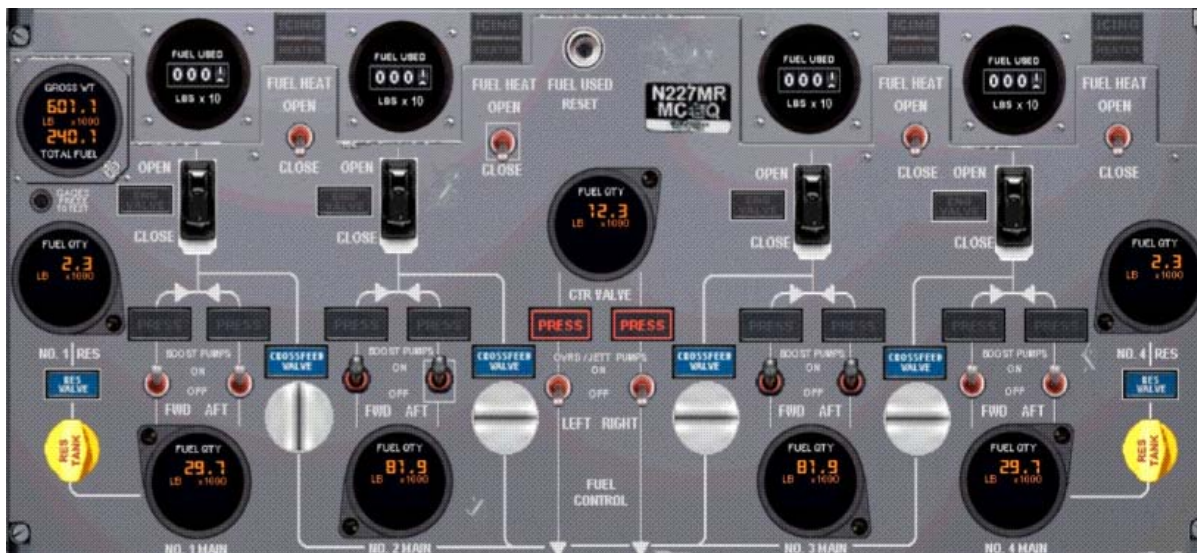


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Landing

- No. 1 Crossfeed Valve OPEN
- All Main Tank Boost Pumps ON
- No. 1 and No. 4 Reserve Valves OPEN



FUEL MANAGEMENT

GENERAL

Boost pump pressure is required during flight to preclude the possibility of engine surge and/or flameout.

For fuel sampling, use takeoff fuel configuration for a minimum of four minutes at idle thrust consumption or equivalent fuel consumption at any time prior to initiating takeoff.

LATERAL FUEL BALANCE

Fuel balance will be maintained during normal operation. Fuel balance procedures may be delayed until the total imbalance reaches 1,000 lbs.

Maintain lateral fuel balance by use of boost pump control. Do not use less than three pumps to feed all engines.

TAKEOFF WITH RESERVE TANKS EMPTY

If takeoff is planned with the reserve tanks empty and additional fuel is required, it may be added to the four main tanks provided the following limitations are observed:

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- Center wing tank must be empty.
- Fuel in any main tank must not exceed 28,000 lbs.
- Takeoff weight must not exceed 703,000 lbs.

LANDING WITH RESERVE TANKS FULL

There are no limitations on fuel remaining in any tank for landing. Therefore, if the next takeoff requires fuel in the reserve tanks, landing is permissible with reserve tanks full.

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MINIMUM FUEL AT DESTINATION

Early in the flight a value for minimum fuel should be determined. This value is by no means fixed; rather, as the flight approaches the destination, it should reflect any additional information as it becomes available.

Minimum planned landing fuels are:

Destination (all flights) - 23,000 lbs (Domestic and International)

Alternate (all flights) – 15,000 lbs (Mandatory)

Minimum planned landing fuel at the alternate may not be reduced below 23,000 lbs. This is based on planned flight to the destination, missed approach, diversion to, and immediate landing at the alternate with 23,000 lbs. Once the flight has departed, if this fuel figure cannot be met, the Captain and Dispatcher should discuss alternate measures to meet this requirement. These may include selecting an alternate closer to the destination, selecting an alternative cruise mode.

MINIMUM FUEL FOR LANDING

No flight should ever plan to land with less than 12,000 lbs. This value includes:

Fuel at Touchdown 2,425 lbs
Execute a Go-Around 5,730 lbs
Fuel Indicator Error 4,000 lbs

The value for Fuel at Touchdown ensures adequate fuel boost pump coverage to keep the engines running for reversing and throughout the landing roll.

The value for Execute a Go-Around is the amount required to execute a pull up at runway threshold to 1,000 feet AFE, fly a pattern, intercept a 3 degree glideslope approximately 2½ miles from the end of the runway and continue to landing.

The value for Fuel Indicator Error represents the maximum design quantity error for the main tanks (center and reserve tanks empty).

Added together as a Minimum Fuel for Landing the total value ensures that sufficient fuel will be onboard at the threshold in a worst-case condition with the maximum indicator error (indicators read too high).

GPWS - Ground Proximity Warning System



The Ground Proximity Warning System alerts the flight crew when one of the following thresholds are exceeded, between 50 and 2,450 feet radio altitude.

- Excessive descent rate
- Excessive terrain closure rate
- Altitude loss after takeoff or go-around
- Unsafe terrain clearance during high speed flight or while in the landing configuration
- Below Glide Slope Deviation alert.

The first 4 aural alerts are accompanied by a red pull up light.

NOTE: The GPWS will not provide a warning of flight toward vertically sheer terrain or of slow descent into unprepared terrain while in a landing configuration.

Modes of Operation

Mode 1 - Excessive Descent Rate

Mode 1 has two boundaries and is independent of aircraft configuration. Penetration of the first boundary generates the repeated aural alert of "SINK RATE". Penetrating the second boundary causes the repeated aural warning of "WHOOH WHOOP PULL UP", until the rate of descent has been corrected.

Mode 2 - Excessive Terrain Closure Rate

Mode 2 monitors mach number, radio altitude and radio altitude rate of change, barometric altitude and airplane configuration. Mode 2 has 2 boundaries. Penetrating the first boundary causes an aural alert of "TERRAIN" repeated twice, followed by the repeated aural alert "WHOOH WHOOP PULL UP". After leaving the PULL UP area, the repeating TERRAIN message will again be heard.

If the landing gear and flaps are in the landing configuration and the aircraft is below 700 feet radio altitude, only the repeating TERRAIN aural alert will occur. The aural warning "WHOOH WHOOP" is inhibited.

If landing gear and wing flaps are not in landing position when leaving the "PULL UP" area, 300 feet of barometric altitude must be gained before the repeating aural TERRAIN alert is silenced.

Mode 3 - Altitude Loss After Take-off or Go-Around

Mode 3 provides an alert if a descent is made during initial climb or a go-around. The aural alert is a voice message of "DON'T SINK", repeated until the flight condition is corrected.

Mode 3 is effective between 50 and 700 feet radio altitude after take-off with flaps or gear raised or during a missed approach when the gear and flaps are raised. Mode 3 does not arm until below 200 feet radio altitude.

Mode 4a - Unsafe Terrain Clearance with landing gear not down

The terrain clearance mode with gear retracted, is armed after take-off upon climbing through 700 feet radio altitude. The aural alert "TOO LOW GEAR" is sounded when the envelope is penetrated at less than .35 mach. When the envelope is penetrated at more than 0.35 mach, the aural alert TOO LOW TERRAIN is sounded and the upper boundary of the envelope is raised to

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1000 feet radio altitude. The applicable voice message will be repeated until the flight condition has been corrected.

NOTE:

If flaps are in landing position, mode 4A TOO LOW TERRAIN aural is inhibited.

Mode 4b - Unsafe Terrain Clearance with Flaps Not in Landing Position

This mode provides an alert when the gear is down and the flaps are not in the landing position. If the envelope is penetrated at less than 0.29 mach with the flaps not in landing position, the aural alert "TOO LOW FLAPS" is sounded. When the envelope is penetrated at more than 0.29 mach, the aural alert of "TOO LOW TERRAIN" is sounded and the upper boundary of the envelope is increased to 1000 feet radio altitude. The applicable voice message is repeated until the condition is corrected. The TOO LOW GEAR alert takes priority over TOO LOW FLAPS.

NOTE:

If the flaps are in landing position, mode 4B TOO LOW TERRAIN IS INHIBITED.

Mode 5 - Below Glide Slope Deviation Alert

This mode alerts the flight crew of a descent of more than 1.3 dots below an ILS glide slope. The envelope has two areas of alerting, soft and loud. In both areas, the alert is a repeated voice message of "GLIDE SLOPE" and illuminating of the BELOW G/S Lamp. The voice message amplitude is increased when entering the loud area. In both areas, the voice message repetition rate is increased as glide slope deviation increases and radio altitude decreases.

- The mode is armed when a valid signal is received by the captains glide slope receiver, landing gear is down.
- The mode may be cancelled or inhibited by pressing the INHIBIT BELOW G/S switch. The mode will rearm again when above 1,000 feet Radio Altitude.
- Mode 1 through 4 have priority over mode 5 aural alerts, however, both PULL UP and BELOW G/S lights could be illuminated at the same time.

The above modes are portrayed as accurately as we could do so with the limitations of Flight Simulator 2000. The above information has been taken directly from the Boeing 747-200 Operations Manual.

Inhibit G/S

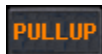


Inhibit Below G/S is a small button to the right of the placard. Only functions when alert is sounding.



When below Glideslope a warning light and aural warning will sound.

Pull Up



Pull Up Warning Light Illuminated in these cases

- Excessive descent rate
- Excessive closure rate
- Altitude loss after takeoff or go around
- Non Landing configuration descent