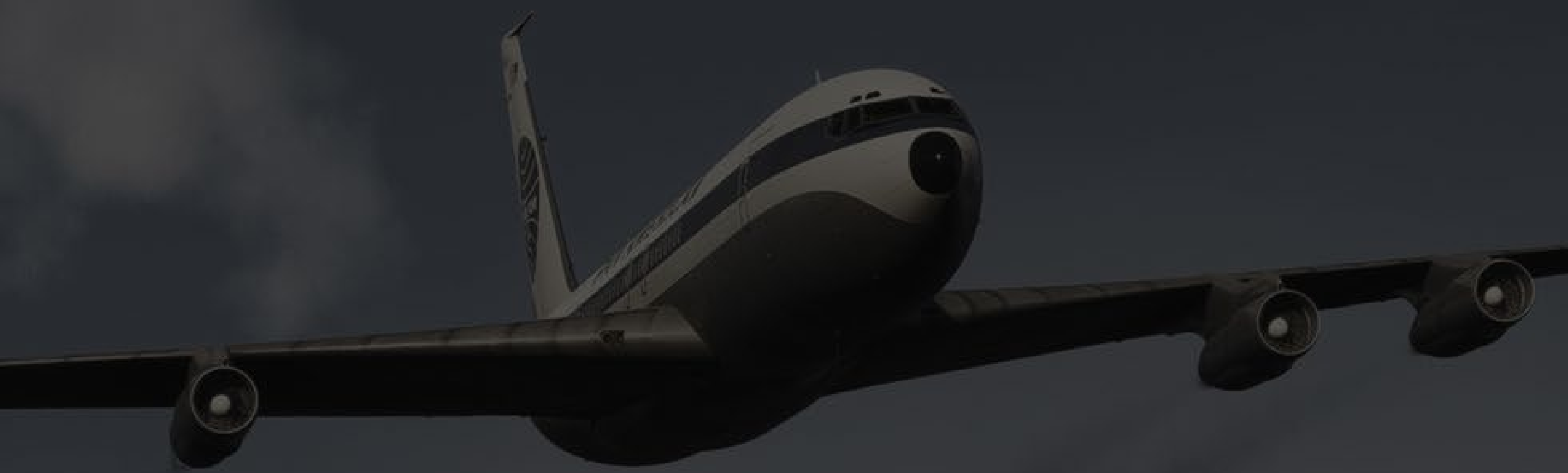
Boeing 707-320C

WORKING TITLE

for Microsoft Flight Simulator 2024



Microsoft Flight Simulator 2024

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PART I

INTRODUCTION & OVERVIEW

PART I — INTRODUCTION & OVERVIEW

Chapter 1 — Introduction

About this chapter

Introduces the Boeing 707-320C: its history, its place in commercial aviation, the convertible -320C variant modeled in this simulation, and the aircraft's key specifications.

Figure 1-1 Boeing 707-320C in TWA livery

1.1 About the Boeing 707-320C

The Boeing 707-320C is a four-engine, narrow-body commercial jet airliner developed and manufactured by Boeing. It is the final and most versatile variant of the historic 707 family — the aircraft that launched the Jet Age. This manual describes the -320C as recreated for Microsoft Flight Simulator 2024, developed jointly by Working Title Simulations and iniBuilds, faithfully modeling the aircraft's systems, flight characteristics, and three historically accurate cockpit configurations.

1.2 Historical Background

By the early 1950s, Boeing had built a strong lineage of military aircraft, including the B-17 Flying Fortress, the B-47 Stratojet, and the B-52 Stratofortress. With an eye on the growing commercial market, the company unveiled the 707 in 1954, and its prototype first flew on December 20, 1957. The aircraft quickly became one of the most successful in Boeing's history, launching the legendary “7x7” lineage. The initial 707-120 entered airline service in October 1958, with improved variants following on routes across the globe.

The airframe also had a long military career. Air forces worldwide operated 707-based tankers, and the U.S. Air Force built several radar and surveillance platforms on the airframe — most notably the E-3 AWACS — while its own KC-135 tanker was a parallel design derived from the same prototype.

1.3 The 707 in Commercial Aviation

The 707 transformed commercial air travel, giving airlines a fast, reliable jet airliner capable of routes that piston-engined aircraft could not economically fly, including long-haul ocean crossings performed with inertial navigation, well before the era of satellite-based navigation. Its introduction reshaped passenger expectations for speed and comfort, and cemented Boeing's position as a leader in commercial jet manufacturing for decades to come.

1.4 The -320C Convertible Variant

Introduced in the early 1960s, the -320C was the “convertible” variant of the 707 family — configurable for passengers, cargo, or a combination of both (a “combi” configuration). It is distinguished by its forward fuselage cargo door and an updated wing fitted with three leading-edge flaps. With 337 built, it became the most numerous variant in the 707 family, remaining in production until 1978; several airframes continued flying into the early 21st century.

Flown by a crew of three — with a navigator added on routes beyond radio-navigation coverage, prior to the introduction of inertial navigation — the -320C could carry up to 219 passengers, 13 pallets of cargo, or a combination of both. This simulation recreates the aircraft in its combi configuration: a main-deck cargo area forward of the wing and a passenger cabin aft, complete with an operable cargo door, galleys, lavatories, and 707-specific exterior animations, from the tab-driven flight control surfaces to the JT3D engines' blow-in doors.

1.5 Aircraft Specifications

Specification	Value
Length	152 ft 11 in
Height	42 ft
Wingspan	145 ft 9 in
Engines	4 × Pratt & Whitney JT3D low-bypass turbofans
Engine thrust	Up to 19,000 lb each
Range	Up to 5,000+ miles depending on payload
High cruise speed	Mach 0.84
Maximum passengers	112 (as configured)
Maximum cargo	4 pallets (as configured)
Flight crew	3 (Captain, First Officer, Flight Engineer)

PART I — INTRODUCTION & OVERVIEW

Chapter 2 — Aircraft Variants

About this chapter

Introduces the three cockpit variants of the Boeing 707-320C, each named and distinguished by its long-range navigation system. Full technical detail for each navigation system is provided in its own chapter — **Chapter 23** (Combi (INS)), **Chapter 24** (Combi (UNS-1Lw)), and **Chapter 25** (Combi (GNS)).

2.1 The Three Cockpit Variants

The Boeing 707-320C is available in three cockpit variants, each built around a different long-range navigation system (Figure 2-1). All three variants are otherwise identical combi airframes, and **all liveries are available for all three variants** — the choice of navigation system is independent of the livery selected.

Figure 2-1 Aircraft selection screen — Combi (UNS-1Lw), Combi (INS), Combi (GNS)

2.2 Combi (INS)

The Combi (INS) variant is equipped with the Delco Carousel IV-A Inertial Navigation System (INS), the aircraft's original long-range navigation fit. Navigation is limited to latitude/longitude waypoint entry, computed by an autonomous inertial reference with no reliance on external signals — the way the 707 actually crossed oceans before the era of satellite navigation. See **Chapter 23**.

2.3 Combi (UNS-1Lw)

The Combi (UNS-1Lw) variant is equipped with the Universal UNS-1Lw, a multi-sensor flight management system providing a traditional airliner FMS experience, including full procedure support and enroute navigation via airways, along with SBAS-enabled vertical guidance for modern approaches. See **Chapter 24**.

2.4 Combi (GNS)

The Combi (GNS) variant is equipped with the Garmin GNS 530W, a modern moving-map GPS navigator combining GPS navigation, a VHF NAV/VOR/ILS receiver, and a VHF COM transceiver in a single unit — a configuration some real 707s still carry in service today. See **Chapter 25**.

2.5 Combi Aircraft Configuration

All three variants share the same combi airframe: a main-deck cargo area forward of the wing and a passenger cabin aft, as described in **§1.4**.

PART I — INTRODUCTION & OVERVIEW

Chapter 3 — Getting Started

About this chapter

Introduces the EFB companion app and provides a quick-start path for a first flight in the Boeing 707-320C, with references to the chapters covering each topic in full detail.

3.1 The EFB Companion App

Getting started with the Boeing 707-320C is straightforward, thanks to a dedicated EFB companion app and a comprehensive Virtual Flight Engineer (VFE) that together can manage nearly every non-flying aspect of a flight — allowing the pilot to focus on flying and navigating the aircraft.

The Boeing 707 EFB app is available whenever you are loaded into any variant of the 707, appearing on the EFB home screen alongside the sim's own Flight Planner, Aircraft, Pilot, and Settings apps. It can be added to your EFB Favorites bar for quicker access (**§26.1**).

The app is organized into up to five tabs:

- **Flight Engineer** — triggers the VFE's phase-of-flight flows and toggles its continuous automations (**Chapter 28**).
- **CIVA** — flight-plan import and options for the Carousel IV-A INS variant only (**Chapter 27**).
- **Doors** — controls all cabin and cargo doors (**§26.2**).
- **Data Cards** — takeoff, landing, and EPR performance calculations (**§26.3**).
- **Options** — global preferences for instrument behavior, realism, and VFE automation (**§26.4**).

The remainder of this chapter provides a quick-start path for a first flight; full detail on the EFB app itself is provided in **Chapter 26**, with the Virtual Navigator and Virtual Flight Engineer covered in **Chapters 27** and **28** respectively.

3.2 First Flight Quick Start

3.2.1 Starting from the Runway

- Use the Flight Planner and/or Aircraft default EFB apps to set fuel, payload, and flight plan if desired.
- Open the Boeing 707 EFB app's **Options** tab and confirm your preferred settings are enabled (**§26.4**).
- Open the **Data Cards** tab and set takeoff trim and speed bugs (**§26.3**).
- Check the available runway length against the required takeoff distance shown on the Data Cards **Takeoff** page.
- Open the Flight Engineer tab and run the Before Takeoff flow (§28.2, §30.5).

- Begin your flight, running subsequent Flight Engineer flows as each phase is reached.

3.2.2 Starting Cold & Dark

- Use the Flight Planner and/or Aircraft default EFB apps to set fuel, payload, and flight plan if desired.
- Open the Boeing 707 EFB app's **Options** tab and confirm your preferred settings are enabled (**§26.4**).
- Open the Flight Engineer tab and run the Cockpit Preparation flow, followed by Before Start (§28.2, §§30.1–30.2).
- Manually start each engine, beginning with engine 3: select the corresponding **Engine Start Control** switch to **GROUND START**, then move that engine's start lever to **START** once N2 passes 15% (see **§§5.6–5.7** for the full sequence and procedure). Repeat one engine at a time until all four are running.
- Run the **After Start** and **Taxi** flows in sequence, completing pushback and taxi to the runway.
- Open the **Data Cards** tab and set takeoff trim and speed bugs.
- Check the available runway length against the required takeoff distance on the Data Cards **Takeoff** page, and select a runway with adequate length.
- Run the **Before Takeoff** flow prior to takeoff.
- Begin your flight, running subsequent Flight Engineer flows as each phase is reached.

3.2.3 Navigation

Pilots may navigate visually, using radio navigation aids only, or using the long-range navigator installed in the selected aircraft variant (see **Chapter 22**). The autopilot, pilot instruments, and flight directors can each be set up to follow any supported navigation source (**Chapter 16**).

3.2.4 Throttle Settings

The 707 has neither an autothrottle nor a FADEC; thrust settings and limits are computed by the VFE and set manually by the pilot, or automatically if the Takeoff/Climb Throttle Assistance option is enabled in the EFB **Options** tab (**§26.4**). Maximum thrust is observed via bugs set on the EPR gauges at the top of each engine's instrument column (**§5.2**); if enabled, the VFE automatically sets these EPR targets throughout the flight, as a real flight engineer would (**§28.4**). Engine thrust is also partially limited automatically by a hydro-mechanical protection system — a crude precursor to a modern FADEC, but effective as a safety limit on maximum thrust.

3.2.5 Descent and Landing

The 707 is a surprisingly slippery aircraft — real world crews noted it could take up to two minutes to decelerate from 300 kt to 200 kt in level flight, partly a result of relatively high idle thrust. Descent and landing should be well planned to allow the aircraft to slow within flap limit speeds; use the speed brake as needed (**§14.4**).

Once below the flap limit speed for the first flap setting, begin extending flaps per the placard below the landing gear handle (**§14.5**). Flaps assist significantly with drag, but early gear extension is also common on 707 approaches.

A final approach will generally require at least 70% N1, by design, to preserve the ability to go around — the engines have significant spool-up time from idle, and flying an approach at or near idle thrust can make a go-around impossible.

Landing is authorized with either flaps 40 or flaps 50, both selectable on the Landing Data Card page. Before beginning the approach, run the Descent Prep and Descent Approach flows to configure aircraft systems for landing (§§30.7–30.8).

Use the Data Cards **Landing** page to set the preferred landing flap setting, runway condition, and landing field elevation, then confirm the landing runway meets the required landing distance shown on that page. Set the landing speed bugs using the button provided.

By the final approach fix — or glidepath interception — set landing flaps, extend the landing gear (**Chapter 15**), slow to the bugged approach speed, and maintain a stable thrust and flight profile to the runway threshold. Run the **Before Landing** flow once configured for landing.

At approximately 30 feet above the runway, reduce thrust to idle and flare smoothly — only a few degrees of pitch-up is needed. Over-flaring can cause floating or a bounced landing, compounded by the engines' slow spool time limiting a quick thrust response.

Upon touchdown, manually extend the speed brakes fully for maximum lift dumping, and engage the thrust reversers until slowing below 60 kt (**§5.9**). Braking is manual and should be applied as needed for deceleration and runway exit.

After exiting the runway, run the **After Landing** flow, taxi to parking, and run the remaining **Shutdown** and **Secure** flows as needed.

> **NOTE**
> VFE flows can be reset for turnaround flights without ending the current flight.

3.3 Simulator-Specific Items

Beyond the aircraft's simulated systems, several cockpit and cabin interactions are specific to how this aircraft is modeled in the simulator, rather than reflecting a system carried on the physical aircraft. This section covers those simulator-specific items.

3.3.1 Cockpit Seat Visibility & Positioning

The navigator's and flight engineer's seats can each be repositioned or hidden independently, using the seat rails on the cockpit floor (Figure 3-1).

- **Mouse over a seat's rails** to interact with that seat.
- **Right-click** the rails to toggle that seat between hidden and shown (Figure 3-2).
- **Left-click and hold** on the rails to move the seat along them.

Figure 3-1 Seat-rail interaction — flight engineer and navigator seats

Figure 3-2 Flight engineer and navigator seats hidden

3.3.2 Cabin

The passenger cabin includes several simulator-specific interactive features:

- **Window shades** — each passenger window shade can be raised or lowered manually. An EFB option can also automate shade positioning based on environmental conditions; see **§20.3** for shade automation and other cabin lighting behavior.
- **Cabin lighting control panels** — the three cabin lighting panels (forward cabin entry, forward galley, aft galley) are modeled and interactive; see **§20.3** for the full control reference.
- **Cabin lighting** — passenger cabin, galley, and lavatory lighting can be adjusted from the cabin panels described above.

3.3.3 Cargo Door

All doors on the aircraft, including the main cargo door, can be controlled from the **Doors** tab on the EFB (see **§26.2**).

The main cargo door can also be controlled locally, from the cargo door control panel located adjacent to the front left main aircraft door (Figure 3-3). The panel provides two controls: a lock/unlock handle, and a door operation switch with **DOOR CLOSED** and **DOOR OPEN** positions.

Figure 3-3 Cargo door control panel

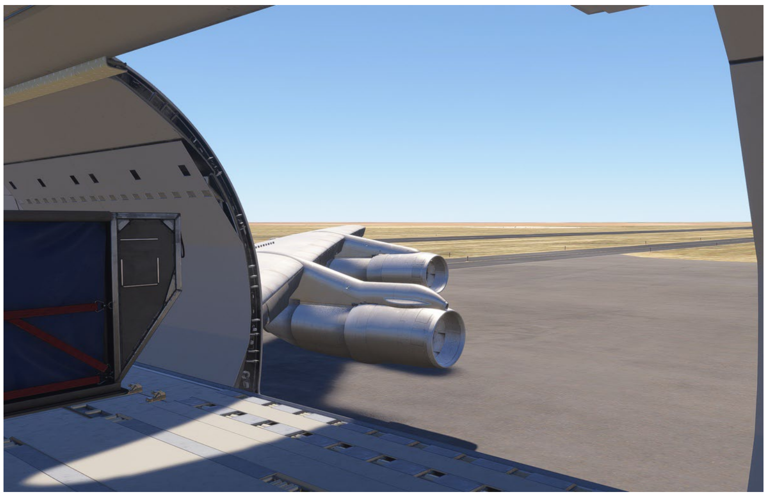

Figure 3-4 Main cargo door open

3.3.4 Ground Services

Ground services can be triggered in the normal way for MSFS 2024. Because this combi aircraft has a cargo cabin forward of the passenger cabin, the main passenger entry is the rear-left entry door, and ground services are configured to use that door for both Free Flight and Career mode.

> **NOTE — Gate parking not recommended**
>
> As a result, **gate parking is not recommended** with this aircraft. Instead, park at a ramp stand and use stairs for passenger boarding and deboarding (Figure 3-5).

Figure 3-5 Passenger boarding via the rear-left entry door using stairs

3.4 Career Compatibility

As a combi aircraft, the 707-320C carries both passengers and cargo. At launch, the aircraft is only compatible with passenger-type Career activities; it is not compatible with cargo-type Career activities due to simulator limitations.

PART II

AIRCRAFT SYSTEMS

PART II — AIRCRAFT SYSTEMS

Chapter 4 — Cockpit, Flight Instruments and Warnings

About this chapter

This chapter is a **visual guide to the flight deck**. It orients you to the cockpit as a whole, maps each panel, and then examines the pilots' flight instruments and the warning systems in detail.

It also serves as a **visual table of contents** for Part II: where a panel or system has its own chapter, this chapter points you to it rather than repeating the detail.

4.1 How This Chapter Is Organized

The flight deck is presented in three levels of detail, working from the whole cockpit down to individual instruments:

- **Cockpit overview** (§4.1) — the major regions of the flight deck and where to find each.
- **Panel maps** (§4.2–§4.6) — each panel in turn, identifying its instruments and controls at an orientation level.
- **Flight instruments & warnings in detail** (§4.7 onward) — a close look at each primary flight instrument and the warning/annunciator systems.

Where the detail lives

Many flight-deck panels control systems that have their own dedicated chapters — electrical, fuel, hydraulics, pneumatics, autopilot, navigation, and so on. For those, this chapter identifies the panel and **directs you to the relevant chapter** for full coverage. The in-depth detail here is reserved for the **pilots' flight instruments** and the **warning and annunciator systems**, which have no other home.

Cockpit Overview — Forward Flight Deck

The forward flight deck comprises the pilots' main instrument panels, the glareshield, the overhead panel, and the control pedestal (Figure 4-1).

Figure 4-1 Forward flight deck — overview

No.	Region
1	**Overhead panel** — systems switches and indications (ice protection, yaw damper, anti-skid, and more). See §4.5.
2	**Captain's main instrument panel (MIP)** — the captain's primary flight instruments. See §4.2.
3	**Center main instrument panel** — engine instruments, landing gear indications, and the standby instruments. See §4.3.
4	**First Officer's main instrument panel (MIP)** — the first officer's flight instruments (mirror of the captain's). See §4.4.
5	**Control pedestal** — thrust levers, flight-control and trim controls, autopilot, radios, and long-range navigator/FMS. See §4.6.

Cockpit Overview — Flight Engineer's Station

The Flight Engineer’s station, aft of the first officer, groups the controls and indications for the aircraft’s major systems (Figure 4-2). Each region is managed in detail in its own chapter, as listed below.

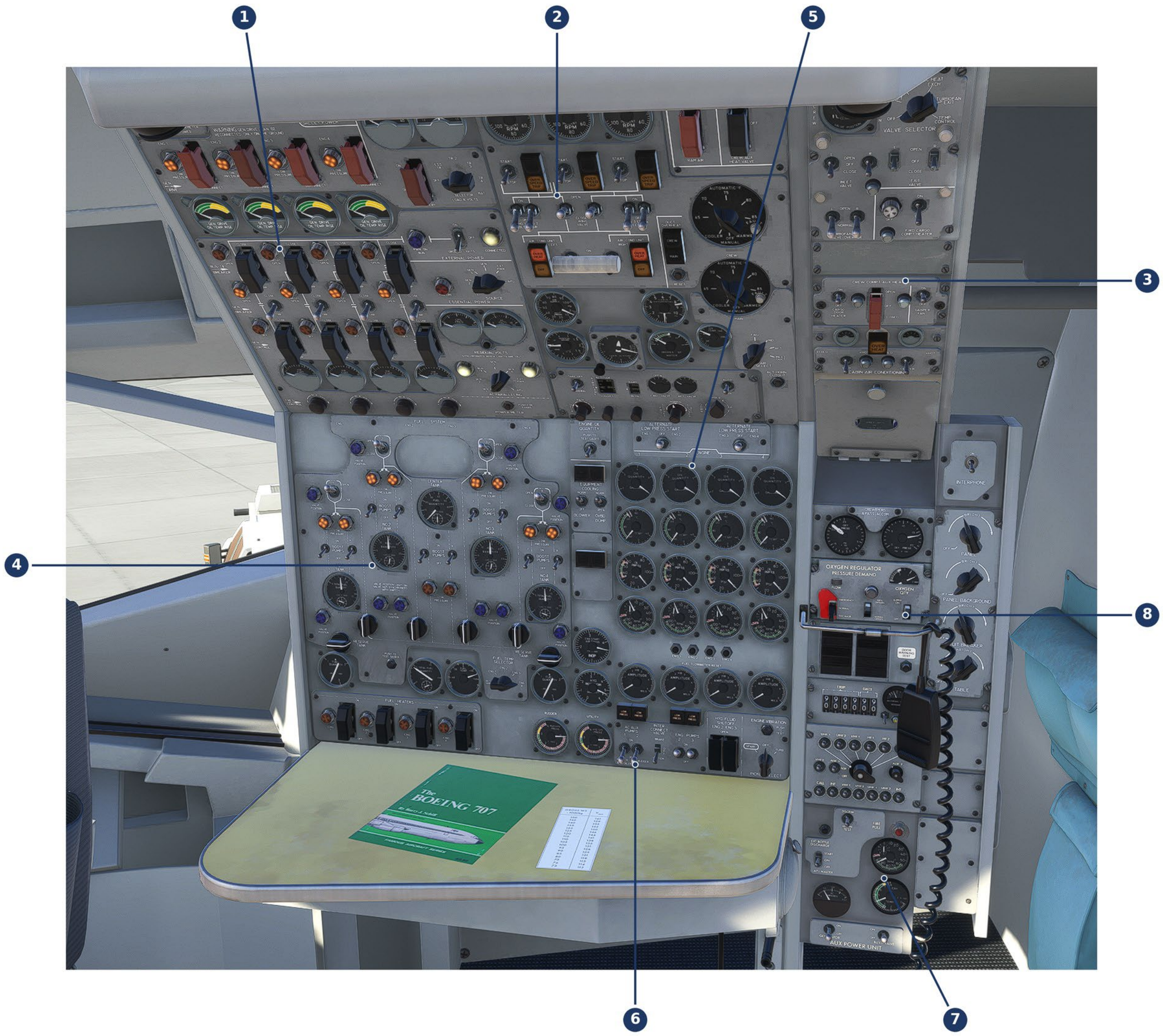

Figure 4-2 Flight Engineer’s station — overview

No.	System region — see chapter
1	**Electrical power** — AC/DC generation, generator paralleling, external and APU power. **Chapter 10**.
2	**Pneumatic system & engine start** — turbocompressors, bleed air, and the engine-start controls. **Chapter 7**.
3	**Air conditioning & pressurization** — packs, coolant air, and cabin temperature/pressurization. **Chapter 8**.
4	**Fuel system** — tanks, boost pumps, crossfeed, and fuel temperature. **Chapter 11**.
5	**Engine instruments** — oil quantity/pressure/temperature and vibration monitoring. **Chapter 5**.

No.	System region — see chapter
6	**Hydraulic system** — utility and auxiliary systems, interconnect, and shutoff. **Chapter 12**.
7	**Auxiliary Power Unit (APU)** — APU controls, indications, and fire protection. **Chapter 13**.
8	**Oxygen, interphone & panel lighting** — crew oxygen, interphone, and lighting controls. **Chapters 19 & 20**.

4.2 Captain's Main Instrument Panel

The captain's main instrument panel carries the captain's primary flight instruments — attitude, airspeed, altitude, heading, and vertical speed — together with the navigation-bearing indicators, warning annunciators, and the instrument-source selectors (Figure 4-2). The first officer's panel (§4.4) is largely a mirror of this one.

Figure 4-2 Captain's main instrument panel

Flight Instruments & Indications

These instruments are examined individually later in this chapter.

No.	Flight instrument / indication
1	**Warning annunciators** — GPWS and BELOW G/S (ground-proximity and glideslope warnings).
2	**Mach number** indicator.
3	**Airspeed indicator** (KNOTS).
4	**Attitude Director Indicator (ADI)** — pitch, roll, and flight-director command bars.

No.	Flight instrument / indication
5	**AP DISENG** annunciator — autopilot-disengage warning (Chapter 16).
6	**MDA** annunciator — minimum descent altitude alert.
9	**Flight-director & autopilot mode annunciators** — F/D ANN and A/P ANN (VOR/LOC · NAV · GS · HDG · ALT).
10	**Altitude alerter annunciator** — ALTITUDE ALERT light; flashes when approaching or deviating from the selected altitude (see the altitude preselector, Chapter 16).
11	**Marker-beacon lights** — INNER · MIDDLE · OUTER.
12	**Barometric altimeter** — pressure altitude with the barometric (IN HG) setting.
13	**Radio altimeter** — height above terrain (HEIGHT, ×100 ft).
14	**ADF bearing pointer** — automatic direction-finding bearing (RMI).
15	**Horizontal Situation Indicator (HSI)** — heading, course, and deviation.
16	**Instantaneous Vertical Speed Indicator (IVSI)** — rate of climb/descent.
17	**VOR bearing pointer** — VOR radial bearing (RMI).
18	**DME 1 / DME 2** — distance-measuring-equipment distance readouts.
19	**Chronometer** — clock / elapsed-time chronometer.

Controls & Source Selectors

These controls set up the panel and select instrument sources; several are covered in dedicated chapters.

No.	Control — see chapter
7	**Nav source selector** (NORMAL / NO. 1 / NO. 2) — selects whether **Nav radio 1 or 2** drives the captain's instruments. **NORMAL** uses Nav 1 on the captain's side (and Nav 2 on the first officer's side). Also covered with the autopilot in **Chapter 16**.
8	**Emergency brake** — EMERG BRAKE lever with HOLD (ON/OFF). See **Chapter 15**.
20	**Mach/Airspeed Warning** — the overspeed-warning unit and its TEST button (see the warning systems later in this chapter).
21	**Instrument data source selectors** — select the data source (NORMAL / NO. 1 / NO. 2) feeding the pilot's instruments (attitude, gyro, compass, and ADF/RMI).
22	**NAV source switch** (NAV – LOC/VOR) — selects whether the HSI displays the on-side nav radio (LOC/VOR) or the long-range navigator (NAV). See **Chapters 16 and 19**.
23	**NAV/CDI annunciator light** — the amber light beside the NAV source switch, annunciating the selected HSI source mode.

First Officer's panel

The **first officer's main instrument panel** (§4.4) carries the same primary flight instruments in a mirror-image layout. Where the two panels differ — for example, the source selectors and the captain-only items above — the differences are noted in §4.4.

4.3 Center Main Instrument Panel

The center main instrument panel is dominated by the four-engine instrument cluster, flanked by standby flight instruments on the left and the landing gear and flap indications on the right (Figure 4-3). Almost everything on this panel belongs to a system with its own chapter; this section identifies each region and directs you there.

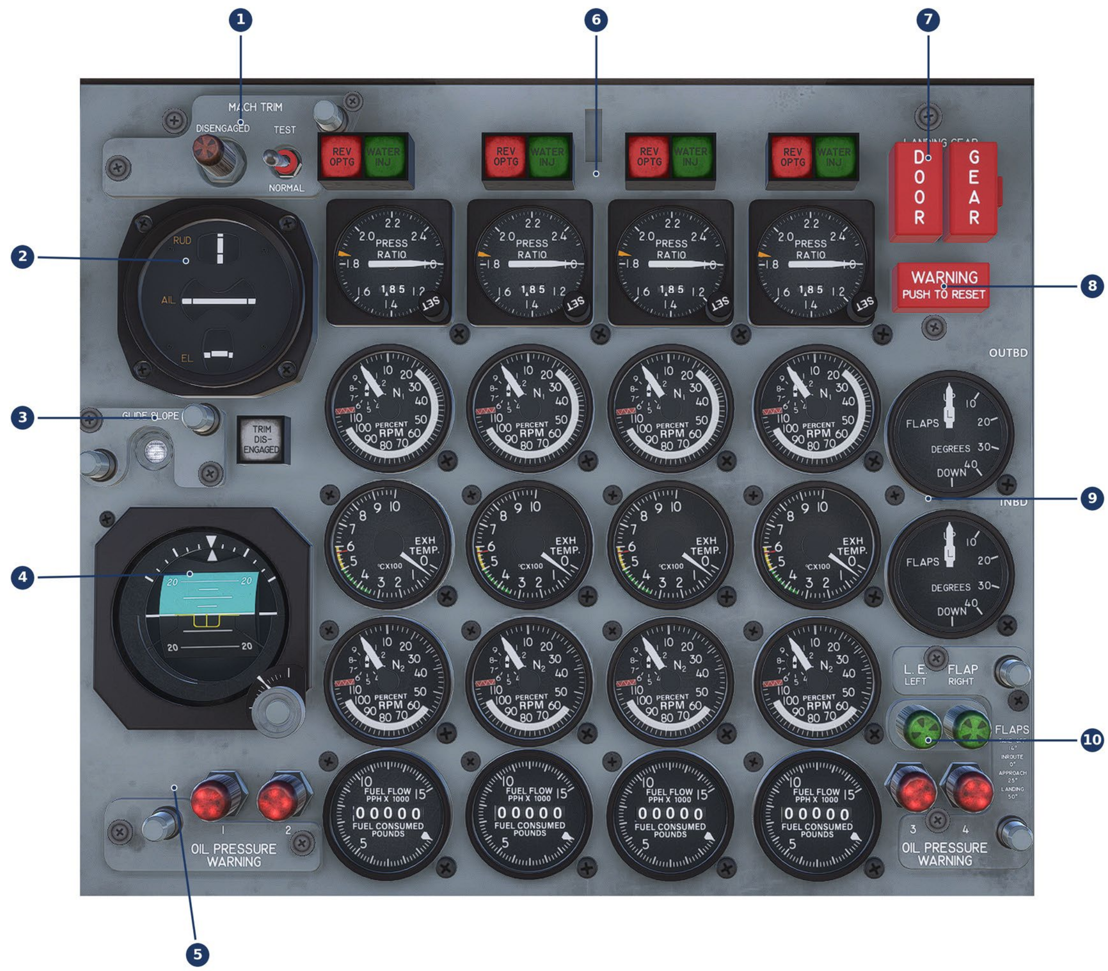

Figure 4-3 Center main instrument panel

Standby Flight Instruments

A small group of standby instruments on the left side of the panel provides backup indications.

No.	Instrument
2	**Three-axis trim indicator** — RUD / AIL / EL, showing rudder, aileron, and elevator trim (and some autopilot servo activity). Also described with the flight controls in **Chapter 14**.
3	**Glide-slope indicator** — a standby glideslope-deviation indicator.
4	**Standby attitude indicator** — a self-contained backup attitude (artificial-horizon) instrument.

Engine, Gear & Flap Indications

These indications belong to systems documented in their own chapters; only their location on this panel is identified here.

No.	Region — see chapter
1	**MACH TRIM** panel — DISENGAGED light and TEST / NORMAL switch for the Mach-trim system. See **Chapter 14**.
5	**OIL PRESSURE WARNING** lights — engines 1 & 2 (left) and 3 & 4 (right). See **Chapter 5**.
6	**Engine instrument cluster** — one column per engine, from top: REV OPTG and WATER INJ lights, EPR (PRESS RATIO), N1, EXH TEMP, N2, and FUEL FLOW / FUEL CONSUMED. See **Chapter 5** (fuel indications also **Chapter 11**).
7	**Landing gear indicator lights** — DOOR and GEAR. See **Chapter 15**.
8	**Landing gear warning** — WARNING / PUSH TO RESET. See **Chapter 15**.
9	**Trailing edge flap indicators** — OUTBD and INBD flap position. See **Chapter 14**.
10	**Leading edge flap lights & flap placard** — L.E. FLAP LEFT/RIGHT green lights and the flap-setting placard. See **Chapter 14**.

An orientation panel

Everything of operational significance on the center panel is covered in its dedicated chapter — engine indications in Chapter 5, landing gear in Chapter 15, and flaps and trim in Chapter 14. Use this section to locate each item; refer to those chapters for how it works.

4.4 First Officer’s Main Instrument Panel

The first officer’s main instrument panel mirrors the captain’s for the primary flight instruments — attitude, airspeed, altitude, heading, and vertical speed — and the navigation-bearing indicators and warning annunciators (Figure 4-4). It differs from the captain’s side in the additional air-data instruments and system items it carries, listed under “First-Officer-side items” below.

Figure 4-4 First Officer’s main instrument panel

Shared Flight Instruments

These are the same instruments as on the captain's panel (§4.2), in mirror-image layout, and are examined individually later in this chapter.

No.	Flight instrument / indication
1	**Warning annunciators** — GPWS and BELOW G/S.
4	**Attitude Director Indicator (ADI)**.
5	**AP DISENG** annunciator (Chapter 16).
6	**MDA** annunciator — minimum descent altitude alert.
7	**Flight-director & autopilot mode annunciators** — F/D ANN and A/P ANN.
8	**Altitude alerter annunciator** — ALTITUDE ALERT (see the altitude preselector, Chapter 16).
9	**Marker-beacon lights** — INNER · MIDDLE · OUTER.
10	**Barometric altimeter** (IN HG).
11	**Radio altimeter** (HEIGHT, ×100 ft).
12	**Mach number** indicator.
13	**Airspeed indicator** (KNOTS).
15	**ADF bearing pointer** (RMI).
16	**Horizontal Situation Indicator (HSI)**.
17	**Instantaneous Vertical Speed Indicator (IVSI)**.
18	**VOR bearing pointer** (RMI).
20	**DME 1 / DME 2** distance readouts.
21	**NAV source switch** (NAV – LOC/VOR) — selects on-side nav radio vs. long-range navigator (Chapters 16 and 19).
22	**NAV/CDI annunciator light** — annunciates the selected HSI source mode.

First-Officer-Side Items

These instruments and controls appear on the first officer's side only. The air-data instruments below are straightforward direct-reading gauges and are described here rather than in the detailed sections.

No.	Instrument / control
2	**Total Air Temperature (TAT)** — outside air temperature including compressibility (ram) heating, in °C. Used with true airspeed and for engine/performance reference.
3	**True Airspeed (TAS)** — airspeed corrected for air density, in knots.
14	**Static Air Temperature (SAT)** — ambient (static) outside air temperature, in °C.
19	**Metric altimeter** — pressure altitude in meters (METER), for operations that use metric altitudes.
23	**Water Injection** panel — the water-injection controls and indications. See **Chapter 6**.

No.	Instrument / control
24	**Hydraulic pressure gauges** — RUDDER (rudder system) and UTILITY (HYD BRAKE PRESS). See **Chapter 12**.

> **Mirror-image layout**
> Because the first officer's panel is a mirror of the captain's, the flight instruments sit in the opposite left/right arrangement. Their function is identical to the captain's instruments (§4.2); only the additional first-officer-side items above differ.

4.5 Overhead Panel

The overhead panel carries the aircraft's systems switching and indications, grouped by function (Figure 4-5). Almost every region belongs to a system with its own chapter; this section identifies each region and directs you there. The two flight-deck warning systems on this panel — Ground Proximity Warning and Attitude Warning — are described later in this chapter with the other warnings.

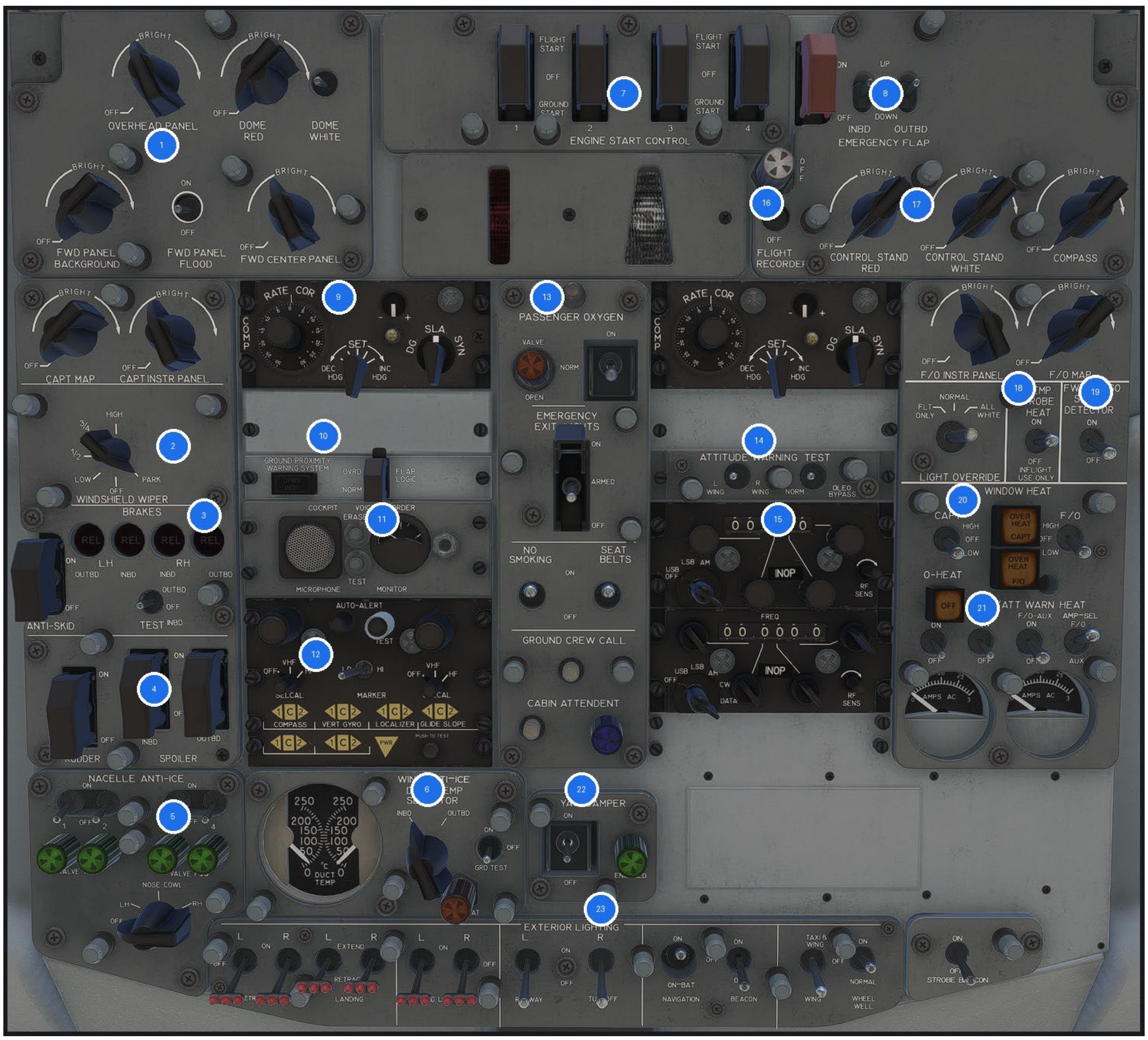

Figure 4-5 Overhead panel

Lighting

Interior and exterior lighting rheostats and switches are grouped across the panel.

No.	Instrument / control
1	**Interior lighting rheostats** — overhead panel, dome (red/white), fwd panel background & flood, fwd center panel, captain map and instrument-panel dimming. See Chapter 20.
17	**Control-stand & first-officer lighting** — control-stand red/white, compass, F/O instrument-panel and map dimming, and light override. See Chapter 20.
23	**Exterior lighting** — landing, runway/turnoff, navigation, beacon, taxi & wing, wing, wheel-well and strobe. See Chapter 20.

Ice Protection & Heating

Anti-ice and probe/window heating controls occupy the lower-left and right sides of the panel.

No.	Instrument / control
2	**Windshield wipers** — HIGH / ¾ / ½ / LOW / PARK / OFF selector. Operated directly.
5	**Nacelle anti-ice** — engines 1–4 nacelle / nose-cowl anti-ice with valve-position lights. See Chapter 9.
6	**Wing anti-ice & duct-temp selector** — wing anti-ice, duct-temperature selector and gauge, TAT and ground test. See Chapter 9.
18	**Temp-probe heat** — TAT probe heat. See Chapter 9.
20	**Window heat** — captain and F/O window heat, Q-HEAT / O-HEAT test and AMP-SEL. See Chapter 9.
21	**Pitot / attitude-warning heat** — probe-heat switches (CAPT, F/O-AUX) and AC ammeters. See Chapter 9.

Engine Start & Flight Controls

Engine-start and flight-control switching sits along the top and left of the panel.

No.	Instrument / control
7	**Engine start control** — flight/ground start selectors, engines 1–4 (start air, Chapter 7). See Chapter 5.
8	**Emergency flap** — INBD / OUTBD electric emergency-flap control. See Chapter 14.
4	**Rudder & spoiler hydraulic switches** — hydraulic power/boost switching for the rudder and spoilers. See Chapters 12 and 14.
3	**Brakes & anti-skid** — brake REL indicator lights, ANTI-SKID switch and system TEST. See Chapter 15.

Navigation, Compass & Recorders

The polar-path compass controllers and the aircraft recorders are grouped through the center of the panel.

No.	Instrument / control
9	**Polar-path gyrocompass** — captain and F/O compass controllers: RATE COR, SET and DG / SLA / SYN. See Chapter 17.
11	**Cockpit voice recorder** — microphone, TEST, MONITOR and ERASE. See Chapter 19.
12	**Audio / SELCAL / marker (Auto-Alert)** — VHF/HF audio selection, SELCAL decodes and marker sensitivity. See Chapter 19.
15	**HF radios** — dual HF communication controllers (INOP as modeled). See Chapter 19.
16	**Flight recorder** — flight-recorder ON / OFF. See Chapter 20.

Warning Systems

Two flight-deck warning systems are located on this panel; both are described in detail later in this chapter.

No.	Instrument / control
10	**Ground Proximity Warning** — GPWS indication and the OVRD / NORM flap-logic switch.
14	**Attitude warning test** — L / R WING, NORM and OLEO BYPASS test controls.

Cabin, Oxygen & Miscellaneous

The remaining regions cover the passenger cabin, cargo protection and the yaw damper.

No.	Instrument / control
13	**Passenger oxygen & cabin signs** — passenger-oxygen valve, No Smoking / Seat Belts signs, emergency exit lights, and ground-crew / cabin-attendant call. See Chapter 20.
19	**Fwd cargo smoke detector** — forward cargo smoke-detector ON / OFF. See Chapter 20.
22	**Yaw damper** — yaw-damper ON / OFF with ENGAGED annunciation. See Chapter 16.

4.6 Center Pedestal

The center pedestal runs aft from behind the throttle quadrant to the trim controls. It carries the thrust and start levers, the flight-control trims, the autopilot and flight-director controllers, and the communication and navigation radios. It is presented in two parts — the forward pedestal (Figure 4-6) and the aft pedestal (Figure 4-7). Almost every control belongs to a system with its own chapter; this section identifies each region and directs you there.

Forward Pedestal

The forward pedestal carries the long-range navigation unit (CIVA in this example), the weather radar and transponder, the thrust and start levers, and the flap, speed-brake and trim controls (Figure 4-6a).

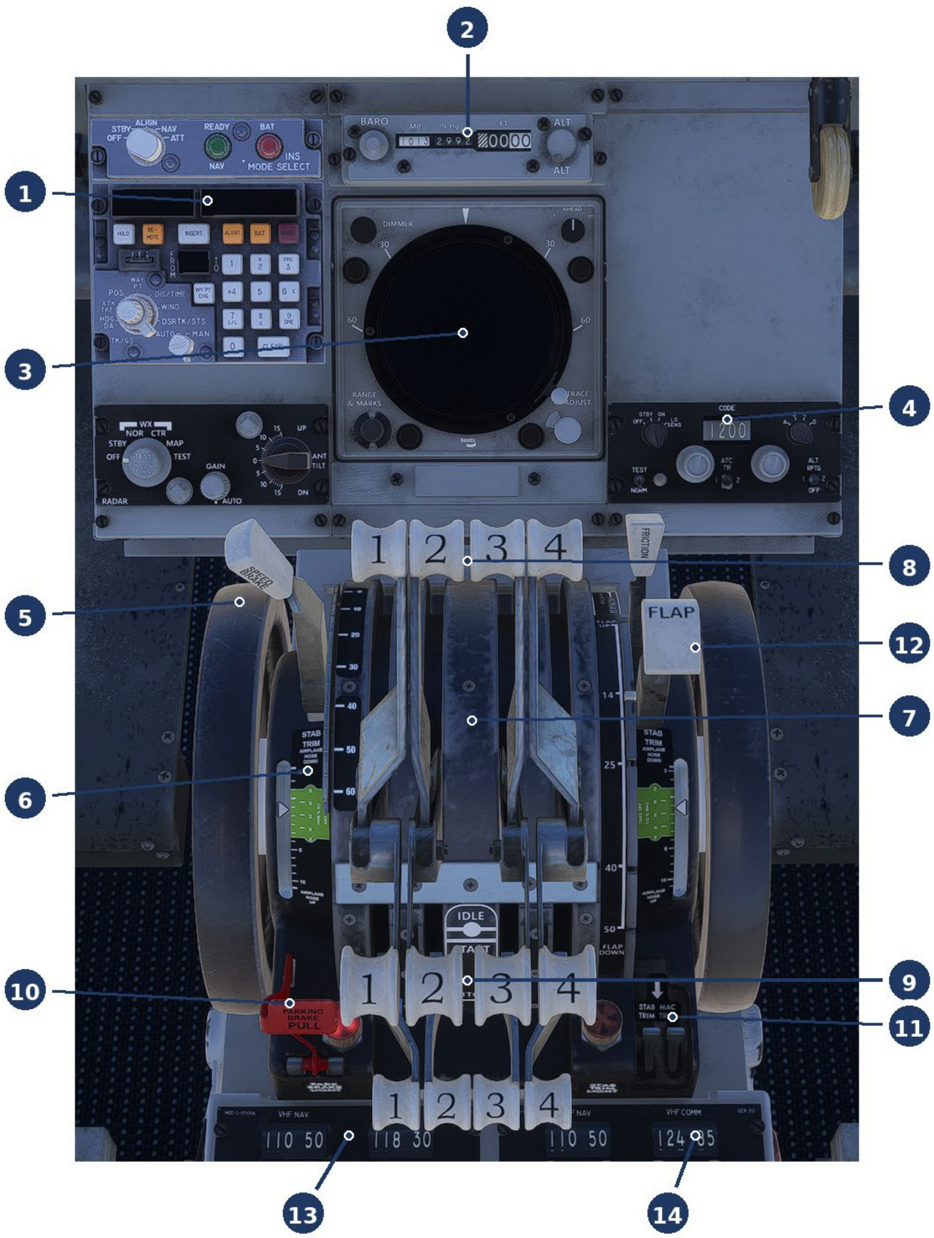

Figure 4-6a Center pedestal — forward

No.	Flight instrument / indication
1	**Long Range Navigation System — (see Part III)**
2	**Altitude alerter and barometric set. (see Chapter 16)**
3	**Weather radar (RDR-1). (see Chapter 18)**
4	**ATC transponder. (see Chapter 19)**
5	**Trim Wheel. (see Chapter 14)**
6	**Speed-brake lever. (see Chapter 14)**
7	**Thrust quadrant. (see Chapter 5)**
8	**Thrust-reverser levers. (see Chapter 5)**
9	**Thrust levers 1–4. (see Chapter 5)**
10	**Parking-brake handle. (see Chapter 15)**
11	**Stabilizer-trim cutout and trim-in-motion indicator. (see Chapter 14)**
12	**Flap lever. (see Chapter 14)**
13	**Nav/Com Radio 1.**
14	**Nav/Com Radio 2.**

Aft Pedestal

The aft pedestal carries the communication and navigation radios, the autopilot controller and the two flight directors, the ADF receivers, and the rudder and aileron trim (Figure 4-6b).

Figure 4-6b Center pedestal — aft

No.	Flight instrument / indication
1	Parking-brake handle and PARK BRAKE light. (see Chapter 15)
2	Stabilizer-trim switches and STAB TRIM light. (see Chapter 14)
3	VHF NAV / VHF COMM radio 1 — captain. (see Chapter 19)
4	VHF NAV / VHF COMM radio 2 — first officer. (see Chapter 19)
5	Autopilot controller. (see Chapter 16)
6	Flight director — captain. (see Chapter 16)
7	Flight director — first officer. (see Chapter 16)
8	ADF receivers. (see Chapter 19)
9	Rudder trim. (see Chapter 14)
10	Aileron trim. (see Chapter 14)
11	Landing-gear warning horn cutout.
12	Aft-panel light rheostat. (see Chapter 20)

4.7 Flight Instruments

This section outlines key flight instruments with unique or complex indications.

4.7.1 Attitude Director Indicator (ADI)

The Attitude Director Indicator (ADI) is the pilot's primary pitch-and-bank reference, combining the artificial-horizon sphere with flight-director command guidance and instrument-approach deviation indications (Figure 4.7.1).

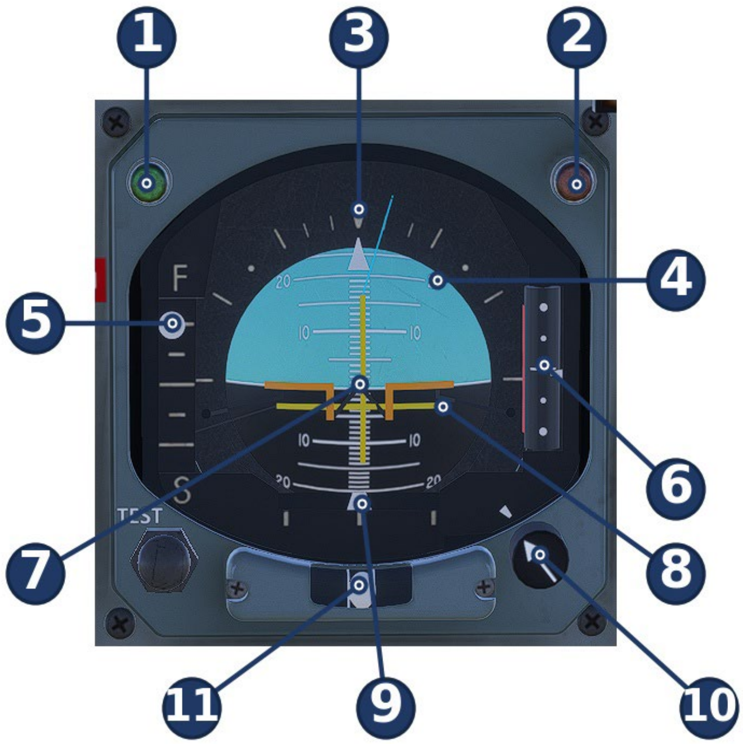

Figure 4.7.1 Attitude Director Indicator (ADI)

No.	Flight instrument / indication
1	**VFE Thrust-Management light** — illuminates green when the Virtual Flight Engineer is actively managing takeoff or climb thrust. See **Chapters 26 and 28**.
2	**Redundant MDA light** — duplicates the main-panel MDA annunciator; same function and trigger.
3	**Bank-angle scale & index pointer** — the fixed triangle reference at the top of the instrument, with the moving degree graduations around the sphere rim.
4	**Pitch scale** — the banked ladder lines with 10°/20° graduations on the pitch sphere.
5	**Reference Speed Indicator** — the vertical scale and pointer on the left side of the instrument face.
6	**Glideslope deviation scale & pointer** — the vertical scale on the right side of the instrument face.

No.	Flight instrument / indication
7	**Miniature aircraft reference symbol** — the fixed wing/dot reference against the moving pitch-and-bank sphere.
8	**Flight-director command bars** — the yellow command bars driven by the flight-director computer. See **Chapter 16**.
9	**LOC/LNAV lateral deviation indicator** — the upward-pointing caret at the base of the sphere; appears once the glideslope is captured, to assist with instrument approaches.
10	**Pitch reference adjustment knob** — adjusts the vertical position of the miniature aircraft symbol relative to the horizon.
11	**Slip/Skid indicator** — the ball-in-tube indicator at the base of the instrument.

4.7.2 Horizontal Situation Indicator (HSI)

The Horizontal Situation Indicator (HSI) presents heading, selected course, and lateral navigation deviation on a single rotating compass card (Figure 4.7.2). The HSI displays exactly one navigation source at a time: either the long-range navigator (CIVA, UNS-1, or GNS) or a VHF NAV radio (NAV 1 or NAV 2), selected via the Nav Radio Source Selector and the HSI NAV/LOC-VOR switch (Figure 4.7.2b). Before treating the displayed course or deviation guidance as valid, the pilot should confirm both switches are in the intended position: with the NAV/LOC-VOR switch in **NAV**, the adjacent light illuminates, indicating the long-range navigator is selected; with the switch in **LOC/VOR**, the light is extinguished, indicating the on-side VHF NAV radio is selected.

On the captain's side, the HSI's selected navigation source generally also supplies lateral guidance to the autopilot. See **Chapter 16**.

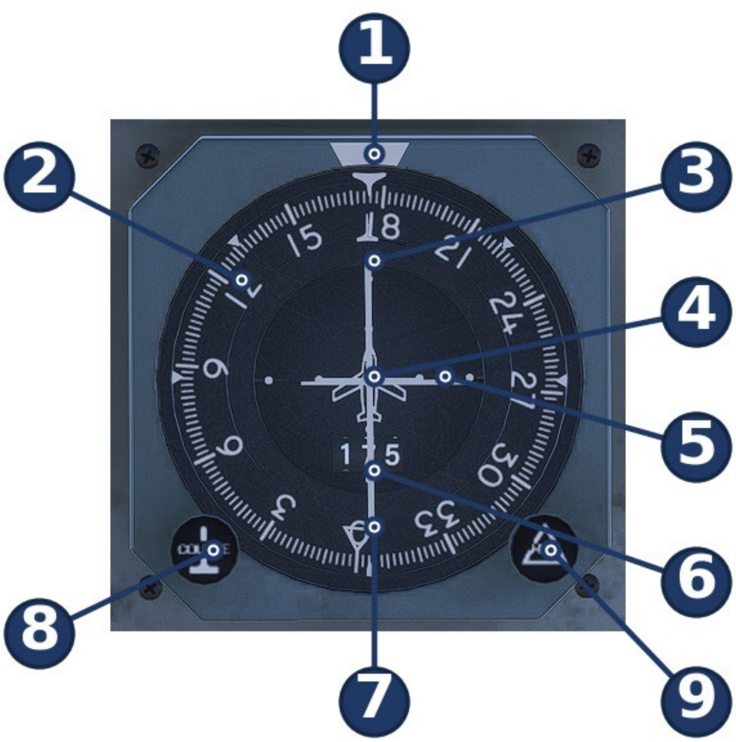

Figure 4.7.2a Horizontal Situation Indicator (HSI)

No.	Flight instrument / indication
1	**Fixed heading (lubber line) index** — the fixed triangle at the top of the instrument, showing current heading against the rotating compass card.
2	**Compass card & heading scale** — the rotating card, graduated in tens of degrees around the outer rim.
3	**Course pointer & deviation scale** — the vertical needle and side dots, indicating the selected course and lateral deviation from the active navigation source.
4	**Fixed aircraft reference symbol** — the center airplane symbol, fixed against the rotating card.
5	**Glideslope/glidepath deviation indicator** — the horizontal bar and dot scale, indicating vertical deviation from the glideslope or glidepath.
6	**Course readout window** — the digital readout of the selected course.
7	**Selected heading bug** — the triangle marker on the compass-card edge, set with the HDG knob.
8	**COURSE selector knob** — sets the selected course shown in the course readout window and by the course pointer.
9	**HDG selector knob** — sets the selected heading bug.

The Nav Radio Source Selector and the HSI NAV/LOC-VOR switch, together with the NAV/CDI annunciator light, are shown together in Figure 4.7.2b. These controls are also identified for orientation in **§4.2**.

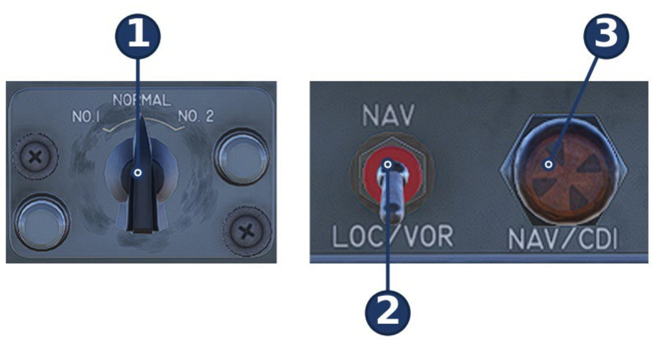

Figure 4.7.2b Nav Radio Source Selector and HSI NAV/LOC-VOR Selector

No.	Flight instrument / indication
1	**Nav Radio Source Selector** (NO. 1 / NORMAL / NO. 2) — selects whether NAV radio 1 or 2 supplies the on-side VHF NAV source. First introduced in **§4.2**.
2	**HSI NAV/LOC-VOR source switch** — selects whether the HSI displays the long-range navigator (NAV) or the on-side VHF NAV radio (LOC/VOR).
3	**NAV/CDI annunciator light** — illuminates when NAV is selected; extinguished when LOC/VOR is selected.

> **NOTE — EFB Options**
>
> **HSI Navigator Behavior (Legacy or Modern)** — this EFB option selects between two HSI display behaviors when the long-range navigator is the selected source. **Modern** behavior is strongly recommended. In **Legacy** behavior, the compass card follows the navigator's track output directly rather than magnetic heading, cross-track deviation is shown as a scaled dot indication, and the TO/FROM sense depends on the navigator's AUTO/MAN/RMT mode.
>
> **Auto Slew HSI Course for LOC or FMS/INS DTK** — this EFB option, when enabled, automatically slews the HSI course to match the localizer course or the long-range navigator's desired track (DTK) whenever that source provides the valid lateral navigation signal.

4.7.3 Chronometer (Clock)

The chronometer is an 8-day mechanical clock combining the main timekeeping hands with a chronograph (elapsed-time) function (Figure 4.7.3). The main dial's Hours & Minute Hands and Sweep Second Hand keep running time, while the upper Elapsed Time subdial and lower Minute Register subdial together form the chronograph, independently started, stopped, and reset. When wound, the clock automatically sets itself to **UTC**.

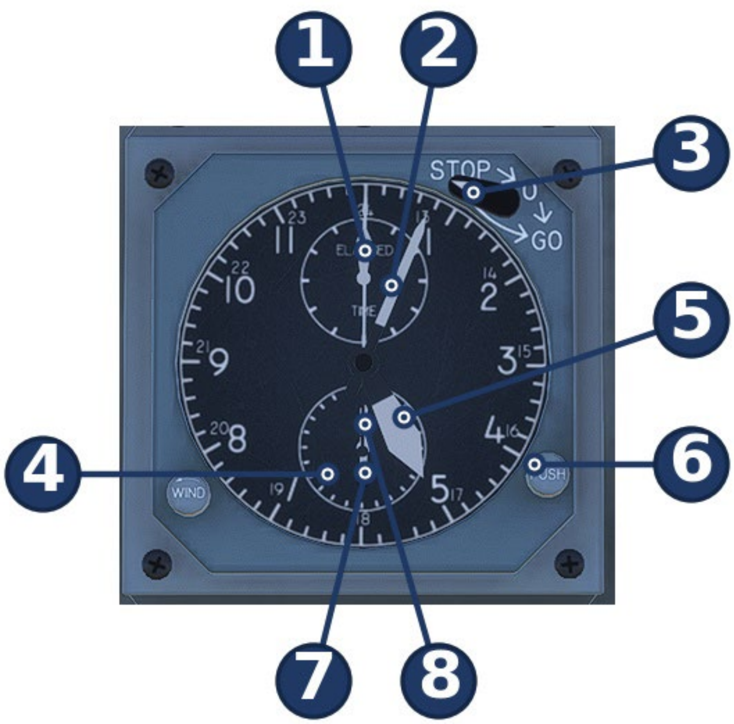

Figure 4.7.3 Chronometer (Clock)

No.	Flight instrument / indication
1	**Elapsed Time Hours & Minutes Hands** — the upper subdial hand, controlled by the Elapsed Time Control.
2	**Hours & Minute Hands** — the main clock's hour and minute hands, set by the Winding & Setting Control.

No.	Flight instrument / indication
3	**Elapsed Time Control** — starts, stops, restarts, or resets the Elapsed Time Hours & Minutes Hands. Rotating clockwise from 0 to GO starts the hands; GO to STOP stops them; STOP to 0 resets them to zero. Rotating counterclockwise from STOP to GO restarts the hands.
4	**Winding & Setting Control** — winds the clock when turned counterclockwise; one complete winding is good for 8 days. When pulled out, turning in either direction sets the main hour and minute hands.
5	**Sweep Second Hand** — the main dial's running seconds hand, started, stopped, and reset by the Sweep Second Hand Control.
6	**Sweep Second Hand Control** — starts, stops, and resets the Sweep Second Hand and Lower Minute Register Hand together, with both hands returning to zero on reset. Pushing once starts the hands; pushing a second time stops them; pushing a third time resets them to zero.
7	**Sweep Second Hand Annunciator** — indicates the state of the Sweep Second Hand: filled for elapsed time operating, half-filled for stopped but not reset, and open for stopped and reset.
8	**Lower Minute Register Hand** — the lower subdial hand, counting elapsed minutes together with the Sweep Second Hand; controlled by the Sweep Second Hand Control (push button).

CAUTION
Do not operate the Elapsed Time Control unless the Sweep Second Hand is in motion. Do not attempt to move the Elapsed Time Control counterclockwise from GO to 0, or from 0 to STOP.

NOTE — EFB Option: Realistic Clock/Chronometer Behavior
This EFB option determines whether the chronometer must be manually wound, as in the physical aircraft. When enabled, the clock is not an electric instrument and requires the user to wind it using the Winding & Setting Control. When disabled, the clock is always automatically wound.

4.7.4 Airspeed Indicator (ASI)

The Airspeed Indicator (ASI) displays indicated airspeed in knots, along with four white reference speed bugs, a yellow primary airspeed bug, and a Maximum Allowable Airspeed pointer (Figure 4.7.4).

The four white reference speed bugs can be set manually, or preset with weight- and condition-appropriate takeoff and landing speeds using the **Set Bugs** button on the EFB Data Cards tab. The yellow primary airspeed bug is set with the bug-set knob, and can also be set automatically by the same EFB Data Cards Set Bugs button. The yellow primary airspeed bug additionally drives the Reference Speed Indicator on the ADI. See **§4.7.1**.

Figure 4.7.4 Airspeed Indicator (ASI)

No.	Flight instrument / indication
1	**Reference speed bug** (white) — manually set by the pilot, or preset with weight- and condition-appropriate takeoff and landing speeds via the EFB Data Cards tab's **Set Bugs** button.
2	**Reference speed bug** (white) — see item 1.
3	**Maximum Allowable Airspeed pointer** — the striped (barber pole) needle indicating the current maximum allowable airspeed.
4	**Reference speed bug** (white) — see item 1.
5	**Reference speed bug** (white) — see item 1.
6	**Primary airspeed bug** (yellow) — set with the bug-set knob, or automatically set by the EFB Data Cards tab's Set Bugs button. Also drives the Reference Speed Indicator on the ADI. See **§4.7.1**.
7	**Bug-set knob** — sets the primary airspeed bug (yellow).

4.7.5 Backup (Standby) ADI

The standby ADI is the aircraft's backup attitude reference (Figure 4.7.5). If the primary ADI fails, this instrument continues to provide pitch and bank information.

The unit is fitted with a combined Gyro Caging and Adjustable Pitch Reference Control knob, described below.

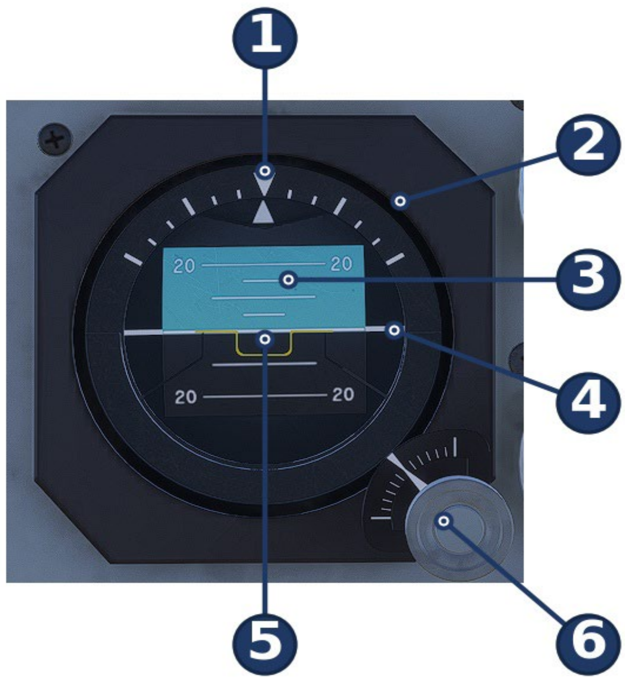

Figure 4.7.5 Backup (Standby) ADI

No.	Flight instrument / indication
1	**Bank index** — the fixed triangle reference at the top of the instrument.
2	**Bank scale** — the graduated marks around the outer rim, read against the bank index.
3	**Pitch scale** — the horizontal reference lines on the sky and ground bands, graduated in degrees.
4	**Horizon line** — the boundary between the sky and ground bands.
5	**Miniature aircraft / pitch reference symbol** (yellow) — the fixed aircraft reference, adjustable in position by the Gyro Caging & Pitch Reference Control knob.
6	**Gyro Caging & Pitch Reference Control knob** — a combined control. Turning the knob adjusts the yellow pitch reference symbol. Pulling and releasing the knob cages the instrument to a straight-and-level indication; releasing it uncages the instrument, and it resumes providing pitch and bank data.

NOTE

> The ADI should only be caged or uncaged while the aircraft is on the ground or confirmed in straight-and-level flight. Caging or uncaging at any other time can produce inaccurate indications.

4.7.6 Radio Altimeter

The radio altimeter displays the height above ground below the aircraft (Figure 4.7.6). The DH set knob sets the Decision Height above ground level for the MDA alert, adjusting the orange DH bug on the gauge.

Figure 4.7.6 Radio Altimeter

No.	Flight instrument / indication
1	**Height needle** — indicates height above ground.
2	**Decision Height (DH) bug** (orange triangle) — set by the DH set knob.
3	**Test button** — tests the MDA/DH indications.
4	**DH set knob** — sets the Decision Height above ground level for the MDA alert, adjusting the orange DH bug.

> **NOTE**
>
> The gauge reads 0 to 500 ft in detail, and continues to 2,500 ft on a reduced scale. The needle hides entirely at or above 2,500 ft.

4.8 Select Warnings and Annunciators

This section outlines key warnings and annunciators not covered elsewhere in the manual.

4.8.1 Altitude Alerter

The altitude alerter assists the pilot in selecting and maintaining a target altitude (Figure 4.8.1a). The alerter has its own altimeter, so its BARO setting should be set appropriately and matched to the pilot's altimeter.
When the aircraft approaches or deviates from the selected target altitude, the ALTITUDE ALERT annunciator illuminates and an aural warning sounds (Figure 4.8.1b).

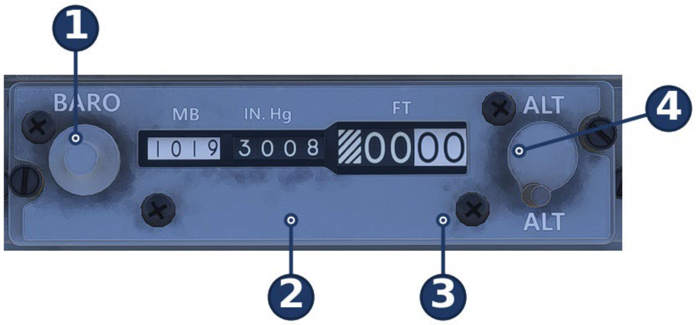

Figure 4.8.1a Altitude Alerter Panel

No.	Flight instrument / indication
1	**BARO knob** — sets the barometric pressure for the altitude alerter's own altimeter, in the barometric setting window.
2	**Barometric setting window** (MB / IN. Hg) — displays the barometric pressure set with the BARO knob. Should be set to match the pilot's altimeter.
3	**Target altitude window** (FT) — displays the selected target altitude, set with the ALT knob.
4	**ALT knob** — sets the target altitude in the target altitude window.

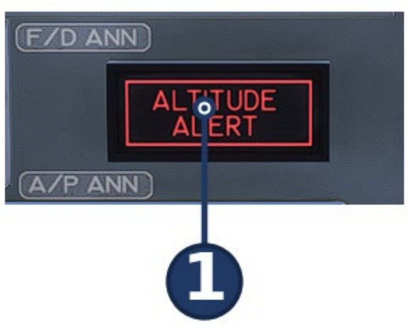

Figure 4.8.1b Altitude Alert Annunciator

No.	Flight instrument / indication
1	**ALTITUDE ALERT annunciator** — illuminates, together with an aural warning, when the aircraft approaches or deviates from the selected target altitude.

> **NOTE — EFB Options**
> The altitude alerter can be enabled as an autopilot altitude preselector through the EFB options tab. The Virtual Flight Engineer (VFE) will also call out when approaching the target altitude if In-Flight Callouts are enabled in the EFB options tab. The altitude alerter's BARO setting can be automatically synced to the captain's altimeter setting if the Sync Captain's Altimeter Setting option is enabled in the EFB options tab.

4.8.2 Warning Annunciator

The WARNING annunciator (Figure 4.8.2) illuminates whenever AC power is lost to the instrument panel. It can be pressed to test and reset the warning annunciation.

Figure 4.8.2 Warning Annunciator

4.8.3 GPWS Alerts

The GPWS (Ground Proximity Warning System) light (Figure 4.8.3) illuminates with any ground proximity alert. The BELOW G/S light illuminates when the aircraft is flying an ILS approach and has deviated below the glideslope. Both lights are accompanied by an aural alert, and both can be pressed to test.

Figure 4.8.3 GPWS and Below G/S Annunciators

PART II — AIRCRAFT SYSTEMS

Chapter 5 — Pratt & Whitney JT3D Engines

About this chapter

Describes the four **Pratt & Whitney JT3D** turbofan engines: their instruments, the throttle-quadrant controls, the Flight Engineer's engine panel, and the ignition/starting system, including the full **engine-start procedures**.

Water injection is covered separately in Chapter 6; the EFB throttle-assist and set-bug automations are covered in Chapter 26.

5.1 Engine Overview

The Boeing 707-320C is powered by four **Pratt & Whitney JT3D** turbofan engines, numbered **1 through 4** from left to right. The JT3D is a **two-spool** engine:

- **N1** — the low-pressure spool, which drives the front fan and low-pressure compressor.
- **N2** — the high-pressure spool, which drives the high-pressure compressor and is the spool turned during starting.

Thrust is set by reference to **Engine Pressure Ratio (EPR)** — the ratio of turbine-discharge pressure to compressor-inlet pressure — shown on the PRESS RATIO gauges (§5.2). Optional water injection provides additional takeoff thrust in hot or high conditions (Chapter 6).

5.2 Engine Instruments

The primary engine instruments are grouped in four columns — one per engine — in the center of the main instrument panel (Figure 5-1). The callouts identify one representative of each instrument; the column repeats for engines 1 through 4.

Figure 5-1 Engine instrument cluster (engine-1 column called out; repeats for engines 2–4)

No.	Control / indicator
1	**REV OPTG** light (amber) — illuminates when that engine's thrust reverser is operating (§5.9).
2	**WATER INJ** light (green) — illuminates when water injection is active for that engine (Chapter 6).

No.	Control / indicator
3	**PRESS RATIO (EPR)** gauge — the primary thrust-setting instrument, with a movable **SET** bug (bottom-right of the gauge) used to mark the target EPR.
4	**N1** — low-pressure spool speed, percent RPM (fan speed).
5	**EXH TEMP** — exhaust gas temperature (°C × 100).
6	**N2** — high-pressure spool speed, percent RPM (the spool turned during start).
7	**FUEL FLOW / FUEL CONSUMED** — fuel flow (PPH ×1000) and the fuel-consumed counter (see also Chapter 11).

EPR set bug — automatic setting

The **SET** bug on each EPR gauge marks the target EPR for the phase of flight. These bug values can be **set automatically by flight phase** by the Virtual Flight Engineer option in the EFB, so the crew is not required to set them manually (Chapter 26).

An **OIL PRESSURE WARNING** light for each engine is provided at the lower corners of the cluster; detailed oil indications are on the Flight Engineer's panel (§5.4).

5.3 Engine Controls — Throttle Quadrant

The engines are controlled from the throttle quadrant on the center pedestal (Figure 5-2). Three sets of levers are provided, one lever per engine in each set.

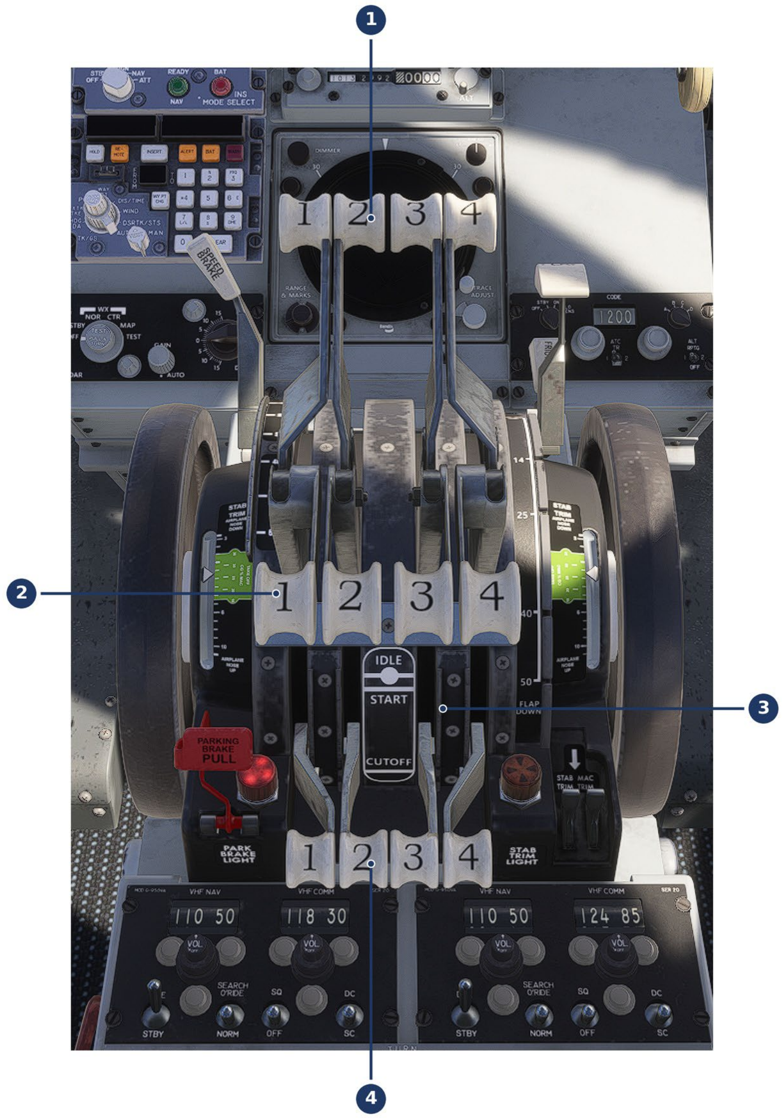

Figure 5-2 Throttle quadrant — reverser levers (1), thrust levers (2), IDLE/START/CUTOFF gate (3), start levers (4)

No.	Control / indicator
1	**Reverse thrust levers** — the upper levers, mounted on (and moving with) the main thrust levers; raised to command reverse thrust (§5.9).
2	**Thrust levers** — the main throttles, one per engine, moved together or individually to set thrust.
3	**IDLE / START / CUTOFF gate** — the central placard marking the positions of the start levers.
4	**Start levers** — the lower levers, one per engine, with positions **CUTOFF · START · IDLE**; they introduce fuel and ignition during starting (§5.7).

No.	Control / indicator
EFB — Takeoff / Climb Throttle Assistance An EFB option enables **Takeoff / Climb Throttle Assistance**: when selected, the Virtual Flight Engineer manages the throttles during **takeoff and climb** to hold the targeted EPR. This feature is described in more detail in the EFB chapter (Chapter 26).	

5.4 Flight Engineer's Engine Panel

The Flight Engineer monitors engine health from the engine section of the FE panel (Figure 5-3), which provides oil and vibration indications for all four engines plus the alternate-start controls.

Figure 5-3 Flight Engineer's engine panel (engine-1 instruments called out; repeat for engines 2–4)

No.	Control / indicator
1	**ALTERNATE LOW PRESS START** switches — select the alternate (low-pressure) start mode for the engine pair.
2	**OIL QUANTITY** gauge — engine oil quantity, gallons.
3	**OIL TEMP** gauge — engine oil temperature (°C), with a green normal band.
4	**OIL PRESS** gauge — engine oil pressure (PSI), with green normal and red/amber limit markings.
5	**Engine Vibration — AMPLITUDE** gauge — vibration amplitude (mils) for each engine.
6	**ENGINE VIBRATION** pickup selector and **PUSH TO TEST** — select the vibration pickup source and test the system.

A **PUSH TO TEST GAGES** control and the **FUEL FLOWMETER RESET** buttons (ENG 1–4) are also on this panel; the fuel-flowmeter reset is described in Chapter 11.

5.5 Ignition & Starting System

Each engine is started by an **air-turbine starter** that spins the **N2** spool up to a self-sustaining speed, while ignition and fuel are introduced with the start lever. Starting air is supplied by the Primary Pneumatic System — from the APU on the ground, or by cross-bleed from a running engine (Chapter 7).

- The **engine start-control switch** (§5.6) admits starter air and arms ignition. **GROUND START** is used on the ground; **FLIGHT START** provides continuous ignition for an in-flight relight.
- The **start lever** (throttle quadrant, §5.3) introduces **fuel and ignition** when moved from CUTOFF to START, then to IDLE for normal idle running.
- The **starter cuts out** automatically as N2 reaches self-sustaining speed.

Adequate starting air is required

A successful start requires adequate pneumatic pressure — at least **30 PSI** on the DUCT PRESS / AIR SUPPLY gauge (Chapter 7). Insufficient pressure produces a slow, hot, or hung start.

5.6 Engine Start Control Panel

The **ENGINE START CONTROL** panel on the center overhead carries one guarded three-position switch per engine (Figure 5-4).

Figure 5-4 Engine Start Control panel — per-engine start switch (1); FLIGHT START / OFF / GROUND START

Position	Function
GROUND START	Normal ground start — admits starter air and arms ignition; releases automatically after the start.
OFF	Normal in-operation position; starter and start ignition de-energized.
FLIGHT START	Provides continuous ignition for an in-flight air start / relight.

5.7 Normal (APU) Engine Start

On the ground, engines are normally started using APU bleed air. Confirm the pneumatic configuration first, then start each engine in turn.

Before Starting

- APU running, **APU RPM** above ~95%, **APU BLEED VALVE ON**.

- **AIR COND UNIT OFF** and the **wing (isolation) valves OPEN** so bleed air reaches the manifold.
- At least **30 PSI** on the **DUCT PRESS / AIR SUPPLY** gauge (Chapter 7).

Start Procedure (each engine)

- Select **GROUND START** for the engine on the Engine Start Control panel (§5.6).
- Monitor **N2** beginning to rise as the starter spins the engine.
- At approximately **15% N2**, introduce fuel by moving the **start lever** from **CUTOFF** to **START**.
- Confirm a light-off: rising **EXH TEMP**, and **N1** and **N2** accelerating. Monitor EXH TEMP for a hot start.
- After the engine stabilizes, move the start lever to **IDLE** for normal idle running; the start switch releases automatically.
- Confirm stable idle indications — EPR, N1, N2, EXH TEMP, oil pressure — before starting the next engine.

> **Typical start sequence**
> Engines are normally started in the order **3, 4, 2, 1**.

5.8 Cross-Bleed Engine Start

When APU bleed is unavailable, an engine can be started using bleed air from an already-running engine, supplied through the turbocompressors (Chapter 7).

- With one engine running, ensure that engine's associated **turbocompressor is running**.
- Increase the **supplying engine's N2** to approximately **80–85%** to build pneumatic pressure.
- Select **GROUND START** on the engine to be started.
- Verify the turbocompressor accelerates to approximately **80–90% RPM** and at least **30 PSI** duct pressure.
- Complete the remaining steps exactly as for a normal (APU) start (§5.7): fuel at ~15% N2, confirm light-off, start lever to IDLE.
- After the start is complete, reduce the **supplying engine back to idle**.

5.9 Thrust Reverser Operation

Reverse thrust is commanded with the **reverse thrust levers** mounted on the main thrust levers (§5.3). Raising a reverse lever deploys that engine's reverser and increases thrust in the reverse direction; the **REV OPTG** light (§5.2) confirms reverser operation.

> **WARNING — Reverse-thrust interlocks**
> Reverse thrust is **interlocked**: the reverse levers cannot be raised until the corresponding **thrust lever is at IDLE**.
> A **weight-on-wheels** sensor further protects the system — reverse thrust is **locked out in flight** and can only be selected on the ground. Do not attempt to select reverse until the aircraft main wheels are firmly on the runway.

To stow reverse, return the reverse levers fully down before advancing the thrust levers again. The REV OPTG light extinguishes when the reverser is stowed.

PART II — AIRCRAFT SYSTEMS

Chapter 6 — Water Injection

About this chapter

Describes the **optional water injection system** — a defining feature of the JT3D-3B — which recovers takeoff thrust when hot or high-elevation conditions would otherwise reduce engine performance.

6.1 System Overview

Water injection is an optional system fitted to the aircraft that increases available takeoff thrust by introducing water into the engines. It is used on high-gross-weight departures and in hot or high-elevation conditions, where density altitude would otherwise limit the thrust the engines can produce.

Because the extra thrust is only needed at the moment of greatest demand, the system is designed to operate **only at high engine power** — that is, at takeoff.

Simulator behavior — water capacity not modeled

In the current simulation, the **water capacity is not modeled** — the supply does not deplete. In practice this means the only required crew actions are to switch **water injection ON at the start of the takeoff roll** and **OFF when reducing thrust after takeoff**.

The real-aircraft finite-supply behavior described later in this chapter (§6.5) is provided as background; the pump-dry and water-quantity considerations do not currently apply in the simulator.

6.2 Operating Principles

Water injection raises thrust through two complementary effects:

- **Increased mass flow.** Injecting water into the engine airflow increases the mass of material passing through the engine, and thrust rises with mass flow.
- **Hot-section cooling.** Turbine engines are normally limited by hot-section temperature. Injected water cools the gas path, which allows a higher fuel flow — and therefore greater thrust — before temperature limits are reached.

The water is injected into the engine diffuser case, and most of the thrust increase comes from the cooling effect, which permits the higher fuel flow. Because the system depends on high power to work correctly, it is armed for takeoff and is not used at low power settings.

Black smoke on a wet departure

The higher fuel flow of a wet takeoff, combined with significant water vapor, produces the trademark **black smoke trails** of a water-injected 707 departure. This is normal and is reproduced by the simulation.

6.3 Controls & Indicators

The water injection controls are grouped on the WATER INJECTION panel (Figure 6-1).

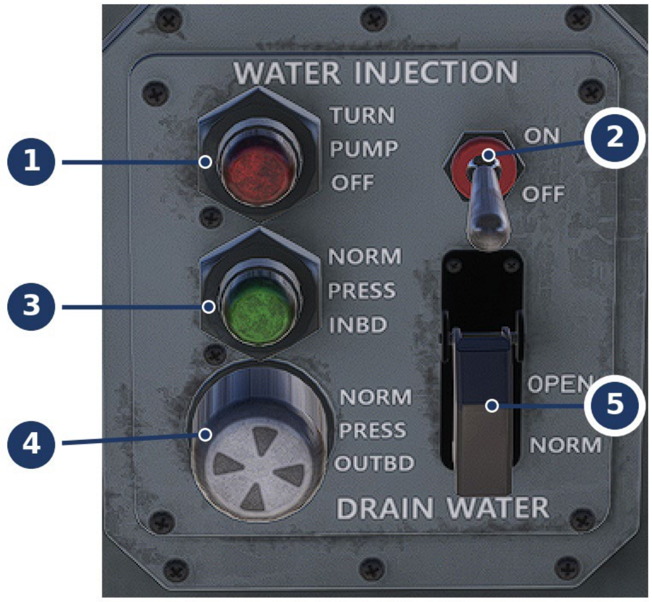

Figure 6-1 Water Injection panel

No.	Control / indicator
1	**TURN PUMP OFF** light (red) — annunciator advising the crew to switch the water pump off (for example, when the water supply is exhausted).
2	**Water injection ON / OFF** switch — arms the system and runs the water pump. Turned ON for a wet takeoff and OFF when water injection is no longer required.
3	**NORM PRESS INBD** light (green) — indicates normal water pressure to the **inboard** engines (2 and 3).
4	**NORM PRESS OUTBD** light — indicates normal water pressure to the **outboard** engines (1 and 4).
5	**DRAIN WATER** lever (OPEN / NORM) — controls the water-injection drain valve; NORM for normal operation, OPEN to drain the system.

6.4 Wet Takeoff Procedure

Water injection is enabled just before takeoff thrust is set and disabled as thrust is reduced for climb. The wet-takeoff EPR targets are taken from the takeoff performance data (Chapter 33).

- Confirm the takeoff data calls for a **wet takeoff** and note the **wet-takeoff EPR** targets.
- Confirm adequate **water quantity** for the planned takeoff.
- Immediately before setting takeoff thrust, switch **water injection ON** and confirm **NORM PRESS INBD** and **NORM PRESS OUTBD** indications.
- Set the **wet-takeoff EPR** targets and confirm the engines reach them.
- After takeoff, as thrust is reduced to climb power, switch **water injection OFF**.
- If the **TURN PUMP OFF** light illuminates (water exhausted), switch the water pump **OFF**.

PART II — AIRCRAFT SYSTEMS

Chapter 7 — Pneumatic System

About this chapter

Covers the aircraft's two pneumatic systems and the air-supply side of the environmental architecture: the sources of compressed air, the distribution manifold, duct-pressure monitoring, and engine-starting air.

The **consumers** of pneumatic air — the air conditioning packs, cabin temperature control, and pressurization — are covered in Chapter 8. The **Anti-Ice Pneumatic System** is introduced here but detailed in Chapter 9.

7.1 System Overview

The Boeing 707-320C uses two separate pneumatic systems. Although both use compressed air, they perform different functions and normally operate independently:

- **Primary Pneumatic System** — supplies engine starting, the air conditioning packs, cabin pressurization, and environmental functions.
- **Anti-Ice Pneumatic System** — a completely separate system whose only source is direct engine bleed air; it supplies engine and wing anti-ice (see Chapter 9).

The Primary Pneumatic System can be fed from three selectable sources — turbocompressors (the normal in-flight source), APU bleed air (ground operations), and direct engine bleed air (a backup supplement). These feed a common manifold that distributes air to the consumers. Figure 7-1 shows the overall architecture.

Figure 7-1 Primary Pneumatic System — sources, manifold, and consumers

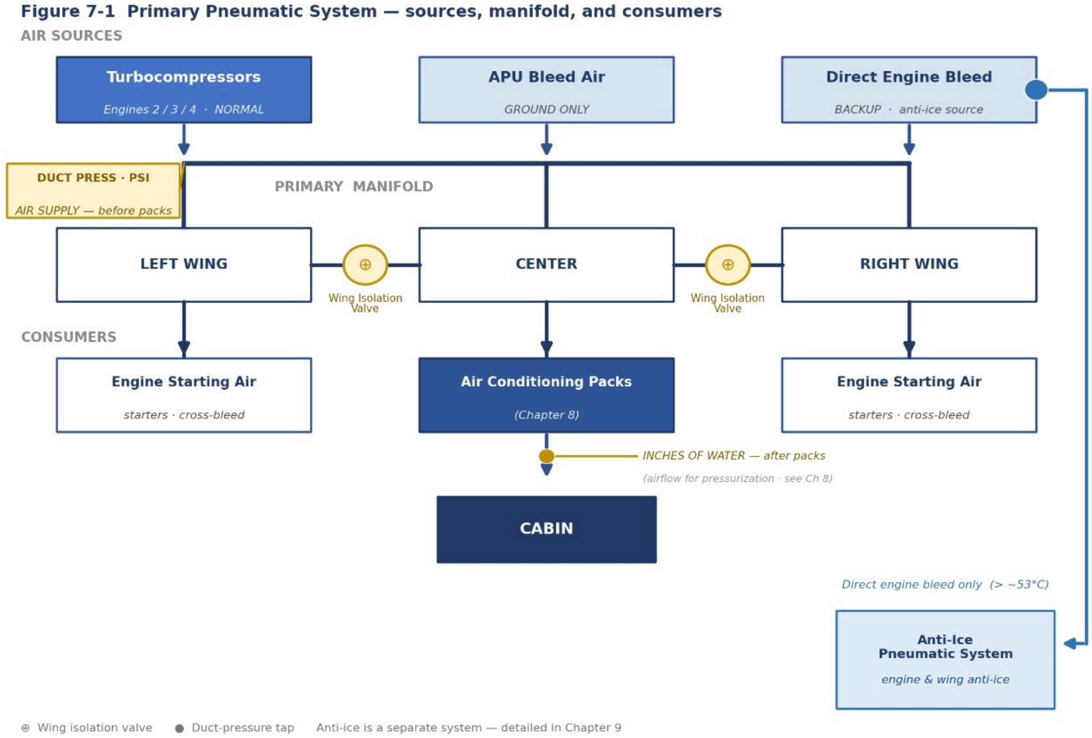

Figure 7-1 Primary Pneumatic System — sources, manifold, and consumers

> **Airflow, not just pressure**
> The Primary Pneumatic System distributes compressed air to the packs, which condition it before it reaches the cabin. Cabin pressurization is achieved through the combination of pack airflow and outflow-valve control, and is therefore part of the environmental system (Chapter 8) rather than a separate pneumatic consumer.

7.2 Air Sources

The Primary Pneumatic System draws from three selectable sources. Under normal flight conditions the turbocompressors supply the system; engine bleed air is held in reserve for anti-ice, and APU bleed is used only on the ground.

7.2.1 Turbocompressors

Three engine-driven turbocompressors are installed on Engines 2, 3, and 4, and are the normal source of pneumatic air in flight. Due in part to large bleed demand efficiency losses in the JT3D (and old low-bypass turbofans in general), the system trades complexity for efficiency: unlike modern bleed air systems, the turbocompressors utilize a comparatively smaller amount of bleed air to instead power a separately mounted turbine/compressor unit, drawing clean atmospheric air from dedicated cowling intakes and physically compressing that air. This lets the aircraft run its environmental systems with a minimum of engine bleed, preserving bleed capacity for the anti-ice systems.

Figure 7-2 Turbocompressor controls — RPM gauge (1), START/STOP (2), LOW OIL PRESS (3), OVER SPEED TRIP (4)

The turbocompressor controls are on the Air Conditioning & Pressurization panel. Each unit has an RPM indicator, a START/STOP switch, and two annunciators:

Control / indication	Function
RPM indicator	Displays compressor speed as a percentage of maximum RPM. Normal operating range is approximately **30–95%**, fluctuating with system demand.
START / STOP switch	Starts and stops each compressor independently. A compressor may only be started when **aircraft electrical power is available and its associated engine is running**.
LOW OIL PRESS	Indicates low oil pressure in the compressor housing. Brief illumination during startup is normal; **continuous** illumination is a malfunction — shut the affected unit down and consider it unavailable.
OVER SPEED TRIP	Illuminates when a governing-system failure lets RPM exceed ~95%, triggering an automatic safety shutdown. Once tripped, that compressor is **unavailable for the remainder of the flight**.

Operating Modes

The turbocompressors cycle automatically between two behaviors. In **Normal Mode** (the default in flight) they regulate output to meet environmental demand. When an engine start is initiated, the associated unit transitions to **Engine-Start Mode** to provide the higher airflow required for starting (see §7.5).

> **Sustained low duct pressure**
>
> If duct pressure cannot be maintained, source capacity is not keeping up with demand — typically because multiple compressors are offline. Under these conditions, direct engine bleed air must be introduced to restore acceptable duct pressure (§7.2.2).

7.2.2 Direct Engine Bleed Air

Direct engine bleed air serves two roles: it is the **sole source** for the Anti-Ice Pneumatic System, and a **supplemental backup** for the Primary Pneumatic System. Unlike the turbocompressors, bleed-air output is unregulated and varies with engine power — increasing with higher N1 and decreasing at lower power settings — which makes it useful during high-power phases but less predictable than turbocompressor output.

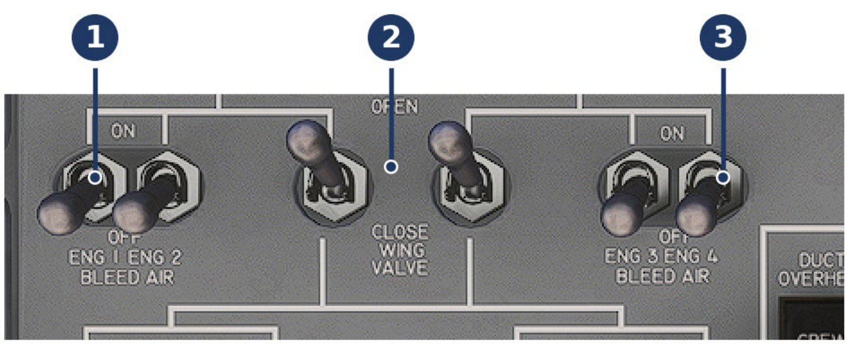

Figure 7-3 Bleed air and wing isolation — ENG 1/2 BLEED AIR (1), CLOSE WING VALVE (2), ENG 3/4 BLEED AIR (3)

The Flight Engineer controls bleed-air contribution to the Primary System using four independent **ENG BLEED AIR** switches (one per engine). Each actuates an electrically-operated valve that admits engine air into the manifold; a valve can only open when electrical power is available and the associated engine is running.

Normal operating philosophy

Under normal conditions the turbocompressors supply the Primary System, and all four **bleed-air valves remain closed** — preserving engine bleed capacity entirely for anti-ice protection. Open the bleed valves only to supplement the system if turbocompressor output is compromised or low duct pressure occurs.

Direct engine bleed remains a **backup** to the turbocompressors, and a turbocompressor and the direct bleed of the **same engine must not be used at the same time** — use one or the other on any given engine (§7.2.2 note).

NOTE — One air source per engine

Do **not** run an engine's turbocompressor and open that same engine's bleed valve simultaneously — use only one air source per engine. Because direct bleed is a backup, the case for using it is on an engine whose turbocompressor is unavailable: for example, if the **Engine 2 turbocompressor is offline**, direct bleed may be taken from **Engine 2** while the turbocompressors on **Engines 3 and 4** continue to supply the manifold.

7.2.3 APU Bleed Air

The APU supplies bleed air for **ground operations only** — chiefly engine starting and pre-departure environmental supply. APU bleed is admitted to the Primary System through the **APU BLEED VALVE** on the Auxiliary Power Unit panel (the APU itself is covered in Chapter 13). Before takeoff, APU bleed is secured and the aircraft transitions to turbocompressor supply.

7.3 Distribution & Wing Isolation Valves

The three sources feed a common manifold divided into three sections — **left wing, center, and right wing** — connected by two **wing isolation valves** (see Figure 7-1). With the isolation valves open, the manifold behaves as a single continuous duct so any source can supply any consumer. Closing a wing isolation valve isolates that wing section, which is used for fault isolation rather than routine management.

The **CLOSE WING VALVE** switches (Figure 7-3) command the isolation valves. In normal operation the valves are open and the manifold is continuous.

7.4 Duct Pressure Monitoring

Duct pressure is the primary indication of pneumatic health, and the 707 provides **two distinct duct-pressure gauges** that measure at different points in the airflow path. Distinguishing them is essential: they answer different questions.

Figure 7-4 Duct pressure — DUCT PRESS / AIR SUPPLY in PSI, in the pneumatic manifold (1); INCHES OF WATER, cabin duct pressure (2)

Gauge	What it indicates
DUCT PRESS / AIR SUPPLY (PSI)	Duct pressure **before the packs**, in the main pneumatic manifold (upstream / supply side).(§7.5).
INCHES OF WATER (green arc)	Cabin Duct pressure **after the packs** (downstream). This indicates the **airflow available for pressurization and environmental systems** and is the gauge the crew monitors continuously in flight.

WARNING — Watch the INCHES OF WATER gauge

The INCHES OF WATER gauge is the primary indication of airflow available to support cabin pressurization. As duct pressure approaches **20 inches of water**, the risk of an operational pack overheat increases sharply.

A reading below approximately **4 inches of water** is the minimum required to hold pressurization and air circulation (see Chapter 8).

Under normal operation — with automatic temperature control active and VFE air-source automation enabled — the system manages valve positioning to keep duct pressure in the green arc and eliminate overheat risk.

7.5 Engine Starting Air

The Primary Pneumatic System supplies the high-volume airflow required to spin the engine starters. Adequate **DUCT PRESS / AIR SUPPLY (PSI)** — the upstream gauge of §7.4 — is the reference for starting; a minimum of approximately **30 PSI** is required at the start valve.

When a start is initiated, the associated turbocompressor transitions to Engine-Start Mode to boost airflow. On the ground the APU normally supplies starting air; in the air, a running engine can supply the others through the manifold. The full normal-start and cross-bleed-start procedures are given in §5.6–§5.9 (Engine Start Control Panel, Normal APU Engine Start, Cross-Bleed Engine Start) and §32.6 (Engine Start Procedure).

7.6 Virtual Flight Engineer Integration

Most normal pneumatic management is handled automatically when the Virtual Flight Engineer (VFE) flows and automations are used. Manual control is always available and fully supported.

Turbocompressor Management

During standard flows the VFE operates the turbocompressor START/STOP switches automatically, bringing the units online as engines start and managing them through the flight.

APU & Air-Source Management

During cockpit preparation and engine start, the VFE will start the APU, monitor APU RPM, and open the APU BLEED VALVE when pneumatic air is required — using APU air for environmental systems and starting. As engine-driven sources become available, the VFE automatically transitions supply away from the APU. Prior to takeoff it normally closes the APU BLEED VALVE and shuts down the APU, transitioning the aircraft to its normal flight configuration on the turbocompressors (and, if required, direct engine bleed).

> **Recommended — normal pneumatic configuration**
>
> In flight: **turbocompressors supplying** the Primary System · **ENG BLEED AIR valves closed** (bleed reserved for anti-ice) · **wing isolation valves open** · **INCHES OF WATER** duct pressure in the green arc. With VFE air-source automation enabled, this configuration is maintained automatically.

PART II — AIRCRAFT SYSTEMS

Chapter 8 — Air Conditioning & Pressurization

About this chapter

Covers the **consumers** of pneumatic air: the air conditioning packs, cabin temperature control, the Coolant Air System, and cabin pressurization. This is the downstream continuation of Chapter 7 (Pneumatic System), which supplies the air these systems use.

All controls described here are on the **Air Conditioning & Pressurization** panel at the Flight Engineer's station.

8.1 Air Conditioning Units

The Boeing 707-320C uses two Air Conditioning Units to cool and condition pneumatic air before it enters the cabin. Each unit processes air through a cooling cycle that combines compression and expansion, heat exchangers, and ambient ram-air cooling. The units are the **primary consumer** of pneumatic airflow during normal operation.

Both units receive air from the center section of the Primary Pneumatic System — normally from the turbocompressors, though APU or direct engine bleed may supply them when required (see Chapter 7). Although there are separate left and right units, they are **not operated independently**: both are controlled together by a single **AIR COND UNIT** ON/OFF switch.

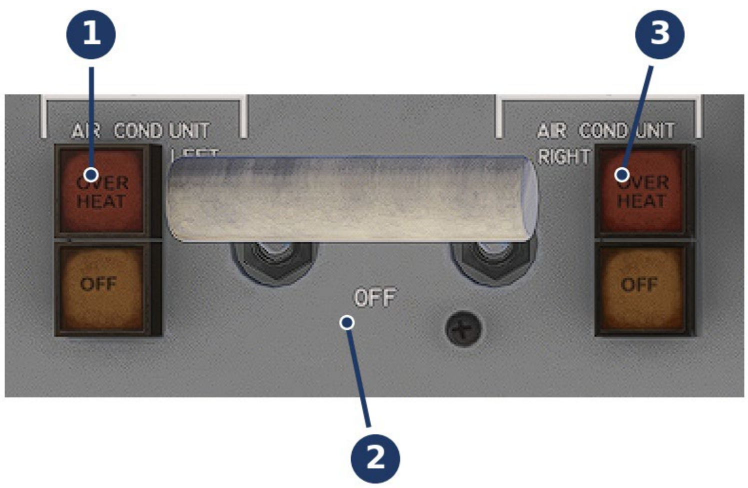

Figure 8-1 Air Conditioning Units — LEFT OVER HEAT annunciator (1), AIR COND UNIT ON/OFF switch (2), RIGHT OVER HEAT annunciator (3)

With the switch **ON**, pneumatic air is admitted to both units, the units receive electrical power, and air conditioning and cabin temperature control operate normally. With it **OFF**, airflow to the units is shut off and air conditioning is unavailable — not a normal in-flight configuration. A red **OVER HEAT** annunciator is provided for each unit.

8.2 Cabin Temperature Control

Cabin temperature is managed in two zones — **CREW** and **MAIN** — each with its own temperature control. Under normal operation the system runs automatically: the Flight Engineer selects a target temperature for each zone and leaves the selector in the automatic range, and the system positions the cooling-air valves as required to achieve and hold that temperature while keeping the packs within thermal limits.

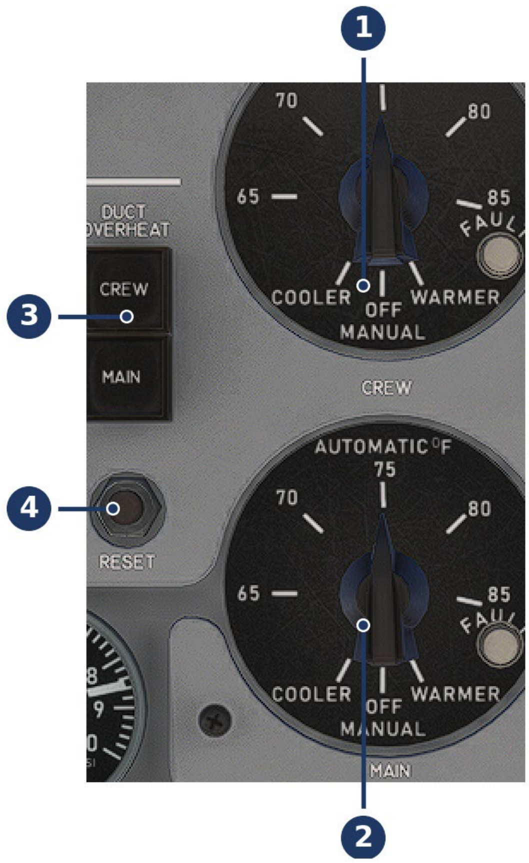

Figure 8-2 Cabin temperature control — CREW control (1), MAIN control (2), DUCT OVERHEAT test (3), RESET (4)

Each control has an **AUTOMATIC** range (selecting a target between roughly 65–85°F) and a **MANUAL** range (COOLER – OFF – WARMER) used only when automatic control is unavailable. A **FAULT** mark indicates a temperature-control fault. The **DUCT OVERHEAT** test buttons (CREW / MAIN) and the **RESET** button are used to check and reset the duct-overheat protection.

> **Recommended — normal temperature configuration**
> **AIR COND UNIT** switch ON · **CREW** and **MAIN** temperatures set as desired in the automatic range. In this configuration the system maintains cabin temperature and protects the packs without further intervention.

8.3 Coolant Air System

The **Coolant Air System** is the hardware that regulates the performance of the Air Conditioning Units — in practical terms, it is the 707's cabin climate-control mechanism. Air supplied by the Primary Pneumatic System enters the units at high temperature and pressure; the Coolant Air System reduces that temperature through a cooling cycle of heat exchangers, compressed-air expansion, and ambient ram-air cooling before the conditioned air is delivered to the cabin.

Under normal operation the Coolant Air System functions **automatically** in response to the CREW and MAIN temperature selections (§8.2); the panel controls below are provided for monitoring and for manual override during abnormal operations or troubleshooting.

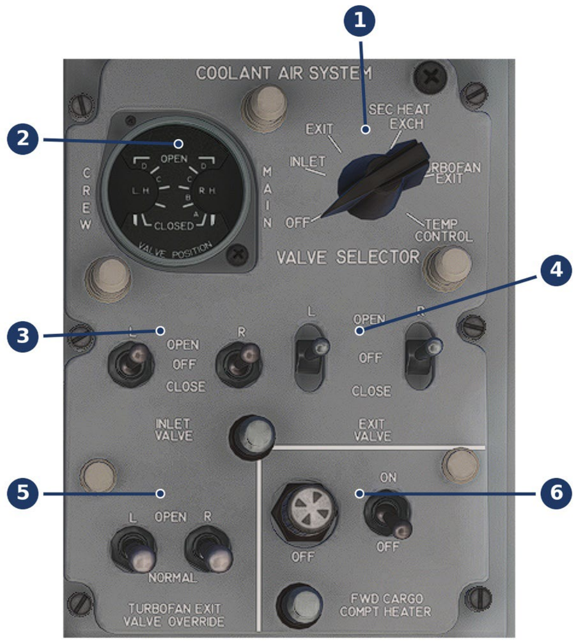

Figure 8-3 Coolant Air System — VALVE SELECTOR (1), valve position indicator (2), INLET VALVE (3), EXIT VALVE (4), TURBOFAN EXIT VALVE OVERRIDE (5), FWD CARGO COMPT HEATER (6)

Control	Function
Valve Selector	Rotary selector that does **not** move any valve. It selects which coolant-air valve position is shown on the adjacent **valve position indicator** (Inlet Valve, Exit Valve, or Turbofan Exit Valve).
Valve position indicator	Displays OPEN/CLOSED position for the valve currently selected on the Valve Selector.
Inlet Valve (L / R)	Manual OPEN / OFF / CLOSE control of each unit's inlet valve. On the ground the inlet valves are held **fully open** by the landing-gear safety (squat) switch, which **overrides** these switches; in flight the inlet valves may be modulated with the switches. Normally left in automatic control.
Exit Valve (L / R)	Manual OPEN / OFF / CLOSE control of each unit's exit valve. On the ground the exit valves are held **fully closed** by the landing-gear safety (squat) switch; they **open automatically when the airplane becomes airborne**, and in flight may be modulated with the switches. Normally left in automatic control.
Turbofan Exit Valve Override (L / R)	Manual override of the turbofan exit valve, normally left in the NORMAL position.
FWD Cargo Compt Heater	ON/OFF control for forward cargo compartment heating.

> **NOTE — Ground vs. flight valve behavior**
> The coolant-air **inlet** and **exit** valves are automatically overridden on the ground by the **landing-gear safety (squat) switch**: on the ground the inlet valves are driven **fully open** and the exit valves **fully closed**. When the airplane becomes airborne, the exit valves open automatically, and both inlet and exit valves may then be modulated with their panel switches. This automatic ground override is why manual manipulation of these valves is reserved for abnormal operations (see CAUTION below).

> **CAUTION — Manual coolant-air operation**
> The manual valve switches are intended for abnormal operations and troubleshooting only. Improper manual manipulation can reduce cooling effectiveness and may contribute to Air Conditioning Unit **overheat**. In normal operation, leave all Coolant Air System controls in automatic and do not manipulate the manual valve switches.

8.4 Pressurization — Overview

The pressurization system maintains a comfortable and safe cabin environment by controlling how the air supplied by the packs is **retained or released** from the fuselage, through the cabin **outflow valves**. The pneumatic system provides the airflow; the pressurization system governs its retention.

> **WARNING — Pressurization depends on pneumatic supply**
> Adequate cabin pressurization always requires sufficient pneumatic airflow from the Primary Pneumatic System. The primary indication is the **INCHES OF WATER** duct-pressure gauge (Chapter 7): as long as it remains in the green arc, sufficient air is available to support pressurization. The outflow valves can only retain air that is actively being supplied.

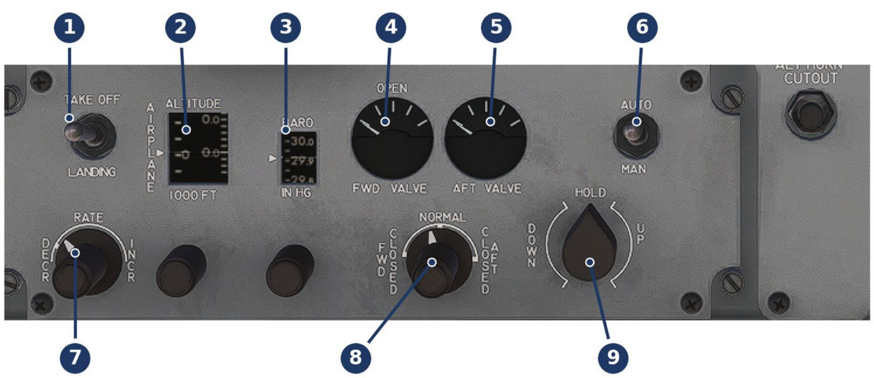

Figure 8-4 Pressurization control — TAKE OFF/LANDING (1), altitude schedule tape (2), BARO (3), FWD valve (4), AFT valve (5), AUTO/MAN (6), RATE (7), airflow distribution (8), HOLD manual control (9)

8.5 Automatic Pressurization

The 707 normally operates in **AUTO** mode. The controller continuously adjusts the outflow valves to follow a cabin-pressure schedule. The crew does not directly select a target cabin altitude; instead the system computes the schedule from the selected aircraft altitude, the barometric correction (**BARO**), the cabin rate selection, and the **TAKE OFF / LANDING** mode.

For normal operation, before takeoff, set the pressurization (selected) altitude to planned cruise altitude + 2,000 ft.

Altitude Schedule Tape

The **Altitude Schedule Display Tape** presents two scales side by side — aircraft altitude on the left and the resulting scheduled cabin altitude on the right. As the altitude selector is adjusted, the scheduled cabin altitude updates. Representative values:

Aircraft altitude (left scale)	Scheduled cabin altitude (right scale)
39,000 ft	7,500 ft
35,000 ft	5,500 ft
31,000 ft	3,500 ft

Takeoff & Landing Modes

1. **TAKE OFF** — pre-pressurizes the cabin slightly (approximately 100–250 ft below ambient departure pressure) to avoid a pressure bump at rotation.
2. **LANDING** — schedules cabin pressure toward the destination elevation and prepares the system for touchdown; on landing the system commands ground depressurization, equalizing cabin and outside pressure smoothly.

Cabin Rate

The **RATE** selector controls how quickly cabin altitude changes to meet its target — a passenger-comfort setting rather than the final target pressure. Higher values produce faster cabin-pressure changes; lower values smooth them out. Note that exceeding the maximum differential pressure of 8.6psi will cause the cabin rate to adjust at that required to maintain the safe pressure differential, regardless of the setting of the rate selector.

> **Recommended**
> Normal cabin rate: **500 FPM**. This provides a comfortable cabin climb and descent for most flights.

8.6 Outflow Valves & Airflow Distribution

Cabin pressure is regulated by the **outflow valves**. In AUTO mode their positioning is managed automatically to follow the programmed schedule, and no manual manipulation is required. The **FWD VALVE** and **AFT VALVE** indicators show outflow-valve position.

The Flight Engineer may adjust the preferred **airflow distribution** between the forward and aft outflow valves using the distribution selector (NORMAL is the standard setting). This influences airflow patterns within the cabin but does not directly affect overall pressurization performance.

8.7 Manual Pressurization

A manual mode is provided as a backup to automatic operation. When **MAN** is selected, cabin pressure is controlled directly with the **DOWN – HOLD – UP** control, which drives the outflow valves:

Position	Effect
DOWN	Opens the outflow valves — releases air, **increasing** cabin altitude (reducing cabin pressure).
HOLD	Freezes the outflow valves in their current position.
UP	Closes the outflow valves — traps air, **decreasing** cabin altitude (increasing cabin pressure).

WARNING — Manual pressurization requires constant monitoring

In manual mode the crew must continuously monitor **cabin altitude, cabin rate, differential pressure, and duct pressure**.

Because the outflow valves only control the release of air, adequate pneumatic supply must still be available: if duct pressure falls below approximately **4 inches of water**, moving the control to UP will not pressurize the aircraft effectively.

8.8 Pressurization Instruments

The panel provides the primary pressurization indications the crew monitors in flight. Three of these — cabin differential pressure, cabin vertical speed, and cabin altitude — are grouped in the instrument cluster shown in Figure 8-5, alongside the duct-pressure gauges described in Chapter 7.

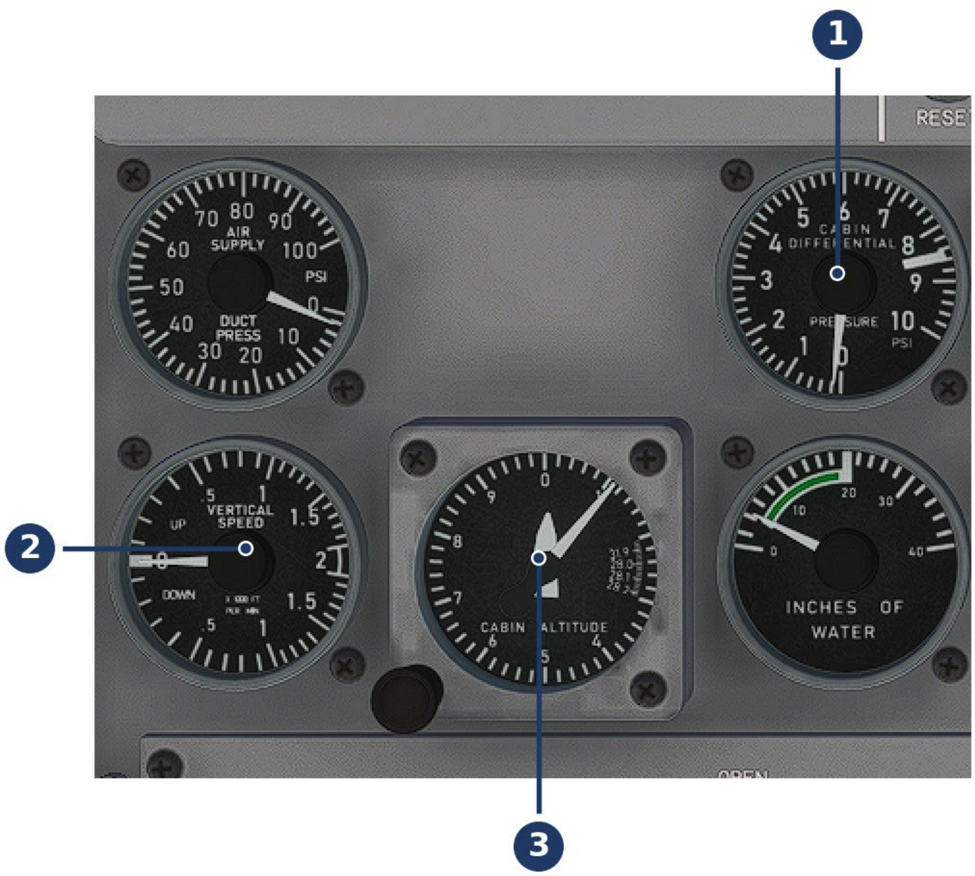

Figure 8-5 Cabin pressurization instruments — Cabin Differential Pressure (1), Cabin Vertical Speed (2), Cabin Altitude (3)

The full set of indications the crew monitors:

3. **Cabin Altitude** — the current pressure altitude inside the cabin.
4. **Cabin Differential Pressure** — the pressure difference between cabin and outside air (PSI).
5. **Cabin Vertical Speed** — the rate at which cabin altitude is changing.
6. **INCHES OF WATER** — duct pressure after the packs; the indication of airflow available to support pressurization (Chapter 7).

Cabin Altitude Warning

The pressurization system sounds an **aural cabin altitude warning** whenever cabin altitude exceeds **10,000 ft** — an indication that the cabin is no longer adequately pressurized.

If the warning sounds, the most likely cause is **insufficient airflow** to the cabin. Respond as follows:

7. Check the **INCHES OF WATER** duct-pressure gauge (Chapter 7) is within the **green arc**.
8. If it is not, ensure **all turbocompressors are ON** and the **air conditioning units are ON** (§8.1) to restore airflow.
9. **Consider a descent** to reduce cabin altitude and differential-pressure demand.

> **Silencing and re-arming the warning**
> The aural warning can be silenced with the **altitude cutout button**. It automatically **re-arms** when cabin altitude falls back below **9,500 ft**, so it will sound again if the condition recurs.

PART II — AIRCRAFT SYSTEMS

Chapter 9 — Ice Protection

About this chapter

Covers the aircraft's ice-protection systems: **Engine Nacelle Anti-Ice** and **Wing Anti-Ice** (bleed-air anti-ice), plus the electrically-heated **Window Heat**, **Pitot / Attitude-Warning Heat**, and **Q-Inlet Heat**.

The two anti-ice systems are supplied by the **Anti-Ice Pneumatic System** — direct engine bleed air only (Chapter 7). The window, pitot/att-warn, and Q-inlet heaters are **electrical** systems, controlled from the WINDOW HEAT panel.

9.1 System Overview

The Boeing 707-320C uses a dedicated **Anti-Ice Pneumatic System** supplied **exclusively by direct engine bleed air**. Unlike the Primary Pneumatic System — which may draw from turbocompressors, the APU, or engine bleed (Chapter 7) — the anti-ice system relies solely on direct engine bleed, so its operation depends on both adequate bleed-air **pressure** and sufficient bleed-air **temperature**.

The system comprises two subsystems, controlled from the anti-ice panel:

- **Engine Nacelle Anti-Ice** — individually controlled per engine (§9.2).
- **Wing Anti-Ice** — controlled as a single aircraft system (§9.3).

Common requirement — bleed-air temperature

Both subsystems require bleed-air temperature above approximately **53°C** before anti-ice airflow can occur. If bleed pressure or temperature is inadequate, the anti-ice valves remain closed even when selected ON.

Figure 9-1 Anti-Ice panel — nacelle anti-ice switches (1), VALVE POS indicators (2), nose-cowl / valve-position selector (3), wing anti-ice DUCT TEMP gauge (4), DUCT TEMP SELECTOR (5), WING ANTI-ICE switch (6), OVERHEAT light (7)

9.2 Engine Nacelle Anti-Ice

Engine nacelle anti-ice uses hot direct engine bleed air to prevent ice accumulation on the engine inlet and nacelle surfaces. Each engine is controlled individually.

Nacelle Anti-Ice Switches

Individual anti-ice switches are provided for **Engines 1, 2, 3, and 4**. Placing a switch **ON** commands anti-ice operation for that engine. Operation occurs only when all of the following are true:

- The switch is **ON**.
- Direct engine bleed **pressure** is available.
- Bleed-air **temperature** exceeds approximately **53°C**.

If sufficient pressure or temperature is unavailable, the anti-ice valves remain closed.

Valve-Position Selector & Indicators

Four green **VALVE POS** indicators — one per engine — confirm that the selected anti-ice valve is actually open, rather than merely commanded. Each engine has three anti-ice valves (left-hand, nose-cowl, and right-hand), so the four lights can only show one valve group at a time. The **valve-position selector** is a four-position rotary that chooses which valve group the lights display:

Selector position	VALVE POS indicators
OFF	No valve group is selected — the VALVE POS lights are blank and indicate nothing.
LH	Each light shows that engine's **left-hand** anti-ice valve: **on = open, off = closed**.
NOSE COWL	Each light shows that engine's **nose-cowl** anti-ice valve: **on = open, off = closed**.
RH	Each light shows that engine's **right-hand** anti-ice valve: **on = open, off = closed**.

In every position except OFF, an illuminated light confirms the corresponding valve is open and anti-ice airflow is being supplied to that engine; an extinguished light indicates that valve is closed. To confirm all valves for a running anti-ice configuration, cycle the selector through LH, NOSE COWL, and RH and verify the expected lights in each position.

Normal Operation

When nacelle anti-ice protection is required:

- Place the required engine **ANTI-ICE** switch(es) **ON**.
- Verify bleed-air temperature exceeds approximately **53°C**.
- Verify the appropriate **VALVE POS** indications illuminate for the selected valve group.

Illumination of the selected valve-position lights confirms that anti-ice airflow is actually being supplied.

> **CAUTION — Prolonged ground operation**
> Extended ground operation with nacelle anti-ice selected increases the likelihood of engine surging due to continued bleed-air extraction. During prolonged ground operation, increase one engine at a time to approximately **80% N1**, repeating about every five minutes as required.

Before Takeoff

If nacelle anti-ice will be required during takeoff or immediately after departure, select it **before takeoff power is applied**. Whenever nacelle anti-ice is required, **Window Heat** should also be selected to HIGH (§9.4).

9.3 Wing Anti-Ice

Wing anti-ice uses hot direct engine bleed air to thermally protect the wing leading edges. Unlike nacelle anti-ice, it is controlled through a **single system switch** and operates as a complete aircraft system, drawing from all operating engines capable of providing adequate bleed air.

Wing Anti-Ice Switch

Position	Function
OFF	System disabled; all anti-ice shutoff valves remain closed.
ON	System commanded on — valves open and hot bleed air is routed into the wing leading-edge ducts (bleed temperature must be at least ~53°C).
GRD TEST	Ground test of the system prior to flight (see below); part of the normal preflight anti-ice check.

Duct-Temperature Monitoring

Wing anti-ice performance is monitored on the **DUCT TEMP** gauge, which tracks four duct temperatures — left/right inboard and left/right outboard. Because the gauge displays two temperatures at a time, the **DUCT TEMP SELECTOR** chooses which pair is shown:

Selector	Displays
INBD	Left and right **inboard** wing-duct temperatures.
OUTBD	Left and right **outboard** wing-duct temperatures.

Typical wing anti-ice duct temperatures range from **75°C to 150°C**, varying with engine power, bleed-air temperature, outside air temperature, altitude, and wing cooling. During normal operation, temperatures should remain well below the overheat threshold.

Overheat Protection

The system continuously monitors duct temperature. If it exceeds **195°C**, the **OVERHEAT** annunciator illuminates, indicating operation outside the normal range.

> **WARNING — OVERHEAT in flight**
>
> If the OVERHEAT light illuminates in flight: set **WING ANTI-ICE to OFF**, monitor duct temperatures, allow them to return to the normal range, and investigate the cause before reselecting wing anti-ice.

Ground Test & the OVERHEAT Light

The **GRD TEST** position verifies the system before departure. When selected, the wing valves open, bleed air enters the ducts, and duct temperature rises. As temperatures reach the test limit, the thermal-protection system overrides GRD TEST and closes the valves to prevent overheating — illuminating the OVERHEAT annunciator to confirm the protection circuitry is working.

> **Understanding the OVERHEAT light**
> The OVERHEAT light primarily indicates that the thermal switch has overridden system operation to prevent excessive duct temperature. Therefore: momentary illumination during ground testing is **expected**; illumination following a successful GRD TEST generally indicates **proper** operation; **continuous** illumination during normal flight warrants investigation. When in doubt, verify duct temperatures on the DUCT TEMP gauge.

9.4 Window Heat

Window Heat is an **electrical** system that provides anti-ice and defog protection for the captain's and first officer's windshields. It is independent of the bleed-air anti-ice systems and is controlled from the WINDOW HEAT panel (Figure 9-2), which also carries the Pitot / Attitude-Warning Heat controls described in §9.5.

Figure 9-2 Window Heat panel — CAPT window-heat switch (1), F/O window-heat switch (2), OVER HEAT lights (3), Q-INLET HEAT switch & OFF light (4), PITOT/ATT WARN HEAT CAPT (5) and F/O-AUX (6) switches, AMP-SEL (7), AMPS AC gauges (8)

Window-Heat Switches

Each windshield has an independent three-position control:

Control	Positions
CAPT	HIGH / OFF / LOW — captain's windshield heat.
F/O	HIGH / OFF / LOW — first officer's windshield heat.

HIGH provides full heating for windshield anti-ice protection; **LOW** provides reduced heating for defog and normal operation. Whenever nacelle anti-ice is required, select Window Heat to **HIGH**.

Overheat Indication

Two amber lights — **OVER HEAT CAPT** and **OVER HEAT F/O** — illuminate if the respective heater lacks required AC power or the windshield exceeds its temperature limit. Window-heat temperature is automatically controlled; an overheat light indicates the automatic control has been exceeded and the affected side should be turned off.

WARNING — Window OVERHEAT light

Airborne: set the affected **WINDOW HEAT** switch **OFF**; hold **250 KTS max below 10,000 ft**. After 5 minutes off, the switch may be returned to **LOW**; if ice forms, cycle it as required.

On the ground: set the affected **WINDOW HEAT** switch **OFF** and correct the malfunction before flight.

9.5 Pitot / Attitude-Warning Heat

The captain, first officer, and a third (auxiliary) pitot tube are anti-iced by integral electric heaters. On this aircraft the same switches also heat the **attitude-warning devices** on the forward inboard section of each wing — hence the panel label **PITOT / ATT WARN HEAT**. The controls share the WINDOW HEAT panel (Figure 9-2).

Control	Function
CAPT (ON / OFF)	Captain's pitot and attitude-warning heat.
F/O-AUX (ON / OFF)	First officer and auxiliary (third) pitot and attitude-warning heat.
AMP-SEL (F/O / AUX)	Selects what the **right** amp meter displays: the **F/O** heater current or the **AUX** (third) heater current.
AMPS AC meters	Two meters monitor heater current. The **left** meter always shows the **CAPT** heater current; the **right** meter shows F/O or AUX per the AMP-SEL switch. A reading of **1 to 2.5 amps** confirms the selected heater is operating.

Recommended

Select **CAPT** and **F/O-AUX** pitot/att-warn heat **ON** for flight. Confirm the **left** meter (CAPT) reads 1–2.5 amps, then use **AMP-SEL** to check the **right** meter in both **F/O** and **AUX** — each should read 1–2.5 amps.

9.6 Q-Inlet (Q-Spring) Heat

The ram-air intake that supplies the rudder **Q-spring** is anti-iced electrically by integral resistance heaters embedded in the leading edge of the intake. Keeping this intake clear preserves the dynamic-pressure ("Q") sensing used by the rudder feel system. The controls are on the WINDOW HEAT panel (Figure 9-2, callout 4).

Control	Function
Q-INLET HEAT switch (ON / OFF)	**ON** heats the ram-air intake to the rudder Q-spring; **OFF** disables heating.
OFF light (amber)	Illuminates to indicate a **failure of the Q-inlet heater**. It is not a normal on/off status light — illumination means the heater is not functioning.

Control	Function
Recommended Select **Q-INLET HEAT ON** for flight in icing conditions and confirm the amber **OFF** (failure) light is **extinguished**. Steady illumination of the OFF light indicates a Q-inlet heater failure and should be investigated.	

9.7 Operations in Icing Conditions

This section describes recommended operating practices when icing conditions are anticipated. It complements the system descriptions above.

Ground De-Icing & Taxi

If icing conditions are possible during takeoff, the Wing Anti-Ice System may be used during taxi to warm the wing leading-edge structure before departure, while also confirming system operation:

- Select **WING ANTI-ICE** to **GRD TEST** during taxi.
- Set the **DUCT TEMP SELECTOR** to **INBD** and verify both inboard duct temperatures rise.
- Set the **DUCT TEMP SELECTOR** to **OUTBD** and verify both outboard duct temperatures rise.
- Monitor duct temperatures throughout the test.
- Return the switch to **OFF** at the start of the takeoff roll.

Nacelle Anti-Ice — Ground & Flight

When icing conditions exist, nacelle anti-ice should be used during both ground and flight operations. Select the required nacelle switches ON, verify bleed-air temperature exceeds ~53°C, and verify the appropriate VALVE POS indications. Observe the prolonged-ground-operation surging precaution (§9.2), and select nacelle anti-ice before takeoff power if it will be needed during or immediately after departure.

Monitoring Wing Anti-Ice In Flight

Monitor the DUCT TEMP gauge periodically. Typical temperatures are 75–150°C and should remain below 195°C. If duct temperature exceeds ~195°C and the OVERHEAT light illuminates, follow the OVERHEAT WARNING procedure in §9.3.

PART II — AIRCRAFT SYSTEMS

Chapter 10 — Electrical System

About this chapter

Describes the aircraft's electrical system — the **DC** and **AC** systems, their power sources, the six main AC busses and sync bus, and the Flight Engineer's controls.

It includes the full manual **generator-paralleling** procedure, along with the available shortcuts for pilots who prefer to skip it.

10.1 System Overview

The electrical system is split into two parts — the **DC system** and the **AC system**.

- **DC power** is provided by the aircraft **battery**, or by any of several **transformer-rectifiers (TRs)** fed either directly from the engine AC busses or from the essential AC bus.
- **AC power** is provided by the four **engine generators**, the **APU**, or an **external power cart**.

There are **six main AC busses**: four are powered by the engine generators, and the other two provide external power or APU power. All are connected through a **sync bus**, which balances power across multiple generators and provides additional redundancy (Figure 10-1).

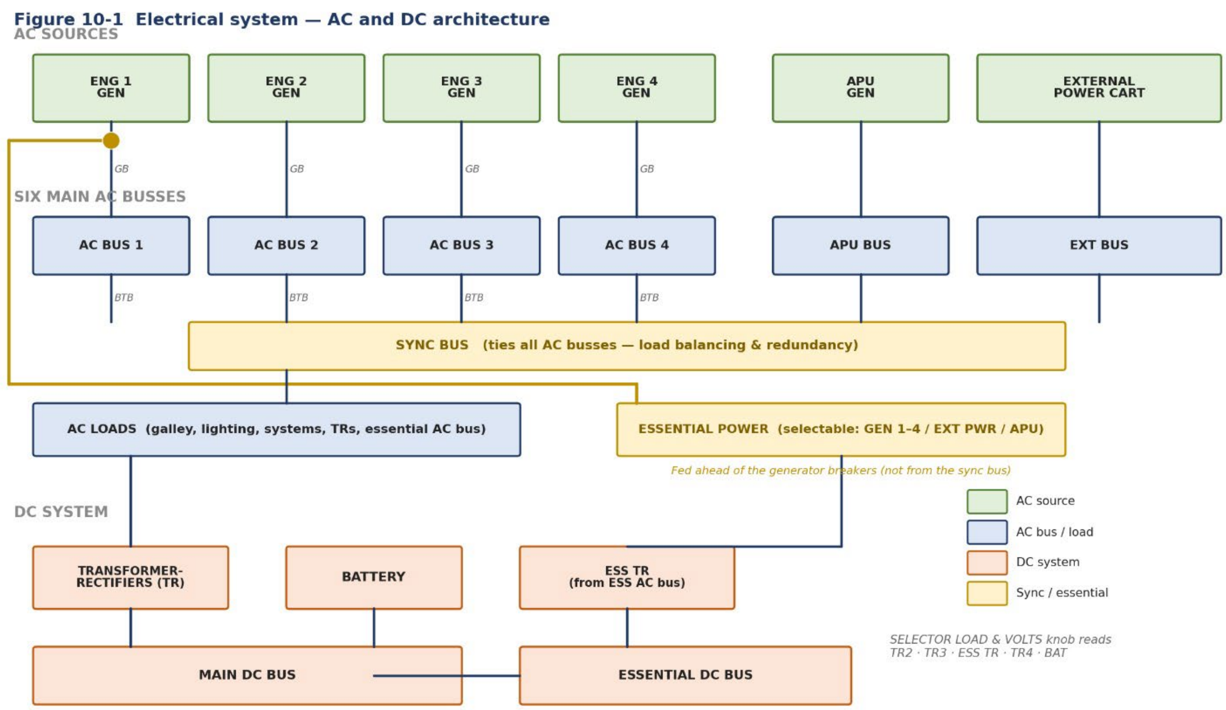

Figure 10-1 Electrical system — AC and DC architecture

10.2 DC System

DC power is supplied by the battery and by the transformer-rectifiers, which convert AC to DC. DC indications and selection are grouped in the **DC POWER** section of the Flight Engineer's panel (Figure 10-2).

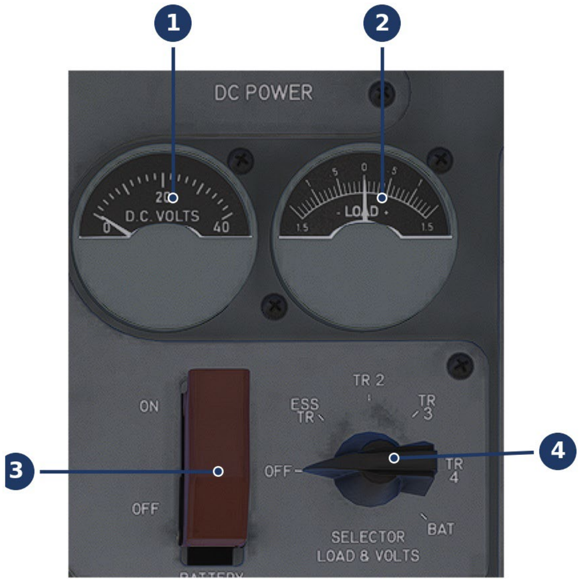

Figure 10-2 DC Power section

No.	Control / indicator
1	**D.C. VOLTS** gauge — DC system voltage for the source selected on the Selector.
2	**LOAD** gauge — DC load for the selected source.
3	**BATTERY** switch (ON / OFF) — connects the aircraft battery to the DC system.
4	**SELECTOR LOAD & VOLTS** knob — selects which DC source the volts/load gauges display: **TR2 · TR3 · ESS TR · TR4 · BAT** (OFF between).

10.3 AC System

The AC system is the primary electrical system in flight, supplying the aircraft's AC loads and feeding the transformer-rectifiers that power the DC system. Its sources are the four engine generators, the APU generator, and external power; its structure is the six main AC busses tied by the sync bus (§10.1).

Source Exclusivity

Only one "ground" source category can feed the AC system at a time — the APU, external power, and the engine generators are mutually exclusive. The system enforces this automatically:

- Setting **external power ON** trips any closed generator breakers and sets the APU generator OFF.
- Setting the **APU generator ON** sets external power OFF and trips any closed generator breakers.
- Closing **any generator breaker** sets external power and the APU generator OFF.

In short

Whichever AC source you bring online takes over, and the others are dropped automatically. You do not need to manually turn off the previous source before selecting a new one.

10.4 Essential Power

Essential power feeds the aircraft's most critical AC loads from a selectable source. Set the **ESSENTIAL POWER** (SOURCE) knob to a source that is **online**: GEN 1–4, EXT PWR, or APU (Figure 10-4).

WARNING — Selecting an offline essential source

If the ESSENTIAL POWER knob is set to a source that is **not online**, the red **FAILURE** light illuminates and the **WARNING – PUSH TO RESET** annunciator on the main cockpit panel flashes. Select a source that is actually online to restore essential power.

NOTE — Essential AC is fed ahead of the generator breakers

The essential AC bus is supplied from a point **ahead of the engine generator breakers (GBs)** — not from the sync bus. The source selected on the **ESSENTIAL POWER** knob therefore feeds the essential loads **directly** from that generator's output, independent of whether the generator is paralleled onto the sync bus (§10.6).

Because essential power is taken upstream of the GBs, it can be supplied from the selected source even when that generator is not connected to the main busses — giving the essential loads a more direct, more resilient supply than the paralleled AC busses.

10.5 Connecting Ground Power

On the ground, AC power is normally supplied by an external cart or the APU before the engines are started.

External Power

With the aircraft at a stand that provides external power — confirmed by the external-power **CONNECTED** light being lit — set the **EXTERNAL POWER** switch to **ON** or **GROUND LIGHTS**:

- **GROUND LIGHTS** — powers **only** the main cabin lighting.
- **ON** — powers the entire AC system.

When an external cart is providing power, the **PWR ON BUS** indicator illuminates.

APU Generator

With the APU running (Chapter 13), set the **APU GENERATOR** switch to **ON**. When the APU generator is providing power, the APU ammeter needle rises from 0 amps.

10.6 Engine Generators & Paralleling

Supplying AC power from the engines is more involved than ground power, because the engine generators must be **paralleled** — their frequency and phase matched to any other generator already connected to the sync bus — before their generator breakers are closed.

> **Shortcuts — skip manual paralleling**
>
> Manual paralleling is optional. To skip it: start the engines with **Ctrl+E**, which automatically parallels the generators; or run the **AFTER START** flow in the Boeing 707 EFB app, which parallels the generators of any engines that have started.
>
> If you begin manual paralleling and become frustrated, you can use the EFB after-start flow at any time to finish the job automatically.

The paralleling controls are the **AC PARALLELING** section (Figure 10-5) and the per-bus **FREQ CONTROL** knobs and **GEN BREAKER** switches on the generator-control matrix (Figure 10-3).

Figure 10-5 AC Paralleling section

No.	Control / indicator
1	**CPS FREQ** gauge — frequency of the source selected on the AC PARALLELING knob (target 400 Hz; ~380 Hz indicates offline).
2	**AC VOLTS** gauge — voltage of the selected source (~100 V indicates offline).
3	**Paralleling light** (left) — one of the two “RESIDUAL VOLTS” synchronizing lights; **synchronized when the lights are out**.
4	**Paralleling light** (right) — the second synchronizing light.

No.	Control / indicator
5	**AC PARALLELING** knob — selects the source monitored for paralleling: BUS TIE · GEN 1–4 · EXT PWR · APU.
6	**POWER METER – PUSH FOR KVARS** — momentary push to read reactive load (KVARS) on the KW/KVAR meters.

Manual Paralleling Procedure

For those who wish to fully emulate the 707 flight-crew experience:

Normally, every generator is synchronized

After engine start the **APU generator is still powering the aircraft**, so there is already a source on the sync bus. To bring the engine generators online **without interrupting power**, each one — including the first — is synchronized to the source already on the bus using the steps below, rather than removing the APU first.

Follow the procedure for **every** generator you connect. The APU generator drops off automatically as the engine generators take over (§10.3).

- Start the engines and connect the aircraft **battery**.
- After engine start, set the **AC PARALLELING** knob to the generator you are paralleling. The gauge above the knob shows that generator's **voltage and frequency** — confirm the needles have moved off their lowest values. (Needles at **380 Hz / 100 V** mean the selected source is **not online**.)
- Rotate that generator's **FREQ CONTROL** knob to set its frequency to **400 Hz**. Attempting to connect a generator that is not at 400 Hz (±1 Hz) will cause it to trip automatically on connection.
- With the generator near 400 Hz, synchronize its **phase** to the sync bus by watching the **two paralleling lights** beside the AC PARALLELING knob. They flash on and off at varying brightness depending on how far out of phase the generator is (this takes some trial and error).
- Finely rotate the **FREQ CONTROL** knob so the flashing **slows**. Eventually the lights change brightness very slowly, letting you time the next step to when the lights are **out**.
- When the paralleling lights are **extinguished**, set that bus's **GEN BREAKER (GB)** switch to **CLOSE**. If done correctly, the **CIRCUIT OPEN** light extinguishes.

CAUTION — Only close the GB when the lights are out

Close the generator breaker **only** when the synchronizing lights are fully extinguished. Closing the GB while the generator is out of phase will trip the bus tie breaker (see below).

Exception — when the first generator is "free"

If the sync bus is genuinely **unpowered** — for example, the APU generator and external power are both off — there is nothing for the first generator to match. In that case it will simply connect when its GB is closed, with **no phase synchronizing required** (it must still be within **400 ±1 Hz**, or it will trip).

This is the exception, not the normal procedure. Because bringing the APU offline first would interrupt power to the aircraft, the usual practice is to leave the APU on the bus and synchronize the first generator to it as described above. Every generator after the first must always be synchronized.

If the Generator Trips on Connection

If the generator is out of phase when the GB is closed, the **BUS TIE BREAKER (BTB)** trips and its **CIRCUIT OPEN** light illuminates. To recover:

- Set the **GB** to **TRIP**; the CIRCUIT OPEN light beside that switch illuminates.
- Set the **BTB** to **CLOSE**; the BTB CIRCUIT OPEN light extinguishes.
- Repeat the paralleling steps above — finely adjusting FREQ CONTROL to slow the synchronizing lights, and closing the GB **only** when the lights are fully out.

10.7 Generator-Control Matrix

Each of the four engine busses has its own column of breaker controls on the generator-control matrix (Figure 10-3). The structure below repeats for buses 1 through 4.

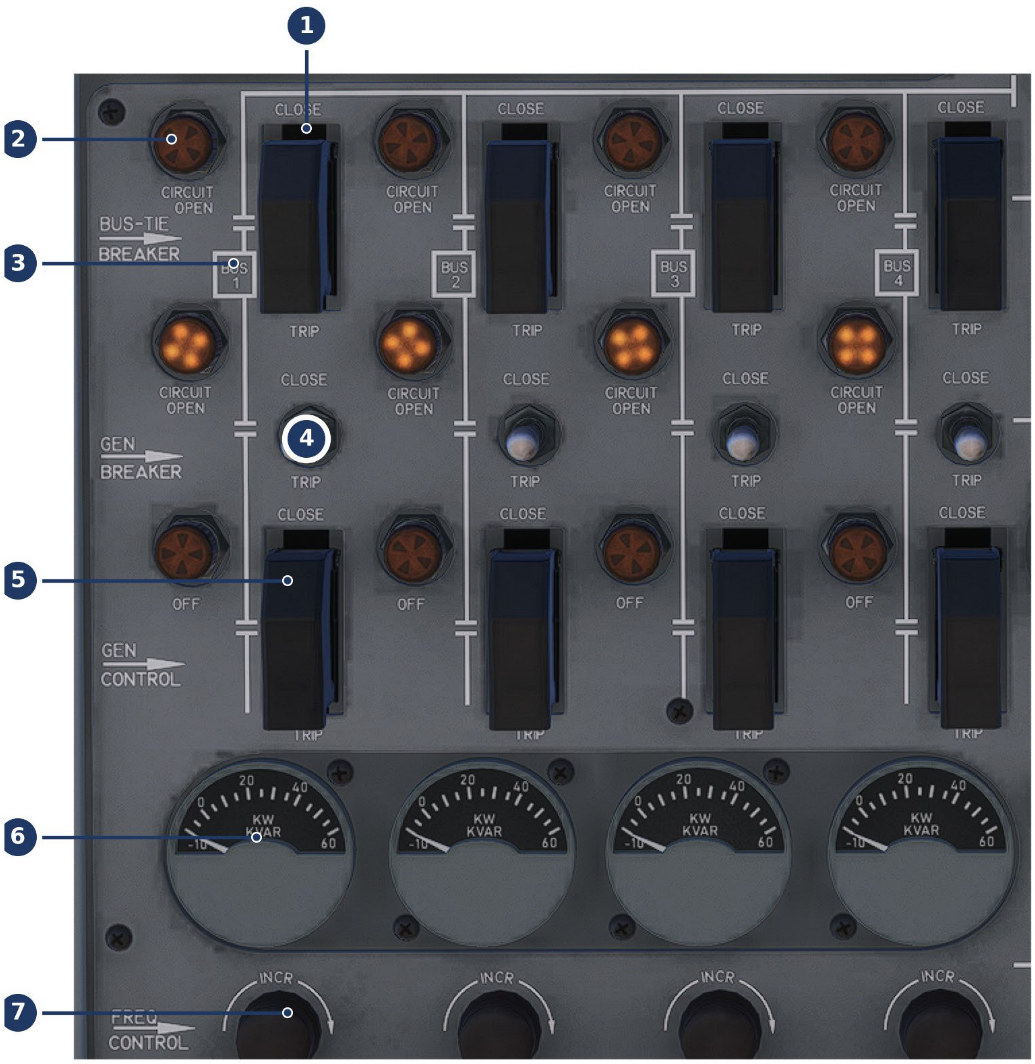

Figure 10-3 AC generator-control matrix (bus-1 column called out; structure repeats for buses 2–4)

No.	Control / indicator
1	**BUS-TIE BREAKER** switch (CLOSE / TRIP) — connects or isolates that bus from the sync bus.
2	**CIRCUIT OPEN** light — illuminates when the associated breaker is open.
3	**BUS 1** identifier — marks the column serving AC bus 1 (2, 3, 4 to the right).
4	**GEN BREAKER (GB)** switch (CLOSE / TRIP) — connects the engine generator to its bus after paralleling (§10.6).
5	**GEN CONTROL** switch (CLOSE / OFF / TRIP) — generator field/control for that engine generator.
6	**KW / KVAR** meter — real load (KW) and, with POWER METER pushed, reactive load (KVAR) for that generator.
7	**FREQ CONTROL** knob (INCR) — adjusts that generator's frequency during paralleling (§10.6).

10.8 Other Electrical Controls

Additional controls in the AC POWER and generator-drive sections of the panel:

Control	Function
GALLEY POWER switch (ON/OFF)	Connects or removes power to the galley loads.
Alternate Fuel Flowmeter Power switch (NORMAL / ALTERNATE)	Selects the power source for the fuel flowmeters.
GEN DRIVE LOW PRESSURE lights (ENG 1–4)	Warn of low generator-drive oil pressure for the associated engine.
DISCONNECT switches (ENG 1–4)	Disconnect the constant-speed generator drive. Per the panel placard, the **gen drive can be reconnected only on the ground**.
GEN DRIVE OIL TEMP RISE gauges (ENG 1–4)	Show generator-drive oil temperature rise for each engine.

CAUTION — Generator-drive disconnect

As placarded on the panel ("GEN DRIVE CAN BE RECONNECTED ONLY ON THE GROUND"), a generator drive that is disconnected in flight **cannot be reconnected until the aircraft is on the ground**. Disconnect a generator drive only when required.

PART II — AIRCRAFT SYSTEMS

Chapter 11 — Fuel System

About this chapter

Describes the fuel system — its seven tanks, the normal engine-feed arrangement, crossfeed and center-tank management, reserve transfer, and fuel-temperature protection.

Fuel controls are on the Flight Engineer's fuel panel; fuel-flow and fuel-consumed indications are on the main-instrument-panel engine cluster.

11.1 System Overview

The fuel system comprises **seven tanks**: four main engine-feed tanks, one center tank for additional capacity, and two outboard reserve tanks (Figure 11-1).

Figure 11-1 Fuel tank layout — seven tanks (top-down schematic)

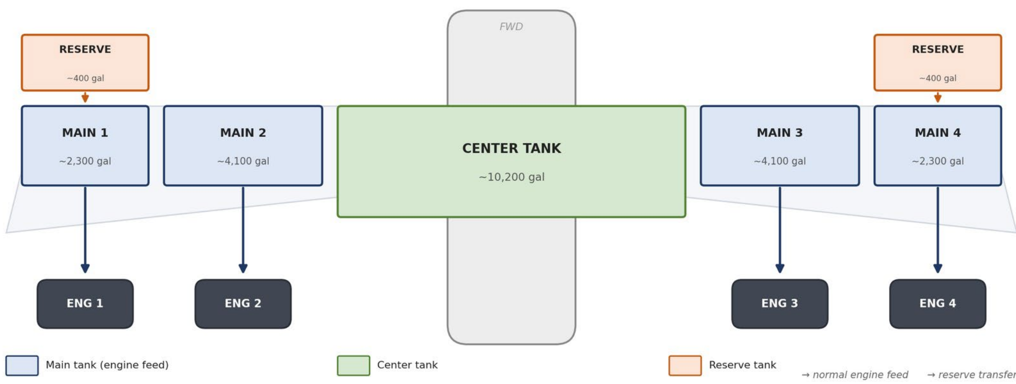

Figure 11-1 Fuel tank layout — seven tanks (top-down schematic)

Tank	Approx. capacity	Notes
Center tank	~10,200 gal	Additional fuel-carrying capacity.
Main 2 / Main 3 (inboard)	~4,100 gal each	Feed engines 2 and 3.
Main 1 / Main 4 (outboard)	~2,300 gal each	Feed engines 1 and 4 — smaller, so more prone to lateral imbalance.
Reserve (two, outboard)	~400 gal each	Transferred into the adjacent main tank.

No inter-tank transfer

The 707 fuel system **cannot** transfer fuel directly from one tank to another. "Crossfeeding" is instead achieved by managing the **crossfeed valves and boost pumps** so that an engine effectively feeds from a different tank (§11.4–11.5). The one exception is reserve transfer, which flows reserve fuel into its own adjacent main tank (§11.6).

11.2 Normal Fuel Feed

In normal operation each engine is fed directly by its own main tank — **engine 1 from main tank 1, engine 2 from main tank 2**, and so on. The standard configuration with the aircraft running is:

1. All **main-tank boost pumps ON**.
2. All **crossfeed valves CLOSED**.
3. All **reserve-transfer valves CLOSED**.

> **Recommended — normal running configuration**
>
> Main-tank boost pumps **ON** · crossfeed valves **CLOSED** · reserve-transfer valves **CLOSED**. In this configuration each engine draws from its own main tank.

11.3 Fuel Panel Controls

The Flight Engineer's fuel panel is arranged symmetrically — an identical column of controls serves each of the four main tanks, with the center tank in the middle (Figure 11-2). The callouts below identify one representative of each control type; the same controls repeat for tanks 1 through 4.

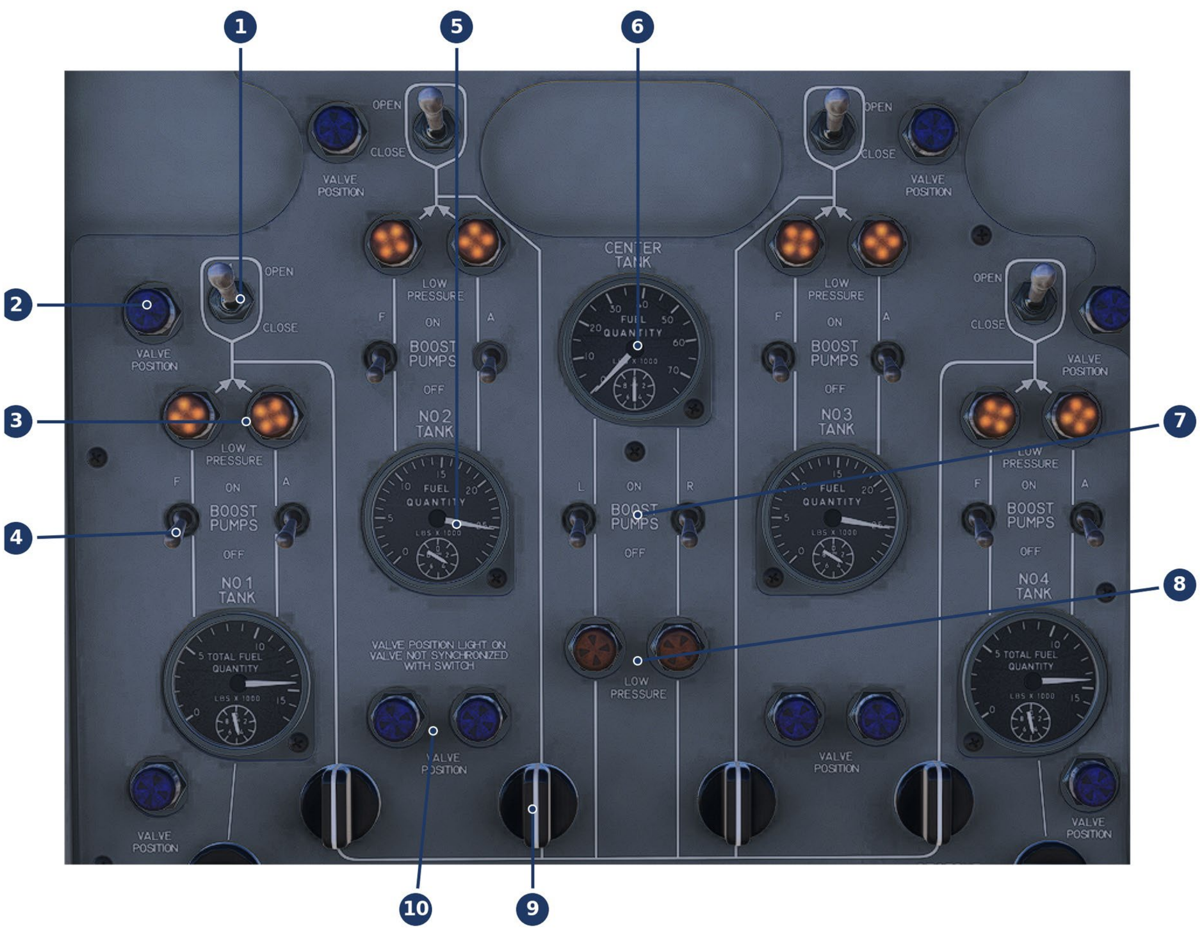

Figure 11-2 Flight Engineer's fuel panel (representative controls called out; layout repeats for tanks 1–4)

No.	Control / indicator
1	**Crossfeed valve** toggle (OPEN / CLOSE) — opens or closes a crossfeed/manifold valve.
2	**VALVE POSITION** light — confirms the actual valve position. (Per the panel: the light being on with the valve not synchronized to the switch indicates the valve is still moving or disagrees with the switch.)
3	**LOW PRESSURE** lights — warn of low boost-pump output pressure for that tank.
4	**BOOST PUMPS** switches, **F**orward / **A**ft (ON / OFF) — the two boost pumps in each main tank.
5	**FUEL QUANTITY** gauge — tank quantity (LBS ×1000).
6	**CENTER TANK FUEL QUANTITY** gauge — center-tank quantity.
7	**Center-tank BOOST PUMPS** switches, **L** / **R** (ON / OFF) — the two center-tank pumps (higher output pressure than the main-tank pumps).
8	**Center-tank LOW PRESSURE** lights - warn of low boost-pump output pressure for that tank
9	**Crossfeed valve** control knob — the per-engine crossfeed valve.
10	**VALVE POSITION** light — confirms the crossfeed valve's actual position.

11.4 Feeding from the Center Tank

The center tank has no engines of its own; its fuel is fed to the engines through the crossfeed system. Because the center-tank boost pumps operate at a **higher pressure** than the main-tank pumps, once they are running the engines draw preferentially from the center tank.

To Feed Engines from the Center Tank

1. Turn the **center-tank boost pumps ON**.
2. Open the **crossfeed valves** for the engines you want to feed from the center tank.
3. Because the center-tank pumps run at higher pressure, fuel now feeds primarily from the center tank to those engines. Monitor the fuel-quantity gauges to confirm the center tank is depleting.

> **Use center-tank fuel first**
> Center-tank fuel is normally used early in the flight (before the main-tank fuel) so that the main tanks — which sit in the wings — remain full for wing bending relief. When the center tank is empty, close its crossfeed valves and return the center-tank boost pumps to OFF.

11.5 Crossfeed — Feeding an Engine from Another Tank

Because the outboard main tanks (1 and 4) are smaller, a **lateral imbalance** can develop — most commonly on engines 1 and 4. The imbalance is managed by feeding an engine from a fuller tank on the opposite side; for example, feeding **engine 1 from main tank 2**.

To Feed an Engine from a Different Main Tank

1. Open the **crossfeed valves** for the tank you wish to feed **from** and the engine you wish to feed.
2. For the engine being fed, set **its own main-tank boost pumps OFF**.

3. Set the **boost pumps of the source tank ON**.
4. If done correctly, you should see **only one tank depleting** — the source tank feeding that engine.

> **CAUTION — Confirm only the intended tank is depleting**
> After setting up a crossfeed, verify on the fuel-quantity gauges that only the intended source tank is depleting. Leaving both an engine's own boost pumps and the crossfeed open can feed the engine from two tanks at once and defeat the balancing you intended.

11.6 Reserve Transfer

Each outboard reserve tank feeds its **adjacent main tank**, not the engines directly. To move reserve fuel into the connected main tank, open that side's **reserve-transfer valve**; fuel then flows quickly from the reserve into the main tank and the reserve depletes. Close the reserve-transfer valve once the reserve is empty.

11.7 Fuel Temperature & Fuel Heaters

Fuel temperature is monitored with the **FUEL TEMP SELECTOR** knob and the adjacent **FUEL TEMP** gauge. The selector chooses which engine/tank temperature is displayed (Figure 11-3).

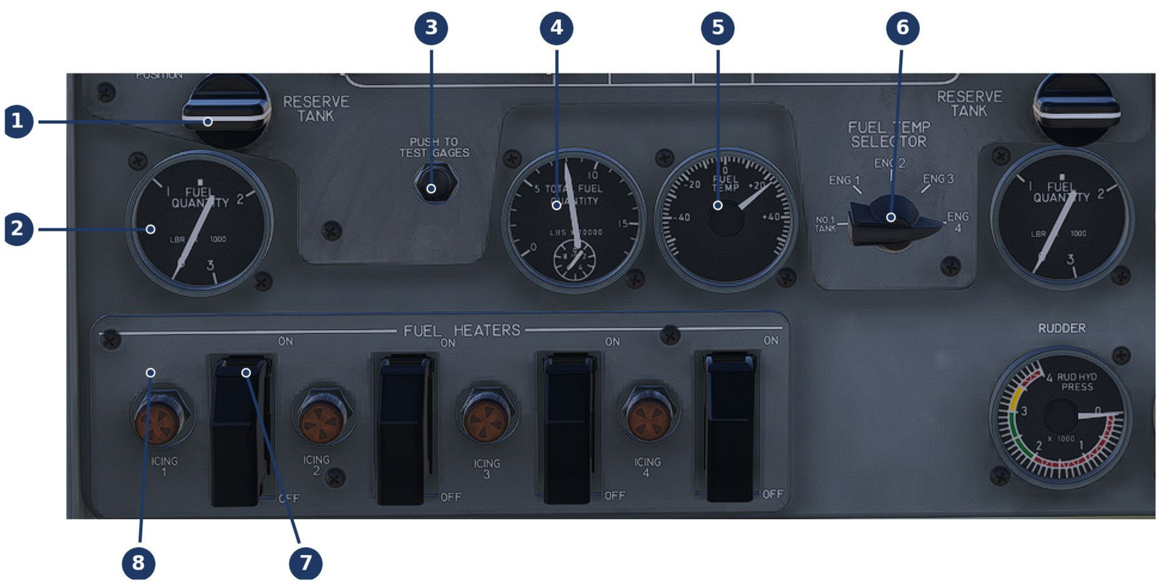

Figure 11-3 Reserve, gauge-test, fuel-temperature and fuel-heater controls

No.	Control / indicator
1	**RESERVE TANK** transfer knob — opens/closes reserve transfer to the adjacent main tank (§11.6).
2	**Reserve FUEL QUANTITY** gauge — reserve-tank quantity.
3	**PUSH TO TEST GAGES** — tests the fuel-quantity gauges.
4	**TOTAL FUEL QUANTITY** gauge — total fuel aboard (LBS ×10000).
5	**FUEL TEMP** gauge — temperature of the source selected on the FUEL TEMP SELECTOR (°C).

No.	Control / indicator
6	**FUEL TEMP SELECTOR** knob — selects the temperature source (ENG 1–4 / NO. 1 TANK).
7	**FUEL HEATERS** switch (ON / OFF) — one per engine; enables that engine's fuel heater.
8	**ICING** light — one per engine; illuminates when icing forms in that engine's fuel filter.

Using the Fuel Heaters

If the fuel temperature indicates a value **at or near 0°C**, enable the **fuel heater** for that tank/engine — ice can begin to form in the fuel filter and clog the fuel line to the engine. If icing forms, the **ICING** light illuminates; turn the fuel heater **ON** immediately.

> **Simulator behavior — fuel temperature is modeled, icing effects are not**
> The simulation **does** model fuel temperature, so the FUEL TEMP gauge and ICING lights behave realistically. However, it does **not** model the downstream effects of fuel icing (such as engine flameout or loss of fuel pressure). Using the fuel heaters as described is good practice and matches real procedure, but a clogged filter will not itself cause an engine failure in the current simulation.

11.8 Fuel Flow & Fuel Consumed

Per-engine fuel-flow and fuel-consumed indications are on the main-instrument-panel engine cluster. Each engine has a combined indicator (Figure 11-4).

Figure 11-4 Per-engine fuel-flow and fuel-consumed indicator

No.	Control / indicator
1	**FUEL FLOW** — current fuel flow for that engine (PPH ×1000).
2	**FUEL CONSUMED** — running total of fuel used by that engine (pounds), on the mechanical counter.

The fuel-consumed counters can be reset per engine using the **FUEL FLOWMETER RESET** buttons below the engine gauges (Figure 11-5).

Figure 11-5 Fuel-flowmeter reset buttons (ENG 1–4)

No.	Control / indicator
1	**FUEL FLOWMETER RESET** buttons (ENG 1–4) — each resets the fuel-consumed total for its engine to zero.

PART II — AIRCRAFT SYSTEMS

Chapter 12 — Hydraulic System

About this chapter

Describes the aircraft's two hydraulic systems — the engine-driven **Utility** system and the electrically-driven **Auxiliary** system — the services they power, and how they can be cross-connected for redundancy.

Controls and indications are found on the Flight Engineer's hydraulics panel and on the co-pilot's main instrument panel.

12.1 System Overview

The Boeing 707-320C has **two independent hydraulic systems**:

- **Utility Hydraulic System** — engine-driven; the primary source during normal flight.
- **Auxiliary Hydraulic System** — electrically driven; supplies dedicated services and can back up the Utility system.

The two systems normally operate independently, each with its own reservoir and pumps, but they can be cross-connected through the **interconnect valves** (§12.4) so the Auxiliary system can support Utility functions when required. Figure 12-1 shows the overall architecture.

Figure 12-1 Simplified block diagram of the hydraulic power system

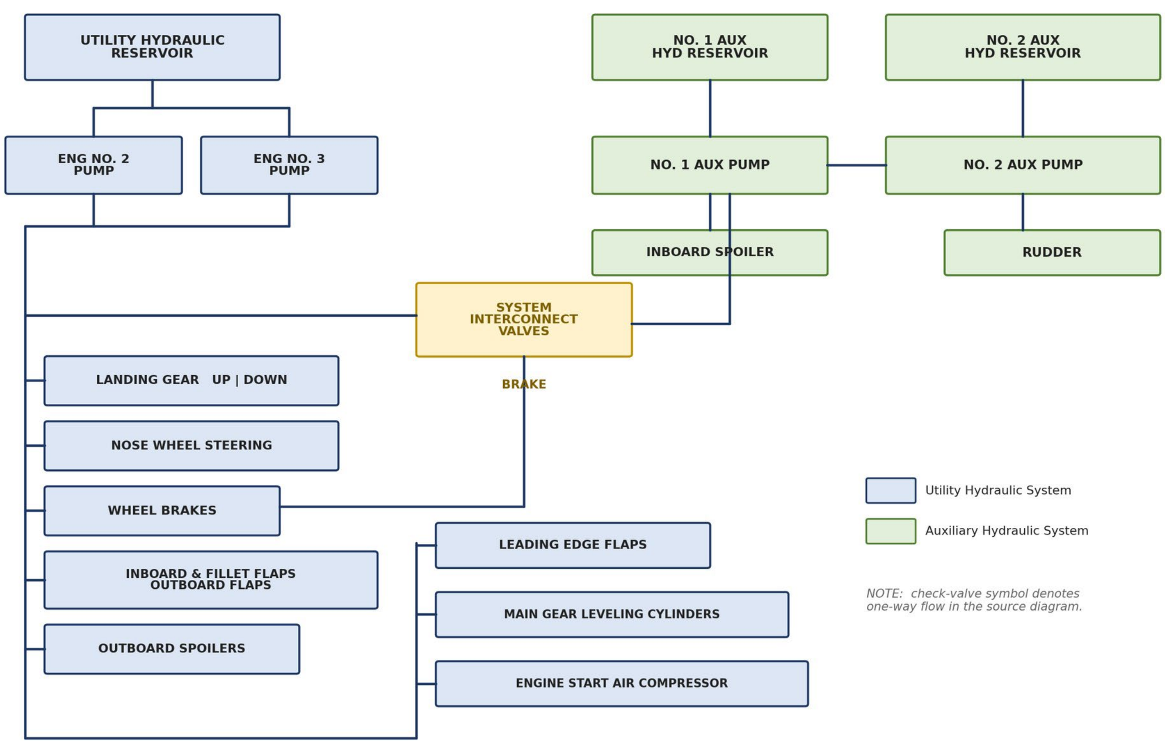

Figure 12-1 Simplified block diagram of the hydraulic power system

12.2 Utility Hydraulic System

The Utility Hydraulic System is the primary source of hydraulic power during normal flight. It is powered by **engine-driven pumps on engines 2 and 3**, drawing from the utility reservoir.

Services Supplied

The Utility system supplies the majority of the aircraft's hydraulic services:

- Landing gear
- Wheel brakes
- Nose wheel steering
- Flaps
- Outboard spoilers
- Other utility services (leading-edge flaps, main-gear leveling cylinders, engine-start air compressor, and related functions)

Normal Pressure

Normal Utility system pressure is **2,900–3,100 PSI**, shown on the **HYD SYS PRESS** (UTILITY) gauge on the Flight Engineer's panel. The co-pilot's panel additionally provides a dedicated **HYD BRAKE PRESS** gauge for brake-system pressure (§12.5).

> **Brake accumulator**
>
> A **brake accumulator** stores hydraulic pressure and provides braking capability even if hydraulic pressurization is lost — preserving a number of brake applications for stopping the aircraft after a system failure.

12.3 Auxiliary Hydraulic System

The Auxiliary Hydraulic System is driven by **two AC electric pumps** rather than the engines, giving it a power source independent of engine operation. It has its own reservoirs (No. 1 and No. 2 aux).

Services Supplied

- **Rudder** boost
- **Inboard spoilers**

In addition to these dedicated services, the Auxiliary system can **back up the Utility system** through the interconnect valves (§12.4). Auxiliary pressure is shown on the **RUD HYD PRESS** (RUDDER) gauge on the Flight Engineer's panel and the **RUDDER** gauge on the co-pilot's panel.

12.4 Interconnect Valves

The interconnect valves determine how the Auxiliary and Utility systems are tied together. The **INTERCONNECT VALVE** switch on the Flight Engineer's panel selects one of three positions:

Position	Effect
SYSTEM	Aux pump No. 1 can pressurize the **Utility system**. Used only during **ground operations** or as a backup to the Utility system.
BRAKE	Both aux pumps can power the **brake system**. Normally used only in **failure scenarios**, to preserve braking when the Utility system cannot supply the brakes.

Position	Effect
OFF	Both systems are **isolated** — no cross-connection; each operates independently.

Normal position

In normal operation the systems run independently. The SYSTEM and BRAKE cross-connections are used for ground operations or failure scenarios, not routine flight.

12.5 Controls & Indicators

Flight Engineer's Hydraulics Panel

The Flight Engineer manages the hydraulic system from the panel shown in Figure 12-2.

Figure 12-2 Flight Engineer's hydraulics panel

No.	Control / indicator
1	**HYD RESERVOIR QUANTITY** gauge — hydraulic fluid quantity in the reservoir.
2	**LOW PRESS** lights — illuminate to warn of low hydraulic pressure in the associated system/pump.
3	**RUD HYD PRESS** gauge (**RUDDER**) — Auxiliary (rudder) system pressure, ×1000 PSI.
4	**HYD SYS PRESS** gauge (**UTILITY**) — Utility system pressure, ×1000 PSI (normal 2,900–3,100).
5	**AC AUX PUMPS 1 & 2** switches — control the two auxiliary electric pumps (No. 1 "RUDDER & SPOILER", No. 2 "RUDDER"), ON/OFF.
6	**INTERCONNECT VALVE** switch — BRAKE / OFF / SYSTEM cross-connection selection (§12.4).
7	**ENG 2 / PUMPS 3** switches — control the engine-driven Utility pumps on engines 2 and 3, ON/OFF.
8	**HYD FLUID SHUTOFF ENG 2 / ENG 3** levers — OPEN/CLOSE fluid shutoff to the engine-driven pumps (used to isolate a pump/engine, e.g., during an engine fire).

Co-pilot's Pressure Gauges

Two hydraulic-pressure indications are provided on the co-pilot's main instrument panel so the flight crew can monitor pressure directly (Figure 12-3).

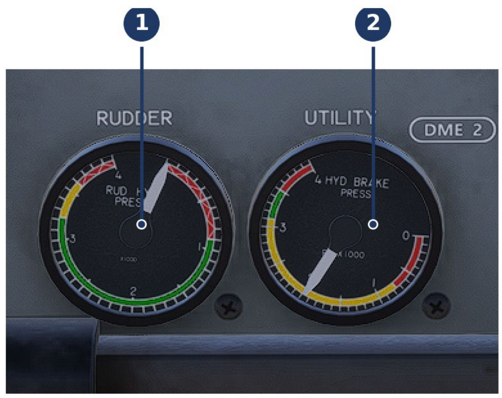

Figure 12-3 Co-pilot's hydraulic pressure gauges — RUDDER (1) and HYD BRAKE PRESS (2)

No.	Control / indicator
1	**RUDDER** — Auxiliary (rudder) system hydraulic pressure.
2	**HYD BRAKE PRESS** — brake-system hydraulic pressure. This gauge displays available brake pressure specifically (fed by the Utility system and its brake accumulator, §12.2).

12.6 Normal Operation

In normal flight the Utility system is pressurized by the engine-driven pumps on engines 2 and 3, and the Auxiliary system is available for rudder boost and inboard spoilers. A typical normal configuration is:

- **ENG 2** and **PUMPS 3** (engine-driven Utility pumps) — **ON**.
- **AC AUX PUMPS 1 & 2** — as required for auxiliary services.
- **INTERCONNECT VALVE** — **OFF** (systems independent) for normal flight.
- **HYD FLUID SHUTOFF ENG 2 / ENG 3** — **OPEN**.

Monitor the **HYD SYS PRESS** (UTILITY) gauge for normal pressure (2,900–3,100 PSI), the **RUD HYD PRESS** (RUDDER) gauge for auxiliary pressure, the **HYD RESERVOIR QUANTITY** gauge, and the **LOW PRESS** lights.

PART II — AIRCRAFT SYSTEMS

Chapter 13 — Auxiliary Power Unit (APU)

About this chapter

Describes the Auxiliary Power Unit — a self-contained gas-turbine that provides **electrical power** and **pneumatic (bleed) air** on the ground, independent of the main engines.

The APU's bleed air feeds the Primary Pneumatic System (Chapter 7); its generator supplies the electrical system (Chapter 10). Engine-start procedures that use APU air are given in §5.6–§5.9 and §32.6.

13.1 System Overview

The Auxiliary Power Unit (APU) is a small gas-turbine engine that supplies the aircraft with electrical power and pneumatic air while on the ground, without requiring ground equipment or a running main engine. Its two principal outputs are:

1. **Electrical** — an AC generator that can power the aircraft electrical system during cockpit preparation, boarding, and engine start.
2. **Pneumatic (bleed air)** — compressed air delivered to the Primary Pneumatic System for engine starting and pre-departure air conditioning (Chapter 7).

The APU is normally started first during cockpit preparation, used to power the aircraft and start the engines, and shut down before or shortly after takeoff. All APU controls and indicators are grouped on the **AUX POWER UNIT** panel.

About this Aircraft's APU

An APU was **not standard** on the 707-320C; it was offered as a factory or retrofit **option**, and this aircraft is configured with it installed. The unit is located in the **lower lobe**, under the main cabin in the vicinity of the wings.

Retrofit note — high-pressure bottle start

Installing the optional APU **deprecated the high-pressure air-bottle engine-start option**. On this aircraft, engine starting air is provided by the APU (on the ground) and by the turbocompressors / cross-bleed (Chapter 7), rather than by a stored high-pressure air bottle.

APU is a ground system

The APU is used primarily on the ground. Once the main engines are running and supplying electrical and pneumatic power, the APU is normally shut down for the flight. The Virtual Flight Engineer manages this transition automatically (§13.8).

13.2 Controls & Indicators

All APU controls and indications are on the AUX POWER UNIT panel (Figure 13-1).

Figure 13-1 AUX POWER UNIT panel

No.	Control / indicator
1	**APU FIRE TEST / DISCRIM** — tests the APU fire-detection (and discriminator) circuit.
2	**FIRE PULL handle** — red fire-warning light and pull handle; pulling it shuts off the APU and arms fire protection (§13.6).
3	**EXT BOTTLE DISCHARGE** — discharges the APU fire-extinguisher bottle.
4	**APU MASTER** switch (START / ON / OFF) — master control for the APU (§13.3).
5	**RPM** indicator (% RPM) — APU rotational speed as a percentage; used to confirm the APU has reached governed speed.
6	**AC AMPERES** — APU generator output current.
7	**EXH TEMP** (×100 °C) — APU exhaust-gas temperature, with a green normal band; monitored during start and operation.
8	**GENERATOR** switch (ON / OFF) — connects the APU generator to the electrical system (§13.5).

No.	Control / indicator
9	**BLEED VALVE** switch (ON / OFF) — admits APU bleed air to the Primary Pneumatic System (§13.4).

Operating values & limits. The APU gauges read as follows in normal operation:

Parameter	Value
RPM — normal (governed)	**100%** (6,000 RPM).
RPM — minimum operating	**95%**.
EXH TEMP — normal indication	Settles at approximately **356 °C** at 100% RPM (ISA +15 °C, bleed on). Normal indications are well within the green band and far below the design limits.
EXH TEMP — limits	**710 °C** continuous, **760 °C** maximum.
AC generator load — max continuous	**165 amps**.

13.3 APU Start

The APU is started with the **APU MASTER** switch. START is a momentary/spring position that initiates the start sequence; the switch then rests at **ON** for normal operation.

Normal APU Start

1. Confirm electrical power is available (battery or external power) and the APU fire-protection system is normal.
2. Move the **APU MASTER** switch to **START**, then let it spring back to **ON**.
3. Monitor **RPM** increasing and **EXH TEMP** during the start; exhaust temperature should peak and then settle into the normal (green) band as the APU accelerates.
4. Confirm the APU stabilizes at governed **RPM** (approximately 95–100%).
5. With the APU running, select **GENERATOR ON** for electrical power (§13.5) and/or **BLEED VALVE ON** for pneumatic air (§13.4) as required.
6. If using the APU for electrical power, set the ESSENTIAL POWER SOURCE selector to APU.

CAUTION — Monitor EXH TEMP during start

A start in which EXH TEMP rises rapidly toward or beyond the red limit (a hot start) should be discontinued. Return the APU MASTER switch to OFF and allow the unit to cool before attempting another start.

13.4 APU Bleed Air

With the APU running and the **BLEED VALVE** switch **ON**, APU bleed air is admitted to the Primary Pneumatic System, where it can supply engine starting and pre-departure air conditioning. APU bleed is a **ground** source; before takeoff the BLEED VALVE is closed and the aircraft transitions to turbocompressor supply (Chapter 7).

Pneumatic prerequisites

For APU-supplied engine starting, confirm **APU RPM** is at governed speed, **BLEED VALVE ON**, **AIR COND UNIT OFF**, the **wing isolation valves OPEN**, and at least **30 PSI** on the

DUCT PRESS / AIR SUPPLY gauge (Chapter 7) before selecting GROUND START. Full start procedures are in Chapter 30.

13.5 APU Generator (Electrical)

The APU drives an AC generator that can power the aircraft electrical system on the ground. With the APU at governed speed, selecting **GENERATOR ON** connects the APU generator to the AC buses; the **AC AMPERES** meter indicates generator load. The APU generator allows the aircraft to be powered without external ground power and supports electrical loads during cockpit preparation and engine start.

CAUTION — APU generator is not paralleled

The APU generator **cannot** be on the buses at the same time as the engine-driven generators. Selecting **APU GENERATOR ON** trips the engine generator breakers (GBs) and sets **external power to OFF**, transferring the buses to the APU generator as the single source.

Because selecting it is an exclusive transfer, avoid switching the APU generator on or off while it is the only source powering essential loads without first establishing an alternate source.

As the engine-driven generators come online after start, electrical supply is transferred back to them (which correspondingly drops the APU generator off the buses). Detailed electrical distribution is covered in Chapter 10.

13.6 APU Fire Protection

The APU has a dedicated fire-detection and extinguishing system, controlled from the top of the AUX POWER UNIT panel.

Control	Function
APU FIRE TEST / DISCRIM	Tests the APU fire-detection loop (and discriminator). Used during preflight to verify the warning system.
FIRE PULL handle	Illuminates red on an APU fire warning. Pulling the handle shuts down the APU and arms the extinguisher.
EXT BOTTLE DISCHARGE	Discharges the APU fire-extinguisher bottle into the APU compartment.

WARNING — APU fire

On an APU fire warning: **pull the FIRE PULL handle** to shut down the APU and arm the system, then **discharge the extinguisher bottle** as required. Do not continue APU operation with a fire indication.

13.7 APU Shutdown

To shut the APU down after its outputs are no longer required:

1. Select **BLEED VALVE OFF** (transfer pneumatic supply to the engines first).
2. Select **GENERATOR OFF** (transfer electrical supply to the engine-driven generators first).
3. Move the **APU MASTER** switch to **OFF**.
4. Confirm **RPM** decreasing and **EXH TEMP** falling.

The APU is normally shut down prior to takeoff. Avoid selecting BLEED VALVE or GENERATOR OFF abruptly while they are carrying the aircraft's only source of that output — transfer the load to the engines first.

13.8 Virtual Flight Engineer Integration

When the Virtual Flight Engineer (VFE) flows are used, the APU is managed automatically. During cockpit preparation and engine start the VFE will start the APU, monitor its RPM, and open the APU BLEED VALVE when pneumatic air is required — using APU air for environmental systems and engine starting. As engine-driven sources become available, the VFE transitions electrical and pneumatic supply away from the APU, then normally closes the BLEED VALVE and shuts the APU down before takeoff. Manual control of all APU functions remains available.

PART II — AIRCRAFT SYSTEMS

Chapter 14 — Flight Controls

About this chapter

Covers the primary flight controls (ailerons, elevator, rudder), the speed brake, the flaps, the trim systems, and nose-wheel steering.

The brake **system** and anti-skid are covered in Chapter 15; the rudder's hydraulic supply is in Chapter 12 and the yaw damper in Chapter 16.

14.1 Overview

The Boeing 707-320C uses an aerodynamically-assisted control system. The primary controls are **cable-driven**: control-yoke and rudder-pedal inputs are carried by cable to the **control tabs** on the aileron and elevator surfaces, and the aerodynamic force on those tabs then moves the surfaces. The aileron and elevator cable runs pass through an **interlock system** that also drives the hydraulic roll spoilers and keeps the left and right ailerons coordinated (§14.2).

The **rudder is the only hydraulically-boosted primary control surface**; its hydraulic supply and the RUDDER pressure gauge are described in Chapter 12, and the yaw damper in Chapter 16. Pitch is trimmed through the movable horizontal stabilizer (§14.6).

14.2 Pitch & Roll — Control Yoke

Each pilot's control yoke commands pitch and roll. Fore/aft movement drives the **elevator control tabs**; rotation drives the **aileron control tabs**. Both act through the interlock system, which additionally drives the hydraulic **roll spoilers** to augment roll and keeps opposite aileron movement coordinated.

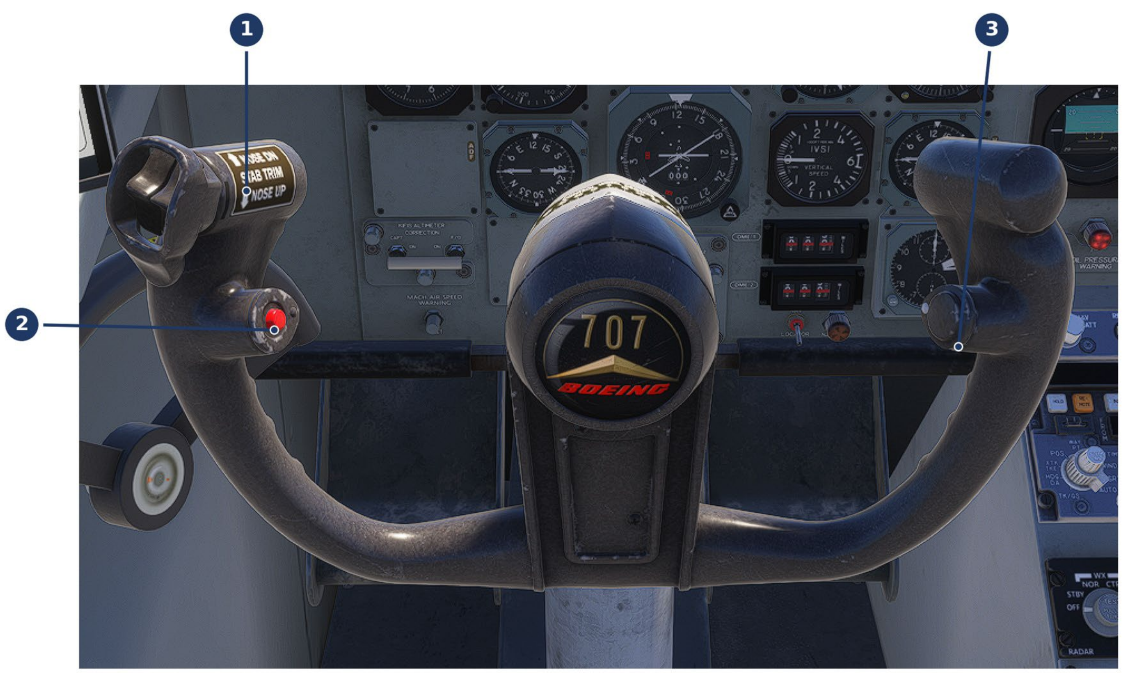

Figure 14-1 Control yoke — electric trim switch (1), autopilot-disconnect button (2), control yoke (3)

> **Outboard ailerons locked out with flaps up**
> The **outboard ailerons are locked out when the flaps are at 0 (UP)** — at cruise, roll is provided by the inboard ailerons and the roll spoilers. The outboard ailerons become active once the flaps are extended.

The left yoke grip carries the red **autopilot-disconnect button** (§16.8) and a **nose-up / nose-down electric trim switch** for the stabilizer trim (§14.6).

14.3 Rudder & Rudder Pedals

The rudder pedals translate fore and aft — the two pedals move opposite one another — to command the rudder. The rudder is **hydraulically boosted** (Chapter 12), and the yaw damper provides automatic yaw control (Chapter 16).

Figure 14-2 Rudder pedals — pedals translate for rudder control (1); pivot at the top for differential braking (2)

Each pedal also **pivots at the top** to apply differential braking to the main-gear brakes — the **left pedal** meters the **left** brakes and the **right pedal** the **right** brakes. The brake system itself, including anti-skid, is described in Chapter 15.

14.4 Speed Brake

The **speed brake** handle on the pedestal deflects the speed-brake surfaces on the wing between **0 and 60°**, adding drag and lift spoiling for descent and speed control. It is **entirely manual** — there is no automatic or touchdown deployment; the surfaces move only as commanded by the handle.

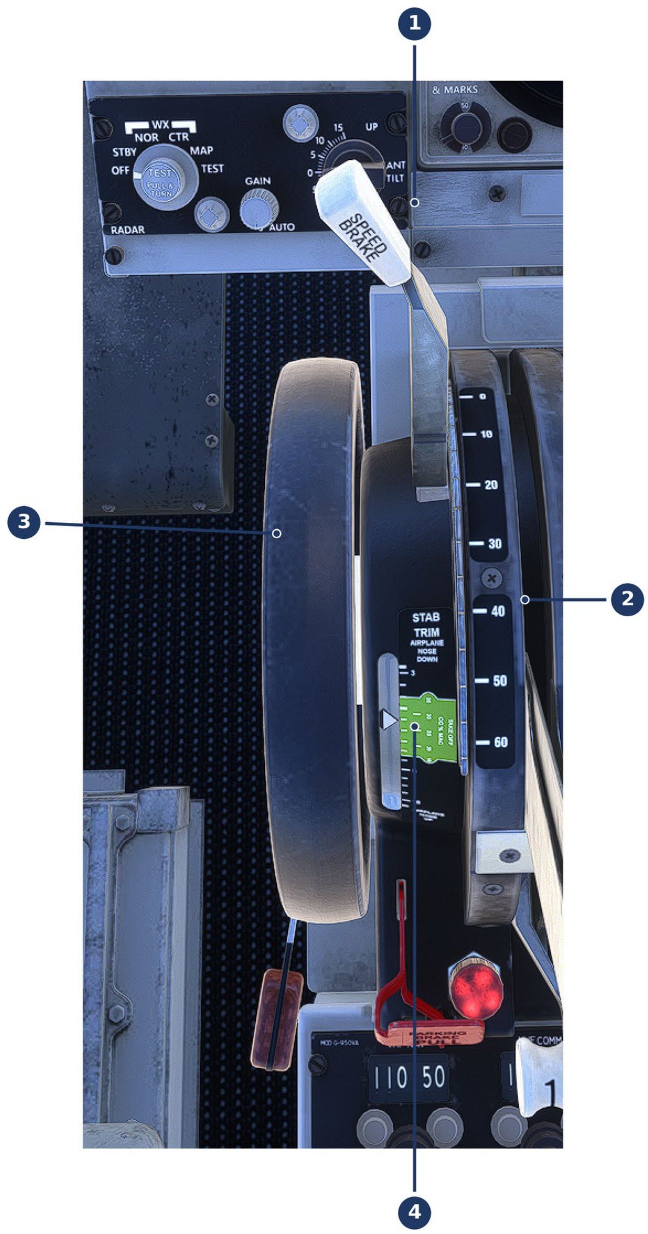

Figure 14-3 Speed brake handle (1), speed-brake position scale 0–60° (2), manual stabilizer-trim wheel (3), take-off trim / CG gauge (4)

14.5 Flaps

Increased lift is provided by trailing-edge flaps and leading-edge Krueger flaps. The **flap handle** (Figure 14-4) selects the trailing-edge position, with detents at **UP, 14°, 25°, 40°, and 50°**.

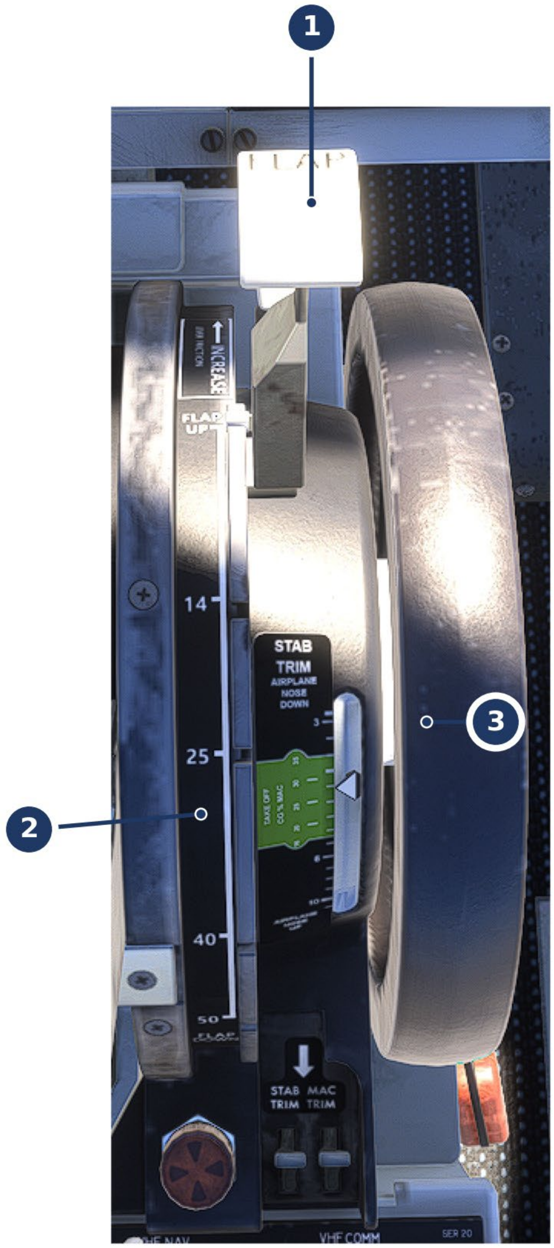

Figure 14-4 Flap handle (1), flap position detents 14/25/40/50° (2), manual stabilizer-trim wheel — F/O side (3)

Leading-Edge Krueger Flaps

The **leading-edge Krueger flaps** extend automatically when **flaps 14** is selected and **remain deployed in all non-zero flap settings**, retracting only when the flaps are returned to UP. Two green **L.E. FLAP** lights — LEFT and RIGHT — illuminate when the Krueger flaps are **not** stowed (Figure 14-5).

Flap Position Indication

Separate **OUTBD** and **INBD** trailing-edge flap indicators show flap deflection in degrees, with the two green **L.E. FLAP** lights below them. A placard lists the standard settings: take-off 14°, enroute 0°, approach 25°, landing 50°.

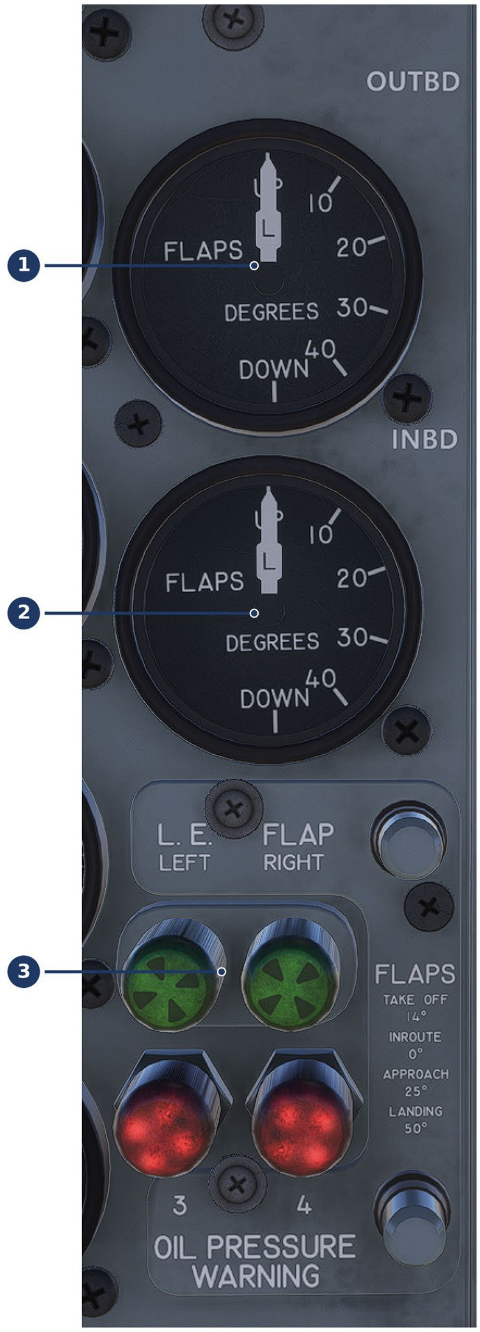

Figure 14-5 Flap indicators — OUTBD trailing-edge (1), INBD trailing-edge (2), L.E. FLAP green lights (3)

14.6 Trim Systems

The aircraft is trimmed in all three axes: pitch (stabilizer), roll (aileron), and yaw (rudder).

Stabilizer (Pitch) Trim

Pitch is trimmed by moving the horizontal stabilizer. Two means are provided:

- **Electric trim** — the nose-up / nose-down trim switch on the control yoke (§14.2) drives the electric stabilizer-trim servo.
- **Manual trim** — the large **trim wheels** beside the pedestal (Figures 14-3 and 14-4). The captain's and first officer's wheels are **interlocked** — they move together — but provide a separate, accessible manual control on each side.

The **take-off trim / CG gauge** beside the trim wheel shows the stabilizer-trim position against the take-off CG (% MAC) band, so the crew can confirm the stabilizer is set within the green take-off range (Figure 14-3).

Trim-in-Motion Light & Cutout

A **trim-in-motion light** illuminates whenever the electric stabilizer-trim servo is running, giving a positive indication of electric trim activity. The **electric-trim cutout switches** beside it disconnect power to the trim servo (Figure 14-6).

Figure 14-6 Trim-in-motion light (1) and electric-trim cutout switches (2)

Rudder & Aileron Trim

Rudder trim and **aileron trim** are set from the aft center pedestal (Figure 14-7). The RUDDER TRIM control commands nose-left / nose-right rudder trim, and the AILERON TRIM wheel commands left/right roll trim, each with its own scale.

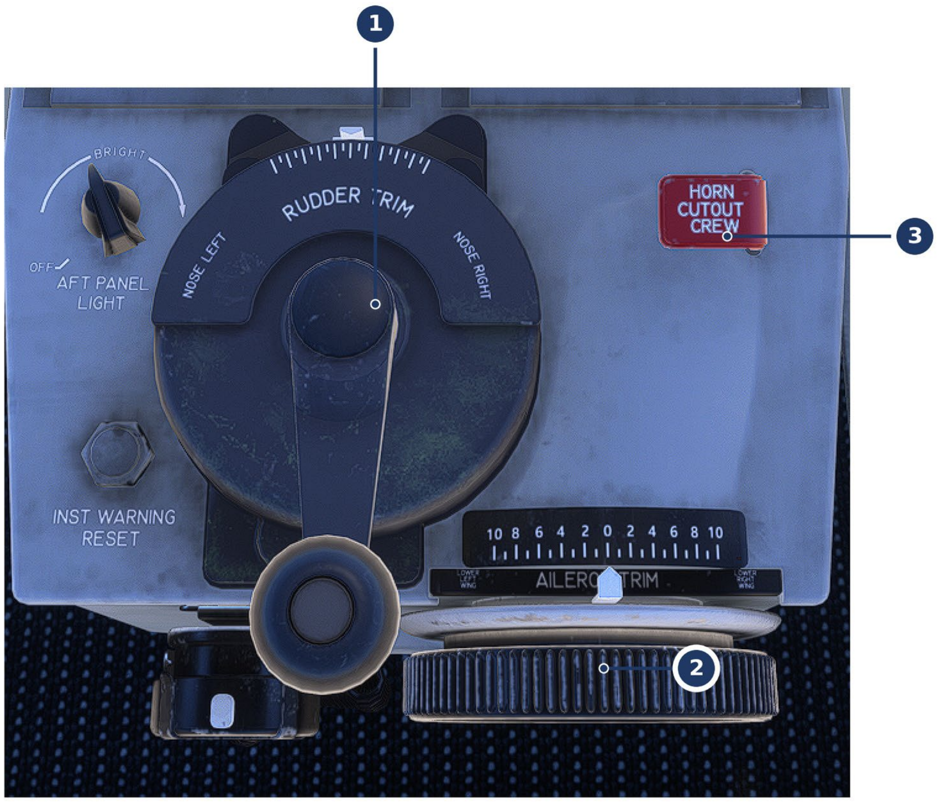

Figure 14-7 Aft-pedestal trim — RUDDER TRIM (1), AILERON TRIM (2), landing-gear warning HORN CUTOUT (3)

Landing-gear warning horn cutout
The red **HORN CUTOUT** button on this panel silences the landing-gear warning horn. It is part of the landing-gear system and is described in Chapter 15.

Three-Axis Trim Indicator

A **three-axis indicator** marked **RUD / AIL / EL** provides a combined visual reference for control positioning, showing trim settings and some autopilot servo activity across the rudder, aileron, and elevator axes (Figure 14-8).

Figure 14-8 Three-axis (RUD / AIL / EL) indicator

14.7 Nose-Wheel Steering

Ground steering is provided by a **nose-wheel steering tiller** (Figure 14-9). The tiller is used for **taxi-speed steering only** — it is not used during takeoff or landing until the aircraft has slowed to taxi speed.

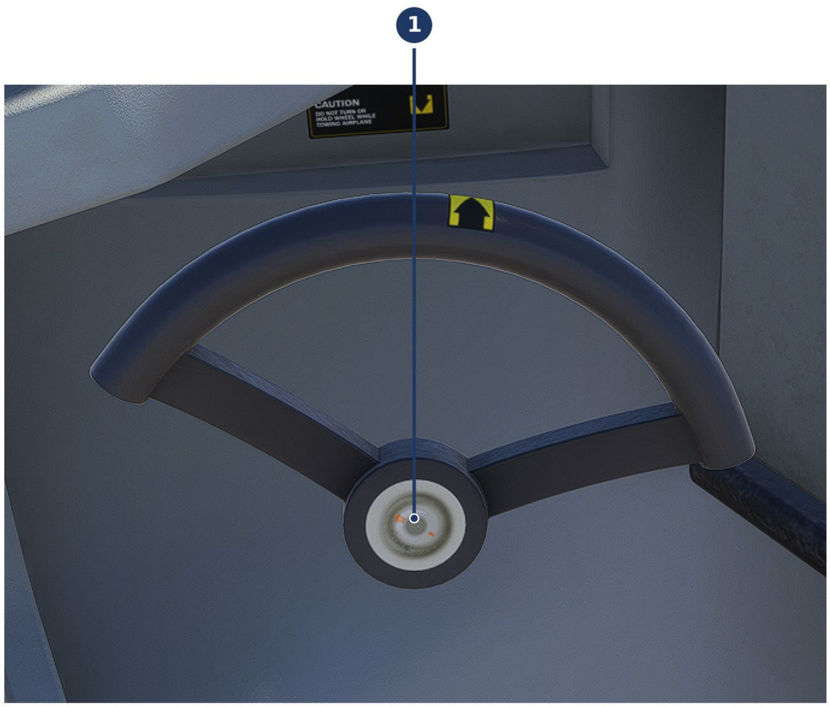

Figure 14-9 Nose-wheel steering tiller

In the simulator, nose-wheel steering can also be commanded with the **rudder pedals**: they provide full nose-wheel steering at low speed, reducing to limited steering authority as speed increases, as on the physical aircraft.

PART II — AIRCRAFT SYSTEMS

Chapter 15 — Landing Gear, Brakes & Anti-Skid

About this chapter

Covers the landing gear — its handle, indications, and warning — and the wheel brakes, parking brake, and anti-skid system.

The gear and brakes are hydraulically powered by the Utility system (Chapter 12). Differential braking through the rudder pedals and nose-wheel steering are described in Chapter 14.

15.1 System Overview

The Boeing 707-320C has a retractable tricycle landing gear — a steerable nose gear and two main gears — hydraulically actuated by the Utility hydraulic system (Chapter 12). The main-gear wheels carry the brakes, which are protected by an anti-skid system. A parking brake holds the main brakes for parking.

Gear extension and retraction are commanded with the landing-gear handle (§15.2), and gear status is shown on the indicator lights beside it (§15.3).

15.2 Landing-Gear Handle & Operation

The landing-gear handle has three positions — **UP**, **OFF**, and **DOWN** (Figure 15-1).

Figure 15-1 Landing-gear handle — UP (1), OFF (2), DN (3), gear handle (4)

Position	Function
DOWN	Commands the gear down. Leave the handle in DOWN until retraction is desired.
UP	Commands the gear up.
OFF	Disengages the extension/retraction mechanism. Selected once the gear is up and stowed and all gear and door lights are out.

Normal Operation

1. To extend: place the handle **DOWN** and confirm three green gear lights (§15.3). Leave the handle DOWN for the approach and landing.
2. To retract after takeoff: place the handle **UP** and confirm the gear and door lights cycle and then extinguish.
3. Once the gear is up and stowed and **all gear and door lights are out**, move the handle to **OFF** to disengage the mechanism.

VFE handles the OFF selection

The Virtual Flight Engineer automatically moves the gear handle to **OFF** as part of the after-takeoff flow, so the crew does not need to select OFF manually when the VFE is in use.

15.3 Gear Position Indication

Gear status is shown by two red lights, three green lights, and a brightness switch beside the handle (Figure 15-2).

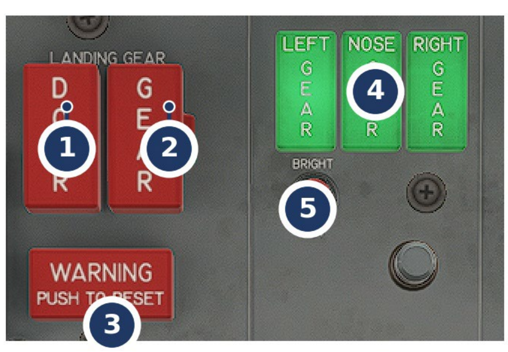

Figure 15-2 Gear indications — DOOR (1), GEAR (2), WARNING/reset (3), green gear lights (4), BRIGHT/DIM switch (5)

No.	Control / indicator
1	**DOOR** (red) — illuminates whenever the gear doors are **not closed**. It comes on while the gear is in transit and extinguishes when the gear is locked up or down — unless a door failure has occurred.
2	**GEAR** (red) — illuminates whenever the gear is **not locked up or down**, when the handle disagrees with the actual position, and when the gear warning is active with the gear not locked down.

No.	Control / indicator
3	**WARNING** — the master warning annunciator.
4	**LEFT / NOSE / RIGHT GEAR** (green) — each illuminates only when its gear is **down and locked**. Three green lights confirm the gear is safe for landing.
5	**BRIGHT / DIM** switch — controls the brightness of all the annunciators; normally BRIGHT by day and DIM at night.

Three greens for landing

The three green **LEFT / NOSE / RIGHT GEAR** lights are the primary confirmation that the gear is down and locked. Confirm all three are illuminated, with the red DOOR and GEAR lights out, before landing.

15.4 Landing-Gear Warning

A landing-gear warning horn sounds when the aircraft is configured for landing without the gear locked down. The **red GEAR light** accompanies the warning (§15.3).

The warning horn can be silenced with the **landing-gear warning HORN CUTOUT** switch on the aft center pedestal (shown in Figure 14-7).

15.5 Wheel Brakes

The main-gear wheels are fitted with hydraulic brakes, powered by the Utility system. The pilots apply the brakes by **pivoting the tops of the rudder pedals** — the left pedal meters the left brakes and the right pedal the right brakes — which also allows differential braking for directional control (Chapter 14).

Brake accumulator

A **brake accumulator** stores hydraulic pressure so that a number of brake applications remain available even if normal hydraulic pressurization is lost (Chapter 12).

15.6 Parking Brake

The parking brake locks the brakes in a parking position, holding pressure on the main-gear brake pads. It is set and released with the **PARKING BRAKE PULL** tab, and the red **PARK BRAKE LIGHT** shows when it is set (Figure 15-3).

Figure 15-3 Parking brake — PARKING BRAKE PULL tab (1), PARK BRAKE red light (2)

An **EFB option** selects realistic parking-brake behavior on or off:

Realistic Behavior (option ON)

4. Depress **both brakes to at least 75%** using the normal pedal braking input.
5. Pull the **parking-brake tab aft** to set the parking brake.
6. Only after the tab is pulled back and the **red PARK BRAKE LIGHT illuminates**, release the pedal pressure — the parking brake remains set.
7. To release: press the brakes again to at least **75%**. The parking brake releases, automatically reverts to the off position, and the light extinguishes.

Simple Behavior (option OFF)

When the realistic option is not enabled, the parking brake can simply be **toggled on/off with the lever** — no brake application is required to set or release it.

15.7 Anti-Skid System

An anti-skid system protects the main-gear brakes from wheel skid during braking. Its status and controls are on the overhead **BRAKES** panel (Figure 15-4), which carries the master **ANTI-SKID** switch (ON / OFF) and a system **TEST** switch, along with per-wheel release indications.

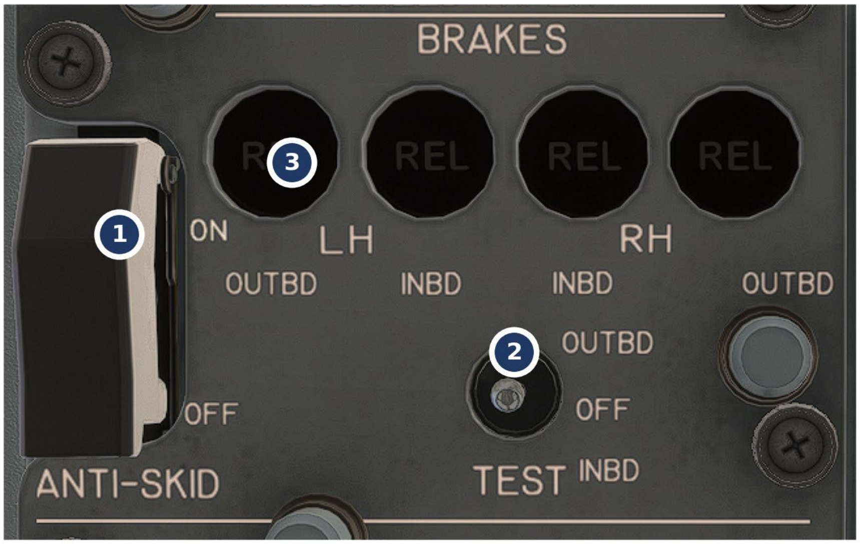

Figure 15-4 Overhead BRAKES panel — ANTI-SKID master switch (1), TEST switch (2), per-wheel REL indicators (3)

For normal operation the anti-skid system is left **ON**. The TEST switch verifies system operation as part of the preflight checks.

PART II — AIRCRAFT SYSTEMS

Chapter 16 — Autopilot & Flight Directors

About this chapter

Describes the **Bendix PB-20D** autopilot and the two independent **flight directors**. The autopilot, the flight directors, and the yaw damper are **separate systems** — the flight directors do not drive the autopilot, and the autopilot has its own guidance computer.

The optional **altitude preselector** and the **navigation source selection** that feeds the autopilot's LOC/VOR and GS modes are also covered here.

16.1 System Overview

The Boeing 707-320C is equipped with a **Bendix PB-20D** autopilot and two flight directors. Three distinct systems are involved:

1. **Autopilot** — has its **own guidance computer** that drives the autopilot servos in pitch, roll, and yaw. It is operated from the Autopilot Controller (§16.2).
2. **Flight directors** — **two completely independent** systems, one for the captain and one for the first officer, each on its own panel. They present guidance on the on-side ADI command bars and do **not** drive the autopilot (§16.7).
3. **Yaw damper** — a separate system, controlled from the overhead panel, and required for autopilot engagement (§16.6).

No autothrottle or speed mode

The aircraft has **no autothrottle** and **no speed mode** (such as flight-level change). Autopilot **pitch** is commanded only by **ALT HOLD**, the **PITCH wheels** (when ALT HOLD is off), and the **GS AUTO / GS MAN** modes. Thrust is managed manually or by the Virtual Flight Engineer (the VFE manages thrust only for **takeoff and climb**, and only if selected to do so on the EFB Options page).

16.2 The Autopilot Controller

The Autopilot Controller, on the pedestal, carries the master switch, mode selector, and the manual flight controls (Figure 16-1).

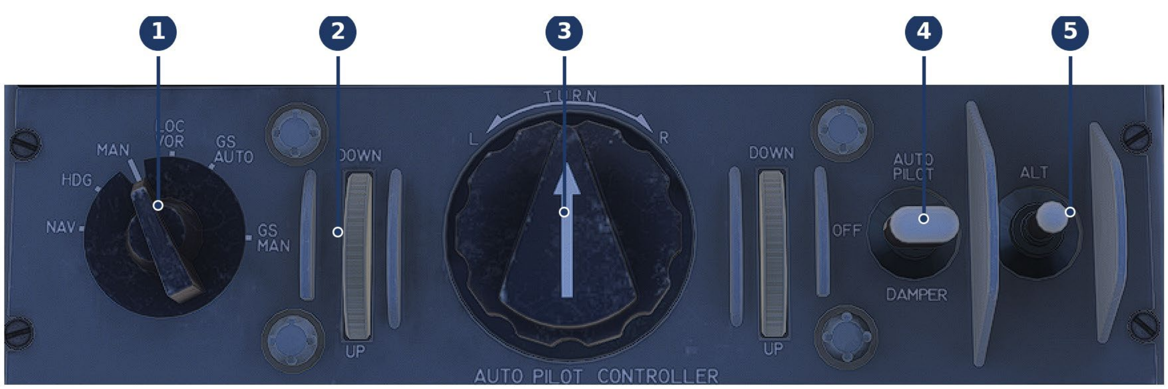

Figure 16-1 Autopilot Controller

No.	Control / indicator
1	**Mode selector** — MAN · HDG · NAV · LOC VOR · GS AUTO · GS MAN (§16.3).
2	**PITCH wheels** (DOWN / UP) — command pitch attitude when ALT HOLD is off.
3	**Turn controller** — commands bank in MAN mode (0–35° per knob position).
4	**AUTOPILOT master switch** — two-position toggle, **AUTOPILOT / OFF**. The **DAMPER** position on this panel is **inoperative** — the yaw damper is controlled from the overhead panel (§16.6).
5	**ALT** — engages Altitude Hold, capturing the altitude present at engagement (§16.5).

Spring-loaded, electromagnetically held

The controller is spring-loaded and magnetically held. With **power off**, the master switch springs to **OFF**, ALT HOLD releases, and the turn and mode controls return to **MAN / 0°**. With **power on**, the controls are magnetically held in the selected position — but on a failure or when an inappropriate mode is selected, they spring back to **MAN**.

16.3 Autopilot Modes

The mode selector chooses how the autopilot steers the aircraft. **MAN, HDG, NAV, and LOC VOR provide lateral (roll) steering only.** The **GS AUTO and GS MAN** modes are the **only modes that command both lateral and pitch** — they are not pitch-only modes. In the GS modes the autopilot steers the aircraft **laterally** (from a localizer or the long-range navigator, per the captain's HSI selection) **and** commands **pitch** to fly the glideslope/glidepath.

Mode	Function
MAN	Manual. The **turn controller** commands a bank angle of **0–35°** in accordance with the knob position; pitch is set with the **PITCH wheels**.
HDG	Turns to and holds the selected heading.
NAV	Provides **lateral steering from** the long-range navigator (CIVA INS, UNS-1, or GNS).
LOC VOR	Provides **lateral steering from** the localizer or VOR selected on the captain's side (§16.4).
GS AUTO / GS MAN	The only modes that command **both lateral and pitch** — lateral from a **LOC or NAV** source (per the captain's HSI) plus **pitch** to fly the glideslope/glidepath (see below).

Glideslope Modes — GS AUTO and GS MAN

Both GS modes provide **lateral and vertical** guidance: they steer the aircraft laterally onto the approach course and command pitch to fly the glideslope/glidepath. Their **lateral** source follows the captain's **HSI NAV/CDI** switch (§16.4):

1. With the captain's HSI in **LOC/VOR**, lateral guidance comes from a **tuned localizer** on the captain's selected nav radio — classic **ILS** operation (localizer lateral + glideslope vertical).
2. With the captain's HSI in **NAV** and the long-range navigator supplying **RNAV LPV** or **LNAV/VNAV** glidepath data, lateral and glidepath both come from the captain's

HSI/navigator. This applies to the **Garmin GNS** and **UNS-1** only — the **CIVA has no approach capability**.

The two modes differ in how they capture:

Mode	Capture behavior
GS AUTO	Captures **only from below** (traditional). The autopilot waits for the deviation to approach zero and then initiates the descent along the glideslope/glidepath.
GS MAN	Intercepts the glideslope/glidepath **immediately** whenever valid deviation data is received — usable for capture from **above or below**.

CAUTION — GS MAN can command an unexpected pitch change

Because GS MAN intercepts immediately on valid deviation data, selecting it can command an **unexpected climb or descent** that conflicts with an ATC clearance. Select GS MAN with care and only when an immediate capture is intended.

WARNING — Verify a valid glidepath before selecting a GS mode

An **RNAV glidepath only becomes available once the final approach fix (FAF) is the active TO waypoint** — no vertical guidance exists prior to that point. The pilot **must** confirm a valid **GP/GS** signal on the HSI before selecting **GS AUTO** or **GS MAN**.

16.4 Navigation Source Selection

Two selectors on each pilot's side determine what feeds the HSI and — on the captain's side — the autopilot's LOC/VOR and GS modes.

Nav Source Selector

The **Nav Source Selector** on the captain's main instrument panel is a three-position switch — **NORMAL / NO. 1 / NO. 2** — that selects which nav radio feeds that side:

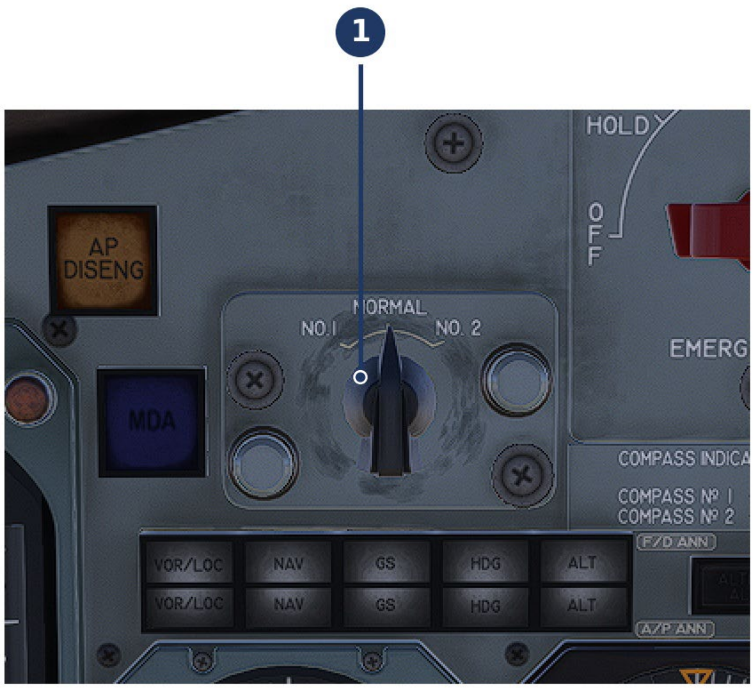

Figure 16-2 Nav Source Selector (captain's panel) — NORMAL / NO.1 / NO.2 selector (1)

Position	Captain's side
NORMAL	Uses **NAV radio 1** as the source for the captain's HSI **and** the autopilot LOC VOR / GS modes.
NO. 1	Selects **NAV 1**.
NO. 2	Selects **NAV 2** for the captain's HSI **and** the autopilot LOC VOR / GS modes.

Copilot selector has no autopilot effect

The first officer has an identical selector, but **NORMAL on the copilot side selects NAV radio 2** for his HSI. The copilot's selector affects **only his HSI display** — it has **no effect on the autopilot**. Only the captain's selection feeds the autopilot.

HSI NAV/CDI Switch

Below the DME indicators on each side is a **NAV / LOC-VOR** switch that selects what the HSI on that side displays:

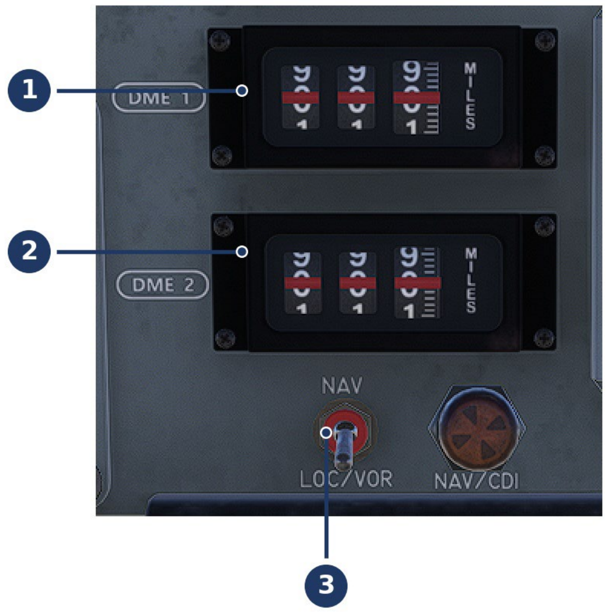

Figure 16-3 DME indicators and the HSI NAV/CDI switch — DME 1 (1), DME 2 (2), NAV – LOC/VOR switch (3)

- **LOC/VOR** — the HSI displays the **on-side nav radio** (localizer or VOR).
- **NAV** — the HSI displays the **long-range navigator** (CIVA, UNS-1, or GNS).

On the captain's side this switch also sets the **lateral source for the GS modes** (§16.3): a tuned localizer when in LOC/VOR, or the navigator's RNAV glidepath when in NAV (GNS / UNS-1 only).

16.5 Altitude Hold & Altitude Preselector

ALT on the Autopilot Controller engages Altitude Hold: the autopilot captures the altitude present at the moment of engagement and holds it. Each flight director provides the same altitude-hold behavior on its own side (§16.7).

Optional Altitude Preselector

An **optional altitude preselector** can be enabled in the **EFB Options** tab. When enabled, the **altitude alerter** on the forward center pedestal becomes a preselector: when the aircraft reaches the altitude set on the alerter, the autopilot **automatically engages ALT HOLD** (Figure 16-6).

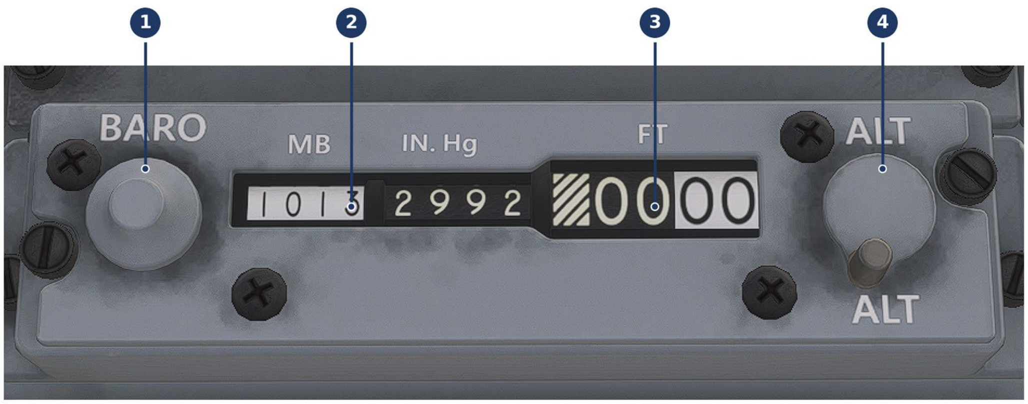

Figure 16-6 Altitude alerter / preselector — BARO knob (1), baro display (2), selected altitude (3), ALT selector (4)

> **WARNING — Keep the alerter BARO synchronized**
> The autopilot operates from the **alerter's altimeter and BARO setting**. The alerter BARO **must** match the **captain's altimeter** BARO, or Altitude Hold and preselector behavior will be unexpected when capturing or holding an altitude.
> The EFB provides an option to **synchronize all cockpit altimeter BARO settings** to the captain's primary altimeter — use it to keep the alerter and captain's altimeter in agreement.

16.6 Yaw Damper

The yaw damper is a **separate system**, controlled from the overhead panel by an **ON / OFF** switch, with a green **ENGAGED** light confirming operation (Figure 16-4). The yaw damper must be **ON and ENGAGED for the autopilot to be available** (§16.8). The DAMPER position on the Autopilot Controller (§16.2) is inoperative and is **not** the yaw-damper control. The yaw damper will engage if the switch is on, it has electrical power, and rudder hydraulic pressure is greater than or equal to 1000psi.

Figure 16-4 Yaw Damper overhead panel — ON/OFF switch (1), ENGAGED light (2)

16.7 Flight Director System

The captain and first officer each have an **independent** flight director, controlled from its own panel (Figure 16-7). The flight directors present guidance on the on-side ADI command crossbars and do **not** drive the autopilot. Each flight director consists of a control panel (below) and a set of FD crossbars on each respective ADI that show the guidance commands selected on the respective flight director panel.

Figure 16-7 Flight Director panels — Captain's panel (left, called out); First Officer's panel (right, identical)

No.	Control / indicator
1	**PITCH COMMAND** knob — sets the commanded pitch reference on that side's flight director.
2	**MODE SELECTOR** — HDG · NAV · VOR/LOC · GS AUTO · GS MAN · OFF.
3	**ALTITUDE HOLD** switch (ON / OFF) — holds the altitude present at engagement, shown on the on-side ADI crossbars.

16.8 Autopilot & Flight Director Annunciators

Two dual annunciator panels, one on the captain's main instrument panel and one on the first officer's, provide an immediate view of which flight director and autopilot modes are currently engaged (Figure 16-8). On each panel, the upper row, labeled **F/D ANN**, reflects only that side's own flight director; the lower row, labeled **A/P ANN**, reflects the single autopilot and is therefore identical on both panels.

Each annunciator light has three states:

- **Unlit** — that mode is not selected.
- **Lit RED** — that mode is selected, but not tracking.
- **Lit GREEN** — that mode is selected and active.

The meaning of a RED indication varies by mode:

- **ALT** — annunciates RED only during a capture event, and only when the altitude alerter is configured as a preselector on the EFB **Options** tab (see **§16.5**). The light illuminates RED when the capture event begins, typically within a few hundred feet of the selected altitude.

- **GS, in GS AUTO** — annunciates RED once the mode is selected but before glideslope/glidepath capture occurs. This is an expected, normal indication while intercepting, since GS AUTO captures only from below (see **§16.3**).
- **LOC VOR and NAV** — can annunciate RED if the signal is uncapturable or no guidance data exists. Unlike the GS AUTO pre-capture case above, this can indicate a guidance problem and should not necessarily be treated as a normal pre-capture indication.

Figure 16-8 Autopilot & Flight Director Annunciators — F/D ANN and A/P ANN rows

16.9 Engagement & Disconnect

Engagement

Autopilot engagement requires **electrical power** and the **yaw damper ON** (§16.6). With these satisfied, move the **AUTOPILOT master switch** to AUTOPILOT; the controller is then magnetically held in the selected mode.

Disconnect

The autopilot can be disengaged by any of the following:

- Pressing the **disconnect button** on either control yoke.
- Moving the **AUTOPILOT master switch** to **OFF**.
- Operating **either electric trim switch**.
- Simulator key events — the **autopilot toggle** and **autopilot off** events, and the standard **trim up / trim down** events.

AP DISENG Warning Light

On any disengagement — for any reason — the amber **AP DISENG** light on the instrument panel (near the ADI) illuminates and **flashes** (Figure 16-9). It continues to flash until it is cancelled by any of:

- Pressing the yoke **disconnect button a second time**.
- Pressing the **flashing AP DISENG light/button** itself.
- Triggering the **autopilot off** or **autopilot toggle** simulator key events.
- **Re-engaging** the autopilot with the master switch.

Figure 16-9 ADI with the AP DISENG warning light — AP DISENG light (1)

16.10 Limitations

Parameter	Limit
Pitch angle	17°
Bank angle — MAN	35°
Bank angle — LOC, GS, and preset HDG	30°
Bank angle — GS after capture	10°
Roll rate	6° per second
Minimum engage altitude	1,300 ft — **recommended, but not enforced by the system**

PART II — AIRCRAFT SYSTEMS

Chapter 17 — Polar Path Directional Gyrocompass

About this chapter

Describes the **Polar Path directional gyrocompass**, the aircraft's primary source of stable heading information. It is a background heading reference — the pilot-operated long-range navigation systems are covered in Part III.

The compass control panel is labeled **COMP** and is the subject of this chapter.

17.1 System Overview

The directional gyrocompass provides a source of stable aircraft compass-heading information. It combines two complementary sensors:

- An **inertial directional gyro** that provides attitude-stable heading.
- A **magnetic flux valve** that detects the earth's magnetic lines of flux at the aircraft's position.

In combination, they allow the aircraft to stably track its magnetic heading. Crucially, the design also allows **gyro-only** operation in polar areas, where the earth's magnetic flux is too weak for the magnetic flux valve to detect reliably. This gyro-only capability is what makes the system suitable for "polar path" navigation.

Two independent compass systems are installed — **No. 1** (captain) and **No. 2** (first officer). Either pilot position can select the opposite system as its source for redundancy; source selection is described in §17.6.

17.2 Controls & Indicators

All compass controls and indications are on the COMP panel (Figure 17-1).

Figure 17-1 Polar Path directional gyrocompass (COMP) panel

No.	Control / indicator
1	**RATE COR** knob — sets the precession-correction rate, in degrees per hour, when the unit is in **DG** mode (§17.4). It has no effect in SLA or SYN.
2	**Synchronization indicator** (− / +) — needle that deflects to show the rate at which the system is synchronizing the directional gyro; stronger deflection right (positive °/hr) or left (negative °/hr) indicates a higher synchronization rate.
3	**Synchronization warning light** — illuminates when **SYN** mode is active, or when the **SET** knob is off its center position, reminding the pilot to exit SYN or re-center the SET knob.
4	**SET** knob (DEC HDG / INC HDG) — rotates the compass card to the desired heading in **DG** mode; spring-centered with slow and fast slew rates left (decrease) and right (increase). No effect in SLA or SYN.
5	**Mode knob** (DG / SLA / SYN) — selects the compass operating mode (§17.3).

17.3 Operating Modes

The mode knob selects one of three operating modes. **SLA is the normal mode.**

Mode	Summary
DG	Manual directional-gyro mode — free gyro, does not follow the flux valve; precession is corrected manually (§17.4).
SLA	Slaved mode — the gyro slowly follows the magnetic flux valve. **Normal operating mode.**
SYN	Fast synchronization — rapidly drives the gyro to the flux-valve heading; used to re-synchronize, then exited.

DG — Manual Directional Gyro

In DG mode the gyrocompass does not follow the magnetic flux valve. The gyro will naturally **precess** at a rate determined by the earth's rotation, the aircraft latitude, and the direction and speed of travel. This precession is corrected using the **RATE COR** knob, and the compass card is set to the desired initial heading using the **SET** knob (§17.4). DG mode is used in polar regions where the flux-valve signal is unreliable.

SLA — Slaved (Normal)

In SLA mode the gyrocompass follows the magnetic flux valve, slowly precessing toward the heading signal the valve provides. This is the **normal mode** for the gyrocompass in most of the world. Note that the flux-valve signal becomes weak at approximately **75° latitude and above**, which may require switching to **DG** mode for manual gyro precession.

SYN — Fast Synchronization

Switching to SYN mode rapidly precesses the gyrocompass to the magnetic-flux-valve heading. Use it when the compass has deviated significantly from the actual magnetic heading and you want to re-synchronize to the correct magnetic heading. While in SYN, the **synchronization warning light** illuminates to remind the pilot to leave SYN mode once synchronized.

> **Return to SLA after synchronizing**
> SYN is a momentary-use mode. Once the compass has synchronized to the correct magnetic heading (and the synchronization indicator settles), return the mode knob to **SLA** for normal operation. The warning light is your cue that SYN is still selected.

17.4 Manual Operation in DG Mode

In DG mode the pilot manages the gyro directly using two knobs. Both are active **only** in DG mode and have no effect in SLA or SYN.

Setting Heading — SET Knob

The **SET** knob rotates the compass card to a desired heading. Turning it toward **DEC HDG** (left) decreases the indicated heading and toward **INC HDG** (right) increases it, each with a slow and a fast slew rate depending on how far the knob is displaced. In the **center** position no slew is applied.

> **Re-center the SET knob**
> Whenever the SET knob is not centered, the **synchronization warning light** illuminates. After setting the heading, return the knob to center so the light extinguishes.

Correcting Precession — RATE COR Knob

Because the free gyro precesses in DG mode, the **RATE COR** knob applies a compensating correction, set in **degrees per hour**, to counter that precession. The correct value depends on latitude and the aircraft's direction and speed of travel; select it from the **rate-correction charts** in §17.7 (Figures 17-3 through 17-8), using the chart closest to the current groundspeed.

17.5 Polar Operation

The system's defining capability is reliable heading at high latitude. Approaching roughly **75° latitude**, the magnetic flux valve's signal weakens to the point that slaved (SLA) operation is no longer dependable. In this region the crew selects **DG** mode and manages the free gyro manually:

- Before the flux-valve signal degrades, ensure the compass is synchronized to the correct magnetic heading (use **SYN** if needed, then return to SLA).
- Select **DG** mode to hold the gyro as a free directional reference.
- Set the initial heading with the **SET** knob, then return the knob to center.
- Set the appropriate **RATE COR** value for the current latitude, heading, and groundspeed (§17.7), adjusting as conditions change.
- On leaving the polar region and regaining a reliable flux-valve signal, re-synchronize and return to **SLA**.

> **CAUTION — High latitude gyro precession**
> At very high latitudes and on specific tracks, the gyro may precess faster than the maximum available setting, and may need to be periodically slewed manually by the pilot.

17.6 Compass Source Selection & Redundancy

Two independent compass systems are installed: **No. 1** serves the captain and **No. 2** serves the first officer. For redundancy, either pilot position can manually switch its instruments to receive input from the opposite system — so a failure of one compass system need not leave a pilot without a heading reference.

Source selection is made on the pilot's instrument-source panel using the **COMPASS** switch (Figure 17-2). In the **NORMAL** position, that pilot's instruments use their own-side compass system (No. 1 for the captain, No. 2 for the first officer). Selecting the opposite side (**No. 2** for the captain, or **No. 1** for the first officer) transfers that pilot's heading input to the other system.

Figure 17-2 Instrument-source panel — COMPASS source-selection switch (1)

> **Own-side vs. cross-side**
>
> **NORMAL** = own-side compass system. On the captain's panel, NORMAL is **No. 1** and the alternate is **No. 2**; on the first officer's panel, NORMAL is **No. 2** and the alternate is **No. 1**. Select the opposite side only when the own-side compass system is unavailable, and note that both pilots then rely on the same system.

The same instrument-source panel also carries **ATTITUDE**, **INST GYRO**, and **ADF/RMI COMPASS** source switches for their respective systems; only the **COMPASS** switch concerns the directional gyrocompass described in this chapter.

17.7 Rate-Correction Charts

In **DG** mode the free gyro precesses and must be corrected with the **RATE COR** knob (§17.4). The charts in this section give the correction to set, in **degrees per hour**, for the current conditions. There is one chart per groundspeed — **0, 100, 200, 300, 400, and 500 kts**.

Reading the Charts

On each chart:

- The **horizontal axis** is the aircraft **track in degrees true** (0–360°).
- The **vertical axis** is the required **rate correction in degrees per hour** (positive or negative).
- Each **line style** is a **latitude**, per the legend — negative values are southern latitudes, positive values northern.

To use a chart: choose the chart closest to your current **groundspeed**, find your **track** on the horizontal axis, follow up to the line for your **latitude**, and read the **correction** on the vertical axis. Set that value on the **RATE COR** knob. Interpolate between charts and between latitude lines as needed, and re-check as track, latitude, or groundspeed change.

> **Note — zero groundspeed**
> At **0 kts** groundspeed (stationary, e.g., during ground alignment) the correction depends on latitude only and is independent of track — the lines are flat (Figure 17-3). At higher groundspeeds the correction varies strongly with track.

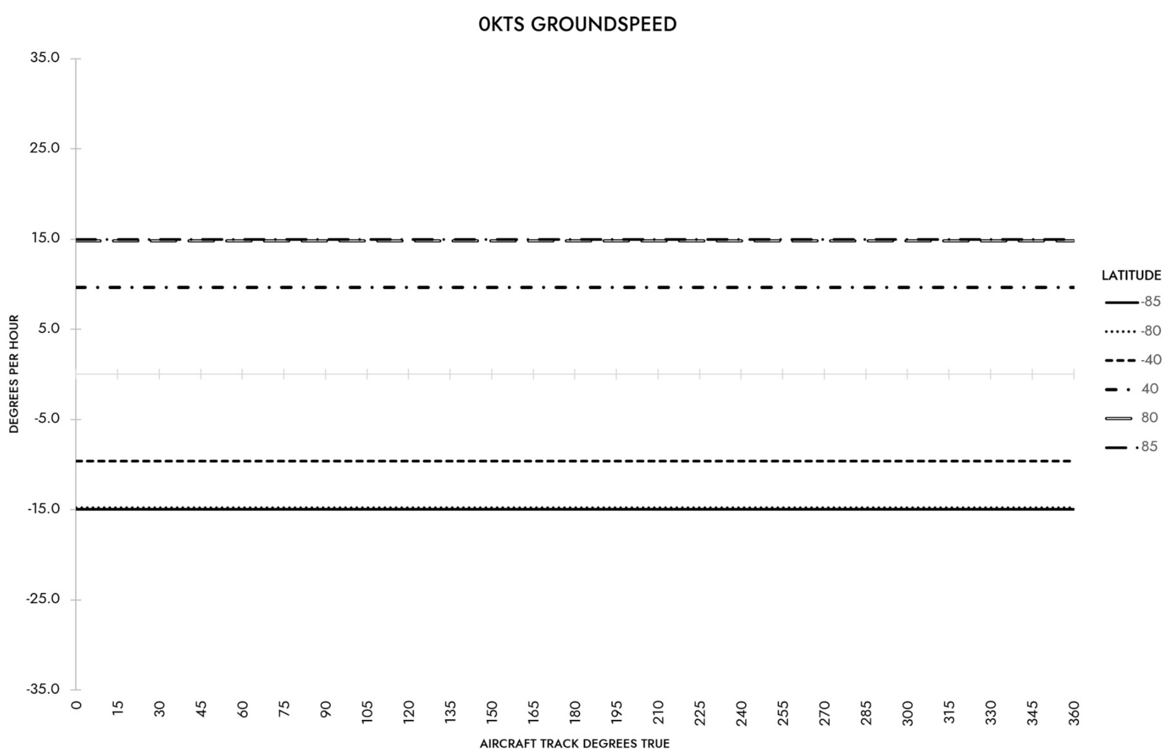

Figure 17-3 Rate correction — 0 kts groundspeed

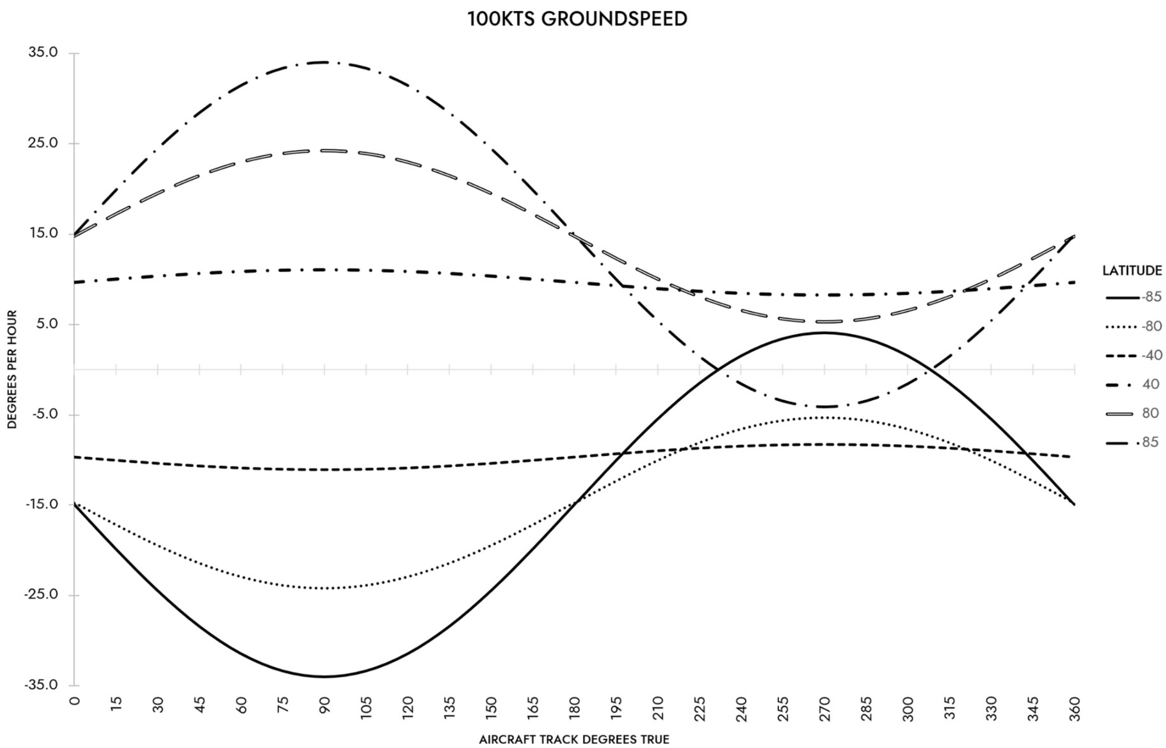

Figure 17-4 Rate correction — 100 kts groundspeed

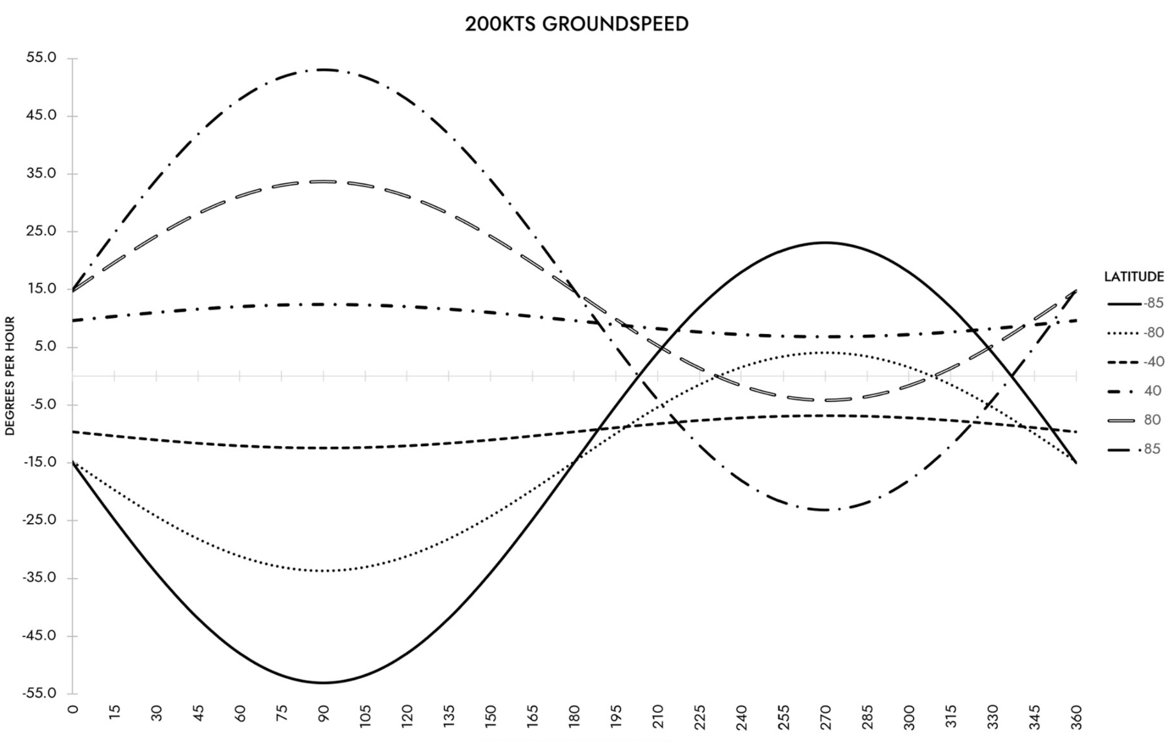

Figure 17-5 Rate correction — 200 kts groundspeed

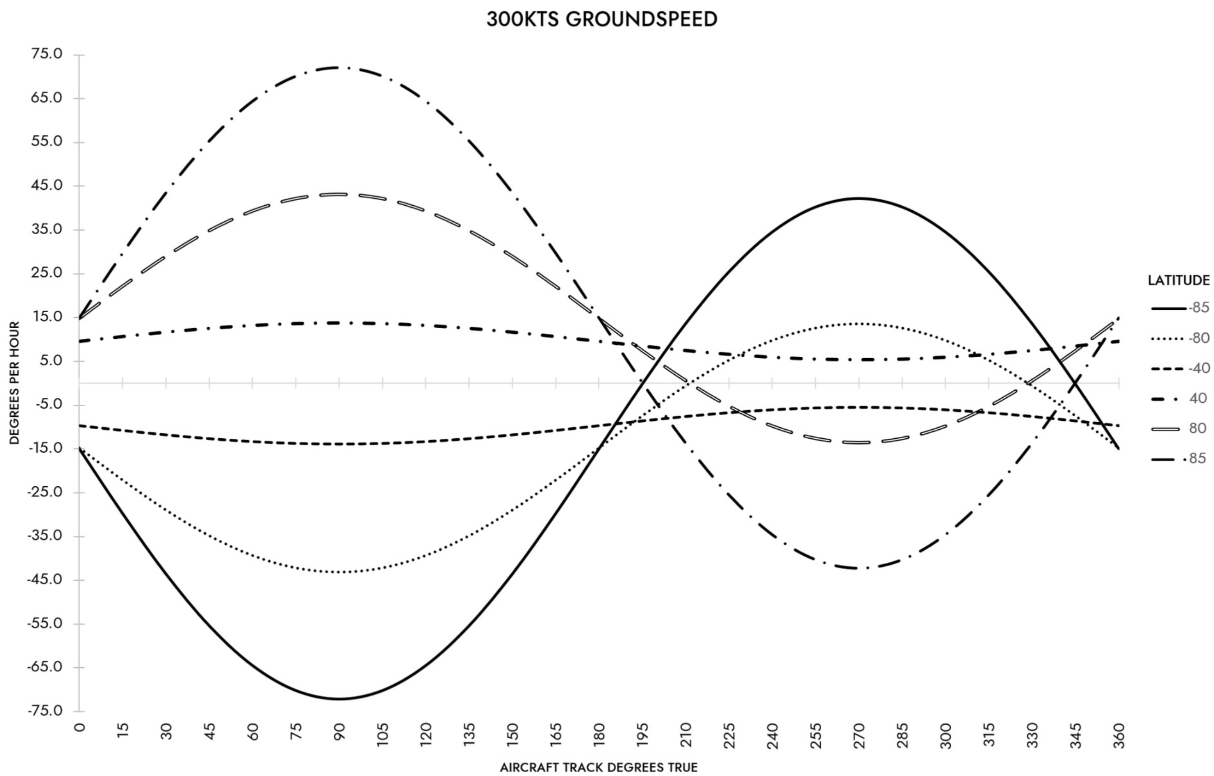

Figure 17-6 Rate correction — 300 kts groundspeed

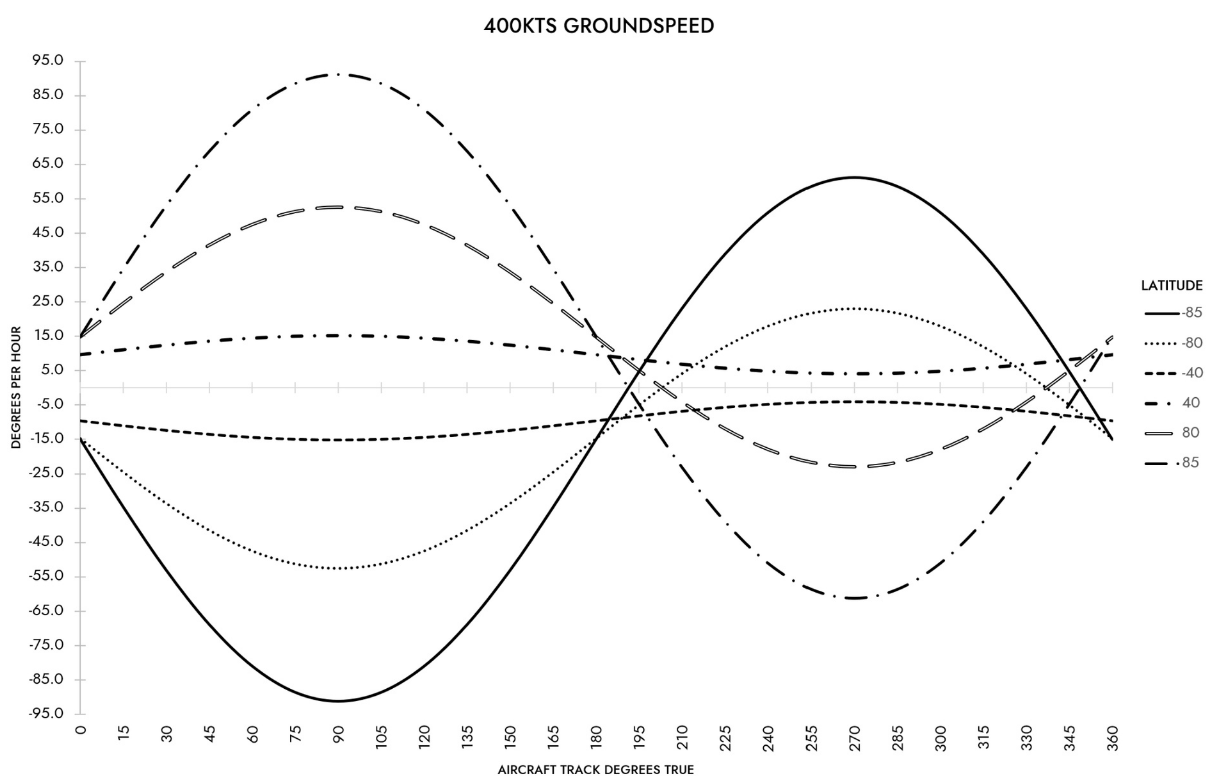

Figure 17-7 Rate correction — 400 kts groundspeed

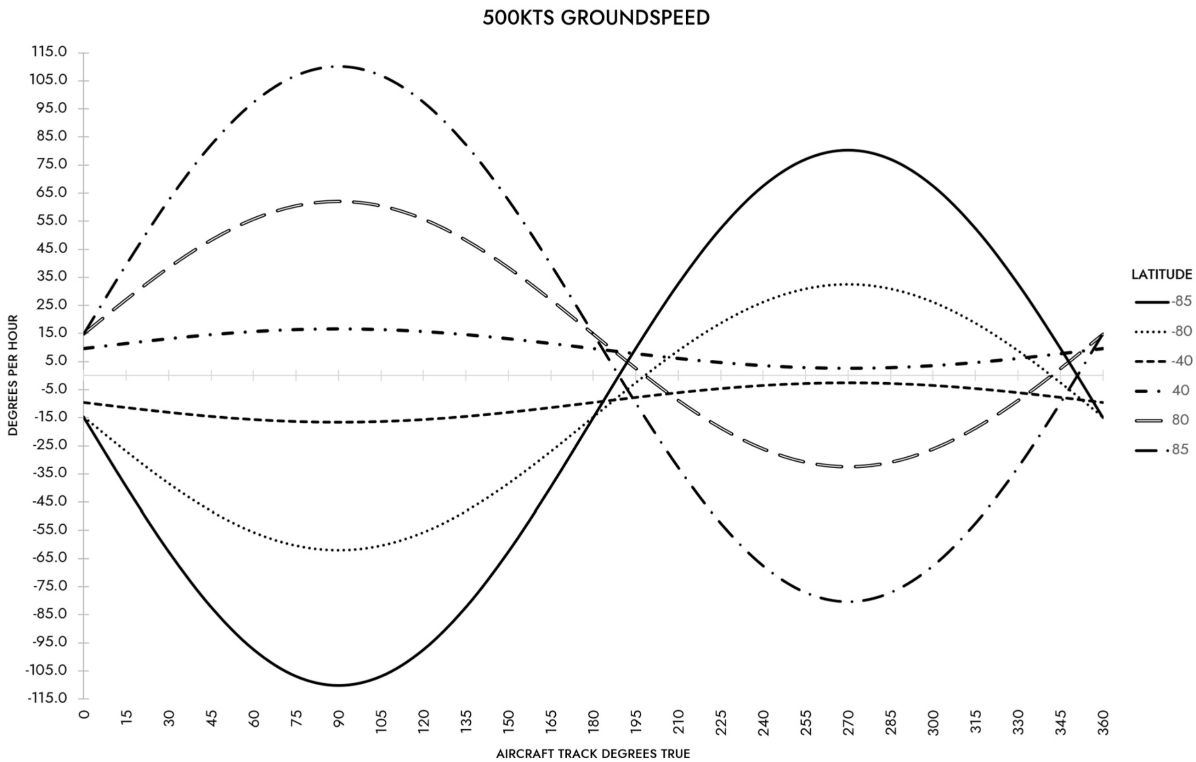

Figure 17-8 Rate correction — 500 kts groundspeed

PART II — AIRCRAFT SYSTEMS

Chapter 18 — Weather Radar

About this chapter

Describes the **Bendix RDR-1 weather radar** — the control panel, the radar indicator, and the display polarizer used for night operation.

Several of the unit's controls are non-functional in the current simulation; these are identified as **INOP** where they occur, so the modeled behavior is clear.

18.1 System Overview

The aircraft is equipped with a **Bendix weather radar** that scans ahead of the aircraft and paints precipitation returns on a circular indicator. The system consists of two units: the **radar control panel** (below the CIVA/navigation controls) and the **radar indicator** (the circular scope to the right). The antenna sweeps a forward sector, and stronger returns appear brighter on the display.

18.2 Radar Control Panel

The RADAR control panel carries the mode selector, gain, and antenna-tilt controls (Figure 18-1).

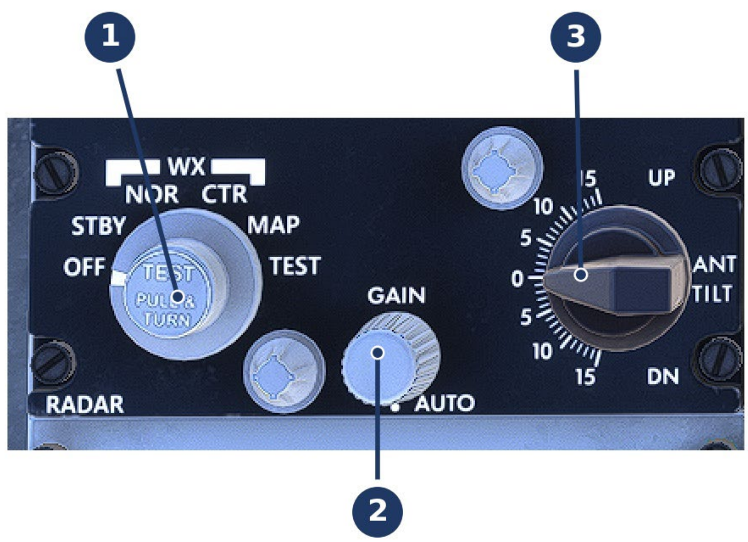

Figure 18-1 Radar control panel — mode selector (1), GAIN (2), ANT TILT (3)

Mode Selector

The rotary mode selector (marked TEST – PULL & TURN) sets the radar operating mode:

Position	Function
OFF	Radar off.
STBY	Standby — the display is powered on but does not paint anything. Used to keep the set warm and ready.

Position	Function
NOR (WX NOR)	Normal operation — the standard weather-display mode.
CTR / MAP / TEST	**INOP** — these positions are not simulated and function the **same as NOR**.

GAIN
The **GAIN** knob adjusts receiver gain: increasing gain strengthens weak returns but also raises background noise. Find the setting that shows the weather clearly without excessive clutter.

ANT TILT
The **ANT TILT** knob pitches the antenna beam up or down by up to **±15°** relative to the horizon. Tilt the beam up to look over nearer returns and down to examine weather closer to the aircraft or the terrain ahead.

18.3 Radar Indicator

The radar indicator presents the forward sector scan on a circular scope, with range arcs and the controls shown in Figure 18-2.

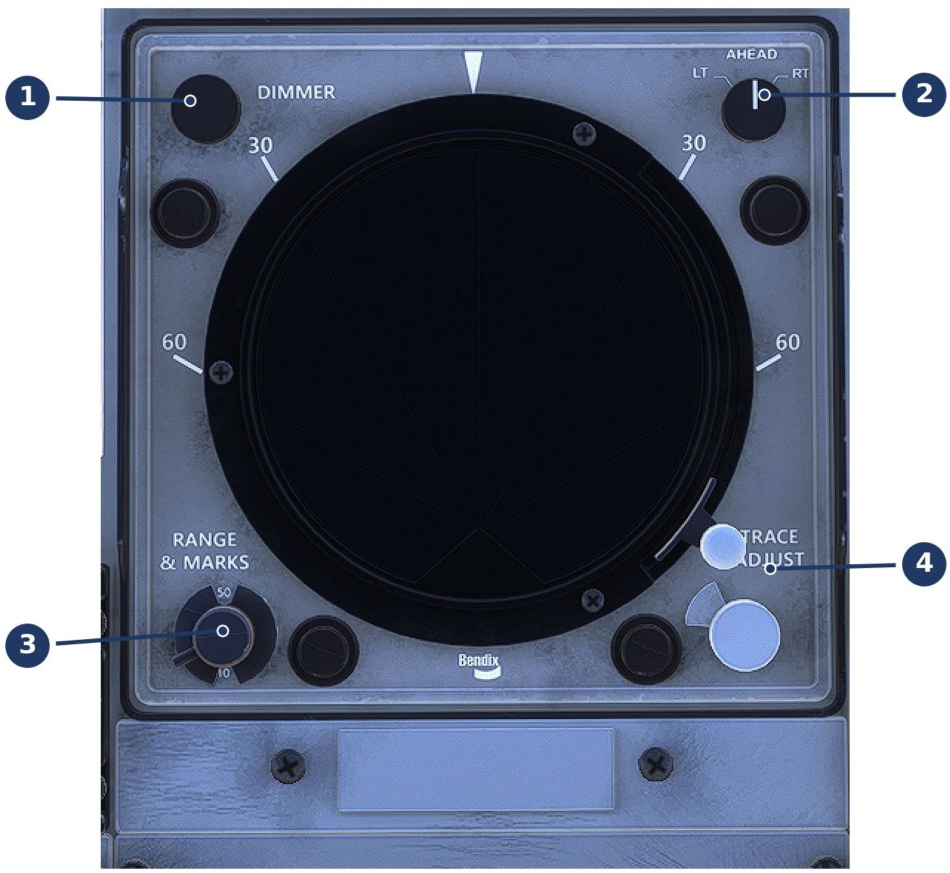

Figure 18-2 Radar indicator — DIMMER (1), LT/AHEAD/RT (2, INOP), RANGE & MARKS (3), TRACE ADJUST (4, INOP)

No.	Control / indicator
1	**DIMMER** — controls overall screen brightness.
2	**LT / AHEAD / RT** — **INOP** (display-centering control, not simulated).
3	**RANGE & MARKS** — selects the display range and the spacing of the range marks (see below).
4	**TRACE ADJUST** — **INOP** (not simulated).

Range & Marks

The **RANGE & MARKS** control selects one of three display ranges, each with its own range-mark spacing:

Range	Range marks every	Use
50 miles	10 miles	Short-range weather / terminal area.
150 miles	25 miles	Mid-range weather avoidance.
300 miles	50 miles	Long-range strategic planning.

18.4 Display Polarizer

An unlabeled **polarizer lever** on the indicator progressively darkens the display by filtering out the blue and green wavelengths, leaving only red. It is intended for **night operation**, where a full-brightness green display would be distracting or harm night vision. As the polarizer is advanced, the picture shifts from bright green, through a dimmer green and amber, to a dim red (Figure 18-3).

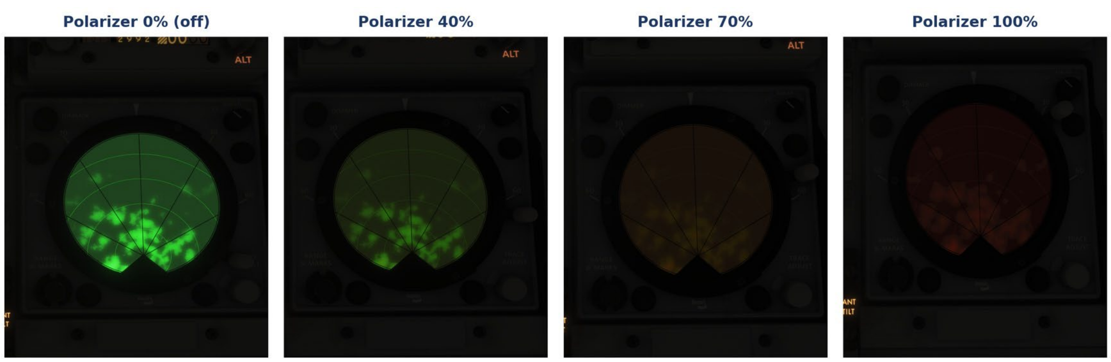

Figure 18-3 Polarizer progression — approximately 0%, 40%, 70%, and 100%

> **Using the polarizer at night**
>
> At night, advance the polarizer to reduce the display's brightness and color to a dim red that preserves night vision while still showing the weather. During the day, leave it off (0%) for the brightest, highest-contrast green picture. The **DIMMER** control (§18.3) can be used together with the polarizer to fine-tune overall brightness.

18.5 Normal Operation

A typical sequence for using the radar in flight:

- Set the mode selector to **STBY** to power the display, then to **NOR** to begin painting weather.
- Select an appropriate **RANGE** for the phase of flight (§18.3).
- Adjust **GAIN** for a clear picture without excessive noise.
- Use **ANT TILT** to scan the vertical extent of weather ahead — tilt up to see distant tops, down to examine nearer cells.
- Set **DIMMER** and, at night, the **polarizer** for a comfortable, night-vision-friendly display.

PART II — AIRCRAFT SYSTEMS

Chapter 19 — Radios and Communication

About this chapter

Covers the aircraft's radios and communication equipment: the VHF NAV/COMM radios, the interphone (ICS), the ADF receivers, and the ATC transponder.

The VHF NAV radios feed the HSI and the autopilot's LOC/VOR and GS modes (Chapter 16); the weather radar is covered in Chapter 18.

19.1 Equipment Overview

The Boeing 707-320C carries a full complement of communication and radio-navigation equipment. The principal units the flight crew operates are:

- **Two VHF NAV / COMM radios** — each combining a VHF NAV receiver (VOR / ILS) and a VHF COMM transceiver (voice).
- **Two HF transceivers** — for long-range communication.
- **Interphone / ICS** — crew intercom and radio audio selection.
- **Two ADF receivers** — automatic direction finding.
- **Two ATC transponders** — radar beacons with altitude reporting.

Supporting systems include DME, a marker-beacon receiver and glideslope receivers.

19.2 VHF NAV / COMM Radios

Two combined VHF NAV/COMM radios are installed on the center pedestal — **No. 1 on the left** and **No. 2 on the right**. Each unit has a **VHF NAV** section (VOR/ILS) and a **VHF COMM** section (voice), each with its own frequency window and tuning knob (Figure 19-1).

Figure 19-1 VHF NAV/COMM radios (No. 1 left, No. 2 right) — VHF NAV window (1), VHF COMM window (2), tuning/volume knob (3), function switches (4)

The **Nav Source Selector** on each side main instrument panel determines whether NAV 1 or NAV 2 feeds the on-side HSI (see §16.4).

Frequency Tuning — the "Wedding-Cake" Knob

Each radio section is tuned with a single concentric knob assembly — stacked like a wedding cake — that combines coarse tuning, fine tuning, and volume (Figure 19-2).

Figure 19-2 Concentric tuning/volume knob — outer/MHz ring (1), middle/decimal ring (2), inner VOL knob (3)

No.	Control / indicator
1	**Outer (lowest) ring** — tunes the digits **left of the decimal** (the MHz portion of the frequency).
2	**Middle ring** — tunes the **decimal** digits (the kHz portion).
3	**Inner (highest) knob** — that radio's output **volume**.

NAV/COM 1 Radio Inop with GNS Variant

The NAV/COM 1 radio on the pedestal is marked inop in the Garmin GNS 530 variant of the aircraft because the NAV/COM 1 radios are controlled through the GNS unit itself on that variant. There is no behavior change, but that radio control unit is replaced by the GNS built in controls for NAV/COM 1 (captain's side).

19.3 Interphone (ICS)

Each crew station has an **Interphone Control Station (ICS)** panel that selects which radios and interphone the operator hears (receive) and transmits on, and sets their relative volumes (Figure 19-3).

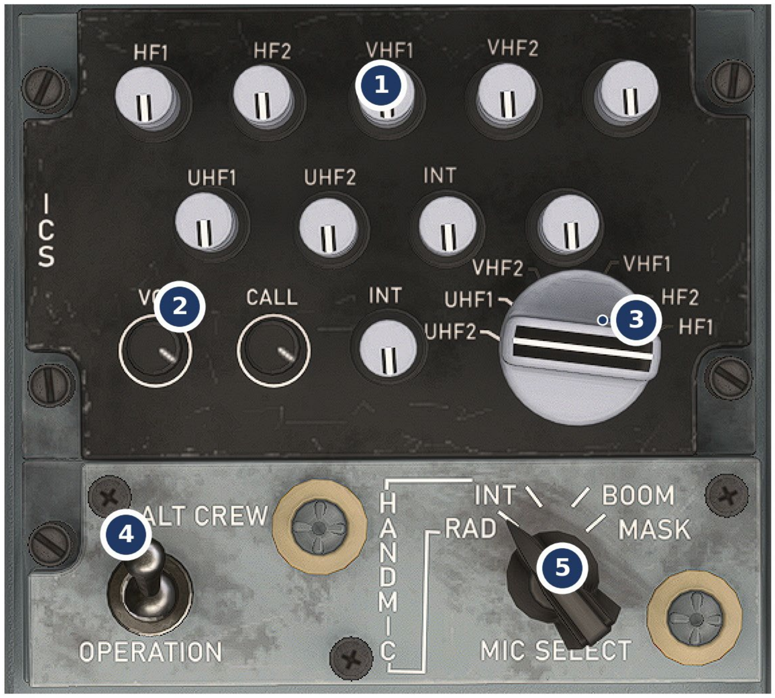

Figure 19-3 Captain's ICS panel — receive-source buttons (1), VOL/CALL/INT knobs (2), transmit selector (3), ALT CREW OPERATION (4), MIC SELECT (5)

No.	Control / indicator
1	**Receive-source buttons** — select which sources are heard: HF1, HF2, VHF1, VHF2, UHF1, UHF2, and INT (interphone). Any combination may be selected.
2	**VOL / CALL / INT** knobs — overall receive volume, the crew CALL function, and interphone level.
3	**Transmit (mic) selector** — rotary selecting which single source the operator transmits on (VHF1/2, HF1/2, UHF1/2).
4	**ALT CREW OPERATION** — toggle for alternate-crew interphone operation.
5	**MIC SELECT** — selects the microphone in use (HAND MIC / BOOM / MASK) and its routing (RAD / INT).

19.4 ADF Receivers

Two **Automatic Direction Finding (ADF)** receivers are provided, each with its own control panel (Figure 19-4). ADF bearings from both radios are displayed on the RMI/compass indicators on each side of the main instrument panel, one each for the captain and first officer.

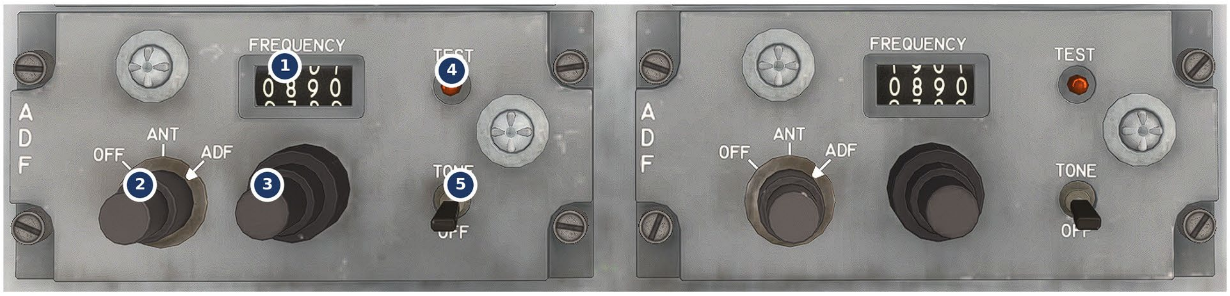

Figure 19-4 ADF control panels (No. 1 left, No. 2 right) — FREQUENCY counter (1), mode knob (2), tuning knob (3), TEST (4), TONE switch (5)

No.	Control / indicator
1	**FREQUENCY** counter — the tuned ADF frequency.
2	**Mode knob — OFF / ANT / ADF**. ANT uses the sense antenna for clearest audio (no bearing); **ADF** provides automatic bearing pointing.
3	**Tuning knob** — sets the frequency shown on the counter.
4	**TEST** — tests the receiver / bearing.
5	**TONE** switch — enables a beat-frequency tone to aid identification of keyed (CW) stations.

19.5 ATC Transponder

The ATC transponder replies to ground radar interrogations with the aircraft's assigned code and, when altitude reporting is on, its pressure altitude. Two transponders are installed, selected by the ATC TR switch (Figure 19-5).

Figure 19-5 ATC transponder — mode knob (1), CODE window (2), reply-code selector (3), ATC TR selector (4), ALT RPTG (5), TEST/NORM & IDENT (6)

No.	Control / indicator
1	**Mode knob — OFF / STBY / ON / LO SENS**. ON is normal operation; STBY keeps the set warm without replying; LO SENS reduces receiver sensitivity.
2	**CODE window** — the four-digit reply code, set with the adjacent selectors (e.g., 1200).
3	**Reply-code selector (A / B / C / D)** — selects the reply mode.
4	**ATC TR selector (1 / 2)** — selects transponder No. 1 or No. 2.
5	**ALT RPTG (1 / 2 / OFF)** — altitude reporting: selects the altitude source, or OFF to reply without altitude (Mode A only).
6	**TEST / NORM** and **IDENT** — self-test, and the IDENT button that flags the aircraft's return on the controller's scope when requested.

19.6 HF

Two **HF transceivers** (not simulated) provide long-range voice communication and are selected and tuned from their own control heads on the overhead panel; their audio is selected on the ICS (§19.3).

PART II — AIRCRAFT SYSTEMS

Chapter 20 — Lighting

> **About this chapter**
> Describes the aircraft's lighting systems in three groups: **Exterior Lighting** (§20.1), controlled from the overhead panel; **Cockpit Lighting** (§20.2), the panel and instrument illumination controls located throughout the flight deck; and **Cabin Lighting** (§20.3), the passenger cabin lighting panels and their associated cockpit controls.

20.1 Exterior Lighting

All exterior lighting controls are located on the overhead panel (Figure 20-1).

Figure 20-1 Overhead Panel — Exterior Lighting

Control	Description
Retractable Landing Lights (L/R)	Four switches: L/R switches (On/Off) control power to each retractable landing light; L/R switches (Extend/Off/Retract) control extension of each light.
Fixed Landing Lights (L/R)	Individual switches (On/Off) for the fixed (non-retractable) landing lights.
Runway Turnoff Lights (L/R)	Individual switches (On/Off).
Navigation Lights	Three-position switch (On/Off/On-Bat); On illuminates the navigation lights on normal aircraft power; On-Bat illuminates them on battery power alone.
Beacon	Switch (On/Off); red anti-collision beacon.
Taxi & Wing Switch	Three-position switch (Off/Wing/Taxi & Wing); Wing illuminates the wing lights only; Taxi & Wing illuminates both the wing lights and the nosewheel taxi light — the normal taxi lighting configuration.
Wheel Well Lights	Switch (On/Normal); Normal: each wheel well light is controlled by its own switch at the light's exterior position; On: forces all wheel well lights on from the cockpit.
Strobe Beacon	Switch (On/Off); controls the white exterior strobe lights, separate from the Beacon switch.

20.2 Cockpit Lighting

Cockpit lighting controls are distributed across five flight-deck locations: the overhead panel on both the captain's and first officer's sides, the aft pedestal, the main instrument panel, and the flight engineer station.

Overhead Panel — Captain's Side

Figure 20-2 Overhead Panel — Captain's Side Lighting Controls

Control	Description
Overhead Panel	Rheostat (Bright/Off).
Dome Red	Rheostat (Bright/Off).
Dome White	Toggle switch (On/Off).
Fwd Panel Background	Rheostat (Bright/Off).
Fwd Panel Flood	Toggle switch (On/Off).
Fwd Center Panel	Rheostat (Bright/Off).
Capt Map	Rheostat (Bright/Off).
Capt Instr Panel	Rheostat (Bright/Off).

Overhead Panel — First Officer's Side

Figure 20-3 Overhead Panel — First Officer's Side Lighting Controls

Control	Description
Pedestal Red	Rheostat (Bright/Off).
Pedestal White	Rheostat (Bright/Off).
Compass	Rheostat (Bright/Off).
F/O Instr Panel	Rheostat (Bright/Off).
F/O Map	Rheostat (Bright/Off).
Light Override	Three-position switch (Flt Only/Normal/All White); provides a quick override of certain individual rheostat settings. In Normal, all rheostats function as set. In either override position, some rheostats are overridden by this switch.

Aft Pedestal

Figure 20-4 Aft Pedestal — Aft Panel Light

Control	Description
Aft Panel Light	Rheostat (Bright/Off).

Main Instrument Panel

Figure 20-5 Main Instrument Panel — Annunciator Bright/Dim Switch

Control	Description
Bright/Dim Switch	Toggle switch controlling the brightness of cockpit annunciators; normally set to Bright during the day and Dim at night.

Flight Engineer Station

Figure 20-6 Flight Engineer Station — Lighting Controls

Control	Description
Panel	Rheostat (Bright/Off).
Panel Background	Rheostat (Bright/Off).
Circuit Breaker	Rheostat (Bright/Off).
Table	Rheostat (Bright/Off).

20.3 Cabin Lighting

Passenger cabin lighting is controlled from three panels within the cabin itself, plus a small set of related controls on the cockpit overhead panel.

Main Cargo Lighting Panel

Located next to the forward left main cabin door (Figure 20-7).

Figure 20-7 Main Cargo Lighting Panel — Forward Cabin Entry

Control	Description
Lav Dome	Switch (On/Off); controls forward lavatory lights. Linked with the Lav switch on the Forward Cabin Lighting panel.
Fwd Flood	Switch (On/Off); controls main/upper cargo deck lighting.
Cabin Flood	Switch (On/Off); inoperative.
Ceiling	Three-position switch (Cargo/Off/Pass.); Cargo forces the passenger cabin ceiling lights on at max brightness; Pass. passes control of passenger cabin ceiling lighting (strip lights and dome lights) to the Ceiling knob on the Aft Cabin Lighting panel.
Brd.	Switch (On/Off); controls forward and aft passenger entry door floor lights. Linked with the Board switches on the Forward and Aft Cabin Lighting panels; automatically moves the Entry lighting knob on the Forward Cabin Lighting panel between Off and Dim as needed to stay in sync.

Cabin Lighting Panel — Forward Galley

Located in the forward cabin galley (Figure 20-8).

Figure 20-8 Cabin Lighting Panel — Forward Galley

Control	Description
Entry	Three-position rheostat switch (Off/Dim/Bright); controls brightness of the boarding floor lights near the passenger doors.
Lounge	Switch (On/Off); controls the ceiling light above the forward passenger entry door.
Board	Switch (On/Off); controls forward and aft passenger entry door floor lights. Linked with the same switch on the Main Cargo Lighting and Aft Cabin Lighting panels.
Lav	Switch (On/Off); controls forward lavatory lights. Linked with the Lav Dome switch on the Main Cargo Lighting panel.
Chime	Inoperative.
Galley	Three-position rheostat switch (Off/Dim/Bright); controls the forward galley ceiling light.

Cabin Lighting Panel — Aft Galley

Located in the aft cabin galley (Figure 20-9).

Figure 20-9 Cabin Lighting Panel — Aft Galley

Control	Description
Galley	Three-position rheostat switch (Off/Dim/Bright); controls the aft galley ceiling light.
Lav	Switch (On/Off); controls aft lavatory lights.
Board	Switch (On/Off); controls all passenger entry door floor lights. Linked with all other Board controls.
Aft Cargo	Inoperative.
Window	Switch (On/Off); passenger cabin strip lights above the windows.
Ceiling	Three-position rheostat switch (Off/Dim-Bright/Night); controls passenger cabin ceiling strip lights and dome lights. Requires the Ceiling switch on the Main Cargo Lighting panel to be set to Pass.

Cockpit Controls

Three related cabin lighting/signage functions are controlled from the cockpit overhead panel rather than from within the cabin (Figure 20-10).

Figure 20-10 Overhead Panel — Emergency Exit Lights, No Smoking, Seat Belts

Control	Description
Emergency Exit Lights	Guarded switch (On/Armed/Off); controls the emergency cabin exit lights. Normally set to Armed and guarded for flight.
No Smoking	Switch (On/Off); illuminates the No Smoking sign in the cabin, set by the pilots per standard procedure.
Seat Belts	Switch (On/Off); illuminates the Seat Belts sign in the cabin, set by the pilots per standard procedure.

PART III

NAVIGATION SYSTEMS

PART III — NAVIGATION SYSTEMS

Chapter 22 — Navigation Systems Overview

About this chapter

Introduces the three pilot-operated long-range navigation systems fitted to the Boeing 707-320C, and how they integrate with the aircraft's flight instruments and automation. Each system is covered in full in its own chapter — **CIVA INS** (Chapter 23), **UNS-1** (Chapter 24), and **GNS 530W** (Chapter 25).

22.1 The Three Cockpit Variants

As introduced in **Chapter 2**, the aircraft is available in three cockpit variants, each built around a different long-range navigation system:

- **CIVA INS** — the classic long-range navigation option. Navigation is limited to latitude/longitude waypoint entry, computed by an autonomous inertial reference (the Delco Carousel IV-A) with no reliance on external signals. It is supported by the **CIVA** tab on the EFB when the CIVA variant is selected. See **Chapter 23**.
- **Universal UNS-1** — provides a traditional airliner FMS experience, including full procedure support and enroute navigation via airways. See **Chapter 24**.
- **Garmin GNS 530W** — a modern moving-map GPS navigator, supporting traditional procedures as well as enroute navigation. See **Chapter 25**.

22.2 Integration with Flight Instruments & Automation

Each of the three navigators integrates with the aircraft's flight instruments — including the HSI and ADI (**§4.7**) — as well as both flight directors and the autopilot (**Chapter 16**), as detailed elsewhere in this manual.

22.3 Flight Plan Synchronization

All three navigators support synchronization with the MSFS 2024 Flight Planner. Routes can be synced from the Flight Planner EFB app to the active avionics unit in the normal way, regardless of which cockpit variant is installed.

PART III — NAVIGATION SYSTEMS

Chapter 23 — Carousel IV-A Inertial Navigation System (CIVA)

About this chapter

Applies to the **INS** cockpit variant equipped with the Delco Carousel IV-A INS. The FMS (UNS-1) and GNS 530 variants are covered in Chapters 24 and 25.

The Virtual Navigator EFB companion (§23.8) is introduced here and cross-referenced from Chapter 27.

23.1 System Overview & Principles of Operation

The Boeing 707-320C is equipped with the Delco Carousel IV-A Inertial Navigation System (INS). Navigation may be accomplished using the standalone hardware unit or with assistance from the EFB Virtual Navigator (§23.8).

Unlike modern GPS-based systems, the Carousel IV-A operates entirely autonomously by measuring aircraft orientation and acceleration through internal gyroscopes and accelerometers, tracking movement relative to a known starting position. Because the system relies on the physical accumulation of movement data, the crew must initialize it by completing a stationary ground alignment and entering precise present-position coordinates before departure.

Once operational, the INS computes great-circle paths between stored waypoints. In-flight position degradation (drift) is corrected using conventional radio aids or definitive position references such as airports, VORs, intersections, coastline crossings, or visual checkpoints.

23.2 Component Layout — MSU & CDU

The Carousel IV-A is split into two flight-deck components:

- **Mode Selector Unit (MSU)** — located at the top of the navigation panel; controls the primary operating states. Positions: **OFF · STBY · ALIGN · NAV · ATT**.
- **Control Display Unit (CDU)** — positioned directly below the MSU; provides the keyboard matrix, control keys, data-selection wheels, and dual digital display windows used to enter coordinates, manage waypoints, track DME stations, and perform position corrections.

NOTE — NAV mode disambiguation

Throughout this chapter we refer to NAV mode as the mode selected on the MSU of the CIVA; not to be confused with NAV mode on the main instrument panel HSI source selector or NAV mode on the flight director or autopilot.

Figure 23-1 Carousel IV-A CDU / MSU — controls and indicators

No.	Control	Function
1	**Mode Selector (MSU)**	Rotary master mode control. Positions: OFF · STBY · ALIGN · NAV · ATT.
2	**READY NAV annunciator (green)**	Illuminates when navigation-quality alignment (Mode 5) is reached.
3	**BAT annunciator — MSU (red)**	Indicates that the INS was operating on emergency battery power and has shut down due to low battery voltage.
4	**Left data display**	Primary numeric readout (e.g., desired track, latitude).
5	**Right data display**	Secondary numeric readout (e.g., distance, waypoint data, status).

No.	Control	Function
6	**HOLD key**	Freezes present position for verification and position updating.
7	**Remote Mode Selector**	Selects the remote waypoint data-entry / display mode. INOP.
8	**INSERT key**	Commits entered data into the navigation computer's memory.
9	**ALERT annunciator (amber)**	Illuminates prior to waypoint passage / alert condition.
10	**BAT annunciator — CDU (amber)**	Indicates INS operating on / reverting to emergency battery power.
11	**WARN annunciator (red)**	System warning / malfunction indication.
12	**Waypoint / DME Selector**	Selects the active waypoint or DME station memory slot (0–9) for display or editing.
13	**FROM / TO display**	Shows the active leg (from-waypoint / to-waypoint) or the selected DME station.
14	**WY PT CHG key**	Initiates a leg (from-waypoint / to-waypoint) or DME station change.
15	**Data Selector**	Rotary selecting the displayed data: TK / GS · HDG / DA · XTK / TKE · POS · WAY PT · DIS / TIME · WIND · DSRTK / STS.
16	**DIM control**	Display brightness[1] (center of the Data Selector).
17	**AUTO / MAN switch**	Selects automatic or manual leg sequencing.
18	**TEST button**	Initiates the system / display test.
19	**Numeric keypad (0–9)**	Data entry. Dual-function keys: 2=N, 3=FRQ, 4=W, 6=E, 7=L/L, 8=S, 9=DME.
20	**CLEAR key**	Clears entered data before it is inserted.

The **DSRTK / STS** (Desired Track / Status) page is the primary window for monitoring alignment progress and, in flight, navigation accuracy. Because it is central to alignment, it is described in detail in §23.3.

23.3 Alignment & Initial Present Position Entry

Alignment establishes the INS' relationship to the Earth and determines true north, using an accurate present position as its starting reference. Because the two tasks are performed together on the ground, they are described here as a single procedure. The aircraft must remain stationary throughout.

The following steps are only necessary when both:

- the INS is in the **OFF** mode or has been moved back into **STBY**, and
- the **INS Align Time** setting in the Virtual Navigator EFB companion is either **QUICK** or **REALISTIC** (see §23.8 — CIVA Options below).

When starting on the runway, in the air, or skipping to taxi or takeoff in Career Mode, the INS will already be fully aligned and in **NAV** mode. This can be verified by rotating the Data Selector knob to **DSRTK / STS** and seeing "**100 05**" on the right display (see **Reading the DSRTK/STS Status Display** below).

Likewise, choosing the **INSTANT INS Align Time** setting in the EFB Companion will allow you to set the mode knob directly to **NAV**.

> **NOTE — Aircraft must remain stationary**
> Any premature movement or rocking during alignment disrupts the gyroscopic calibration and requires the crew to restart the procedure.

Alignment Procedure

- Verify the aircraft is stationary.
- Place the Mode Selector to **ALIGN**.
- Enter the aircraft's present position (see **Present Position Entry** below).
- Select **DSRTK / STS** on the Data Selector.
- Monitor alignment progress as the status value decreases through the alignment modes.
- Wait for **READY NAV** and **Align Mode 5**.
- Select **NAV** or remain in **ALIGN** longer to continue refinement and further reduce long-term drift.

Present Position Entry

The position entered during alignment becomes the foundation for all subsequent navigation calculations, so accurate entry is critical. This is the only place coordinates are typed during setup.

There are two methods for inserting the present position: *manual entry*, as would be done with the real unit; or *automatic entry*, which simply inserts the current, accurate position already shown on the POS display.

Automatic Entry:

- Select **POS** on the Data Selector.
- Press **INSERT**.
- **INSERT** button should be extinguished.

Manual Entry:

- Select **POS** on the Data Selector.
- **INSERT** button should be illuminated.
- Press **N (2)** or **S (8)** to select the latitude hemisphere.
- Enter latitude in degrees, minutes, and tenths of minutes, and press **INSERT**.
- Press **W (4)** or **E (6)** to select the longitude hemisphere.
- Enter longitude in degrees, minutes, and tenths of minutes, and press **INSERT**.
- **INSERT** button should be extinguished.

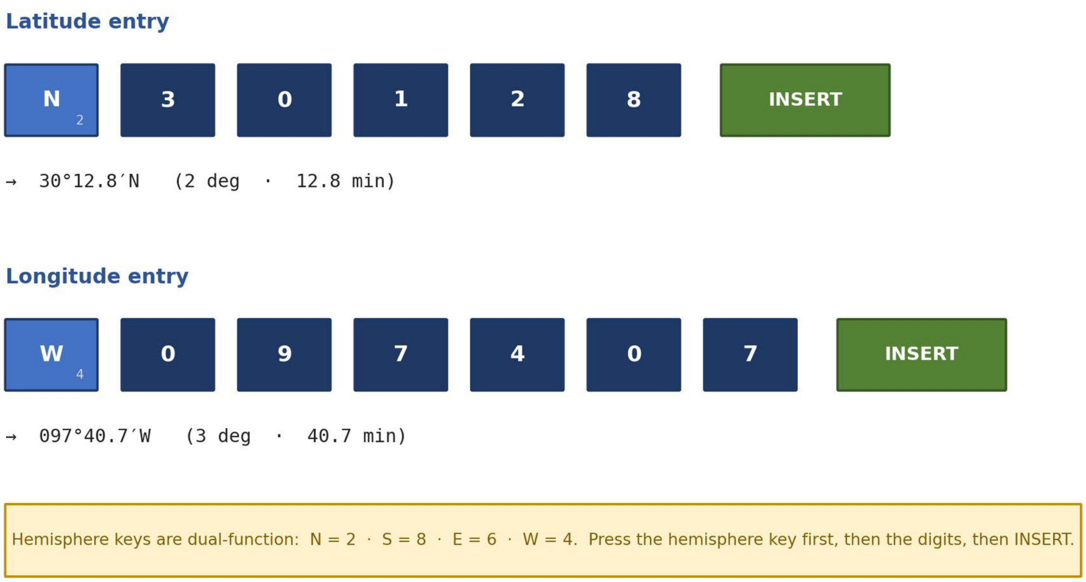

Figure 23-2 Present position entry — keystroke sequence (worked example)

Understanding Alignment Progress

When first placed into **ALIGN**, the system begins establishing true north and its Earth reference. The status value on the **DSRTK / STS** page decreases through the alignment modes (counting down 8→0 as the platform refines).

Initial present position may be entered at any time, even in **STBY**, but will not progress past Mode 7 until entered (see **Present Position Entry**, above).

READY NAV and Mode 5 indicate navigation-quality alignment. Additional time in ALIGN may further reduce long-term drift.

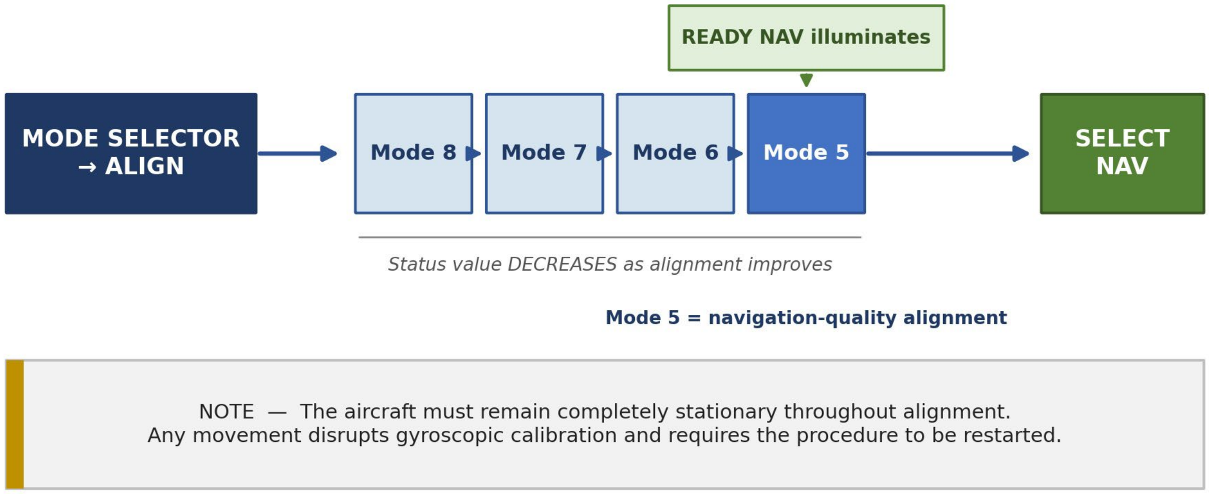

Figure 23-3 INS Alignment — status / mode progression

Reading the DSRTK / STS Status Display

With the Data Selector at **DSRTK / STS**, the left-hand window shows the **desired track angle** to the active waypoint (or a placeholder value of 225° during alignment), and the right-hand window shows a six-position **system-status word**. It can be decoded as follows:

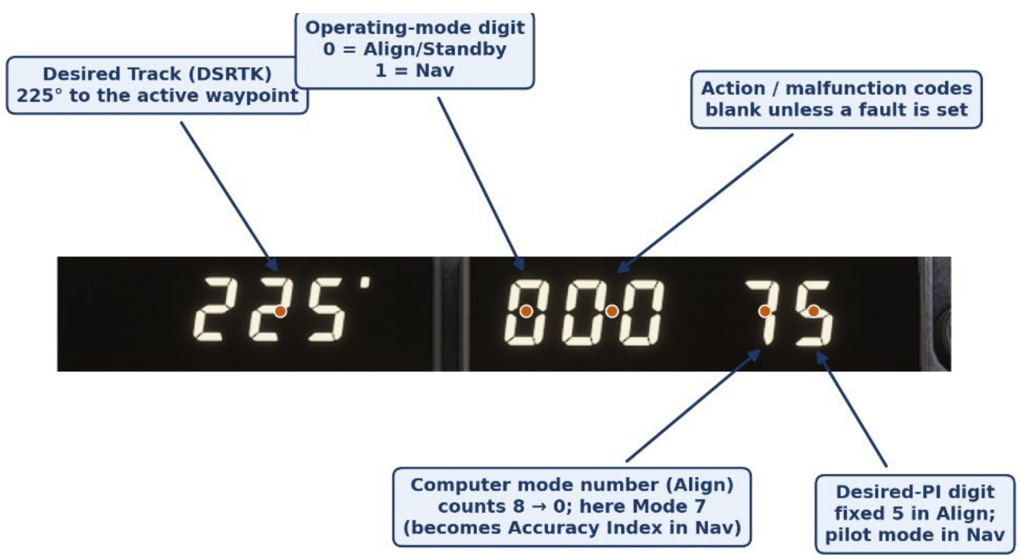

Figure 23-4 DSRTK/STS display — desired track and the six-position status word (shown mid-alignment, Mode 7)

Position	Meaning
1st	**Operating mode** Reflects the true computer mode (i.e. whether the unit is able to perform navigation), and may lag the MSU knob when it set to **NAV** but the unit is still performing its alignment. **0 — STBY** or **ALIGN** **1 — NAV**
2nd–3rd	**Action and malfunction codes** Blank in normal operation; light only when a fault is set.
4th	*Blank*
5th	*This digit has one of two meanings depending on the Operating Mode (first digit).* In **STBY** or **ALIGN**: **Align Mode** This represents the status of the alignment process, starting at 9 in **STBY** and then decreasing from 8→0 in **ALIGN**. In **NAV**: **Accuracy Index (AI)** This is a proxy for amount of IRS drift accumulated during the flight, with 0 = best and 9 = worst. It grows proportionally with time and is reduced by either DME Corrections or Position Updates (see §23.6).
6th	**Desired Performance Index (PI)** This digit is best thought of as commanding and identifying one of three possible **NAV sub-modes**: **0/2/3/5 — Normal Inertial Operation** While not currently counteracting the effects of IRS drift by means of DME station corrections, it retains any corrections previously made. **4 — Aided Inertial Operation** It's able to counteract the effects of IRS drift by means of DME station corrections and retains any corrections previously made (see §23.6). **1 — Position Update Eradication** It purges all corrections previously made and does not allow any further corrections (either from DME stations or manual Position updates) until the mode is changed. Fixed at **5** during **ALIGN**.

Worked example — the display in Figure 23-4

```
Left window    225°         →  Desired Track placeholder during alignment
Right window   0  00   7 5  →  Align (0) · no fault (00) · Align Mode 7 · fixed at 5
```

Because the aircraft is in **ALIGN** with present position loaded, the 5th digit is the **Align Mode**. Once **NAV** is entered, the first digit changes to **1** and that same 5th digit instead displays the **Accuracy Index** (or **AI** number).

23.4 Waypoint Storage & Programming

The Carousel IV-A stores route information in waypoint memory locations numbered 0 through 9, each a latitude/longitude pair used to calculate great-circle paths. Empty, uninitialized slots display 00°00.0′N 000°00.0′E.

> **NOTE — Waypoint 0**
> Waypoint 0 is a special, reserved slot for holding the present position when programming a Direct-To leg. Only waypoints 1–9 are available for route storage.

As with Present Position Entry, **there are two methods for inserting waypoints**: manually, as would be done with the real unit and outlined here; or by using the **Import Route** button in the Virtual Navigator EFB companion (see §23.8 — Importing a Flight Plan).

Manual Waypoint Entry

- Set the Data Selector to **WAY PT**.
- Select the desired waypoint slot with the **Waypoint / DME Selector** wheel, *avoiding slot 0 (see note above)*.
- Enter waypoint coordinates using the method specified in §23.3 — Present Position Entry — Manual Entry.
- Repeat for each additional waypoint in the route.

Example:

```
N42540  INSERT  →  42°54.0’N
W087549 INSERT  →  087°54.9’W
```

Typical Route Layout

Slot	Target	Purpose
0	Present position	Programming Direct-To legs
1–9	Route Waypoints	Sequential route waypoints

> **NOTE — Longer routes: recycle slots and wrap around**
> The layout above is only a simple example for a route that fits within the nine slots. For a longer route you are **not** limited to a fixed set of enroute fixes: as each waypoint is passed, reprogram its now-unused slot with an upcoming waypoint and let the **AUTO** sequencer wrap around (…8-9, 9-1, 1-2…) to fly the route continuously (§23.5).
> The Virtual Navigator’s **Auto-Sync** performs exactly this slot-recycling automatically, advancing the nine-waypoint buffer as the flight progresses so routes far longer than nine waypoints can be flown without manual re-entry (§23.9).

23.5 Navigation Operation

With the MSU in **NAV** and a valid route stored, the INS computes and steers great-circle tracks between any two waypoints. When the **AUTO / MAN** switch is in **AUTO**, the current leg's TO waypoint becomes the new leg's FROM waypoint, and the next waypoint becomes the new TO waypoint.

When in **MAN**, upon reaching the end of the leg, the **ALERT** light will illuminate and *navigation commands to the autopilot will be suspend*. To resume navigation, either turn the switch to **AUTO** or manually enter a new leg as described below.

When in **AUTO**, navigation will also suspend when sequencing to an uninitialized waypoint.

> **NOTE — AUTO Leg waypoint wrap-around**
> When in **AUTO**, legs will sequence 1-2, 2-3 … 7-8, 8-9, **9-1**, 1-2 … and so on indefinitely.

CDU Display Pages

Navigation information is available on the CDU display pages and drives the aircraft's flight director and autopilot when the INS is selected as the navigation source (autopilot coupling is described in Chapter 16). They are as follows:

TK / GS

- Track (*degrees true*) or heading when Ground Speed < 75 knots
- Ground Speed (*knots*)

HDG / DA

- Heading (*degrees true*)
- Drift Angle—difference between track and heading (*degrees Left or Right*) or zero when Ground Speed < 75 knots

XTK / TKE

- Cross Track Distance (*nautical miles Left or Right* of desired track)
- Track Angle Error (*degrees Left or Right* of desired track angle)

POS

- Present position

WAY PT

- Coordinates of
  - The waypoint corresponding to the Waypoint/DME Selector wheel position
  - The DME station corresponding to the Waypoint/DME Selector wheel position *when in the DME Station Position subpage* (see §23.7)
  - The raw, uncorrected present position *when the **HOLD** button is illuminated* (see §23.6 — "Uncorrected" and "Corrected" Positions)
- Elevation and frequency of the DME station corresponding to the Waypoint/DME Selector wheel position *when in the DME Station Elevation & Frequency subpage* (see §23.7 below)

DIS / TIME

- Distance (*nautical miles*)
  - To next waypoint
  - Between waypoints *when the **WY PT CHG** key is lit*
  - To DME station *when in the Distance to DME Station subpage* (see §23.7 below)

- Time (*minutes*) to fly the distance shown in the left display at the present Ground Speed (*note that this only shows for waypoints, not DME stations*)

WIND

- Direction (*degrees true*) or zero if True Airspeed < 152 knots
- Speed (*knots*) or zero if True Airspeed < 152 knots

DSTRK / STS

- Desired Track (*degrees true*) or 225 during **STBY** or **ALIGN**
- System Status code (see §23.3 — Reading the DSRTK / STS Status Display)

Manual Leg Change

To manually change the current leg:

- Press **WAY PT CHG** (both it and **INSERT** will light)
- Press the number of the new FROM waypoint
- Press the number of the new TO waypoint
- Press **INSERT** (both it and **WAY PT CHG** will go out)

23.6 Drift & Position Corrections

Drift is inherent to inertial navigation and grows proportionally with time spent with the MSU set to **NAV** since the last alignment. On long, overwater legs, where no radio references are available, expect the **Accuracy Index** to climb, and plan corrections opportunistically as suitable references are encountered. Longer, higher-quality ground alignments (**Mode 5** and lower) reduce the baseline error.

> **NOTE — Drift is DISABLED by Default**
> The drift simulation is **disabled by default** but can be enabled or disabled in the Virtual Navigator EFB companion Settings window (see §23.8 — CIVA Options).

Correcting for Drift

While the accumulated drift error of an inertial navigation system can never be "removed" (as the system, by definition, has no intrinsic awareness of this value), it can be compensated for by calibrating against known geographic reference points.

Any such calibrations, or *corrections*, generated after the initial alignment simply add an offset to the unit's raw, inertial present position in order to "place" the unit at the location you've told it that it now is.

There are two methods for applying these corrections:

- Present-position updates
- DME Station updates

The main difference between these two strategies is that the former is a singular, one-time update that *immediately* resets the Accuracy Index to 0, while the latter is a slower, continuous process of gradual refinement. They are discussed in further detail below.

"Uncorrected" and "Corrected" Positions
As stated above, the unit maintains two "versions" of the present position.

The first is the *raw, inertial position* calculated directly by the internal mechanisms of the IRS. This value contains any offset error that was present when the initial position was inserted during Alignment as well as all accumulated drift errors since the it was placed into **NAV**. Once in NAV, this value cannot be directly modified.

*This value is displayed when the Data Selector is at **WAY PT*** and *the **HOLD** button is illuminated.*

The second, "corrected" value is the "uncorrected" position, outlined above, with the addition of all subsequent corrections. These corrections can come from either of the two methods discussed previously. They may also be purged by setting **PI Mode 1** (for details on setting the **PI Mode**, see §23.7 — Enabling Automatic DME Updating), after which the "corrected" position will be identical to the "uncorrected" one, unless or until future corrections are once again applied. *This is the value that is used for all navigation calculations.*

*This is value is displayed when the Data Selector is at **POS**.*

Accuracy Index Guidance
As mentioned previously, since the INS has no ability to measure its own accumulated position error due to drift, the Accuracy Index (see §23.3 — Reading the DSRTK / STS Status Display) is used as a proxy for the amount of uncorrected drift that exists and is used to judge when an update is warranted.

> **NOTE — Accuracy Index is only a guide**
> Even though the value caps at 9, drift error will continue to accumulate. Furthermore, if the **AI** has been at **9** for a significant period of time, the uncorrected error will be proportionately higher for a given **AI** number as it decreases, due to DME updates, than it was as the number initially grew.

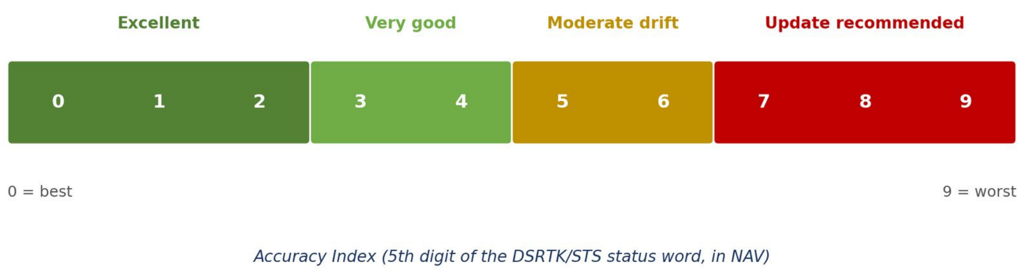

Figure 23-6 Accuracy Index — interpretation scale

Present-Position Updates

A present-position update immediately corrects for accumulated error using a known, geographic reference, such as an airport, VOR, intersection, coastline crossing, or visual reporting point.

To perform a Present Position Update:

- Set the Data Selector to **POS**.
- Press **HOLD** the *exact* moment the aircraft passes above the known reference point.
- The **HOLD** light illuminates and the INS position at that moment is frozen.
- This "corrected" position may be compared to the raw, "uncorrected" position the unit maintains internally (see *"Uncorrected" and "Corrected" Positions* earlier in this section) by setting the Data Selector to **WAY PT**.
- With the Data Selector set to **POS**, enter *the coordinates that the aircraft was at the time **HOLD** was pressed* using the method specified in §23.3 — Present Position Entry — Manual Entry.
- The INS *instantly* applies the correction, resetting the **Accuracy Index** to 0 and dropping all previous corrections, and resumes navigation; the **HOLD** and **INSERT** lights extinguish.

DME Station Updates

As this is a more involved process, the next section (23.7) is devoted entirely to this topic.

23.7 DME Station Programming & Aided Inertial Operation

The Carousel IV-A can refine its position by tuning and processing land-based DME stations. Each station is stored as a specialized waypoint slot containing four parameters:

- Station latitude
- Station longitude
- Station elevation / altitude
- Broadcast frequency

DME Station Subpages

Viewing and modifying DME station data occurs in three specific DME subpage views:

- Position
- Elevation & Frequency
- Distance to Station

One commonality shared by all DME station subpages, and the easiest way to tell if you're viewing a DME station subpage (as opposed to similar-looking Waypoint pages), is that the **FROM-TO** display will show only a *single, flashing number*. *This identifies which DME station slot will be used for position corrections* when in **PI Mode 4**—*Aided Inertial Navigation* (see §23.3 — Reading the DSRTK / STS Status Display).

The **DME Station Position subpage** may be entered the following ways:

- Setting the Data Selector to **WAY PT** and pressing **7 (L/L)**.
- If already in the DME Station Elevation & Frequency subpage, simply pressing **7 (L/L)**.

- If already in the Distance to DME Station subpage, simply moving the Data Selector to **WAY PT**.

The **DME Station Elevation & Frequency subpage** may be entered the following ways:
- Setting the Data Selector to **WAY PT** and pressing **3 (FRQ)**.
- If already in the DME Station Position subpage, simply pressing **3 (FRQ)**.
- If already in the Distance to DME Station subpage, moving the Data Selector to **WAY PT** pressing **3 (FRQ)**.

The **Distance to DME Station subpage** may be entered the following ways:
- Setting the Data Selector to **DIS / TIME** and pressing either **3 (FRQ)** or **7 (L/L)**.
- If already in either the DME Station Position or Elevation & Frequency subpages, simply moving the Data Selector to **DIS / TIME**.

To exit any of the DME subpages, turn the Data Selector to any position *other than* **WAY PT** or **DIS / TIME**.

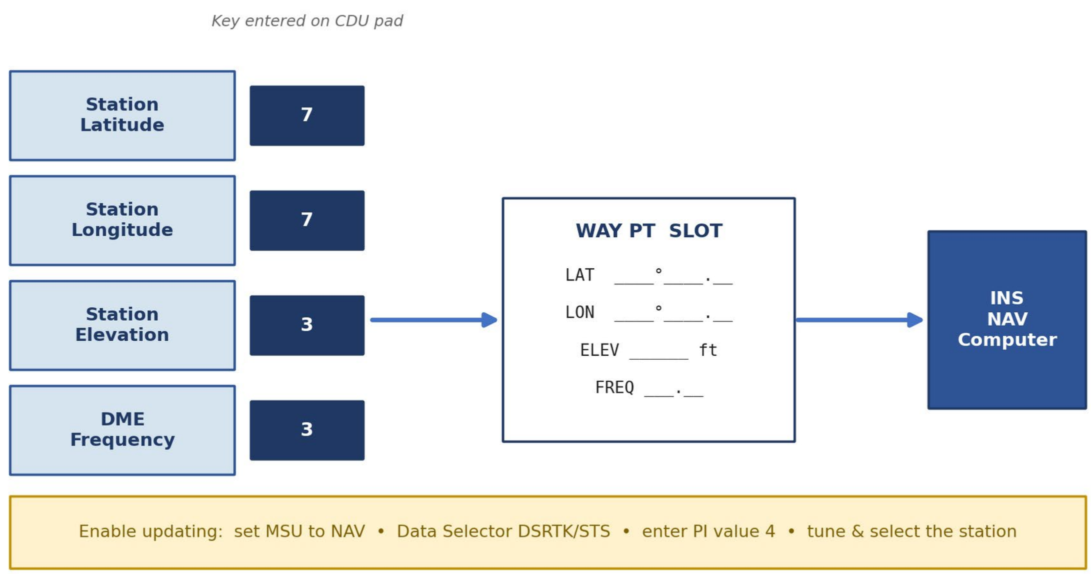

Figure 23-5 DME station — data mapping into a waypoint slot

NOTE — Slot 0
As with waypoints, DME slot 0 is a special, reserved slot used for disabling correction updates without leaving **PI Mode 4**—*Aided Inertial Navigation* (see §23.3 — Reading the DSRTK / STS Status Display). Only waypoints 1–9 are available for DME storage. When the **Waypoint / DME Selector** wheel is set to slot 0, it will mirror what is stored in slot 1.

Programming a DME Station

- Select the desired DME slot with the **Waypoint / DME Selector** wheel, *avoiding slot 0 (see note above)*.
- Open the DME Station Position subpage by setting the Data Selector to **WAY PT** and pressing **7 (L/L)**.
- Enter the DME Station coordinates using the method specified in §23.3 — Present Position Entry — Manual Entry.
- Open the DME Station Elevation & Frequency subpage by pressing **3 (FRQ)**.
- Enter station elevation by

Pressing either **N (2)** or **S (8)**.

The **INSERT** button should be illuminated with the left display showing “0.0”.

Enter station elevation *to the nearest thousand feet* and press **INSERT**. *Note that the decimal shown does not apply to this number.* So 6600 ft would be entered as **7** and show as “.7”, while 12,300 ft would be entered as **12** and show as “1.2”.

- Enter station broadcast frequency by

Pressing either **W (4)** or **E (6)**.

The **INSERT** button should be illuminated with the right display showing “00°00.0”.

Enter the five-digit station frequency and press **INSERT**. *Again, ignore the symbols.* For example, the frequency 117.50 MHz would be entered as **11750**. *Also note that the final digit will automatically be rounded to 0 or 5.*

> **NOTE — Data entry accuracy matters**
> Entering an incorrect station position will either result in flawed corrections or the system refusing to apply any corrections at all, depending on the size of the error. Likewise, entering an incorrect station elevation will limit the amount of correction that can be applied and will prevent the **Accuracy Index** (AI) from falling below **2**.

Selecting the DME Station to use for position corrections

- Open any of the three DME Station subpages, as discussed above.
- The **FROM-TO** display will begin flashing the DME station to be used.
- Press **WAY PT CHG** (both it and **INSERT** will light, and the number will stop flashing)
- Press the number of the desired DME station (*note that selecting 0 will disable further position corrections,* just as if you had selected a **Desired PI** of 0, 2, 3, or 5. See §23.3 — Reading the DSRTK / STS Status Display).
- Press **INSERT** (both it and **WAY PT CHG** will go out and the number will resume flashing).

Enabling Automatic DME Updating

- Ensure the MSU is in **NAV**.
- Set the Data Selector to **DSRTK / STS**.
- Set **PI Mode 4** by pressing **4** (the **INSERT** button should illuminate and “000004” will show on the right display).
- Press **INSERT** (the rightmost digit will now be **4**, indicating that the unit is operating in *Aided Inertial Navigation* mode).
- The unit will automatically tune its internal NAV radio to the new frequency and begin attempting to receive DME station data.

- If these conditions are not met within 2 ½ minutes, *the unit will automatically change the selected DME station to slot 0* to indicate a failure to apply corrections. See below.

Disabling Automatic DME Updating

There are two methods for disabling DME updates while still preserving the corrections which have already been applied:

- With the Data Selector at **DSRTK / STS**, set **PI Mode 5** by pressing **5** and then **INSERT** (as described in the section above — Enabling Automatic DME Updating), or
- Set selected DME station slot to 0 (as described in the section above — Selecting the DME Station to use for position corrections).

DME Correction Criteria

When in **PI Mode 4**—*Aided Inertial Navigation,* position corrections can only take place when the following requirements are met:

- The selected station slot is not 0
- A valid return signal is received from the station
- The station is within 250 nautical miles
- The calculated distance to the entered station coordinates and the received distance from the station itself are within approximately 1 degree of each other

Due to either errors in initial station data entry or changing conditions over time, these requirements may never be, or eventually fail to be, met. If that happens, *the unit will automatically change the selected DME station to slot 0* to indicate a failure to apply corrections. Therefore, **to ensure that corrections are actively being applied, it is necessary to have both a PI Mode of 4 *and* a non-zero station slot selected**.

23.8 Integration with the Virtual Navigator

The Virtual Navigator CIVA EFB app bridges modern flight-planning workflows and the Carousel IV-A, which was designed around manual coordinate entry. It can import flight plans, convert waypoints to latitude/longitude, automatically load and sequence the route beyond the native nine-waypoint limit, and rejoin an active route after a reposition. The Virtual Navigator is reached from the **CIVA** tab of the EFB; the EFB chapter (Chapter 27) refers back to this section for its full description.

The Navigation Log Page

The Navigation Log is the Virtual Navigator’s main page. Before a route is loaded it shows an empty log with the import controls across the top.

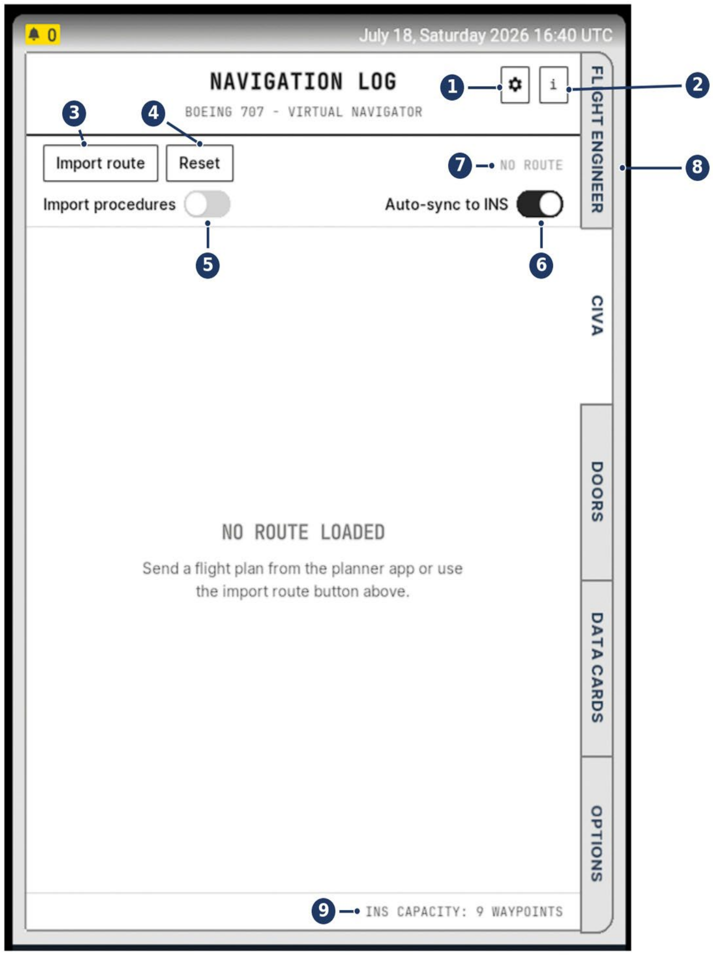

Figure 23-7 Virtual Navigator — Navigation Log (no route loaded)

No.	Control / element
1	**Settings (gear)** — opens the CIVA Options dialog (see Figure 23-9).
2	**Info (i)** — opens the Virtual Navigator information popup.
3	**Import route** — imports the active flight plan from the EFB planner.
4	**Reset** — clears the currently loaded route.
5	**Import procedures** (toggle) — if enabled, SIDs/STARs will be included when importing a route; otherwise only enroute waypoints will be populated.
6	**Auto-sync to INS** (toggle) — automatically loads and progressively advances waypoints beyond the nine-slot buffer.
7	**Route status** — shows the number of loaded waypoints or NO ROUTE.
8	**EFB tab strip** — Flight Engineer · CIVA · Doors · Data Cards · Options.
9	**INS capacity** — a reminder of the Carousel’s nine-waypoint native limit.

Importing a Flight Plan

- Open the Virtual Navigator page on the EFB and select **Import Route**.
- Configure options (see below), then review any warnings.
- Verify the navigation log against your operational flight plan.
- Press **SEND** on a waypoint, or enable **Auto-Sync**, to load and manage the route in the INS.

Reading & Sending Waypoints

Once a plan is imported, each waypoint appears as a row showing its position in the plan, the INS slot it occupies, its identifier and coordinates, and the bearing and distance of the leg. The active leg is highlighted.

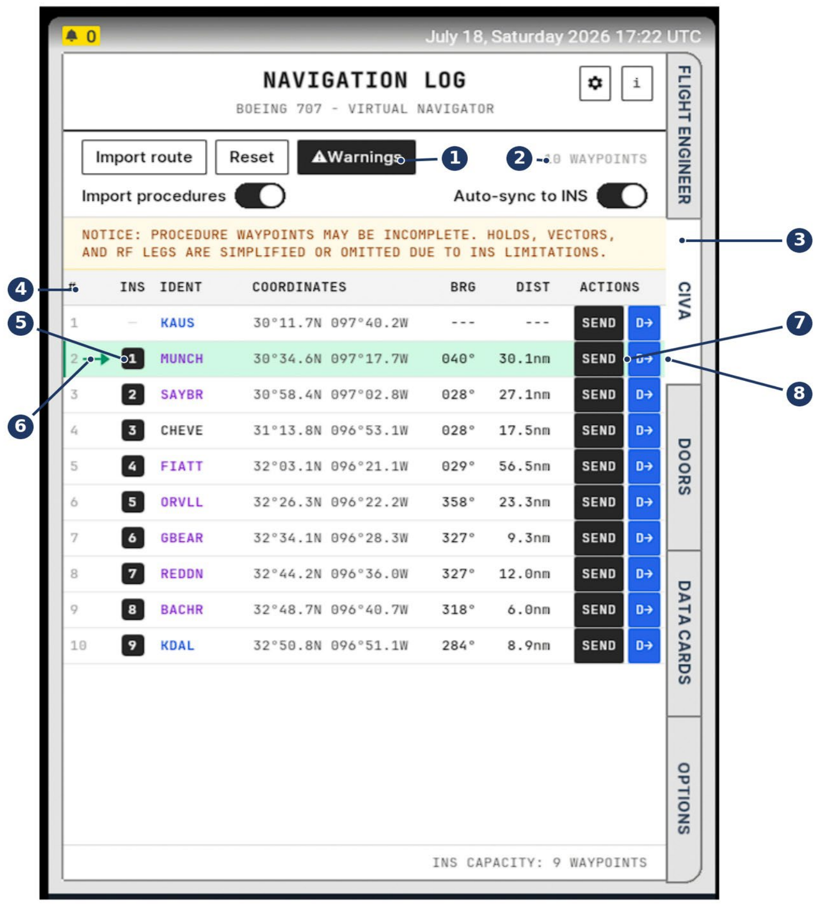

Figure 23-8 Virtual Navigator — Navigation Log with a route loaded

No.	Control / element
1	**Warnings** — opens the list of route modifications made during import.
2	**Waypoint count** — total waypoints in the imported plan.
3	**NOTICE banner** — advises that procedure legs may be simplified or omitted.

No.	Control / element
4	**Plan order (#)** — the waypoint's sequential position in the imported plan.
5	**INS slot** — the Carousel buffer slot (1–9) the waypoint occupies; the origin is not assigned a slot.
6	**Active leg** — the current to-waypoint, shown highlighted with an arrow.
7	**SEND** — loads that individual waypoint into the INS.
8	**Direct-to (D→)** — proceeds directly to that waypoint, making it the active leg.

NOTE — The nine-waypoint buffer
The plan above contains ten waypoints, but the Carousel holds only nine. The origin (KAUS) is not assigned an INS slot; slots 1–9 hold the next nine waypoints. With **Auto-sync** enabled, the Virtual Navigator advances this window automatically as the flight progresses, so plans longer than nine waypoints can be flown without manual re-entry.

Auto-Sync & Import Warnings

Auto-Sync continuously manages the waypoint buffer, loading additional waypoints as the flight progresses so routes far larger than nine waypoints can be flown without manual mid-route entry. The **Warnings** button lists automatic route modifications — duplicate-waypoint removal, RF-leg simplification, hold removal, and vector omission — and does **not** normally indicate a failed import. Always cross-check the navigation log after any import.

WARNING — Terminal approach constraints
Instrument approach procedures (ILS, localizer, or VOR final approaches) are **never** imported into the Carousel IV-A flight plan, regardless of settings, because they contain leg types the legacy INS cannot represent. During arrival, the crew must manually transition the primary navigation source away from the INS and select conventional radio guidance (VOR / LOC / ILS) to fly the approach.

Import Procedures Option

When **Import Procedures** is ON, SIDs and STARs are converted into INS waypoints. When OFF, only the enroute portion is imported. Instrument approaches are excluded either way (see WARNING above).

CIVA Options

The gear icon opens the **CIVA Options** dialog, which controls how faithfully the Carousel is simulated and provides the route-rejoin function.

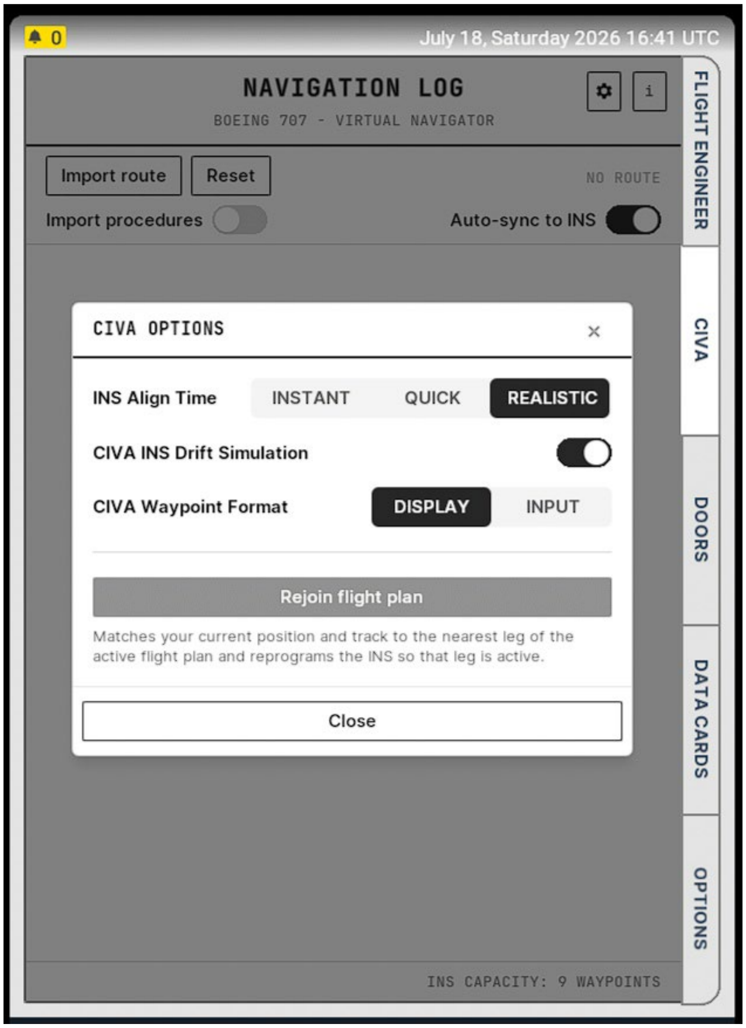

Figure 23-9 Virtual Navigator — CIVA Options dialog

Option	Effect
INS Align Time	Instant (completes immediately) · Quick (shortened) · Realistic (full-length alignment).
CIVA INS Drift Simulation	ON models gyroscopic drift requiring monitoring and updates; OFF holds perfect position.
CIVA Waypoint Format	Selects how waypoint coordinates are presented — Display or Input format.
Rejoin Flight Plan	Matches current position and track to the nearest leg of the active plan and reprograms the INS so that leg is active.

Two related controls sit on the main Navigation Log page rather than in this dialog: **Import Procedures** and **Auto-Sync to INS** (see Figure 23-7).

Rejoining a Flight Plan

- Open **CIVA Options** and select **Rejoin Flight Plan**.
- Allow the Virtual Navigator to reconcile current coordinates against the master route.
- Verify the active waypoint on the CDU before continuing normal navigation.

Recommended Configurations

Setting	Profile A — Realistic	Profile B — Convenience
INS Align Time	Realistic	Instant
Drift Simulation	ON	OFF
Auto-Sync to INS	ON	ON
Import Procedures	OFF (fly SIDs/STARs on raw VOR/DME)	User preference

Recommended

Profile A delivers an authentic 1970s airline-style workload. **Profile B** minimizes cockpit data entry for rapid setups and solo flights.

PART III — NAVIGATION SYSTEMS

Chapter 24 — UNS-1 Flight Management System

About this chapter

Introduces the **Universal UNS-1** Flight Management System, one of three long-range navigation options available on the Boeing 707-320C (see **Chapter 22**). This chapter is intentionally brief — it covers the system's role on the aircraft and the basics of entering a flight plan, rather than serving as a full UNS-1 operator's manual.

24.1 UNS-1 Overview

Universal Avionics introduced the UNS-1 in 1982 as the industry's first multi-sensor flight management system (FMS). In this simulation, we have included the UNS-1Lw, which is SBAS-enabled to provide support for non-RNP AR approaches with vertical guidance, such as LPV and LNAV/VNAV approaches.

The UNS-1 gives the pilot a single point of control over the aircraft's navigation sensors, computerized flight planning, and fuel management, and is capable of flying the entire pilot-programmed route — from departure procedures and airways through arrivals and approaches.

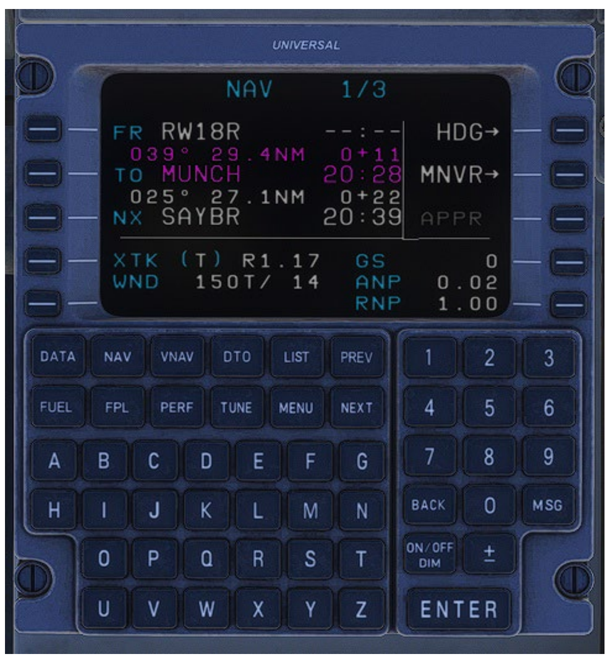

Figure 24-1 UNS-1 NAV Page

24.2 UNS-1 Integration with the 707

- The UNS-1 can provide the autopilot and both flight directors with lateral guidance when any of those are set to **NAV** mode. When in NAV mode, the steer adapter takes guidance data from the active leg on the UNS-1 and guides interception and tracking. The steer adapter will not provide guidance unless a valid leg is active on the UNS-1.

The UNS-1 can provide vertical glidepath guidance to the autopilot or flight directors under the following conditions:

- The active leg is either TO the final approach fix (FAF) or on the final approach leg between the FAF and the missed approach point (MAP).
- The captain's HSI Nav Source Selector switch is set to **NAV**.
- The autopilot or flight director mode is set to **GS MAN** or **GS AUTO** (see **Chapter 16** for more details).
- The selected approach in the UNS-1 is active, supports glidepath, and is not an RNP AR approach; the 707-320C with UNS-1 is **not** approved for RNP AR approaches, even if they may be selected in the UNS-1.

24.3 Entering a Basic Flight Plan

A flight plan is built by first entering the departure and destination airports, then attaching a departure procedure, en route waypoints, and an arrival procedure with its approach.

> **NOTE — UNS-1 Menu Interaction**
>
> Interacting with the UNS-1 differs from many other common FMS designs. Rather than pressing the line-select key (LSK) next to a desired item, the primary method of navigating menus and building procedures is to type the **index number** shown next to the desired item and press ENTER. For example, when adding a departure procedure, the pilot types the number next to the desired runway, then the number next to the desired SID, then the number next to the desired transition — rather than pressing the LSK beside each. To skip an optional entry (for example, when no transition is desired), simply press ENTER without typing a number.

Origin and destination. From the FPL page, enter the departure airport as the first waypoint and the destination airport as the last waypoint. The UNS-1 will confirm each airport against its navigation database before accepting it.

Adding a departure (SID). With the departure airport as the first waypoint and the FPL page open, press the MENU button to open the flight plan menu, then select the departure function. This presents a list of available runways for that airport; selecting a runway then presents the SIDs available for it, followed by any enroute transition for the selected SID. Once all three are chosen, the complete SID — from runway to the enroute transition fix — is inserted into the flight plan automatically.

Adding en route waypoints. Additional waypoints, airways, and airway segments can be added directly into the flight plan between the SID and the arrival procedure, either by identifier or by selecting an airway and its entry/exit points.

Adding an arrival (STAR) and approach. With the destination airport as the last waypoint and the FPL page open, press MENU to open the flight plan menu again, then select the arrival function. This works the same way in reverse: select an arrival runway, then the available STAR, then its transition, then the desired approach, and finally the approach transition. As with the SID, the entire procedure is linked into the flight plan once all selections are made.

Reviewing the active leg. Once a flight plan is loaded, the NAV page (Figure 24-1) shows the active leg at a glance — the FR and TO waypoints of the leg currently being flown, along with the next (NX) waypoint, course and distance to each, and estimated time of arrival.

PART III — NAVIGATION SYSTEMS

Chapter 25 — Garmin GNS 530W

> **About this chapter**
> Introduces the **Garmin GNS 530W**, one of three long-range navigation options available on the Boeing 707-320C (see **Chapter 22**). This chapter is intentionally brief and does not cover flight-plan entry, since GNS 530W documentation is widely available elsewhere; it focuses instead on the unit's role and integration on this aircraft.

25.1 GNS 530W Overview

Garmin introduced the GNS 530 in the late 1990s as an all-in-one GPS, VOR/ILS navigation receiver, and VHF communication radio with a color moving-map display, and it went on to become one of the most widely installed GPS navigators in general aviation. In 2006, Garmin released the WAAS-enabled “W” variant, the GNS 530W included in this simulation, adding SBAS-based approach capability that supports precision-like vertical guidance — such as LPV approaches — at airports without ground-based approach aids.

The GNS 530W combines GPS navigation, a VHF NAV/VOR/ILS receiver, and a VHF COM transceiver into a single unit, paired with a moving-map display for enhanced situational awareness.

Figure 25-1 Garmin GNS 530W

25.2 GNS 530W Integration with the 707

- The GNS 530W can provide the autopilot and both flight directors with lateral guidance when any of those are set to **NAV** mode. When in NAV mode, the steer adapter takes guidance data from the active leg on the GNS 530W and guides interception and tracking. The steer adapter will not provide guidance unless a valid leg is active on the GNS 530W.

The GNS 530W can provide vertical glidepath guidance to the autopilot or flight directors under the following conditions:

- The active leg is either TO the final approach fix (FAF) or on the final approach leg between the FAF and the missed approach point (MAP).
- The captain's HSI Nav Source Selector switch is set to **NAV**.
- The autopilot or flight director mode is set to **GS MAN** or **GS AUTO** (see **Chapter 16** for more details).
- The selected approach in the GNS 530W is active and supports glidepath.

25.3 NAV/COM Radio 1 Replaced by GNS

When the Garmin GNS 530W is the active avionics unit, the **#1 NAV/COM radio control** on the aft pedestal is **inoperative (INOP)**, as shown in Figure 25-2. Its NAV and COM functions are entirely replaced by the NAV and COM radios built into the GNS 530W unit itself. The #2 NAV/COM radio remains fully functional and independent of the GNS 530W.

Figure 25-2 Aft Pedestal NAV/COM 1 — INOP when GNS 530W is Active

PART IV

EFB & AUTOMATION

PART IV — EFB & AUTOMATION

Chapter 26 — Electronic Flight Bag

About this chapter

Introduces the Boeing 707 Electronic Flight Bag (EFB) companion app and covers the **Doors**, **Data Cards**, and **Options** tabs. The **Flight Engineer** tab is covered in **Chapter 28**; the **CIVA** tab (Virtual Navigator) is covered in **Chapter 27**.

26.1 EFB Overview

The Boeing 707 EFB app is available whenever you are loaded into any variant of the 707, and appears on the EFB home screen (Figure 26-1).

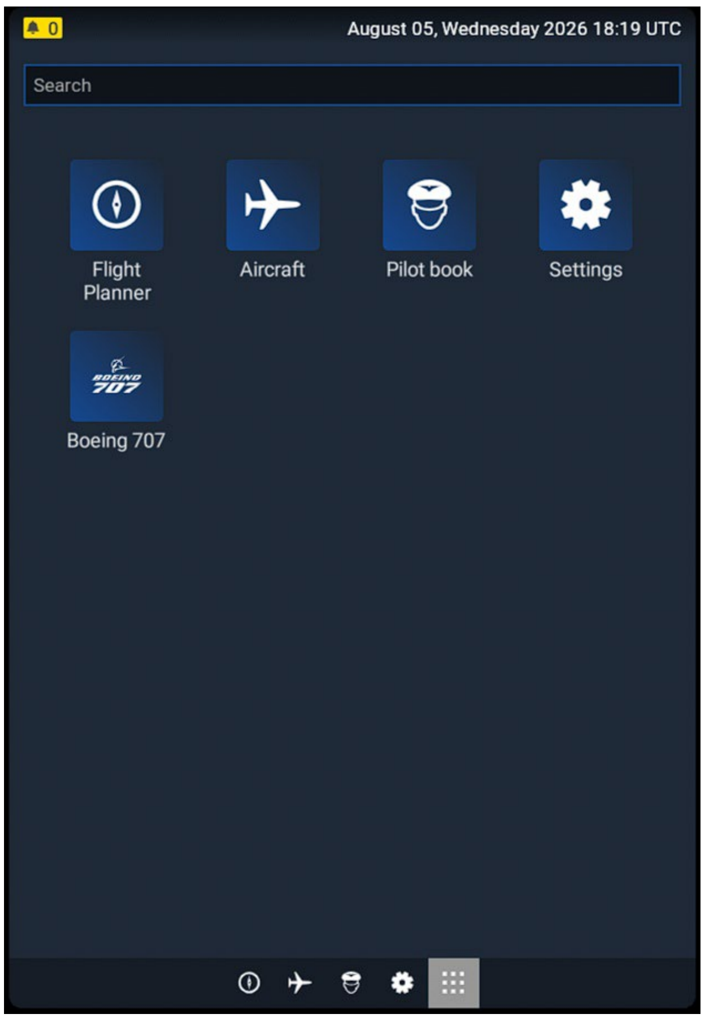

Figure 26-1 EFB Home Screen

You can add the app to your Favorites bar by opening the main EFB **Settings** app and selecting the Boeing 707 app from the list (Figure 26-2). Note that you can have only five favorites at a time, so you may need to remove another favorite to add the 707 app.

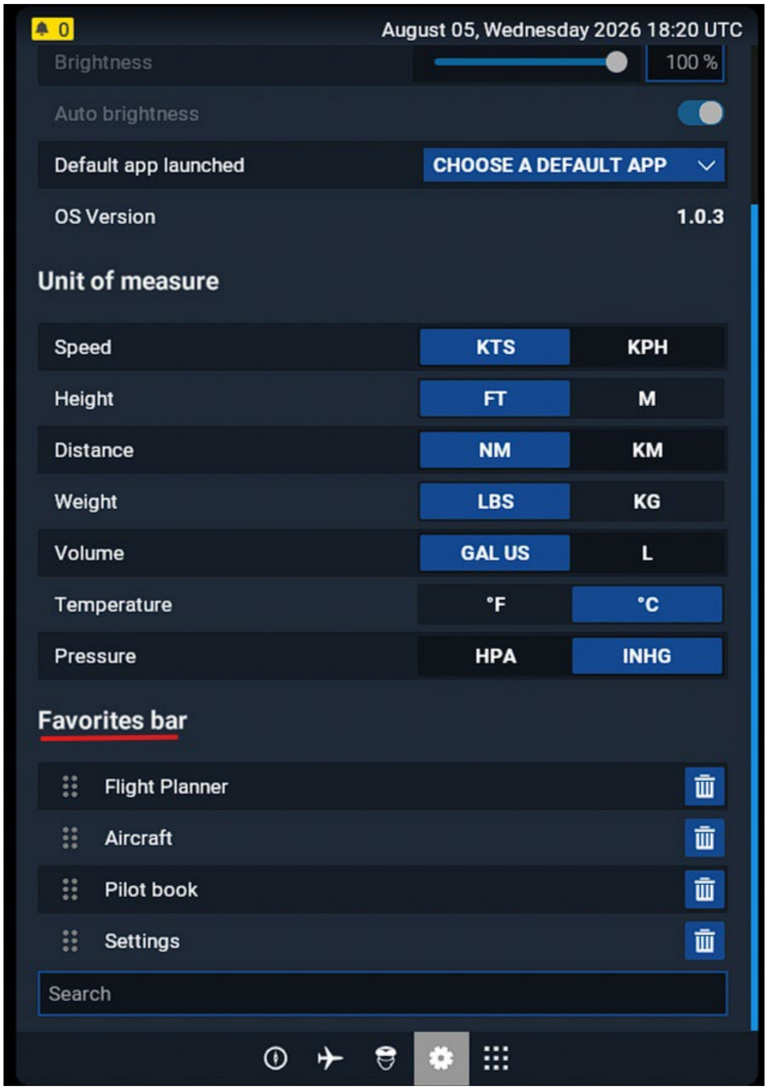

Figure 26-2 EFB Settings — Favorites Bar

The companion EFB app is the central interface for aircraft configuration, door control, performance calculations, and operational preferences. It presents up to five tabs: **Flight Engineer**, **CIVA**, **Doors**, **Data Cards**, and **Options**. The CIVA tab is visible only when the CIVA INS variant is loaded; otherwise, only the remaining four tabs are shown. Each EFB page includes an info icon (lowercase i) in the upper right that displays hints and details about the current page. The Flight Engineer tab is covered in **Chapter 28**; the CIVA tab is covered in **Chapter 27**.

26.2 Doors

The Doors tab allows control of all main-deck and lower-deck doors for baggage, cargo, and passengers (Figure 26-3). Doors are shown black when closed, yellow when in transit, and red when open. Doors will not open if there is any differential pressure between the cabin and ambient pressure.

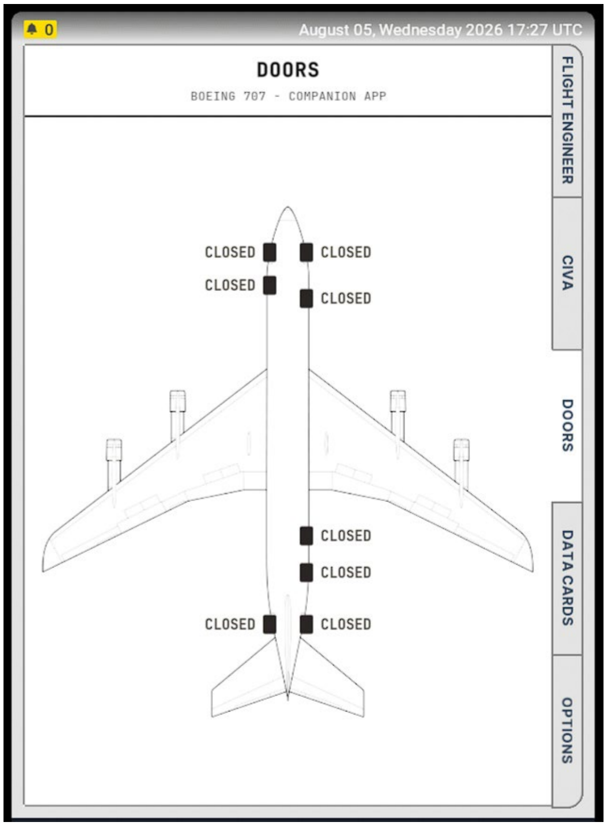

Figure 26-3 Doors Tab

26.3 Data Cards

The Data Cards tab contains takeoff, landing, and EPR performance calculations for the flight, accessed via three links along the top of the page — **TAKEOFF**, **LANDING**, and **EPR** — with a refresh button beside the EPR link to reset all cards with fresh data.

Takeoff Card

Presents automatically computed takeoff speeds (V1, VR, V2) and the minimum runway length required, computed from the detected weight and CG, detected static air temperature, atmospheric pressure and pressure altitude, and a user-entered HEADWIND value (positive for headwind, negative for tailwind). Pilots should cross-check the presented minimum takeoff runway length against the planned departure runway to ensure adequate length is available for the weight and conditions.

The card also presents the stabilizer trim setting for takeoff and the dump time, in minutes, for fuel dumping to reach maximum landing weight in the event of an immediate return. Two buttons are available: **Set Bugs** (automatically sets the takeoff speed bugs on the ASI) and **Set Trim** (automatically sets the takeoff trim setting).

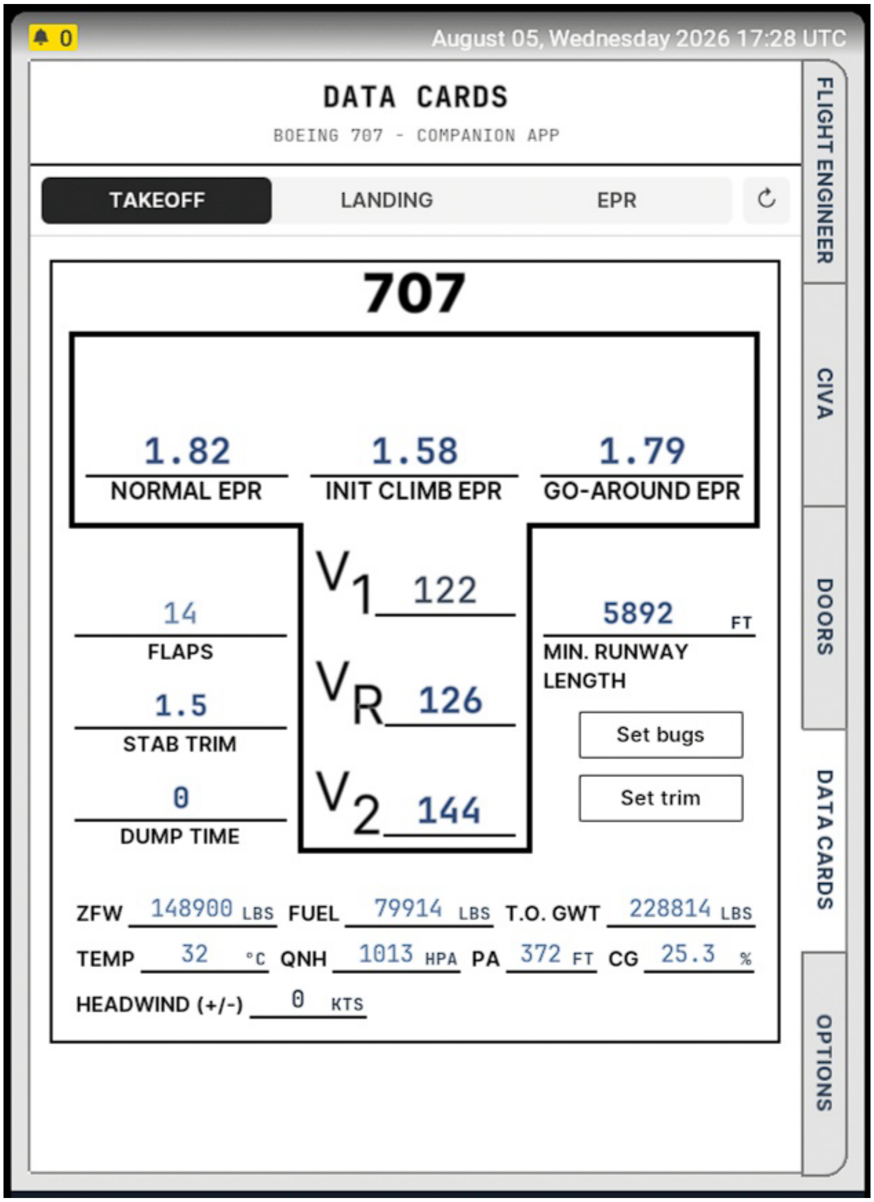

Figure 26-4 Takeoff Data Card

If the aircraft is overweight for takeoff, or conditions prevent a takeoff on any runway length, **NO TAKEOFF** appears in red in place of the minimum runway length (Figure 26-5).

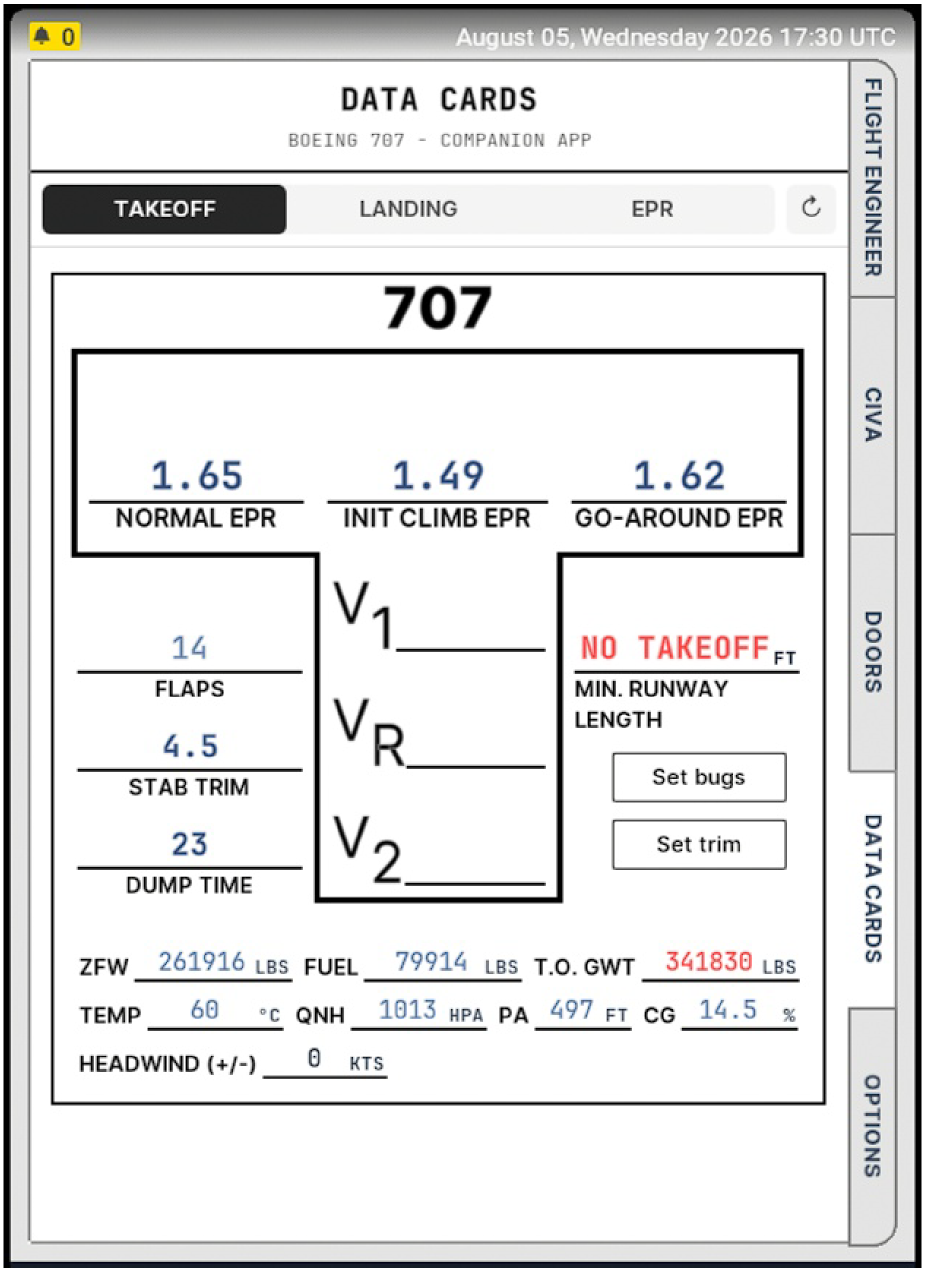

Figure 26-5 Takeoff Data Card — Overweight / No Takeoff

Landing Card

Presents landing speeds, the required runway length for landing, and go-around settings; pilots should similarly cross-check the runway length against the planned landing runway. The user selects Landing Flaps (40 or 50, defaults to 50), Runway Condition (Dry or Wet, defaults to Dry), Field Elevation (the landing field elevation above mean sea level; no default), and Wind Correction (defaults to 5 kt). One button is available: **Set Bugs** (sets the approach and landing speed bugs on the ASI).

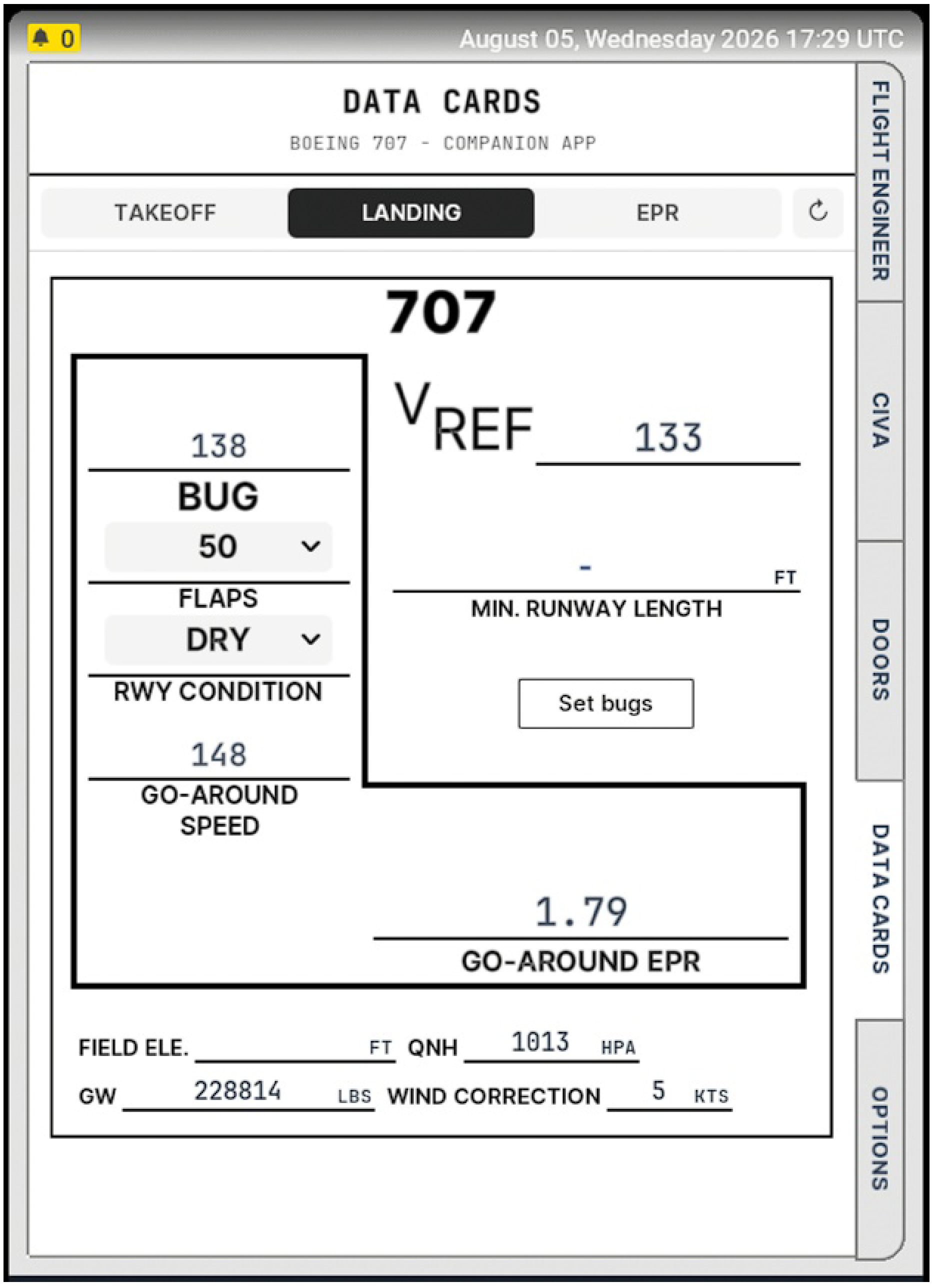

Figure 26-6 Landing Data Card

If field elevation is not entered, the minimum runway length is left blank. If the aircraft is overweight, the runway length and weight fields turn red (Figure 26-7). Three speed values are computed: **VREF** (the absolute threshold reference speed for landing), **BUG** (VREF plus wind correction, never less than VREF + 5 kt), and **GO-AROUND** (the target go-around climb speed, to be flown together with the go-around EPR setting).

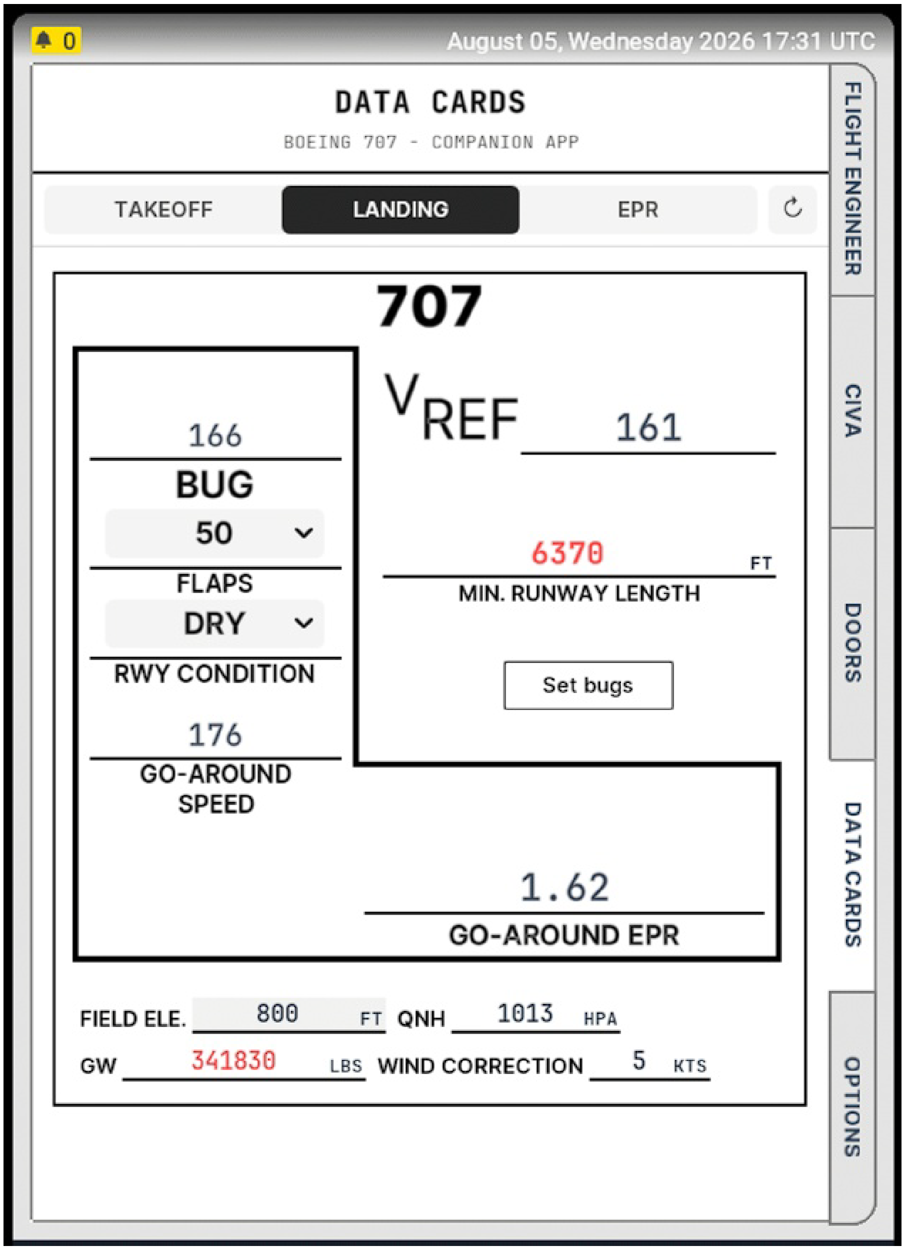

Figure 26-7 Landing Data Card — Overweight

EPR Card

Presents five target EPR values for thrust — Max Allowed Thrust, Full Takeoff Thrust, Max Cruise Thrust, Go-Around Thrust, and Max Continuous (Climb) Thrust. While the Virtual Flight Engineer can automatically manage these bugs (**Chapter 28**), this card provides a quick way to view the currently calculated values and set the EPR bugs manually via the **Set Bugs** button beside each value — for example, pressing Set Bugs beside Full Takeoff Thrust sets that EPR value as the bug on all four engines. The EPR card continuously recomputes its values based on current ambient pressure and temperature.

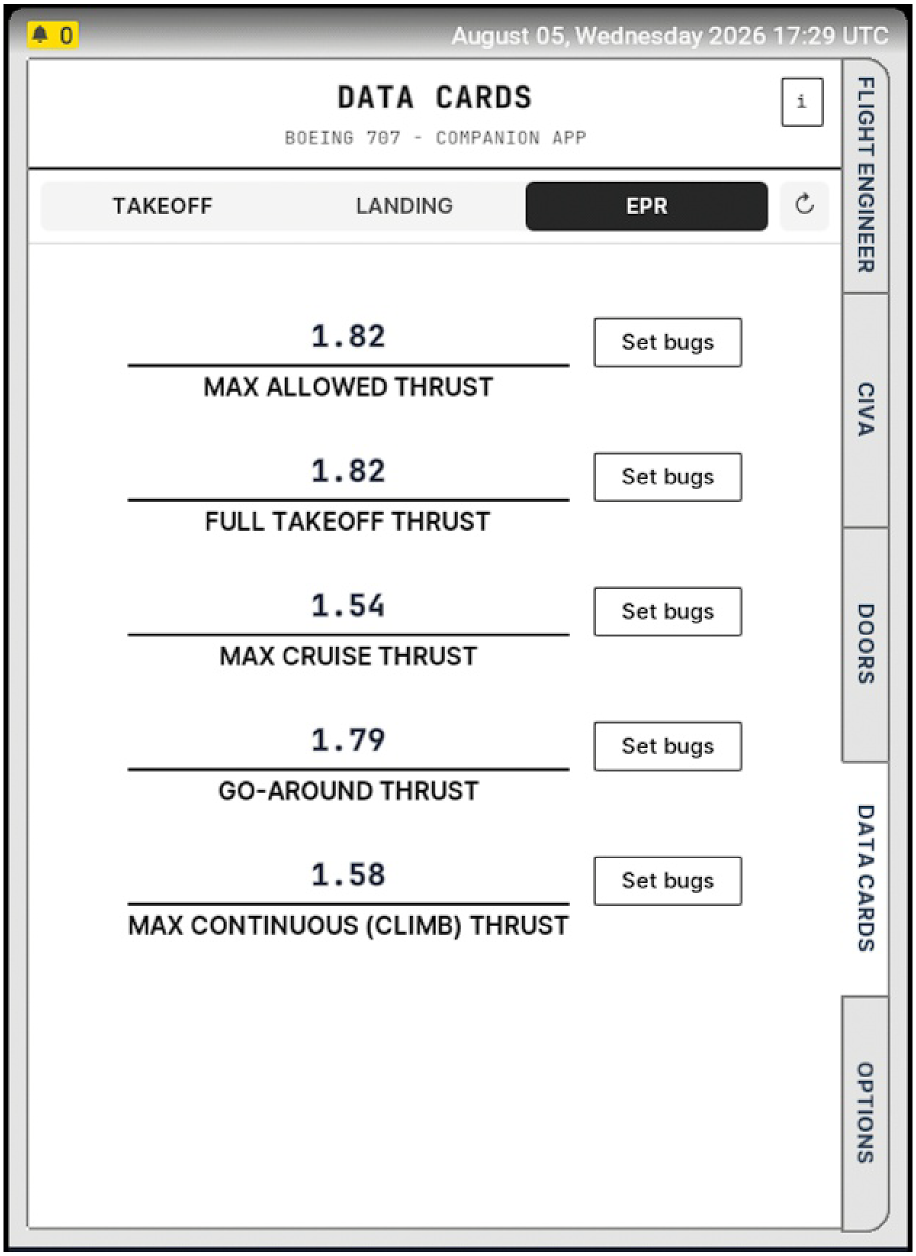

Figure 26-8 EPR Data Card

26.4 Options

The Options tab is divided into two sections — **General Options** and **Flight Engineer Options** — separated by a thin grey line (Figure 26-9). These options are persistent per aircraft variant (INS, UNS, GNS) but are shared across liveries of the same variant.

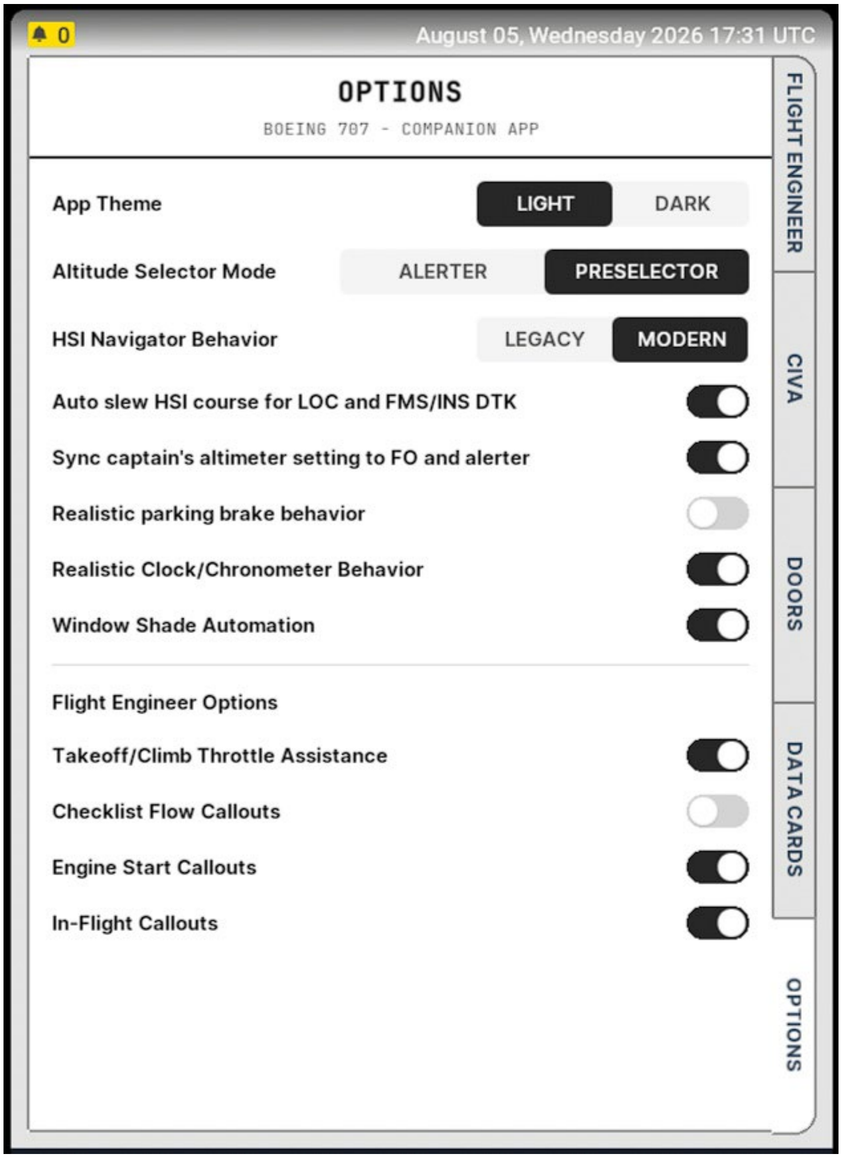

Figure 26-9 Options Tab

General Options

- **App Theme** — LIGHT or DARK; dark mode is recommended for night flights.
- **Altitude Selector Mode** — ALERTER or PRESELECTOR. In PRESELECTOR, the altitude alerter also acts as an autopilot altitude preselector: climbing or descending to the selected altitude with the autopilot engaged will automatically capture and hold that altitude. In ALERTER, the aircraft sounds the altitude alert when approaching the selected altitude, but the autopilot does not capture it. This option affects the autopilot only, not the flight directors. See **Chapter 16**.
- **HSI Navigator Behavior** — LEGACY or MODERN. See **§4.7.2** for the full behavior description.
- **Auto Slew HSI Course for LOC and FMS/INS DTK** — enables or disables automatic slewing of the course needle to the localizer inbound course or the navigator's desired track; when off, course must be set manually.

- **Sync Captain's Altimeter Setting to First Officer and Alerter** — automatically syncs the captain's BARO setting to the other cockpit altimeters; when off, each altimeter and the altitude alerter must be set individually.
- **Realistic Parking Brake Behavior** — when enabled, setting the parking brake requires holding the foot brakes while setting the parking brake switch, and release requires pressing the foot brakes again; when disabled, the parking brake simply toggles on and off with the switch. See **Chapter 15**.
- **Realistic Clock/Chronometer Behavior** — when enabled, the clock must be manually wound, as it is not electrically powered; when disabled, it is always automatically wound. See **§4.7.3**.
- **Window Shade Automation** — when enabled, window shades animate realistically based on environmental conditions (generally closed when hot and parked, open for takeoff and landing, and otherwise more closed on the sunny side of the aircraft and more open on the shady side); when disabled, shades do not move automatically but can still be adjusted manually in the cabin.

Flight Engineer Options

- **Takeoff/Climb Throttle Assistance** — when enabled, the Virtual Flight Engineer assists in setting thrust for the takeoff and climb phases of flight. It engages when the user sets the throttles to near takeoff thrust, at which point the VFE announces setting thrust and manages thrust through the climb. A green indicator light in the upper-left of the captain's ADI illuminates whenever this assistance is active (Figure 26-10; see also **§4.7.1**, callout 1). The feature disengages when the aircraft levels off and will not reactivate after a descent begins until the next takeoff. The user may override the throttle setting at any time — the indicator light flashes during any override — and the VFE retakes the throttles after 10 seconds of user inactivity.

Figure 26-10 Captain's ADI — Takeoff/Climb Throttle Assistance Indicator

- **Checklist Flow Callouts** — enables or disables VFE voice callouts of flow steps.
- **Engine Start Callouts** — enables or disables VFE voice callouts of relevant engine start values.
- **In-Flight Callouts** — enables or disables all in-flight VFE callouts, including airspeeds, altitudes, and similar.

PART IV — EFB & AUTOMATION

Chapter 27 — Virtual Navigator

About this chapter

Describes the Virtual Navigator, the EFB companion app for the Carousel IV-A INS, reached from the **CIVA** tab (see **§26.1**). This app is available only when the CIVA INS cockpit variant is loaded. For the underlying INS hardware itself — the MSU, CDU, alignment, and manual waypoint programming — see **Chapter 23**.

27.1 Overview

The Virtual Navigator is a custom-built EFB companion app created specifically to bridge the gap between modern digital flight-planning tools and the Carousel IV-A INS — hardware originally designed around manual latitude/longitude entry and a nine-waypoint memory buffer. Rather than replacing the authentic operation of the Carousel IV-A, the Virtual Navigator automates the tedious parts of working with it: importing a flight plan, translating named fixes into coordinates, and managing the waypoint buffer as the flight progresses — while leaving the INS itself, and its underlying operational characteristics, unchanged.

The Virtual Navigator is reached from the **CIVA** tab of the EFB, and is available only when the CIVA INS variant is loaded (see **§26.1**). Its main features are:

1. **Route Import** — imports the active flight plan from the EFB's flight planner directly into the Virtual Navigator's navigation log.
2. **Coordinate Conversion** — translates named waypoints, airways, and terminal fixes into the latitude/longitude pairs the Carousel IV-A requires, without any manual typing.
3. **Buffer Management** — tracks the full imported route in an external navigation log and loads waypoints into the INS's native nine-slot memory, sending them individually or automatically as the flight progresses.
4. **Auto-Sync** — continuously advances the INS waypoint buffer during flight, so routes far longer than nine waypoints can be flown without manual mid-route entry.
5. **Rejoin** — reconciles the aircraft's current position against the loaded flight plan and reprograms the INS with the correct active leg, useful after a reposition, scenario load, or ATC-directed route deviation.
6. **CIVA Options/Settings** — configures INS alignment time, drift simulation, waypoint coordinate format, and the two options above (Import Procedures and Auto-Sync).

Because SIDs, STARs, and instrument approaches use leg types that the Carousel IV-A cannot represent, the Virtual Navigator can optionally import SIDs/STARs as simplified waypoint sequences, but it never imports instrument approaches under any setting — these must always be flown using conventional radio navigation. Full details on the Virtual Navigator's pages, controls, and options are given below; the underlying INS hardware itself — the MSU, CDU, alignment, and manual waypoint programming — is described in **Chapter 23**.

27.2 Route Import

The Navigation Log is the Virtual Navigator's main page. Before a route is loaded, it shows an empty log with the import controls across the top (Figure 27-1).

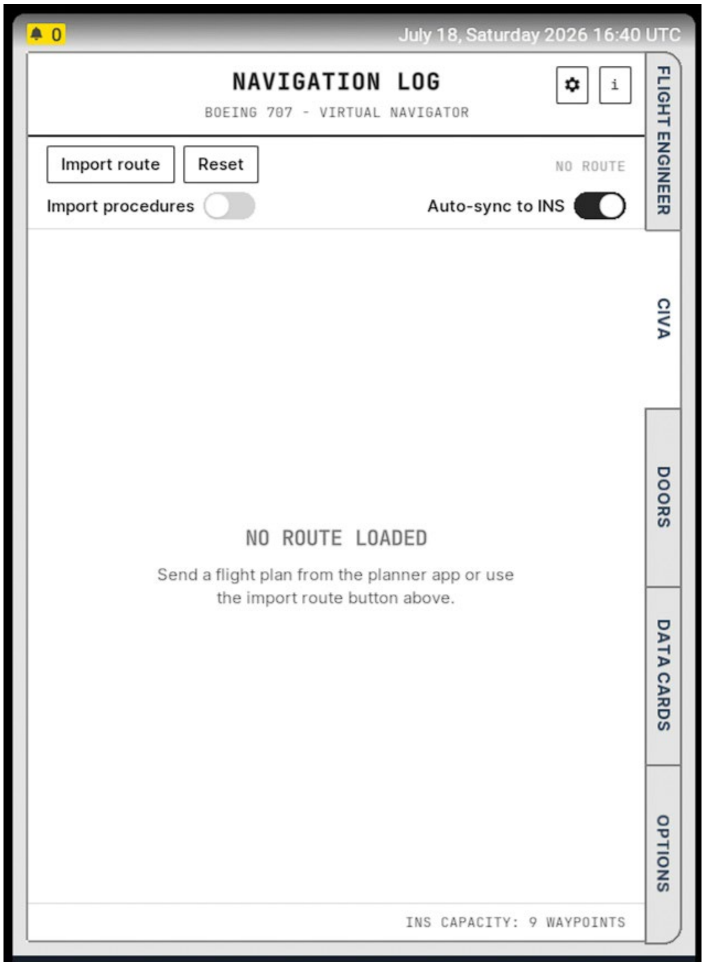

Figure 27-1 Virtual Navigator — Navigation Log (no route loaded)

No.	Control / element
1	**Settings (gear)** — opens the CIVA Options dialog (see Figure 27-3).
2	**Info (i)** — opens the Virtual Navigator information popup.
3	**Import route** — imports the active flight plan from the EFB planner.
4	**Reset** — clears the currently loaded route.
5	**Import procedures** (toggle) — include SIDs/STARs when enabled; enroute-only when off.
6	**Auto-sync to INS** (toggle) — automatically loads and advances waypoints beyond the nine-slot buffer.
7	**Route status** — shows NO ROUTE, or the loaded waypoint count.
8	**EFB tab strip** — Flight Engineer · CIVA · Doors · Data Cards · Options.
9	**INS capacity** — reminder of the Carousel's nine-waypoint native limit.

Importing a Flight Plan

7. Power on the aircraft and ensure the INS units are receiving electrical power.
8. Open the Virtual Navigator page on the EFB and select **Import Route**.
9. Configure options (see **§27.6**), then review any warnings.
10. Verify the navigation log against your operational flight plan.
11. Press **SEND** on a waypoint, or enable **Auto-Sync**, to load and manage the route in the INS.

27.3 Coordinate Conversion

Once a plan is imported, each waypoint appears as a row showing its position in the plan, the INS slot it occupies, its identifier and coordinates, and the bearing and distance of the leg. The active leg is highlighted (Figure 27-2).

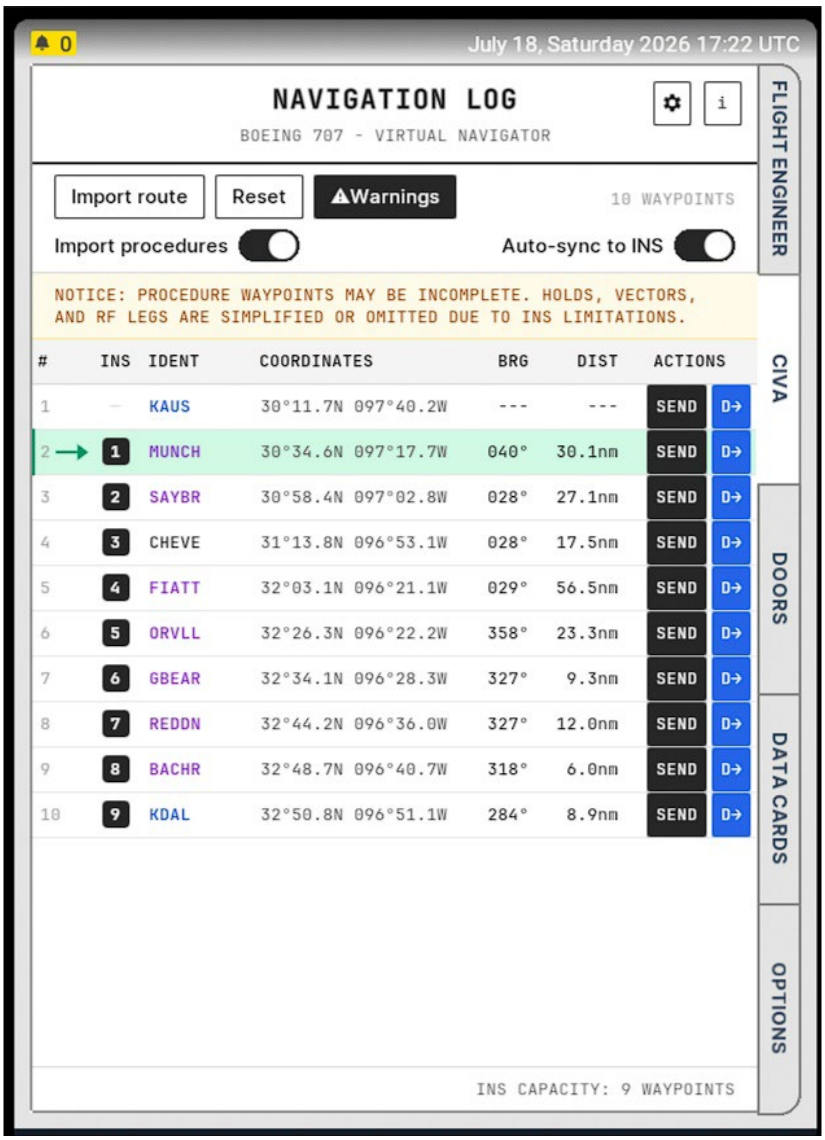

Figure 27-2 Virtual Navigator — Navigation Log with a route loaded

No.	Control / element
1	**Warnings** — opens the list of route modifications made during import.
2	**Waypoint count** — total waypoints in the imported plan.
3	**NOTICE banner** — advises that procedure legs may be simplified or omitted.
4	**Plan order (#)** — the waypoint's sequential position in the imported plan.
5	**INS slot** — the Carousel buffer slot (1–9) the waypoint occupies; the origin is not assigned a slot.
6	**Active leg** — the current to-waypoint, shown highlighted with an arrow.
7	**SEND** — loads that individual waypoint into the INS.
8	**Direct-to (D→)** — proceeds directly to that waypoint, making it the active leg.

NOTE — The nine-waypoint buffer

The plan above contains ten waypoints, but the Carousel holds only nine. The origin (KAUS) is not assigned an INS slot; slots 1–9 hold the next nine waypoints. With **Auto-sync** enabled, the Virtual Navigator advances this window automatically as the flight progresses, so plans longer than nine waypoints can be flown without manual re-entry.

27.4 Auto Synchronization

Auto-Sync continuously manages the waypoint buffer, loading additional waypoints as the flight progresses so routes far larger than nine waypoints can be flown without manual mid-route entry. The Warnings button lists automatic route modifications — duplicate-waypoint removal, RF-leg simplification, hold removal, and vector omission — and does not normally indicate a failed import. Always cross-check the navigation log after any import.

WARNING — Terminal approach constraints

Instrument approach procedures (ILS, localizer, or VOR final approaches) are never imported into the Carousel IV-A flight plan, regardless of settings, because they contain leg types the legacy INS cannot represent. During arrival, the crew must manually transition the primary navigation source away from the INS and select conventional radio guidance (VOR / LOC / ILS) to fly the approach.

When **Import Procedures** is on, SIDs and STARs are converted into INS waypoints. When off, only the enroute portion is imported. Instrument approaches are excluded either way (see WARNING above).

27.5 Rejoin

The Rejoin Flight Plan feature reconciles the aircraft's current position and track against the loaded flight plan, reprogramming the INS so the correct leg becomes active. It is useful after a mid-route reposition, testing distinct route legs, skipping sections due to ATC directives, or loading a mid-route scenario.

12. Open **CIVA Options** and select **Rejoin Flight Plan**.
13. Allow the Virtual Navigator to reconcile current coordinates against the master route.
14. Verify the active waypoint on the CDU before continuing normal navigation.

27.6 Settings

The gear icon opens the CIVA Options dialog, which controls how faithfully the Carousel is simulated and provides the route-rejoin function (Figure 27-3).

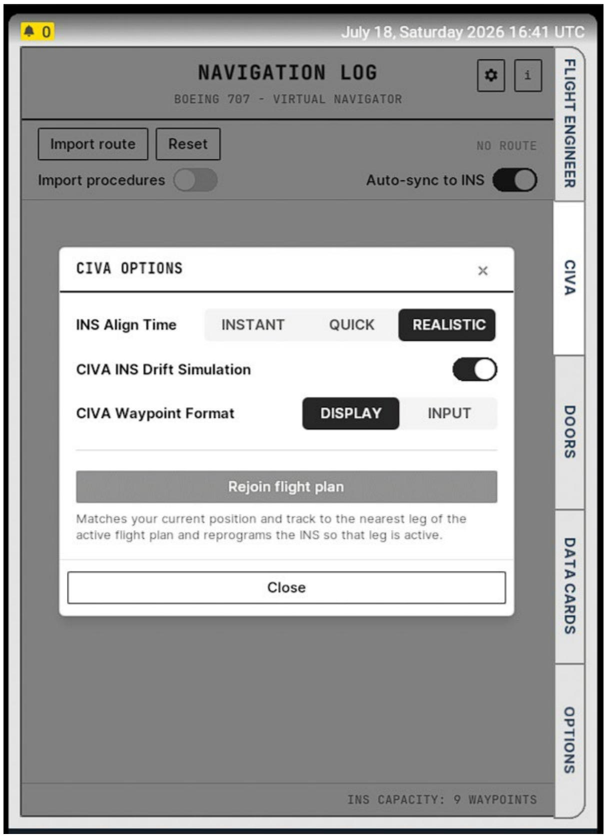

Figure 27-3 Virtual Navigator — CIVA Options dialog

Option	Effect
INS Align Time	Instant (completes immediately) · Quick (shortened) · Realistic (full-length alignment).
CIVA INS Drift Simulation	When on, gyroscopic drift is simulated and requires monitoring and updates; when off there will be no position drift.
CIVA Waypoint Format	Selects how waypoint coordinates are presented — Display or Input format.
Rejoin Flight Plan	Matches current position and track to the nearest leg of the active plan and reprograms the INS so that leg is active.

Two related controls sit on the main Navigation Log page rather than in this dialog: Import Procedures and Auto-Sync to INS (see Figure 27-1).

Recommended Configurations

Setting	Profile A — Realistic	Profile B — Convenience
INS Align Time	Realistic	Instant
Drift Simulation	ON	OFF
Auto-Sync to INS	ON	ON
Import Procedures	OFF (fly SIDs/STARs on raw VOR/DME)	User preference

Profile A delivers an authentic 1970s airline-style workload. **Profile B** minimizes cockpit data entry for rapid setups and solo flights.

PART IV — EFB & AUTOMATION

Chapter 28 — Virtual Flight Engineer

About this chapter

The Virtual Flight Engineer (VFE) is reached from the **Flight Engineer** tab of the EFB (see **§26.1**). This chapter describes its operating philosophy, its phase-of-flight flows, and its continuous automations. A detailed, step-by-step listing of every action within each flow is provided in the Appendices (**§35.4**) rather than here, since flow contents continue to evolve as the simulation develops.

28.1 Operating Philosophy

The Boeing 707-320C is a complex, manual-intensive aircraft by the standards of modern simulation. The Virtual Flight Engineer exists to make an aircraft of this generation and operational complexity manageable for the full range of simmers — serving two complementary goals: making the aircraft approachable and usable by pilots of all skill levels, and adding deep immersion for experienced simmers through realistic flows and callouts.

The VFE provides two complementary forms of assistance:

- **Phase-of-flight flows** — configure the aircraft at defined points during a flight, triggered manually by the crew.
- **Continuous automations** — monitor and manage selected systems independently throughout the flight, without requiring a triggered flow.

Three levels of operation are supported: **Recommended** (run each flow and enable all automations for the fullest realistic-yet-manageable experience), **Mixed** (run flows while manually managing selected systems, useful for learning individual systems), and **Full Manual** (no VFE assistance; the crew performs every flight engineer duty using the in-sim checklists as a guide).

The flight crew always remains responsible for flying the aircraft, navigation and flight control operation.

NOTE

The Before Start flow sets up the aircraft for engine start, but actually starting the engines remains the captain's responsibility. This includes selecting Ground Start for each engine individually and moving the corresponding start lever from CUTOFF to START, one engine at a time. See §5.6–§5.9 and §32.6.

28.2 Phase-of-Flight Flows

Flows perform a sequence of flight crew actions appropriate to a specific phase of operation (Figure 28-1). There are 12 flows: Cockpit Preparation, Before Start, After Start, Taxi, Before Takeoff, After Takeoff, Descent Prep, Descent Approach, Before Landing, After Landing, Shutdown, and Secure.

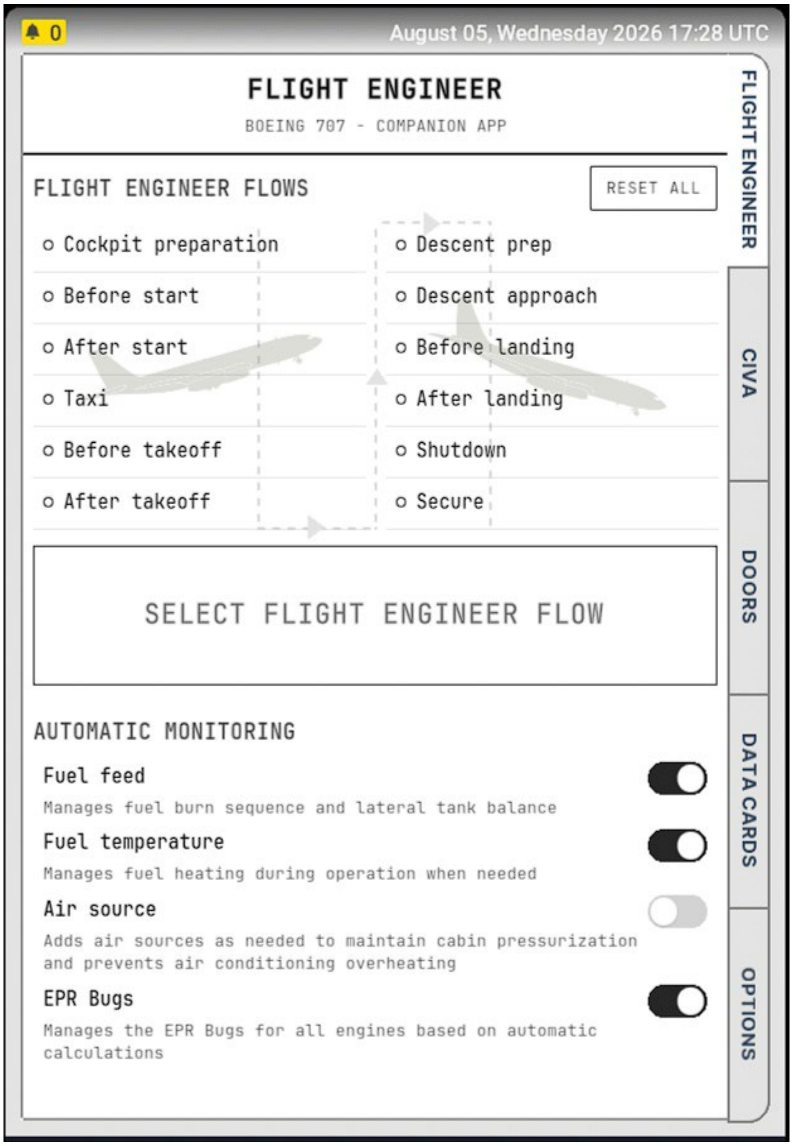

Figure 28-1 Flight Engineer Tab — Flows and Automatic Monitoring

Flow	Purpose
Cockpit Preparation	Configures a cold-and-dark aircraft for normal pre-start procedures, including APU start/configuration, system tests, and initial electrical/pneumatic/fuel setup.
Before Start	Prepares the aircraft for engine start using the APU as the pneumatic source, including opening the APU Bleed Valve and confirming adequate duct pressure.
After Start	Reconfigures the aircraft once all desired engines have started and stabilized, transitioning electrical and pneumatic sources to the normal flight configuration.
Taxi	Prepares the aircraft for departure, including setting takeoff trim and flaps and confirming departure configuration.

Flow	Purpose
Before Takeoff	Completes final configuration checks before departure, including transponder and weather radar setup. Run immediately before entering the runway.
After Takeoff	Cleans up the aircraft after departure, including returning the gear lever to OFF and confirming flap retraction and climb configuration.
Descent Prep	Prepares the aircraft for descent and arrival. Run before leaving cruise altitude.
Descent Approach	Configures the aircraft for terminal-area operations, including exterior lighting, continuous ignition, and selecting LANDING mode on the pressurization system.
Before Landing	Confirms the aircraft is correctly configured for landing, including landing flaps, landing gear, and exterior lighting.
After Landing	Configures the aircraft for taxi-in and gate operations, including retracting flaps/speed brakes and starting the APU.
Shutdown	Transitions the aircraft from engine power to APU power and shuts down the engines.
Secure	Returns the aircraft to a cold-and-dark state, normally the final flow after a flight.

A flow is triggered by selecting it from the list, which populates it in the middle box; pressing **RUN** starts it. If **Checklist Flow Callouts** is enabled (see **§26.4**), the VFE calls out each step realistically as it runs; if disabled, the flow runs much faster, showing only the flow step text and a progress bar of steps completed/remaining in the middle window. Progress-box text is localized, so the progress of each flow remains clear even for non-English speakers. An individual flow can be reset with the **CLEAR** button in the middle box; all flows can be reset at once with **RESET ALL** in the upper right.

28.3 Continuous Automations

Unlike flows, which execute once for a specific phase of operation, continuous automations remain active throughout the flight, continuously evaluating aircraft conditions and adjusting as needed. These automations mirror the real-world, ongoing monitoring responsibilities of a flight engineer, rather than a single checklist-style action. Each automation is shown in the lower half of the Flight Engineer tab (Figure 28-1) and can be enabled or disabled independently:

- **Fuel Feed** — manages fuel burn sequence and lateral tank balance.
- **Fuel Temperature** — manages fuel heaters to maintain normal fuel temperatures.
- **Air Source** — manages pneumatic air sources to maintain pressurization and prevent air conditioning overheating.
- **EPR Bugs** — manages EPR bugs for all engines based on automatic calculations.

Each is described in more detail below.

28.4 EPR Bug Management

Automatically positions the thrust-reference bugs on all four EPR gauges, continuously updating them to the appropriate target for the current phase of flight — takeoff, climb, maximum cruise, and go-around. These targets are not driven by phase of flight alone; they are also continuously recalculated based on environmental conditions, including pressure altitude and temperature. **EPR Bug Management does not control engine thrust**; the bugs are a visual reference only, and the flight crew remains responsible for setting throttle position. Current EPR targets can be reviewed at any time under EFB **Data Cards** → **EPR** (see **§26.3**).

28.5 Fuel Management

Fuel Feed Management automates the fuel-feed and crossfeed systems, selecting appropriate tanks, maintaining the normal fuel-burn sequence, and managing lateral tank balance and crossfeed-valve operation. **Fuel Temperature Management** continuously monitors fuel temperature and manages fuel heaters as needed, particularly useful during high-altitude cruise where prolonged cold soak can lower fuel temperature. Both automations reflect routine duties normally performed by a flight engineer; see **Chapter 11** for the underlying fuel system hardware.

28.6 Air Source Management

Continuously monitors the pneumatic system and brings additional sources online as needed to maintain cabin airflow and pressurization capability, preventing insufficient pneumatic capacity while keeping the air conditioning units available in flight. Routine adjustments may take several minutes while the VFE evaluates the trend, but the system takes immediate corrective action if duct pressure falls outside safe operating limits. The primary indication of pneumatic system performance is the **INCHES OF WATER** duct-pressure gauge; see **Chapters 7 and 8**.

28.7 Throttle Management

Takeoff/Climb Throttle Assistance allows the VFE to automatically set and maintain throttle position during takeoff and climb, using the same EPR targets provided by EPR Bug Management (**§28.4**). It engages automatically when the crew advances the throttles close to the takeoff EPR target, announces that it has assumed thrust management, and illuminates a green indicator on the captain's ADI (see **§4.7.1**, callout 1). The crew may override the automation at any time by moving the throttles manually.

This option is not located on the Flight Engineer tab with the other automations above; it is enabled or disabled on the EFB **Options** tab instead, and is mentioned here for convenience. Full details on this option, along with its complete indicator and override behavior, are provided in **§26.4**.

PART V

OPERATING PROCEDURES

PART V — OPERATING PROCEDURES

Chapter 29 — Flight Planning

About this chapter

Covers flight planning for the 707-320C using the MSFS 2024 Web and EFB Flight Planner apps, including route creation, performance profile selection, and payload/fuel planning.

29.1 Overview

Flight planning for the 707 is most easily accomplished with the MSFS 2024 Web or EFB Flight Planner apps. The web-based planner is available at **planner.flightsimulator.com**. Flight plans created there can be saved and loaded directly in the EFB.

29.2 Creating a Route

In the EFB, open the Flight Planner app and select the **Route** page (Figure 29-1). Three methods are available for building a route:

- Create a route by hand, selecting departure and arrival airports and procedures, along with enroute waypoints.
- Select only a departure and arrival airport, then use **Find Route** to automatically generate a route.
- Add departure and arrival airports, then provide a route string directly with **Enter Route String**.

Once a route and alternate are selected, along with a cruise altitude, proceed to the **Performance** page. The example in Figure 29-1 shows a route from KJFK to KIAD, with KRIC as the alternate: the JFK5 departure procedure, enroute waypoints joining the SEG6 arrival at the LVZ VOR, and an ILS approach to runway 19L at IAD.

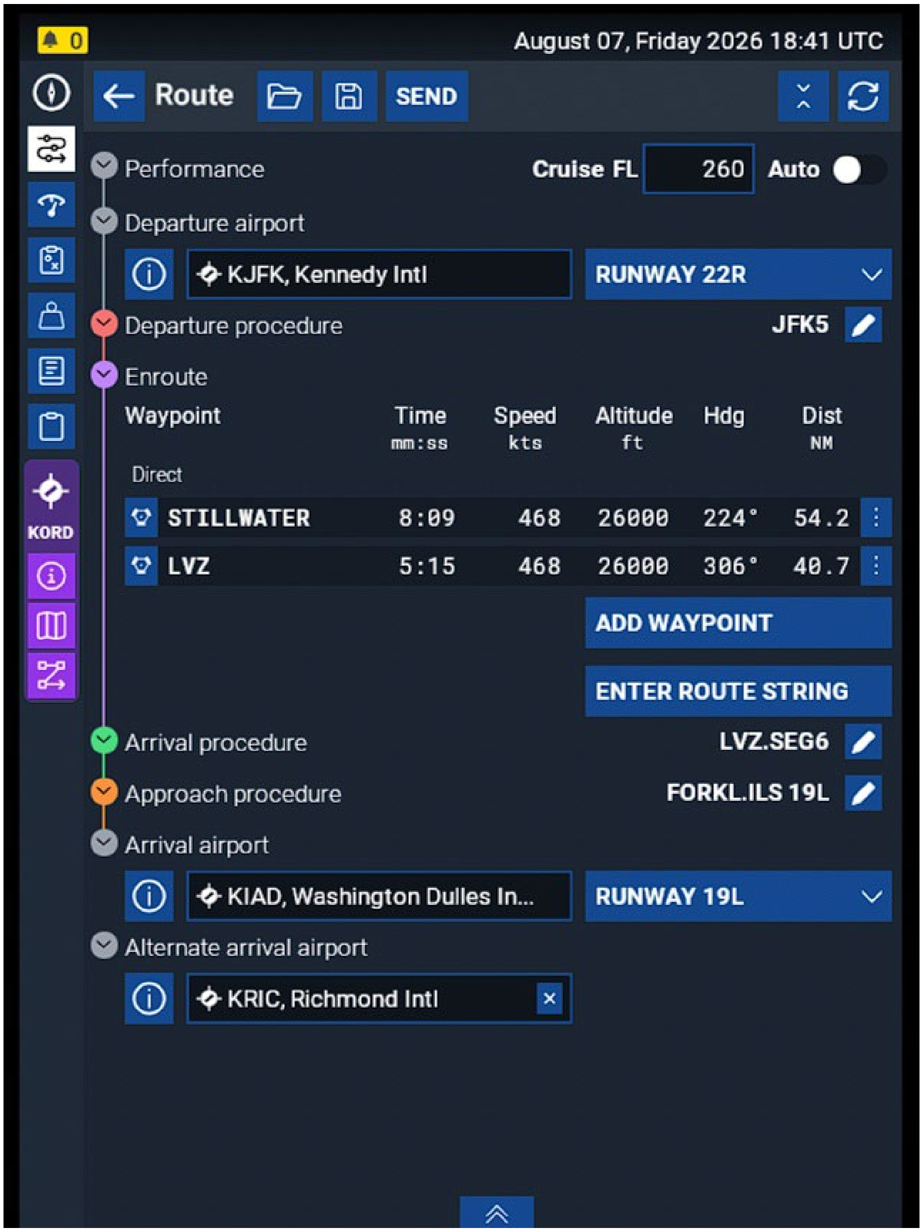

Figure 29-1 Flight Planner — Route page

29.3 Performance Profiles

On the Performance page (Figure 29-2), confirm the cruise altitude and choose performance profiles for climb, cruise, and descent. In addition to manual entry, three fixed profiles are available for climb and cruise, and two for descent. The example uses:

- Climb: 280 kt / M0.78
- Cruise: 300 kt / M0.80
- Descent: 280 kt / M0.80

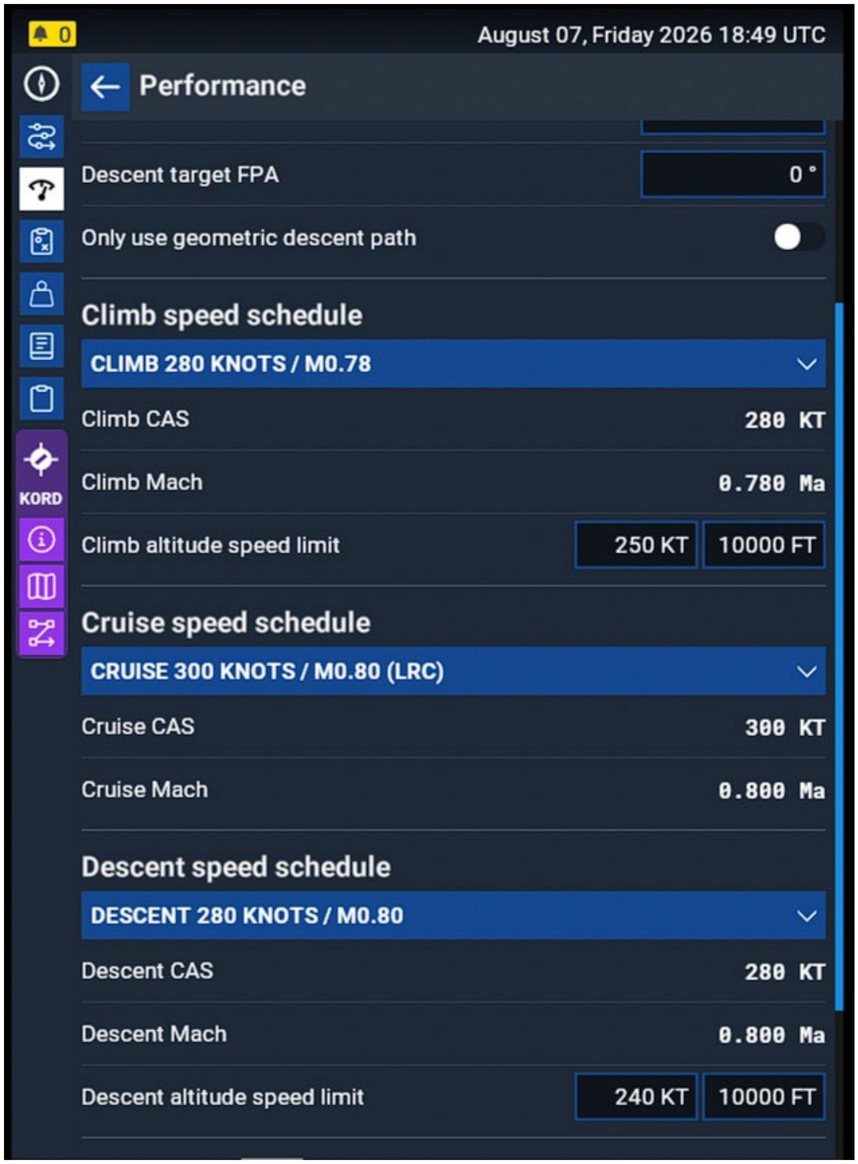

Figure 29-2 Flight Planner — Performance page

29.4 Payload & Fuel Planning

The **Payload & Fuel** page (Figures 29-3, 29-4) is where passengers, cargo, and fuel are specified.

- Set the desired passenger count and cargo weight. The example uses 110 passengers and 20,000 lb of cargo.
- Trip fuel, alternate fuel, and final reserve are calculated automatically — in the example, 11,193 lb, 6,703 lb, and 9,854 lb respectively.
- Taxi fuel and contingency fuel can be added manually; the example adds 1,000 lb of taxi fuel and 3,000 lb of contingency fuel, for a total block fuel of 31,749 lb.
- Selecting **LOAD** applies the payload and fuel immediately. Alternatively, **CONFIGURE** allows manual load configuration in the Aircraft app, under **Flight Performance** → **Mass and Balance**.

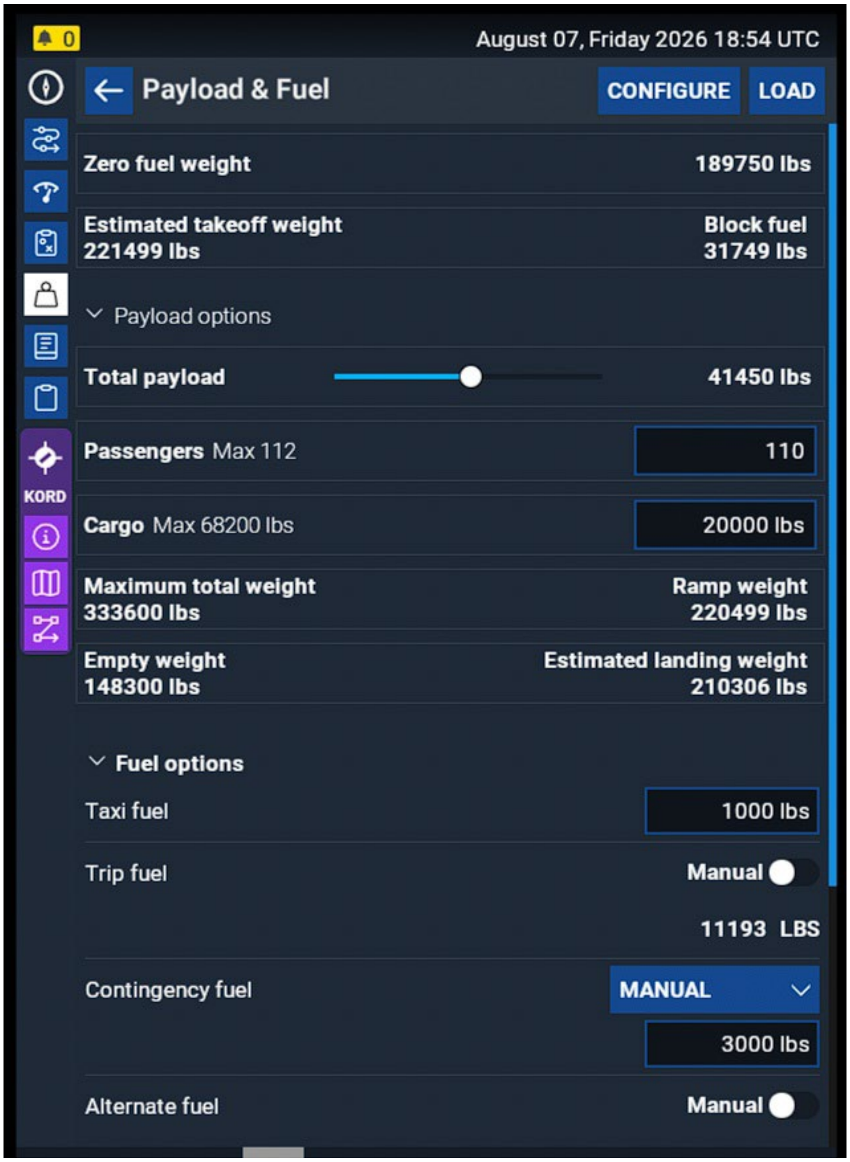

Figure 29-3 Flight Planner — Payload & Fuel page (payload and fuel options)

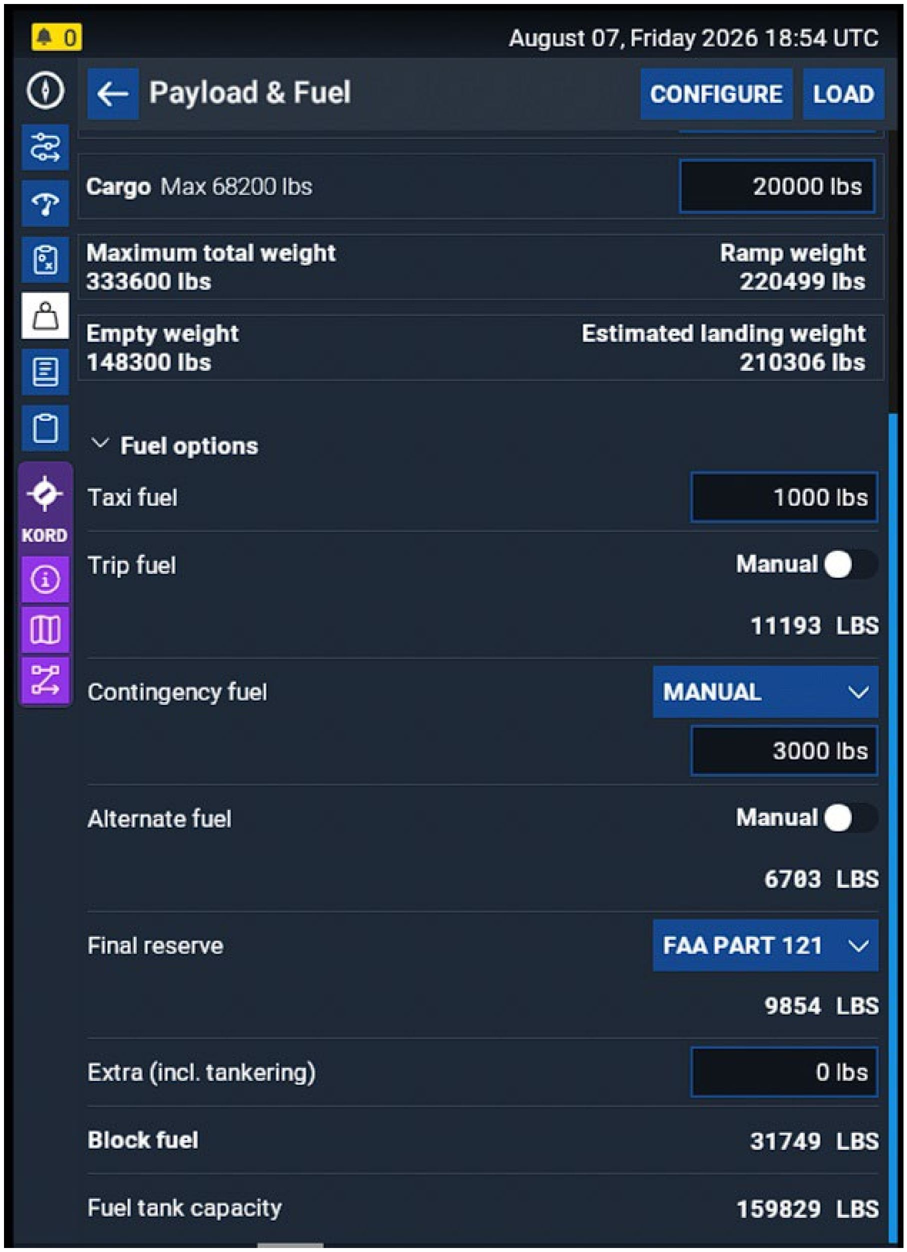

Figure 29-4 Flight Planner — Payload & Fuel page (fuel summary and block fuel)

> **NOTE**
> The pilot is always responsible for inspecting the Mass and Balance to confirm loading is within CG limits, as indicated in the Aircraft app.

29.5 Sending the Flight Plan to Aircraft Navigation System

Once loaded into the simulator, use the **SEND** button on the Route page to send the flight plan directly to the GNS or UNS-1. For the CIVA variant, it is recommended to use the **CIVA** tab in the Boeing 707 EFB app to load the flight plan into the CIVA INS automatically (see **Chapter 27**).

PART V — OPERATING PROCEDURES

Chapter 30 — Virtual Flight Engineer Flow Reference

About this chapter

Provides a complete, enumerated reference of every step within each of the 12 Virtual Flight Engineer phase-of-flight flows (see **§28.2**). Each section below corresponds to one flow, listing every step's title and a developer-level description of the action performed. This reference reflects the flow definitions as implemented at the time of writing and may change as the simulation continues to develop.

30.1 Cockpit Preparation Flow

Title	Developer Description
Cockpit Prep — Start	Flow start marker; no aircraft action.
Electrical — Battery — ON	Set electrical battery to ON.
Cockpit Safety Inspection — Landing Gear Lever — DOWN	Confirm landing gear lever in DOWN.
Emergency Flaps Guard and Switches	Close emergency flap master guard if open, and flaps switches to off.
Cockpit Safety Inspection — Landing Lights — Retracted and OFF	Turn off and retract all landing lights.
Cockpit Safety Inspection — WX Mode Selector — OFF	Set WX radar mode selector to OFF.
Cockpit Safety Inspection — Transponder Function Selector — STBY	Set transponder function selector to STBY.
Cockpit Safety Inspection — Galley Power Switch — OFF	Set galley power switch to OFF; will be turned ON later in flow.
Cockpit Safety Inspection — AC Aux Pumps — OFF	Set AC Auxiliary Pumps to OFF.
Cockpit Safety Inspection — Fuel Dump Panel Cover — CLOSED	Set fuel dump panel cover (engineer panel hatch) to CLOSED.
APU Fire Test Selector — TEST	Hold APU fire test selector at TEST; momentary switch springs back to OFF.
APU Master Switch — START	Pulse APU master switch to START to start the APU.
Waiting for APU Start	Verify the APU is started; stalls the flow until it is.
APU Generator — ON	Pulse APU generator switch to ON.
Flight Recorder — ON	Set flight recorder to ON.
APU Bleed Valve — OPEN	Set APU bleed valve to OPEN.
Mach Airspeed Warning — PUSH TEST	Hold the mach warn push button to verify the warning system.

Title	Developer Description
Mach Trim — TEST and RE-ENGAGE	Hold mach trim selector at TEST; momentary switch springs back to NORMAL.
Engine Oil Quantity — TEST	Hold the engine oil quantity test button to verify oil quantity indicators.
Door Warning — TEST	Hold door warning test switch at TEST; momentary switch springs back to OFF.
Electrical — Essential Power Selector — APU	Set essential power selector to APU.
Cockpit Safety Inspection — External Power Switch — OFF	Set external power switch to OFF; APU will be the only power source for cockpit prep.
Pneumatics — Air Conditioning — ON	Set air conditioning switches to ON. Will be turned off for engine start in the Before Start flow.
Electrical — Radio Master Switches — ON	Set radio master switches to ON.
Spoiler and Rudder Test Guards — CLOSED	Close Spoiler and Rudder Test Guards if open.
Engine Start Switches — OFF & Guard CLOSED	Set all engine starter switches to OFF, then close guards if open.
Cabin — Passenger Signs — ON	Set No Smoking and Seat Belt signs switch to ON.
Wing Anti-Ice — OFF	Set wing anti-ice to OFF.
Passenger Oxygen — NORM	Set passenger and personnel accommodations oxygen switch to NORM.
Window Heat Switches — LOW	Set captain and F/O window heat to LOW.
Probe Heaters — TEST and OFF	Set TAT/Pitot probe heaters ON to verify heater function, then turn off.
Lighting — Navigation and Wheel Well Lights — ON	Set navigation and wheel well lights to ON.
Pneumatics — Turbofan Exit Valves Overrides — NORMAL	Set turbofan exit valves override to NORMAL.
Pneumatics — Gasper Air Fan — ON	Set gasper air fan to ON.
Fuel — Dump Chute — CLOSED	Set fuel dump chute to RETRACT/CLOSED.
Galley Power Switch — ON	Set galley power switch to ON.
Fuel — All Heaters — OFF	Set all fuel heaters to OFF.
Fuel — Temperature Selector — NO. 1 TANK	Rotate fuel temperature selector to NO. 1 TANK.
Fuel — Temperature Selector — ENG 1	Rotate fuel temperature selector to ENG 1.
Fuel — Temperature Selector — ENG 2	Rotate fuel temperature selector to ENG 2.
Fuel — Temperature Selector — ENG 3	Rotate fuel temperature selector to ENG 3.

Title	Developer Description
Fuel — Temperature Selector — ENG 4	Rotate fuel temperature selector to ENG 4.
Fuel — Gauge Test — PRESS	Press and hold the fuel gauge test button.
Fuel — Test Fuel Boost Pumps	Set all fuel boost pumps to ON, then OFF, going from left to right.
Fuel — Test Fuel Crossfeed Valve Position Lights	Set all crossfeed valves to CLOSED, then OPEN.
Fuel — Test Reserve Tank Transfer Valve Position Lights	Set all reserve tank transfer valves to CLOSED, then OPEN.
Hydraulic — Shutoff Valve Eng 2 & 3 — GUARD CLOSED	Close engine 2 & 3 hydraulic shutoff guard if open.
Hydraulic — Engine 2 & 3 Hydraulic Pumps — ON	Set Eng 2 & 3 and Aux hydraulic pumps to ON.
Hydraulic — AC Auxiliary Pump 2 — ON	Set AC Auxiliary Pump No. 2 (Rudder Aux Pump) to ON.
Hydraulic — Interconnect Valve — BRAKE (test)	Pulse interconnect valve to BRAKE to verify brake hydraulic pressurization via aux pump.
Hydraulic — Interconnect Valve — SYSTEM	Return interconnect valve to SYSTEM; final operating position.
Hydraulic — AC Auxiliary Pump 2 — OFF	Set AC Auxiliary Pump No. 2 to OFF.
Hydraulic — AC Auxiliary Pump 1 — ON	Set AC Auxiliary Pump No. 1 (Rudder/Spoilers Aux Pump) to ON.
Hydraulic — AC Auxiliary Pump 1 — OFF	Set AC Auxiliary Pump No. 1 to OFF.
Pneumatics — Engine Bleed Air Switches — OFF	Set all engine bleed air switches to OFF.
Pneumatics — Wing Isolation Valves — OPEN	Set left and right wing isolation valve to OPEN.
Crew Oxygen — 100% and ON	Set crew oxygen diluter to 100% and ON per dispatch requirement.
Cockpit Prep — Complete	Flow end marker; no aircraft action.

30.2 Before Start Flow

Title	Developer Description
Before Start — Start	Flow start marker; no aircraft action.
Electrical — Battery — ON	Set electrical battery to ON.
Lighting — Emergency Exit Lights — ARMED	Set emergency exit light switch to ARMED by closing the guard.
Cabin — Passenger Signs — ON	Set No Smoking and Seat Belt signs switch to ON.

Title	Developer Description
Emergency Flaps Guard and Switches	Close emergency flap master guard if open. And flaps switches to off.
Anti-Skid — ON	Close the guard and set anti-skid switch to ON.
Spoiler and Rudder Test Guards — CLOSED	Close Spoiler and Rudder Test Guards if open.
Compass Mode — SLA (MAG)	Set compass controllers to SLA / Slaved.
Instrument Source — INST	Set instrument transfer switch to INST — normal position.
Attitude Source — NO 1	Set attitude source switch to NO 1 — normal position.
Transponder — ON	Set transponder function selector to ON.
Transponder Altitude Reporting — 1	Set transponder altitude reporting switch to 1.
Radar — STBY	Set WX radar mode selector to STBY.
Yaw Damper — ENGAGED	Set Yaw Damper switch to ON.
Window Heat Switches — LOW	Set captain and F/O window heat to LOW.
Engine Start Levers — CUTOFF	Set engine pedestal start levers to CUTOFF; confirm position before start.
Parking Brake — SET	Set parking brake switch to ON.
Trim — Rudder & Aileron — FREE & ZERO	Set rudder and aileron trim to neutral (0 percent over 100).
Fuel — Boost Pumps — ON	Set all boost pumps to ON.
Fuel — Crossfeed Selector 1, 3 and 4 — CLOSED	Set crossfeed selectors 1, 3 and 4 to CLOSED.
Fuel — Crossfeed Selector 2 — OPEN	Set crossfeed selector 2 to OPEN.
Pneumatics — Air Conditioning — OFF	Set air conditioning switches to OFF.
Galley Power — OFF	Set galley power switch to OFF.
Start Pressure — ≥ 30 PSI	Verify duct pressure ≥ 30 PSI; ensures enough air pressure is available for engine start.
Wheel Well Light — OFF	Set wheel well light to OFF.
Lighting — Beacon and Nav — ON	Set beacon lights to ON; set nav lights to ON.
Pneumatics — Wing Isolation Valves — OPEN	Open both wing isolation valves (required for routing start air).
Engine Start Control — Guards OPEN	Set all engine starter guards to open.
Before Start — Complete	Terminal step; no-op marker for UI/audio callout.

30.3 After Start Flow

Title	Developer Description
After Start — Start	Flow start marker; no aircraft action.
Engine Start Switches — OFF & Guard CLOSED	Set all engine starter switches to OFF, then close guards.
Engine Start Levers — IDLE	Set all engine pedestal start levers to IDLE.
APU Bleed Valve — CLOSE	Set APU bleed valve to CLOSED.
Electrical — Generators — Checked	Parallel all generators, then set to Gen 3.
Electrical — Essential Power Selector — GEN 3	Set essential power selector to GEN 3.
Pneumatics — Air Compressors — START	Set all air compressor start switches to START.
Galley Power — ON	Set galley power switch to ON.
Fuel — All Boost Pumps — ON	Set all fuel boost pumps to ON.
Hydraulic — AC Auxiliary Pump 2 — ON	Set AC Auxiliary Pump No. 2 (Rudder Aux Pump) to ON.
Hydraulic — Engine Pumps — ON	Set all engine hydraulic pumps to OFF, then ON.
Hydraulic — Interconnect Valve — OFF	Set interconnect valve switch to OFF.
Pneumatics — Air Conditioning — ON	Set air conditioning switches to ON.
APU Master Switch — OFF	Set APU Master Switch to OFF.
Doors — CLOSED	Verify all configured doors closed; stalls the flow until they are.
After Start — Complete	Terminal step; no-op marker for UI/audio callout.

30.4 Taxi Flow

Title	Developer Description
Taxi — Start	Flow start marker; no aircraft action.
Lighting — Taxi Lights — ON	Turn runway turnoff / taxi lights L and R ON.
Electrical — Essential Power Selector — GEN 3	Set essential power selector to GEN 3.
Probe Heat — Temperature Probe — ON	Set temperature probe heat to ON, followed by pitot heat 1 and 2.
Transponder — ON	Set transponder function selector to ON for departure.
Speed brake Lever — FULL FORWARD	Stow speed brake fully forward (percent 0).
Galley Power — ON	Set galley power switch to ON.
Fuel — All Boost Pumps — ON	Set all fuel boost pumps to ON.
Fuel — All Heaters — OFF	Set all fuel heaters to OFF.

Title	Developer Description
Flaps — 14, GREEN LIGHTS	Set flaps to 14.
Stabilizer Trim — SET	Set stabilizer trim to the calculated value if available, otherwise set to a reasonable takeoff trim without knowing an exact value.
Altimeter — SET	Set local altimeter setting.
KFIS Altimeter Correction — ON	Set KFIS Altimeter Correction to ON.
Taxi — Complete	Terminal step; no-op marker for UI/audio callout.

30.5 Before Takeoff Flow

Title	Developer Description
Before Takeoff — Start	Flow start marker; no aircraft action.
Pneumatics — Air Compressor 3 — STOP	Set air compressor 3 to STOP.
Pneumatics — Coolant Air System Valve Selector — TEMP CONTROL	Set coolant air system valve selector to TEMP CONTROL to monitor main temperature control valve position.
Pressurization Mode — TAKEOFF	Set pressurization mode to takeoff.
Transponder — ON	Set transponder state to ON.
Radar — NORM	Set WX radar mode selector to NORM for departure.
Engine Start Switches — FLIGHT START	Open guards and set engine start control selectors to FLIGHTSTRT; sim equivalent of the physical aircraft's BOTH position.
Lighting — Strobes — ON	Turn strobe light ON for takeoff.
Lighting — Landing Lights — EXTEND and ON	Turn all landing lights L and R ON and EXTEND.
Before Takeoff — Complete	Flow end marker; no aircraft action.

30.6 After Takeoff Flow

Title	Developer Description
After Takeoff — Start	Flow start marker; no aircraft action.
Landing Gear — UP	Set landing gear lever to OFF; stalls until gear is verified fully retracted.
Engine Start Switches — OFF & Guard CLOSED	Set all engine starter switches to OFF, then close guards.
Pneumatics — Set	Set exit valves to open and turbofan exit valve overrides to normal.
Pneumatics — Temperature Selectors — AUTO	Set temperature selectors to AUTOMATIC.
Pneumatics — Air Compressor 3 — ON	Set air compressor 3 to ON.

Title	Developer Description
After Takeoff — Completed	Flow end marker; no aircraft action.

30.7 Descent Prep Flow

Title	Developer Description
Descent Prep — Start	Flow start marker; no aircraft action.
Pneumatics — Air Compressors — START	Set air compressor start switches to position 2.
Fuel — Crossfeed Selectors — CLOSED	Set crossfeed selectors to CLOSED.
Fuel — Central Fuel Boost Pumps — OFF	Set central fuel boost pumps to OFF.
Descent Prep — Completed	Flow end marker; no aircraft action.

30.8 Descent Approach Flow

Title	Developer Description
Approach — Start	Flow start marker; no aircraft action.
Pressurization Mode — LANDING	Set pressurization mode to landing.
Pneumatics — Set	Set exit valves and inlet valves to OPEN.
Cabin — Passenger Signs — ON	Set Seat Belt and No Smoking sign to ON.
Lighting — Landing Lights — EXTEND and ON	Turn all landing lights L and R ON and EXTEND.
Fuel — Boost Pumps — ON	Set all boost pumps to ON.
Fuel — All Heaters — OFF	Set all fuel heaters to OFF.
Hydraulic — AC Auxiliary Pumps — ON	Set AC Auxiliary Pumps to ON.
Speed brake Lever — FULL FORWARD	Stow speed brake fully forward (percent 0).
Approach — Completed	Flow end marker; no aircraft action.

30.9 Before Landing Flow

Title	Developer Description
Before Landing — Start	Flow start marker; no aircraft action.
Spoiler and Rudder Test Guards — CLOSED	Close Spoiler and Rudder Test Guards if open.

Title	Developer Description
Engine Start Switches — FLIGHT START	Open guards and set engine start control selectors to FLIGHTSTRT; sim equivalent of the physical aircraft's BOTH position.
Cabin — Passenger Signs — ON	Set Seat Belt and No Smoking sign to ON.
Pneumatics — Air Compressor 3 — STOP	Turbocompressor 3 start/stop switch to STOP; one compressor off for landing.
Altimeter — SET	Set local altimeter setting.
Before Landing — Completed	Flow end marker; no aircraft action.

30.10 After Landing Flow

Title	Developer Description
After Landing — Start	Flow start marker; no aircraft action.
Cockpit Safety Inspection — Landing Lights — Retracted and OFF	Turn off and retract all landing lights.
Lighting — Strobes — OFF	Turn strobe light OFF for taxi.
Lighting — Taxi Lights — ON	Turn runway turnoff / taxi lights L and R ON.
APU Master — START	Pulse APU master switch to START.
Flaps — UP	Set flaps to UP detent.
Speed brake Lever — FULL FORWARD	Stow speed brake fully forward (percent 0).
Window Heat — OFF	Set window heat to OFF.
Probe Heaters — OFF	Set all probe heaters to off.
Radar — STBY	Set WX radar mode selector to STBY.
Engine Start Switches — OFF & Guard CLOSED	Set all engine starter switches to OFF, then close guards if open.
Galley Power — OFF	Set galley power switch to OFF.
DC Meter Selector — BATT	Set DC ammeter/voltmeter gauge selector to BATTERY to monitor battery during APU start.
Fuel Boost Pumps Fwd — ON	Ensure forward boost pumps ON (one per tank).
Fuel Boost Pumps Aft — OFF	Turn aft boost pumps OFF (one pump per tank remains on).
Pneumatics — SET	Set outflow/exit valves to OPEN.
APU Generator — ON	Pulse APU generator switch to ON.
APU Bleed Valve — OPEN	Set APU bleed valve to OPEN.
Gasper Fan — ON	Set gasper fan switch to ON.
After Landing — Completed	Flow end marker; no aircraft action.

30.11 Shutdown Flow

Title	Developer Description
Shutdown — Start	Flow start marker; no aircraft action.
Pneumatics — Air Conditioning — OFF	Set air conditioning units OFF.
Pneumatics — Air Compressors — STOP	Set all air compressor start switches to STOP.
Anti-Ice — Nacelle — OFF	Set nacelle anti-ice to OFF.
Wing Anti-Ice — OFF	Set wing anti-ice to OFF.
Pneumatics — Engine Bleed Air Switches — OFF	Set all engine bleed air switches to OFF.
Transponder — OFF	Set transponder state to OFF.
WX Mode Selector — OFF	Set WX radar mode selector to OFF.
Electrical — Essential Power — APU	Transfer essential AC bus to APU.
Engine Start Levers — CUTOFF	Set engine pedestal start levers to CUTOFF; confirm position before start.
Lighting — Taxi Lights — OFF	Turn runway turnoff / taxi lights L and R OFF.
Lighting — Beacon — OFF	Set beacon light to OFF.
Lighting — Emergency Exit Lights — OFF	Open guard, set emergency exit lights to OFF.
Cabin — Passenger Signs — OFF	Set Seat Belt and No Smoking sign to OFF.
Fuel — Boost Pumps — OFF	Set all boost pumps to OFF.
Hydraulic — AC Auxiliary Pumps — OFF	Set AC auxiliary hydraulic pumps OFF.
Hydraulic — Engine 2 & 3 Pump — OFF	Close engine 2 & 3 hydraulic pump shutoff.
Shutdown — Completed	Flow end marker; no aircraft action.

30.12 Secure Flow

Title	Developer Description
Secure Aircraft — Start	Flow start marker; no aircraft action.
Crew Oxygen — Flow — OFF	Close crew oxygen supply at the FE station by setting flow to OFF.
Electrical — APU Generator — OFF	Set APU generator switch to OFF.
Electrical — External Power — OFF	Set external power switch to OFF.
Electrical — APU Master — OFF	Set APU master switch to OFF to shut down the APU.
Lighting — Navigation Lights — OFF	Turn navigation lights OFF as the aircraft is no longer powered up.
Flight Recorder — OFF	Set flight recorder to OFF.

Title	Developer Description
Electrical — Battery — OFF	Open the battery master cover and switch the battery master switch to OFF.
KFIS Altimeter Correction — OFF	Set KFIS Altimeter Correction to OFF.
Secure Aircraft — Completed	Flow end marker; no aircraft action.

PART V — OPERATING PROCEDURES

Chapter 31 — Normal Procedures Checklists

About this chapter

Presents the eight normal checklist cards used throughout a flight, in the concise challenge/response format used on the flight deck. Each checklist is shown in two columns, as on a printed checklist card. The **Crew** column indicates which crew position(s) call or respond to each item (CAPT, F/O, F/E). Amplifying notes are broken out onto their own row beneath the relevant item. This reference reflects the checklist content at the highest level of procedural detail modeled in the simulation and may be condensed at lower checklist-detail settings.

31.1 Before Start Checklist

When all appropriate preflight procedures are completed, the Captain will call for the Before Start Checklist. The First Officer will read aloud each challenge and receive the appropriate response from the designated crew member.

Item	Crew	Response
Cockpit Preparation	CAPT, F/O, F/E	COMPLETE
Emergency Flaps	CAPT	OFF
Mach Airspeed Warning	CAPT	CHECKED
Anti-Skid	CAPT	CHECKED & ON
Rudder & Spoiler Switches	CAPT	ON
Emergency Exit Lights	CAPT, F/O	ARMED
No Smoking & Seat Belts Switches	CAPT, F/O	ON
Compass Controller Mode Switch	F/O	SLA
Radio Altimeters	F/O	CHECKED
Yaw Damper	F/O	ENGAGED
Window Heat	CAPT	LOW
Pneumatic Brake	CAPT, F/O, F/E	CHECKED
Flt Inst, Altimeter & Flt Dir	CAPT, F/O	SET & X-CHECKED
Compasses	CAPT, F/O	SYNC & X-CHECKED
Instrument Transfer Switches	CAPT	NORMAL
Radios, Radar & Transponder	CAPT, F/O	SET & STANDBY
Check radios set for departure and radar and transponder set to STBY.		

Item	Crew	Response
Start Levers	CAPT	CUTOFF
Parking Brakes	CAPT	SET
Rudder & Aileron Trim	CAPT	FREE & ZERO
Battery	F/E	ON
Fuel	F/E	___ KGS SET FOR START
Check fuel loading per tank in accord with manifest and appropriate boost pumps on for engine start.		
Air Cond Units	F/E	OFF
When cleared for engine start:		
Continue the checklist after receiving start clearance from the tower and ground personnel.		
Galley Power	F/E	OFF
Start Pressure	F/E	___ PSI
Check air supply duct pressure indicator and announce the pressure. 30 PSI or higher is desirable for sea level starting; however, starts can be made with lower pressures. The 30 PSI desirable pressure may be reduced 1/2 PSI per 1000 feet in altitude. Monitor EGT closely when starts are made with less than desirable manifold pressure. Abort the start if EGT rise appears unusually rapid and is approaching the EGT start limit.		
Beacon	CAPT	ON
Before Start Checklist	F/O	COMPLETE

31.2 After Start Checklist

Prior to taxi, and on the Captain's command, the First Officer will read aloud each challenge and receive the appropriate response from the designated crew member.

Item	Crew	Response
Ground Equipment	CAPT	CLEAR
Observe ground equipment clear or receive signal from ground crew that all ground equipment has been removed.		
Hydraulics	F/E	PRESS & QTY NORMAL, INTERCONNECT CLOSED
Check utility and AC aux pump switches ON, all pressures (including hydraulic brake) and quantity normal. Check interconnect valve switch OFF.		

Item	Crew	Response
Doors	F/E	CLOSED
Check all door annunciator lights extinguished.		
After Start Checklist	F/O	COMPLETE

31.3 Before Takeoff Checklist

After leaving the gate and prior to taking the runway, the Captain will call for the Before Takeoff Checklist. The Flight Engineer will read aloud each challenge and receive the appropriate response from the designated crew member.

Item	Crew	Response
Nacelle Anti-Ice	F/O	OFF/ON
Check nacelle anti-ice valves positioned OFF or ON as required.		
Ground Start Switch	F/O	OFF
Yaw Damper	CAPT	CHECKED
Window Heat	F/O	HIGH
Check window heat switches on HIGH and OVERHEAT lights extinguished.		
Probe Heaters	F/O	ON
Check probe heater switches ON and HEAT ON lights illuminated.		
Flt Dir, Flt Inst and Radios	CAPT, F/O	SET FOR DEPARTURE
Speed brake Lever	CAPT	FULL FORWARD
Flaps	CAPT	14, 14, GREEN LIGHTS
Check both flap position indicators indicate 14 and green LE FLAP lights illuminated.		
Start Levers	CAPT	IDLE DETENT
Stabilizer Trim	CAPT	___ UNITS
Check stabilizer trim setting agrees with computed setting.		
Flight Controls	CAPT	CHECKED
Electrical	F/E	NO LIGHTS, ESS 3
Check all generator drive LOW PRESSURE, CIRCUIT OPEN and essential power FAILURE warning lights are extinguished and essential power selector is positioned to GEN 3.		

Item	Crew	Response
Galley Power	F/E	ON
Fuel	F/E	SET FOR T.O.
Check fuel system set for proper takeoff configuration, appropriate boost pump switches ON, and LOW PRESSURE lights for operating boost pumps extinguished.		
Fuel Heat	F/E	OFF
Hydraulics	F/E	PRESS & QTY NORMAL
Check system pressures normal, AC auxiliary and engine pump LOW PRESS lights extinguished and tank quantity at least full.		
APU Door Open Light	F/E	EXTINGUISHED
Cockpit Door	F/E	LOCKED
Takeoff Briefing & Data	CAPT, F/O, F/E	REVIEWED, BUGS SET
The pilot making the takeoff shall review the takeoff data and brief the other crewmembers on their expected actions during and immediately after takeoff. Check that airspeed and EPR bug settings agree with the computed data.		
CLEARED FOR TAKEOFF: *Continue the checklist after receiving takeoff clearance.*		
Air Cond & Press	F/E	SET FOR T.O.
Check only two air compressors operating, pressurization mode switch positioned to TAKEOFF and cabin altitude 200 to 250 feet below airport elevation.		
Transponder	F/O	ON
Engine Start Control Selectors	F/E	Flight Start
Landing Lights	F/O	ON
For collision avoidance check the fixed landing lights ON.		
Before Takeoff Checklist	F/E	COMPLETE

31.4 After Takeoff Checklist

When commanded by the Captain, the Flight Engineer will read silently each challenge and verify that the appropriate action has been accomplished. If any action has not been accomplished, he will read aloud the challenge to the designated crew member and after the action has been completed, receive the correct response. After all actions have been completed and verified the Flight Engineer will announce to the Captain: "After Takeoff Checklist complete."

Item	Crew	Response
Anti-Ice	F/E	OFF/ON
Check anti-ice switches positioned as required for flight conditions. If not in icing conditions move switches to OFF one at a time, observing equal EPR rises.		
Engine Start Control Selectors	F/E	OFF/ON
Check engine start control selectors set as required for flight conditions.		
No Smoking & Seat Belts Switches	F/E	OFF/ON
Check switches OFF if flight conditions permit.		
Gear	F/E	UP & OFF
Check landing GEAR down light and GEAR and DOOR warning lights extinguished and landing gear lever in OFF position.		

Item	Crew	Response
CAUTION: *DO NOT ACTUATE BRAKE PEDALS DURING GEAR RETRACTION. SUFFICIENT BRAKING IS AUTOMATICALLY APPLIED TO WHEELS WHEN HANDLE IS UP AND GEAR IS IN TRANSIT. SUDDEN APPLICATION OF BRAKE PEDAL FORCE DURING RETRACTION CAUSES VIOLENT PITCHING OF MAIN GEAR TRUCK AND INDUCES HEAVY LOADS ON TRUCK LEVELING SYSTEM. IF BRAKE PEDALS HAVE BEEN ACTUATED INADVERTENTLY DURING GEAR RETRACTION MAINTENANCE INSPECTION MUST BE CARRIED OUT.*		
Flaps	F/E	UP, NO LIGHTS
Check flaps retracted and LE FLAPS lights extinguished.		
Hydraulics	F/E	PRESS & QTY NORMAL
Check utility system and brake pressures 2800 psi minimum after landing gear and flap retraction; rudder pressure 2800 psi minimum below 245 kts or 2250 psi above 245 kts; quantity normal for landing gear and leading edge flaps retracted.		
Air Cond & Press	F/E	CHECKED & SET
Check cabin altitude selection indicator set to planned cruise altitude plus 1500 to 2000 feet, cabin rate of climb normal, cabin air duct pressure in green band, crew and main cabin temperature selectors in automatic range.		
After Takeoff Checklist	F/E	COMPLETE

31.5 Descent/Approach Checklist

When commanded by the Captain, the Flight Engineer will read aloud each challenge and receive the appropriate response for the items accomplished by Captain and First Officer, reading and responding in a normal voice those items accomplished by himself.

Item	Crew	Response
Pressurization	F/E	SET
Verify cabin altitude selector set for landing. Check pressurization mode switch in LANDING.		
Anti-Ice	F/O	OFF/ON
Check Anti-ice OFF or ON as required.		
Coolant Air Valves (19000 Feet)	F/E	OPEN
Circuit Breakers	F/E	CHECKED
Complete after reaching final approach altitude:		
Seat Belts Switch	F/E	ON
Landing Lights	F/O	ON
For collision avoidance check the fixed landing lights ON when descending through 10,000 feet.		
EPR & Airspeed Bugs	CAPT, F/O	SET

Item	Crew	Response
Altimeters	CAPT, F/O, F/E	SET & X CHECKED
Check altimeters and barometric correction indicator set at current airport barometric pressure, and altimeters in agreement.		
Radio Altimeters	CAPT, F/O	SET
Set minimum decision altitude.		
Flt Dir, Flt Inst & Radios	CAPT, F/O	SET & X-CHECKED
Check flight directors, flight instruments and radios set for approach and corresponding instruments in agreement.		
Fuel	F/E	SET FOR LANDING
Check all main tank boost pump switches ON, all main tank LOW PRESSURE lights extinguished, system configured main-tank-to-engine and fuel heater switches OFF.		
Hydraulics	F/E	PRESS & QTY NORMAL
Check utility and AC auxiliary pump switches ON, all LOW PRESS lights extinguished and quantity normal.		
Descent-Approach Checklist	F/E	COMPLETE

31.6 Landing Checklist

Prior to landing, when directed by the Captain, the Flight Engineer will read the following challenges and receive the specified response from the appropriate crew member.

Item	Crew	Response
Speed brake Lever	CAPT	FULL FORWARD
Spoiler Switches	CAPT	ON
No Smoking Switch	F/E	ON
Gear	CAPT	DOWN, IN, 3 GREEN
Check landing gear lever positioned down and in, and 3 green landing GEAR DOWN lights illuminated.		

Item	Crew	Response
Anti-Skid	F/E	4 RELEASES
Flaps	CAPT	50, 50, GREEN LIGHTS
Check inboard and outboard flaps at selected landing flap position, and green LE FLAP lights illuminated.		
Hydraulics	F/E	PRESS & QTY NORMAL
Landing Checklist	F/E	COMPLETE

31.7 After Landing Checklist

When clear of the active runway, the Captain will call for the After Landing Checklist. The Flight Engineer will read silently each challenge and verify that the appropriate action has been accomplished. If any action has not been accomplished, he will read aloud the challenge to the designated crew member and after the action has been completed, receive the correct response. After all actions have been completed and verified, the Flight Engineer will announce to the Captain: After Landing Checklist complete.

Item	Crew	Response
Anti-Ice	F/O	OFF/ON
Engine Start Control Selectors	F/E	OFF
Window Heat	F/O	LOW/OFF
Window heat may remain in LOW if through flight is planned.		
Probe Heat	F/O	OFF
Flaps	F/O	UP, NO LIGHTS
Check flap indicator zero and LE FLAPS lights extinguished.		
Speed brake Lever	CAPT	FULL FORWARD
Radar & Transponder	F/O	STDBY/OFF

Item	Crew	Response
Galley Power	F/E	OFF
Fuel	F/E	1 PUMP/ENGINE
Check one boost pump is on in each main tank which is supplying fuel to an operating engine.		
Hydraulics	F/E	PRESS & QTY NORMAL
APU (If Required)	F/E	ON BUS
If APU on bus, verify APU generator is providing power to all load busses.		
Outflow Valves	F/E	OPEN
After Landing Checklist	F/E	COMPLETE

31.8 Shutdown Checklist

After parking the airplane, and when commanded by the Captain, the Flight Engineer will read aloud each challenge and receive the appropriate response for the items accomplished by Captain and First Officer, reading and responding in a normal voice those items accomplished by himself. On a through flight the checklist will be read down to the line. On a terminating flight complete the checklist.

Item	Crew	Response
Electrical	F/E	EXTERNAL/APU POWER ON
Seat Belts Switch	F/E	OFF
Beacon	F/O	OFF
Exterior Lights	F/O	AS REQUIRED
Check all exterior lights not required: OFF		
Start Levers	CAPT	CUTOFF
Parking Brakes	CAPT	RELEASED/SET
Fuel Boost Pumps	F/E	OFF
AC Aux Pumps	F/E	OFF

Item	Crew	Response
Air Cond Units	F/E	OFF
Shutdown Checklist (Through Flight)	F/E	COMPLETE
If terminating flight:		
Emergency Exit Lights	F/O	OFF
Ext/APU Power	F/E	OFF
Battery	F/E	OFF
Oxygen Regulators	CAPT, F/O, F/E	OFF, 100%
Shutdown Checklist (Terminating Flight)	F/E	COMPLETE

PART V — OPERATING PROCEDURES

Chapter 32 — Amplified Procedures

About this chapter

Presents the long-form, step-by-step normal procedures underlying the concise checklist cards in Chapter 31. Where a procedure is split by crew position, it is broken into its own subsection for the Captain (CAPT), First Officer (F/O), Flight Engineer (F/E), or Navigator (NAV). The Crew column indicates which position performs or calls each item where specified in the source procedure. This reference reflects procedural content at the highest level of detail modeled in the simulation and may be condensed at lower checklist-detail settings.

32.1 General

Any lights which are not illuminated during a system test should be checked by press-to-test.

32.2 Cockpit Safety Inspection

This inspection is performed on each originating trip or crew change to ensure the cockpit controls are configured so as to permit electrical hydraulic and pneumatic power to be safely applied to the airplane at the proper time.

Item	Crew	Response
Emergency Flap Switches		OFF
Check: Arming switch guard closed. Inboard and outboard switches off.		
Landing Lights Switches		OFF
Landing Gear Lever		DOWN
CAUTION: *LANDING GEAR LEVER SHOULD NOT BE PLACED IN OFF DURING GROUND OPERATION DUE TO POSSIBILITY OF COLLAPSING NOSE GEAR.*		
Radar Mode Selector		OFF
Transponder Mode Selector		STBY
Galley Power Switch		OFF
AC Aux Pump Switches		OFF
Fuel Dump Panel Cover		CLOSED

32.3 Preliminary Prep

(Beginning with no power on airplane) Cockpit systems and controls are checked for normal operation, and the airplane is configured for exterior inspection, if required, and engine start.

Item	Crew	Response
Circuit Breakers		CHECK
Check circuit breakers set or collared.		

Item	Crew	Response
Radio Master Switches		OFF
External Power Switch		OFF
Battery Test		
NOTE: *If APU in operation, do not switch battery OFF for test. This would shut down the APU.*		
DC Load & Volts Selector		BATT
Battery Switch		OFF
Check DC volt meter indicates at least 24V & load meter indicates zero.		
Battery Switch		GUARD CLOSED
Position battery switch guard closed and check generator breaker CIRCUIT OPEN lights illuminated. Check DC volt meter indicates 24V & load meter indicates positive or zero.		
APU Fire & Overheat Test Switch		TEST
Check that the fire warning bell rings and that the APU Fire Warning and Master Fire Warning lights illuminate.		
APU		START
AC Paralleling Selector		APU
Check voltage and frequency stabilized within limits.		
APU Generator Switch		ON
APU Bleed Valve Switch		OPEN
Essential Power Source Selector		APU
Check essential power failure warning lights extinguish.		
Radio Master Switches		ON

32.3.1 Preliminary Prep — Captain

Item	Crew	Response
Panel Lights		TEST
Check all panel lights can be adjusted to desired intensity.		
Mach Airspeed Warning Test Switch		TEST
Check Mach airspeed warning sounds intermittently.		
Mach Trim		TEST & RE-ENGAGE
If MACH TRIM DISENG light extinguished proceed to Mach Trim Test. If MACH TRIM DISENG light illuminated proceed to Mach Trim Engage.		
Mach Trim Engage		
Automatic Stabilizer Trim Cutout Switch		CUTOUT
Stabilizer Trim Switch		ACTUATE MOMENTARILY
Automatic Stabilizer Trim Cutout Switch		NORMAL
Check MACH TRIM DISENG light extinguishes.		
Rudder Switch		GUARD CLOSED
Spoiler Switches		GUARDS CLOSED

Item	Crew	Response
Fire Warning Test		
Engine Fire Switches		IN
Transfer Switches		NORM
Engine Fire Test Switch		ENGINE FIRE & HOLD
Check engine fire warning bell rings and numbered fire warning and master FIRE warning lights illuminate.		
Engine Fire Test Switch		RELEASE
Check engine fire warning and W/WELL FIRE warning lights extinguish.		
Engine Fire Test Switch		DISCRIMINATOR & HOLD
Check SHORT CIRCUIT lights illuminate.		
Engine Fire Test Switch		RELEASE
Check SHORT CIRCUIT lights extinguish.		
Engine Start Control Selectors		GUARDS CLOSED
Wing Anti-Ice Switch		OFF
No Smoking & Seat Belts Switches		ON
Check chime sounds twice when seat belt switch positioned to ON.		
Emergency Exit Lights Test		
Emergency Exit Lights Switch		ON
Check emergency exit lights illuminated.		
Emergency Exit Lights Switch		OFF
Check emergency exit lights extinguished. CAUTION: THIS CHECK SHOULD BE ACCOMPLISHED QUICKLY TO AVOID DEPLETION OF EXIT LIGHT BATTERIES.		
Personnel Accommodations Call Switch		PRESS
Check chime sounds in forward cabin area.		
Cabin Attendant Call Switch		PRESS
Check chime sounds in forward cabin area.		
Yaw Damper Switch		ON
Check engage light extinguished.		
Window Heat Test		
Window Heat Switches		LOW
Overheat Lights		PRESS
Check OVERHEAT lights illuminate.		
Window Heat Switches		OFF
Check OVERHEAT lights extinguish.		
Window Heat Switches (If Required for Defogging)		LOW
CAUTION: *WINDOW HEAT SWITCHES SHOULD BE OFF IF SLIDING WINDOWS ARE TO BE OPEN FOR MORE THAN 10 MINUTES WHEN OAT IS 70°F (21°C) OR BELOW.*		
Probe Heater Switches		OFF

Item	Crew	Response
Wheel Well, Wing and Navigation Light Switches		ON
Pneumatic Brake		CHECK
Check pneumatic brake handle safetied. Check emergency brake pressure indicates 1200 ± 50 psi.		
Thrust Reverser Operating Lights		EXTINGUISHED
Engine Instruments		CHECK
Check: EPR indicators 1.0 and bugs move freely. N1 RPM indicators zero. EGT indicators normal. Fuel flow indicators minimum indication.		
Landing Gear Lights		CHECK
Check: Landing GEAR warning light extinguished. Landing gear DOOR warning light extinguished (doors closed) or illuminated (doors open). Landing GEAR down lights illuminated.		
Warning Lights Intensity Switch		DAY, THEN NIGHT
Check green lights change intensity.		
Warning Lights Intensity Switch		AS DESIRED
Flap Lever & Indicators		IN AGREEMENT
Total Air Temperature Indicator		CHECK
Check TAT OFF flag not in view.		
Brake Accumulator Precharge		CHECK
Actuate brake pedals until hydraulic brake pressure steady. Check pressure stabilized at precharge.		
Takeoff Warning Horn		CHECK
With flaps or stabilizer out of takeoff range or speed brake lever out of full forward:		
Engine No. 3 Thrust Lever		ADVANCE UNTIL HORN SOUNDS
Thrust Lever		RETARD TO IDLE

32.3.2 Preliminary Prep — Flight Engineer

Item	Crew	Response
Panel Lights		TEST & SET
AC Paralleling Selector		ANY GEN
Check synchronization lights illuminate.		
Essential Power Failure Warning Lights		TEST
Rotate essential power source selector to any GEN position and check both essential power FAILURE lights illuminated. Rotate selector back to EXT PWR position and check lights extinguished.		
DC Load & Volts Selector		TEST
Select TR No. 4, 3, 2 and ESS TR and check 24-28V DC and equal load indication on DC meters at 4, 3 & 2 positions. Leave selector in ESS TR position.		
Galley Power Switch		ON
AC Electrical System		CHECK

Item	Crew	Response
Check: Generator drive disconnect switch guards closed & safetied. Generator drive LOW PRESSURE lights illuminated. Generator drive oil temperature rise indicators in green band. Bus-Tie breaker CIRCUIT OPEN lights extinguished. Generator breaker CIRCUIT OPEN lights illuminated. Generator control OFF lights extinguished. KW/KVAR meters zero.		
Fuel System Test		
NOTE: *Note initial fuel quantity indications.*		
Fuel Quantity Gages Test Switch		PRESS & HOLD
Check each tank quantity indication decreases.		
Fuel Quantity Gages Test Switch		RELEASE
Check all quantity indicators stabilize at original indications. Check fuel totalizer quantity agrees with sum of fuel quantity indications.		
All Forward Boost Pump Switches		ON
Check all forward LOW PRESSURE lights extinguish and all aft LOW PRESSURE lights remain illuminated.		
Center Tank Left Boost Pump Switch		ON
(Only when tank contains fuel.) Check center tank left LOW PRESSURE light extinguishes and right LOW PRESSURE light remains illuminated.		
All Forward Boost Pump Switches		OFF
Center Tank Left Boost Pump Switch		OFF
Check all LOW PRESSURE lights illuminated. Repeat procedure for all aft boost pumps and center tank right boost pump.		
Tank No. 2 Aft Boost Pump Switch		ON
All Crossfeed Selectors		CLOSE
Check VALVE POSITION lights illuminate momentarily, then extinguish.		
All Crossfeed Selectors		OPEN
Check VALVE POSITION lights illuminate momentarily, then extinguish.		
Reserve Tank Fuel Transfer Selectors		OPEN
Check VALVE POSITION lights illuminate momentarily, then extinguish.		
Reserve Tank Fuel Transfer Selectors		CLOSE
Check VALVE POSITION lights illuminate momentarily, then extinguish.		
Fuel Temperature Selector		NO. 1 TANK, ENG 1, ENG 2, ENG 3, ENG 4
Check temperature indication at each position.		
Fuel Temperature Selector		NO. 1 TANK
Fuel Heat Switches		OFF
Check fuel icing lights extinguished.		
Hydraulic Systems Test & Set		
Hydraulic Reservoir Indicator		FULL
Ground Clearance for Hydraulic Pump Operation - OBTAIN		
Engine 2 and 3 Pump Switches		ON
Hydraulic Fluid Shutoff Switches		GUARDS CLOSED & SAFETIED
Interconnect Valve Switch		BRAKE

Item	Crew	Response
AC Auxiliary Pump No. 2 Switch		ON
Check: AC auxiliary pump No. 2 LOW PRESS light extinguished and AC auxiliary pump No. 1 LOW PRESS and both engine driven pump LOW PRESS lights illuminated. Rudder pressure at least 2800 psi. YAW DAMP ENGAGED light illuminated, RUDDER BOOST LOW PRESS light extinguished and hydraulic brake pressure at least 2800 psi. Check utility hydraulic pressure remains at precharge.		
Interconnect Valve Switch		SYSTEM
Check utility hydraulic pressure remains at precharge and hydraulic brake pressure at least 2800 psi.		
Parking Brakes		SET
Check hydraulic brake pressure drops, then stabilizes.		
AC Auxiliary Pump No. 2 Switch		OFF
Check AC auxiliary pump No. 2 LOW PRESS light illuminated.		
AC Auxiliary Pump No. 1 Switch		ON
Hydraulic System		CHECK
Check: AC auxiliary pump No. 1 LOW PRESS light extinguished, both engine pump LOW PRESS lights illuminated and rudder and utility hydraulic pressures rise, then stabilize. YAW DAMP ENGAGED light illuminated hydraulic brake pressure rises, then stabilizes and leading edge flap lights extinguish.		
NOTE: *If the Utility pressure does not rise, then stabilize, position the Interconnect Switch to OFF. If then the RUDDER pressure increases to a minimum of 2800 PSI, the auxiliary hydraulic system check is satisfactory.*		
Engine Vibration Monitor Systems Test		
Pickup Selector		DIFF
Test Switch		PRESS & HOLD
Check amplitude 4.0 ± 0.5 mils on each indicator in each position of vibration filter selector.		
Pickup Selector		TURB
Check amplitude 4.0 ± 0.5 mils on each indicator in each position of vibration filter selector.		
Test Switch		RELEASE
Engine Instruments		CHECK
Check: N2 RPM and oil pressure indicators zero. Oil temperature indicators within normal range.		
Equipment Cooling System Check		
Equipment Cooling Blower Switch		NORM
Overboard Dump Switch		NORM
Check NO AIR FLOW light extinguished and VALVE OPEN light illuminated.		
Engine Oil Quantity Indicators Test		
NOTE: *Note initial oil quantity indications.*		
Engine Oil Quantity Test Switch		PRESS & HOLD
Check all oil quantity indications decrease.		
Engine Oil Quantity Test Switch		RELEASE
Check all oil quantity indications stabilize at approximately original indications.		
Engine Oil Quantities		CHECK
Check oil quantities adequate for dispatch.		
Pressurization System Test & Set		
Rate Selector		SET

Item	Crew	Response
Rotate to upper end of index mark.		
Takeoff-Landing Mode Switch		LANDING
Altitude Selector		SET
Position selector to planned cruise altitude plus 2000 ft.		
Barometric Correction Selector		SET
Set to 29.92		
Outflow Valve Balance Selector		NORMAL
Pressurization Manual Control		HOLD
Auto-Manual Mode Switch		AUTO
Check outflow valve position indicators open.		
Takeoff-Landing Mode Switch		TAKEOFF
Check outflow valve position indicators move toward close.		
Takeoff-Landing Mode Switch		LANDING
Check outflow valve position indicators move toward open.		
Cabin Rate of Climb Indicator		ZERO
Cabin Differential Pressure Indicator		ZERO
Air Conditioning System Test & Set		
Cabin Air Temperature Source Selector		CHECK
Rotate selector to FWD, MID, AFT and INLET DUCT and check for normal indications at each position.		
Air Supply Duct Pressure		CHECK
Zero unless ground air supplied.		
Crew & Main Temperature Selectors		AUTOMATIC & SET
Check FAULT light extinguished.		
Crew and Main Duct Overheat Lights		EXTINGUISHED
Air Conditioning Unit Switches		OFF/ON
Check unit OVERHEAT lights extinguished.		
Engine Bleed Air Switches		OFF
Wing Valve Switches, L and R		OPEN
Air Compressor LOW OIL PRESS Lights		ILLUMINATED
Air Compressor RPM Indicators, Eng's 2, 3 & 4		0.2
Ram Air Switch		GUARD CLOSED
Crew Aux Heat Valve Switch (C Model Only)		GUARD CLOSED
Coolant Air System		
Valve Selector		INLET
Check LH and RH valves indicate full open.		

Item	Crew	Response
Valve Selector		EXIT
Check LH and RH valves indicate full closed.		
Valve Selector		SEC HEAT EXCH
Check LH and RH valves indicate full open.		
Valve Selector		TURBOFAN EXIT
Check LH and RH valves indicate full open.		
Valve Selector		TEMP CONTROL
Check LH and RH valves indicate full closed (modulating if A/Cond on).		
Turbofan Exit Valve Override L and R Switches		NORMAL
Air Conditioning System Test & Set		
Main Cabin Heating Panels Switch		AS REQUIRED
Note: Not normally required on ground unless outside temperatures are below freezing; may be used as desired for passenger comfort. Under these conditions, surface covering temperatures are thermostatically regulated to provide comfortable heat augmentation.		
Gasper Air Fan Switch		AS REQUIRED
Cabin Temp Zone Control		CHECK
Check OVERHEAT light extinguished and valve indicators mid position (valves closed).		
Fuel Dump Panel Cover		CLOSED
Oxygen Pressure Indicators		CHECK
Verify bottles are serviced by reference to pressure-temperature charts.		
Flight Recorder		SET
Enter flight number and date.		
APU		CHECK
Check all indicators and annunciator lights are proper for APU condition.		

32.4 Exterior Inspection

Item	Crew	Response
Nose Section		CHECK
Check: Left pitot clear. Radome in acceptable condition and secure. Right pitots clear. TAT probe clear and undamaged. Fuselage skin in acceptable condition. Forward Service panels closed if not in use.		
Nose Gear and Wheel Well		CHECK
CAUTION: *NOSE GEAR GROUND LOCK HANDLE SHOULD BE INSTALLED WHENEVER HYDRAULIC SYSTEM IS NOT PRESSURIZED. Check: Condition and inflation of tires acceptable. Nose gear strut extension for satisfactory exposed inner cylinder surface. Steering cylinders, cables and fairings in acceptable condition. Nose wheel well light illuminated. Nose gear lock inspection window clean. Nose gear ground lock in place. Steering links connected and pinned unless airplane to be pushed back. Nose gear door actuating arms reconnected. Shutoff valve plunger riding on cam.*		
Lower Nose Compartment Door		CLOSED AND LATCHED
Forward Fuselage - Right Side		CHECK

Item	Crew	Response
Check: Forward water drain mast clear and heated. Air flow from equipment cooling overboard vent and potable water door closed. Lower VHF antenna in acceptable condition. Static ports clear. Right wing illumination light illuminated. Forward Cargo door; if closed, check door latched. Crew and personnel accommodations oxygen thermal discharge disc in place. Alternate static port clear. Preconditioned air connection access panel closed and latched, if not in use. Forward outflow valve open. Coolant air inlet clear. Runway turnoff and fixed landing lights extinguished, lenses intact and clear.		
Right Wing and Engines No. 3 and 4 Check		
NOTE: *Check: Inboard wing under surfaces, stall warning transducer leading edge flaps in acceptable condition, no evidence of fluid leakage and all panels closed and latched.*		
Engine No. 3		CHECK
Engine and strut in acceptable condition, access panels closed and latched, no evidence of fluid leakage. Exhaust section in acceptable condition and unobstructed. Mid wing under surface and leading edge flaps in acceptable condition, no evidence of fluid leakage and all panels closed and latched, if fueling not in progress.		
Engine No. 4		CHECK
Inspection same as No. 3 engine except fire bottle pressure acceptable and bottle discharge indicator discs. Outboard wing under surface and leading/trailing edge flaps in acceptable condition, no evidence of fluid leakage and all panels closed and latched.		
Main Gear Area - Right Side		CHECK
Check: Tire condition and inflation acceptable. Landing gear strut, plumbing and wiring in acceptable condition. Brake wear indication acceptable and no hydraulic fluid leakage. Truck leveling cylinder, leveling switch and truck beam in acceptable condition. Main gear door release handle agrees with gear door position. Wheel well lights illuminated and check Switch in NORMAL position. Brake and truck leveling cylinder lockout deboost handles (5) in green band. Hydraulic system bypass valve safetied CLOSED. Turbofan exit open and clear, coolant air exit valve closed. Wheel well wiring, plumbing, cables and structure in acceptable condition. Raider shutoff valve lockwired OPEN. Main gear inspection window clear.		
Aft Fuselage - Right Side		CHECK
Check: Center wing cavity drain clear. Safety valve closed and cabin air thrust valve vent clear. Lower beacon light lens intact and clean. APU Fire extinguisher bottle discharge indicator discs in place. Fuselage skin in acceptable condition. Fuselage doors and panels (if not in use) closed and latched, no fluid leakage. Aft cargo door; if closed, check door latched. Passenger thermal oxygen relief disc in place. Auxiliary cargo door; if closed, check door latched. Aft outflow valve open, cabin air thrust valve vent clear. Aft service panels closed (if not in use). Aft drain mast clear.		
Empennage and Control Surfaces		CHECK
Check: Upper main wing surfaces in acceptable condition, and vortex generator in place. Horizontal stabilizer under surface. Vortex generators in place. Navigation light lens intact and light illuminated. Fixed and movable surfaces in acceptable condition, no fluid leakage, and panels closed and latched. Static dischargers intact. H.F. antenna probe in acceptable condition. Q-inlet probe in acceptable condition.		
Aft Fuselage - Left Side		CHECK
Inspection same as right aft fuselage. Aft cabin temperature sensor overboard discharge clear.		
Main Gear Area - Left Side		CHECK
Inspection same as right main gear and wheel well with the following exception: Utility hydraulic system fluid above tank sight gage.		
Left Wing and Engine No. 1 and 2		CHECK
Inspection same as right wing and engines No. 3 and 4 except no air compressor on No. 1 engine.		
Forward Fuselage - Left Side		CHECK
Inspection same as right forward fuselage with the following exception: Cabin air thrust valve vent clear. Center wing cavity vent clear. Main cargo door (C model only) closed and locked if not in use. Main cargo door lock indicators in view (4 places) and (2) pressure panels flush.		

32.5 Cockpit Prep

32.5.1 Cockpit Prep — Captain

Item	Crew	Response
Radio Altimeters		TEST
MDA Bugs		SET APPROXIMATELY 20 FEET
Check MDA lights on approach progress displays illuminate.		
Panel Lights		SET
Flight Recorder		ON
Check OFF light extinguished.		
Mach Airspeed Warning Test Switch		PRESS
Check Mach-airspeed warning sounds intermittently. Originating flight or crew change check is accomplished by Flight Engineer.		
Anti-Skid On & Test		
Anti-Skid Switch Guard		CLOSED
Check anti-skid switch guard closed.		
Anti-Skid Test Switch		OUTBD & HOLD
Check inboard REL lights illuminate, and outboard REL lights remain extinguished.		
Anti-Skid Test Switch		INBD & HOLD
Anti-Skid Test Switch		RELEASE
Selcal		SET
Place selcal switches as desired.		
Marker Beacon Sensitivity Selector		SET
Compass Controller Mode Switch		SLA
Emergency Exit Lights Switch		GUARD CLOSED
Exterior Lights		SET
Check: Wheel well lights switch NORM. Wing lights switch ON/OFF. Beacon light switch OFF. Runway turnoff lights switch OFF.		
Flight Director (If Required)		TEST & SET
Pneumatic Brake		CHECK
Check pneumatic brake handle safetied and emergency brake pressure indicates 1200 ± 50 psi. Originating flight or crew change check is accomplished by Flight Engineer.		
Flight Instruments Check & Set		
Mach Airspeed Indicator		CHECK & SET
Check airspeed pointer zero, Mach indicator warning flag retracted. Set V1, VR, and V2 airspeed bugs in accordance with takeoff data card, if available.		
ADI		CHECK
Check warning flag retracted.		
Current Barometric Pressure		SET
Check altitude comparable with field elevation.		
Radio Altimeter		CHECK

Item	Crew	Response
Check warning flag retracted and pointer at zero.		
Clock		WIND & SET
HSI		CHECK & SET
Set heading pointer and desired course for departure.		
RMI		CHECK & SET
Vertical Speed Indicator		CHECK
Check pointer at zero.		
HSI Source		LOC/VOR
True Airspeed Indicator		CHECK
Check warning flag retracted.		
Standby Horizon		CHECK & SET
Check warning flag retracted, gyro erect and airplane symbol properly positioned.		
EPR Gauge Bugs		CHECK & SET
Set EPR bugs in accordance with takeoff data card, if available.		
Weather Radar		STANDBY
Range Marks		SET AS DESIRED
Speed Brake Lever		FULL FORWARD
Engine Controls		SET FOR START
Check reverse thrust levers full down, thrust levers closed and engine start levers CUTOFF.		
Parking Brake		SET
Stabilizer Trim Test		
NOTE: *Coordinate with F/O stabilizer trim test. Ensure both stabilizer trim wheel handles are retracted.*		
Stabilizer Trim Switches		NOSE DOWN & HOLD
Check stabilizer trim wheels and indicators move nose down and stabilizer trim operating light illuminates.		
Main Electric Trim Switch		CUTOUT
Check trim wheels stop and light extinguishes.		
Main Electric Trim Switch		NORMAL
Check trim wheels move and light illuminates.		
Stabilizer Trim Switches		NOSE UP AND HOLD
Check stabilizer trim wheels and indicators move nose up and stabilizer trim operating light illuminates.		
Stabilizer Trim Switches		RELEASE
VHF Navigation		SET FOR DEPARTURE
Departure Frequency		SET
Identify station. Check HSI VOR/LOC warning flag retracted. Check RMI bearing pointers for proper bearing. Perform system test if required.		
DME Mode Selector		TEST & HOLD
DME displays indicate all zeroes and off flags retract.		
Communications		SET FOR DEPARTURE

Item	Crew	Response
Autopilot		DISENGAGED
Perform autopilot test if required.		
ADF		SET FOR DEPARTURE
Rudder Trim Free & Zero		
Rudder Trim		FULL LEFT THEN FULL RIGHT
Check for freedom of travel and corresponding rudder pedal movement.		
Rudder Trim		ZERO
Aileron Trim Free & Zero		
Aileron Trim		FULL LEFT THEN FULL RIGHT
Check for freedom of travel and corresponding control wheel movement.		
Aileron Trim		ZERO
When cleared for engine start:		
Beacon Switch		ON

32.5.2 Cockpit Prep — First Officer

Item	Crew	Response
Panel Lights		SET
Adjust panel lights to desired intensity.		
Compass Controller Mode Switch		SLA
Radio Altimeters		TEST
MDA Bugs		SET APPROXIMATELY 20 FEET
Check MDA lights on approach progress displays illuminate.		
MDA Bug Controls		SET TO ZERO
Check MDA lights extinguish.		
Yaw Damper		ENGAGED
Check YAW DAMP ENGAGED light illuminated.		
Window Heat		LOW
CAUTION: *SLIDING WINDOWS SHOULD BE CLOSED TO AVOID OVERHEATING.*		
Flight Director (If Required)		TEST & SET
Altitude Alert		TEST & SET
Current Barometric Pressure		SET
Altitude Selector		SET MORE THAN 1000 FEET ABOVE FIELD ELEVATION
Altitude Selector		SLOWLY RESET TO FIELD ELEVATION
As the selected altitude nears 1,000 feet above field elevation, check tone sounds once, and ALTITUDE ALERT lights illuminate. As selected altitude nears 375 feet above field elevation check ALTITUDE ALERT lights extinguish.		
Transponder		SET & STANDBY
Set desired code.		

Item	Crew	Response
Takeoff Data		CHECK
Verify takeoff data, and display takeoff data card on forward panel.		
Stabilizer Trim		TEST
Coordinate with Captain's stabilizer trim test.		
Stabilizer Trim Switches		NOSE UP THEN NOSE DOWN
Verify stabilizer trim wheels move for corresponding switch position, and stabilizer trim light illuminates during the test.		
Stabilizer Trim		SET
Set stabilizer trim units in accordance with takeoff data card.		
Flight Instruments		CHECK & SET
Check and set as described for Captain.		
Ground Proximity System Test Switch		PUSH & HOLD
Check aural warnings sound and GRD PROXIMITY lights illuminate momentarily. Check warnings discontinue for a short time and resume.		
Ground Proximity System Test Switch		RELEASE
Check warnings discontinue after a short time.		
VHF Navigation		SET FOR DEPARTURE
Departure Frequency		SET
Identify station. Check HSI VOR/LOC warning flag retracted. Check RMI pointers for proper bearing. Perform system test if required.		
DME Mode Selector		TEST & HOLD
DME displays indicate all zeroes and off flags retract.		
Communications		SET FOR DEPARTURE
ADF		SET FOR DEPARTURE

32.5.3 Cockpit Prep — Flight Engineer

Item	Crew	Response
If inflight flaps up weight will not exceed normal max. inflight weight, flaps up, and center tank fuel (other than payload fuel) is less than 20,000 lb (9000 kg), or empty:		
Main Tank Boost Pumps		1 ON PER TANK
Position one boost pump switch ON in tanks No. 1, 3 & 4. Check No. 2 ON. Check associated LOW PRESSURE lights extinguished.		
Crossfeed Selectors No. 1, 3 & 4		CLOSE
Check VALVE POSITION lights illuminate, then extinguish. Check crossfeed selector No. 2 open.		
If inflight flaps up weight will not exceed alternate max. inflight weight, flaps up, and center tank fuel (other than payload fuel) exceeds 20,000 lb (9000 kg):		
Tank No. 2 & 3 & Center Tank Boost Pumps		1 ON PER TANK
Position one boost pump switch ON in tanks No. 3 & center. Check No. 2 ON.		
Crossfeed Selectors No. 2 & 3		CLOSE

Item	Crew	Response
Check VALVE POSITION lights illuminate then extinguish. Check crossfeed selector No. 1 & 4 open.		
When cleared for engine start:		
Galley Power Switch		OFF
Air Conditioning Unit Switches		OFF

32.5.4 Cockpit Prep — Navigator

Item	Crew	Response
Table, Panel and Flood Lights		SET
Adjust lights to desired intensity.		
Ram Air Temperature Indicator		CHECK
Altimeter		SET
Set current barometric pressure and cross check with field elevation.		
RMI		CHECK
Check warning flag retracted. Cross check heading with all compasses.		

32.6 Engine Start Procedure

The normal engine starting sequence is 3, 4, 2, 1.

Item	Crew	Response
Engine Start Sequence	CAPT	ANNOUNCE
Announce engine start sequence.		
Announce Start Engine No. __	CAPT	ANNOUNCE
Announce "Start Engine No. ___".		
Engine Start Control Selector	F/O	GROUND
Position selector.		
Engine Run-up	F/E	ANNOUNCE
Check decrease in duct pressure and announce "Start Valve Open". Announce "N2 Rotating, Oil pressure rising" (within 30 sec.) Announce "15% N2".		
Engine Start Lever	CAPT	Start Detent
Position Engine Start Lever to START detent when 15% N2 RPM reported and N 1 rotation observed.		
Fuel Flow & EGT	CAPT	CHECK
Check fuel flow and EGT indication.		
Engine Start Control Selectors		CHECK
Check that the selector is in the OFF position.		
N2 & Duct Pressure	F/E	ANNOUNCE
Call "35% N2." Check rapid increase in duct pressure and announce "Starter Cutout".		
ENG LOW PRESS Light	CAPT, F/O	CHECK
Check ENG LOW PRESS light extinguished.		
Oil Pressure	F/E	CHECK
Check oil pressure stabilizes within limits.		

Item	Crew	Response
EGT & Normal Engine Indications	CAPT, F/O	CHECK
Check EGT stabilized, and engine instruments for normal indications.		
Engine Start Lever		IDLE DETENT
NOTE: *Use same procedures for starting remaining engines.*		
CAUTION: *ADVANCING ENGINE START LEVER PREMATURELY CAN CAUSE A HOT START.*		
CAUTION: *KEEP HAND ON ENGINE START LEVER WHILE OBSERVING RPM, EGT, AND FUEL FLOW UNTIL STABILIZED.*		
CAUTION: *IF FUEL IS SHUT OFF INADVERTENTLY, BY CLOSING ENGINE START LEVER, DO NOT REOPEN ENGINE START LEVER IN AN ATTEMPT TO RESTART ENGINE.*		
CAUTION: *FAILURE TO HOLD ENGINE START CONTROL SELECTOR IN GND UNTIL STARTER CUTOUT RPM IS REACHED CAN RESULT IN A HOT START. DO NOT RE-ENGAGE ENGINE START CONTROL SELECTOR UNTIL ENGINE HAS STOPPED ROTATING. STARTER DRIVE SHAFT MAY SHEAR IF STARTER IS ENGAGED DURING COAST DOWN.*		

32.7 After Start Procedure

Item	Crew	Response
APU Bleed Valve Switch		CLOSED
Airplane Electrical Power		ESTABLISH
AC Paralleling Selector		GEN 2, GEN 1 return to GEN 3
Check voltage and frequency in GEN 2 and GEN 1 positions.		
Essential Power Selector		GEN 2, GEN 1 return to GEN 3
Check Essential Power FAILURE warning light extinguished in GEN 2 and GEN 1 positions.		
Generator Breaker Switches		GEN 2 - CLOSE, GEN 1 - CLOSE
Check generator breaker CIRCUIT OPEN lights extinguish.		
Air Compressor 2, 3, and 4 Start Switches		START
Galley Power Switch		ON
Fuel Boost Pump Switches		ON
Position appropriate boost pump switches ON for fuel configuration and check associated LOW PRESSURE lights extinguish.		
Hydraulic System		
AC Auxiliary Pump No. 2 Switch		ON
Check LOW PRESS light extinguishes.		
Engine Pump No. 3 Switch		OFF
Check LOW PRESS light illuminates and utility system pressure indicates 2800-3100 psi at idle thrust.		
Engine Pump No. 2 Switch		OFF
Check LOW PRESS light illuminates and utility pressure decreases, indicating interconnect valve closed.		
Engine Pump No. 3 Switch		ON
Check LOW PRESS light extinguishes and utility system pressure indicates 2800-3100 psi at idle thrust.		
Engine Pump No. 2 Switch		ON

Item	Crew	Response
Check LOW PRESS light extinguishes.		
Interconnect Valve Switch		OFF
Check utility, brake and rudder pressure indicate 2800-3100 psi.		
Air Compressor 2, 3, and 4 Indications		CHECK
Check air compressor tachometers stabilized and LOW OIL PRESS lights extinguished.		
Air Conditioning Unit Switches		ON
After external air is disconnected: Position air conditioning unit switches ON individually. Check duct pressure decreases (approx 1 to 5 psi drop) as each valve opens.		
APU Master Switch		OFF
Operate APU with no pneumatic load for 1 minute or until EGT decreases below 350°C, whichever occurs first, before positioning the APU Master Switch to OFF. Check all door annunciator lights extinguished.		

32.8 Taxi Procedure

Good taxi technique requires an awareness of the proximity of obstacles, the effects of excessive noise, the force of the jet exhaust, and the possibility of ingestion of foreign objects.

Item	Crew	Response
NOTE: *Nose wheel steering and engine thrust are used for directional control. To make smooth turns grasp the steering wheel firmly and pressure it in the desired direction.*		
NOTE: *The airplane should be taxied with all four engines at idle thrust. When an outboard engine is used to assist in a turn use as little power as possible.*		
NOTE: *Differential braking is not normally used for steering during taxi and should not be used in conjunction with nose wheel steering.*		
NOTE: *At light gross weights allow the airplane to accelerate, then brake to a very slow taxi speed, release the brakes and repeat the sequence.*		
Taxi Clearance		OBTAIN
Parking Brake		RELEASE
Check parking brake lever returns to OFF position and parking brake warning light extinguishes.		
Taxi		INITIATE
Flaps		EXTEND
Check LE FLAPS lights illuminate and both outboard and inboard flap position indicators indicate 14.		
Exterior Lights		SET
Strobe Lights		ON
Retractable and Fixed landing lights, Runway Turn off lights		AS REQUIRED
Nacelle Anti-Ice		TEST, OFF/ON
Accomplish the Nacelle Anti-ice Test, checking the valve open light for each of the 3 valves. When anti-ice is not required, leave the nacelle anti-ice switches OFF. When icing conditions exist, or are anticipated, leave all nacelle anti-ice switches ON and check that all valve open lights remain illuminated. Icing conditions exist when the OAT on the ground and for takeoff, or TAT inflight is 10°C or below, and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet and ice crystals). Icing conditions also exist when the OAT on the ground and for takeoff is 10°C or below when operating on ramps, taxiways or runways where surface snow, ice, standing water, or slush may be ingested by the engines or freeze on engines, nacelles or engine sensor probes.		

Item	Crew	Response
Attitude Warning		TEST
With Wing Flaps 14, Attitude Warning Switch - OLEO BYPASS & HOLD		
Test Switch and Attitude Warning Switch		RELEASE
Ground Start Switch		GUARD CLOSED
Window Heat Switches		HIGH
Probe Heater Switches		ON
Flight Directors, Flight Instruments and Radios		CHECK, SET FOR DEPARTURE
Check flight director set to desired heading and pitch attitude. Compare indication of all ADI's, HSI's, RMI's, and standby compass during turns. Check radios and HSI's set for departure.		
Stabilizer Trim		SET FOR TAKEOFF
Set stabilizer trim in accordance with computed data. Setting the stabilizer trim anywhere in the green band range is not necessarily satisfactory for takeoff.		
Flight Controls		CHECK
Rotate control wheel full left then full right. Push then pull control column through its full fore and aft travel. Note that initial travel during control tab movement requires only light forces, but heavy forces are required to move control surfaces. (In heavy winds, it may not be possible to move surfaces.) Move rudder pedals through full travel and check for freedom of movement. Check RUDDER LOW PRESS light extinguished and normal pressure fluctuations in utility and rudder system pressures as controls are exercised.		
Engine Operation		CHECK
Check engine indicators normal, warning lights extinguished.		
Electrical System		CHECK
Check generator drive oil temperature rise indicators in green band and generator drive LOW PRESSURE, CIRCUIT OPEN and essential power FAILURE warning lights extinguished. Check KW loads on all 4 generators are approximately equal.		
Fuel System		SET FOR TAKEOFF
CAUTION: *FUEL FROM TANKS TO BE USED FOR TAKEOFF MUST BE SAMPLED FOR A MINIMUM OF 4 MINUTES AT IDLE THRUST. Recheck configuration for fuel load and gross weight. Check fuel heater switches OFF and engine fuel temperatures decreasing or low readings.*		
Hydraulic System		CHECK
Check pressures and quantity normal, pump LOW PRESS lights extinguished.		
Equipment Cooling NO AIRFLOW Light		EXTINGUISHED
Air Conditioning and Pressurization Systems		CHECK
The airplane may be pressurized to a maximum of .125 psi positive cabin differential during takeoff and landing. Check: Duct temperature normal for conditions. MAIN and CREW duct overheat lights extinguished. Unit OVERHEAT and OFF lights extinguished. Operating air compressors for RPM indication and LOW OIL PRESS light extinguished. Temperature control valve positioned as required for existing conditions. Check coolant air system valve selector in TEMP CONTROL and valve position indicator for appropriate indications.		
Takeoff Briefing		CONDUCT
Pilot making takeoff will brief other pilot and Flight Engineer to monitor engine instruments and call out any failure affecting safety. He will request other pilot to hold column forward (with displaced lateral control if in crosswind), to set takeoff EPR to computed value by 80 kts, to call out V1 and Rotate at VR and to silence fire bell if it rings.		
When cleared onto the runway:		

Item	Crew	Response
WARNING: *WHILE THIS POSITION IS THE MOST CONVENIENT FOR FLIGHT ENGINEER, MAXIMUM SAFETY CONFIGURATION IS WITH SEAT FACING FORWARD AND SHOULDER HARNESS ON.*		
One Air Compressor (Normally No. 4)		OFF
Pressurization System		SET FOR FLIGHT
Pressurization Mode Switch		TAKEOFF
Check outflow valves move toward CLOSE. Check cabin vertical speed indicator for selected rate of descent. Check cabin altitude descends to 200 to 250 feet below airport elevation.		
Altitude Alert		SET
Prepare for Takeoff		ANNOUNCE
Notify cabin attendants and passengers over PA system to prepare for takeoff.		
When cleared for takeoff:		
Transponder Mode Selector		ON
Engine Start Control Selectors		Flight Start
Landing Lights		ON

32.9 Climb Procedure

Item	Crew	Response
Autopilot (If Desired)		SET FOR VOR NAVIGATION
Radios		SET FOR VOR NAVIGATION
Tune radios to desired frequencies, check warning flags retracted and identify stations. Set course pointer as desired.		
Autopilot (If Desired)		SET FOR NAVIGATION
With autopilot engaged, position mode selector to HDG and select desired heading. When aircraft is on intercept heading, rotate mode selector to LOC VOR and check autopilot V/L light on approach progress display illuminates amber. When airplane has captured selected radial, observe autopilot V/L light illuminates green.		
Flight Director (If Desired)		MONITOR
Check ADI and HSI warning flags retracted. Position controls on flight director control panel as desired for enroute navigation.		
Climb Thrust		OFF
Reset climb EPR, as necessary, using quick reference data and existing TAT and altitude.		
Landing Lights		OFF
Fixed landing lights should be turned OFF when passing through 10,000 feet.		
Operating Systems		
Electrical System		CHECK
Check: AC voltage and frequency within limits. DC system voltmeter & load meter indications normal. Generator drive LOW PRESSURE lights extinguished. Generator drive oil temperature rise indications normal. Bus tie breaker CIRCUIT OPEN lights extinguished. Generator breaker CIRCUIT OPEN lights extinguished. KW/KVAR loads within limits and balanced.		
Fuel System		CHECK
Check: Operating boost pump LOW PRESSURE lights extinguished. Quantity indicator operation and fuel used consistent with operation. Fuel temperature at least 3°C above fuel freezing point.		

Item	Crew	Response
Hydraulic System		CHECK
Check: Hydraulic quantity indicator reflects gear and flap retraction. Note quantity decreases as OAT decreases, due to cold soak effect at high altitude. Utility hydraulic system pressure normal and rudder pressure reduced to 2250 psi above 245 kt IAS. AC auxiliary and engine pump LOW PRESS lights extinguished.		
Engine Operation		CHECK
Check: Engine vibration indications N1 & N2 indications within limits. EGT indications stabilized & within limits. Fuel flow approximately equal for each engine. Engine oil pressure and temperature indications within limits. Engine oil quantities sufficient for remainder of flight.		
Air Conditioning and Pressurization Systems		CHECK
Check: Cabin altitude ascending at selected rate or stabilized at preset cabin altitude. Cabin differential pressure within limits. The recommended maximum number of pressurization air sources vs altitude: 0-15,000 ft - 2 air compressors; 15-32,000 ft - 3 air compressors; 0-32,000 ft - 1 engine bleed may be substituted for 1 air compressor. Above 32,000 ft - 3 air compressors or 2 air bleeds for each inoperative air compressor. No engine should be used to supply air compressor and engine bleed air at the same time. Check: Conditioned air duct pressure indication in green band. Main and crew cabin temperatures as desired. Air conditioning unit OVERHEAT and OFF lights extinguished. Air compressor LOW OIL PRESS and OVERSPEED TRIP lights extinguished and rpm indication normal for conditions.		
CAUTION: *IMPROPER COMBINATION OF ENGINE BLEED AND AIR COMPRESSORS COULD RESULT IN OVERVENTILATION CREATING EXCESSIVE PRESSURES AND VELOCITIES WHICH MAY DAMAGE DUCTING OR SIDEWALL LININGS AND TRIP AN AIR CONDITIONING UNIT DUE TO OVERHEAT.*		
Coolant Air System		CHECK
Check: Inlet and exit valves positioned OPEN or as desired for performance. Secondary heat exchanger valves positioned to agree with temperature control valve position. Turbo fan exit valve positioned closed. Temperature control valve positioned as required for existing conditions.		
Main Cabin Heating Panels		AS DESIRED
Gasper Fan Switch		AS REQUIRED FOR VENTILATION
Oxygen Systems		CHECK
Check pressures normal.		
Cruise Data		PRECOMPUTE
Compute projected gross weight at level-off. Use appropriate performance tables to determine indicated Mach No. (if required), indicated airspeed, average EPR and fuel flow for cruise.		
Altimeters		SET & CROSS-CHECK
At transition altitude each pilot and navigator sets altimeters to 1013 MB/29.92 in Hg and cross-checks. F/E resets cabin altitude.		
Altitude Alert		SET
Reset assigned altitude.		
Fuel Management (As Required)		ACCOMPLISH

32.10 Cruise Procedure

Item	Crew	Response
Cruise Thrust		SET
When cruise altitude is reached, allow airplane to accelerate slightly higher than cruise chart speed.		
Cruise Thrust EPR		SET
Adjust cruise thrust according to gross weight as fuel is burned off to maintain charted speed schedule. If indicated speed falls below charted value, use up to maximum continuous thrust to recover charted speed.		

Item	Crew	Response
Autopilot (If Desired)		SET FOR DESIRED NAVIGATION
Flight Director (If Desired)		SET FOR DESIRED NAVIGATION
Fuel Management		MONITOR
Accomplish fuel management according to fuel usage procedure. Monitor fuel quantities at frequent intervals. Compute total fuel and gross weight hourly and as required for navigation reports.		
Operating Systems		MONITOR
Continue monitoring operating systems for normal indications.		
Cabin Temperature Zone Control (as desired)		ADJUST
To Warm or Cool the Aft Zone:		
Main Cabin Temperature Selector		SET AS DESIRED
Cabin Air Temperature Indicator (Aft Zone)		MONITOR
To Warm the Fwd or Mid Zone:		
Zone Temperature Control Switch (Affected Zone)		WARMER
Hold the switch for short intervals to produce small increments of temperature change; allow time for affected cabin zone temperature to stabilize. Repeat as necessary.		
Zone Temperature Valve Indicator(s)		MONITOR
Check that zone temperature rises.		
Cabin Air Temperature Indicator (Affected Zone)		MONITOR
Check that zone temperature rises.		
To Cool the Fwd or Mid Zone:		
Zone Temperature Control Switch (Affected Zone)		COOLER
Hold the switch for short intervals to produce small increments of temperature change; allow time for affected cabin zone temperature to stabilize. Repeat as necessary.		
Zone Temperature Valve Indicator(s)		MONITOR
Check that zone temperature rises.		
Cabin Air Temperature Indicator (Affected Zone)		MONITOR
Check that zone temperature decreases.		

32.11 Descent/Approach Procedure

Item	Crew	Response
Pressurization		SET
Move cabin altitude selection indicator to landing field elevation minus 200 to 250 feet. Check cabin rate of descent normal.		
Pressurization Mode Switch		LANDING
Anti-Ice		OFF/ON

Item	Crew	Response
Check anti-ice OFF or ON as required.		
Descent		INITIATE
Coolant Air Valves (19000 Feet)		OPEN
Position inlet and exit valve switches to OPEN. Open exit valve first, then inlet, in increments. Check indicators move to full OPEN position.		
Circuit Breakers		CHECK
Seat Belts Switch		ON
Landing Lights		ON
For collision avoidance turn ON the turn off lights when descending through 10,000 feet.		
Altimeters		SET & CROSS-CHECK
When descending through transition altitude each pilot sets current altimeter setting and cross-checks altimeter readings. F/E sets barometric correction indicator and cabin altitude to altimeter setting of destination airport (QNH).		
Altitude Alert		SET
Reset barometric control.		
Radio Altimeter		SET
Set minimum decision altitude.		
Flight Director (If Required)		SET FOR DESCENT
Position mode selector to HDG or VOR/LOC and altitude hold switch OFF. Set heading pointer to desired heading. Adjust pitch command control for desired descent attitude. ADI command bar directs flight to a selected heading or radial and pitch angle.		
Autopilot (If Desired)		SET FOR DESCENT
Position mode selector to HDG or VOR LOC as desired and position altitude hold switch OFF. Set heading pointer to desired heading. Pitch control may be maintained using the pitch controller. Check airplane tracks selected heading or radial and pitch angle.		
EPR & Airspeed Bugs		SET
Fuel System		SET FOR LANDING
Position all main tank fuel boost pump switches ON and observe all main tank LOW PRESSURE lights extinguish. If fuel temperature is below 0°C, operate fuel heaters for one minute prior to landing. Check fuel heater switches OFF. Set main-tank-to-engine configuration.		
Hydraulic Systems		PRESSURES & QUANTITY NORMAL
If brake pressure increases above 3500 psi, actuate brakes momentarily to bleed off pressure.		
Speed Brake Lever		FULL FORWARD
Spoiler Switches		GUARDS CLOSED
ADF Radios		SET FOR APPROACH
Tune to frequency of outer marker or other fix and identify station. Verify RMI bearing to station.		
VHF NAV Radios		SET FOR APPROACH
Tune to ILS frequency, identify station and observe appropriate ADI and HSI warning flags retracted. Set course pointers/counters to localizer course.		
Autopilot		SET FOR APPROACH
With autopilot engaged, position mode selector to HDG. Select desired heading. When aircraft is on intercept heading, rotate mode selector to G/S AUTO and observe amber illumination of autopilot V/L and G/S annunciators. At ILS entry altitude, place altitude hold switch ON. If ILS coupled approach is not desired, use autopilot in manual mode to make approach, tracking raw data or flight director indications.		

Item	Crew	Response
Flight Director		SET FOR APPROACH
Position mode selector from HDG to AUTO-APP and check flight director V/L and G/S annunciators illuminate amber. Check command bar directs flight on selected heading until localizer capture. Engage altitude hold when appropriate.		
Localizer		CAPTURE (AUTOPILOT)
At 2 dots displacement of course bar, check airplane banks to align with localizer, and autopilot V/L annunciator illuminates green. Check airplane tracks localizer.		
Localizer		CAPTURE (FLIGHT DIRECTOR)
At 2 dots displacement of course bar, check command bar directs a bank to align with localizer and flight director V/L annunciator illuminates green. Check command bars track localizer.		
Glide Slope		CAPTURE (AUTOPILOT)
At glide slope capture, check autopilot G/S annunciator illuminates green, and altitude hold switch trips OFF. Check airplane tracks glide slope.		
Glide Slope		CAPTURE (FLIGHT DIRECTOR)
Immediately prior to glide slope beam center, check command bars direct a pitch-down to track glide slope, altitude hold switch trips OFF, and flight director G/S annunciator illuminates green.		

32.12 Landing Procedure

Prior to and during the final approach, accomplish the following tasks in sequence to properly configure the airplane for landing. The pilot not flying executes standard callouts in the approach.

Item	Crew	Response
CAUTION: *RE-TRIM AIRPLANE ON APPROACH TO MAINTAIN ZERO ELEVATOR CONTROL FORCES. SUFFICIENT ELEVATOR CONTROL FOR FLARE MAY NOT BE AVAILABLE IF STABILIZER TRIM IS SET SO AS TO REQUIRE SUBSTANTIAL BACK PRESSURE ON CONTROL COLUMN TO MAINTAIN FLIGHT PATH AND APPROACH AIRSPEED. LANDING FLARE SHOULD BE PERFORMED BY USE OF ELEVATOR CONTROL ONLY.*		
NOTE: *The Boeing recommended approach speed and wind correction is ½ the steady headwind component plus all of the gust value up to a maximum of 20 knots. In all cases the gust correction should be maintained to touchdown while the steady wind correction may be bled off as the airplane approaches touchdown.*		
NOTE: *Fly the airplane onto the runway at the desired touchdown point. Do not bleed off excess airspeed in the air by holding the airplane off the runway as a long landing will result.*		
NOTE: *It is recognized that the actual wind encountered on the approach may vary from that reported by the tower due to terrain or climatic phenomenon. However, unless actual conditions are known, i.e., reported wind shears or known terrain induced turbulence areas, it can be considered reasonable for convenience of operation and to avoid additional cockpit workload to adjust the approach speed by the ½ steady wind plus gust values as reported by the Tower. Headwind corrections are made for any steady wind in the forward 180° arc ±90° on each side of the runway heading.*		
NOTE: *When the wind is reported calm or light and variable, and no wind shear exists, Vref + 5 knots is the recommended airspeed on the final approach. The 5 knots will normally bleed off during the flare as the airplane approaches touchdown.*		

32.13 After Landing Procedure

Item	Crew	Response
CAUTION: *OPERATING TWO ENGINES IN REVERSE TO DECREASE TAXI SPEEDS MAY RESULT IN ENGINE DAMAGE SINCE THE REVERSE JET BLAST MAY BE SUFFICIENTLY STRONG TO LIFT FOREIGN OBJECTS UP IN FRONT OF ENGINE INLETS. TAXIING IN REVERSE MAY ALSO RESULT IN INGESTION OF EXHAUST GASES INTO AIR CONDITIONING SYSTEM.*		

Item	Crew	Response
Exterior Lights		AS REQUIRED
Flaps		UP, NO LIGHTS
Retract flaps when convenient prior to entering a congested area.		
Speed brake Lever		FULL FORWARD
Anti-Ice Switches		OFF/ON
As required by ground conditions.		
Window Heat		LOW/OFF
On through flights all window heat switches may be left in the LOW position if conditions require. On terminating flights position all switches to OFF.		
Probe Heat Switches		OFF
Radar Mode Selector		STBY/OFF
Position selector to STBY on through flights and to OFF on terminating flights.		
Transponder Mode Selector		STBY/OFF
Position selector to STBY on through flights and to OFF on terminating flights.		
Radios		SET FOR GROUND OPERATION
Engine Start Control Selectors		OFF
AC Paralleling Selector		EXTERNAL POWER
Galley Power Switch		OFF
DC Meter Selector		BATT
If APU to be started.		
Boost Pumps		ONE PER ENGINE
Hydraulic & Brake Pressure		MONITOR
Outflow Valves		CHECK OPEN
APU (If Required)		START
Observe normal indications for APU start.		
APU Generator Switch		AS DESIRED
Air Compressor Switches/APU Bleed		AS DESIRED
Operate at least 2 air compressors for ventilation.		
Coolant Air Valves		CHECK POSITION
Position coolant air valve selector to EXIT and check CLOSED. Position coolant air valve selector to TURBOFAN EXIT and check OPEN. Reposition selector to TEMP CONTROL.		
Gasper Fan Switch		ON
Position gasper fan switch as desired.		

32.14 Parking Procedure

Allow the airplane to roll straight ahead a few feet before stopping following a turn to relieve torsional stresses in the main landing gear structure.

Item	Crew	Response
Parking Brake		SET
Check parking brake warning light illuminates.		
CAUTION: *ASCERTAIN THAT BOTH BRAKE PEDALS REMAIN FULLY DEPRESSED AFTER SETTING PARKING BRAKE TO INSURE BRAKING ON BOTH TRUCKS.*		
CAUTION: *FOLLOWING A HIGH ENERGY STOP OR A SERIES OF SUCCESSIVE FULL STOP LANDINGS, A COOLING PERIOD MUST BE ALLOWED BEFORE SETTING THE PARKING BRAKE. SEE BRAKE LIMITATIONS CHART CHAPTER 23.*		
Air Conditioning Units		OFF
Air Compressors		STOP
Anti-Ice		OFF
Check that the anti-ice is OFF before engine shutdown.		
Engine Start Levers (1, 2, 4)		CUTOFF
Electrical Power		APU
Check external power CONNECTED light illuminates. Position AC paralleling selector to EXT/APU and check frequency and voltage within limits. Position external power switch or APU generator switch to ON and essential power source selector to EXT/APU.		
Engine Start Lever No. 3		CUTOFF
Beacon Light Switch		OFF
Emergency Exit Lights Switch		ARMED/OFF
Emergency exit lights may remain ARMED if through flight is planned.		
Seat Belts Switch		OFF
Parking Brake		RELEASE
Release Parking Brakes when CHOCKS are in place. Check parking brake warning light extinguishes.		
Galley Power Switch (If Required)		ON
Fuel Boost Pumps		OFF
AC Auxiliary Pumps		OFF
Temperature Control Valves		FULL CLOSED
Oxygen Regulators		ON/OFF, 100%
Oxygen supply levers may remain ON if through flight is planned.		
If terminating flight:		
External/APU Power		OFF
Battery		OFF