Black Square

BLACK SQUARE'S STARSHIP

OPERATIONS MANUAL

For Microsoft Flight Simulator

Published By:
Just Flight

"Virtual Aircraft. Real Engineering."

Starship User Guide

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

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Introduction

After a prolonged development period beginning in 1979, the first Starship entered service in 1989. The radical design was intended to replace the King Air fleet, and compete with the equally radical Avia Lear Fan. Only 50 airframes were delivered to customers, and six remain airworthy today. Despite being a notable failure in corporate aviation history, the Starship was one of the most groundbreaking designs ever to see production. It was the first certified canard wing aircraft, the first business aircraft with an all-composite structure, the first certified twin pusher turboprop, the first general aviation aircraft with an all-glass cockpit, and it remains one of only three civilian turboprops with a service ceiling of 41,000 feet. When combined with the sharp appearance of a Burt Rutan design, the Starship is an unforgettable sight, inside and out. The computerized composite construction technology required to create the Starship led the way for the composite airliners of the 21st century, and saw the production of the second largest autoclave in North America. While EFIS screens had started permeating commercial cockpits as early as 1980, the Starship was the first to have a completely glass panel cockpit, where all flight information was presented through computer generated displays. With such novel technology came concerns for operators; therefore, the Starship was equipped with one of the most redundant avionics suites in any aircraft with dozens of possible reversionary modes. More so than most aging aircraft, the Starship is a flying monument to innovation, ambition, and the price paid for being too far ahead of one's time.

Black Square's Starship brings you one of the most technically advanced aircraft simulations for Microsoft Flight Simulator, with over 230 possible failures including new turbine engine failures, an accurate recreation of the one-of-a-kind Collins AMS-850 avionics suite, and the most advanced pressurization and cabin temperature simulations in MSFS. Avionics and instrument panel temperatures are simulated, and require proper management of cooling systems for continued operation. Black Square's new tablet interface lets you configure all options, manage payload, control failures, and monitor engines, electrical schematics, and environmental control systems, all from within the simulator. The failure system allows for persistent wear, MTBF, and scheduled failures for nearly every component in the aircraft. The Starship's electrical system is the most accurate yet for Black Square, featuring the Starship's implementation of the King Air triple-fed bus layout, and backup batteries for essential avionics. All systems in the Black Square Starship were created with reference to over 10,000 pages of operating handbooks, maintenance manuals, parts catalogs, and electrical schematics. Users may choose whether to fly with modern GPS capabilities that have been added to the original AMS-850, with autopilot coupling to a GNS430 for modern approach, departure, and arrival capabilities, or with only the navigational functionality of the original Starship, including VLF and Omega radionavigation. A 190+ page manual provides instruction on all equipment, and 62 in-game checklists with control/instrument highlighting are included for normal, abnormal, and emergency procedures.

This simulation was created in partnership with real Starship owners to ensure the legacy of Starship and the operational knowledge lives on for a new generation of Starship admirers.

For more information on this product's capabilities and a list of all included avionics and equipment, see the extensive operating manual at www.JustFlight.com.

Feature Overview

Black Square’s best aircraft yet will challenge you with unapologetically realistic systems, like…

- **190+ page manual** with your complete guide to flying the Black Square Starship, including systems guide, tutorials, operating limitations, performance tables, and electrical schematics
- **Tablet Interface** for configuring options, payload settings, failure management, and real time visualizers for engines, electrical schematics, and environmental systems.
- **One-of-a-kind Collins AMS-850** “14-tube” (CRT) avionics suite and associated line-replaceable-unit failure logic, quirks, eccentricities, and never-seen-again features of the first all glass panel cockpit and flight management system in a business aircraft.
- **Very Low Frequency (VLF) & Omega** radionavigation systems from the pre-GPS era. Configure the aircraft to tune stations on the other side of the globe, and manage six DME receivers to maintain accurate position information in a time before GPS.
- **Avionics & instrument panel temperature simulation** require you to properly manage the equipment cooling systems on the aircraft, or else be faced with electronics and display failures that will necessitate reversionary modes and hardware redundancy.
- **230+ Random, scheduled, or performance triggered failures**, settable via the tablet interface, including engine damage, compatible with 3rd party UI’s and instructor stations.
- **Fully simulated environmental control and pressurization system** for heating, air conditioning, ventilation, and ram air cooling. Cool things off by opening a door, or watch the airplane heat up in the sun. Monitor via the new tablet interface.
- **NEW terrain & weather radar technology** creates a functioning terrain radar without the use of WASM modules or external desktop software applications. Aircraft pitch, antenna position, transceiver gain, precipitation rate, and altitude all influence the radar depiction.
- **Completely simulated electrical system**, with 170+ circuit breakers and failures.
- **Functional windshield wipers** clear rain with realistic visuals.
- **Improved turboprop dynamics**, including (ITT, TRQ, Ng, FF, FP), hot starts, residual heat, and exhaust back pressure, P2.5 HP & LP valve simulation, and fuel-oil heat exchanger.
- **Turbine engine failures**, such as compressor stall and surging, fuel control failure, fuel filter clogs, propeller governors, and fire suppression systems.
- **FOD damage based on surface type.** Use the inertial separators to avoid engine damage. Tablet interface displays the type and intensity of FOD.
- **NEW physics-driven propeller governor and feathering simulation** and beta range from the Black Square Duke
- **Floppy disk reader** for updating navigation databases, and reading other data files.

- **Gyroscope physics simulation** for electric and pneumatic gyroscopes with precession, and partial failures, based on a coupled quadrature oscillator.
- **Voltage-based light dimming,** an immediately recognizable effect to nighttime pilots.
- **Strobe light system** causes realistic distracting flashes in clouds.
- **St. Elmo's Fire** & static discharge on static wicks and windshields in severe weather.
- **Mathematically accurate VOR & ADF signal attenuation and noise degradation.**
- **Physics based instrument needles** bounce and respond to aerodynamic forces.
- **Functional exterior elements (Interactive in MSFS2024)**: chocks, pitot covers, engine covers, gear downlock pins, and ground power generator. Pitot cover flags blow in the wind.
- **Cathode Ray Tube (CRT) simulation** & warmup based on instrument panel temperature.
- Improper engine management will slowly **damage engines to failure**.
- Carbon Monoxide leaks are possible, and can be detected with the CO detector.
- State saving for fuel, radio selection, radio frequency memory, cabin aesthetics, etc.
- Crew/Passenger oxygen depletes according to pressure altitude, passenger occupancy.
- Ultra-custom dynamic registration number system for livery creators.

Checklists

Over 600 checklist items are provided for 62 Normal, Abnormal, and Emergency procedures in textual form in the manual, and in-game, using the MSFS native checklist system with control and instrument highlighting. If it's in the checklist, it's settable in the aircraft!

Sounds

Black Square's Starship features a custom soundset created by Boris Audio Works, recorded from the real aircraft. High quality engine and cockpit sounds will immerse you in the simulation. Sounds like engine starting are not mere recordings, but instead many layered sounds, constructed based on the underlying simulation.

Flight Dynamics

Black Square's Starship features a flight model with performance to match the real world aircraft based on real Starship owner feedback and in-flight data. The flight model also features the best canard aerodynamics possible in MSFS 2020, building upon Black Square's Velocity XL. Engine and aerodynamic performance should be within 2% of POH values, though no two engines are ever the same. The flight model uses the most up to date features available in MSFS, such as CFD propeller and stall physics, and SU15 improved ground handling and flexible tire physics.

Aircraft Specifications

Length Overall	46’1”
Height	12'1"
Wheel Base	22’6"
Track Width	16’10"
Main Wingspan	54’4”
Forward Wingspan	21’11” (retracted) 25’8” (extended)
Wing Area	280.88 sqft.
Flight Load Factors	+3.06/-1.22 G’s (+2.0/-0.0 G’s with Flaps Down)
Design Load Factor	150%
Cabin W/L/H	66" x 21’1” x 63"
Baggage Capacity	Forward: 160 lbs (19.5 cuft) Aft: 525 lbs (35.0 cuft)
Oil Capacity	3.6 U.S. Gallons / Engine
Seating	9
Wing Loading	53.0 lbs/sqft
Power Loading	6.21 lbs/hp
Engines	1,200 SHP (895 kW) Pratt & Whitney PT6A-67A Free-Turbine
Propellers	5-Blade McCauley, Constant Speed, Fully Reversible, Aluminum, Hydraulically Actuated, 104.0 inch propeller. Fully fine blade angle of 15.0°, Low pitch blade angle of 62.5°, feathering angle of 91.3°. Approved Fuel Grades: JET A (ASTM-D1666) JET A-1 (ASTM-D1666) JET B (ASTM-D1666) JP-4 (MIL-DTL-5624) JP-5 (MIL-DTL-5624) JP-8 (MIL-DTL-5624)
Fuel Capacity	Total Capacity: 565.0 gal Total Usable: 550.2 gal Capacity Each Tank: 194.5 (Main) 88.0 (Aft) Usable Each Tank: 189.5 (Main) 85.6 (Aft)
Electrical System	
Voltage:	28 VDC
Batteries:	24V, 34 amp-hour, Nickel Cadmium (NiCad)
Generators:	28V, 300 amp @ 1,700 RPM, each engine
Pressurization System	8.4 PSI Maximum Pressure Differential Pressurization Rate Controller 150 ft/min to 2,000 ft/min Minimum/Maximum attainable altitude -1,000 ft / 21,400 ft

Aircraft Performance

Maximum Cruising Speed	337 ktas
Normal Cruising Speed	325 ktas
Economy Cruising Speed	255 ktas
Takeoff Distance (35ft obstacle)	3,955 ft (flaps extended) 4,070 ft (flaps retracted)
Landing Distance	2,390 ft
Landing Ground Roll	1,265 ft
Accelerate/Stop Distance	4,080 ft
Normal Range (45 min. reserve)	1,450 nm
Maximum Range (45 min. reserve)	1,575 nm
Rate of Climb	2,750 ft/min
Single Engine Rate of Climb (feathered)	670 ft/min
Single Engine Rate of Climb (windmilling)	50 ft/min
Service Ceiling	41,000 ft (under 13,000 lbs) 35,800 ft (14,900 lbs)
Empty Weight	10,055 lbs
Max Ramp Weight	15,010 lbs
Max Takeoff Weight	14,900 lbs
Max Landing Weight	13,680 lbs
Useful Load	4,845 lbs
Usable Fuel Weight	3,685 lbs
Full Fuel Payload	1,160 lbs
Maximum Operating Temp.	+37°C
Glide Ratio (Props Feathered)	19:1

Maximum Demonstrated Crosswind Component: 21 kts

V-Speeds

Vr	108 kts*	(Rotation Speed, Flaps Extended) *MGTOW - See table for more weights
Vr	102 kts*	(Rotation Speed, Flaps Retracted) *MGTOW - See table for more weights
Vs	97 kts	(Clean Stalling Speed)
Vso	92 kts	(Dirty Stalling Speed)
Vmc	89 kts	(Min. Controllable Speed w/ Critical Engine Feathered, Flaps Extended)
Vmc	94 kts	(Min. Controllable Speed w/ Critical Engine Feathered, Flaps Retracted)
Vx	115 kts	(Best Angle of Climb Speed)
Vy	140 kts	(Best Rate of Climb Speed)
Vxse	115 kts	(Best Single Engine Angle of Climb Speed)
Vyse	130 kts	(Best Single Engine Rate of Climb Speed)
Va	181 kts	(Maneuvering Speed)
Vb	170 kts	(Turbulent Air Penetration)
Vg	130 kts	(Best Glide Speed)
Vfe	180 kts	(Maximum Full Flap Extension Speed)
Vle	200 kts	(Maximum Landing Gear Extension Speed)
Vlo	180 kts	(Maximum Landing Gear Retraction Speed)

Vne Variable from 265-173 kts, Approx. 0.60 Mach above 10,000 ft (Do Not Exceed Speed)

Engine Limitations

Engine Speed	1,700 RPM (T/O), 1,690 RPM (Continuous), 1,600 RPM (Cruise)
Torque	100% (T/O & Continuous), 97% (Cruise), 84% @ 1,690 RPM or 89% @ 1,600 RPM (Climb)
ITT	850°C (T/O) 840°C (Climb) 840°C (Cruise) 1000°C (Starting)
Gas Generator	104.0% (All Phases)
Oil Temperature	50°F (10°C) (min.) 221°F (105°C) (max.) -40°F (-40°C) (Starting)
Oil Pressure	90 PSI (min.) 135 PSI (max.)
Fuel Temperature	-27°C (-17°F)

Other Operating Limitations

- Aerobatic maneuvers, including spins, are prohibited.
- Reverse thrust operation limited to durations of one minute.
- The left and right standby pumps must be operative for takeoff.
- Do not takeoff if the fuel quantity gauges indicate less than 270 pounds per side.
- Fuel crossfeed is permitted only during ground and cruise flight operation.
- Maximum allowable fuel imbalance between wing fuel systems is 150 pounds.
- Ground operation of integrated avionics with cabin temperatures exceeding 95°F shall be limited to 30 minutes.
- Half bank mode is required when above 30,000 feet with the autopilot engaged.
- Fluorescent cabin lighting must be inspected prior to flight. If any bulb is inoperative, flickering, or not installed, the bulb must be replaced or the lights rendered inoperative by pulling the RDG/TAB LIGHTS circuit breaker on the right circuit breaker panel.

Starter Limitations

30 seconds ON - 5 minutes OFF
30 seconds ON - 5 minutes OFF
30 seconds ON - 30 minutes OFF

External Power: 28.0V - 28.4V, 300A continuous, 1000A momentarily.

Paint Schemes

The Black Square Starship comes with six paint schemes, plus one blank scheme for livery creators. The Starship also comes with five interior upholstery packages in various styles and states of modernization. This product makes use of Black Square's highly customizable dynamic tail number system, which can be configured by livery makers. See the "Custom Dynamic Tail Numbers" section of this manual for more information.

Instrumentation/Equipment List

Main Panel

- ASI-850A Airspeed Indicator (ASI)
- ALI-850A Altitude/Vertical Speed Indicator (ALI)
- PFD-870 Primary Flight Display (PFD)
- ND-870 Navigation Display (ND)
- ECD-870 Engine/Caution Display (EICAS)
- MFD-870 Multifunction Display (MFD)
- CDU-850A Control Display Unit (CDU)
- SDU-640A Sensor Display Unit (SDU)
- RTU-870A Radio Tuning Units (RTU)
- CHP-850 Course/Heading Panel (CHP)
- AAP-850 Altitude Awareness Panel (AAP)
- MSP-850A Autopilot Mode Select Panel (MSP)
- APP-85D Autopilot Panel (APP)
- ARINC 429 Digital Clock
- Reversionary & Switching Panel (Pilot/Copilot/Center)
- Airspeed, Attitude & Altitude Standby Instrumentation

Other Equipment & LRU's

- ADC-850 Air Data Computer (ADC)
- FMC-851A Flight Management Computer (FMC)
- EDC-850 Engine Data Concentrator (EDC)
- DAU-850 Data Acquisition Unit (DAU)
- FCC-850 Flight Control Computer (FCC)
- DBU-850 Data Base Unit (DBU)
- RTA-854 Weather Radar (RTA)
- Angle of Attack Indicator (AOA)
- Garmin GNS 430 (GNS)
- HF-9000 High Frequency Communication Transceiver (HF)

Electrical/Miscellaneous

- 172+ Circuit Breakers
- Voltmeters & Ammeters
- Fire Detector & Extinguishers
- Pneumatic Pressure Indicators
- Fuel Temperature & Quantity Indicators
- Oxygen Pressure Indicator
- Cabin Temperature Indicator
- Carbon Monoxide Detector

Installation, Updates & Support

Installation

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

1. Click on the ‘Account’ tab on the Just Flight website.
2. Log in to your account.
3. Select the ‘Your Orders’ button.
4. A list of your purchases will appear and you can then download the software you require.
5. Run the downloaded installation application and follow the on-screen instructions

If you already have an earlier version of this software installed, the installation application will detect this and update your existing software to the new version without you needing to uninstall it first.

Accessing the Aircraft

To access the aircraft:

1. Click on ‘World Map’.
2. Open the aircraft selection menu by clicking on the aircraft thumbnail in the top left.
3. Use the search feature or scroll through the available aircraft to find the ‘Starship’ by Black Square.
4. After selecting the aircraft, use the ‘Liveries’ menu to choose your livery.

Uninstalling

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

Control Panel -> Programs and Features
or
Settings -> Apps -> Apps & features

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

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

Updates and Technical Support

For technical support (in English) please visit the Support pages on the Just Flight website.
As a Just Flight customer, you can get free technical support for any Just Flight product.

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

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Liveries & Custom Dynamic Tail Numbers

This aircraft features Black Square's highly customizable dynamic registration number system. This system allows livery creators to adjust many features of how registration numbers are displayed on the aircraft. The following image shows all the areas on the aircraft where a tail number can be positioned (in blue).

For those interested in creating custom liveries, a custom PANEL.CFG file should be included in the livery package, and referenced via the livery's AIRCRAFT.CFG. In this PANEL.CFG, the [VPainting01] section, specifically the "painting00" can be edited to alter the appearance of the tail number. The parameters between the '?' and the ',' separated by '&', control the tail number. Below is an example tail number configuration, followed by an explanation of all the parameters.

font_color=red&stroke_size=30&stroke_color=black&sv=1&sx=18&sy=41&sr=0&sk=20&ss=250&tv=1&tx=16&ty=8&tr=0&tk=20&ts=225&wv=1&wx=32&wy=20&wr=9&wk=30&ws=150

Each position ("s" = side, "t" = tail, and "w" = winglets) has the following associated variables:

"v" = whether to show the tail number in that position (0=false, 1=true)

"x" = the nose-tail position of the tail number

"y" = the top-bottom position of the tail number

"r" = the rotation of the tail number (will accept decimals)

"k" = shears the tail number, positive values shear top towards tail

"s" = the font size of the tail number

Example "tk=30": t = tail, k = skew. This will shear the registration on the tail towards the tail of the aircraft by 30 degrees.

These values can be edited live using the Coherent GT Debugger from the MSFS SDK.

Tail Number Positioning:

Side +X -> Forward, -Y -> Up

Tail -X -> Forward, -Y -> Up

Wing -X -> Forward, -Y -> Up

Unlike the default dynamic tail number system, these tail numbers will not automatically resize, so make sure there is room for a full six character registration.

New fonts can be added in livery packages, and any font/outline/shadow color may be selected from the standard JavaScript colors by name, or by Hex Code.

The resolution of the tail numbers can be adjusted with the resolution values at the end of the painting00 entry, and the "size_mm" entry above. Large resolutions may affect performance.

Cockpit & System Guide

Main Panel

Master Warning/Caution

The Black Square Starship is equipped with Master Caution, and Master Warning annunciators with integrated push buttons on the glareshield wings. The Master Caution annunciator illuminates with yellow “MASTER CAUTION” text, and the Master Warning annunciator illuminates with a red background behind “MASTER WARNING” text. Both are latching annunciators, meaning that they illuminate when triggered by a specific aircraft condition, and remain illuminated until canceled by a crew member by pressing the annunciator’s integrated push button.

A Master Warning is triggered by any condition that illuminates one of the 14 red glareshield annunciators. These conditions require immediate pilot action to rectify. A Master Caution is triggered by any condition that illuminates one of the yellow caution messages on the Engine Instrument and Crew Alerting System (EICAS) display. These conditions likely require pilot action to rectify, and might lead to a more severe condition if not rectified soon. See the “ECD-870 Engine/Caution Display (EICAS)” section of this manual for more information on the crew alerting system and a complete list of caution messages.

Annunciator Panel

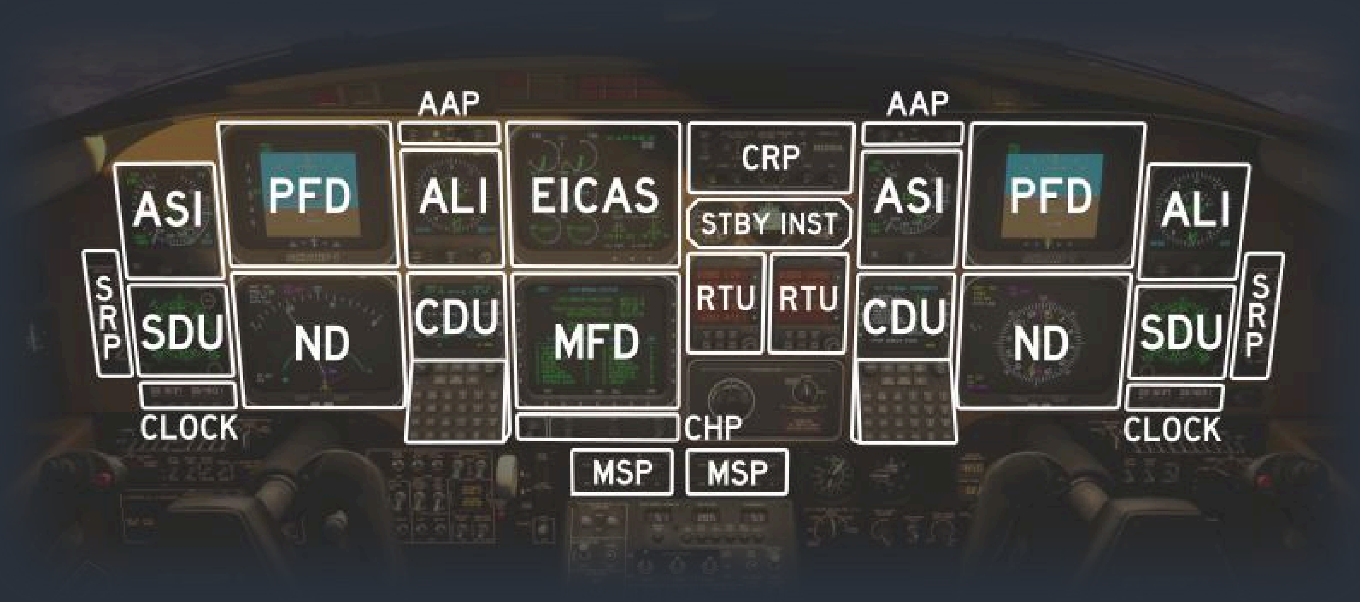
The glareshield annunciator panel consists of 14 incandescent annunciator lights, which trigger the latching master warning annunciators. To test the annunciator panel, press and hold the "ANNUN" button on the pilot's left subpanel. Power is supplied to the annunciators via the five annunciator light circuit breakers on the copilot's circuit breaker panel. The annunciators are dimmed automatically via a photocell light sensor in the overhead panel.

The following annunciators illuminate to indicate the associated condition:

Message	Condition
L FUEL PRES LOW	Left fuel pressure below 4.75 PSI
L OIL PRES LOW	Left oil pressure below 60 PSI
DOOR UNLOCKED	Cabin door open or improperly latched
BATT CHG RATE	Battery charge rate is excessive, and battery may overheat
CABIN ALT HI	Cabin pressurization altitude above ~10,000 feet
CABIN DIFF HI	Cabin differential pressure above 8.4 PSI
L BLEED FAIL	Main bleed air supply failure in left engine nacelle
FUS BLEED FAIL	Cabin bleed air supply failure in aft plumbing
R BLEED FAIL	Main bleed air supply failure in right engine nacelle
ROLL TRIM FAIL	Roll trim servo has been activated without arming power
PITCH TRIM FAIL	Pitch trim servo has been activated without arming power
RUD TRIM FAIL	Rudder trim servo has been activated without arming power
R FUEL PRES LOW	Right fuel pressure below 4.75 PSI
R OIL PRES LOW	Right oil pressure below 60 PSI

Avionics Layout & Acronyms

Descriptions of all the following avionics systems can be found in the Cockpit & System Guide.



Panel Mounted Avionics

ASI - ASI-850A Airspeed Indicator

PFD - PFD-870 Primary Flight Display

EICAS - ECD-870 Engine/Caution Display

CDU - CDU-850A Control Display Unit

RTU - RTU-870A Radio Tuning Units

AAP - AAP-850 Altitude Awareness Panel

SRP - Side Reversionary Panel

CRP - Center Reversionary Panel

APP* - APP-85D Autopilot Panel

HF* - HF-9000 High Frequency Communication Transceiver

*Mounted in pedestal, not pictured above.

ALI - ALI-850A Altitude/Vertical Speed Indicator

ND - ND-870 Navigation Display

MFD - MFD-870 Multifunction Display

SDU - SDU-640A Sensor Display Unit

CHP - CHP-850 Course/Heading Panel

MSP - MSP-850A Autopilot Mode Select Panel

CLOCK - ARINC 429 Digital Clock

STBY INST - Standby Instrumentation

Line Replaceable Remote Units

ADC - ASI-850A Airspeed Indicator

FMC - FMC-851A Flight Management Computer

FCC - FCC-850 Flight Control Computer

RTA - RTA-854 Weather Radar

EDC - EDC-850 Engine Data Concentrator

DAU - DAU-850 Data Acquisition Unit

DBU - DBU-850 Data Base Unit

ASI-850A Airspeed Indicator (ASI)

Two identical airspeed indicator displays present airspeed information processed by the Air Data Computers (ADC) on a conventional round-dial scale from 60 to 320 knots indicated. A hollow green needle displays the indicated airspeed, while a hatched red needle displays the barber-pole speed (Vmo). A magenta arc extends from the tip of the green needle to indicate airspeed trend. The arc ends at the approximate airspeed of the aircraft in ten seconds, assuming constant acceleration or deceleration. The barber-pole speed is continuously adjusted by the ADC in relationship to pressure altitude. The red needle will remain steady at 245 kts from 0 to 10,000 feet, climbing to 265 kts by 12,000 feet. The needle will again remain steady until climbing through 21,900 feet, at which point it will reduce to 173 kts through 41,000 feet, which corresponds with 0.6 Mach. Indicated airspeed is displayed numerically at the center of the screen in green text, which emulates the movement of a mechanical drum display. Should the indicated airspeed exceed Vmo, this text will flash red. Removal of all airspeed information and display of the red “ADC” flag indicates that the on-side ADC has failed, or is performing a self test. A yellow “TEST” flag indicates the instrument is performing a self-test.

The outside of the airspeed scale is adorned with the customary red line to indicate the single engine minimum controllability speed (Vmc), and a cyan line to indicate the best single engine rate of climb speed (Vyse). A single white arc denotes the flap operating range, and a double white arc denotes the flaps extended stalling speed. A white rectangle marking at 200 kts indicates the maximum landing gear extension speed.

A cyan bug moves around the scale to indicate the on-side selected reference airspeed, which can be set automatically by selecting one of the autopilot airspeed profile modes on the Autopilot Mode Select Panel (MSP), or by rotating the knob on ASI. The airspeed reference bug can be shown or hidden by pressing the center of the adjustment knob, so long as the on-side Flight Control Computer (FCC) is not currently using this reference airspeed to command the autopilot. If the on-side FCC is using this airspeed as reference, a cyan “FD” appears at the top right of the display. The currently selected reference airspeed is displayed numerically at the bottom right of the display.

The true airspeed calculated by the ADC is displayed continuously at the upper left of the display. Three air temperatures can be displayed at the bottom left of the display. Normally, Indicated Outside Air Temperature (IOAT) is displayed until the “OAT/ISA” button is pressed. Pressing the button cycles through IOAT, the International Standard Atmosphere (ISA) temperature, and the Outside Air Temperature (OAT), adjusted for compressibility effects. After five seconds, the temperature display will default to IOAT mode.

ALI-850A Altitude/Vertical Speed Indicator (ALI)

Two identical combined altitude and vertical speed indicator displays depict information processed by the Air Data Computers (ADC) on two concentric round-dial displays. The outer scale is graduated in 20 foot increments of altitude, and labeled in hundreds of feet. A green pointer arrow makes one complete revolution around this scale every 1,000 feet. Indicated altitude is displayed numerically at the center of the screen in green text, which emulates the movement of a mechanical drum display.

The inner scale is graduated in 500 fpm increments, and a green arc traverses the inside of the scale to indicate vertical speed. A cyan bug moves around the scale to indicate the on-side selected vertical speed reference, which can be set by rotating the center knob on the ALI. When either the vertical speed or vertical speed reference exceeds +/-600 fpm, the inner scale is extended from 1,000 fpm to 6,000 fpm. The vertical speed reference bug can be shown or hidden by pressing the center of the adjustment knob, so long as the on-side Flight Control Computer (FCC) is not currently using this reference vertical speed to command the autopilot. If the on-side FCC is using this vertical speed as reference, a cyan “FD” appears at the top right of the display. The currently selected reference vertical speed is displayed numerically at the top left of the display.

The indicated altitude's barometric pressure setting is displayed at the bottom left of the display in cyan, and is adjusted with the leftmost knob. Pressing the center of this knob will set the barometric pressure to standard. If the pressure remains at standard when descending through 18,000 feet, or is not set to standard after climbing through 18,000 feet, these digits will flash until either the barometric pressure is adjusted, or the center of the adjustment knob is pressed. This transition altitude alert can be disabled with the "FL180 DISABLE" switch on the on-side reversionary switch panel. Similarly, the barometric pressure unit can be toggled using the "BARO" switch on the same panel.

The selected target altitude is displayed at the bottom right of the display, normally in cyan, and is adjusted with the rightmost knob. When the aircraft is arriving at this altitude, the digits will flash until within 200 feet of the target altitude. If the aircraft leaves this altitude by 300 feet or greater, the digits will flash yellow. Removal of all altitude and vertical speed information and display of the red "ADC" flag indicates that the on-side ADC has failed, or is performing a self test. A yellow "TEST" flag indicates the instrument is performing a self-test.

PFD-870 Primary Flight Display (PFD)

Two identical primary flight displays take the form of a conventional artificial horizon, framed by supplementary flight information. The artificial horizon will display red chevrons at extreme pitches, and the horizon line will never recede from view completely to aid in upset attitude recovery. If the Attitude and Heading Reference System (AHRS) selected by the "AHRS X-SIDE" switch has failed, a red "ATT" flag will replace the artificial horizon. If the selected AHRS is aligning, a white "AHRS ALIGNING" message will flash continuously. A magenta flight director command cue is visible whenever the autopilot is engaged, and will remain visible until either the autopilot disengage yoke button is pressed a second time, or the "FD OFF" button on the active Autopilot Mode Select Panel (MSP) is pressed. A red "FD" flag will replace the flight director command cue if the on-side Flight Control Computer (FCC) is unable to produce a flight director depiction. A yellow "DH" decision height and yellow "MDA" minimum descent altitude flashing alert is also shown within the artificial horizon. Lastly, color coded, boxed indicators for marker beacon reception are shown at the top right of the artificial horizon.

Active autopilot modes are depicted in green at the top left of the display, while armed modes are depicted in white. If the autopilot has been disengaged, but the flight director is still visible, the autopilot modes commanding the flight director are depicted in yellow. The arrow next to the

“AP” master text indicates which FCC is commanding the autopilot (as selected by the “AP XFER” button) by pointing to either the pilot’s side or copilot’s side of the aircraft. Also across the top of the screen, the decision height selected via the Altitude Awareness Panel (AAP) is shown in cyan if the decision height alert is active.

The radar altimeter height is shown as either large digits when above 1,000 feet AGL, or a round-dial display when below 1,000 feet AGL at the top right of the display. Regardless of the depiction, the digits will be shown in green if the aircraft is above the decision height, and yellow if it is below. When below 1,000 feet, a colored arc will rotate around the outside of the altitude scale to depict the radar altitude. The arc is yellow below the decision height. If the decision height alert is active, a cyan triangle bug will be shown on the outside of the round dial to indicate the decision height. If the radar altimeter fails, a red “RA” flag will replace the radar altimeter depiction. At the bottom right of the display, the minimum descent altitude or reporting altitude (as selected via the AAP) is shown in cyan if the selected alert type is active. If the selected alert type is a reporting altitude, these digits will flash when approaching the selected altitude. For more information on setting the three types of altitude alerts discussed in this section, see the “AAP-850 Altitude Awareness Panel (AAP)” section of this manual.

To the left of the artificial horizon, a speed deviation indicator will be displayed any time the speed reference bug is displayed on the on-side ASI. A green rectangle will move vertically to indicate whether the indicated airspeed is higher or lower than the reference airspeed. Full deflection of the indicator represents a deviation of 10 kts. In the event of an on-side Air Data Computers (ADC) failure, the speed deviation indicator is replaced by a red “SPD” flag.

To the right of the artificial horizon, a vertical glideslope deviation scale and pointer are displayed only when a valid source of vertical guidance exists. If the course selected via the Course/Heading Panel (CHP) is more than 180 degrees away from the aircraft heading or GNS 430 LPV course, the vertical deviation scale will be replaced by a white “BACK CRS” flag. If the glideslope receiver fails while in use, the scale is replaced by a red “GS” flag. The glideslope deviation pointer will be shown in green when the on-side receiver is selected as the active source of navigation via the Control Display Unit (CDU), and yellow when the cross-side receiver is selected as the active navigation source. If the GNS 430 is selected as the autopilot navigation source, FMS is selected as the active navigation source on the CDU, and the GNS is providing vertical guidance, the glideslope indicator will be shown in white.

At the bottom of the artificial horizon, a horizontal lateral deviation scale and pointer are displayed only when a valid source of lateral guidance exists. The lateral navigation pointer can take the form of a hexagonal VOR symbol to indicate VOR navigation, a trapezoidal runway to indicate localizer reception, or a white four-pointed star symbol to indicate that the FMS is selected as the active navigation source via the CDU. If the NAV receiver fails while in use, the scale is replaced by a red “LOC” flag. The lateral deviation pointer will be shown in green when the on-side receiver is selected as the active source of navigation via the CDU, and yellow when the cross-side receiver is selected as the active navigation source. When the FMS is selected as the active navigation source via the CDU, the scale will have linear deviation, with full scale deflection being indicated as 10nm during enroute navigation, and 2nm on approach segments.

The PFD has several reversionary features to transfer data in the event of a system or display failure. A partial horizontal situation indicator (HSI) can be displayed at the bottom of the instrument, along with related navigation data by placing the composite mode switch on the on-side reversionary switch panel into the up position. Cross-side AHRS and CDU functionality is indicated by yellow “XATT” and “XCDU” flags. More information on PFD reversionary modes can be found in the “Reversionary & Switching Panel (Pilot/Copilot/Center)” section of this manual. If the selected CDU source or FCC has failed, a red “CDU” flag will be shown at the bottom right of the display.

ND-870 Navigation Display (ND)

Two identical navigation displays take the form of a digital Horizontal Situation Indicator (HSI) with rotating compass card, or partial compass arc (ARC) with navigation data, framed by supplementary navigation information. The ND display modes and features are controlled via the top six buttons on the Control Display Unit (CDU) keypad, between the two rotary knobs.

In all display modes, persistent active and preset navigation information is shown at the top left and top right of the display, along with selected heading reference information. All compass cards are adorned with a magenta heading reference bug. When heading information is not available from the Attitude and Heading Reference System (AHRS) selected by the "AHRS X-SIDE" reversionary switch, the compass lubber line inverted triangle will be replaced by a red "HDG" flag. Cross-side AHRS and CDU functionality is indicated by yellow "XATT" and "XCDU" flags. More information on ND reversionary modes can be found in the "Reversionary & Switching Panel (Pilot/Copilot/Center)" section of this manual. If the selected CDU source or Flight Control Computer (FCC) has failed, a red "CDU" flag will be shown at the left of the display. A wind direction arrow and numerical wind speed readout are also included in all display modes when the calculated ambient wind speed exceeds approximately 6 kts.

For all display modes, the active and preset navigation sources are selected via the Active Nav Source screen on the CDU, accessed by pressing the “NAV SOURCE” button on the CDU keypad. The course arrows and navigation text information will conform to the same color palette as the navigation pointers on the Primary Flight Display (PFD) depending on the source that is selected. On-side radionavigation sources (VOR/LOC) will result in green pointers and text, cross-side radionavigation sources will result in yellow pointers and text, and FMS sources will result in white pointers and text. The preset navigation source pointers and text will always be depicted in cyan. Active navigation sources are depicted with solid pointers, while preset sources are depicted with hollow, dashed, cyan pointers. The Crosstrack Deviation Indicators (CDI) for active and preset sources will only appear when a valid source of navigation is detected. When the FMS is selected as the active or preset navigation source via the CDU, the CDI scales will have linear deviation, with full scale deflection being indicated as 10nm during enroute navigation, and 2nm on approach segments.

At the right of the display, a vertical glideslope deviation scale and pointer are displayed only when a valid source of vertical guidance exists. If the course selected via the Course/Heading Panel (CHP) is more than 180 degrees away from the aircraft heading or GNS 430 LPV course, the vertical deviation scale will be replaced by a white “BACK CRS” flag. If the glideslope receiver fails while in use, the scale is replaced by a red “GS” flag. Supplementary navigation information for both active and preset sources include the selected course, station identifier (if received), active/preset navigation source name, the preset to/from indication, distance to the navaid (if available in the case of DME distance), time-to-go (TTG) until arriving at the navaid, and ground speed. If FMS is selected as the active or preset source, the distance and TTG will be the FMS calculated straight line distance and time to the next waypoint. If FMS is the active navigation source, the system control mode, selected via the System Control screen on the CDU, will be displayed beneath the active navigation supplementary information. Lastly, a yellow “DR” flag will appear beneath the active navigation supplementary information if the FMS is in dead reckoning mode due to poor positional accuracy estimates. If the DME information displayed for either the active or preset navigation source is the result of a held frequency, the “NM” distance unit will be replaced by an “H”.

The “HSI” button will always return the ND to its default HSI depiction. In this mode, only the active and preset, course pointers with CDI bars are shown, along with the magenta bearing pointer. The bearing pointer source is selected via the Bearing Pointer screen on the CDU, and its source is displayed at the bottom left of the ND display when a valid signal is received.

The “ARC MAP” button toggles the ND between an expanded HSI ARC view, and a map display (MAP). The arc view subtends approximately 70° of the compass card, and only the active navigation course pointer is visible. In both ARC and MAP modes, the heading bug may not be visible at all times; therefore, a dashed magenta line extending from the aircraft symbol towards the heading bug is superimposed when the bug is off screen. In ARC mode, a weather or terrain radar depiction can be added beneath the navigation data by pressing the “RDR” button on the CDU, assuming the RTA-854 Weather Radar (RTA) is properly configured via the Radar Control screen on the CDU, accessed by pressing the “RDR CONTROL” button. When radar is being displayed on the ND, a column of radar information will appear at the left of the display, including the transceiver gain (-3 to +3), the antenna tilt position (-14° to +14°), the radar operating mode, radar hold, and unstabilized antenna indicators. For more information on the weather and terrain radar capabilities of this aircraft, see the “RTA-854 Weather Radar (RTA)” section of this manual. Additionally, a single cyan range arc will be displayed in ARC mode, with a numerical indication of the radar’s range. This range is adjusted with the range knob on the CDU keypad. Should the selected CDU or on-side radar channel fail, the red “RDR CTL FAULT” and “RDR FAIL” flags will appear, respectively.

The ND's MAP mode features a rotating map of flight plan waypoints and tuned radionavigation stations within the expanded compass card of the ARC display. The radar image buffer can also be displayed in this mode by pressing the "RDR" button on the CDU keypad. When in MAP mode, no course pointers or CDI bars are shown. Instead, tuned stations are displayed in their correct geographic location on the map relative to the aircraft symbol. The station symbols are colored with the same palette as the course pointers in other display modes, and the symbol contains a "1" or "2" to indicate which navigation radio is receiving the station. On the MAP display, active and preset stations are depicted with a solid or hollow to/from course line, much like a GPS OBS function. The course lines to the stations are continuous, while the lines away are dashed. The course lines can be rotated with the on-side CHP knob.

NOTE: One might expect the CRS1 CHP knob to adjust the active navigation source and the CRS2 knob to adjust the preset course; however, they actually control the pilot and copilot's active navigation source unless the associated CDU is on the Preset Nav Source screen.

In addition to tuned navaids, the MAP mode also displays the waypoints in the FMS flight plan as four-pointed star symbols. The waypoint symbols are white, unless they are the currently active waypoint in the flight plan, in which case they are magenta. In Automatic Leg (AUTO LEG) and Manual Leg (MAN LEG) system control modes, the waypoints are connected via lines. In AUTO LEG mode, the active leg is shown in magenta, while in MAN LEG mode, all legs are shown in white to indicate that automatic waypoint sequencing has been suspended. In Selected Course (SEL CRS) mode, no lines are shown between waypoints. Instead, a solid to/from course line, much like a GPS OBS function and the radionavigation MAP depiction described above, is shown. The course line to the active waypoint is continuous, while the line away is dashed. The course line can be rotated with the on-side CHP knob, so long as FMS is selected as the active navigation source. The course to the station can also be selected with the keypad on the CDU Flight Plan or System Control screen. The autopilot will fly inbound or outbound along this course, just as it would with a conventional radio navaid. If no flight plan is currently active, a white “NO FLIGHT PLAN” flag will be displayed over the map.

ECD-870 Engine/Caution Display (EICAS)

The Engine Instrument and Crew Alerting System (EICAS) displays both engine indications, and general aircraft system status messages in a digital format designed to replace large banks of annunciator lights. The CAS is dependent on the dually redundant Data Acquisition Units (DAU). If both DAU's fail, the CAS will be replaced by a red "CAS" flag. If more messages are available for display than can fit in the CAS, then a boxed page number will be shown in place of the boxed "END" flag. The pilot may scroll through CAS pages using the up and down arrow line select keys on the bezel of the EICAS. A white "AHRS ALIGNING" message will flash at the bottom of the CAS when either Attitude and Heading Reference System (AHRS) is aligning.

The messages displayed by the CAS are color coded to indicate three priority levels. Higher priority messages are displayed first in the CAS list, while lower priority messages are the first to be pushed to secondary message pages. Yellow messages are the highest priority and trigger the master caution flasher when they appear on the CAS. These messages represent conditions that likely require pilot action to rectify, and might lead to a more severe condition if not rectified soon. White messages are the second highest priority, and represent conditions that are not currently of concern, but could lead to a more severe condition if they remain, for example, transferring fuel from one side of the aircraft to the other to correct an imbalance. Green messages are the lowest priority, and are neither harmful, nor potentially harmful, but may be undesired depending on the phase of flight. Messages will appear immediately when their triggering condition is met, but will not disappear until a four second delay has elapsed.

Message	Condition
CAUTION TEST	Caution test initiated by pressing the "ANNUN" test button
STBY ATT GYRO OFF	No power applied to standby avionics bus
STBY ATT BATT LO	Standby avionics battery voltage is low
L F/W VALVE FAIL	Left firewall valve button toggled, but valve failed to close
R F/W VALVE FAIL	Right firewall valve button toggled, but valve failed to close
PITCH TRIM OFF	Pitch trim arming power not detected
PITCH TRIM SYNC	Pitch trim A & B circuits not actuating simultaneously
ROLL TRIM OFF	Roll trim arming power not detected
ROLL TRIM SYNC	Roll trim A & B circuits not actuating simultaneously
RUDDER TRIM OFF	Rudder trim arming power not detected
RUDDER TRIM SYNC	Rudder trim A & B circuits not actuating simultaneously
L FLAP MON FAIL	Left flap monitor failure while right is powered, or "FLAP MON" test
R FLAP MON FAIL	Right flap monitor failure while left is powered, or "FLAP MON" test
L WING BOOT FAIL	Suction lost, or "VAC TEST", or boot integrity lost during actuation
R WING BOOT FAIL	Suction lost, or "VAC TEST", or boot integrity lost during actuation
L FWD BOOT FAIL	Suction lost, or "VAC TEST", or boot integrity lost during actuation
R FWD BOOT FAIL	Suction lost, or "VAC TEST", or boot integrity lost during actuation
MAIN DEICE FAIL	Main deice circuit failure, or "MAIN DEICE" test
STBY DEICE FAIL	Standby deice circuit failure, or "STBY DEICE" test
L ICE VANE FAIL	Left inertial separator switch activated, but vanes have not moved
R ICE VANE FAIL	Right inertial separator switch activated, but vanes have not moved
PITOT OVERHEAT	Either pitot heater has been on for over 2min while on the ground
L STALL WRN FAIL	Left stall warning switch is activated, but the element is not heated
R STALL WRN FAIL	Right stall warning switch is activated, but the element is not heated
PUSHER MOTOR ON	The column pusher motor is energized, but the clutch is not energized
PUSHER CLUTCH ON	The column pusher clutch is energized, but the motor is not energized
PUSHER INOP	The column pusher is disabled due to unusual system conditions
AVIONIC AIR FAIL	Reduced cooling air in the nose avionics compartment detected

DUCT OVERTEMP	Cabin bleed air duct overheat
L BLEED OFF	Left bleed air valve closed
R BLEED OFF	Right bleed air valve closed
BATTERY TIE OPEN	Battery bus tie (battery bus to triple-fed bus) is open when battery is on
ROLL DISAGREE	AHRS roll integrity lost due to extreme operating conditions
PITCH DISAGREE	AHRS pitch integrity lost due to extreme operating conditions
HDG DISAGREE	AHRS heading integrity lost due to extreme operating conditions
LOC DISAGREE	NAV 1 & 2 receivers are tuned to the same station and HSI disagree
GS DISAGREE	NAV 1 & 2 receivers are tuned to the same station and GSI disagree
L FUEL LEVEL LO	Left total fuel quantity is below 135 lbs
R FUEL LEVEL LO	Right total fuel quantity is below 135 lbs
ICING	Ice detected, but all ice protection systems are not activated
HYD FLUID LOW	Landing gear hydraulic fluid reservoir level is low
PNEU PRESS LOW	Pneumatic pressure is below ~12 PSI and too low for boot inflation
ANTI-SKID INOP	Anti-skid system is not energized and gear is extended
POWER BRAKE INOP	Power brake system is not energized and gear is extended
L GEN INOP	Left generator is not online
R GEN INOP	Right generator is not online
L GEN TIE OPEN	Left generator bus tie is open
R GEN TIE OPEN	Right generator bus tie is open
OXYGEN NOT ARMED	The “Oxygen Sys Ready” pull handle is not pulled outwards
OXYGEN PRES LO	Oxygen system is armed, but cylinder pressure is below 500 PSI
AFX OFF	Gear is extended, but autofeather circuits are not energized
AFX DISABLED	Autofeather arming conditions are met, but synchronization lost on ground
WHEELWELL OVHT	Hot brakes have been retracted into the wheel well and damage may occur
NS GEAR UP	Manual gear extension activated, and nose gear is fully retracted
L GEAR UP	Manual gear extension activated, and left main gear is fully retracted
R GEAR UP	Manual gear extension activated, and right main gear is fully retracted
NS GEAR IN TRANS	Manual gear extension activated, and nose gear is in transit
L GEAR IN TRANS	Manual gear extension activated, and left main gear is in transit
R GEAR IN TRANS	Manual gear extension activated, and right main gear is in transit
PASS OXYGEN ON	Passenger oxygen masks are deployed, either automatically or manually
AFX DISABLED	Autofeather arming conditions are met, but synchronization lost in air

ICING	Ice detected, and all ice protection systems are activated
L CHIP DETECT	Left engine chip detector has sensed metal particulate in oil from damage
R CHIP DETECT	Right engine chip detector has sensed metal particulate in oil from damage
L ENG SECURED	Left engine is secure after in-flight shutdown
R ENG SECURED	Right engine is secure after in-flight shutdown
FUEL TRANSFER>	Fuel is crossfeeding from the left main tank to the right main tank
FUEL TRANSFER<	Fuel is crossfeeding from the right main tank to the left main tank
ROLL COMP OFF	Roll comparator is disabled due to loss of signal on one side
PITCH COMP OFF	Pitch comparator is disabled due to loss of signal on one side
HDG COMP OFF	Heading comparator is disabled due to loss of signal on one side
EXT POWER CONN	External power is connected to the receptacle on the left wing
EMER BLEED ON	The emergency fuselage bleed air bypass valve is open
STBY BATT TEST	Standby instrument battery test initiated
STBY ATT BATT OK	Standby instrument battery voltage and discharge tests passed
AV ALTN BLWR ON	Alternate nose avionics blowers energized
MAN TIES CLOSED	Left & right generator bus ties closed manually via switch
L IGNITION ON	Left engine ignition system is energized
R IGNITION ON	Right engine ignition system is energized
L ENG ANTICE ON	Left engine inertial separator on, and induction intake is heated
R ENG ANTICE ON	Right engine inertial separator on, and induction intake is heated
WSHLD STBY POWER	Pilot's side windshield heater activated
AFX ENABLED	Both autofeather circuits energized and all arming conditions are met

On the left side of the display, engine instrumentation is presented graphically and numerically in two columns. The top digital gauge combines Interstage Turbine Temperature (ITT) with propeller torque (TORQ) on one scale. ITT is indicated with the normally white cruciform pointer, which becomes red if operating or starting limits are exceeded, and yellow when within the caution range beyond the yellow cruciform marker at 840°C. During engine start, the scale is extended from 550-850°C to 550-1,000°C with an additional red triangle marker at the 1,000°C starting limit. If the ITT pointer exceeds either limit, the scale will be extended to the tip of the pointer with a red arc. The ITT numerical readout colors mirror the pointer colors.

The normally green arrow pointer indicates propeller torque as a percentage of maximum from 0-100%. If the propeller torque exceeds 100%, the pointer will become red, and the scale will be extended to the tip of the pointer with a red arc. The cyan arrow marker on the scale at 80% of maximum torque denotes the Maximum Normal Operating Power (MNOP) (80% torque at 1,600 RPM) which is the maximum allowable power setting for which the aircraft complies with FAA FAR §36 noise standards. The torque numerical readout colors mirror the pointer colors.

The propeller RPM (PROP) scale is unique compared to most other analog or or digital propeller RPM readouts. One complete revolution of the diamond pointer is equivalent to 1,000 RPM, beginning at the 12:00 position. The scale appears as a complete circle until propeller RPM exceeds 1,050 RPM, at which point the scale becomes segmented to denote the engine running operating range of 1,000 to 1,700 RPM. Operation within the red ranges should be avoided due to cooling and vibration concerns. The green double arc denotes the normal cruise operating range of 1,580-1,600 RPM. The cyan arc denotes the maximum normal operating range for FAA FAR §36 noise compliance from 1,600-1,690 RPM. The yellow arc denotes the caution range from 1,690-1,700 RPM, which should be avoided except for takeoff and landing. If the diamond RPM pointer exceeds the 1,700 RPM limit, the scale will be extended to the tip of the pointer with a red arc. The diamond pointer and numerical RPM readout will conform to whatever scale color is beneath the tip of the pointer.

Within the RPM scale, green “AFX” text appears to indicate that the autofeathering system is armed for the associated engine. If autofeathering actuation is imminent, the “AFX” text on the opposite engine will disappear before the engine displaying “AFX” goes into automatic feather. For more information on autofeathering systems, see the “Autofeather” section of this manual. Between the two RPM scales is a propeller synchronphaser consisting of a horizontal tape with white squares. The squares will move towards whichever propeller is spinning faster in proportion to the RPM difference between the two.

NOTE: Also within the RPM scale, an optional “BETA” text may appear when the power levers are within the beta range. This feature is enabled by default, but may be disabled with the “Beta Annunciator” persistent option on the tablet options page.

The gas generator RPM (N1) scale and diamond pointer indicate the gas generator RPM as a percentage of maximum from 0-104%. A green arc denotes the normal operating range from 65-104%. If the N1 diamond pointer exceeds the 104% limit, the scale will be extended to the tip of the pointer with a red arc. The diamond pointer and numerical N1 readout will conform to whatever scale color is beneath the tip of the pointer.

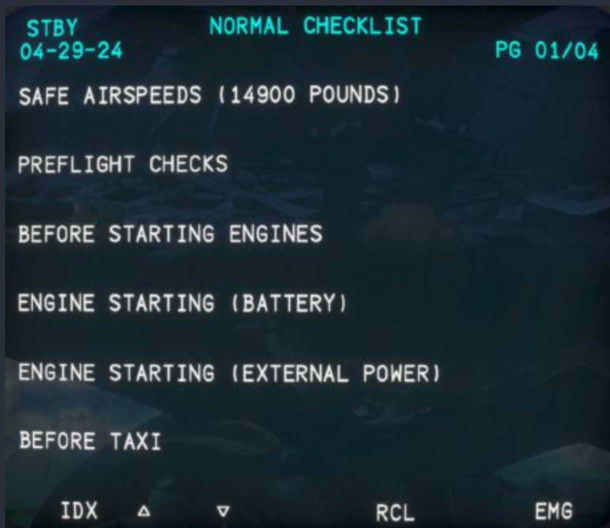
Beneath the CAS message area, fuel flow in pounds per hour (PPH) is always shown numerically in green text. Beneath the fuel flow text, two vertical scales for engine oil temperature and pressure are shown when the “OIL DSPL” line select key is pressed. The oil temperature and pressure display will automatically become visible if the temperatures or pressures exceed the normal operating range. The oil temperature and pressure display cannot be hidden while an exceedance condition exists. The four triangle pointers and numerical readouts within this display will conform to whatever scale color is beneath the tip of the pointers. Hiding the oil display allows for more CAS messages to be displayed on one page.

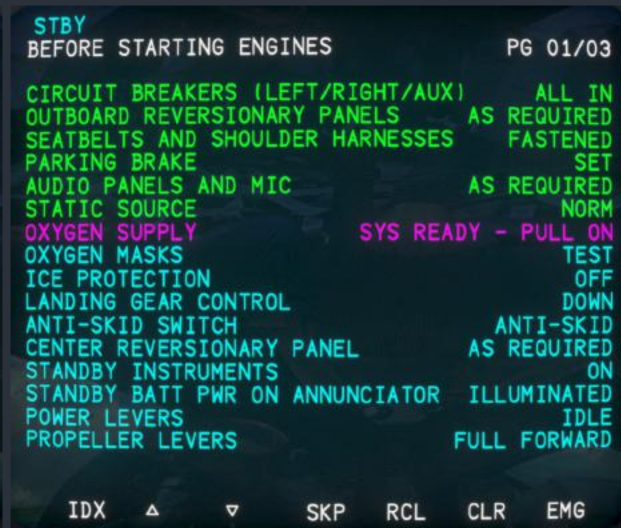
The EICAS engine instrumentation is driven by two Engine Data Concentrators (EDC), and the redundant DAU’s. Should a dual DAU failure occur, engine information can be accessed directly via the “ENG DATA” RTU reversionary mode. In the event of an EICAS screen failure, the EICAS can also be duplicated on the Multifunction Display (MFD) with the use of the “EICAS REV” switch on the center reversionary switch panel. For more information on reversionary modes, see the “Reversionary & Switching Panel (Pilot/Copilot/Center)” section of this manual.

MFD-870 Multifunction Display (MFD)

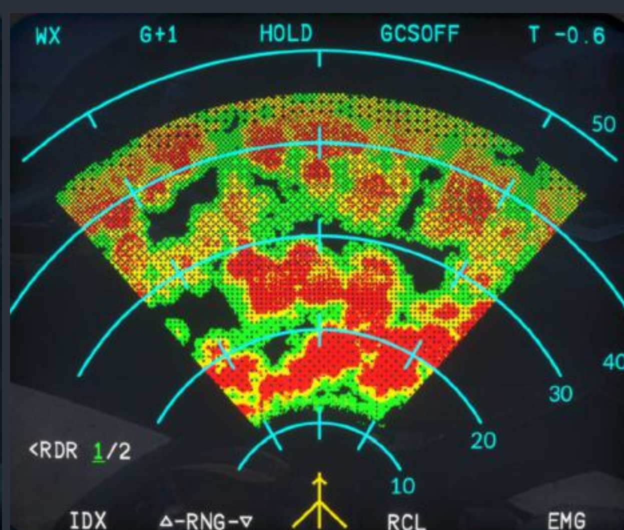
The multifunction display consists of a single screen, capable of displaying checklists, maps, flight plan information, and more, with 19 buttons around the bezel. From the Index screen, the user may select several sub-menus by pressing the appropriate line select key. On all MFD screens, the topmost row of cyan text is reserved for abbreviated radar mode status text, and the title of the current screen. On screens where the radar is depicted, the entire top row is occupied by complete radar mode information.

The normal and abnormal checklist categories are accessed from the Index screen after a checklist acknowledgment screen has been displayed. Each category screen shows all the checklists in that category, split into multiple pages, if necessary. The current page number is shown at the top right of the screen. The pages are scrolled through with the up and down arrow line select keys on the bottom of the bezel. Pressing the line select key adjacent to the desired checklist will load the checklist page. Each checklist consists of cyan uncompleted items, green completed items, and one current magenta item. Items can be skipped with the "SKP" line select key, or moving the joystick down. The up arrow line select key, or moving the joystick up, will retreat through the checklist, returning items to their uncompleted state. The down arrow line select key, or the "LINE ADV" button on the yoke (emulated by the HTML command "H:MFD_LineAdvance") will complete the active checklist item, turning it green.





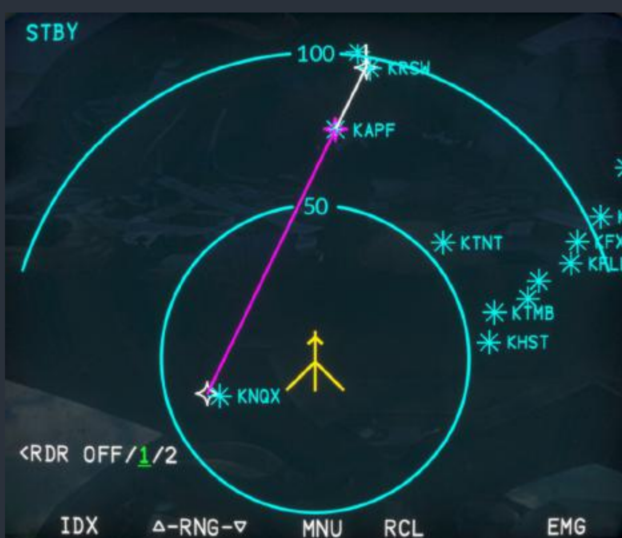
When every item in the checklist is complete, “CHECKLIST COMPLETE” will appear in green at the bottom of the last page. If items were skipped in the checklist, the first uncompleted item can be recalled as the active item by pressing the “RCL” line select key. From all other screens on the MFD, pressing the “RCL” line select key will return to the first uncompleted item in the most recently accessed checklist. The “CLR” line select key can be used to clear the current checklist and return to the first item. At any time while on the checklist screens, the Course/Heading Panel (CHP) joystick can be moved left or right to traverse all the checklists in the same category in sequence. Emergency checklists function in the same way as normal and abnormal checklists, except the emergency category is accessed with the “EMG” line select key, which is persistent across all MFD screens.



The Radar screen depicts the weather or terrain radar buffered image with the aircraft symbol at the bottom of the display. All radar parameters are controlled via the Radar Control screens on the Control Display Unit (CDU) and the CDU keypad, except range, which can be adjusted with the up and down line select keys on the MFD. The bottommost left line select key on this screen is used to select which radar channel buffer is viewed on the MFD. If the RTA-854 Weather Radar (RTA) is in synchronized channel mode, then this text will not appear on screen.

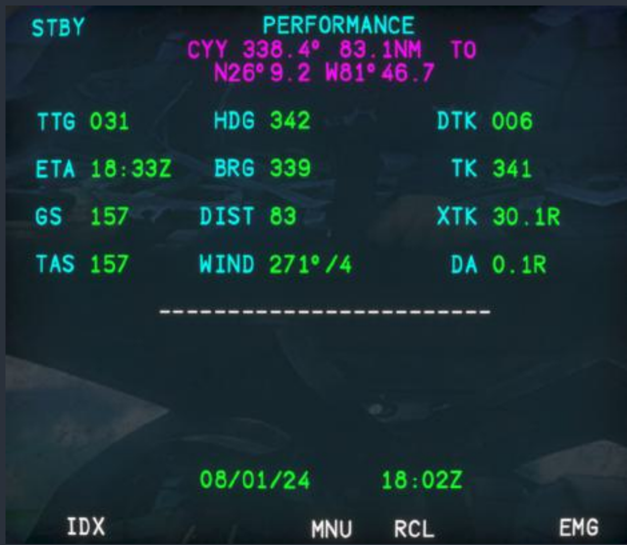
When the Present Position Map is selected from the Index screen, a map options menu is displayed first. By pressing the right line select keys, the user can select or deselect map facilities to be displayed on the present position and planning maps. Facility types shown in green will be displayed, while those in white will not. Intersections and terminal waypoints will also be hidden automatically at higher map ranges. As on the MFD Radar screen, the bottommost left line select key is used to select which radar channel buffer is viewed on the map, if any. If the RTA is in synchronized channel mode, then only “ON” and “OFF” options are shown. Pressing the line select key for “DISPLAY” will show the present position map. The present position map is always oriented with the aircraft heading up, and with two cyan range rings. The map’s range is adjusted with the up and down arrow line select keys. The map options menu can be recalled with the “MNU” line select key.

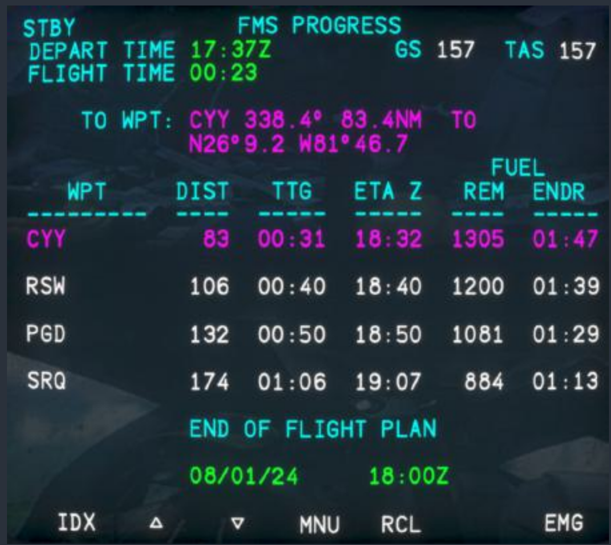
The Planning Map screen functions almost identically to the present position map, also first displaying the map options screen. The planning map is always oriented north up, has no aircraft symbol, and cannot display the radar buffered image. The center of the planning map is located at the waypoint on the second line of the selected CDU’s Flight Plan screen. The CDU from which to gather this data is toggled by pressing the leftmost bottom line select key with the adjacent “CDU1/CDU2” text. In absence of an active flight plan, the aircraft’s last known position will be used as the center of the planning map.



On the present position and planning map screens, displacing the CHP’s joystick will activate a cursor. This cursor can be used to measure distances and bearings, and build entire flight plans from the MFD. For more information on the operation of this joystick, see the “CHP-850 Course/Heading Panel (CHP)” section of this manual. On both map screens, if the number of facilities displayed exceeds a sensible number that makes their labels difficult to read, the text, “MAP INCOMPLETE - REDUCE RANGE OR DESELECT MENU ITEMS” will be shown at the top of the display. Should the selected CDU or radar channel fail, the red “RDR CTL FAULT” and “RDR FAIL” flags will appear.

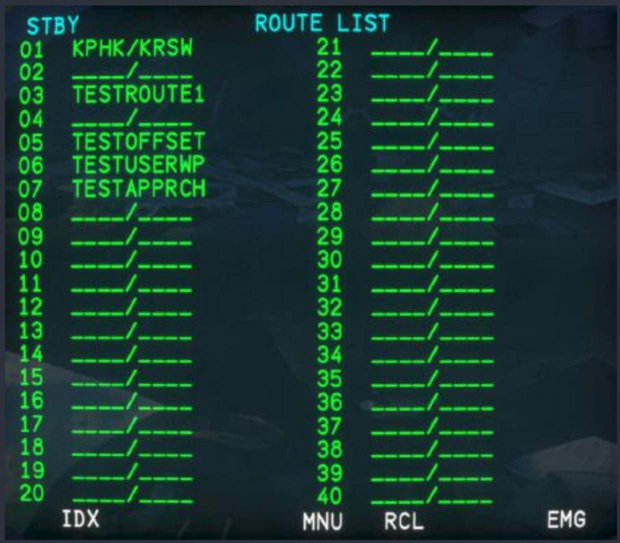
The FMS menu contains six sub-screens pertaining to the flight management system on board the aircraft. The Performance screen is useful for monitoring the data produced by the FMS to ensure navigational integrity is maintained.



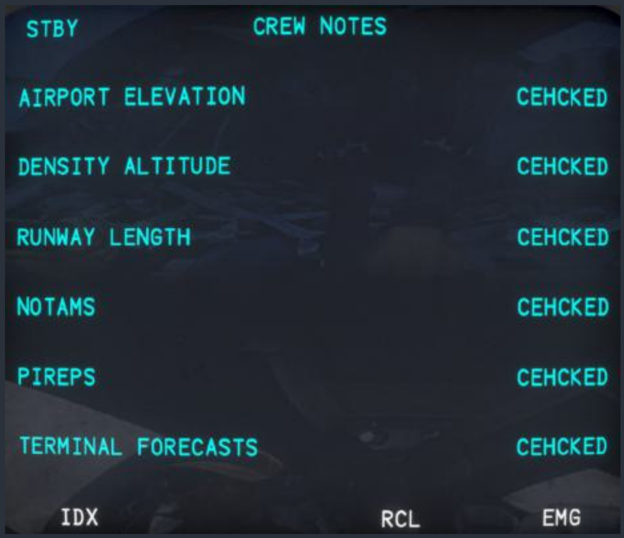


The Progress screen is useful throughout the flight to easily monitor waypoint progression. On the Progress screen, waypoint time and fuel estimates will appear in yellow when the aircraft is on the ground to indicate that these are estimates derived from either default ground speed and fuel burn or user inputs from on the CDU's Trip Planning screen, rather than current flight data. Waypoints that have been passed will scroll off the top of this screen. The currently active waypoint will always be shown in magenta. If there are more waypoints than fit on the screen, the list can be scrolled with the up and down arrow line select keys.

The Route List screen shows all of the saved routes in memory with their index number so that they can be easily identified and loaded on the CDU. Routes with invalid waypoint or approach information are shown in yellow instead of green.

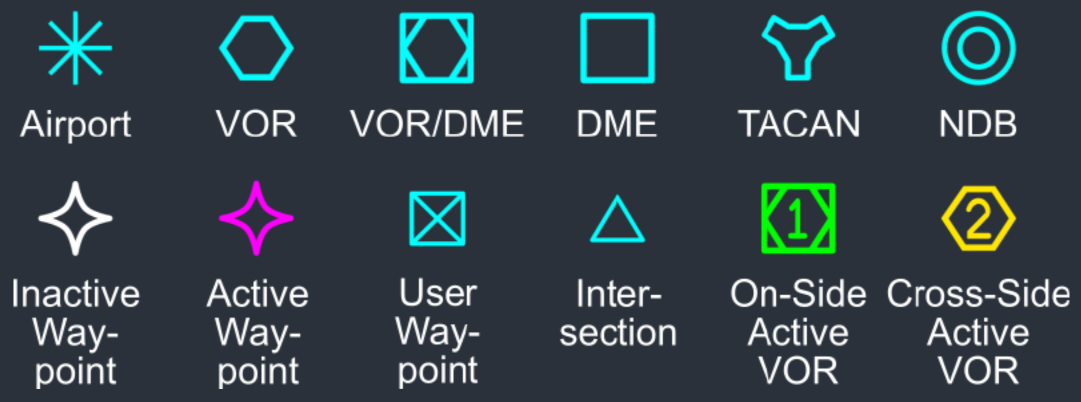


The VOR/DME Status screen shows the current frequency, received identifier, and DME distance to all six DME receivers and two VOR receivers on the aircraft. This screen is useful for monitoring the automatic navaid tuning required to generate an accurate positional estimate when GNSS is deselected as a source of position information.



The Avionics Status screen displays any currently active fault codes from any of the aircraft's Line Replaceable Units (LRU), and decodes them into human readable status messages. For example, if the copilot's side Sensor Display Unit (SDU) has overheated, the status message "SENSOR DSPLY 2 OVERHEAT" will be displayed. Crew notes are accessed from the Index screen, and can contain any items programmed through the Data Base Unit (DBU).

For information on the VLF/Omega Status screen, Position Summary screen, and VLF/Omega navigation system and its simulation in this aircraft, see the "No GPS Navigation & Position Estimation" section of this manual.

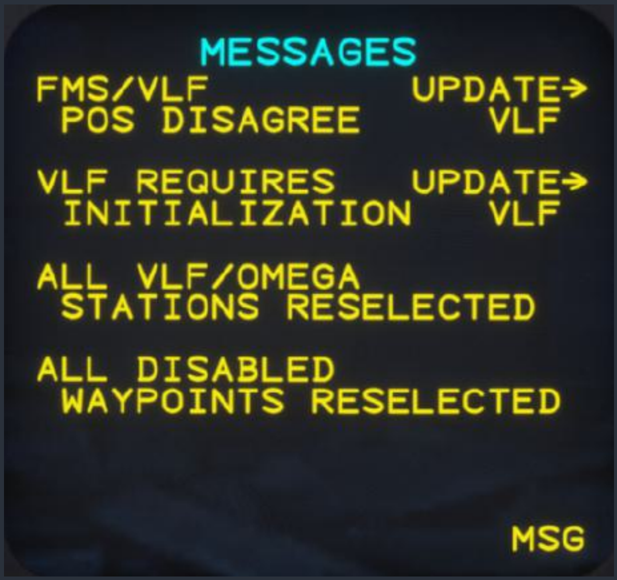


ND and MFD Map Symbols

CDU-850A Control Display Unit (CDU)

Two identical control display units provide access to all flight planning and system control functions of the Flight Management System (FMS). When the CDU is powered on, it will display a self-test screen. If the on-side FMS, Flight Control Compute (FCC), and CDU tests pass, the user will be prompted to initialize the system. If the database is up to date, the user can proceed to the Index screen. Otherwise, the user can elect to use the outdated database (with no effect on the simulation), or follow prompts to update the database via the Data Base Unit (DBU) floppy drive. If the positional estimate presented on this screen is poor, the user may elect to manually enter a position update via the Position Update screen, or tune a nearby navaid with the Radio Tuning Unit (RTU), which will then appear on the initialization page with the green "(RECEIVED)" message.

Once the system has been initialized, the Message screen can be accessed from any other screen by pressing the “MSG” button on the CDU keypad. Pressing the same button again will return to whichever screen was most recently accessed. There are new messages awaiting acknowledgment whenever the yellow “MSG” text is displayed at the bottom right of the screen. Some messages can be canceled immediately by reviewing the message screen, while others will persist. The persistent messages are accompanied by a recommended action, which can be initiated by pressing the line select key to the right of the associated message.



Message	Action	Condition
POSITION UNCERTAIN	**UPDATE POSITION**	GNSS is not available as a source of position information and the FMS position uncertainty exceeds 3.0 nm
FMS/VLF POS DISAGREE	**UPDATE VLF**	GNSS is available as a source of position information and the FMS and GNSS positions disagree by 2.5 nm
VLF REQUIRES INITIALIZATION	**UPDATE VLF**	VLF position has not been updated since a cold start of the FMS
SYS/VLF GMT DISAGREE	**UPDATE POSITION**	The ship’s clock and the received VLF time disagree
ALL VLF/OMEGA STATIONS RESELECTED	None	Displayed at every CDU cold start
ALL DISABLED WAYPOINTS RESELECTED	None	Displayed at every CDU cold start
DATA BASE EXPIRED	None	The database has expired
FINAL WPT PASSED	None	The final FMS waypoint has been passed
FMS IN DR MODE	None	GNSS is not available as a source of position information and the VLF/Omega signal is weak.
MEMORY HAS >90 WPTS	None	Approaching 99 maximum allowable user waypoints
MEMORY HAS >30 FPLNS	None	Approaching 40 maximum allowable saved routes

Data is entered into the CDU either via the scratchpad, or direct entry. These methods are referred to as postdesigation and predesignation, respectively. When white chevron brackets appear on the last line of the CDU screen, that screen is in postdesigation mode, meaning that data is first entered into the scratchpad, and then a line select key is used to insert the data into a field. Instead, if yellow underscores or dashes appear next to a field on the screen, this screen is in predesignation mode, and data entered via the keypad will be placed directly into this field. All data is entered into the CDU via an alphanumeric keypad, which has letters on each numeric key. This is often referred to as a “T9” or “text on 9 keys” layout. Unlike other systems, where multiple presses of the same numeric key trigger the input of letters, letter entry is accomplished by first pressing the associated numeric key, and then pressing the “LTR” key several times to cycle through the letters which appear on the numeric key. For example, to enter the letter ‘W’, the user would press the ‘8’ key once, followed by the “LTR” key twice. The “CLR” button is used as a backspace to clear the previous character.

NOTE: Clicking on the CDU screen will trigger keyboard entry mode, which is indicated by cyan scratchpad brackets and cyan “KYBD” text replacing the yellow “MSG” text on the bottom line of the CDU screen. To deactivate keyboard entry mode, either click the screen again, or wait five seconds for the automatic timeout.

Some CDU screens are accessed from the Index screen, while others can only be accessed from the physical keys on the CDU keypad. From the Index screen, the user can review the route library, reinitialize the system, read and write data to and from the DBU floppy diskette drive, inspect the navigation database, review fuel burn estimates, plan legs of a trip, review basic FMS data, and access system maintenance commands such as clearing all user data via the “FMSSFP” debugger menu.

The Fuel Management and Trip Planning screens allow the user to input the current fuel and payload weights for use with the FMS fuel estimates displayed on the Mutlifunction Display (MFD) Progress screen, and review basic weight and endurance estimates on the CDU. This page is only available if the FMS is receiving valid fuel flow data from both Engine Data

Concentrators (EDC). The trip planning screen allows the user to enter a pair of from and to waypoints and expected fuel burn and ground speed to produce a gross estimate of the trip's fuel requirements before entering the entire flight plan into the CDU.

The Inspect Waypoint screen allows a facility identifier to be entered, and database information for that facility will be displayed. If more than one facility with the entered identifier is found in the database, the direct entry line will be replaced with a scrolling longitude and latitude list of matching facilities, which can be traversed with the CDU's up and down arrow keys. When reviewing an airport in the database, line select text will appear for reviewing any associated terminal waypoints and runway thresholds. The FMS Data screen displays only the most basic FMS information useful for monitoring integrity, or overcoming a multiple system failure.

The Route Library screen displays a scrolling list of all saved routes, of which there can be a maximum of 40. Pressing the line select key next to a saved route will trigger the Route Preview screen. Saved route numbers can also be entered directly to preview the route without scrolling. From the route preview screen, the user can scroll through the route's waypoints to review them, rename the route by pressing the green arrow line select key to the left of the green flight plan name. To save the currently active flight plan to the route library for recall on future flights, preview an empty route and enter "00" into the direct entry field. Routes can also be erased from the same page.

The most essential screen on the CDU is the main Flight Plan screen. When the CDU is initialized, no flight plan will be active in the FMS. When the "FLT PLAN" key is pressed to access the Flight Plan screen, the waypoint entry screen will be shown automatically with features for rapid entry of a flight plan. If the user desires to load a preexisting route from the route library, enter the two digit (with leading zero, if necessary) route number into the direct entry field, and press the line select key for "ENTER". If the route is valid, a menu will appear for loading the route in normal or reverse order. Routes can also be appended or inserted into existing flight plans using the same method. If both the active flight plan and selected route contain an approach, the Approach Deconfliction screen will appear with options for loading the route without or without the approach waypoints. Individual waypoints are entered by the same method as the Inspect Waypoints screen, discussed above. The cumulative distance of all flight plan legs is displayed to the right of the waypoints. When the flight plan is complete, pressing the line select key for "END FPL" will return the CDU to the main Flight Plan screen.

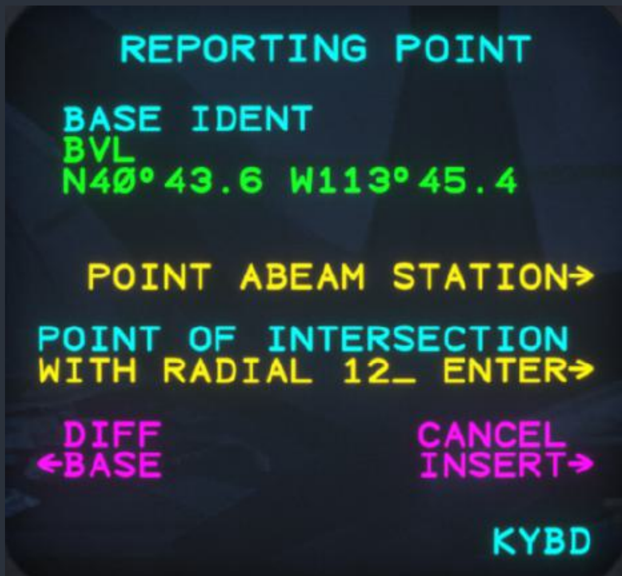
NOTE: For an expanded introduction to flight planning, see the "Introduction to Flight Planning" section of this manual, below.

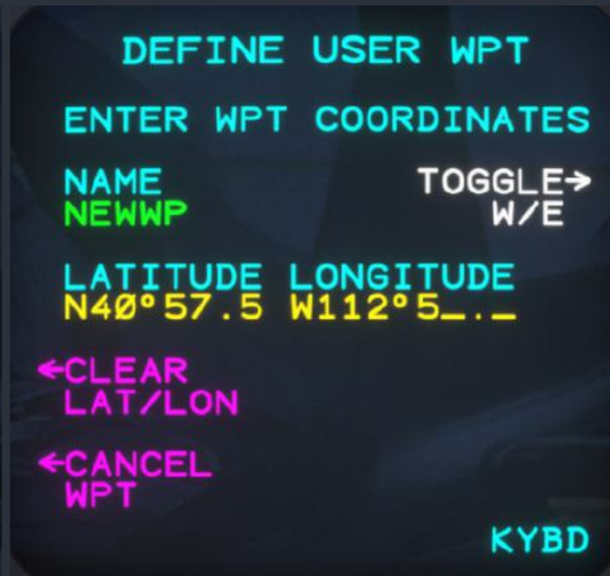
The main Flight Plan screen displays each FMS waypoint in sequence with the currently active waypoint in magenta. The current leg is denoted with cyan “TO” and “FROM” headers. Approach segments are denoted by the approach name in cyan at the beginning of all approach waypoints, and “END OF APPR” at the end of all approach waypoints. The waypoint list is scrolled with the up and down arrow keys. When the end of the flight plan is reached in the list, “END OF FPL” text in cyan is displayed below the last waypoint. When AUTO LEG or MAN LEG system control modes are selected, the planned distance and track along the displayed legs are shown on the right of the screen under the header “CRS/DIS”. When SEL CRS system control mode is selected, this is instead replaced by the currently selected course and the header “---SEL CRS---”. The selected course can be entered via the scratch pad in this mode, and line select keys for stepping forward and backwards through the flight plan will be present when in MAN LEG or SEL CRS modes.

From the main Flight Plan screen, waypoints can be appended to the end of the flight plan by pressing the line select key for “ADD WPTS” after scrolling to the end of the flight plan. Waypoints can also be added or modified from the Select Change Type screen, which is triggered by pressing the line select key next to a given waypoint. The Select Change Type screen contains prompts for adding a waypoint after the selected waypoint, replacing the selected waypoint, deleting the selected waypoint, inserting a reporting point after the selected waypoint, adding a radial and distance offset to the selected waypoint, and erasing the current flight plan. Radial and distance offsets can be added to any waypoint that is not part of an approach by following the prompts to enter a radial in miles, and magnetic radial.

Reporting points are new waypoints that can be inserted into the enroute portion of a flight plan via two methods. First, a base facility is entered and confirmed, as any other waypoint. Then, the user is prompted to choose between “POINT ABEAM STATION” and “POINT OF INTERSECTION WITH RADIAL”. The first method will calculate the point directly abeam the entered facility along the selected flight plan leg and insert the waypoint in the flight plan. The second method prompts the user for a radial outbound from the facility upon which to insert the waypoint on the selected flight plan leg. In both cases, it is possible for there to be no intersection between the entered radial or the abeam radial, and the selected flight plan leg. If this is the case, then “NO INTERSECTION WITH FPL LEG” will be displayed.

Waypoints that have been offset will appear with a star symbol on the CDU, MFD, ND, PFD, and their map screens. On the main Flight Plan screen, offset waypoints will appear with their entire offset definition after the star symbol.



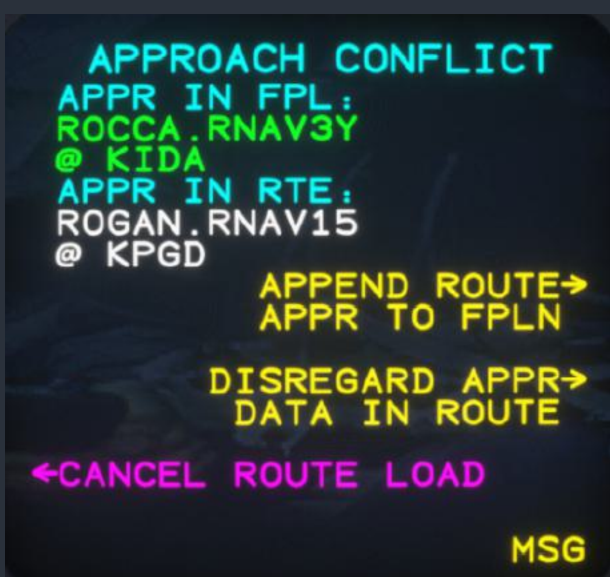


If a facility is not found while searching for a matching identifier, a user facility may be created by pressing the line select key for “DEFINE WPT”, which will appear when a search of the database fails to return any results. The user waypoint is defined using the same method of longitude and latitude entry required of the Position Update screen. User waypoints are saved between flights, and can be reviewed from the Inspect Waypoints screen. User waypoints can be deleted from the Inspect Waypoints screen by pressing the line select key for “DISPLAY PILOT DEFINED WPTS NOT USED IN ANY ROUTES OR FLIGHT PLAN”. User waypoints are depicted geographically on the MFD map screens with cyan crossed box symbols.

The flight plan name is displayed in green at the top of the main Flight Plan screen. This name is either assumed from a loaded route, or generated from the origin and destination airports in the flight plan. When the main Flight Plan screen is displayed, pressing the line select key for the white arrow to the right of the flight plan name will trigger the Origin/Destination screen. From this screen, the user may enter or modify origin and destination airports, and alternate airports. These entries must be airports, not any other type of facility, and not runway thresholds. The destination does not necessarily need to be the last waypoint in the flight plan. The primary purpose of these entries is to enable the Approach Selection screen.

Once at least a destination airport has been assumed from the flight plan, loaded from a saved route, or entered via the Origin/Destination screen, the main Flight Plan screen will show “APPR” in cyan to the left of the flight plan name. Pressing the line select key for “APPR” will trigger the Approach Selection screen. This screen will prompt the user to select an approach for the destination airport, or select another airport from the Origin/Destination screen. If the selected airport has approach data, pressing the line select key for an approach will prompt the user to select a transition. If the approach is valid, it will be appended to the end of the flight plan, replacing the destination airport if it was the last waypoint in the flight plan. Approach waypoints cannot be modified, but the entire approach can be removed from either the Approach Selection screen, or the Select Change Type screen.

Once a flight plan has been created, pressing the "VNAV" key will display all of the upcoming waypoints in the flightplan in a similar manner to the Progress screen on the MFD, with the active waypoint in magenta. The user can enter desired target altitudes into the rightmost column of the screen by using the scratchpad and pressing the appropriate line select key. Once a desired altitude is entered, the required vertical speed to arrive at the desired altitude from the last waypoint with a desired altitude (or the current active waypoint, in absence of any other) will be displayed in the middle column. If the required vertical speeds are depicted in yellow instead of green, the VNAV calculator is using either a default ground speed or the user entered groundspeed on the Trip Planning screen to estimate the required vertical speed while on the ground. Individual altitudes can be cleared by pressing the "CLR ALT" line select key, followed by the altitude to be cleared. All target altitudes can be cleared at once with the "CLEAR ALL" screen.



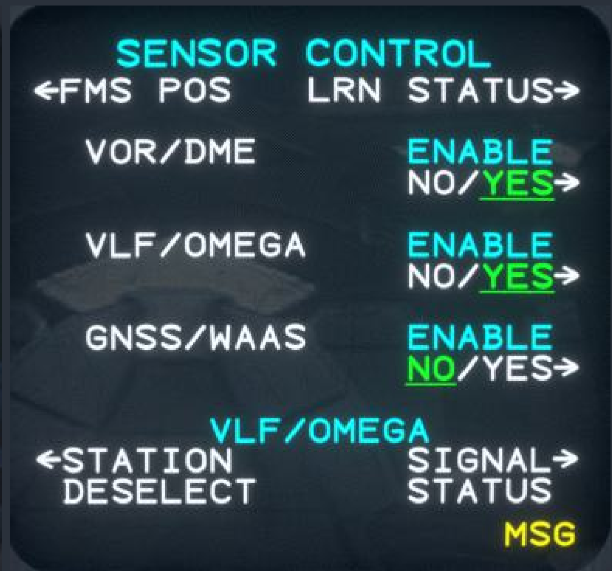
Pressing the “DIR” key triggers the Direct screen. From this screen, a new flight plan can be created by entering a facility identifier, or selecting a nearest airport via the Closest Airports screen. If no flight plan exists, either method will result in a standalone flight plan between the aircraft’s present position and the chosen destination. If a flight plan does exist, the chosen destination will be inserted into the flight plan before the next waypoint, and a leg will be created from the aircraft’s present position directly to the chosen destination. Flight plan continuity from the last waypoint will be lost while direct-to mode is active. Direct-to mode can be canceled from the Select Change Type screen by selecting the direct-to destination waypoint. After arriving at the direct-to destination, the autopilot will rejoin the original flight plan. When direct-to mode is active, the “TO” header on the main Flight Plan screen will be replaced by a “DIRECT TO” header.

Two other methods exist for selecting a direct-to destination when a flight plan already exists. The Direct screen will show all the flight plan waypoints on the left of the screen, with the active waypoint depicted in magenta. Pressing the line select key next to one of these waypoints will break flight plan continuity and a leg will be created from the aircraft’s present position directly to the chosen waypoint. This waypoint may be ahead or behind the aircraft in the flight plan. If the waypoint has already been passed, the leg will be created, but no other modification to the flight plan will take place. If the waypoint is ahead of the aircraft in the flight plan, then all waypoints between the aircraft and the chosen direct-to destination will be deleted from the flight plan. Lastly, the “FROM/TO” line select key can be used to create a leg between any two waypoints in the flight plan by removing all waypoints between them. The Direct screen cannot be used to create direct-to waypoints into or out of approach segments, although an entire approach may be deleted using the From/To direct-to prompts.

Pressing the “SYS CTRL” key will trigger the System Control screen, which is used to adjust position estimation sources and change the current FMS system control mode. At the top left of the screen, the three system control modes are shown: Automatic Leg (AUTO LEG), Manual Leg (MAN LEG), and Selected Course (SEL CRS). AUTO LEG is the default mode, which will automatically sequence FMS waypoints as they are passed. MAN LEG suspends waypoint sequencing, and offers the user line select keys to advance or retreat through the flight plan. SEL CRS mode removes all waypoint continuity and instead allows the user to fly to and from waypoints using an omni-bearing selector mode with inbound and outbound radials from the active waypoint. The selected course can be set on this screen via the scratchpad, or by the same method on the main Flight Plan screen. The selected course can also be adjusted with the course knobs on the Course/Heading Panel (CHP), assuming the FMS is selected as the on-side active navigation source. For more information on how the system control mode affects map depictions on the ND and MFD, see the “ND-870 Navigation Display (ND)” section of this manual. Also from the System Control screen, the user can provide a manual position estimate via the Position Hold screen, access the GPS RAIM screen, access the Sensors Status screen, and toggle the GNS 430 as the overriding autopilot navigation source. For more information on the GNS 430 “AP NAV SRC” option, see the “Garmin GNS 430 (GNS)” section of this manual.

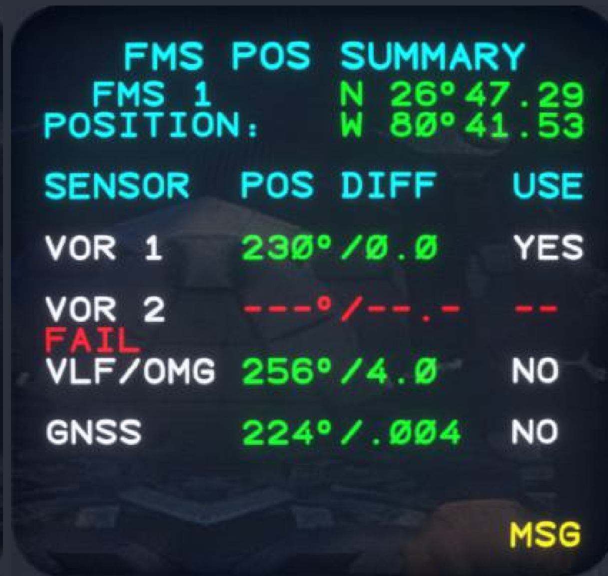
The line select key for “POSITION HOLD” allows the user to manually inform the onboard position estimating computer of a known position fix, either by longitude and latitude coordinates, or when directly overhead a named facility in the navigation database. Entering “POSITION HOLD” mode will hold the currently estimated position of the aircraft in memory, so that the user can take their time entering the fix information. The line select key for “UPDATE VLF” instead updates the VLF/Omega position estimate from the FMS’s estimate, which can be useful if the two disagree, such as when GPS information is available. For more information on position estimation and updating the position estimate, see the “Position Estimation” section of this manual.

The GPS RAIM screen is used to provide an estimate of GPS signal integrity and positional accuracy at a specific time and location. The RAIM screen assumes that the last waypoint in the flight plan is the destination, and will use the FMS calculated estimated time of arrival as a basis for the RAIM calculation. The result is presented after a few seconds of calculation in five minute intervals on either side of the estimated time of arrival at the final waypoint. If NOTAMS are in effect that preclude the use of certain GPS satellites, the satellite constellation numbers to exclude in the RAIM calculation can be entered at the bottom of the screen via the scratchpad.



The Sensor Control screen allows the user to select which sources of position information are used in the FMS's estimation of the aircraft's position. This includes, VOR/DME receivers, VLF/Omega receivers, and WAAS enabled GNSS receivers. From here, the Signal Status screen shows numerical signal reception strength values for every VLF and Omega station around the globe from the top and bottom antenna on the aircraft. The VLF/Omega Deselect screen allows the user to deselect specific stations which are known to be producing counterproductive position or timing information.

Just as the VLF/Omega receiver status can be monitored from the Signal Status screen, the optional GPS position augmentation can be monitored via the Long Range Navigation (LRN) Status screen. As GPS satellites are acquired, positional accuracy will increase, as expressed by the Horizontal Figure of Merit (FOM) and Position Uncertainty. The Integrity Limit expressed on this page determines when the FMS will disregard the GPS position in its position estimate and the "POSITION UNCERTAIN" CDU message will be displayed.



The FMS Position Summary screen displays the same information as the Position Summary screen on the Multifunction Display (MFD), with failed sensors flagged in red with the “FAIL” message. Unlike the Sensor Control screen with the heading “Enable”, the “Use” column on these pages depict whether the sensor is currently being used to create the FMS’s position estimate. The sensor may be disregarded by the FMS due to a sensor failure, possibly erroneous positioning (high positional difference with the current FMS position estimate), or because it has been deselected manually by the operator on the Sensor Control screen.

The NAV Source screens are triggered by pressing the “NAV SOURCE” button on the CDU keypad, and are used to select the active and preset navigation sources for use by the autopilot’s lateral modes and display on the ND. On the Active Nav Source screen, the user may choose between VOR1, VOR2, FMS1, and FMS2 as the active navigation sources. This selection will be immediately reflected in the information displayed on the Primary Flight Display (PFD) and ND. If the GNS 430 has been selected as the overriding navigation source on the System Control screen, this screen will display a green “GNS IS NAV SOURCE” message when FMS1 or FMS2 are selected as the active navigation source. Pressing the “NAV SOURCE” button a second time while on this screen, or pressing either the up or down arrow buttons on the CDU keypad will toggle between the Active Nav Source screen and the Preset Nav Source screen. On this screen, the same four options are available as preset navigation sources, plus an additional “PRESET OFF” option. On both screens, a line select key for “CRS XFER” or “RECALL CRS” allows the user to transfer the preset navigation source into the active navigation source, or recall the previous active navigation source. For more information on how these selections affect autopilot navigation, depictions on the ND, and the color code applied to the different sources, see the “ND-870 Navigation Display (ND)” section of this manual.

The magenta bearing pointer on the ND and PFD composite reversionary display are controlled via the Bearing Pointer screen, triggered by pressing the “BRG” button on the CDU keypad. On this screen, seven possible options may be selected: VOR1, VOR2, ADF1, ADF2, FMS1, FMS2, and “POINTER OFF”. The Radar Control screen, triggered by pressing the “RDR CONTROL” button on the CDU keypad, is used to adjust all weather and terrain radar operating parameters. For information on this screen and the radar operating modes and depiction, see the “RTA-854 Weather Radar (RTA)” section of this manual.

The four leftmost keys on the CDU keypad pertain to radio and transponder tuning. The four screens control both on-side and cross-side COM radios, NAV radios, ADF receivers, and transponder. Each page allows for presets to be saved after being entered from the scratchpad. Presets can then be recalled into the active line at the top of the screen by pressing the appropriate line select key. The CDU NAV and ADF screens allow for frequency entry by station identifier. The identifier can be entered manually, or received from the MFD map cursor. If the station is found nearby in the navigation database, its frequency will automatically be entered into the selected line. On the NAV screen, the bottom two line select keys are used to toggle automatic radio tuning mode. When the NAV radio receiver is not being used as either the active navigation source or the preset source, “AUT” radio tuning allows the FMS to automatically tune nearby stations. This will increase the positional estimate accuracy, and show the nearby stations on the ND in cyan. Automatic radio tuning can be monitored from the CDU NAV screen, the RTU’s, or the MFD VOR/Omega Status screen. Automatic radio tuning can be inhibited using the “RAD RMT TUN DSBL” switch on the center reversionary switch panel. For more information on RTU reversionary modes, see the “Reversionary & Switching Panel (Pilot/Copilot/Center)”.

NOTE: The COM screen of the CDU supports 8.33 kHz frequency tuning, a feature unsupported by the actual hardware. While these frequencies cannot be displayed by the RTU's, they can be adjusted with the knobs, and will be displayed on the CDU COM screen.

NOTE: To enter ADF frequencies with decimal components (usually 500 Hz spacing), the numerical entry MUST consist of five digits with a leading zero, if the frequency to be tuned is less than 1 MHz. For example, an entry of "07455" will tune a frequency of 745.5 kHz.

SDU-640A Sensor Display Unit (SDU)

Two identical sensor display units with green monochromatic screens, located outboard on the pilot and copilot's main panels, function as standby navigation instruments. Each SDU receives power from differing cross-side electrical distribution buses to provide the greatest likelihood of continued electrical power in the event of a failure. The SDU displays information from five operating modes, which are selected with the "FORMAT" rotary knob. While the knob rotates continuously, the mode selection will not roll over. An arrow will be shown on the screen, adjacent to the format knob, to indicate which direction the knob must be rotated to access more modes. The current mode is shown at the top left of the display.

In RMI mode, the SDU functions as a traditional Radio Magnetic Indicator (RMI), displaying two digital needles on a rotating compass card, the navigation sources of which can be selected with the two bottom knobs on the unit. The source for each needle is displayed adjacent to the knob and a solid or hollow needle symbol. If a source of navigation is unavailable, the needle will not be displayed, and the navigation source name will be crossed out.

VLF mode displays the same information as RMI mode, except the centers of the two needles are removed and replaced with the Flight Management System's (FMS) position estimation information. This includes ground speed, ground track, longitude, and latitude, or "VLF FAIL" if the VLF/Omega navigation system is disabled.

DME mode displays the same information as RMI mode, except the centers of the two needles are removed and replaced with Distance Measuring Equipment (DME) information, including the slant line distance to the station, and station identifier as received from its morse code transmission. If the selected navigation source is not receiving a station, or DME information is not present, the identifier and DME information will be blanked with X's, or dashes, respectively.

VOR1 and VOR2 modes replace the pair of RMI needles with a single split course pointer, Crosstrack Deviation Indicator (CDI), heading bug, and glideslope deviation indicator, functioning as a conventional Horizontal Situation Indicator (HSI). The bottom right knob on the unit adjusts the course in this mode, and the bottom left knob adjusts the heading reference bug. In this mode, the selected source is shown at the top left of the screen, as well as DME information at the top right. If the displayed DME information is the result of a held frequency, a boxed “H” is displayed beneath the DME information.

NOTE: Due to limitations of MSFS, the heading and course adjustments on the SDU are shared with those made from the Course/Heading Panel (CHP). The parameters shown on the SDU can always be adjusted regardless of the ones currently displayed on the Navigation Display (ND), however.

RTU-870A Radio Tuning Units (RTU)

Two identical radio tuning units in the center of the main panel are used to tune radio frequencies and adjust radio settings from various menus. Normally, each RTU displays and modifies the on-side radios, meaning the left RTU is used to program the primary radios, while the right is used to program the secondary radios. While all basic radio functionality can be accessed from the RTU's, the radio tuning screens of the Control Display Unit (CDU) have more convenience features, such as frequency presets, a numerical keypad, and entry by navaid identifier.

The RTU screens consist of five 7-segment and 14-segment display lines. Normally, the lines display the following information from top to bottom: active COM frequency, preset COM frequency, active NAV frequency, active ADF frequency, and active transponder mode and code. A star cursor can be positioned on each line by pressing the appropriate line select key. Pressing the same line select key again will trigger that radio system's control menu, or swap the active and preset COM frequencies in the case of the COM preset line. To return to the default screen, press the line select key next to the "RTN" text. The unit will also revert to the default screen after 15 seconds if there has been no further interaction. While the cursor is positioned next to a frequency or transponder code, the dual concentric rotary encoders can be used to adjust the frequency.

NOTE: Pressing the center of the dual concentric encoder allows for 8.33 kHz frequency tuning. The RTUs will display an extra digit in 8.33 kHz mode, so the knobs can be used to tune the desired frequency. The CDU's COM screen will also adjust to display 8.33 kHz frequencies.

The transponder can be toggled between the selected transmitting mode (altitude reporting, or not) by pressing the “ATC STBY” button. The transponder’s active mode is displayed on the last line with the text “STBY” or “ATC”. Pressing the integrated “ATC ID” button, or the yoke mounted transponder ident button will momentarily display “ID” as the transponder mode. The green “REPLY” light at the top of the unit will illuminate when the transponder is interrogated by ground equipment. Pressing the “DME HOLD” button will hold the currently tuned DME frequency, which can be reviewed in the NAV menu screen. While this frequency is being held and displayed on navigation equipment, the amber “DME HOLD” light at the top of the unit will be illuminated. To cancel the DME hold, press the “DME HOLD” button again.

Both RTU’s can also display and modify information from the cross-side radios by placing the RTU reversionary switches to the “X-SIDE” position, or by holding the “1/2” push button. The “1/2" push button will become toggling, rather than momentary, when the RTU is in cross-side reversionary mode. Both RTU’s can also display essential engine information by placing the RTU reversionary switches in the “ENG DATA" position. For more information on reversionary modes see the “Reversionary & Switching Panel (Pilot/Copilot/Center)” section of this manual.

CHP-850 Course/Heading Panel (CHP)

Below the Multifunction Display (MFD), the course/heading panel consists of three knobs with integrated push buttons and one joystick. The joystick is used to control various functions on the MFD. On the MFD checklist pages, the joystick can be used to quickly advance or retreat through checklists by moving the joystick up and down. Moving the joystick left and right will page through checklists in the same category (normal/abnormal/emergency) in sequence.

When displaying the present position map, or the planning map, the joystick will operate a cursor on the MFD. The cursor is connected to the aircraft symbol with a dashed white line. Beside the cursor is text indicating the cursor's bearing and distance from the aircraft on the map. When the cursor is moved, a "ENT" line select key prompt will be added to the bottom of the MFD display. This enter key can be used to transfer the nearest navigational facility under the cursor on the map to the Control Display Unit (CDU). By this method, the user can build entire flight plans using only the MFD map and cursor. The CDU will accept facility identifiers from the MFD whenever the scratchpad or direct entry is available, and the input type accepts identifiers. For example, this includes the Trip Planning screen, NAV Radio Tuning screen, Waypoint Inspection screen, main Flight Plan screen, and more.

The heading rotary knob is used to adjust the heading reference bug for whichever Flight Control Computer (FCC) is currently selected as the autopilot source with the "AP XFER" button on the Autopilot Panel (APP). Pressing the center of the knob will synchronize the heading reference with the aircraft's current magnetic heading.

The two course (CRS) knobs are used to adjust the active and preset navigation courses. One might expect the CRS1 CHP knob to adjust the active navigation source and the CRS2 knob to adjust the preset course; however, they actually control the pilot and copilot's active navigation source unless the associated CDU is displaying the Preset Nav Source screen. Pressing the center of the CRS knobs will synchronize the appropriate course with the bearing directly to the station, assuming the station is being received. The same method can be used to synchronize the FMS selected course with the bearing directly to the active FMS waypoint when FMS is selected as the active navigation source, and while operating in SEL CRS system control mode.

AAP-850 Altitude Awareness Panel (AAP)

The altitude awareness panels operate independently and are designed to control the various altitude alerting functions of the Primary Flight Display (PFD). The left knob controls the decision height, which appears on the PFD whenever the knob is rotated. To hide the decision height and associated alert from the PFD screen, press the center of the left knob. To the right of this knob, the white “RA TEST” push button can be used to test the radar altimeter, by triggering an output of 50 feet. The decision height should be set to above 50 feet before pressing this button to trigger the flashing “DH” alert on the PFD screen and associated tone to properly perform the test.

The right knob is used to set either a minimum descent altitude, or reporting altitude. The small switch to the left of this knob is used to select which of these two altitude alert modes is active. Pressing the center of the knob will hide either altitude and alert from the PFD display.

MSP-850A Autopilot Mode Select Panel (MSP)

Two identical autopilot mode select panels are located just above the console panel. These two panels each control one of the Flight Control Computer’s (FCC) to command the autopilot. Only the active MSP, as selected with the “AP XFER” button on the Autopilot Panel (APP), will function and illuminate with the active autopilot modes. The active and armed autopilot modes are also indicated at the top of the Primary Flight Display (PFD) screen. The “FD OFF” button can only be used to hide the flight director when the autopilot is disengaged. The FCC’s commanding autopilot reference information (such as target altitude or airspeed) will come from the on-side avionics, as selected with the “AP XFER” button. This is indicated on each piece of avionics by the cyan “FD” symbol when it is driving the autopilot.

While most of the autopilot modes are self explanatory, not all users will be familiar with “IAS PROF”, “DESCEND” and “IAS” modes. In Indicated Airspeed (IAS) mode, the autopilot will control the aircraft’s pitch to climb or descend at whatever speed is selected by the on-side Airspeed Indicator (ASI), and displayed on the PFD’s speed deviation indicator. This reference speed is selected when IAS mode is activated, can be adjusted by the airspeed reference knob on the ASI, and will never change automatically.

In IAS Profile (PROF) mode, the autopilot will also control the aircraft’s pitch to climb or descend at whatever speed is selected on the on-side ASI. This is very similar to IAS mode, except the FCC will automatically reduce the reference airspeed by two knots for every 1,000 feet the aircraft has climbed since IAS Profile mode was activated. The FCC will never reduce the reference airspeed below 130 kts in this mode.

In Descend mode, the FCC will continuously command a reference airspeed 25kts below the barber-pole speed (Vmo) until reaching 10,000 feet, at which point the reference speed will become steady at 225 kts. If the reference speed is adjusted manually using the airspeed reference knob on the ASI while Descend mode is activated, then the new speed offset with Vmo will be maintained until 10,000 feet.

NOTE: There is no indication of master autopilot engagement on this panel. The only indication of master autopilot engagement is at the top of the PFD screen.

NOTE: An invisible clickspot between the two MSP's has been included to trigger the master autopilot switch for your convenience. It will behave identically to the lever on the APP.

APP-85D Autopilot Panel (APP)

The autopilot panel, located on the lower pedestal, consists of a roll control knob, colocated pitch control knob, two push buttons, and two spring-loaded solenoid-held levers. The two levers are used for engaging the autopilot and the yaw damper. The levers are held into place by solenoids, meaning that when the autopilot is disconnected, or cannot be engaged at all, the levers will spring back into their off positions. The roll knob is used to command a constant bank angle from the autopilot by lifting the knob out of the center detent, and selecting a bank angle from 0-28°, left or right. Lifting the roll knob from its detent, will cancel all other lateral autopilot modes and enter roll hold mode. The pitch control knob can be used to adjust the target pitch in pitch hold mode by rolling the wheel up and down. The "AP XFER" button is used to toggle between the pilot and copilot's Flight Management Computer (FMC) as the autopilot source. When the copilot's side FMC is the autopilot source, the button's integrated green indicator lamp will illuminate. The "TURB" button is used to activate the autopilot's turbulence compensation mode, which adjusts the control loop gains of the autopilot for a smoother ride in turbulent conditions. The activation of turbulence mode is indicated by the button's integrated green indicator lamp.

ARINC 429 Digital Clock

Each digital chronometer has two screens, capable of presenting a combined six modes, which are indicated at the bottom of each screen. Pressing the “L SEL” button will cycle through modes on the left screen, and pressing the “R SEL” button will cycle through modes on the right screen. The default mode on the left screen is “TRP”, which displays the trip time, counting from when weight on the wheels is no longer detected. The default mode on the right screen is “LC”, which displays the local time in 24-hour format.

On the left screen, “SW” mode displays a stopwatch, which can be started and stopped by pressing the “ST/SP” button, or zeroed with the “Z/ADV” button. In “DC” mode, this screen displays a countdown timer, which can be set, started, and stopped by pressing the “ST/SP” button. The initial downcount time is set by pressing the “SET” button for each digit pair of the clock, advancing to the next with the “Z/ADV” button. When the downcount timer reaches zero, the clock will begin counting up again with a flashing display.

On the right screen, “GMT” mode displays the Greenwich Mean Time in 24-hour format. The “FHRS” mode displays the total flight time of the aircraft, counting whenever there is no weight on the wheels detected.

Reversionary & Switching Panel (Pilot/Copilot/Center)

On the pilot and copilot's side of the main instrument panel are two identical reversionary switch panels. They are used to control the reversionary (backup/redundancy) features of the avionics suite. The three position "CMPST" (composite) mode switch is used to display both essential flight and navigation information on either the Primary Flight Display (PFD) or Navigation Display (ND), in the event of a screen failure. The "AHRS X-SIDE" switch is used to select the cross-side Attitude and Heading Reference System (AHRS) as the source of flight and navigation data for the on-side PFD and ND. The "CDU X-SIDE" switch is used to select the cross-side Control Display Unit (CDU) as the source of navigation source selection for the on-side ND. The locking momentary "AHRS REINIT" switch can be held upwards to force reinitialization of the on-side AHRS. The momentary "FAST SLAVE" switch can be held to force the AHC-85D Attitude Heading Computer (AHC) to come about to the FDU-70 Flux Detector Unit's sensed magnetic heading, bypassing the normal filtering constants. The "BARO" switch can be used to select the barometric pressure adjustment unit on the Altitude/Vertical Speed Indicator (ALI) as either millibars, or inches of mercury. Lastly, the "FL180 DISABLE" switch will inhibit the transition altitude (flashing barometer setting digits) warning on the ALI when passing through 18,000 feet.

In the center of the main instrument panel, the center reversionary switch panel contains volume control knobs for various radio receivers, a transponder select switch, a marker beacon sensitivity switch, and center panel reversionary features. The "EICAS REV" switch allows the Engine Instrument and Crew Alerting System (EICAS) to be displayed in its entirety on the Multifunction Display (MFD) screen. The three rightmost bottom line select keys on the MFD serve the same purpose as the EICAS line select keys in EICAS reversionary mode. The two three-position Radio Tuning Unit (RTU) reversionary mode switches allow each RTU to display the other's information, and control all cross-side features when in the "X-SIDE" position. This is similar to the operation of the "1/2" swap buttons on the RTU's, which will momentarily display information from the cross-side RTU. When an RTU's reversionary switch is in the "X-SIDE" position, the "1/2" button will toggle which side's information is displayed on the RTU, rather than it only momentarily being displayed. When in the "ENG DATA" position, both RTU's are capable of displaying essential engine performance information. The "RAD RMT TUN DSBL" is used to prevent the Integrated Avionics Processor System (IAPS) from remotely tuning the radios, as can be commanded from the CDU's NAV Radio Tuning page.

NOTE: All reversionary mode switches possess an integrated red/orange LED in the switch lever, which illuminates when the switch is positioned in a reversionary mode.

Airspeed, Attitude & Altitude Standby Instrumentation

Three conventional standby instruments are located below the center reversionary panel. The instruments have integrated lighting, and can be powered by a backup battery whenever the standby avionics switch is in the on position and there is no other power applied to the standby instrumentation bus. When the standby battery is discharging, the white “BATT PWR ON” annunciator light will illuminate.

The attitude indicator is an electric gyroscope, which implements Black Square’s gyroscope physics simulation, making it susceptible to temperature, voltage drop, and the forces on the aircraft. For more information, see the “Gyroscope Physics Simulation” section of this manual. The altimeter has an integrated vibrator motor to prevent it from sticking, due to the low airframe vibration of this aircraft compared to a reciprocating engine aircraft.

Other Equipment & LRU's

ADC-850 Air Data Computer (ADC)

Two redundant computers collect conventional pitot-static information from the independent pilot and copilot's side pitot-static plumbing. This data is processed by the Attitude and Heading Reference System (AHRS), displayed on the Airspeed Indicator (ASI) and Altitude/Vertical Speed Indicator (ALI), and referenced by the Flight Management Computer (FMC) and altitude reporting transponder via the associated Radio Tuning Unit (RTU). Should an ADC fail, airspeed and static pressure information will be lost for the on-side avionics.

FMC-851A Flight Management Computer (FMC)

The two flight management computers are part of the Flight Management System (FMS), which provides flight plan and navigation data to the FMC-852A Navigation Computer, and various other computerized systems on the aircraft. The user interacts with the FMC through either Control Display Unit (CDU), the Altitude Awareness Panel (AAP), and the Course/Heading panel (CHP). If either FMC fails, the associated CDU will become inoperative. The integrity of the FMS is checked during every startup when the CDU displays the yellow self test message.

EDC-850 Engine Data Concentrator (EDC)

Each engine is equipped with an engine data concentrator to collect engine data that would otherwise be transmitted mechanically to the cockpit instrumentation. The engine data is processed by the Data Acquisition Units (DAU) and displayed on the Engine Instrument and Crew Alerting System (EICAS), and fuel flow information is referenced by the FMS. Should an EDC fail, all engine information will be lost for the associated engine. Should the dually redundant DAU's fail, engine data will be lost on the EICAS and the Flight Management System (FMS). In this scenario, it is possible to access essential engine performance data directly via the "ENG DATA" reversionary mode on either RTU.

DAU-850 Data Acquisition Unit (DAU)

Two redundant data acquisition units collect aircraft and engine status information from various pieces of equipment for visual display and status monitoring on the Engine Instrument and Crew Alerting System (EICAS). Should both DAU's fail, engine data will be lost on the EICAS and the Flight Management System (FMS), and the CAS message on the EICAS will become blanked with the red "CAS" flag.

FCC-850 Flight Control Computer (FCC)

Two redundant flight control computers are part of the Flight Control System (FCS), which provide autopilot control, flight director guidance, and servo motor control. The aircraft can be flown on a single FCC in the event of a failure by pressing the "AP XFER" button on the Autopilot Panel (APP), located on the pedestal. Autopilot modes are then selected via the copilot's side Autopilot Mode Select Panel (MSP).

DBU-850 Data Base Unit (DBU)

This avionics system has the ability to read and write data to/from a 3.5 inch floppy diskette. The floppy disk reader is located in one of the baggage shelves behind the copilot's seat, near the floor of the cabin. Click on a floppy disk to select it, and click the floppy again to insert it into the floppy drive. To eject the floppy, click on the latching lever over the slot. Once a floppy is inserted, it can be read via the "READ/WRITE DISKETTE" screen, accessible via the Control Display Unit's (CDU) index page. When read or write operations are occurring, the floppy drive's activity light will flash.

Approximately five weeks after you first install the aircraft, the CDU will warn of an outdated navigation database during initialization. This message can be ignored by pressing the line select key for "USE EXPIRED DATA BASE" without any ill effects. The database can be updated by following the menu prompts on the "UPDATE DATA BASE" screen by inserting the navigation data floppy disk and performing the diskette read operation.

RTA-854 Weather Radar (RTA)

The radar Receiver/Transmitter/Antenna (RTA) consists of a single 14-inch antenna and processing unit in the nose radome of the aircraft. The radar is capable of detecting precipitation, turbulence, and ground returns up to 300nm in front of the aircraft. The unit is controlled via the Radar Control screens on either Control Display Unit CDU, and imagery can be displayed on the Navigation Display (ND), and the Multifunction Display (MFD).

While the RTA consists of only a single antenna, two channels can be controlled independently, seemingly as two separate transceivers by the two CDU's. The RTA accomplishes this by writing to the radar image buffer on alternating sweeps of the antenna. If a higher update rate is desired, the RTA can be placed in synchronized channel mode by selecting "SYNC" on the Radar Control screen of the CDU. This will force all radar parameters into parity on the two CDU's and the MFD.

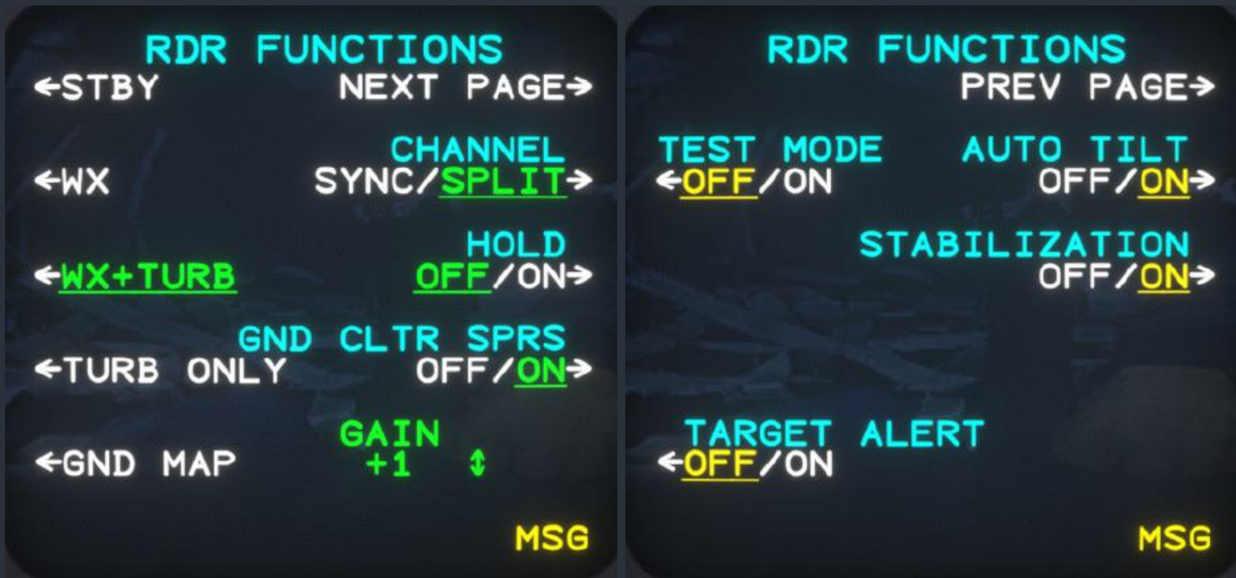
The antenna can be tilted up or down by 14 degrees using the tilt knob on the CDU keypad. Pressing the center of the tilt knob will return the antenna to its vertically centered position. The receiver's gain can be adjusted between -3 and +3 units by pressing the up and down arrow buttons on the CDU.

Weather radar with VOR active course

- In STBY mode, the transceiver channel is off. Both channels must be off during ground operations to protect personnel and sensitive equipment.
- WX mode is the basic weather radar mode.
- WX+TURB will display areas of turbulence in magenta on top of the weather depiction.
- TURB ONLY displays only areas of turbulence in magenta.
- GND MAP displays radar returns from the surrounding terrain using a different color palette than the weather returns.
- GND CLTR SPRS (Ground Clutter Suppression) mode reduces the density of erroneous ground returns on the weather radar depiction, but at the cost of hiding light precipitation.
- TEST mode displays a test pattern generated by the RTA to ensure that the transceiver and image buffer are behaving properly.

- AUTO TILT mode will continuously adjust the antenna tilt position in an attempt to cancel out the pitch of the aircraft relative to targets on the horizon. This is especially useful while climbing and descending in mountainous areas and using the GND MAP mode, as changing the pitch of the aircraft by a few degrees may cause even large obstructions on the distant horizon to disappear from the image buffer.

Terrain radar with VOR active and preset course



CDU Radar Control screens

Radar test pattern on ND ARC display

Angle of Attack Indicator (AOA)

The angle of attack indicator depicts the angle of attack of the aircraft as a unitless value from 0.0 to 1.0. Angle of attack information comes from one of two independent sensors located on the nose of the aircraft. The toggle switch below the gauge is used to select which sensor's output is being displayed on the gauge. Unlike other angle of attack indicators, often located on the glareshield of the aircraft or on the primary flight display, this one is not intended to be referenced by the pilot while in flight. Instead the angle of attack gauge is included to confirm the functioning of the angle of attack sensors as they relate to the stall protection system.

During the full before takeoff checklist, pressing the STALL WARN test push button will activate a self-test sequence, driving the angle of attack signal from its minimum to maximum. When the displayed angle of attack exceeds 0.6, the stick shaker and column pusher will activate, attempting to push the yoke towards the nose down position. When the test completes successfully, the stall warning horn will sound, and the column pusher will deactivate, releasing the yoke to be returned to the neutral position.

Garmin GNS 430 (GNS)

This 2000’s era full-color GPS is implemented by a 3rd party developer. In this aircraft, the GNS 430 can be used simply as an additional source of reference navigation data, or used to drive the aircraft’s autopilot and primary flight and navigation displays. When “GNS” is selected as the “AP NAV SRC” on the System Control Screen of the Control Display Unit (CDU), all navigation and guidance information on the Primary Flight Display (PFD) and Navigation Display (ND) will reference the GNS, and the autopilot will fly with lateral and vertical guidance from the GNS. This allows for additional approach types, arrivals, departures, procedure turns, holds, and vertical guidance to be flown than with the Starship’s original equipment.

Flightplan and FMS progress information on the CDU and Multifunction Display (MFD) will still reference the FMS’s internal navigation, and not that of the GNS 430. The CDU can still be used to edit the FMS’s flightplan while the autopilot is navigating via the GNS 430. The recommended method for executing a procedure with the GNS that the Starship is otherwise incapable of is to fly enroute legs with the original equipment, load the desired approach waypoints in the CDU, load the approach in the GNS, and then fly the procedure with the GNS as the autopilot’s navigation source. This allows the user to switch back to the original equipment and continue an amended flight plan with minimal interruption.

HF-9000 High Frequency Communication Transceiver (HF)

The HF-9000 is a High Frequency (HF) band radio transceiver, which operates between approximately 3-30MHz. The radio has independent volume and squelch controls controlled via the left dual concentric rotary encoder. The right dual concentric rotary encoder can be used to change operating modes, change emission modes, select numeric channels for reception, assign specific frequency values for reception when in “MAN” operating mode, and select the transmitting power of the antenna. The center encoder is used to quickly select preset channels when not in “MAN” operating mode.

NOTE: For the HF radio to be audible, the “HF” audio switch on the pilot’s audio control panel must be in the up position.

Electrical/Miscellaneous

Circuit Breakers

The Starship's circuit breaker panels are located under the pilot and copilot's armrests, and beside the pilot's left knee. The exposed panel by the pilot's knee contains the external lighting and some ice protection circuit breakers. The pilot's side circuit breakers include many high load and essential items, such as bus tie control, warning systems, environmental control, ice protection, fuel items, engine items, and flight control surfaces. The copilot's side circuit breakers are almost exclusively avionics related, including avionics power distribution and bus feeders. This panel also includes circuit breakers for annunciator lights and cabin accessories. Many of the power distribution circuit breakers on the copilot's circuit breaker panel are mirrored on the Live Schematic page of the tablet interface, and are depicted on the "Overview Electrical Schematic" in this manual.

Breakers may be pulled or pushed to disable electrical circuits and bus connections within the aircraft. All the corresponding electrical circuits are modeled. The status of the electrical system can be monitored via the volt and amp meters discussed below. In an emergency situation, such as the detection of smoke, acrid burning smells, loss of engine, or alternator failure, all non-essential electrical systems should be switched off, workload permitting.

Fire Detector, Extinguishers & Firewall Valves

This aircraft is equipped with fire detector loops in each engine nacelle. When temperatures in the nacelle are sufficiently high, the presence of an engine fire is likely, and the red “ENG FIRE” annunciator light will illuminate. Simultaneously, the red “CLOSED” text will flash below the plastic lens marked “F/W VALVE PUSH”, prompting the pilot to lift the lens and close the firewall valve. After pushing the flashing button, the firewall valve will take a few seconds to close, separating the engine from its fuel supply, and isolating the cabin from the engine’s bleed air.

When the valve is fully closed, the flashing “CLOSED” annunciator will become steady, and the white “EXTINGUISHER” text will illuminate, prompting the pilot to push the extinguisher button. After the extinguisher button is pressed, the “EXTINGUISHER” text will extinguish, and the amber “DISCH” text will illuminate a few seconds later to indicate that the fire bottle has been discharged. The fire bottles can be monitored and refilled via the engine visualizer page of the tablet interface. See the “Engine Visualizer Page” section of this manual for more information.

The fire detectors and extinguishers can be tested by pressing the “FIRE DET” and “FIRE EXT” buttons on the pilot’s left subpanel. When the “FIRE DET” button is pressed, the “ENG FIRE” annunciator should illuminate and trigger a master warning. When the “FIRE EXT” button is pressed, the green extinguisher “OK” annunciator should illuminate. The fire bottle charges can be refilled from the Engine Visualizer pages of the tablet interface.

Voltmeters & Ammeters

At the top of the electrical control panel on the pedestal, there are three LCD screens. The outboard screens display measurements of current, while the inboard screen displays measurements of voltage. Normally, the ammeter screens display the load on each generator as a percentage of the maximum allowable load. When the “BATT AMP” button is held down, the leftmost screen momentarily displays the total amperage being discharged from the battery.

The voltmeter screen in the center of the panel displays the voltage at any one of the six sensing locations, selected with the radio push buttons below the screens. Refer to the "Overview Electrical Schematic" in this manual for a graphical depiction of each of these sensing locations, and take note of the diodes that may produce different voltages across the system when all bus ties are closed.

Fuel Temperature & Quantity Indicators

At the bottom of the electrical control panel on the pedestal, there are three LCD screens. Normally, the two larger screens provide a graphical and numerical depiction of the total fuel quantity in each wing fuel system. The digits indicate the TOTAL fuel weight, and the horizontal bar graph depicts the quantity as a fraction of the whole. When the "AFT TANK QTY" button is pressed, the display momentarily indicates the quantity of fuel in ONLY the aft fuel tank.

NOTE: DO NOT mistakenly add the normally displayed TOTAL quantity with the aft tank quantity to arrive at the total fuel aboard, as this will overestimate the total quantity of fuel remaining. The normally displayed value is the total quantity in BOTH main and aft thanks.

NOTE: The primary purpose of checking the aft fuel tank quantities is to ensure that the jet pumps are transferring fuel from the aft tanks to the main tanks, or to monitor for fuel imbalance. Unless operating at the maximum allowable fuel load, expect to see the aft tank quantity near zero, as the fuel will have been transferred to the main tanks by the jet pumps or by gravity.

The bottom display indicated the fuel temperature as sensed within the left wing. The fuel is heated by a fuel-oil heat exchanger when the engines are running. Fuel must be kept above -27°C (-17°F), as Jet-A has a freezing point of -40°C (-40°F), while the aircraft is able to fly at altitudes where ambient temperatures may approach -85°C (-120°F).

Pneumatic Pressure Indicators

To the left of the landing gear handle, two LCD screens indicate the bleed air pressure available after the firewall shutoff valves and flow control valves in PSI. This pressure will vary with gas generator RPM, and will be reduced by various pneumatic loads, such as cabin pressurization and deicing boot inflation. The yellow “PNEU PRESS LOW” Crew Alerting System (CAS) message will appear when pneumatic pressures drop below approximately 12 PSI, which is no longer sufficient to inflate the deicing boots.

Carbon Monoxide Detector

At the bottom right of the copilot’s main panel, is a carbon monoxide detector.   Carbon monoxide is a potentially deadly gas that results from the combustion of hydrocarbons, such as in an aircraft’s turbine engine. The gas is odorless, and colorless, making it extremely difficult to detect. To test this carbon monoxide detector, depress the “TEST/RESET” button on the unit. Both the amber and green “ALERT” and “STATUS” lights should illuminate. The detector is battery operated, and the green status light should blink once every few seconds to indicate that the unit is functioning properly. The detector can both fail, and detect an exhaust gas leak via the integrated failures system. If carbon monoxide is detected, a warning tone will sound, and action should be taken immediately. The source of the leak is indicated on the cabin climate visualizer in the tablet interface by the presence of a gray gradient in the air ducts.

Lighting Controls

Cabin Lighting

Cabin lighting consists of overhead fluorescent lights in the main cabin, overhead fluorescent lights in the cabin entry vestibule, aisle lighting below the carpet, incandescent reading lights for every seat, two incandescent lavatory lights, two incandescent lights in the baggage compartment, and a door panel light to illuminate the airstair steps. When power is applied to the cabin accessories bus with the cabin door closed, the cabin overhead and aisle lights are controlled by the overhead lighting panel in the cockpit. When the cabin door is open, the aisle, entry, and door lights are controlled by toggling push buttons on a panel forward of the entry door. If these toggling buttons are left in their on (depressed) positions, the cabin will be illuminated for convenient entry and exit when the cabin door is open. Power for the cabin lights is derived from the hot battery bus when the cabin door is open. The individual reading lights are activated by toggling push buttons at each seat. The lavatory overhead lights are activated by two toggling push buttons in the ceiling lighting panels. If any of the fluorescent cabin lights are inoperative, they must be repaired or disabled prior to flight.

Cabin aisle lighting (left), and fluorescent cabin overhead lighting (below)

Individual passenger reading lights switch, seatbelt & no smoking sign (left), and lavatory lighting fixtures (right)

Cabin entry lighting control panel (left), and fluorescent cabin vestibule entry lighting (right)

NOTE: The “BAR” light push button on the overhead lighting panel controls a light above the integrated refreshment cabinet, which is not modeled in this simulation.

Cockpit Lighting

General cockpit illumination is accomplished by activating the dimmable cockpit area light and associated lights in each footwell. The brightness of these lights is controlled via the “COCKPIT AREA” potentiometer on the overhead lighting panel. A fourth toggling push button on the entry lighting panel discussed above allows the cockpit area light to be connected to the hot battery and activated at full brightness whenever the cabin door is open. In case of an emergency, a white flood light fixture in the cockpit ceiling is always connected to the hot battery bus, and can be controlled via the “STORM FLOOD” rotary selector knob. In the low position, only one of the two lights in the storm flood light fixture is illuminated. In the high position, both lights are illuminated. Two map reading lights are recessed into the cockpit walls above the cupholders on the pilot and copilot’s side, which are activated by turning their integrated knobs.

Storm flood light “LOW” (left), and pilot’s map reading light (right)

Cockpit area light between two speakers

Panel Lighting

General panel illumination can be accomplished by activating the pale blue under-glareshield electroluminescent lighting via the “INSTR INDIRECT” potentiometer on the overhead lighting panel. This light is also connected to the hot battery bus for use during an electrical emergency. All panels in the aircraft, including the circuit breaker panels, are equipped with amber electroluminescent integrity lighting. This backlighting is adjusted via the “MAIN PANEL” and “CONSOLE PANEL” potentiometer . These two potentiometers also control the analog gauge lighting for the standby instruments, angle of attack indicator, and cabin pressurization panel. The standby instrument lights are also connected to the standby instrument backup battery to ensure the instruments are lighted in the event of an electrical failure. For the integrated panel lights to function, the “LIGHTS MASTER” toggling push button must be depressed.

Glareshield electroluminescent lighting

The brightness of the various annunciator, LED indicators, and reversionary switch lights are continuously controlled by a photocell light dimmer circuit. The photocell, mounted in the overhead lighting control panel, senses the ambient light intensity and adjusts all the cockpit annunciator lights to best suit the conditions.

Overhead lighting control panel

Screen Brightness

The brightness of the LCD screens located on the pilot and copilot subpanels and pedestal console are controlled by the “SUBPANEL DISPLAYS” potentiometer. The main avionics screen brightnesses are controlled by the remaining three potentiometers, marked “PILOT DISPLAYS”, “CENTER DISPLAYS”, and “COPILOT DISPLAYS”. When the “LIGHTS MASTER” toggling push button is not activated, these potentiometers have no effect on the display brightnesses. Full display brightness is set by the small “BRT” adjustment knobs on the bezel of each display. When the “LIGHTS MASTER” button is activated, the brightness of all the displays will be reduced to the level set on the three potentiometers. The small “BAL” adjustment knobs on the bezel of each of the main displays serves as a backup to overcome an overhead lighting panel dimmer failure. Do not leave the “BRT” adjustment knobs in the fully clockwise position, as this will defeat the overhead screen dimmers.

To properly adjust the display brightnesses, follow these steps:

1. Deactivate the “LIGHTS MASTER” toggling push button.
2. Adjust the small “BAL” adjustment knobs on the bezel of each main display to their center positions where the “BAL” text reads horizontally from left to right.
3. Adjust the small “BRT” adjustment knobs on the bezel of each display down from maximum brightness until dimming is just noticed.
4. Active the “LIGHTS MASTER” toggling push button.
5. Reduce the three overhead screen dimming potentiometers to comfortable level for nighttime viewing.

Exterior Lighting

The bottom row of toggling push buttons on the overhead lighting panel controls all the exterior lights. The taxi and nose landing gear lights are only available when the landing gear is extended. The two strobe light switches are mutually exclusive, with the low overriding the high. The simplest way to operate the strobe lights is to leave the “ANTI-COLL” button depressed at all times, and depress the “LOW” button when operating on the ground in the vicinity of other aircraft, or within reduced visibility conditions.

Voltage-Based Light Dimming

Black Square’s aircraft now support an advanced dynamic interior and exterior lighting and panel backlighting system that simulates several characteristics of incandescent lighting. Mainly, real world pilots will be intimately familiar with interior lights dimming during engine starting, or becoming brighter when an alternator is switched on. The brightness of the lights in this aircraft are now calculated as the square of the available voltage.

The lights in this aircraft will react to even the smallest changes in the electrical system’s load. For example, a generator failure in flight will result in the dimming of lights. Should a second, or standby generator, not provide sufficient power to support the remaining systems on the aircraft, this is signaled by the dimming of lights in response to even small additional loads, such as exterior lighting. The incandescent lights also simulate the dynamics of filaments, creating a noticeably smoother effect to changes in their intensity. This system has the advantage of allowing for easier dimmer setting with L:Vars, and preset configurations when loading the aircraft in different lighting conditions.

State Saving

This aircraft implements “selective” state saving, meaning that not all variables are saved and recalled at the next session, but some important settings are, primarily to enhance the user experience. Of primary interest, the radio configuration is saved, as well as any preset frequencies/distances/radials/etc that are entered into radio memory. Many radio and switch settings are also saved for recall, including cabin environmental controls, and the state of other cabin aesthetics, such as sun visors, armrests, and windows. No action is required by the user to save these configurations, as they are autosaved periodically, or whenever required by the software. The state of switches that affect the primary operation of the aircraft, such as battery switches, de-icing, etc, are not saved, and are instead set when the aircraft is loaded based on the starting position of the aircraft. Engine health and oxygen pressure are saved between flights, and can be reset via the tablet interface.

Fuel tank levels will be restored from the last flight whenever a flight is loaded with the default fuel levels. Due to a currently missing feature in MSFS, payload and passenger weights cannot be restored in the same method, although the code has been implemented to do so.

Whether or not the engine covers, pitot covers, downlock pins, and wheel chocks are deployed when loading the aircraft on the ground is controlled via the “Load with Covers & Chocks Deployed” option on the tablet’s options page.

All saved routes and user defined waypoints generated on the Control Display Unit (CDU) are saved for future flights, and can be exported using the Coherent GT Debugger.

Note: Since this aircraft uses the native MSFS state saving library, your changes will only be saved if the simulator is shut down correctly via the “Quit to Desktop” button in the main menu.

Environmental & Pressurization Simulation & Controls

This aircraft is equipped with a simulated environmental control system, allowing the user to learn the essentials of passenger comfort while operating this aircraft. Cabin temperature is calculated distinctly from outside air temperature. Since the walls of the aircraft are insulated, it will take time for the cabin temperature of the aircraft to equalize with the outside air temperature. The cabin will also heat itself beyond the outside air temperature during warm sunny conditions, and slowly equalize with the outside air temperature after sunset. The cabin climate controls are located on the copilot's left subpanel.

Without the need for any aircraft power, the cabin temperature can be partially equalized with the outside air temperature by opening the cabin door, and fully equalized by ram air cooling, so long as the airspeed of the aircraft is great enough. Cabin temperature can also be equalized with use of the three electric vent blowers. The rate of temperature equalization, active heating, or active cooling can be increased by rotating the dual concentric "CKPT/CABIN BLOWERS" knobs clockwise to increase the speed of the electric ventilation fans.

Cabin Temperature Monitoring

On the copilot's left subpanel, an LCD screen indicates the average cabin temperature in degrees Fahrenheit. The screen can be forced to display the cabin temperature in degrees Celsius by enabling the persistent "Force Cabin Temperature Display Celsius" option on the Options page of the tablet interface. This is the same temperature that is depicted on the Cabin Climate Visualizer page of the tablet interface.

Two small optional LED's, located above the Airspeed Indicator (ASI), indicate when cabin temperatures are unacceptably hot or cold within the pilot's primary field of view, and call the pilot's attention to the cabin temperature settings. The "CABIN TEMP LOW" light illuminates when cabin temperatures are below approximately 50°F, or 10°C. The "CABIN TEMP HIGH" light illuminates when cabin temperatures are above approximately 90°F, or 32°C. Both lights will flash alternately when the cabin pressurization altitude exceeds approximately 15,000 ft without supplemental oxygen to indicate a hypoxic cabin. These lights can be activated with the "Show Extreme Cabin Temperature Lights" option on the Options page of the tablet interface.

NOTE: The entirety of the cabin climate state can also be inspected via the cabin page of the tablet interface. For more information on the tablet's cabin page, see the "Cabin Climate Visualizer Page" section of this manual.

Cabin Environmental Controls

The climate control system is activated by rotating the “TEMP MODE” knob to either “MAN” or “AUTO”. In “AUTO” mode, the system will monitor the cabin temperature and appropriately mix incoming air to produce the desired temperature. The desired temperature is set with the dual concentric “CKPT/CABIN AUTO TEMP” knobs. The desired temperature can range from approximately 55°F (13°C) to 80°F (27°C). In “MAN” mode, the automatic temperature control is bypassed and the cabin vent temperature is set manually by holding the “MAN TEMP” momentary toggle switch to either “INCR” or “DECR”. The manually set vent temperature can range from 50°F (10°C) to 90°F (32°C).

Ambient air enters the environmental dome behind the cabin through a large NACA duct on the underside of the tail, facilitated by the electric axial vane blower. This blower operates any time air conditioning is requested by the temperature controller, or when the cabin bleed air ducting is hot. This air is passed over the bleed air heat exchanger to reduce the temperature of incoming bleed air from the engines. This air is also used to cool the working fluid of the vapor-cycle air conditioning system, rather than having an additional scoop for the condenser on the exterior of the aircraft. This ambient air is distributed to the cockpit and cabin via ducting.

Independent electric blowers fans blow air into the cabin volume through air conditioning evaporators, which cool the air, if required. This cooled ambient air also serves as the instrument cooling air, and is forced behind the panel by the cockpit blower fan. The forward cabin blower operates whenever the integrated avionics switches are on. Airflow to the cockpit can be further metered with the pilot and copilot air pull handles near both yokes. The air conditioning compressor is driven through a clutch on the right engine’s accessory gearbox.

Hot bleed air pulled from the operating engines enters the environmental dome through the firewall shutoff valves and flow control valves. Once cooled to the desired vent temperature by the ambient air heat exchanger, heating air is admitted to the cabin and cockpit defrosters through ducting. When the aircraft is operating at high altitudes where ambient temperatures can approach -85°C (-120°F), it may become necessary to place the bleed air valves rotary selector knob in the “HIGH FLOW” position. Should the red “FUS BLEED FAIL” annunciator illuminate, place the bleed air valve selector in the “EMER” position, which will bypass the heat exchanger plumbing discussed above, and restore pressurized bleed air to the cabin.

NOTE: For more information on managing the cabin temperature, see the “Cabin Climate Visualizer Page” section of this manual.

NOTE: The cabin climate also impacts instrument panel cooling. For more information on instrument panel cooling, see the "Avionics Cooling" section of this manual.

Cabin Pressurization System

The cabin pressurization is controlled via the three knobs on the pressurization panel beneath the Radio Tuning Units (RTU). The selector dial consists of two offset control knobs. The small knob at the bottom left controls the cabin climb/descent rate from between approximately 150 ft/min to 2,000 ft/min. A position approximately one third of the knob's full rotation from the counterclockwise stop should produce a desirable climb rate of around 700 ft/min. The larger, centrally located knob controls the destination cabin altitude by rotating a scale visible through the plastic window above the knob.

The upper scale of this rotating card (labeled "CABIN") is used to set the desired cabin altitude from -1,000 ft to 15,000 ft. The lower scale (labeled "ACFT") rotates with the upper scale and depicts the approximate aircraft pressure altitude at which the pressurization controller will no longer be able to maintain the desired cabin pressure. For example, when the upper scale is set to 8,000 ft at the small black index mark on the plastic window, the inner scale will read approximately 39,800 ft at the same black index mark. This means that the pressurization controller will be able to maintain a cabin pressure equivalent to 8,000 feet pressure altitude until the aircraft reaches 39,800 feet pressure altitude. If the aircraft continues climbing without an adjustment being made to the pressurization controller, the cabin altitude will begin climbing beyond the desired 8,000 feet. If the cabin pressure differential becomes negative, or increases beyond 8.4 psi, the electric safety valve will activate, rapidly dropping the pressure differential. The electric safety valve can be disabled by pulling the "PRESS SYS" circuit breaker on the pilot's circuit breaker panel.

The “MANUAL CABIN ALT CONTROL” knob on the right of the panel is used to manually actuate the cabin outflow and safety valves, located under the nose of the aircraft. Rotating the knob fully clockwise will open both pressurization valves, allowing the cabin to depressurize rapidly. Dumping the cabin pressure can be debilitatingly painful for passengers and crew. This knob should only be used in case of a dangerous overpressurization, to ensure that the cabin pressure is equalized with the ambient pressure before opening the cabin door, or before takeoff to operate the aircraft unpressurized. Given that all manner of failures are possible in Black Square aircraft, be sure to verify the cabin pressure differential is near zero before placing the switch in the dump position once on the ground. On the copilot’s left subpanel, two round-dial instruments depict cabin altitude, differential pressure, and cabin climb rate.

On the pilot’s left subpanel, a push button marked “PRESS” provides a method for testing the cabin pressurization system while on the ground. Pressing the button will bypass the weight-on-wheels sensor, allowing the cabin to pressurize at approximately -150 fpm while on the ground, assuming bleed air is available.

Cabin pressurization air is derived from the bleed air sources of the turbine engines, and cooled by a heat exchanger in the environmental dome. The bleed air is controlled by two flow control valves, two shutoff valves, and two firewall valves in each engine nacelle. The bleed air valves are controlled by the “BLEED AIR VALVES” rotary selector knob on the copilot’s left subpanel. The pressure of bleed air available for pressurizing the cabin is limited by the gas generator RPM of the engine, meaning that pressure may slowly be lost when operating at high cabin pressure differentials with the engines at idle. In the event of a fire, carbon monoxide leak, or other hazardous condition, it may become necessary to isolate an engine from the breathable air in the cabin by placing the knob in the “OFF” position. Bleed air can also be shut off by closing the firewall valves during an in-flight engine shutdown and securing. The bleed air valve selector knob can also be used to test the pressurization supply air of each engine during the ground pressurization test, to ensure both are functional.

Opening the cabin door will rapidly and dangerously decompress the cabin. If the door has suffered a latching failure in flight, do not attempt to secure the door. Instead, reduce the cabin pressure differential as much as possible and land as soon as practical.

NOTE: The cabin pressurization state can also be monitored via the cabin page of the tablet interface. For more information on the tablet’s cabin page, see the “Cabin Climate Visualizer Page” section of this manual.

Cabin & Crew Oxygen Systems

A single oxygen cylinder is capable of providing emergency oxygen to the passengers and crew so long as the master oxygen valve on the cylinder has been opened when it was installed. A second valve is required to make oxygen available to the aircraft's occupants, which is activated from the cockpit by pulling the "OXYGEN SYS READY" pull handle below the pilot's yoke.

Crew oxygen is available from two automatic pressure breathing diluter-demand, quick-donning oxygen masks with integral microphones located forward of the pilot and copilot's cupholders. To activate the flow of oxygen, squeeze the red "PRESS FOR CREW OXY" tabs on the mask. When the crew oxygen system is activated, the sound of labored breathing in the mask will be audible.

Passenger oxygen is available from continuous flow face masks, which deploy from compartments in the cabin headliner. The passenger oxygen masks can be deployed manually by pulling the red "MAN DEPLOY" pull handle below the pilot's yoke. The masks will be automatically deployed when the cabin pressurization altitude exceeds approximately 12,500 feet, assuming the system is armed, and the "OXY CONTROL" circuit breaker has not been tripped. When the passenger oxygen system is activated, the sound of pressurized gas flowing through pipes will be audible.

Oxygen will be consumed by the occupants only in accordance with the current cabin pressure altitude of the aircraft, and the weights of the passengers and crew. The oxygen pressure is saved between flights, and can be refilled via the payload screen of the tablet interface.

NOTE: The oxygen system can be monitored via the cabin page of the tablet interface. For more information on the tablet's cabin page, see the "Cabin Climate Visualizer Page" section of this manual.

On the copilot's subpanel, an LCD screen indicates the oxygen pressure available in the onboard, refillable oxygen cylinder. This cylinder is normally pressurized to 1,800 - 2,000 PSI when serviced. The cylinder can be refilled via the Payload page of the tablet interface.

Approximate duration of useful consciousness following a cabin depressurization event:

30,000 ft MSL - 1 to 2 minutes
28,000 ft MSL - 2-1/2 to 3 minutes
25,000 ft MSL - 3 to 5 minutes
22,000 ft MSL - 5 to 10 minutes
18,000 ft MSL - greater than 30 minutes

Miscellaneous Systems

Audible Warning Tones

The Black Square Starship comes equipped with several warning tones to alert the operator to important configuration changes, or potentially dangerous situations. These tones can be disabled by pulling the circuit breaker for the respective tone's underlying warning system. These tones are as follows:

- Altitude Alerter Tone: A traditional C-Chime will sound when the aircraft is within 1,000 ft of the selected altitude displayed on the ALI-850A Altitude/Vertical Speed Indicator (ALI).
- Autopilot Disconnect Tone: Whenever the autopilot is disconnected via the autopilot master lever, the control yoke mounted disconnect buttons, or automatically disconnects for any reason, a warning buzzer will sound.
- Stall Warning Horn: After the stick shaker has been active or cancelled for 15 seconds without a reduction in angle of attack, the dual stall warning horns will activate.
- Overspeed Horn: When the aircraft exceeds the VNE (red line) airspeed on the airspeed indicator, a steady high pitched tone will sound until the speed of the aircraft is reduced to below VNE.
- Gear Configuration Warning Horn: When both power levers are reduced below approximately 20% of their travel, or the flaps are placed in their landing configuration, and the landing gear has not been deployed, a repeating tone will sound.
- Carbon Monoxide Detector: When a turbine engine becomes compromised, it is possible for poisonous gas to leak into the cabin of the aircraft. When this colorless, odorless, gas is present, a beeping alarm will sound. The alarm will continue to sound as long as the gas is present. Follow the checklists for Carbon Monoxide leaks, and close (pull) the cabin pressurization air shutoff valves immediately.

NOTE: Have you ever noticed that the wind sound in all other MSFS aircraft is erroneously based on true airspeed rather than indicated airspeed? This makes wind noise during high altitude cruise far too loud. All Black Square aircraft now have wind sounds based on indicated airspeed, which makes them much more enjoyable to fly at high true airspeed.

Altitude Preselect & Vertical Speed Preselect

This is the first Black Square aircraft to implement proper altitude and vertical speed preselecting, despite the shortcomings of the MSFS native autopilot implementation. This allows users to select a newly desired altitude or vertical speed with the knobs on the Altitude/Vertical Speed Indicator (ALI) without the autopilot immediately trying to capture this altitude, or remaining stuck at 0 ft/min vertical speed. For the autopilot to function properly, users with external hardware must use the HTML events found in the "Instrument Events" section of this manual rather than the native autopilot events.

Turboprop Engine Operation

The turbine engine simulation in this aircraft is significantly more complex than most employed in flight simulators, especially as it pertains to engine starting. Improper technique can destroy an engine in seconds. The turboprop simulation in this aircraft requires careful management due to effects from oil viscosity, fuel pressure, residual heat, debris ingestion, and more.

NOTE: The entirety of this complex engine simulation can be monitored via the engine pages of the tablet interface. For more information on the tablet's engine pages, see the "Engine Visualizer Page" section of this manual.

Fuel Pumps & Fuel Tanks

This aircraft is equipped with two standby electric fuel pumps, four engine-driven boost pumps, and six jet transfer pumps. The high and low pressure engine-driven fuel pumps are sufficient to supply the engines with fuel, but do not ensure that fuel is positioned for uptake in the fuel system. Two transfer jet pumps move fuel from the main tanks into a hopper tank before the fuel is picked up by the two primary jet pumps for ingestion by the engine-driven pumps. If the primary jet pump fails, the low fuel pressure will trigger the red "FUEL PRES LO" annunciator and master warning flasher. The electric standby pumps can be used to provide sufficient pressure to the engine-driven pumps should a primary jet pump fail.

The remaining two jet pumps transfer fuel from the aft tank into the hopper tank. While the hopper tank is located within the main tank of the wing and can be ignored for the purposes of fuel planning, the aft tanks are separate. Most of the fuel in the aft tanks will transfer to the main tanks by gravity, and the rest can be transferred by the aft tank transfer jet pumps. Should the aft tank transfer jet pumps fail, the total usable fuel may be reduced. Proper aft tank fuel transfer can be monitored via the fuel quantity instrumentation. For more information on monitoring fuel levels, see the "Fuel Temperature & Quantity Indicators" section of this manual.

The electric standby pumps are also activated automatically during engine start by the engine start switches to supply the Fuel Control Unit (FCU) with the pressure it requires to operate. Lastly, the electric fuel pumps are used to provide the increased pressure required for fuel crossfeed. When the "TRANSFER FLOW" rotary selector switch is moved from its "OFF" detent, the standby fuel pump on the side of the aircraft from which fuel is to be transferred is activated. If the electric standby pump on the receiving side of the aircraft is also operating, the transfer speed may be reduced.

Turbine Engine Fuel Control Failures

This aircraft implements two types of partial engine failures that are unique to turbine engines. The first is a fuel control failure, resulting in the engine's power lever having minimal or zero control over the engine's fuel flow. This failure can occur during any phase of flight, and is often the result of a broken control cable, or mechanical Fuel Control Unit (FCU) failure. In the case of the Black Square Starship, this failure may necessitate an engine shutdown, as there is no auxiliary fuel control system, unlike some other turboprop aircraft.

The second type of failure is engine compressor surging. Turboprop engine surging is the result of disrupted airflow to the engine, and manifests as unstable gas generator RPM, or sudden changes in engine performance. This may occur as the result of severe turbulence, ingestion of large debris (such as birds), or catastrophic failure of internal engine components. At the first indication of compressor stall or surging, engine power should be reduced, and continuous ignition armed to prevent flameout. The surging will be less severe when power is reduced, but the flight should only be continued to the nearest practical field for landing.

Inertial Separators (Ice Vanes)

Most turboprop engines possess a method of separating particulate from engine induction air by repositioning louvers within the engine air intake. These louvers can be inspected from the exterior of the aircraft. When operating normally, incoming air takes a direct path to the PT6's internal radial intake. When the inertial separator (sometimes called an ice vane, or simply "bypass") is activated, the airflow must take a sharp turn, which ejects particulates through a vent on the sides of the engine nacelle in this aircraft. The inertial separators have the disadvantage of reducing free airflow to the engine, thus reducing maximum torque, or torque available at a given ITT for a given set of conditions. This aircraft also simulates damage from foreign objects caused by operation on unimproved surfaces. For more information, see the "Foreign Object Debris Damage" section of this manual.

The inertial separators are controlled via switches located on the pilot's right subpanel, marked "ENGINE" among the "ICE PROTECTION" switches. The nearby locking toggle switches marked "ACTUATORS" control whether the ice vanes are positioned by the "MAIN" actuator motors, or the "STBY" motors. The inertial separators should be used whenever operating on unimproved or marginal surfaces, and whenever entering visible moisture. It takes 15-20 seconds for the inertial separator louvers to reposition, so anticipation of sky conditions as far as five miles ahead of the aircraft may be required to ensure proper use.

Turbine Engine Ignition

The turboprop engines in this aircraft are equipped with continuous ignition systems that are activated automatically by the engine start switches, and can also be armed for automatic operation at low torque settings by the "ENGINE AUTO IGNITION" switches on the center console panel. The "ARM" position should be used whenever the inertial separators are required, during moderate and severe turbulence, when operating at high altitudes at night, and during extreme weather conditions to prevent engine flameout. When armed, the igniters will only be energized when the torque of the associated engine falls below approximately 17%.

Starting Temperature, Residual Heat & Dry Motoring

The rate at which heat is dissipated or accumulates in the combustion chamber of a turboprop engine is largely determined by the rate of airflow through the engine. When the engine is not self-sustaining combustion, this airflow is created by the gas generator, or the wind flowing around the aircraft.

During starting, it is essential to allow the gas generator to reach its maximum attainable RPM while operating on the starter motor before introducing fuel to the engine. This will keep engine starting temperatures to a minimum. The rate of airflow while starting is also influenced by the apparent wind around the engine nacelles. Facing the aircraft into the wind before starting will help keep temperatures low, but starting with a significant tailwind opposing the exhaust flow can lead to excessively hot starts.

After shutdown, ITT may remain sufficiently hot to preclude a safe engine start without exceeding upper temperature limits. This limitation may present itself during quick turnarounds in high ambient temperatures with little wind to provide passive cooling. In this situation, the engine can be dry motored to reduce temperatures to safe levels before attempting a start. Should the ITT remain above around 150°C, cranking the engine with the electric starter motor will promote airflow through the compressor section, more quickly cooling the engine. Repositioning the aircraft into the wind will also help cool the engine before attempting a restart.

P2.5 Bleed Air Valves

The P2.5 Bleed Air valves are a feature of the PT6A engine, which stabilize the engine at lower power settings by allowing excess air to escape from the gas generator section of the engine, thus reducing the amount that makes its way into the combustion chamber. Both valves are operated by the pressure differential between the higher pressure P3, and lower pressure P2.5 compressor air. When the engine is not running, the valves rest in the open position. The low pressure P2.5 bleed valve closes around 68% Ng, while the high pressure P2.5 bleed valve closes around 92% Ng. Both valves can fail, becoming stuck in their open positions. This will prevent the combustion chamber from receiving the air it needs to produce full power. Should the aircraft not develop the full power expected on takeoff, but all other indications are normal, a stuck P2.5 bleed air valve should be suspected.

Propeller Governors

The propeller governor is an essential component of a high performance aircraft that controls the pitch of the propeller blades, usually by metering oil pressure to the propeller hub. In multi-engine aircraft, the propeller blade pitch system is usually configured to automatically feather the propellers when oil pressure is lost. For this reason, an increase in indicated oil pressure is expected while exercising propeller pitch on the ground. To ensure that these systems are functioning properly, a propeller governor test switch is provided for use during the runup procedures. Holding the “PROP TEST” switch to the “OVERSPEED GOV” position will offset the overspeed propeller governor to a lower RPM, limiting the propeller to around 1,600 RPM. Holding the switch to the “LOW PITCH” position will allow the propeller speed to fall below the normal ground fine RPM of 1,000 RPM. Should the governor fail to maintain the expected RPM in flight, or on the ground, the flight should be discontinued as soon as practical. This aircraft is equipped with a more advanced propeller governor simulation than previous Black Square aircraft, producing smoother, more realistic physics-based operation, and additional failure types.

Autofeather

This aircraft simulation is equipped with a completely custom propeller feathering and autofeathering implementation, which is improved from previous Black Square aircraft thanks to the new propeller governor simulation. The purpose of autofeathering systems is to spare vital seconds and airspeed in the event of an engine failure, usually after takeoff. The system is designed to fully feather the failed engine with no input from the pilot.

During normal operation, the autofeather system is armed when the “AUTOFEATHER” switch is in the “ARMED” position, the respective engine’s gas generator RPM is above 90%, and its torque is above ~17%. This can be confirmed by the presence of the green “AFX” text inside the propeller RPM scale on the Engine Instrument and Crew Alerting System (EICAS). The system can be armed for ground testing at lower gas generator RPM by placing the “AUTOFEATHER” switch in the “TEST” position.

To test the autofeather system, advance both power levers through ~17% torque until the green “AFX” text appears. Then, slowly reduce the torque of one engine. The opposite engine’s “AFX” text will disappear when its torque falls below ~15%, indicating that the autofeathering system is armed for the engine with reduced power. The engine’s autofeather functionality will activate when torque falls below ~9%. This is confirmed by the remaining “AFX” text disappearing, and the propeller RPM subsequently dropping. If the opposite engine’s power is reduced below ~17% torque, both propellers will unfeather, and the autofeather system will be completely disabled. Be aware that the propellers will not fully feather while the engines are running, as ground idle torque is still enough to prevent them from doing so fully. This is why the propeller RPM will cycle up and down while completing the autofeather test. Should the engine fail during flight, the propeller will fully feather and RPM will approach zero.

Air Conditioning Temperature Effects

When the air conditioner is operating, the load is increased on the right engine’s accessory gearbox. The load is proportional to the differential between the outside air temperature and the desired cabin temperature. During low airspeed climbs or while operating at low altitudes, the additional cooling required by the right engine may send interstage turbine temperatures and oil temperatures into a dangerous regime if not properly managed. Increased ITT in the right engine may require a reduction of power during climbs to observe ITT limits.

Engine Power Settings

Shaded areas denote operation at max. torque or max. ITT. **T/O & Climb figures at MGTOW.**

Take-Off Power 100% Torque - Standard Day (ISA) No Wind

Press. Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH/Eng)	35ft Obstacle T/O Dist. (ft)	Rate of Climb (ft/min)
SL	100	1,700	792	3,953	1,950
2,500	100	1,700	776	4,336	1,880
5,000	100	1,700	760	5,243	1,840
7,500	100	1,700	744	5,898	1,790
10,000	100	1,700	731	8,115	1,730

Cruise Climb 89% Torque (or limit) - Standard Day (ISA)

Target Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	Time to Climb (min)	Fuel to Climb (lbs)	Dist. to Climb (nm)
10,000	89	1,600	535	7	125	18
20,000	89	1,600	562	12	225	37
30,000	72	1,600	511	22	375	73
35,000	56	1,600	418	37	515	127
41,000*	40	1,600	412	65	760	242

Recommended Climb Airspeeds: 180 kts to 10,000 ft, 160 kts to 20,000 ft, 140 kts to 30,000 ft, 130 kts to 41,000 ft. *Applicable only at gross weight of 12,000 lbs.

Take-Off Reference Speeds (V Speeds) - Standard Day (ISA)

T/O Weight (lbs)	Flaps Extended			Flaps Retracted		
	V_1	V_R	V_2	V_1	V_R	V_2
14,900	100	101	113	104	108	117
14,000	95	98	110	100	106	115
13,500	93	96	109	99	106	116
12,000	91	91	105	98	106	117

Shaded areas denote operation at max. torque or max. ITT.

Maximum Cruise Power (or limit) - (ISA) 14,500 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)
SL	74	1,600	556	242	649
10,000	85	1,600	511	279	804
20,000	97	1,600	517	328	1,023
30,000	72	1,600	381	315	1,320
37,000	51	1,600	284	286	1,428

Recommended Cruise Power (or limit) - (ISA) 14,500 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)
SL	74	1,600	556	242	649
10,000	85	1,600	511	279	804
20,000	89	1,600	478	314	1,052
30,000	67	1,600	361	310	1,364
37,000	47	1,600	267	267	1,447

Maximum Range Power - (ISA) 14,900 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)
SL	56	1,600	479	216	679
10,000	54	1,600	393	233	911
20,000	53	1,600	328	253	1,208
30,000	51	1,600	289	269	1,492
35,000	53	1,600	296	291	1,568

Shaded areas denote operation at max. torque or max. ITT.

Maximum Cruise Power (or limit) - (ISA) 12,000 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)*
SL	72	1,600	548	242	346
10,000	82	1,600	502	279	429
20,000	97	1,600	517	331	550
30,000	72	1,600	383	332	742
41,000	40	1,600	228	272	797

Recommended Cruise Power (or limit) - (ISA) 12,000 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)*
SL	72	1,600	548	242	346
10,000	82	1,600	502	279	429
20,000	89	1,600	477	318	568
30,000	67	1,600	361	320	750
39,000	43	1,600	243	283	888

Maximum Range Power - (ISA) 12,000 LBS

Pressure Alt. (ft)	Torque (%)	Prop RPM	Fuel Flow (PPH / Eng)	True Airspeed	Range (nm)*
SL	50	1,600	450	209	262
10,000	47	1,600	364	255	361
20,000	44	1,600	294	240	493
30,000	41	1,600	247	255	595
39,000	44	1,600	250	291	599

*Maximum range estimations at 12,000 lbs gross weight assume 2,000 lbs of fuel at engine start

Tips on Operation within MSFS

Turboprop Engine Simulation

This aircraft makes use of Black Square's turboprop engine simulation, which offers a vast improvement over the default behavior. Along with the beta range, propeller governor, and feathering implementation, these systems produce one of the most realistic turboprop simulations in MSFS. Expect realistic hot starts and residual heat based on numerous environmental factors, accurate ITT and oil temperature behavior that becomes limiting at high altitude, and precise beta operations while taxiing. Engine covers, ambient wind, electrical voltage, and more affect gas generator RPM and resultant engine performance.

NOTE: The entirety of this complex engine simulation can be monitored via the engine pages of the tablet interface. For more information on the tablet's engine pages, see the "Engine Visualizer Page" section of this manual.

Engine Limits and Failures

When an engine is operated beyond its limits, damage is accumulated according to the severity of the limit exceedance and the type of limit exceeded. For instance, exceeding starting ITT limits will destroy an engine in seconds, while a slight exceedance of the maximum governed propeller RPM would not cause an engine failure for quite some time. When engine health is reduced to 25%, the CHIP DETECT Crew Alerting System (CAS) message will appear. If engine parameters are not brought back within limits soon, the engine will fail.

NOTE: The "Engine Stress Failure" option must be enabled in the MSFS Assistance menu for the engine to fail completely.

Exceeding the engine starter limitations stated in this manual significantly will permanently disconnect the starter from electrical power. Be aware that the Starship does not possess an annunciator or CAS message pertaining to starter motor overheat, so failure may arise unannounced.

Electrical Systems

The native MSFS electrical simulation is greatly improved from previous versions of Flight Simulator, but the underlying equations are unfortunately inaccurate. Users familiar with electrical engineering will recognize that the default battery simulation has no internal resistance, for example. Voltage drop and battery charging rate is accurately simulated in this aircraft, however, meaning that the battery charge rate in amps is proportional to the voltage difference between the aircraft generators and the battery. Battery charging rate should be kept to a minimum whenever possible, and takeoff limits should be observed.

NOTE: The state of the aircraft's electrical system can be monitored via the electrical page of the tablet interface. For more information on the tablet's engine pages, see the "Live Schematic Page" section of this manual.

Battery Temperature

This aircraft is equipped with a realistic battery temperature simulation. The nickel cadmium batteries in this aircraft are particularly susceptible to battery overheating. The internal resistance of a battery and the contact resistance of the terminals will produce heat when charging or discharging. Battery temperature should be considered particularly after starting, before takeoff, and in the event of a generator failure. If the red “BATT CHG RATE” annunciator is illuminated and the battery is not disconnected from the power source, or the charge rate reduced, the battery terminals will become damaged and the battery will not be available for use on the remainder of the flight. High battery charge rates are acceptable after startup when the battery is recharging; however, care should be taken while taxiing to avoid overcharging.

Deicing and Anti-Icing Systems

Ice accumulation and mitigation has been buggy since the release of MSFS. As of Sim Update 11 (SU11), the underlying variables for airframe, engine, pitot-static, and windshield icing have been verified to be working correctly. Unfortunately, the exterior visual airframe icing may continue to accumulate regardless of attempted ice mitigation. Apart from the visual appearance, this should not affect the performance of the aircraft. Windshields can always be cleared by deicing equipment, thankfully.

The Black Square Starship is equipped with pitot heat, fuel vent heat, engine control cable heaters, stall warning heat, windshield heat, deicing boots, windshield defrosters, inertial separators, heated engine air inlets, and brake deicers. Electrical anti-icing for the pitot-static probes, angle of attack sensors, windshields, engine control cables, and fuel vents work continuously, and will slowly prevent or remove ice buildup from these areas of the aircraft. The engine induction air inlets and brakes are heated by bleed air from the engines. Emergency window defrosting is provided by the cabin heating system, and requires the following conditions to be met: the “DEFROST AIR” handle must be pulled away from the panel, the environmental control system must be operating, and bleed air must be available. For more information on the defrosters and associated controls, see the “Environmental Controls” section of this manual.

The aircraft is also equipped with deicing boots that use bleed air to inflate, either manually, or automatically, to shed ice from the leading edges of the aircraft. The leading edges are divided into three zones: inboard and outboard main wings, and the forward wing. The two, three-position momentary toggle switches below the pneumatic pressure LCD displays allow the pilot to manually inflate each of these zones separately, or automatically in sequence. This aircraft is also equipped with dually redundant ice detectors. Once in flight, the ice detectors will activate the sequential boot inflation system when ice buildup is detected on the airframe. No action is required of the pilot to deice the aircraft, and Crew Alerting System (CAS) messages alert the pilot to deicing system failure; however, the pilot should always be vigilant in monitoring for ice accretion on the airframe.

NOTE: This aircraft does not require propeller heat, as the pusher configuration allows hot exhaust from the turbine engines to prevent ice buildup on the propellers.

Foreign Object Debris Damage

This aircraft simulates damage caused to turbine engines by ingestion of particulate matter, better known as foreign object debris, or “FOD”. FOD can include dust, sand, gravel, ice, etc., and is typically associated with operating on unimproved runways. The amount of damage caused by the FOD is calculated based on which of the 25 recognizable surface types the aircraft is currently operating on, the thrust of the propeller, and the position of the inertial separator vanes. In order to prevent damage, be sure to use the inertial separators whenever operating on unimproved surfaces, including all ground operations, and whenever ice is present.

NOTE: The quantity and type of FOD encountered, as well as the position and functioning of the inertial separators, can be monitored via the engine pages of the tablet interface. For more information on the tablet’s engine pages, see the “Engine Visualizer Page” section of this manual.

Beta Range

Due to the large static thrust produced by turboprop engines, they are often equipped with a “beta range”. When the power levers are moved over a gate into this range below the normal flight idle position, the propeller pitch is further flattened to reduce thrust. This aids in controlling the aircraft on the ground without causing excessive brake wear.

This aircraft makes use of Black Square’s beta range implementation, which is designed to provide accurate ground handling for advanced users, while not interfering with the basic functionality for novices. Beta range is incorporated into the bottom 15% of forward throttle input. Users can assign this 0-15% range to their hardware using 3rd party applications, or with physical detents. The remaining throttle input, including reverse, is assigned normally. By default, the beta range will be inaccessible during flight. An optional power lever beta range annunciator has been added to the Engine Instrument and Crew Alerting System (EICAS) for users who do not have hardware or software detents for their throttle input. The annunciator is enabled by default, but can be disabled from the options page of the tablet interface.

NOTE: Inadvertent activation of propeller beta range will be prevented anytime the aircraft is airborne, unless the “Unrestricted Beta Range” option is enabled on the options page of the tablet interface. Use of beta range in flight is not permitted by this aircraft’s operating limitations.

Realistic Strobe Light Bounce

Most light aircraft possess a placard somewhere in the cockpit containing the warning, “turn off strobe lights when operating in clouds or low visibility.” While this message may appear a polite suggestion, real world pilots who have ignored this advice will have experienced the disorienting effects of bright strobe lights bouncing off the suspended water particles in surrounding clouds, and back into their cockpit. The strobe lights on Black Square aircraft will now produce this blinding effect while in clouds or reduced visibility. While the disorienting effects are best experienced in VR, photosensitive users should be strongly cautioned against flying into clouds at night with the strobe lights operating. This feature can be disabled via the options page of the tablet interface.

St. Elmo’s Fire & Electrostatic Discharge

When aircraft operate at high speeds within charged areas of the atmosphere, such as around thunderstorms or in clouds of ash, the metal skin of the aircraft can accumulate charge. Normally, this charge is dissipated to the atmosphere slowly through the static discharge wicks located on the trailing edges of the wings and tail. If the charge buildup is very severe during intense storm conditions, a faint purple glow can emanate from sharp objects on the aircraft, including the static wicks. This corona discharge is colloquially called St. Elmo’s Fire, and it may precede more stunning electrostatic discharges across the aircraft.

Corona Discharge (St. Elmo’s Fire), and Electrostatic Discharge

Though often mistakenly referred to as St. Elmo’s Fire, aircraft windshields may rarely experience electrostatic discharges across them in the same extreme weather. These discharges are due to the dissimilar electron affinities of the painted aircraft skin, and the polycarbonate windows installed in most aircraft. As a charge gradient develops between the windshield and the skin, a harmless discharge will take place between the two. No action is required of the pilot should this occur, but the flashes may be disorienting at night.

Third Party Navigation and GPS Systems

Unlike other Black Square aircraft, the only 3rd party avionics used in this aircraft is the Working Title GNS 430. No additional downloads are necessary for the GNS 430 to function at the time of this writing; however, older versions of the GNS 430, or related GPS packages in the Community Folder always have the potential to interfere with the current version of this software. See the “Garmin GNS 430 (GNS)” section of this manual for information on how the GNS 430 can be used as the primary source of navigation data and autopilot control in this aircraft. If the autopilot is behaving strangely, a GNS 430 Community Folder incompatibility should be suspected.

Control Locks

A functioning control lock is provided for the pilot's yoke and throttle quadrant. The control lock is removed with a click, and is stowed beside the copilot's seat. To access the control lock in its stowed position with a companion occupying the right seat, either just click through the character model, or unload them first via the tablet's payload interface.

Landing Gear Downlock Pins

Due to the Starship having tall, hydraulically actuated landing gear, it is essential to install downlock pins into the gear as soon as possible after shutdown to prevent inadvertent gear retraction while attempting to tow the aircraft. The pins are adorned with red "REMOVE BEFORE FLIGHT" streamers that flutter in the wind. The pins are stowed in the baggage shelves behind the copilot's seat, within view of the pilot's seat for visual confirmation. If the pins are not removed before takeoff, the landing gear will be inoperable in flight.

Brake Temperature & Anti-Skid

Brake temperature is simulated in this aircraft, and indicated by color gradient on the cabin visualizer page of the tablet interface. Brakes will heat up whenever in use to slow or stop the aircraft. This temperature can become extreme if continuous pressure is applied at high gross weights during a rejected takeoff or short landing. If the landing gear is retracted after heavy braking, the “WHEELWELL OVHT” Crew Alerting System (CAS) message may appear. This aircraft is also equipped with an anti-skid braking system, which ensures maximum braking effort is applied, especially in wet or icy runway conditions. Should the anti-skid system fail, the “ANTI-SKID INOP” CAS message will appear, prompting the pilot to use the appropriate landing distance tables and anticipate reduced braking effectiveness upon landing.

External Power

Aircraft batteries are sized much smaller for their application than automotive batteries to save on weight. Running all the aircraft systems on the ground will be enough to drain the battery completely in 20-30 minutes. Starting in cold weather can also prove difficult, as batteries will provide less current with a greater voltage drop in cold conditions. For this reason, this simulation is equipped with an external power generator. The cart is capable of supplying an essentially limitless amount of diesel generated power, with almost no voltage drop due to high instantaneous loads while starting the aircraft. The external power cart is deployed from the “Exterior Elements” menu on the payload page of the tablet interface.

Avionics Cooling

For being the first of its kind, the all glass panel cockpit in this aircraft comes at the cost of great electrical power consumption. All the avionics displays, computers, and circuit boards in this aircraft consume around 200A at 28V during flight operations. This produces immense heat, which must be dissipated for the continued health and operation of the equipment. The majority of the avionics equipment in this aircraft is contained within the forward avionics bay above the forward wing, and also behind the main instrument panel. These two areas of the aircraft are actively cooled to keep temperatures within operating limits.

The forward avionics bay is cooled with ambient air that enters through circular screened ports in the nose landing gear doors. This air exits the landing gear bay through square screened ports, and enters the left and right halves of the avionics bay through blower fans. After cooling the avionics equipment racks, the air takes advantage of the chimney effect, and is exhausted through vent openings on either side of the fuselage above the trailing edge of the forward wing. While in flight, ram air pressure is used to move air through this series of compartments. The avionics compartment is equipped with a thermostat, which will activate the nose avionics blower fans whenever temperatures in the compartment exceed ~90°F, so long as the triple-fed avionics bus is powered.

If ambient temperatures are high, airspeed is low, the blower fans fail, or the screened ports become clogged with debris, the nose avionics compartment may overheat, and components may begin to fail. Most equipment in the forward avionics bay will fail silently, or without Crew Alerting System (CAS) messages, so long as the redundant system is still functioning. The equipment in this bay consists mostly of computers that process data for the cockpit instrumentation. To monitor the status of forward avionics equipment, check the Avionics Status screen on the Multifunction Display (MFD). For more information on avionics status codes, see the “MFD-870 Multifunction Display (MFD)” section of this manual.

The instrument panel equipment and displays are cooled with forced cabin environmental air from the cockpit blower fan. The cockpit blower fan is activated when either generator is online or the aircraft is receiving external power, and any of the three integrated avionics switches are on, and either the automatic or manual environmental control mode is selected. The blower fan speed is controlled via the “CKPT” blower knob on the copilot’s left subpanel. The minimum blower speed is 50% of its maximum. When the cabin is hotter than the desired temperature, the instrument panel receives conditioned air from the forward air conditioning evaporator. Otherwise, average cabin temperature return air is used.

Should the cockpit blower fan fail, or when cabin temperatures are high, an additional centrifugal fan can be operated by the “AVIONICS ALTN BLOWER” toggle switch on the electrical console panel. The instrument panel ducting is equipped with an airflow sensor, which will trigger the green “AVIONIC AIR FAIL” CAS message, if the cockpit blower fan fails and the alternate avionics blower is not operating.

If instrument panel temperatures become excessive, the six main integrated avionics displays will produce flashing red “DISPLAY TEMP” messages. If the condition is allowed to persist and temperatures continue to rise, the display will begin to fade, eventually becoming blank. Since the instrument panel cooling outlet ducts are at the bottom of the instrument panel, avionics located higher in the panel will begin to fail first, as the cooling source is not as effective. To diagnose a display overheat, as opposed to another type of malfunction, the corresponding Line Replaceable Unit (LRU) overheat fault code can be observed on the MFD’s Avionics Status screen. For more information on avionics status codes, see the “MFD-870 Multifunction Display (MFD)” section of this manual.

The pilot's operating handbook limits operation of the integrated avionics to 30 minutes when cabin temperatures exceed 95°F (35°C). As a general rule, the instrument panel is able to maintain safe temperatures for operation using only the cockpit blower fan during this period. If cabin temperatures exceed 95°F (35°C) during ground operations, or ambient temperatures exceed 100°F (38°C) during flight operations, the cockpit blower fan speed should be set to maximum, the desired cabin temperature should be set to minimum, and the alternate avionics blower should be activated. The same procedure should be followed immediately if any display shows the flashing "DISPLAY TEMP" message.

Cathode Ray Tubes & Liquid Crystal Displays

With the exception of the GNS 430, all display screens in this aircraft are either 7/14 segment Liquid Crystal Displays (LCD), or Cathode Ray Tubes (CRT). Many of the LCD displays have a blue tint when lit from the front in daylight, and a red tint when lit from behind at night. The 7/14 segment LCD's warm up almost instantly in all but the coldest environments.

All 14 integrated avionics displays are CRT's, which can take a considerable time to warm up during cold conditions. If the cabin of the aircraft is not warmed up before starting the aircraft on a particularly cold day, it may take several minutes for the displays to reach full brightness. Similarly, when the displays begin to overheat, the image will become faint and eventually blank. There can also be a considerable delay between when the integrated avionics switch is activated, and when the first image appears on the display.

Engine & Pitot Covers

Unlike other Black Square aircraft, it is essential to remove the gear downlock pins, engine covers, and pitot covers before starting the aircraft, as they will not be removed automatically. Deployed pitot covers will cause Air Data Computer (ADC) faults, and render the pitot-static standby instrumentation useless. Deployed downlock pins will prevent the gear from being retracted after takeoff. Deployed engine covers will cause almost instantaneous destruction of the engines, as the cooling air is almost completely restricted. Users should suspect that the engine covers have been left in place in response to suspiciously low gas generator RPM. Pitot cover and downlock pin "REMOVE BEFORE FLIGHT" flags can also act as a wind indicator.

VOR & ADF Signal Degradation

Unlike in the real world, navigation receivers in Microsoft Flight Simulator produce only ideal readings. Signal strength is not affected by distance, altitude, terrain, or atmospheric conditions. When a station is out of range, the signal is abruptly switched off. This is unrealistic, and does not give the feel of navigating with the physical systems of the real aircraft.

All Steam Gauge Overhaul and Standalone Black Square aircraft solve this problem by providing variables for VOR and ADF indications with distance and height above terrain based signal attenuation and noise. This noise is mathematically accurate for the type of signal (phased VHF for VOR, and MF for NDB), and adheres to the international standards for station service volumes. Combined with the two-pole filtering and physics of the instrument's needles in the cockpit, this creates a very convincing facsimile of the real world instrument's behavior. The To-From indicators of the VOR instruments will even exhibit the fluttering that is characteristic of the "cone of confusion" directly over the ground-based stations that pilots are taught to recognize during instrument training.

Functional Windshield Wipers

This aircraft is one of exceedingly few for MSFS with functioning windshield wipers, with Black Square's Analog King Air being another. The wipers dynamically clear the windshield of rain droplets as the wiper moves over the windshield, and the windshield becomes obscured again in accordance with the rate of precipitation. This aircraft brings a significant improvement over the Analog King Air, with reduced performance impact, and streaking on the cleaned glass.

NOTE: The wipers can cause a slight performance degradation (1 fps), **only when they are operating**. The wiper effects can be removed completely by making a small edit to the behaviors XML file in the root aircraft folder. In "Starship_Interior.XML", search for "WindshieldWiperEffects", and follow the instructions to make this simple change.

Gyroscope Physics Simulation

This aircraft is equipped with the most realistic gyroscope simulation for MSFS yet, which simulates many of the effects real world pilots are intuitively familiar with from their flying.

Most recognizable of these effects is the “warbling” of a gyroscope while it is spinning up, such as after starting the aircraft’s engines. This is simulated with a coupled quadrature oscillator, and is not merely an animation. Unlike the default attitude indicators, the attitude indicators in this aircraft are simulated with physics, and their ability to display correct attitude information is dependent on the speed of an underlying gyroscope.

Gyroscope Physics

Gyroscopes function best at the highest possible speeds to maximize inertia. When the gyroscope speed is high, the attitude indicator display will appear to settle rapidly during startup, and is unlikely to stray from the correct roll and pitch, except during the most aggressive flight maneuvers, such as spins. When gyroscope speed is slower than optimal, precession of the gyroscope may cause the display to warble about the correct reading, before eventually settling out on the correct reading, if unperturbed. When gyroscope speed is slow, and well below operating speeds, the forces imparted on it by its pendulous vanes, which usually keep the gyroscope upright without the need for caging, can be enough to prevent the gyroscope from ever settling. Gyroscope speeds generally increase to operating speed quickly (within a few seconds), whether electric or pneumatic, but will decrease speed very slowly (10-20 minutes to fully stop spinning).

When these effects are combined, a failed gyroscope may go unnoticed for several minutes while performance degrades. So long as torque is not applied to the gyroscope by maneuvering the aircraft, or turbulence, the attitude display will remain upright. Either when the gyroscope speed gets very low, or when small torques are applied in flight, the display will begin to tumble uncontrollably. This can be extremely jarring to a pilot during instrument flight, especially if the condition goes unnoticed until a maneuver is initiated.

NOTE: All of the above effects are simulated in this aircraft, and both total and partial gyroscope failures are possible.

Electric Gyroscopes

Electrically powered gyroscopes avoid many of the complications of pneumatic powered gyroscopes, but are often only used as backup instrumentation in light aircraft. The internal components of an electric gyroscope often result in a more expensive replacement than an external pneumatic pump, however, and allow for less system redundancy, especially in multi-engine aircraft. A total electrical failure in the aircraft will result in the failure of electric gyroscope information, and often more quickly than a pneumatic gyroscope, due to the additional resistance of the motor windings on the gyroscope. Unlike a pneumatic gyroscope, an electric gyroscope will often settle almost completely after an in flight failure.

Introduction to Flight Planning

1. After the Control Display Unit (CDU) is initialized, the home Index screen is displayed. To begin creating a new flight plan, press the physical “FLT PLAN” key on the CDU keypad.

2. The new flight plan page displays only a “predesignation” field to enter a new waypoint identifier, the last entered waypoint identifier, the total flight plan distance, and the flight plan name.

3. Type the waypoint identifier using the CDU keypad, or by clicking anywhere on the CDU screen to activate keyboard entry mode. When “KYBD” is displayed, you may enter characters using your desktop keyboard. Press enter on your keyboard, or click the CDU screen again to exit keyboard entry. To enter letters on the keypad, press the number key with the letter, then press the “LTR” button until the desired letter appears.

4. The CDU will only accept the identifier of an airport, VOR, NDB, intersection, or user defined waypoint. Once you have completed the data entry, press the softkey beside “ENTER□”. If the entered waypoint identifier appears only once in the database, press the softkey beside “OK□” to add this waypoint to the flight plan.

5. If the waypoint appears more than once in the database, the duplicate waypoint menu will allow you to scroll up and down with the arrow keys on the CDU keypad to select the desired waypoint. Press the softkey beside "OK□" to add the selected waypoint to the flight plan.

6. Repeat this process until all desired flight plan waypoints have been entered, and then press the softkey beside "□END FPL". The main flight plan screen will then be displayed.

7. Scroll through waypoints on the main flight plan screen using the up/down arrow keys on the CDU keypad. To add more waypoints to the end of the flight plan, press the softkey beside "□ADD WPTS". A similar screen to what we observed on the new flight plan screen will allow you to enter a waypoint using the same steps as above.

8. To edit the flight plan, press the softkey to the left of any waypoint on the main flight plan screen. This will display the "Change Type" screen. From this screen, you may insert a waypoint after the selected waypoint, replace the waypoint, delete the waypoint, add radial/distance offset, add a reporting point based on another fix, or delete the entire flight plan.

9. Waypoints can also be entered by selecting them on the present position or plan map on the MFD screen. Use the joystick below the MFD to move the cursor on the screen over the waypoint you wish to add. Press the softkey below "ENT" to immediately add this waypoint to the new flight plan. The MFD cursor can be used to enter any identifier into any appropriate field on the CDU.

10. To save the current flight plan to memory, press the home index "IDX" button on the CDU keypad, followed by the softkey for the Route Library. Select any empty route on this screen. Enter the number "00" in the "ENTER RTE #" field, and then press the softkey beside "ENTER□". The route has now been saved and can be recalled on future flights.

11. To load a route from the route library as the current flight plan (or append it to the current flight plan), first find the route's identifying number in the route library. The up/down arrow keys on the CDU keypad can be used to scroll this list.

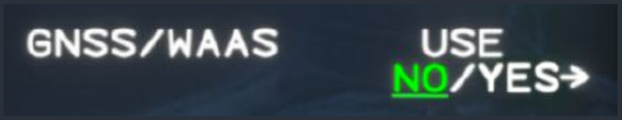
12. Enter the route's two digit number (with leading zero) into any add waypoint field, and press "ENTER□". You will then be prompted for whether you would like to add the waypoints in forward or reverse order.

No GPS Navigation & Position Estimation

In 1973, an effort began to create a satellite based Global Positioning System (GPS) for military use. GPS would not become available to the public until 1983 after the downing of Korean Airlines 007 after it strayed from its intended route. Before GPS saw wide acceptance in regulated markets like aviation, several other services existed to provide position information around the globe. The earliest of these systems were developed in the 1940's. Among them were LORAN (LOng RAnge Navigation), and the Decca Navigator System, which required remaining within ~1,000 nautical miles of at least two ground stations. In airborne applications, ground based stations, such as VOR and DME transmitters can be used to estimate position, but only when within ~100 nautical miles of a high power transmitter. It wasn't until the 1980's that computer technology would automate the process of receiving multiple VOR or DME stations and newer long range signals like Omega, and converting these signals into one continuously updated position estimate.

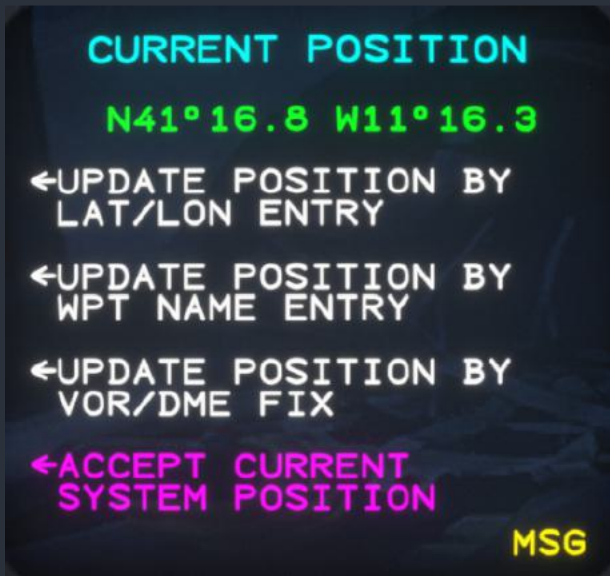
Position Estimation

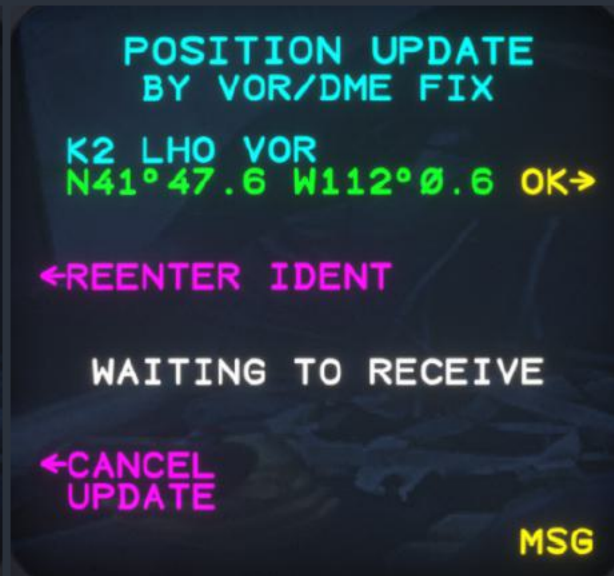
In absence of a Global Navigation Satellite System (GNSS), the AMS-850 avionics suite was designed to monitor all available navigation sources to produce a position estimate and resulting moving map graphics on the Navigation Display (ND) and Multifunction Display (MFD). This position estimate is informed by the aircraft's initial position at startup, nearby VOR and DME stations in the navigation database, Very Low Frequency (VLF) and Omega navigation receivers, and aftermarket GNSS position augmentation. To fly with only the original equipment, the user can disable the GNSS position augmentation in this aircraft from the Sensor Status screen of the Control Display Unit (CDU) by toggling off "GNSS/WAAS" as a position source.



When the Flight Management System (FMS) performs a cold start, the CDU will prompt the pilot to verify the last known location of the aircraft in the computer's memory. On the Verify screen, the CDU will also display the nearest VOR to the aircraft's last known position. If the pilot uses one of the Radio Tuning Units (RTU) to tune the frequency for this station, and it is subsequently received, the position estimate will be updated based on the aircraft's position relative to this station. Otherwise, the pilot may choose to update the initial position manually by pressing the line select key for "UPDATE POSITION". The position update functions are also available from the System Control screen on the CDU after the FMS has been initialized.

Three methods exist for updating the FMS's position estimate from the CDU, which can be crucial when operating without the GNSS selected as a source of position information. The position can be updated by manual entry of longitude and latitude, selection of the nearest facility in the database, and reception of a nearby VOR. Once the system is initialized, accessing the position update functions from the System Control screen by pressing the line select key for "POSITION HOLD", holds the currently estimated position of the aircraft in memory such that a known fix can be entered at the user's leisure.





Once an initial position is established, the FMS will use a complex algorithm that weights the influence of each position input based on its confidence that the input is providing an accurate position. A key element of this weighting is the aircraft's currently estimated position, which is why manually entered position updates can become crucial when operating far from navaids.

During normal operation, the FMS will automatically tune four DME receivers autonomously to nearby stations in the navigation database to augment its position estimate. In addition, the pilot may relinquish control of the two navigation receivers via the NAV screen on the CDU whenever the receivers are not being used as the active or preset navigation sources. All six of these receivers can be monitored via the MFD's VOR/DME Status screen. Manually tuned stations will also be used for position estimates. While distance, altitude, and service volume have an effect on the positional accuracy the system can derive from a single navaid, the number of navaids tuned at one time also has a great impact on positional accuracy.

In addition to VOR's and DME's, the system will also incorporate into its position estimate an independently calculated estimate based on VLF and Omega stations. The VLF/Omega navigation network is discussed at greater length below in the "Very Low Frequency (VLF)/Omega Navigation" section of this manual.

When total signal strength is poor, the radius of uncertainty will begin to grow. When positional uncertainty exceeds 3.0 nm, a yellow "DR" indicator will appear under the active navigation source on the ND, the text "VLF/OMEGA IS IN DR MODE" will appear on the VLF/Omega Status screen of the MFD, and a CDU message will alert the pilot. If the GPS position disagrees with the VLF/Omega position estimate by 2.5 nm or greater, the pilot will be prompted by an "Update VLF" message on the CDU to update the VLF position to the FMS position.

When the uncertainty of the FMS position estimate becomes large, or when convenient proactively, the pilot should seek an opportunity to use the Position Hold screen on the CDU to update the positional estimate with a known fix to reduce the uncertainty. For more information on updating the position estimate, see the "CDU-850A Control Display Unit (CDU) section of this manual.

Very Low Frequency (VLF)/Omega Navigation

In the 1970's, a new type of hyperbolic radio navigation system entered use based on lower frequency transmitters than LORAN or Decca. The Omega transmitters operated in the Very Low Frequency (VLF) band between 10 to 14 kHz. At such low frequencies, the radio waves produced by these transmitters bounce between the surface of the Earth and the ionosphere so effectively that they can be received on the other side of the globe. Only eight Omega transmitters were required to cover the globe in radio signals that could position aircraft and vessels within three miles of their true position. The eight Omega transmitters and eight other VLF transmitters used by this aircraft were known by a letter or number identifier, and the name of their geographic locations, such as Japan, Hawaii, Norway, and Great Britain. The transmitters were typically enormous towers, or were mounted on steel cables suspended between cliff sides several miles apart.

Each station transmitted a repeating pattern synchronized to a cesium oscillator atomic clock that the receiver used to determine the signal propagation time from the transmitter to the receiver, including all ionospheric bounces. Combined with the station's unique identifier signal and a database containing the location of each station, the receiver could calculate its own position. This had the added bonus of disseminating highly accurate date and time information with the position signal. For a primer on the Omega system, a 1969 United States Navy training film can be found under the title "Omega Navigation System US Navy Training Film."

VLF Stations			Omega Stations		
Station	Latitude	Longitude	Station	Latitude	Longitude
1 AUSTRALIA	21.816S	114.165E	A NORWAY	66.421N	13.151E
2 JAPAN	32.092N	130.829E	B LIBERIA	6.306N	10.662W
3 G BRITAIN	54.911N	3.279W	C HAWAII	21.405N	157.831W
4 MAINE	44.645N	67.285W	D N DAKOTA	46.366N	98.336W
5 HAWAII	21.420N	158.154W	E LA REUNION	20.974S	55.290E
6 MARYLAND	38.978N	76.453W	F ARGENTINA	43.054S	65.191W
7 WASHINGTON	48.204N	121.917W	G AUSTRALIA	38.481S	146.935E
8 PUERTO RICO	18.399N	67.177W	H JAPAN	34.615N	129.454E

In addition to the transmitters, a network of ground based receivers around the world monitored the integrity of the transmitters and used their fixed locations to create corrections that could be applied to the signals for greater positional accuracy. Those familiar with differential GPS and the Wide Area Augmentation System (WAAS) should recognize this arrangement.

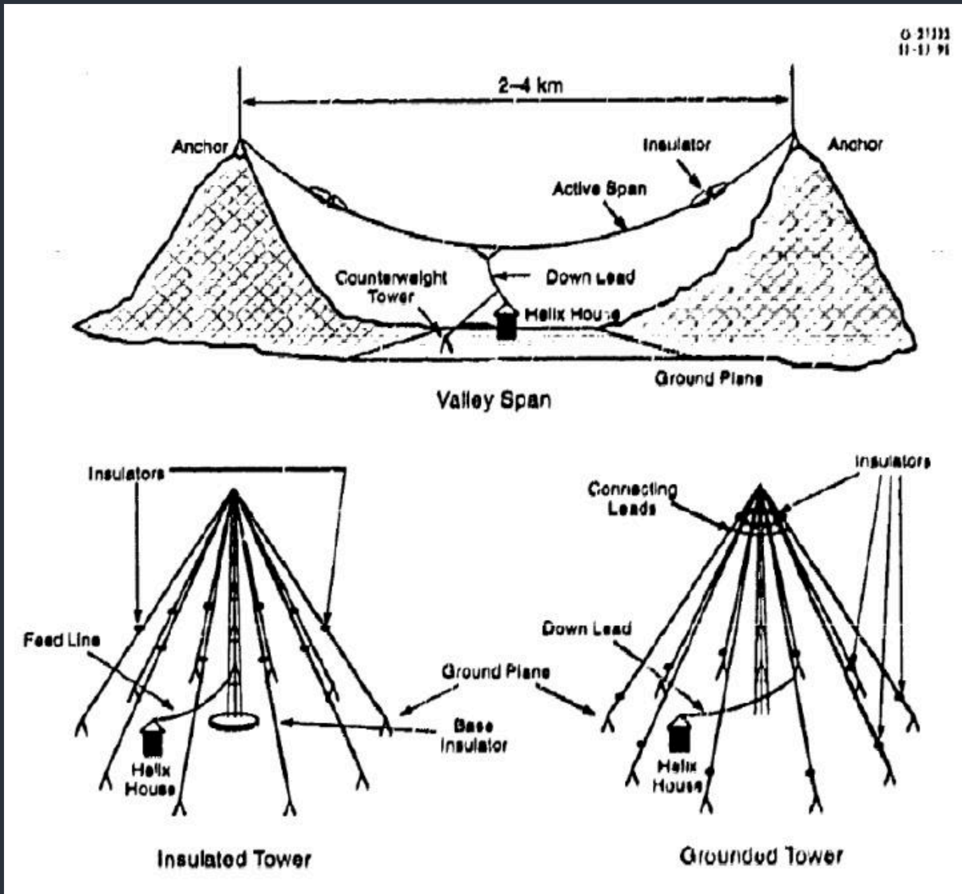
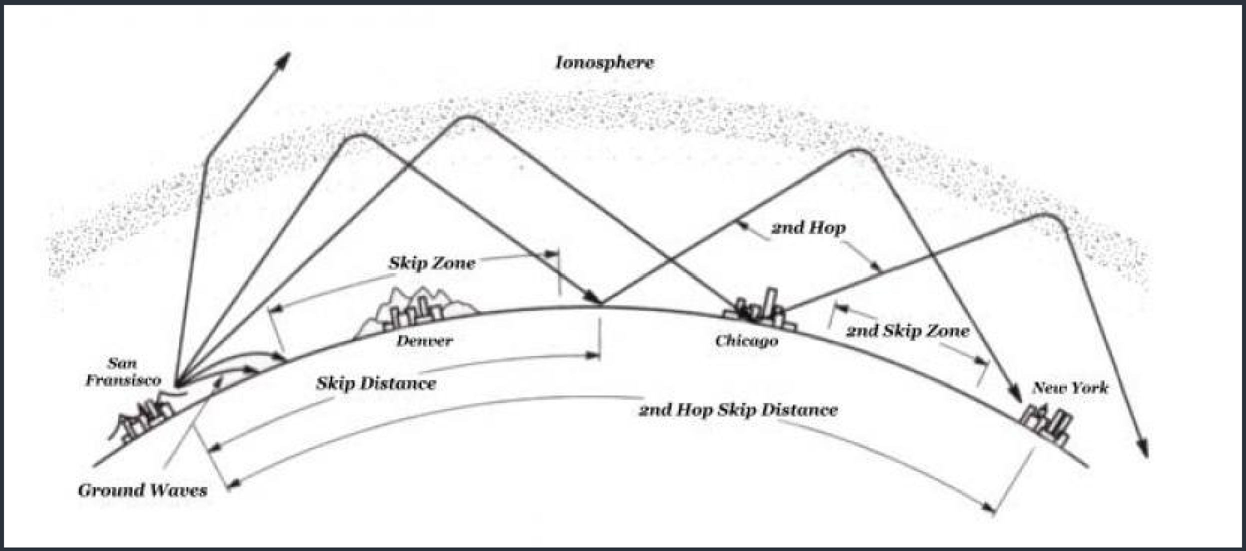


Figure 2.3-3 The Three Primary Types of Omega Antennas

(All images from the U.S. Coast Guard Omega Navigation System Center ca. 1994)

The positional accuracy estimated from the VLF/Omega receivers depended on several factors, including the number of stations received, as with VOR/DME. Due to the nature of its signal propagation, one major influence was the time of day, as the height of the ionospheric waveguide increases by around 25% at night. Additionally, merely the receiver's position on the globe and vertically in the atmosphere could make a substantial difference due to skip zones from distant stations and resulting signal-to-noise ratio at any given location.



Local precipitation could also decrease the apparent signal strength of the VLF/Omega transmissions, meaning that an aircraft's position could become less certain when visibility was reduced by rain, right when the pilot needed it most. Even atmospheric gravity waves in the upper atmosphere could affect propagation. Lastly, the effect of tides was also well known to marine users, as water volume in bays and rivers could improve signal propagation.

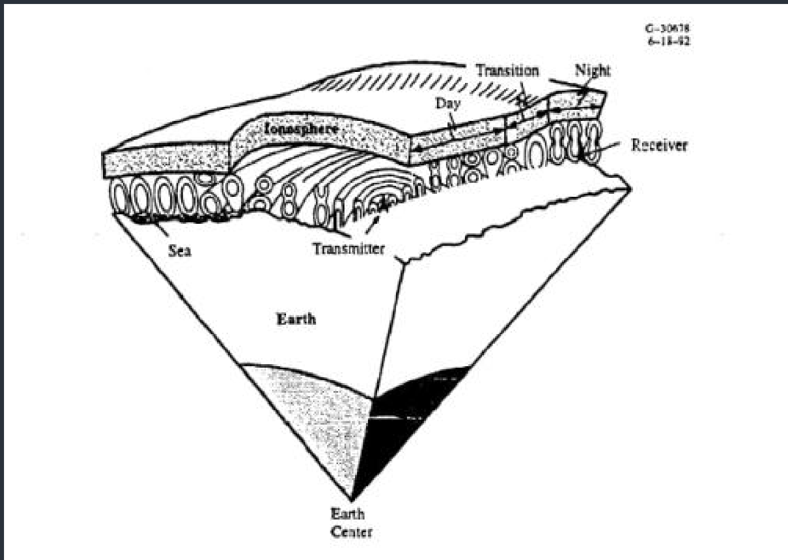


Figure 5.1-2 Electric Field Patterns Within the Earth-Ionosphere Waveguide

Many of these effects are simulated in this aircraft to create a believable recreation of the Omega network, including its influence on FMS position estimation.

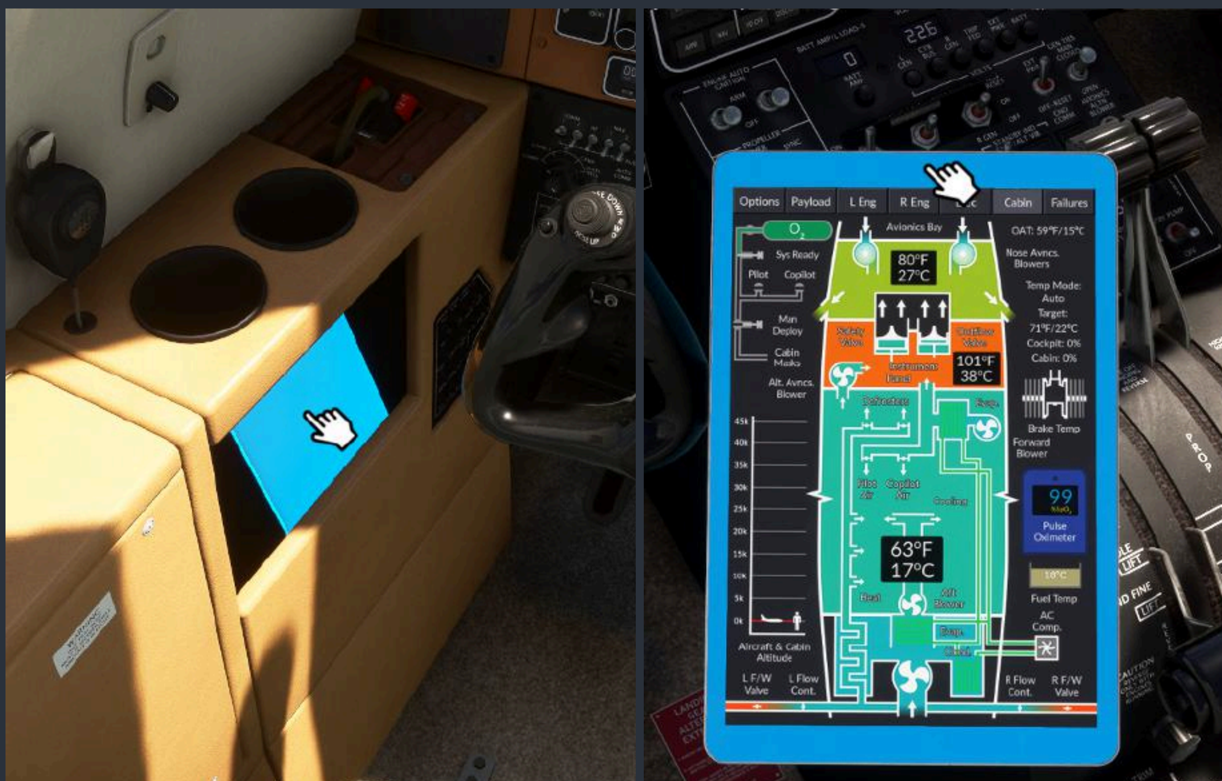
Monitoring FMS Position

The Multifunction Display's (MFD) VLF/Omega Status screen is used to monitor the status of the Very Low Frequency (VLF) and Omega receivers and their resultant positional accuracy. All 16 worldwide stations are displayed with their identifiers. The "USE" column indicates whether a station is beyond the range of the antenna ("N"), currently being received and used to generate the position estimate ("Y"), or manually deselected ("DSLCT") on the Sensors screen of the Control Display Unit (CDU). If the position estimate of the VLF/Omega system becomes large while operating without GNSS position augmentation, the position estimate should be updated manually by following the prompts on the Position Update screen of the CDU. A yellow "VLF/OMEGA IS IN DR MODE" message will appear if VLF/Omega signal reception is reduced, such as in remote areas of the globe, while on the ground, or in heavy precipitation.

The Position Summary screen provides the overall longitude and latitude position estimate produced by the FMS, and also the bearing and distance from that position estimate to each individual estimate produced by the radio receivers and GNSS. If the GNSS is not selected as a source of position information, a yellow "FMS POSITION UNCERTAIN" message will appear when the radius of positional certainty rises above 3.0 nautical miles. Signal strength for the individual VLF/Omega stations can be reviewed on the CDU's Signal Status screen.

Tablet Interface

The Black Square tablet interface is an invaluable resource for the enhanced understanding of complex aircraft systems. The tablet also allows the user to configure all options, manage payload, control failures, monitor engines, electrical schematics, and environmental control systems, all from within the simulator.

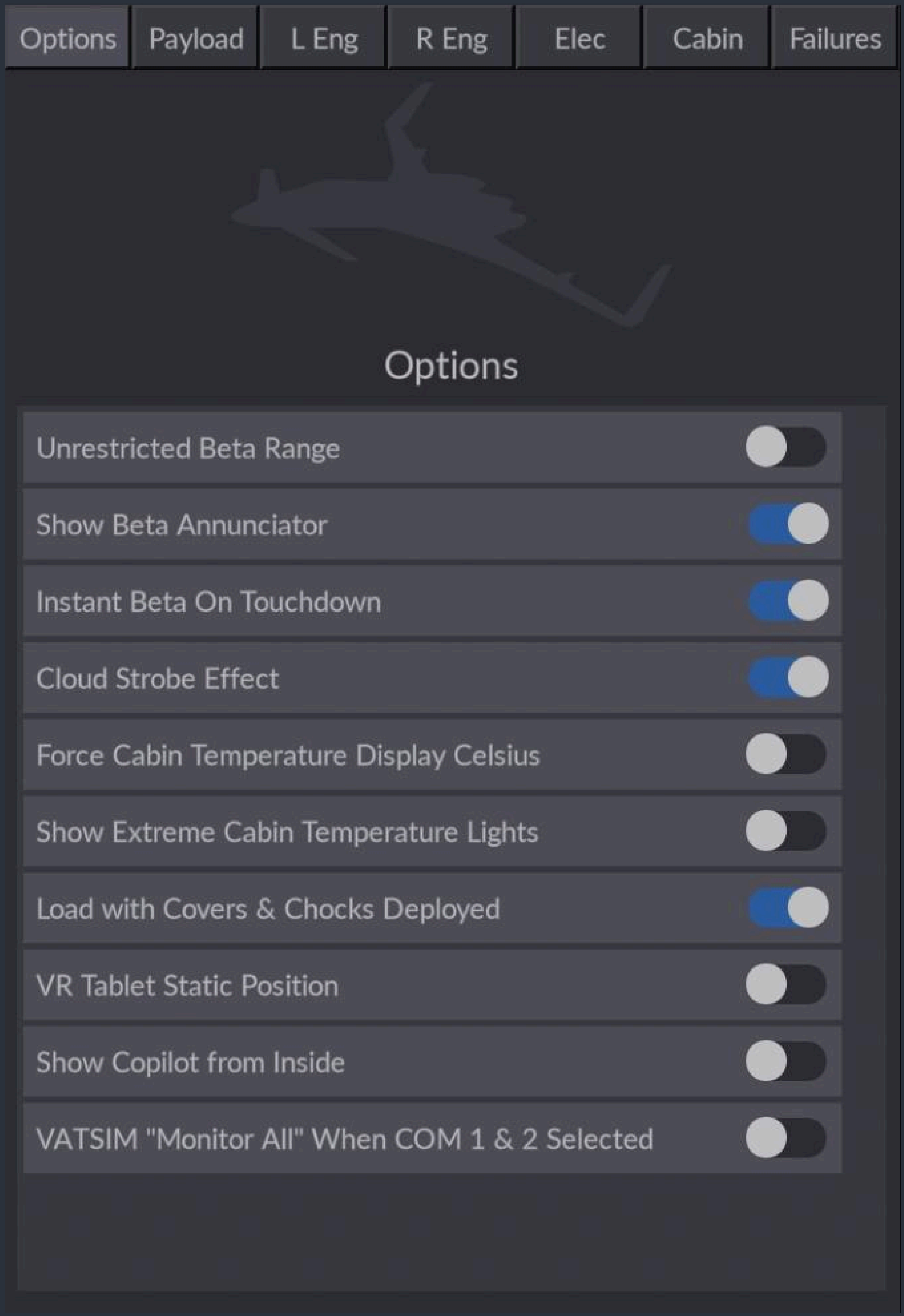


To show or hide the tablet, click on the tablet in the document holder to the left of the pilot's seat. The tablet can be moved around the cockpit by dragging the frame of the tablet.

NOTE: Due to the large amount of information rendered on some pages of the tablet interface, it **may have a noticeable impact on the graphical performance of the simulator on less powerful systems.** This is only a symptom of rendering the graphics, and the rest of the aircraft has been designed to be as frame rate friendly as possible, often outperforming the default aircraft with large glass panel instrumentation. **If you experience this, simply hide the tablet interface when it is not in use, and it will have no further impact on performance.** In testing, the impact of the visualizer has been observed to be **less than 2-3 fps** when open.

Options Page

Selections made on this options page will be saved and restored next time the aircraft is loaded.



Payload Page

NOTE: Using the payload configuration tools in this tablet interface is optional.

You may always use the simulator's native payload and fuel interface, though the two may be desynchronized when the aircraft is first loaded. This is a simulator limitation.

1. Payload Data

This text area contains real-time weight and balance information, as well as range and endurance estimates. The toggle switch above the payload data block can be used to switch units from gal/lbs to L/kg. The maximum gross weight will appear in red when it exceeds the maximum gross ramp weight, and yellow when it exceeds the maximum landing weight.

2. Exterior Actions

The buttons in this list execute actions pertaining to the exterior of the aircraft, such as opening doors, and refilling the oxygen cylinder. The cabin door can also be opened from the inside of the aircraft without the tablet interface. If the door fails to open, its operation is being impeded by the aircraft's condition, such as airflow around the aircraft, or the cabin pressurization.

3. Fuel Stations

Each fuel tank in the aircraft is represented by a fuel block. Each block depicts the current fraction of the tank that is filled in the color of the fuel type appropriate to the aircraft, the total gallons or liters of fuel in the tank, and the weight of the fuel. Below each block is the name of the tank, and its maximum capacity. The quantity of the fuel in the tank can be adjusted with the up and down buttons, or the simulator's native payload interface.

4. Payload Stations

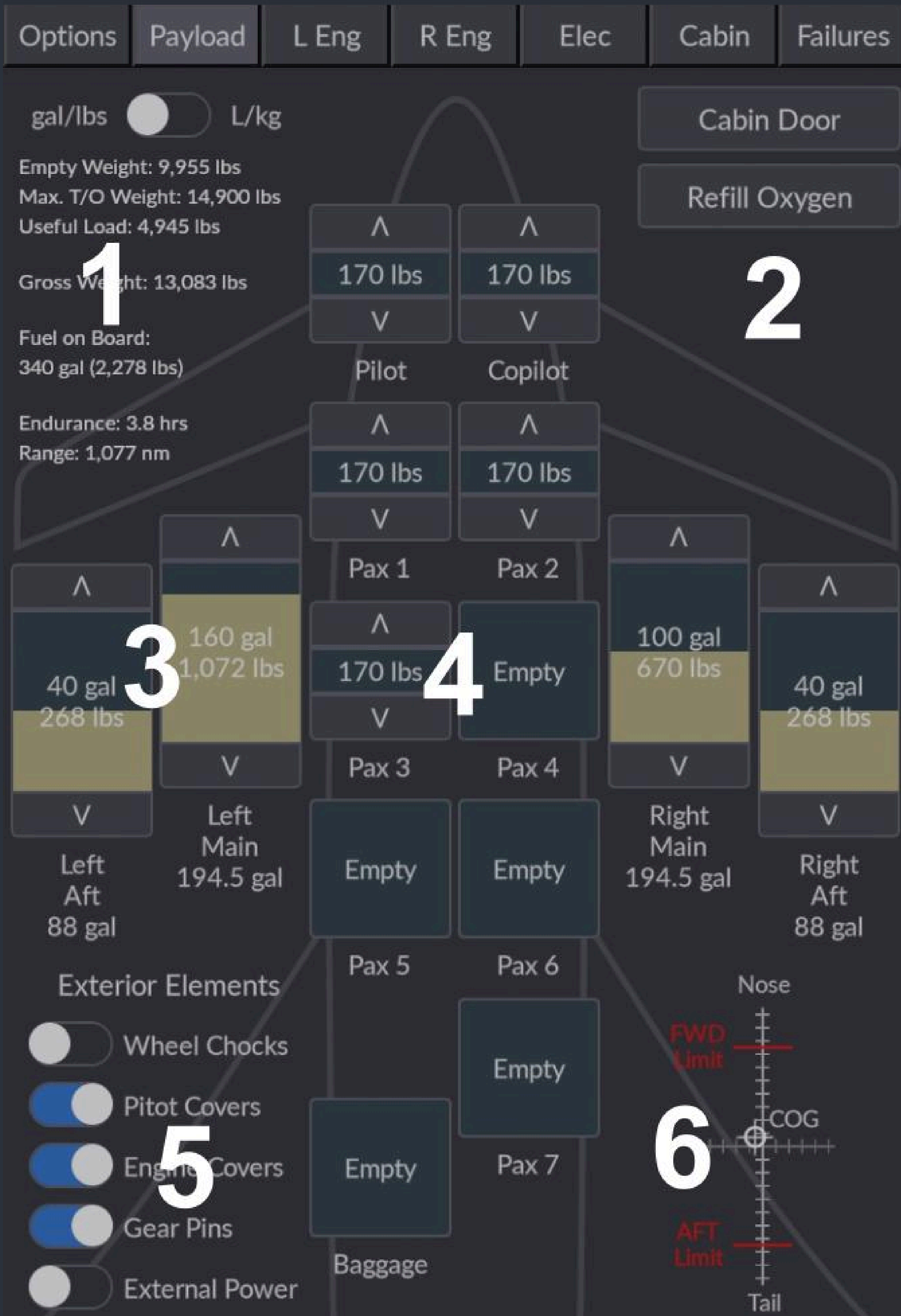
Each payload station in the aircraft is represented by a payload block. When occupied by passengers or cargo, each block shows the current weight of the station in its center. Clicking in the center of the block will toggle the payload between empty, and the default station weight. The weight of the payload station can be adjusted with the up and down buttons, or the simulator's native payload interface.

5. Exterior Elements

The toggle switches in this list control the visibility of exterior elements around the aircraft, such as wheel chocks and engine covers. The functioning wheel chocks and gear downlock pins can also be toggled by clicking on the stowed equipment in the aircraft cabin.

6. Center of Gravity

This relative depiction of the center of gravity limitations can be used to assess the balance of your payload. When the aircraft's center of gravity exceeds the lateral or longitudinal limits, the crosshair will turn red.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
gal/lbs
L/kg
Cabin Door
Refill Oxygen
Empty Weight: 9,955 lbs
Max. T/O Weight: 14,900 lbs
Useful Load: 4,945 lbs
Gross Weight: 13,083 lbs
Fuel on Board:
340 gal (2,278 lbs)
Endurance: 3.8 hrs
Range: 1,077 nm
1
2
3
4
5
6
170 lbs
Pilot
170 lbs
Copilot
170 lbs
Pax 1
170 lbs
Pax 2
170 lbs
Pax 3
Empty
Pax 4
Empty
Pax 5
Empty
Pax 6
Empty
Pax 7
Empty
Baggage
40 gal
268 lbs
Left
Aft
88 gal
160 gal
1,072 lbs
Left
Main
194.5 gal
100 gal
670 lbs
Right
Main
194.5 gal
40 gal
268 lbs
Right
Aft
88 gal
Exterior Elements
Wheel Chocks
Pitot Covers
Engine Covers
Gear Pins
External Power
Nose
FWD
Limit
COG
AFT
Limit
Tail

Engine Visualizer Page

While the engine visualizer does not depict every operating parameter of the engine, as this would be a nearly impossible task, it depicts many of the parameters and conditions designed by Black Square that were previously invisible to users. This visualizer is probably most helpful for ensuring cool engine starts, but also for troubleshooting failures.

Cold Engine

This is how the engine visualizer will appear when the aircraft is first loaded on the ground.

1. Repair Engine

Clicking the Repair Engine button will reset only the engine's core condition, which can be observed on the adjacent engine condition bar. This action requires confirmation. Resetting the engine condition will not perform any of the actions performed by the column of buttons on this page, such as clearing the engine, or recharging the batteries. The engine condition can also be reset via the legacy weather radar systems display.

The engine condition is represented by a percentage of total engine health. When the engine's condition reaches 0%, a catastrophic failure will occur, and the engine will become inoperable. When the engine condition falls below 20%, the engine's performance will begin to suffer, making further degradation likely if power is not reduced immediately.

2. Engine Condition Reset Buttons

These buttons will not reset the engine's overall condition, but instead will reset individual elements of the engine's operating condition that may have become damaged or inoperable due to mismanagement, as opposed to failure.

The Clear Engine button will reset the engine temperatures to ambient, remove all fuel from the lines and combustion chamber, and prepare the engine for a normal cold start.

The Repair Starter button will reconnect the starter with the aircraft's electrical system, and set the starter's casing to the ambient temperature. The starter may become disconnected from the electrical system due to overuse, which results in a high temperature.

The Clean Filters button will remove any contaminants from the oil and fuel filters. These filters are depicted by cross-hatched rectangles in this visualizer. Clogged filters may result in higher than normal oil temperatures, or lower than normal fuel pressures, accompanied by a warning light.

The Recharge Battery button will fully recharge the battery, set its internal temperature to the ambient, and reconnect it with the hot battery bus. The battery may become disconnected from the hot battery bus if it is charged or discharged too quickly, which results in high temperatures.

3. Fuel & Oil Lines

Each engine on this aircraft has an electric fuel boost pump, two engine-driven pumps, three associated jet pumps, an inline primary fuel filter which can become clogged, and an oil-to-fuel heat exchanger.

As oil is circulated through the engine's galleries, a brown slug of oil will move down the lines depicted on the engine visualizer. The speed at which oil permeates the engine is determined by the oil's viscosity. Oil viscosity is determined mostly by temperature. The color of the oil depicts its temperature. Dark browns indicate very cold and viscous oil. The oil has a large normal operating temperature span, throughout which its color will be the brown seen below.

4. Output Shaft

On the front of the engine is the output shaft, which is directly connected to the propeller. This shaft drives the propeller governor, and incorporates the torquemeter, and beta feedback ring.

5. Planetary Reduction Gearbox

The planetary reduction gearbox is responsible for reducing the 30,000+ shaft RPM of the power turbine to a higher torque and more useful speed to drive the propeller. Since this is such a high wear area of the engine, it receives a constant flow of oil, and has its own oil sump.

6. Power Turbine

The power turbine blades are positioned just downstream of the combustion chamber, and capture the energy of the rapidly expanding exhaust gasses. One of the three turbines in this section returns power back to the gas generator to sustain combustion. Important to the understanding of free turbines, the power turbine and the gas generator are not connected by a common shaft or gears. There is no mechanical connection between the two sections. Instead, only the airflow that passes between the two connects them.

7. Gas Generator

The gas generator comprises a set of turbines and stators that progressively compress ram air to about ten times its ambient density. This air is then distributed through small holes into the combustion chamber. The gas generator is driven by expanding exhaust gasses when the engine is running, and the starter motor while starting.

8. Accessory Gearbox

The accessory gearbox resides on the back of the engine, and is used to transfer power from the gas generator to accessory equipment, such as fuel and oil pumps, the fuel control unit, and the starter-generator. The gearbox contains reduction gears to reduce the high RPM, low torque output of the gas generator to lower RPM, higher torque output for the accessories. It is important to remember that in a free turbine engine, accessories are driven by the gas generator, not the propeller output shaft. The main oil reservoir and sump separate the accessory gearbox from the rest of the engine.

9. Induction & Bleed Air Controls

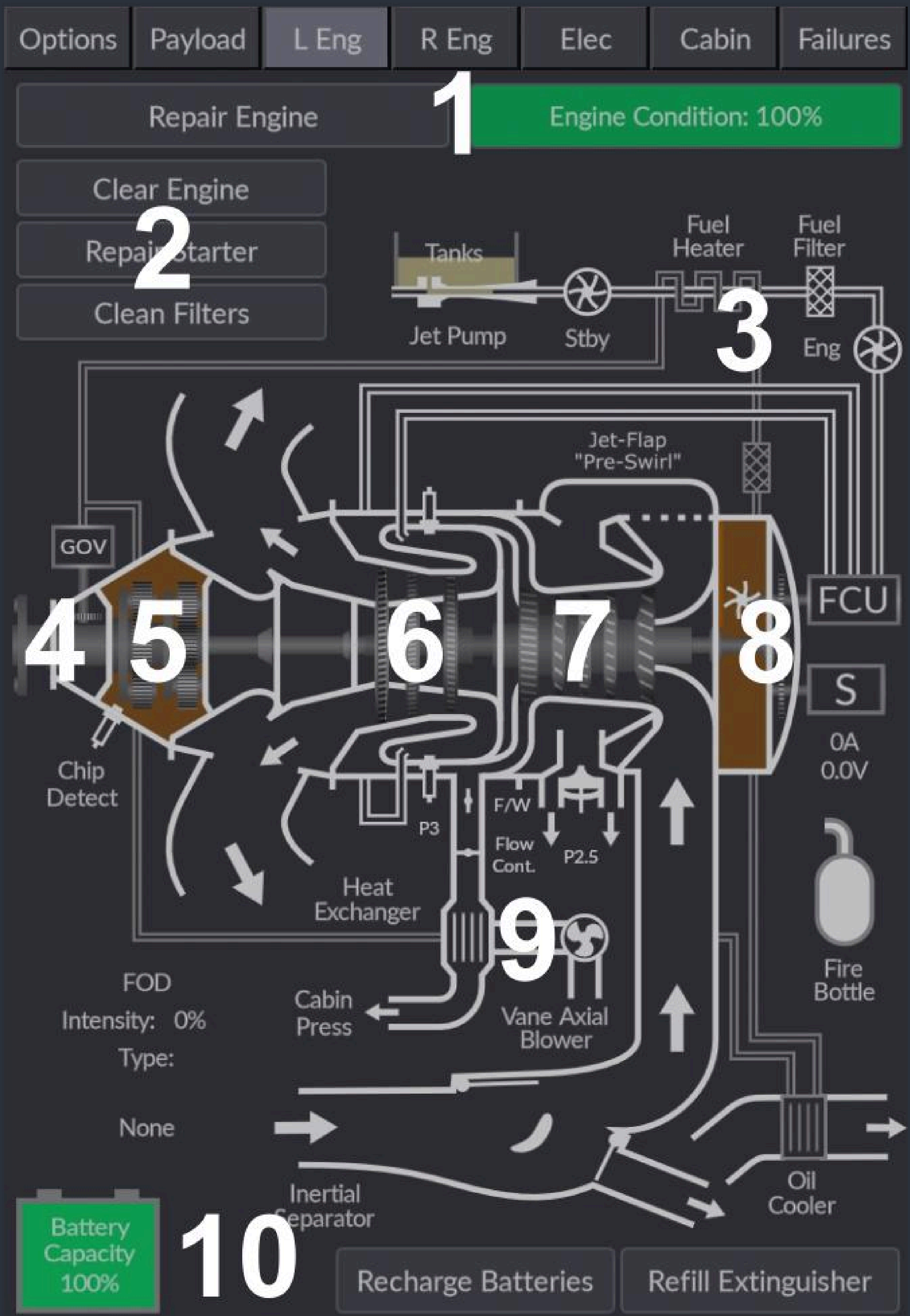
Control of the engine's intake and bleed air relies on a series of valves and louvers. Ambient air enters the induction system through the air inlet under each engine, at the bottom of the visualizer. This air is always at the same temperature and pressure as the air surrounding the aircraft. Ambient pressure and temperature ram air is pressurized by the gas generator before entering the combustion chamber.

The air used to pressurize and heat the cabin is extracted from the high pressure P2.5 and P3 bleed air valves after the gas generator. See the "Cabin Environmental Controls" section of this manual for more information on bleed air sources and climate control.

The bleed air is metered by the bleed flow valves, before being passed through the bleed air heat exchanger in the environmental dome at the aft of the cabin. Should the bleed air become contaminated, such as by a carbon monoxide leak, the bleed air valves can be closed by moving the bleed air control switch to the off position. See the "Cabin Environmental Controls" section of this manual for more information on the pressurization and bleed air controls.

10. Active & Inactive Batteries

The capacity of each battery is displayed as a percentage of total amp-hours remaining. Batteries should generally not be discharged below 70-80% of their total capacity, unless they are specially designed "deep-cycle" batteries. When a battery is not connected to the main bus of the aircraft, it will appear grayed out.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Repair Engine
1
Engine Condition: 100%
Clear Engine
2
Repair Starter
Clean Filters
Tanks
Jet Pump
Stby
Fuel Heater
Fuel Filter
3
Eng
Jet-Flap "Pre-Swirl"
GOV
4
5
6
7
8
FCU
S
0A
0.0V
Chip Detect
P3
F/W
Flow Cont.
P2.5
Heat Exchanger
9
Vane Axial Blower
Fire Bottle
FOD
Intensity: 0%
Type:
None
Cabin Press
Inertial Separator
Oil Cooler
Battery Capacity 100%
10
Recharge Batteries
Refill Extinguisher

Starting Engine

This visualizer can be very helpful for understanding the starting sequence of a free turbine engine, and learning how to keep the engine as cool as possible during starting.

1. Fuel Pumps

When the electric boost pump or engine-driven fuel pump runs, fuel will flow from the tank into the fuel control unit (FCU). Dashed lines indicate the rate of fuel flow. Not until this slug reaches the FCU will the engine be capable of sustaining combustion.

2. Ignitors

In order to ignite the relatively non-volatile jet fuel, several ignitors are mounted radially around the combustion chamber. Not unlike spark plugs in a reciprocating engine aircraft, an exciter coil sends a high voltage pulse of electricity to these electrodes to produce a spark. The ignitors can be energized automatically whenever the engine is at low power output with the auto ignition switches. This is usually recommended when the aircraft encounters severe turbulence or precipitation. See the “Turbine Engine Ignition” section of this manual for more information

3. Jet-Flap Intake System (Pre-Swirl)

This version of the PT6A engine incorporates only one P2.5 bleed valve, as opposed to other variants of the same engine, which have high and low pressure P2.5 bleed valves. In the place of one of these valves is the jet-flap intake system, which routes pressurized air from the P2.5 compressor stage back into the radial inlet through a series of holes. These holes are designed to introduce a cyclonic “pre-swirl” into the induction air, which increases compressor efficiency, improves low-speed compressor characteristics, and reduces the chances of compressor stall.

4. Fuel Control Unit & Starter Motor

The Fuel Control Unit (FCU) is a purely mechanical control system in a turbine engine that meters the amount of fuel injected into the combustion chamber to achieve the desired power output set by the power lever. A combination of pressurized fuel and pressurized bleed air are provided as inputs to the FCU. When the FCU is receiving pressurized fuel and functioning normally, its internal volume will be shown in green. When an FCU failure has occurred, it will be shown in red. For more information on the FCU and its possible failures, see the “Turbine Engine Fuel Control Failures” section of this manual.

When the starter motor is in use, the interior body of the starter will be depicted in green. Should the starter fail, it will turn red. Since the starter motor is also the generator, the interior body will also be green when the generator is in use, except the letter “G” will be shown, instead of “S” for starter.

The exterior casing of the starter-generator will change color to indicate its temperature. When the starter-generator is cold, the casing color will be gray. As it warms, the color will change from blues and greens, to ambers and reds.

5. Intake Air

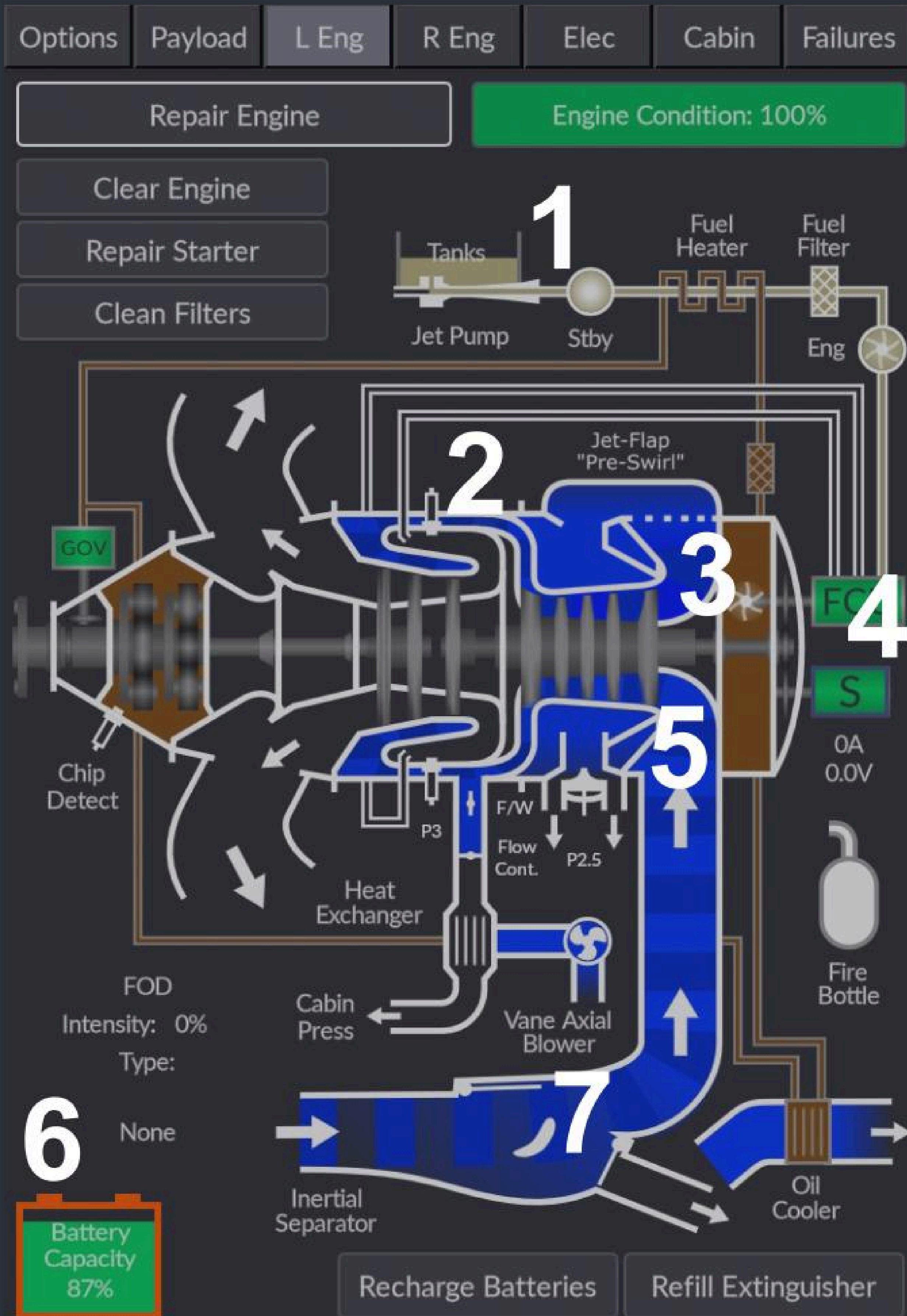
The gasses in the intake manifold are color-coded not for temperature, but pressure. Fully saturated, bright blue indicates sea level pressure. Darker blues indicate higher pressures, and greens and yellows indicate lower than sea level pressures. Seen here, the intake air is at the same pressure as the ambient air, but the air in the combustion chamber has been compressed by the gas generator. Before the engine is sustaining combustion the P2.5 bleed air valves will be open, as there is no P3 bleed air pressure to close them. For more information on P2.5 bleed valve operation and failures, see the “P2.5 Bleed Air Valves” section of this manual.

6. Battery Temperature

Here, the battery can be seen connected to the main electrical bus. The exterior casing of the battery will change color to indicate the temperature of the battery’s terminals and electrodes. When the battery is cold, the casing color will be gray. As the battery warms, the color will change from blues and greens, to ambers and reds. For more information on battery charging and temperature, see the “Battery Temperature” section of this manual.

7. Inertial Separator Stowed

With the inertial separator in the stowed (normal) position, ram air will flow unimpeded through the intake manifold and into the engine’s radial inlet. While this configuration is best for engine performance and cooling, it allows Foreign Object Debris (FOD) to enter the engine. For best practices regarding the inertial separator, see the “Inertial Separators (Ice Deflectors)“ section of this manual.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Repair Engine
Engine Condition: 100%
Clear Engine
Repair Starter
Clean Filters
1
Tanks
Jet Pump
Stby
Fuel Heater
Fuel Filter
Eng
2
Jet-Flap "Pre-Swirl"
3
FC
4
S
0A
0.0V
GOV
5
Chip Detect
P3
F/W
Flow Cont.
P2.5
Heat Exchanger
Fire Bottle
FOD
Intensity: 0%
Type:
Cabin Press
Vane Axial Blower
6
None
7
Inertial Separator
Oil Cooler
Battery Capacity 87%
Recharge Batteries
Refill Extinguisher

Running Engine

While the engine is running, the engine visualizer is best used for detecting component failure, monitoring air intake valve positions, and bleed air valve activation.

1. Propeller Governor

The propeller governor controls the pitch of the propeller to indirectly control engine torque and output shaft RPM. The governor's flyweights are driven by a mechanical connection to the output shaft, and meter the high pressure oil supply to the propeller hub. When the propeller governor is receiving oil and functioning properly, it will be depicted with a green body. The body will become red if the governor fails. For information on the testing and failure modes of the governor, see the "Propeller Governors" section of this manual.

2. Exhaust Gasses

When the engine has achieved self-sustaining combustion, the resultant exhaust gasses are expelled through the power turbine, and out the exhaust stubs on either side of the engine. While the intake gasses are color-coded for pressure, the exhaust gasses are color-coded for temperature. The color spectrum is the same as for the other elements discussed above. As the gasses warm, their color will change from yellows and oranges, to reds and magentas. Magenta should be considered dangerously hot for any equipment depicted in this visualizer.

3. Combustion Chamber

When the ignitors successfully light off self-sustaining combustion, flame will emanate from the fuel injector nozzles. This engine has two injector circuits, primary and secondary. The primary injectors work alone when the engine is spooling up from a cold start, while the secondary injectors begin to function at around 40% Ng. Should an injector fail, fuel will not be shown in the pipeline, and the flame will be absent.

4. Bleed Air Valves

This engine has two bleed air valves. P3 bleed air is drawn from just prior to the combustion chamber, and is used to supply the heating and pressurization system. The P2.5 bleed valve helps maintain the correct engine operating RPM, and is sometimes used for heating and pressurization in other aircraft. The position of these valves is indicated on the visualizer. Should a valve fail and become stuck open, the valve body will be shown in red. For more information on P2.5 bleed valve operation and failures, see the "P2.5 Bleed Air Valves" section of this manual.

5. Oil Pumps, sumps & Lines

While dark brown oil in the lines indicated very cold and viscous oil, red indicates oil that is too hot. Here, the engine driven oil pump can also be seen running inside the main engine oil sump.

6. Chip Detector

The chip detector is a magnetic pair of electrodes at the bottom of the planetary reduction gearbox oil sump. This is the most likely location in the engine for metallic particles to collect due to wear. The magnet attracts the particulate, and the electrodes allow for a complete circuit to be created when the metallic particles collect on them. When the presence of metal particles in the oil is detected, the body of the chip detector will show red, and a yellow Crew Alerting System (CAS) message is triggered. A chip detect warning is usually indicative of incipient engine failure, and power should be reduced immediately.

7. Fire Extinguisher Bottle

The extinguisher bottle shows the level of retardant in the bottle. When the bottle is empty, the letter “E” will be visible. The presence of lines emanating from the nozzle indicates that the bottle is currently dispensing retardant inside the engine nacelle. The fire bottles can be refilled with the “Refill Extinguisher” button.

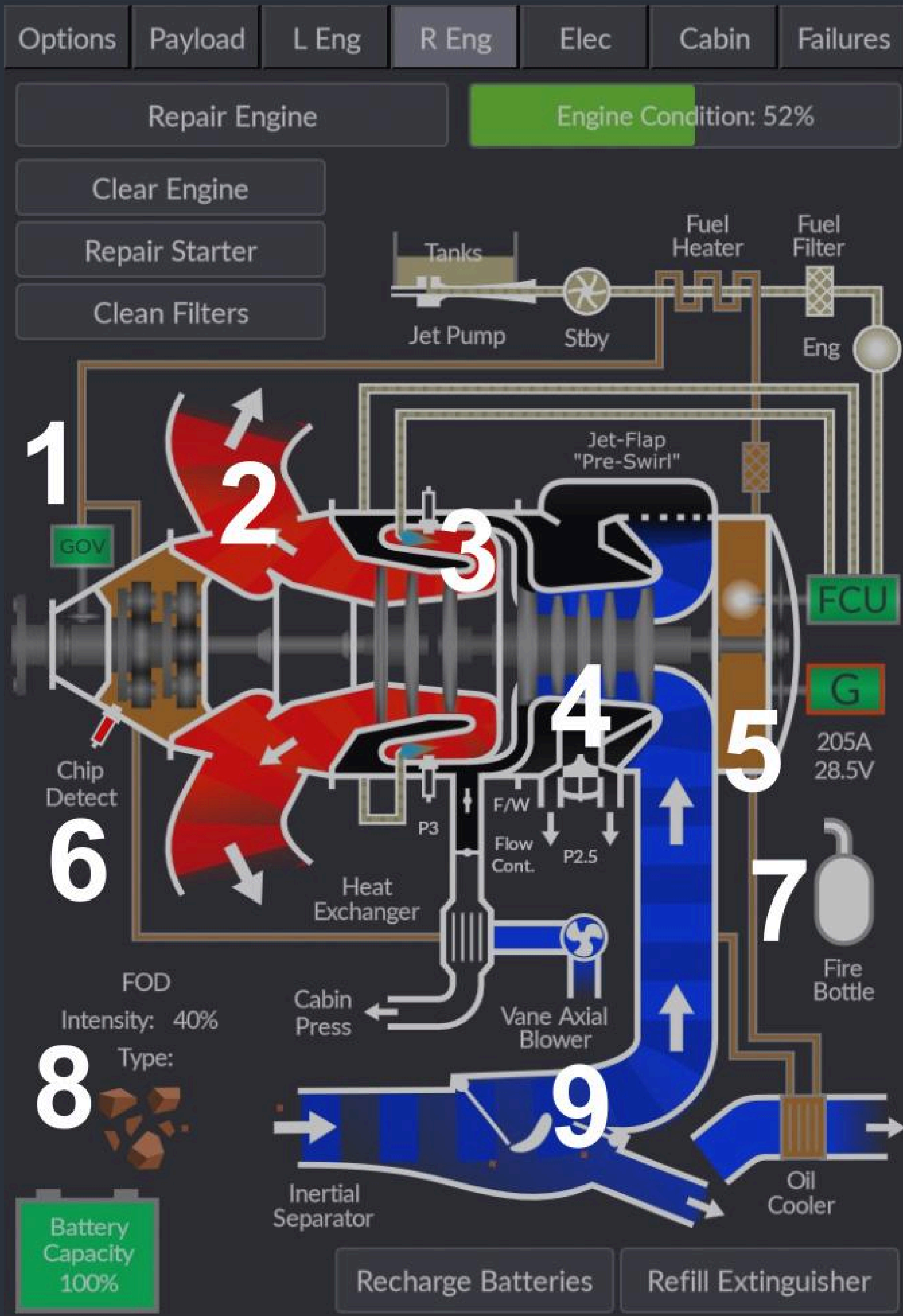
8. Foreign Object Debris (FOD)

It is possible to encounter Foreign Object Debris (FOD) whenever operating on the ground, particularly on unimproved or worn surfaces. FOD can also enter the engine in flight in the form of ice, heavy precipitation, or birds. An icon representing the current type of FOD being encountered will appear on this visualizer. The intensity of the FOD is expressed as a number from 0 to 100%. Particles of FOD can be seen entering the air inlet, and flowing either into the engine or out the ejection ports, depending on how the inertial separator is positioned. For more information on the avoidance of FOD, and the consequences of encountering FOD, see the “Foreign Object Debris Damage” section of this manual.

No FOD | Rain | Ice/Snow | Asphalt/Stone | Dirt | Sand

9. Inertial Separator Deployed

When the inertial separator is in the fully deployed (bypass) position, any Foreign Object Debris (FOD) that enters the engine air intake below the propeller will flow harmlessly out the ejection ports at the rear of the nacelle. If the inertial separator’s louvers fail to fully deploy, the amount of FOD admitted to the engine is proportional to their position. For best practices regarding the inertial separator, see the “Inertial Separator“ section of this manual.



Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Repair Engine
Engine Condition: 52%
Clear Engine
Repair Starter
Clean Filters
Tanks
Jet Pump
Stby
Fuel Heater
Fuel Filter
Eng
Jet-Flap "Pre-Swirl"
1
2
3
4
5
6
7
8
9
GOV
FCU
G
205A
28.5V
Chip Detect
P3
F/W
Flow Cont.
P2.5
Heat Exchanger
Fire Bottle
FOD
Intensity: 40%
Type:
Cabin Press
Vane Axial Blower
Inertial Separator
Oil Cooler
Battery Capacity 100%
Recharge Batteries
Refill Extinguisher

The live schematic in the tablet interface is an almost identical recreation of the static schematic in the "Overview Electrical Schematic" section of this manual. For more information on the enhanced electrical simulation of this aircraft, also see the "Electrical Systems" section of this manual.

1. Active & Inactive Equipment

When a circuit component, such as a starter motor, is inactive, it will be grayed out. Failed components may appear in red, such as the left bus tie contactor, as seen here.

2. Switches

Toggle switches control whether a circuit is open or closed. Wherever possible, the switches in the live schematic will be oriented so that the head of the toggle switch points towards the direction of current flow when it is in the on position.

3. Voltmeters

Voltmeters measure the electrical potential between two points in the aircraft's electrical system. Here, the direct current (DC) voltmeter measures the voltage between the main bus, and the chassis (ground) of the aircraft.   As opposed to current measuring devices, voltmeters are depicted beside the point at which they measure voltage, or across two points between which the potential is measured, rather than as in-line devices.

4. Buses & Circuit Connections

An electrical bus is any point in an electrical system at which multiple circuits, or other buses, attach. They are often solid pieces of highly conductive metal to which many wires attach, though they can also be purely conceptual, and used to aid one's understanding of the system.

Connections between circuit elements and buses are depicted with solid lines and "hop-overs" wherever two lines must cross without making contact. In this live schematic, buses and circuit connections receiving any voltage from the battery, generators, or external power are highlighted in green, and are otherwise red. For the sake of readability, some circuit connections appear in red when no apparent switch isolates that part of the circuit from normally powered buses. For example, the circuit connection to the external power plug remains red, even when the main bus is powered.

Logic or signal connections, which do not carry any meaningful current, are depicted as dashed lines. For example, in this aircraft, the avionics controller sends a trigger voltage to the avionics contactors to close, thus supplying power to the avionics buses. A contactor is a large mechanical relay, often used in older aircraft for switching large loads.

5. Loadmeters

The load meters in most light aircraft do not indicate the total load required of the aircraft's electrical system for all of its electrical equipment. Instead, the loadmeters indicate the load on each generator. This will always be a positive number, as opposed to ammeters in aircraft that can be used to observe battery charge and discharge rates. As opposed to voltmeters, current measuring devices are depicted as in-line with their load, rather than as point measurements. In this aircraft, the only ammeter is positioned in-line with the battery, so that the operator can determine whether the battery is being charged or discharged.

6. Diodes

Diodes permit the flow of current within a circuit in only one direction. Here, the left generator bus does not receive power from the triple-fed bus, because a diode is blocking the current. Diodes also cause a small drop in voltage from the supply side to the demand side, which is called the forward voltage. Here, the center bus and right generator bus on the supply side are at a 28V potential, but the triple fed bus is at a 27V potential due to the two diodes feeding it.

7. Circuits

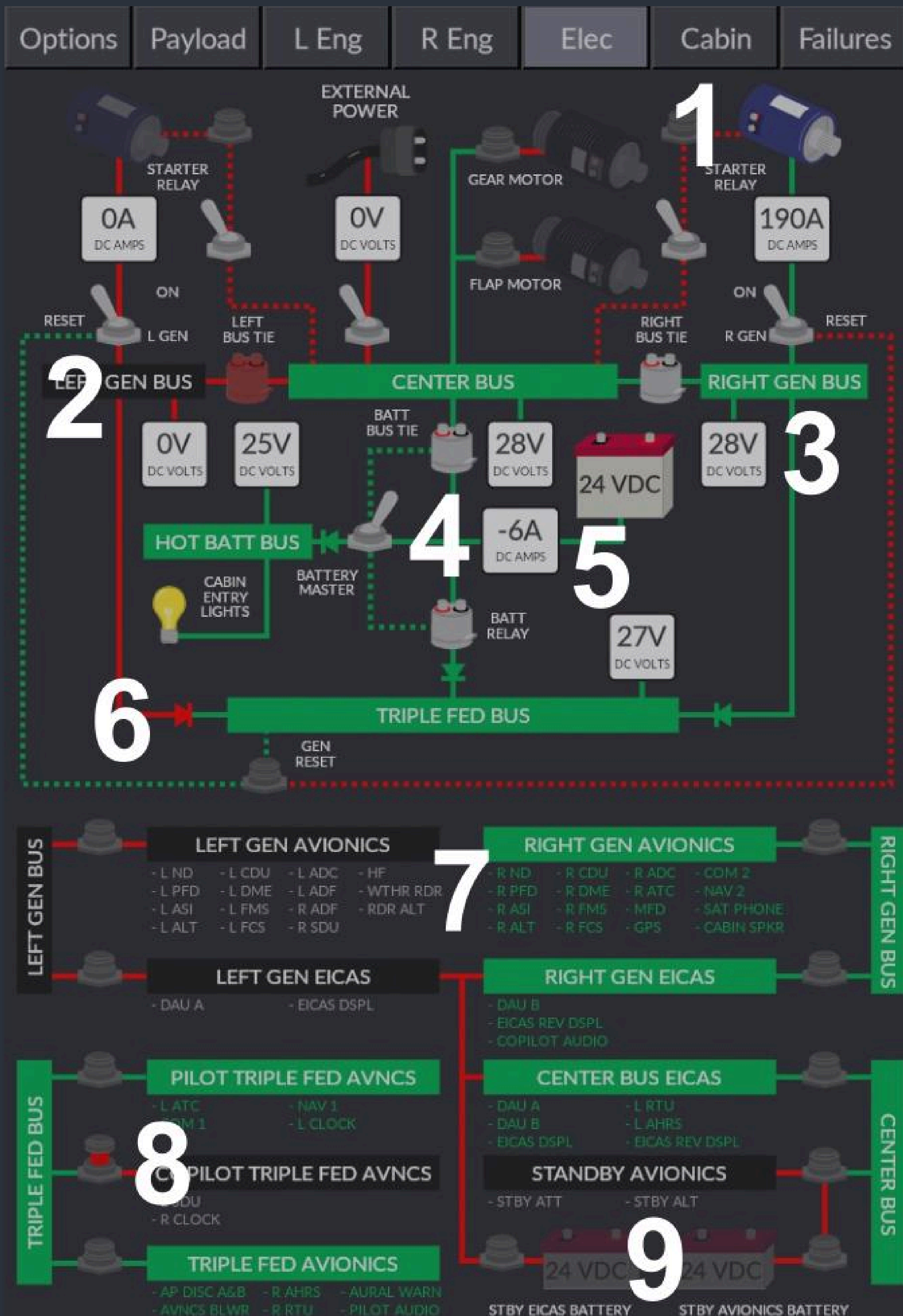
Not all circuits in the aircraft are named on this visualizer, as there would be over 200 labels. Instead, only the key avionics components are shown in an attempt to better depict the system redundancy. When the circuit is in use and powered, its name will be highlighted in green. Otherwise, the name will be grayed out.

8. Circuit Breakers

Circuit breakers will show their red collar when the breaker has been tripped by excessive current. The breaker can be reset manually by clicking on the tripped breaker in the cockpit. If the breaker has tripped due to a failure, it will trip again soon, assuming the circuit is still under load and producing heat. For more information on the circuit breaker layout and power distribution logic, see the "Circuit Breakers" section of this manual.

9. Standby Batteries

This aircraft has two main standby batteries, which are designed to supply power to the most essential equipment in the aircraft in the case of a complete electrical failure. The Engine Instrument and Crew Alerting System (EICAS) standby battery will power basic aircraft data collection computers, the EICAS display, and the pilot's side Radio Tuning Unit (RTU). The standby avionics battery will power the electric attitude indicator, the altimeter vibrator motor, and associated integral lighting. When the standby avionics battery is operating, a white "BATT PWR ON" annunciator will illuminate on the electrical console panel.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
EXTERNAL POWER
1
STARTER RELAY
STARTER RELAY
GEAR MOTOR
FLAP MOTOR
0A
DC AMPS
0V
DC VOLTS
190A
DC AMPS
ON
ON
RESET
L GEN
LEFT BUS TIE
RIGHT BUS TIE
R GEN
RESET
2
LEFT GEN BUS
CENTER BUS
RIGHT GEN BUS
BATT BUS TIE
0V
DC VOLTS
25V
DC VOLTS
28V
DC VOLTS
24 VDC
28V
DC VOLTS
3
HOT BATT BUS
4
-6A
DC AMPS
5
CABIN ENTRY LIGHTS
BATTERY MASTER
BATT RELAY
27V
DC VOLTS
6
TRIPLE FED BUS
GEN RESET
LEFT GEN BUS
LEFT GEN AVIONICS
- L ND - L CDU - L ADC - HF
- L PFD - L DME - L ADF - WTHR RDR
- L ASI - L FMS - R ADF - RDR ALT
- L ALT - L FCS - R SDU
7
RIGHT GEN AVIONICS
- R ND - R CDU - R ADC - COM 2
- R PFD - R DME - R ATC - NAV 2
- R ASI - R FMS - MFD - SAT PHONE
- R ALT - R FCS - GPS - CABIN SPKR
RIGHT GEN BUS
LEFT GEN EICAS
- DAU A - EICAS DSPL
RIGHT GEN EICAS
- DAU B
- EICAS REV DSPL
- COPILOT AUDIO
TRIPLE FED BUS
PILOT TRIPLE FED AVNCS
- L ATC - NAV 1
- L CLOCK
CENTER BUS EICAS
- DAU A - L RTU
- DAU B - L AHRS
- EICAS DSPL - EICAS REV DSPL
8
COPILOT TRIPLE FED AVNCS
- R CLOCK
STANDBY AVIONICS
- STBY ATT - STBY ALT
CENTER BUS
TRIPLE FED AVIONICS
- AP DISC A&B - R AHRS - AURAL WARN
- AVNCS BLWR - R RTU - PILOT AUDIO
24 VDC
9
24 VDC
STBY EICAS BATTERY
STBY AVIONICS BATTERY

Cabin Climate Visualizer Page

With such high performance aircraft, the environmental control systems begin to approach the complexity of light jets and commuter aircraft, and understanding them is paramount to safety.

Cooling Cabin

When the desired cabin temperature is below the outside ambient air temperature, cooling is provided by the vapor cycle cooling system, more commonly known as an air conditioner. For more information on the environmental control systems, see the “Environmental Simulation & Controls” section of this manual.

1. Nose Avionics Bay Volume

The nose avionics bay resides over the forward wing, in front of the windshields. It contains many of the data processing computers required for primary flight instrumentation. Avionics cooling is essential to avoiding in-flight failures of essential equipment. For more information, see the “Avionics Cooling” section of this manual. Much like the cabin, the nose avionics bay is also heated by the sun during daytime conditions. Expect this volume to be the second hottest of the three volumes during steady-state operation.

2. Nose Avionics Blowers

The nose avionics bay is cooled by vents in the nose landing gear doors and two electric blower fans activated by thermostats. The cooling air forced into the nose avionics bay exits through vents above the trailing edge of the forward wing. For more information, see the “Avionics Cooling” section of this manual.

3. Instrument Panel Volume

The instrument panel mounted equipment receives cooling air from the cockpit blower fan, which carries either ambient cabin air, or cool air conditioned by the cockpit evaporator coil. If the instrument panel becomes too hot, displays may begin to fail. For more information, see the “Avionics Cooling” section of this manual. Expect this volume to be the hottest of the three volumes during steady-state operation.

4. Vent Valves & Ducts

The pilot, copilot, and defroster vent valves will actuate with the pull handles in the cockpit. The temperature color gradient exiting the duct outlets indicates that the duct has positive pressure.

5. Cockpit Blower & Evaporator

This aircraft possesses two main cabin air handlers and two air conditioning evaporators. The cockpit blower is situated under the cockpit floor and also provides cooling air for the instrument panel avionics. Should the cockpit blower cease to function, insufficient cooling air will reach the instrument panel and the displays may begin to overheat.

6. Main Cabin Volume

The temperature of the main cabin, and all ducts and vents in the visualizer, can be estimated from the same absolute temperature scale used elsewhere in this tablet interface. Dark blues are the coldest, greens and yellows are moderate, and reds and magentas are the hottest. The cabin's current temperature is shown in Fahrenheit and Celsius at the bottom of the visualizer. Expect this volume to be the coolest of the three volumes during steady-state operation.

7. Cabin Blower, Evaporator & Axial Vane Blower

This aircraft possesses two main cabin air handlers and two air conditioning evaporators. The cabin blower is located in the environmental dome and supplies air to the overhead ducts in the cabin. The environmental dome is also home to the air conditioning condenser coil and the bleed air heat exchanger. Cool ambient air is brought into the environmental dome through a large NACA duct on the bottom of the aircraft by the electric axial vane blower. This blower operates only when the air conditioning is operating, or when the cabin bleed air ducting is above approximately 170°F. For more information on the three electric blower fans and their uses, see the "Cabin Environmental Controls" section of this manual.

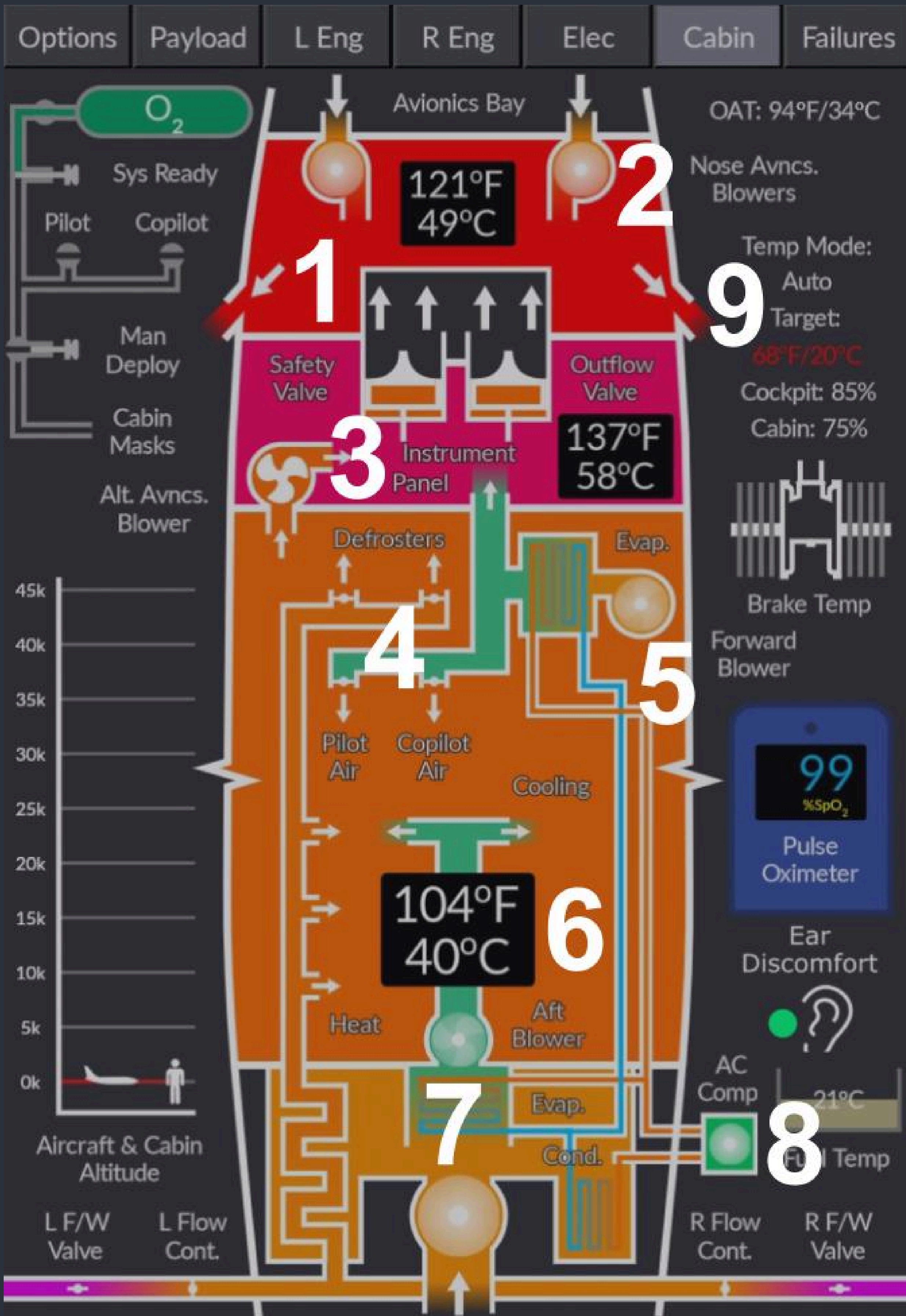
8. Air Conditioning Compressor & Refrigerant Loop

The air conditioning system (also known as a vapor cycle cooling system), is driven by a clutched compressor on the right engine's accessory gearbox. This compressor will only engage when the RPM of the gas generator is high enough, at which point the compressor will indicate with green on this visualizer, and the impeller will begin to rotate. The uninsulated air conditioning pipes pass through a condenser in the environmental dome, which requires cooler ambient air to operate. When the air conditioning compressor is operating, chilled refrigerant will be passed through the refrigerant loop to the forward and aft evaporator coils.

9. Climate Control Modes & Target

The operating mode of the climate control system is controlled by the "TEMP MODE" rotary selector switch, discussed in the "Cabin Environmental Controls" section of this manual. This mode is annunciated, along with the temperature controller's target cabin temperature.

The target temperature will show the numeric set point of the "CKPT/CABIN AUTO TEMP" rotary selector knob when in automatic mode, or the set vent temperature in manual mode. Otherwise, the target will appear as "None". When the target temperature is not attainable in the current ambient conditions, the target value will appear in red. This should be the operator's cue to select the "HIGH FLOW" bleed air valve position, or that the air conditioner is operating at maximum capacity. Here, the automatic cooling target temperature can be seen in degrees Fahrenheit and Celsius.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Avionics Bay
OAT: 94°F/34°C
Sys Ready
Pilot
Copilot
121°F
49°C
2
Nose Avncs.
Blowers
1
9
Temp Mode:
Auto
Target:
68°F/20°C
Man
Deploy
Safety
Valve
Outflow
Valve
Cockpit: 85%
Cabin: 75%
Cabin
Masks
3
Instrument
Panel
137°F
58°C
Alt. Avncs.
Blower
Defrosters
Evap.
Brake Temp
45k
40k
35k
30k
25k
20k
15k
10k
5k
0k
4
Forward
Blower
5
Pilot
Air
Copilot
Air
Cooling
99
%SpO2
Pulse
Oximeter
104°F
40°C
6
Ear
Discomfort
Heat
Aft
Blower
AC
Comp
7
Evap.
21°C
8
Aircraft & Cabin
Altitude
Cond.
Fuel Temp
L F/W
Valve
L Flow
Cont.
R Flow
Cont.
R F/W
Valve

Heating Cabin

When the desired cabin temperature is warmer than the outside ambient air, heating is provided by the pressurized P3 bleed air. The bleed air is heated by compression, and by proximity to the engine's combustion chamber. For more information on the environmental control systems, see the “Environmental Simulation & Controls” section of this manual.

1. Oxygen System

The pressure of oxygen in the cylinder (a surrogate for the quantity remaining) is indicated by the green volume in the cylinder. This quantity can be refilled on the payload page of the tablet interface. The valve immediately to the left of the cylinder, here seen in the open position, depicts the position of the oxygen isolation valve, which can only be operated from the outside of the aircraft. Subsequent valves control the flow of oxygen within the aircraft, to the pilot and copilot’s quick donning masks, and to the passengers’ continuous flow oxygen masks concealed within the ceiling.

2. Safety & Outflow Valves

Cabin pressurization is controlled primarily by a set of two valves, the safety and outflow valves, located beneath the cockpit floor, and visible from the exterior of the aircraft. This complex topic is discussed at length in the “Cabin Pressurization System” section of this manual. Here, the outflow valve is open, venting cabin pressure to atmosphere, while the safety valve remains closed. The safety valve is also depicted in red here, which indicates that it has suffered a failure and will not move from the closed position.

3. Alternate Avionics Blower

As discussed in the previous section, the instrument panel avionics may overheat and cease functioning if the cockpit blower fan stops supplying the instrument panel with cooling air. Should this occur, activating the alternate avionics blower via the switch on the electrical console panel can help cool the instruments with ambient cabin air. For more information on best avionics cooling practices, see the “Avionics Cooling” section of this manual.

4. Brake Temperature

Brake temperature is depicted using the same absolute color gradient as elsewhere on this screen. For more information on brake temperature calculation and heating repercussions, see the “Brake Temperature & Anti-Skid” section of this manual.

5. Cabin Pressurization Graph

To the left of the main cabin volume is a graph depicting the aircraft altitude (airplane symbol), and the cabin pressurization altitude (human symbol) on the same scale. When the two are sufficiently apart, the cabin differential pressure will be shown between them, always in red.

6. Pulse Oximeter

Loss of conscientiousness and impaired cognitive functioning in low oxygen environments does not happen instantaneously. Except in the case of the most severe decompression events, oxygen must leave the blood supply in order for hypoxia to take effect. This process can take over an hour at lower cruising altitudes, or a few seconds at high altitude. Use the pulse oximeter to monitor the concentration of oxygen in the pilot's bloodstream. If the concentration becomes too low, decrease the cabin pressurization altitude, descend if the cabin is unpressurized, or open the oxygen valve to use supplemental oxygen.

Generally speaking, 98% oxygen saturation (SpO2) is normal at sea level for a healthy adult.

The recommended, and legally required, altitudes for supplemental oxygen use of around 12,000 - 14,000 feet correspond to an SpO2 of roughly 90-92% for exposure under 60 minutes.

An SpO2 below 90% results in cognitive impairment, possibly detrimental to flight safety.

An SpO2 below 80% can lead to incapacitation after exposure of just a few minutes.

7. Ear Discomfort Index

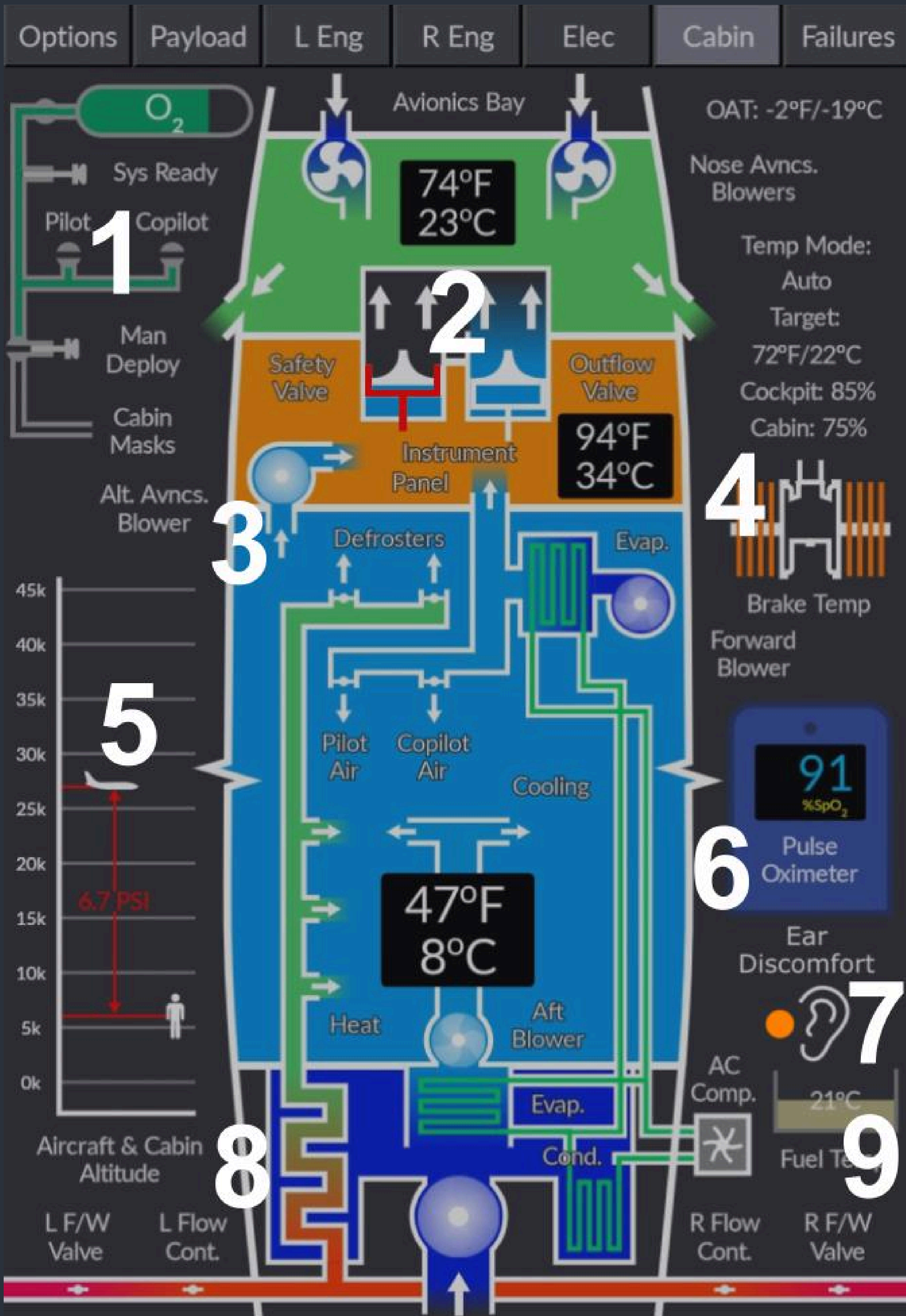
Ear discomfort is a frequent consideration while operating both pressurized and unpressurized aircraft. The colored dot in this visualizer gives some sense of ear discomfort due to pressure equalization between the outer ear and the middle ear. While everyone's physiology is different, rates of climb/descent in excess of 700 ft/min will create noticeable discomfort if pressure is not consciously equalized through the eustachian tubes. For those used to flying in light aircraft, climb/descent rates of 1,500 ft/min can be a routine affair; however, climb/descent rates of 3,000 ft/min or above will be very uncomfortable for most occupants.

8. Bleed Air Heat Exchanger & Bleed Air Valves

Hot bleed air is admitted to the environmental dome plumbing through the firewall shutoff valves and flow control valves in each engine nacelle. The firewall valves are actuated by the lighted push buttons on the glareshield, and the flow control valves are actuated by the bleed air control rotary selector knob on the environmental control valve. Once inside the environmental dome, the bleed air is cooled to manageable temperatures by the bleed air heat exchanger before being admitted to the cabin.

9. Fuel Temperature

Total fuel quantity and fuel temperature is displayed below the pulse oximeter. For more information on the fuel-oil heat exchanger and fuel temperature operating limitations, see the "Fuel Temperature & Quantity Indicators" section of this manual.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
O2
Sys Ready
Pilot
Copilot
1
Man
Deploy
Cabin
Masks
Avionics Bay
74°F
23°C
2
Safety
Valve
Outflow
Valve
Instrument
Panel
94°F
34°C
Alt. Avncs.
Blower
3
OAT: -2°F/-19°C
Nose Avncs.
Blowers
Temp Mode:
Auto
Target:
72°F/22°C
Cockpit: 85%
Cabin: 75%
4
Brake Temp
Forward
Blower
Defrosters
Evap.
45k
40k
35k
30k
25k
20k
15k
10k
5k
0k
5
6.7 PSI
Pilot
Air
Copilot
Air
Cooling
91
%SpO2
Pulse
Oximeter
6
47°F
8°C
Heat
Aft
Blower
Ear
Discomfort
7
Aircraft & Cabin
Altitude
8
Evap.
Cond.
AC
Comp.
21°C
Fuel Te
9
L F/W
Valve
L Flow
Cont.
R Flow
Cont.
R F/W
Valve

Failures Page

This aircraft is equipped with an underlying software system that is capable of triggering a failure of almost any simulated aircraft system, in response to the users mismanagement of the aircraft, at appropriately timed random (MTBF) intervals, or within a scheduled window of time. These failures are managed through the failures page of the tablet interface. A list of all possible failures is provided below in the "List of Possible Failures" section of this manual. Failures are saved between flights, leaving you to discover what failed on the previous flight during your before flight checklists.

MTBF Failures

In Mean Time Between Failure (MTBF) mode, the user can set custom failure probabilities in the form of a mean time between failure time in hours. While real world electromechanical components follow an exponentially decaying failure probability after their fabrication, this would be inconvenient for users of virtual aircraft, since it would subject new users to high component mortality rates just after purchasing the product; therefore, the probability of component failure is constant throughout aircraft operation. This means that the probability of failure can be considered to be exactly the mean at all times.

While many of these failures may be randomly generated, they will feel like an authentic system failure (which are essentially random in real life), because they will only fail while the system is in use, and at a rate appropriate to the real world system.

1. Restore Defaults & Reset All Failures

The Restore Defaults button can be used to reset all MTBF times to their default value. As adjustments to MTBF times are saved and restored for the next flight, this action requires a confirmation to complete. For instructions on adjusting the MTBF time for individual components see point 6, below. The reset all failures button can be used to reset all currently active failures at once. For instructions on triggering individual failures, see point 7, below.

2. MTBF / Scheduled Mode Switch & Show Only Active Failures

Use the MTBF / Scheduled Mode switch to toggle between the two modes of operation for the failure system. The Show Only Active Failures switch can be used to filter the results of the scrolling failure list to only those that are currently active. This also applies to the results of the search function.

3. Global Failure Rate Slider

The global failure slider is used to control the global failure rate, indicated by the text below the slider. The maximum allowable rate is 1000 times real-time. All MTBF and scheduled failures can be disabled completely by positioning the slider all the way to the left, until "Failures Off" appears below the slider. The global failure rate multiplies the probability of random failures occurring while in MTBF mode, but does nothing in scheduled failure mode.

For Example, if a specific failure is expected to occur once in every 5,000 hrs of flight time, a global failure rate of 1000x, will result in this failure occurring roughly once in every 5 hrs of flight time instead. Settings between 10x and 50x are recommended to add a little excitement to your virtual flying experience, as many hundreds of hours can be flown at 1x real-time failures without encountering a single failure, while settings above 250x almost guarantee multiple failures per flight.

4. Active Failures

The current number of active failures can be seen at all times below the global failure rate slider. This number is also shown on the systems page of the weather radar display so that the number of current failures can be monitored from the cockpit without the tablet visible.

5. Search Failures

All failures shown in the scrolling list are searchable. Click in the search window and start typing to search. The text entry mode should deactivate automatically a few seconds after you stop typing. When the “show only active failures” option is selected, the search will only return results among the currently active failures.

6. Adjust MTBF

Upon loading the aircraft for the first time, default MTBF values will be displayed for each system, which are representative of their real world counterparts in accordance with published NASA guidelines whenever available. These failure probabilities can be modified by pressing the left and right arrow buttons beside the MTBF value. The minimum allowable MTBF is 100 hrs, and the maximum is 1,000,000 hrs. If adjusted from the default, the selected MTBF time will be saved and restored on the next flight.

7. Instantaneously Fail or Reset Failure

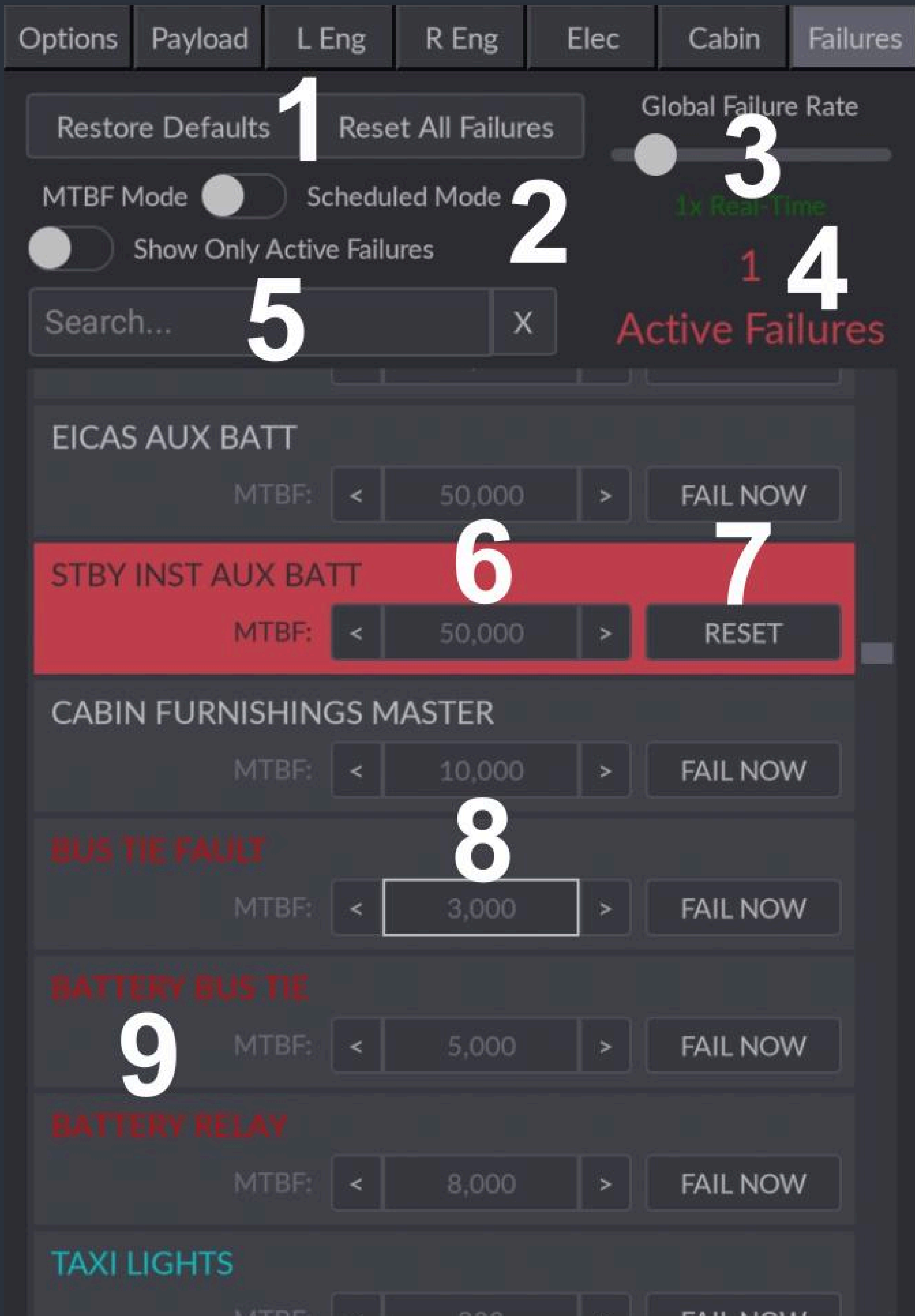
After being triggered by any means, individual failures can be reset by pressing the “RESET” button. Failures can also be triggered manually in this mode by pressing the “FAIL NOW” button.

8. Restore Default MTBF

Clicking on the displayed MTBF value will restore it to the default for that specific component. When the button is grayed out, the component’s MTBF is already set to the default value.

9. Failure Names & Color Codes

Failures are color coded into groups. Magenta is used for catastrophic engine failures, red for major systems failures, white for power distribution failures, and cyan for circuit breaker protected electromechanical failures. The failure names as they appear in this list can be used to trigger the failures via any 3rd party software or hardware interface that is capable of sending HTML (H:Events) to the simulator. See the “Failure System HTML Interface” section of this manual for more information.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Restore Defaults
1
Reset All Failures
Global Failure Rate
3
1x Real-Time
MTBF Mode
Scheduled Mode
2
Show Only Active Failures
1
4
Active Failures
Search...
5
X
EICAS AUX BATT
MTBF:
<
50,000
>
FAIL NOW
STBY INST AUX BATT
6
7
MTBF:
<
50,000
>
RESET
CABIN FURNISHINGS MASTER
MTBF:
<
10,000
>
FAIL NOW
BUS TIE FAULT
8
MTBF:
<
3,000
>
FAIL NOW
BATTERY BUS TIE
9
MTBF:
<
5,000
>
FAIL NOW
BATTERY RELAY
MTBF:
<
8,000
>
FAIL NOW
TAXI LIGHTS

Scheduled Failures

In scheduled failures mode, individual failures can be scheduled to occur within a specific time window after the present time. Failures have a constant probability of occurring between the two times shown, and will occur only after the failure has been armed. This allows for variability in scenario training, while ensuring that a given failure occurs in the desired phase of flight.

1. Restore Defaults & Reset All Failures

The Restore Defaults button can be used to reset all scheduled failure windows to the default. This action requires a confirmation to complete. For instructions on adjusting the scheduled failure time window for individual components see point 6, below. The Reset All Failures button can be used to reset all currently active failures at once.

2. MTBF / Scheduled Mode Switch & Show Only Active Failures

Use the MTBF / Scheduled Mode switch to toggle between the two modes of operation for the failure system. The Show Only Active Failures switch can be used to filter the results of the scrolling failure list to only those that are currently active. This also applies to the results of the search function.

3. Global Failure Rate Slider

The global failure rate has no effect on the rate of failures in the scheduled failure mode; however, it will prevent all failures from occurring when placed in the "No Failures" position.

4. Active Failures

The current number of active failures can be seen at all times below the global failure rate slider. This number is also shown on the systems page of the weather radar display so that the number of current failures can be monitored from the cockpit without the tablet visible.

5. Search Failures

All failures shown in the scrolling list are searchable. Click in the search window and start typing to search. The text entry mode should deactivate automatically a few seconds after you stop typing. When the "show only active failures" option is selected, the search will only return results among the currently active failures.

6. Adjust Time Window

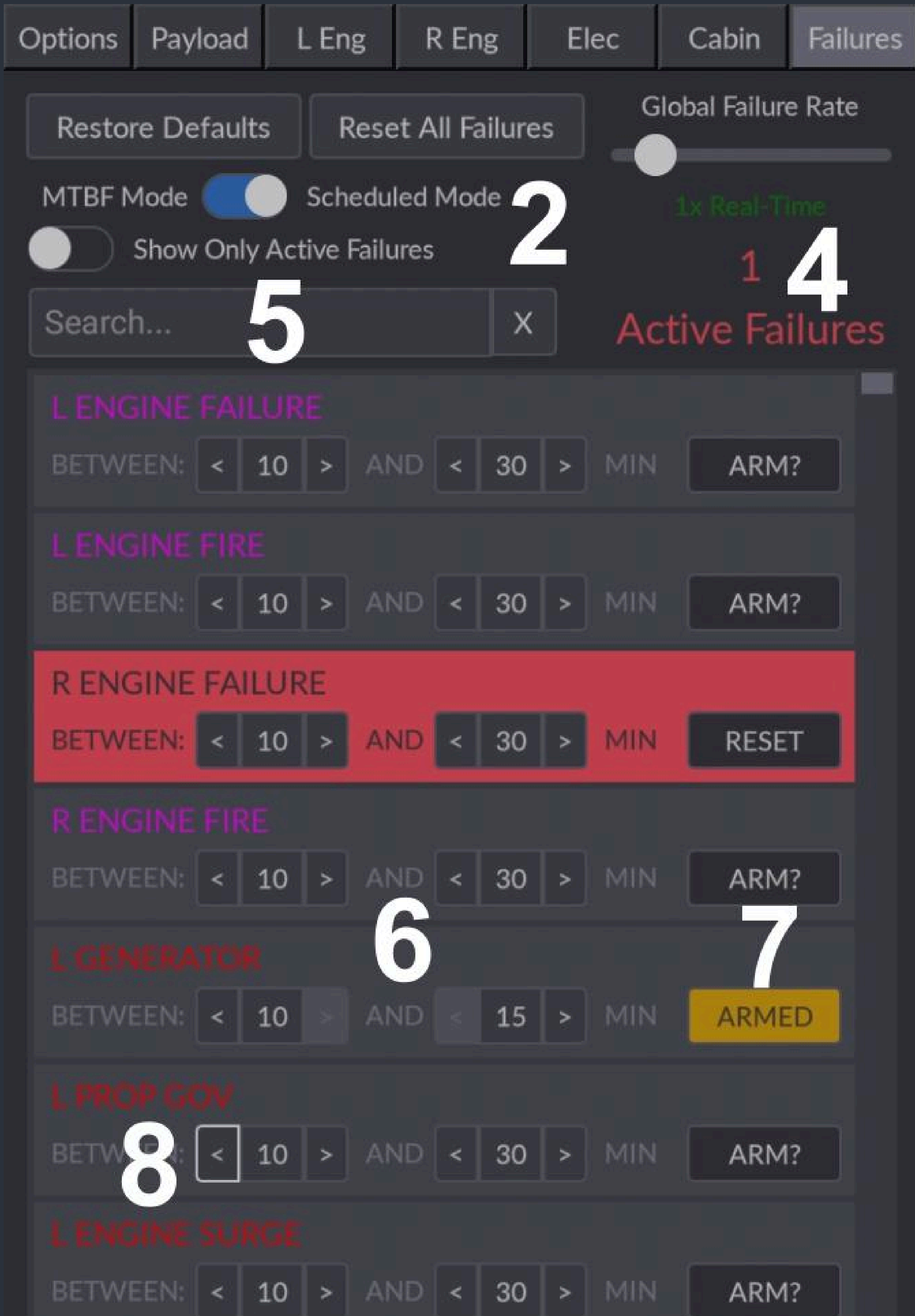
The time window in which a specific failure will occur can be adjusted with the arrow buttons beside the "after" and "before" times. These times are expressed in minutes. The minimum time after which a failure will occur is one minute, and the maximum time before which a failure will occur is ninety minutes. When the time cannot be adjusted up or down as it would exceed the minimum or maximum, or when it is constrained by the other time, the adjustment buttons will be grayed out.

7. Arm or Reset Failure

Clicking the “ARM?” button will arm the failure with the currently selected time window. Once armed, this button will appear in yellow, with the text “ARMED”. Clicking the button again anytime before the failure has occurred will disarm the failure. After the failure has occurred, the button will read “RESET”, and clicking the button will reset the failure, returning it to an unarmed state.

8. Failure Names & Color Codes

Failures are color coded into groups. Magenta is used for catastrophic engine failures, red for major systems failures, white for power distribution failures, and cyan for circuit breaker protected electromechanical failures. The failure names as they appear in this list can be used to trigger the failures via any 3rd party software or hardware interface that is capable of sending HTML (H:Events) to the simulator. See the “Failure System HTML Interface” section of this manual for more information.


Options
Payload
L Eng
R Eng
Elec
Cabin
Failures
Restore Defaults
Reset All Failures
Global Failure Rate
MTBF Mode
Scheduled Mode
2
1x Real-Time
Show Only Active Failures
1
4
Active Failures
Search...
X
5
L ENGINE FAILURE
BETWEEN: < 10 > AND < 30 > MIN
ARM?
L ENGINE FIRE
BETWEEN: < 10 > AND < 30 > MIN
ARM?
R ENGINE FAILURE
BETWEEN: < 10 > AND < 30 > MIN
RESET
R ENGINE FIRE
BETWEEN: < 10 > AND < 30 > MIN
ARM?
6
7
L GENERATOR
BETWEEN: < 10 > AND < 15 > MIN
ARMED
L PROP GOV
8
< 10 > AND < 30 > MIN
ARM?
L ENGINE SURGE
BETWEEN: < 10 > AND < 30 > MIN
ARM?

Failure System HTML Interface

To facilitate users who wish to initiate failures instantaneously via an external software interface, such as an instructor station, webpage, or tablet interface, access has been provided into the failure system using MSFS's HTML events. Any software that is capable of sending HTML events (also known as H:Vars), is capable of triggering failures without any additional configuration. These failures will appear in the in-cockpit tablet interface's failures page, and can be reset from the same interface, or by sending the same HTML event again.

This interface allows users to create and share profiles for popular 3rd party interface applications to trigger and reset failures, or even mimic more complex emergency scenarios. Popular software capable of sending HTML events to MSFS include:

- Air Manager
- Axis and Ohs
- Mobiflight
- SPAD.neXt
- FSUIPC
- Many other SimConnect-based interfaces

To trigger or reset any failure in any Black Square aircraft, simply send an HTML event with the prefix "BKSQ_FAILURE_", and the exact name of the failure as it appears in the in-cockpit tablet interface's failures page with spaces replaced by underscores.

For example, to trigger or reset a failure named "L FUEL QTY", the HTML event would be:

>H:BKSQ_FAILURE_L_FUEL_QTY

All failures can be reset at once by issuing the following command:

>H:BKSQ_FAILURE_RESET_ALL_FAILURES

Depending on your programming environment, be sure to check the exact syntax needed to trigger HTML events. Some graphical programming environments may require you to omit the leading ">" from the event, while others may require this ">" to be expressed as ">", such as in reverse polish notation.

List of Possible Failures

Major System Failures

L ENGINE FAILURE
L ENGINE FIRE
R ENGINE FAILURE
R ENGINE FIRE
L GENERATOR
L PROP GOV
L ENGINE SURGE
L FUEL CONTROL
L PRIMARY INJECTORS
L SECONDARY INJECTORS
L LP BLEED
L HP BLEED
L FUEL FILTER
L ENG DRIVEN FUEL PUMP
L AUTO FEATHER
R GENERATOR
R PROP GOV
R ENGINE SURGE
R FUEL CONTROL
R PRIMARY INJECTORS
R SECONDARY INJECTORS
R LP BLEED
R HP BLEED
R FUEL FILTER
R ENG DRIVEN FUEL PUMP
R AUTO FEATHER
L BRAKE
R BRAKE

PITOT BLOCKAGE
STATIC BLOCKAGE
CABIN SAFETY VALVE
CABIN OUTFLOW VALVE
INFLOW CONTROL UNIT
CABIN DOOR LATCH
L MAIN FUEL LEAK
R MAIN FUEL LEAK
L MAIN AUX LEAK
R MAIN AUX LEAK
L ENG CO LEAK
R ENG CO LEAK
L PRIMARY JET PUMP
R PRIMARY JET PUMP
L AFT TANK JET PUMP
R AFT TANK JET PUMP
L FWD WING BOOT INTEG
R FWD WING BOOT INTEG
INBD MAIN WING BOOT INTEG
OTBD MAIN WING BOOT INTEG
L BLEED SYSTEM
R BLEED SYSTEM
FUSELAGE BLEED
DUCT OVERTEMPERATURE
OXYGEN CYLINDER VALVE
OXYGEN LEAK
CO DETECTOR
MANUAL GEAR HANDLE
LOW GEAR HYD FLUID
NOSE AVNCS VENT CLOGGED
FUEL OIL HEAT EXCHANGER

Breaker Protected Failures

TAXI LIGHTS
WING LIGHTS
STROBE LIGHTS
NAVIGATION LIGHTS
L LANDING LIGHTS
R LANDING LIGHTS
NOSE LANDING LIGHTS
L VALVE HEATER
R VALVE HEATER
L CABLE HEATER
R CABLE HEATER
GROUND ICE DETECT
GENERATOR RESET
L BUS TIE CONT
R BUS TIE CONT
CABIN DIFF PRESS
GEAR WARNING
L FUEL QTY WARNING
R FUEL QTY WARNING
L FUEL PRESS WARNING
R FUEL PRESS WARNING
L OIL PRESS WARNING
R OIL PRESS WARNING
BLEED AIR WARNING
CABIN ALT WARNING
L STALL WARNING
R STALL WARNING
COLUMN PUSHER MOTOR
COLUMN PUSHER CLUTCH
L PNEUMATIC IND
R PNEUMATIC IND
PRESSURIZATION
OXYGEN
L BLEED AIR CONT
R BLEED AIR CONT
COCKPIT BLOWER
CABIN BLOWER
AXIAL VANE BLOWER
L MAIN INERT SEP
R MAIN INERT SEP
L STBY INERT SEP
R STBY INERT SEP
L PITOT HEAT
R PITOT HEAT
L FUEL VENT HEAT
R FUEL VENT HEAT
L STALL WARN HEAT
R STALL WARN HEAT
L WINDSHIELD HEAT
R WINDSHIELD HEAT
STBY WINDSHIELD HEAT
BRAKE DEICE
SURFACE DEICE MON
SURFACE DEICE MAN

MAIN SURFACE DEICE
STBY SURFACE DEICE
MAIN ICE DETECTOR
STBY ICE DETECTOR
FUEL TEMPERATURE
FUEL TRANSFER PUMP
L FIREWALL VALVE
R FIREWALL VALVE
L FUEL QTY
R FUEL QTY
L STBY FUEL PUMP
R STBY FUEL PUMP
AUTOFEATHER
PROP GOV TEST
PROP SYNC TEST
L ENGINE DATA
R ENGINE DATA
L CHIP DETECT
R CHIP DETECT
L FIRE DETECT
R FIRE DETECT
L OIL PRESS SENSE
R OIL PRESS SENSE
L IGNITION
R IGNITION
L STARTER
R STARTER
ANTI-SKID
WINDSHIELD WIPERS
STATIC SOURCE SELECT
FLAP INDICATION
FLAP CONTROL
L FLAP MONITOR
R FLAP MONITOR
ROLL TRIM A
ROLL TRIM B
PITCH TRIM A
PITCH TRIM B
RUDDER TRIM A
RUDDER TRIM B
GEAR INDICATION
GEAR CONTROLLER
WEATHER RADAR

L ND
L PFD
L ASI
L ALT
L CDU
L DME
L FMS
L FCS
L ADC
ADF
HF RADIO
RADAR ALTIMETER
MFD
R ND
R PFD
R ASI
R ALT
R CDU
R DME
R FCS
R FMS
R ADC
GPS
L RTU
L ARHS
L SDU
L TRANSPONDER
L COM RADIO
L NAV RADIO
L CHRONO
R RTU
R AHRS
R SDU
R TRANSPONDER
R COM RADIO
R NAV RADIO
R CHRONO

SATELLITE PHONE
CABIN STEREO
NOSE AVIONICS BLOWER
DAU A FLIGHT
EICAS DISPLAY FLIGHT
DAU B FLIGHT
EICAS REV DISPLAY FLT
DAU A GROUND
DAU B GROUND
EICAS DISPLAY GND
EICAS REV DISPLAY GND
STANDBY GYRO
STBY ALT VIB
AP DISC A
AP DISC B
AURAL WARNINGS
PILOT AUDIO
COPILOT AUDIO
CABIN AUDIO
AVNCS MASTER CONT
CABIN READING LIGHTS
ANNUNCIATORS 1
ANNUNCIATORS 2
ANNUNCIATORS 3
ANNUNCIATORS 4
ANNUNCIATORS 5

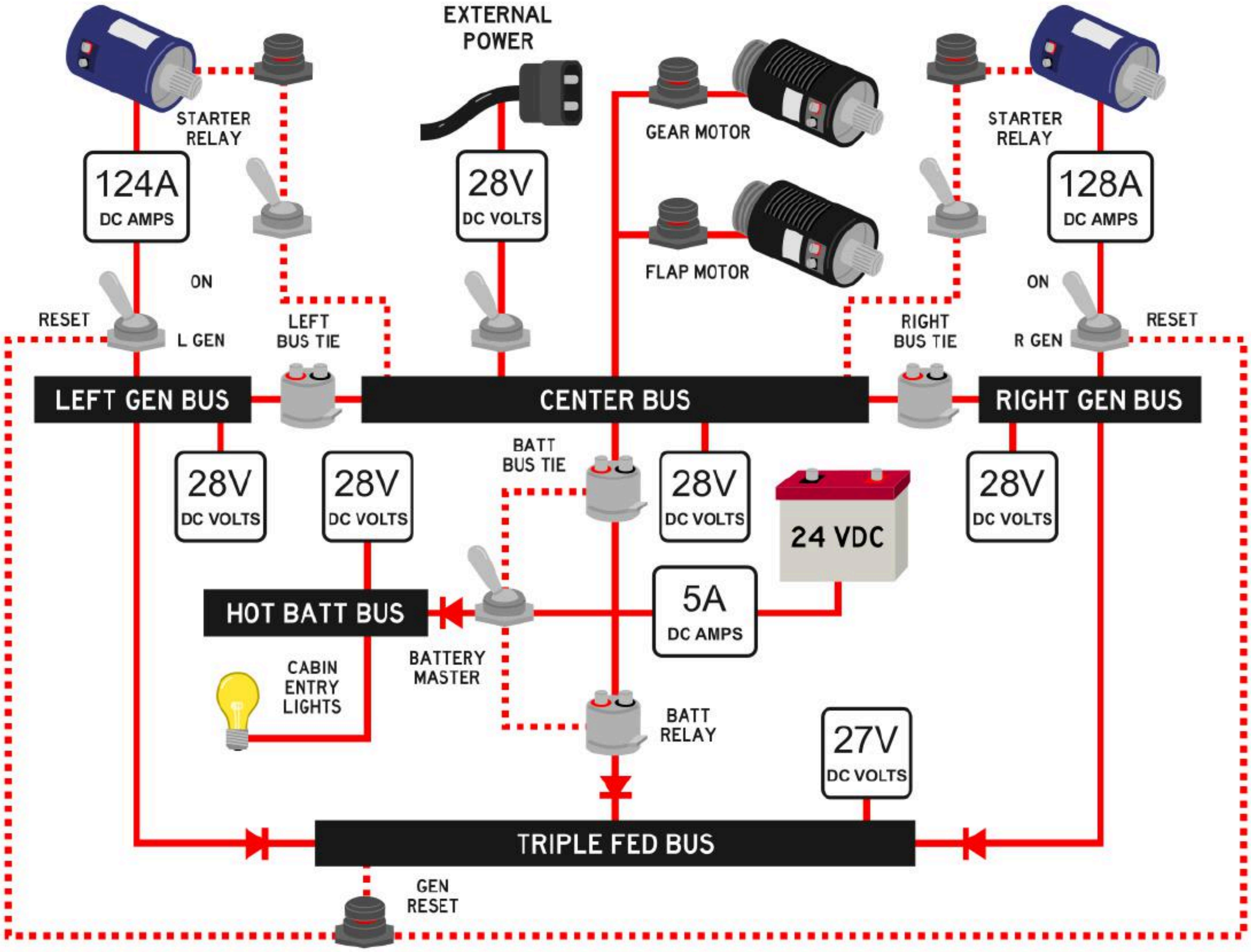
Power Distribution Failures

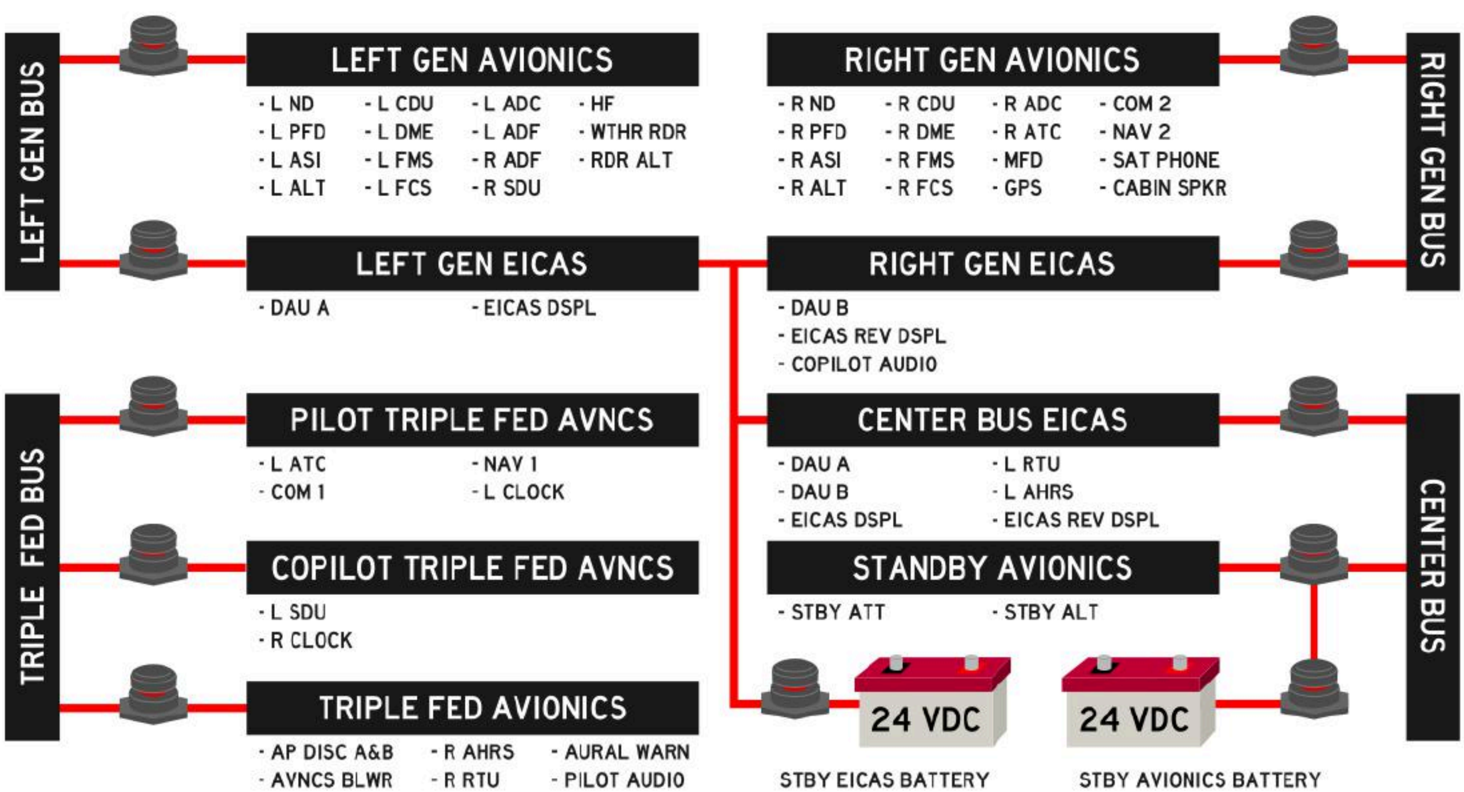
LANDING LIGHT CONTROLLER
L AVNCS BUS FDR
R AVNCS BUS FDR
PILOT AVNCS BUS FDR
TRIPLE FED AVNCS FDR
COPILOT AVNCS BUS FDR
L EICAS BUS FDR
R EICAS BUS FDR
CTR EICAS BUS FDR
EICAS AUX BATT
STBY INST AUX BATT
CABIN FURNISHINGS MASTER
BUS TIE FAULT
BATTERY BUS TIE
BATTERY RELAY

Overview Electrical Schematic

The Starship's electrical system closely resembles that of larger King Airs, featuring the "Triple-Fed Bus" layout. This layout offers great power distribution redundancy to dually redundant avionics, and also automatic load shedding in the case of generator failure. The Starship also possesses backup batteries for powering the EICAS bus (including both DAU's, left RTU, left AHRS, and nose avionics blower), and the three standby flight instruments. The EICAS backup battery will supply power whenever the EICAS avionics power switch is in the ON position, and the standby flight instrument backup battery will supply power when the standby instruments switch is in the ON position. The white "BATT PWR ON" annunciator will illuminate any time the standby instrument backup battery is discharging, and should be checked before every flight.

NOTE: The aircraft's electrical system can be monitored via the electrical page of the tablet interface, where a schematic nearly identical to this one is presented. For more information on the tablet's engine pages, see the "Live Schematic Page" section of this manual.


EXTERNAL POWER
STARTER RELAY
124A DC AMPS
28V DC VOLTS
GEAR MOTOR
FLAP MOTOR
STARTER RELAY
128A DC AMPS
ON
RESET
L GEN
LEFT BUS TIE
RIGHT BUS TIE
ON
R GEN
RESET
LEFT GEN BUS
CENTER BUS
RIGHT GEN BUS
28V DC VOLTS
28V DC VOLTS
BATT BUS TIE
28V DC VOLTS
24 VDC
28V DC VOLTS
HOT BATT BUS
5A DC AMPS
CABIN ENTRY LIGHTS
BATTERY MASTER
BATT RELAY
27V DC VOLTS
TRIPLE FED BUS
GEN RESET


LEFT GEN BUS
LEFT GEN AVIONICS
- L ND - L CDU - L ADC - HF
- L PFD - L DME - L ADF - WTHR RDR
- L ASI - L FMS - R ADF - RDR ALT
- L ALT - L FCS - R SDU
RIGHT GEN AVIONICS
- R ND - R CDU - R ADC - COM 2
- R PFD - R DME - R ATC - NAV 2
- R ASI - R FMS - MFD - SAT PHONE
- R ALT - R FCS - GPS - CABIN SPKR
RIGHT GEN BUS
LEFT GEN EICAS
- DAU A - EICAS DSPL
RIGHT GEN EICAS
- DAU B
- EICAS REV DSPL
- COPILOT AUDIO
TRIPLE FED BUS
PILOT TRIPLE FED AVNCS
- L ATC - NAV 1
- COM 1 - L CLOCK
CENTER BUS EICAS
- DAU A - L RTU
- DAU B - L AHRS
- EICAS DSPL - EICAS REV DSPL
COPILOT TRIPLE FED AVNCS
- L SDU
- R CLOCK
STANDBY AVIONICS
- STBY ATT - STBY ALT
CENTER BUS
TRIPLE FED AVIONICS
- AP DISC A&B - R AHRS - AURAL WARN
- AVNCS BLWR - R RTU - PILOT AUDIO
24 VDC
24 VDC
STBY EICAS BATTERY
STBY AVIONICS BATTERY

Normal Checklists

Preflight Checks

PARKING BRAKE	SET
CONTROL LOCKS	REMOVE
LANDING GEAR CONTROL	DOWN
BATTERY	ON
PITCH/ROLL/RUDDER TRIM	SET TO 0 (NEUTRAL)
FUEL QUANTITY	CHECK
OXYGEN PRESSURE	CHECK
AIRSTAIR DOOR ANNUNCIATOR	CHECKED
BATTERY	OFF
WHEEL CHOCKS	REMOVED
PITOT/STATIC COVERS	REMOVED
ENGINE COVERS	REMOVED
GEAR LOCKING PINS	STOWED
EMERGENCY EXIT	SECURE
AIRSTAIR DOOR	LOCKED

Before Starting Engines

CIRCUIT BREAKERS (LEFT/RIGHT/AUX)	ALL IN
OUTBOARD REVERSIONARY PANELS	AS REQUIRED
SEATBELTS AND SHOULDER HARNESSES	FASTENED
PARKING BRAKE	SET
AUDIO PANELS AND MIC	AS REQUIRED
STATIC SOURCE	NORM
OXYGEN SUPPLY	SYS READY - PULL
OXYGEN MASKS	TEST
ICE PROTECTION	OFF
LANDING GEAR CONTROL	DOWN
ANTI-SKID SWITCH	ANTI-SKID
CENTER REVERSIONARY PANEL	AS REQUIRED
STANDBY INSTRUMENTS	ON
STANDBY BATT PWR ON ANNUNCIATOR	ILLUMINATED
POWER LEVERS	IDLE
PROPELLER LEVERS	FULL FORWARD
CONDITION LEVERS	FUEL CUTOFF
BLEED AIR VALVES	OFF
TEMP MODE	OFF
BATTERY	ON
TRIPLE-FED BUS VOLTS	22V MINIMUM
CENTER BUS VOLTS	23V MINIMUM
EICAS	ON
FIREWALL FUEL VALVES	PUSH CLOSED
EXTINGUISHER AND F/W VALVE	ILLUMINATED
STANDBY PUMPS	ON
FUEL PRESS LO ANNUNCIATORS	ILLUMINATED
FIREWALL FUEL VALVES	PUSH OPEN
EXTINGUISHER AND F/W VALVE	EXTINGUISHED
FUEL PRESS LO ANNUNCIATORS	EXTINGUISHED
STANDBY PUMPS	OFF
FUEL PRESS LO ANNUNCIATORS	ILLUMINATED
TRANSFER FLOW	LEFT AND RIGHT
FUEL TRANSFER MESSAGE	ILLUMINATED
FUEL PRESS LO ANNUNCIATOR	EXTINGUISHED
TRANSFER FLOW	OFF
AVIONIC AIR FAIL MESSAGE	ILLUMINATED
AVIONICS ALTERNATE BLOWER	ON
AV ALT BLWR ON MESSAGE	ILLUMINATED
AVIONIC AIR FAIL MESSAGE	EXTINGUISHED
AVIONICS ALTERNATE BLOWER	OFF
FUEL QUANTITY (TOTAL AND AFT)	CHECK
OXYGEN PRESSURE	CONFIRM
LIGHTS	AS REQUIRED

Engine Starting (Battery)

R IGNITION AND ENGINE START	ON
R CONDITION LEVER (12%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR
R OIL PRESSURE	CHECK
R IGNITION AND ENGINE START	OFF
R CONDITION LEVER (65%N1 MINIMUM)	RUN
R GENERATOR	RESET THEN ON
R GEN VOLTS	27.5-29.0V
CHARGE BATTERY UNTIL	LOADMETER <50%
L IGNITION AND ENGINE START	ON
L CONDITION LEVER (12%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR
L OIL PRESSURE	CHECK
L IGNITION AND ENGINE START	OFF
L CONDITION LEVER (65%N1 MINIMUM)	RUN
L GENERATOR	RESET THEN ON
L GEN VOLTS	27.5-29.0V
GEN TIES	OPEN
L AND R GEN TIES OPEN MESSAGES	ILLUMINATED
TRIPLE-FED BUS VOLTS	26.5-28.0V
GEN TIES	NORM
L AND R GEN TIES OPEN MESSAGES	EXTINGUISHED
GENERATOR LOAD	PARALLELED

Engine Starting (External Power)

BATTERY VOLTS	20V MINIMUM
PROPELLER LEVERS	FEATHER
EICAS PILOT AND COPILOT AVIONICS	OFF
L GEN AND R GEN	OFF
BATTERY	ON
EXTERNAL POWER SOURCE	CONNECT
EXT POWER VOLTS	28.0-28.4V
EXT POWER SWITCH	ON
EICAS	ON
R IGNITION AND ENGINE START	ON
R CONDITION LEVER (12%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR
R OIL PRESSURE	CHECK
R IGNITION AND ENGINE START	OFF
R CONDITION LEVER (65%N1 MINIMUM)	RUN
L IGNITION AND ENGINE START	ON
L CONDITION LEVER (12%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR

L OIL PRESSURE	CHECK
L IGNITION AND ENGINE START	OFF
L CONDITION LEVER (65%N1 MINIMUM)	RUN
EXT POWER SWITCH	OFF
EXTERNAL POWER SOURCE	DISCONNECT
R GENERATOR	RESET THEN ON
R GEN VOLTS	27.5-29.0V
L GENERATOR	RESET THEN ON
L GEN VOLTS	27.5-29.0V
GEN TIES	NORM
L AND R GEN TIES OPEN MESSAGES	EXTINGUISHED
GENERATOR LOAD	PARALLELED
PROPELLER LEVERS	FULL FORWARD

Before Taxi

PILOT AND COPILOT AVIONICS	ON
STANDBY INDICATORS	ON
BLEED AIR VALVES	BOTH
BLOWERS/TEMPERATURE	SET
TEMP MODE SELECTOR	AUTO
LIGHTS	AS REQUIRED
CABIN LIGHTS OR FURNISHINGS	AS REQUIRED
NO SMOKE AND SEATBELTS	ON
PILOT AND COPILOT INSTRUMENTS	OPERATING
FLAP/FORWARD WING	RETRACT
AHRS ALIGNING MESSAGE	EXTINGUISHED
CDU TIME DATE AND POSITION	VERIFY
RADAR	STANDBY
BRAKES	CHECKED

Before Takeoff (Full)

FIRE EXT TEST	DISCH AND OK ILLUMINATED
FIRE DETR TEST	ENG FIRE ILLUMINATED
FLAP/FWD WING MONITOR TEST	CHECK EICAS
AUX BATT TEST	CHECK EICAS
BATT MONITOR TEST	BATT CHG ILLUMINATED
FUEL LO WARN TEST	CHECK EICAS
STALL WARNING TEST	AOA & SHAKER & HORN
VMO/MMO TEST	HORN
LDG GR TEST	ILLUMINATED AND HORN
ANNUN TEST	ALL LIGHTS ILLUMINATED
BLEED AIR TEST	L R FUS FAIL ILLUMINATED
POWER	AS REQUIRED FOR 23 PSI
BLEED AIR VALVES	OFF
PNEU PRESS LOW MESSAGE	ILLUMINATED
PNEUMATIC PRESS	ZERO FOR OFF POSITION
DEICE VAC	BOOT FAIL MESSAGES
BLEED AIR VALVES	L THEN R
PNEU PRESS LOW MESSAGE	ILLUMINATED
BLEED AIR VALVES	BOTH
PNEU PRESS LOW MESSAGE	EXTINGUISHED
BOOT FAIL MESSAGES	EXTINGUISHED
PNEUMATIC PRESS	23-25 PSI FOR BOTH
PRESS TEST	CHECK CABIN RATE
FWD WING MAN SWITCH	BOOTS INFLATE
MAIN WING INBD SWITCH	BOOTS INFLATE
MAIN WING OUTBD SWITCH	BOOTS INFLATE
DEICE STBY	YELLOW ICING MESSAGE
STANDBY DEICE FAIL	MESSAGE ILLUMINATED
DEICE MAIN	WHITE ICING MESSAGE
MAIN DEICE FAIL	MESSAGE ILLUMINATED
ENGINE ICE ACTUATOR SWITCHES	BOTH STBY
ENGINE ICE PROTECTION	BOTH ON
STALL WARNING HEAT ON	LOADMETER INCREASE
PITOT/STATIC HEAT ON	LOADMETER INCREASE
WINDSHIELD HEAT HIGH	LOADMETER INCREASE
VENT/CABLE HEAT ON	LOADMETER INCREASE
BOTH ENGINE ANTI-ICE MESSAGES	ILLUMINATED
ENGINE ICE ACTUATOR SWITCHES	BOTH MAIN
ENGINE ICE PROTECTION	BOTH OFF
BOTH ENGINE ANTI-ICE MESSAGES	EXTINGUISHED
ICE PROTECTION	ALL OFF
DEICE SEQ SWITCH	INFLATE IN SEQUENCE
POWER LEVERS	IDLE
PRESSURIZATION ALTITUDE	1000FT ABOVE CRUISE
RATE KNOB	10:00 POSITION
MANUAL CABIN ALT CONTROL	NORM (FULL CCW)
AVIONICS	CHECK AND SET
RADAR ALTIMETER TEST	DH ALERT
AUTOPILOT	ENGAGE
PFD AP MODES	CONFIRM
HEADING HOLD MODE	ENGAGE
HEADING BUG	SET 10 DEGREES LEFT
YOKE MOVEMENT	OBSERVE
HEADING BUG	SET 10 DEGREES RIGHT
YOKE MOVEMENT	OBSERVE
AUTOPILOT	YOKE DISCONNECT
PITCH TRIM SWITCH	NORM
PITCH TRIM	EXERCISE YOKE SWITCH
PITCH TRIM SWITCH	STBY
PITCH TRIM DUAL SWITCHES	EXERCISE
PITCH TRIM SWITCH	NORM
ROLL TRIM SWITCH	NORM
ROLL TRIM	EXERCISE YOKE SWITCH
RUDDER TRIM SWITCH	NORM
RUDDER TRIM TEST SWITCH	SLIDE TO A-TEST
RUDDER TRIM	EXERCISE KNOB
RUDDER TRIM TEST SWITCH	SLIDE TO B-TEST
RUDDER TRIM	EXERCISE KNOB
RUDDER TRIM TEST SWITCH	SLIDE TO CENTER
PITCH/ROLL/RUDDER TRIM	SET FOR TAKEOFF
FLAP/FWD WING	AS DESIRED
FLIGHT CONTROLS	FREE AND CORRECT
POWER LEVERS	IDLE (ABOVE BETA)
PROPELLER TEST SWITCH	HOLD TO LOW PITCH
PROPELLER RPM	NOTE DECREASE
PROPELLER TEST SWITCH	HOLD TO OVERSPEED
POWER LEVERS	INCREASE TO 1600 RPM
PROPELLER TEST SWITCH	RELEASE
PROPELLER RPM	NOTE INCREASE
POWER LEVERS	IDLE
ENGINE AUTO-IGNITION	ARM
BOTH AUTO-IGNITION MESSAGES	ILLUMINATED
POWER LEVERS	ADVANCE TO 17% TORQUE
BOTH AUTO-IGNITION MESSAGES	EXTINGUISHED
POWER LEVERS	IDLE
ENGINE AUTO-IGNITION	OFF
PROPELLER LEVERS	LOW RPM
AUTOFEATHER SWITCH	HOLD TO TEST
POWER LEVERS	SET APPROX 17% TORQUE
AFX MESSAGES	ILLUMINATED ON EICAS
LEFT POWER LEVER	RETARD TO FEATHER

LEFT POWER LEVER	RESET TO 17% TORQUE
RIGHT POWER LEVER	RETARD TO FEATHER
RIGHT POWER LEVER	RESET TO 17% TORQUE
AUTOFEATHER	ARM
PROPELLER MANUAL FEATHERING	CHECK
POWER LEVERS	IDLE
PROPELLER LEVERS	FULL FORWARD
STANDBY ALTIMETER	SET
FLIGHT AND ENGINE DISPLAYS	CHECK

Before Takeoff (Abbreviated)

ANNUNCIATORS	PUSH TO TEST
SURFACE DEICE & ICE PROTECTION	AS REQUIRED
PRESSURIZATION ALTITUDE	1000FT ABOVE CRUISE
RATE KNOB	10:00 POSITION
MANUAL CABIN ALT CONTROL	NORM (FULL CCW)
AVIONICS	CHECK AND SET
AUTOPILOT	ENGAGE
AUTOPILOT	YOKE DISCONNECT
PITCH/ROLL/RUDDER TRIM	SET FOR TAKEOFF
FLAP/FWD WING	AS DESIRED
FLIGHT CONTROLS	FREE AND CORRECT
AUTOFEATHER	ARM
STANDBY ALTIMETER	SET
FLIGHT AND ENGINE DISPLAYS	CHECK

Before Takeoff (Final Items)

STALL WARNING HEAT	ON
PITOT/STATIC HEAT	ON
ENGINE ICE PROTECTION	AS REQUIRED
VENT/CABLE HEAT	ON
BLEED AIR VALVES	BOTH
TRANSPONDER	ON
ANNUNCIATORS AND EICAS MESSAGES	CONSIDER
EXTERNAL LIGHTS	AS REQUIRED
COCKPIT LIGHTS	DIM FOR TAKEOFF
WINDSHIELD HEAT	LOW
ENGINE AUTO-IGNITION	AS REQUIRED
GENERATOR LOADS	CHECK
PITCH/ROLL/RUDDER TRIM	CENTERED/GREEN

Takeoff

BRAKES	HOLD
TAKEOFF POWER	(100% TRQ 850 ITT 1700 RPM)
AFX MESSAGES	ILLUMINATED ON EICAS
BRAKES	RELEASE
VR SPEED	ROTATE TO 8 DEGREES
LANDING GEAR	UP
FLAP/FWD WING	RETRACT

Climb

YAW DAMPER	ON
CLIMB POWER	(90% TRQ 840 ITT 1600 RPM)
PROPELLER SYNC	ON
ENGINE DISPLAY	MONITOR
CABIN PRESSURIZATION	MONITOR
NO SMOKE AND SEATBELTS	AS REQUIRED
LIGHTS	AS REQUIRED

Cruise

CLIMB POWER	(97% TRQ 840 ITT 1600 RPM)
AUTOFEATHER	OFF
LIGHTS	AS REQUIRED
ENGINE DISPLAY	MONITOR
FUEL QUANTITY	MONITOR

Descent

PRESSURIZATION ALTITUDE	500FT ABOVE LANDING
RATE KNOB	AS DESIRED
STANDBY ALTIMETER	SET
NO SMOKE AND SEATBELTS	AS REQUIRED
POWER	AS REQUIRED
LIGHTS	AS REQUIRED

Before Landing

APPROACH SPEED	CONFIRM
PRESSURIZATION	CHECK PROGRESS
NO SMOKE AND SEATBELTS	ON
AUTOFEATHER	ARM
LANDING GEAR	DOWN
FLAP/FWD WING	EXTEND
LIGHTS	AS REQUIRED
AUTOPILOT	DISCONNECT
PROPELLER SYNC	OFF
RADAR	AS REQUIRED
YAW DAMPER	OFF

Normal Landing

POWER LEVERS	IDLE
PROPELLER LEVERS	FULL FORWARD
POWER LEVERS	GROUND FINE
BRAKES	AS REQUIRED

Maximum Reverse Landing

POWER LEVERS	IDLE
PROPELLER LEVERS	FULL FORWARD
POWER LEVERS	SELECT REVERSE
BRAKES	MAXIMUM APPLICATION
POWER LEVERS	GROUND FINE BELOW 40 KTS

Balked Landing

POWER	MAXIMUM ALLOWABLE
AIRSPEED	118 KTS
FLAP/FWD WING	RETRACT
LANDING GEAR	UP

After Landing

STALL WARNING HEAT	OFF
PITOT/STATIC HEAT	OFF
WINDSHIELD HEAT	AS REQUIRED
VENT/CABLE HEAT	OFF
ENGINE AUTO-IGNITION	OFF
TRANSPONDER	STANDBY
LIGHTS	AS REQUIRED
TRIM	SET
FLAP/FWD WING	RETRACT

Shutdown & Securing

PARKING BRAKE	SET
OXYGEN SUPPLY	PUSH OFF
ENGINE ICE PROTECTION	OFF
WINDSHIELD HEAT	OFF
PILOT AND COPILOT AVIONICS	OFF
STANDBY INSTRUMENTS	OFF
BLEED AIR VALVES	OFF
TEMP MODE	OFF
BATTERY	CHARGED
ITT	STABILIZED AT MIN FOR 1 MIN
CONDITION LEVERS	FUEL CUTOFF
PROPELLERS	FEATHERED
ITT	MONITOR FOR FUEL CUTOFF
OVERHEAD PANEL SWITCHES	ALL OFF
EICAS	OFF
MASTER SWITCHES	OFF
CONTROL LOCKS	INSTALL
WHEEL CHOCKS	INSTALL
GEAR LOCKING PINS	INSTALL
PARKING BRAKE	OFF
EXTERNAL COVERS	INSTALL

Engine Clearing

CONDITION LEVER	FUEL CUTOFF
IGNITION AND ENGINE START	STARTER ONLY

Fuel Transfer

STANDBY PUMPS	OFF
TRANSFER FLOW	L OR R AS REQUIRED
FUEL TRANSFER MESSAGE	ILLUMINATED

Alternate Gear Extension

AIRSPEED	BELOW 200 KTS
GEAR CONTROL CIRCUIT BREAKER	PULL
LANDING GEAR CONTROL	DOWN
GEAR PUMP HANDLE	PUMP UNTIL THREE GREEN

Gear Retract After Alt. Ext.

GEAR CONTROL CIRCUIT BREAKER	RESET
LANDING GEAR CONTROL	UP

Simulated Engine Failure

PROPELLER LEVERS	1700 RPM
POWER LEVERS	5% TORQUE

Abnormal Checklists

Air Start (Starters)

POWER LEVER (INOP ENGINE)	IDLE
PROPELLER LEVER (INOP ENGINE)	LOW RPM
CONDITION LEVER (INOP ENGINE)	FUEL CUTOFF
FIREWALL FUEL VALVE (INOP ENGINE)	PUSH OPEN
ENGINE ANTI-ICE (INOP ENGINE)	OFF
AUTOFEATHER	OFF
PROPELLER SYNC	OFF
GENERATOR (INOP ENGINE)	OFF
GENERATOR TIES	MAN CLOSED
MAN TIES CLOSED MESSAGE	ILLUMINATED
BLEED AIR VALVES	SELECT OPERATING
ALTITUDE	30000 FT MAXIMUM
AIRSPEED	120 KTS MINIMUM
IGNITION AND ENGINE START (INOP ENGINE)	ON
CONDITION LEVER (12%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR
IGNITION AND ENGINE START	OFF
CONDITION LEVER (65%N1 MINIMUM)	RUN
GENERATOR	RESET THEN ON
GENERATOR TIES	NORM
PROPELLER SYNC	AS DESIRED
AUTOFEATHER	AS REQUIRED
ELECTRICAL EQUIPMENT	AS REQUIRED
BLEED AIR VALVES	BOTH
ENGINE ANTI-ICE	AS REQUIRED

Air Start (Windmilling)

POWER LEVER (INOP ENGINE)	IDLE
PROPELLER LEVER (INOP ENGINE)	LOW RPM
CONDITION LEVER (INOP ENGINE)	FUEL CUTOFF
FIREWALL FUEL VALVE (INOP ENGINE)	PUSH OPEN
ENGINE ANTI-ICE (INOP ENGINE)	OFF
ENGINE AUTO-IGNITION (INOP ENGINE)	ARM
AUTOFEATHER	OFF
PROPELLER SYNC	OFF
GENERATOR (INOP ENGINE)	OFF
STANDBY PUMP (INOP ENGINE)	ON
BLEED AIR VALVES	SELECT OPERATING
ALTITUDE	20000 FT MAXIMUM
AIRSPEED	180 KTS MINIMUM
CONDITION LEVER (8%N1 MINIMUM)	START
N1 AND ITT (1000C MAXIMUM)	MONITOR
IGNITION AND ENGINE START	OFF
CONDITION LEVER (65%N1 MINIMUM)	RUN
GENERATOR	RESET THEN ON
PROPELLER SYNC	AS DESIRED
AUTOFEATHER	AS REQUIRED
STANDBY PUMP (INOP ENGINE)	OFF
ELECTRICAL EQUIPMENT	AS REQUIRED
BLEED AIR VALVES	BOTH
ENGINE ANTI-ICE	AS REQUIRED

Fuel Level Low

FUEL QUANTITY	CHECK
IF FUEL QUANTITY...	ABOVE 135 POUNDS
STANDBY PUMP	ON
AFT FUEL QUANTITY	CHECK
IF FUEL LEVEL LOW	DOES NOT EXTINGUISH
AFT FUEL QUANTITY	CHECK

Generator Inoperative

GENERATOR SWITCH	RESET THEN ON
IF GENERATOR...	WILL NOT RESET
GENERATOR SWITCH	OFF
ELECTRICAL LOAD	MONITOR

Single Generator Tie Open

LOADMETER	MONITOR OPEN BUS
IF LOAD...	LESS THAN 100%
GEN TIES SWITCH	OPEN THEN NORM
IF LOAD...	GREATER THAN 100%
OPEN BUS GENERATOR	OFF

Dual Generator Tie Open

IF DUAL GEN FAILURE...	DO NOT RESET TIES
IF BOTH LOADS...	LESS THAN 100%
GEN TIES SWITCH	OPEN THEN NORM
BATTERY CURRENT	MONITOR

Battery Tie Open

CENTER BUS VOLTAGE...	IF NORMAL (24-28V)
GEN TIES SWITCH	OPEN THEN NORM
CENTER BUS VOLTAGE...	IF ZERO
GEN TIES SWITCH	OPEN
CENTER BUS VOLTAGE...	IF ZERO
LAND	AS SOON AS PRACTICAL

Pressurization Failure

MANUAL CABIN ALT CONTROL	CW FOR CLIMB
MANUAL CABIN ALT CONTROL	CCW FOR LEVEL
IF CABIN CLIMB...	OVERPRESSURE LIKELY
BLEED AIR VALVES	PERIODICALLY TO OFF
DESCEND	BELOW 10000 FT
LAND	AS SOON AS PRACTICAL

Duct Overtemperature

CABIN/COCKPIT BLOWERS	HIGHEST SETTING
IF OVERTEMPERATURE...	CONDITION PERSISTS
TEMP MODE SELECTOR	MAN
MAN TEMP SWITCH	HOLD DECR FOR 60s
IF OVERTEMPERATURE...	CONDITION PERSISTS
BLEED AIR VALVE	RIGHT ENGINE

Severe Icing Encounter

AUTOPILOT	DISENGAGE
STALL WARNING HEAT	ON
PITOT/STATIC HEAT	ON
VENT/CABLE HEAT	ON
WINDSHIELD HEAT	HIGH
ENGINE ICE PROTECTION	ON
ENGINE AUTO-IGNITION	ON

Engine Anti-Ice Failure

ENGINE ICE ACTUATOR SWITCHES	BOTH STBY
ENGINE ICE PROTECTION	BOTH ON
IF ICE VANE FAIL MESSAGE...	PERSISTS
EXIT	ICING CONDITIONS
ASSUME ANTI-ICE IS ON	FOR PERFORMANCE CALC

Pneumatic Pressure Low

BLEED AIR VALVES	CHECK ON BOTH
PNEUMATIC PRESSURE DISPLAYS	CHECK
EXIT	ICING CONDITIONS

Cracked Windshield

AIRSPEED	BELOW 200 KTS
ALTITUDE	BELOW 25000 FT
PRESSURIZATION	SET LESS THAN 4.0 DPSI
WINDSHIELD HEAT	OFF FOR AFFECTED SIDE
MAINTAIN POSITIVE CABIN PRESS	UNTIL LANDING

Single RTU Failure

FAILED RTU REVERSIONARY SWITCH	X-SIDE
TUNE ALL RADIOS WITH X-SIDE RTU OR CDU	

Dual RTU Failure

BOTH RTU REVERSIONARY SWITCH	X-SIDE
TUNE ALL RADIOS WITH PILOT CDU	

Uncommanded Radio Tuning

RAD RMT SWITCH	TUN DSBL
TUNE ALL RADIOS WITH PILOT CDU	

Avionics Cooling Air Failure

CABIN/COCKPIT BLOWERS	HIGHEST SETTING
IF MESSAGE...	PERSISTS
AVIONICS ALTERNATE BLOWER	ON
AV ALTN BLWR ON MESSAGE	ILLUMINATED

EICAS Failure

EICAS REVERSIONARY SWITCH	REV
MFD	CHECK FOR PROPER EICAS INFO
IF MFD...	DOES NOT DISPLAY EICAS INFO
FLIGHT DAU A AND B CIRCUIT BREAKERS	RESET
EICAS FLIGHT DISPLAY CIRCUIT BREAKER	RESET

EICAS & MFD Failure

RTU REVERSIONARY SWITCH	ENG DATA

Display Overtemperature

CABIN/COCKPIT BLOWERS	HIGHEST SETTING
AVIONICS ALTERNATE BLOWER	ON
IF PERSISTS…	COPILOT AVIONICS OFF

Emergency Checklists

Engine Fire or Failure

CONDITION LEVER	FUEL CUTOFF
PROPELLER LEVER	FEATHER
FIREWALL FUEL VALVE	PUSH
F/W VALVE CLOSED	ILLUMINATED
EXTINGUISHER	PUSH
EXTINGUISHER DISCH	ILLUMINATED
ENGINE AUTO-IGNITION	OFF
PROPELLER SYNC	OFF
GENERATOR (AFFECTED ENGINE)	OFF
ELECTRICAL LOAD	MONITOR
BLEED AIR VALVES	SELECT OPERATING ENGINE

Engine Fire on Ground

CONDITION LEVER	FUEL CUTOFF
FIREWALL FUEL VALVE	PUSH
F/W VALVE CLOSED	ILLUMINATED
IGNITION AND ENGINE START	STARTER ONLY
IF...	FIRE PERSISTS
EXTINGUISHER	PUSH
EXTINGUISHER DISCH	ILLUMINATED

Engine Failure During Takeoff

POWER LEVERS	GROUND FINE
BRAKES	MAXIMUM APPLICATION

Engine Failure After Takeoff

POWER	MAXIMUM ALLOWABLE
LANDING GEAR	UP
PROPELLER (AFFECTED ENGINE)	VERIFY FEATHER
FLAP/FWD WING	RETRACT AT 400 FT AGL
AIRSPEED	ACCELERATE TO BLUE LINE
POWER	MAXIMUM CONTINUOUS
CONDITION LEVER	FUEL CUTOFF
PROPELLER LEVER	FEATHER
FIREWALL FUEL VALVE	PUSH
F/W VALVE CLOSED	ILLUMINATED
ENGINE AUTO-IGNITION	OFF
PROPELLER SYNC	OFF
GENERATOR (AFFECTED ENGINE)	OFF
ELECTRICAL LOAD	MONITOR
BLEED AIR VALVES	SELECT OPERATING ENGINE

Oil Pressure Low

OIL PRESSURE DISPLAY	CONFIRM BELOW 60 PSI
SECURE AFFECTED ENGINE	OR...
LAND AT NEARBY AIRPORT	WITH MINIMUM POWER

Fuel Pressure Low

STANDBY PUMP	ON
IF FUEL PRESS LO ANNUNCIATOR	PERSISTS...
LAND	AS SOON AS PRACTICAL

Electrical Smoke or Fumes

OXYGEN MASK	DON
MIC SELECTOR SWITCH	OXY MASK
AUDIO SPEAKER	ON
ALL AIR VENTS	OPEN
PILOT AIR	PULL ON
DEFROST AIR	PULL ON
BLEED AIR VALVES	HIGH FLOW
AUTO TEMP	CKPT FULL INCREASE
L AND R GEN	OFF
NONESSENTIAL EQUIPMENT	OFF
IF...	SMOKE CEASES
RESTORE	ELECTRICAL EQUIPMENT
ISOLATE	DEFECTIVE EQUIPMENT
IF...	SMOKE PERSISTS
MANUAL CABIN ALT CONTROL	CW FOR CLIMB
LAND	AS SOON AS POSSIBLE

Environmental Smoke or Fumes

OXYGEN MASK	DON
MIC SELECTOR SWITCH	OXY MASK
AUDIO SPEAKER	ON
ALL AIR VENTS	OPEN
PILOT AIR	PULL ON
DEFROST AIR	PULL ON
BLEED AIR VALVES	LEFT
IF...	SMOKE CEASES
CONTINUE OPERATION	ON LEFT BLEED AIR
IF...	SMOKE PERSISTS
BLEED AIR VALVES	RIGHT
IF...	SMOKE CEASES
CONTINUE OPERATION	ON RIGHT BLEED AIR
IF...	SMOKE PERSISTS
BLEED AIR VALVES	OFF
LAND	AS SOON AS POSSIBLE

Airstair Door Unlocked

DO NOT ATTEMPT	TO SECURE DOOR IN FLIGHT
NO SMOKE AND SEATBELTS	ON
CABIN PRESS DIFFERENTIAL	REDUCE OR ZERO
CREW OXYGEN	AS REQUIRED
PASSENGER OXYGEN	AS REQUIRED
LAND	AS SOON AS PRACTICAL

Emergency Descent

CREW OXYGEN	AS REQUIRED
PASSENGER OXYGEN	AS REQUIRED
POWER LEVERS	IDLE
PROPELLER LEVERS	FULL FORWARD
AIRSPEED	MAINTAIN 200 KTS
LANDING GEAR	DOWN

Glide

LANDING GEAR	UP
FLAP/FWD WING	RETRACT
PROPELLERS	FEATHERED
AIRSPEED	130 KTS

Dual Generator Failure

GENERATORS	RESET THEN ON
DO NOT EXCEED	100% LOAD ON EITHER
IF...	NO GENERATOR OPERABLE
NONESSENTIAL EQUIPMENT	OFF
1 OR 2 RTU REV SWITCH	ENG DATA
PILOT SENSOR DISPLAY UNIT	SELECT REQUIRED
LANDING GEAR	EXTEND MANUALLY
FLAP/FWD WING	DO NOT EXTEND
TAXI LIGHT	AS REQUIRED

Battery Charge Rate

BATTERY SWITCH	OFF
IF BATT CHARGE RATE MESSAGE...	ILLUMINATED
LAND	AS SOON AS PRACTICAL

Pitch Trim Failure

PITCH TRIM SWITCH	OFF RESET
IF PITCH TRIM FAIL MESSAGE...	ILLUMINATED
PITCH TRIM SWITCH	STBY
PITCH TRIM DUAL SWITCH	RETRIM
AUTOPILOT	DISENGAGE

Roll or Rudder Trim Failure

TRIM SWITCH	OFF RESET
IF TRIM FAIL MESSAGE...	ILLUMINATED
AUTOPILOT	DISENGAGE

Cabin Decompression

CREW OXYGEN	AS REQUIRED
PASSENGER OXYGEN	AS REQUIRED
BLEED AIR VALVES	CHECK PROPER POSITION
MANUAL CABIN ALT CONTROL	CCW NORM
IF CABIN ALTITUDE	CONTINUES TO CLIMB...
EXECUTE	EMERGENCY DESCENT
OXYGEN DURATION	CALCULATE

High Differential Pressure

BLEED AIR VALVES	OFF
DIFFERENTIAL PRESSURE	MONITOR
DIFFERENTIAL PRESSURE	WHEN DECREASES...
BLEED AIR VALVES	BOTH
MANUAL CABIN ALT CONTROL	CW UNTIL STABLE
DIFFERENTIAL PRESSURE	CONTINUES INCREASE...
BLEED AIR VALVES	OFF
CREW OXYGEN	AS REQUIRED
PASSENGER OXYGEN	AS REQUIRED
DESCEND	AS REQUIRED

Single Bleed Failure

BLEED AIR VALVES	SELECT OPPOSITE ENGINE
ENGINE ITT	MONITOR

Fuselage Bleed Failure

BLEED AIR VALVES	EMER
CABIN/COCKPIT BLOWERS	HIGHEST SETTING
ENGINE ITT	MONITOR

More Information on Operation

Black Square aircraft are created by an avid pilot who believes that every switch, knob, and button should be interactable, and the user should be able to follow real world procedures without compromising results from the simulation. This aircraft was designed and tested using real world handbooks and procedures, and leaves little to the imagination in terms of functionality. For the most immersive experience, it's recommended that you seek out manuals, handbooks, checklists, and performance charts from the real aircraft represented in this simulation. Although this aircraft and simulation is not suitable for real world training, and should not be used for such, every effort has been taken to ensure that the simulation will represent the real aircraft until the fringe cases of instrument flying, or system failure.

In the case of this particular product, the original pilot's operating handbook, flight manual, and avionics handbook have been preserved online, on Starship owner, Robert P. Scherer's, personal website. Be aware that the Starship's avionics have received numerous updates through the years that are not reflected in this original documentation. The original documentation also contains many examples of incorrect colors, typos, and no longer relevant text. This software was designed from a currently updated example of this avionics suite, and often does not necessarily resemble the original documentation in all aspects.

Hardware Inputs & Outputs

A nearly complete list of input and output variables and events is provided below for home cockpit builders. If this list is not enough to accomplish the amount of interactivity you are looking to achieve in your home cockpit, anything is possible with a little code. Nothing in any Black Square aircraft is "hard coded", or made inaccessible behind encrypted or compiled files. If you have further questions, contact Just Flight Support, or reach out to me directly in the Just Flight Community forums, where I will be happy to help.

Inputs

Exterior & Cabin Element Variables

Description	Variable	Range
Yoke & Throttle Control Locks	L:bksq_controlLocks	Boolean
Gear Downlock Pins	L:bksq_DownlockPins	Boolean
Pitot Covers	L:bksq_PitotCovers	Boolean
Engine Covers	L:bksq_EngineCovers	Boolean
Wheel Chocks	L:bksq_WheelChocks	Boolean
Tablet Visibility	L:bksq_TabletVisible	Boolean
Tablet Horizontal Position	L:var_efb_rot_x	-1 - 1
Tablet Vertical Position	L:var_efb_rot_y	-1 - 1
Main Cabin Door	L:bksq_CabinDoor	Boolean
Left Baggage Compartment Door	L:var_BaggageDoorHandle_L	0 - 100
Right Baggage Compartment Door	L:var_BaggageDoorHandle_R	0 - 100
Pilot's Sun Visor Position	L:var_Visor_L	0 - 100
Copilot's Sun Visor Position	L:var_Visor_R	0 - 100

Primary Control Variables

Description	Variable	Range
Condition Lever	K:CONDITION_LEVER_SET L:BKSQ_ConditionLever_1	Boolean
Condition Lever	K:CONDITION_LEVER_SET L:BKSQ_ConditionLever_2	Boolean
Hide Pilot's Yoke	L:XMLVAR_YokeHidden1	Boolean
Hide Copilot's Yoke	L:XMLVAR_YokeHidden2	Boolean
Control Wheel Steering Yoke Button	L:var_PilotCws	Boolean
Left Generator Reset	L:var_GeneratorReset_L	Boolean
Right Generator Reset	L:var_GeneratorReset_R	Boolean
External Power Switch	L:var_ExternalPowerSwitch	Boolean
Bus Tie Switch Manual Open	L:var_busTieManOpen	Boolean
Bus Tie Switch Manual Close	L:var_busTieManClose	Boolean
Alternate Avionics Blower	L:var_AvionicsAlternateBlowerSwitch	Boolean
EICAS Avionics Power Switch	L:var_AvionicsEicasSwitch	Boolean
Pilot Avionics Power Switch	L:var_AvionicsPilotSwitch	Boolean
Copilot Avionics Power Switch	L:var_AvionicsCoPilotSwitch	Boolean
Standby Instrument Power Switch	L:var_StandbyInstrumentsSwitch	Boolean
Left Standby Fuel Pump	L:var_StandbyFuelPump_L	Boolean
Right Standby Fuel Pump	L:var_StandbyFuelPump_R	Boolean
Left Auto Ignition Arm	L:var_AutoIgnitionSwitch_L	Boolean
Right Auto Ignition Arm	L:var_AutoIgnitionSwitch_R	Boolean
Autofeather Switch	L:var_AutoFeatherSwitch	0 = TEST, 1 = ARM
Propeller Governor Test Switch	L:var_PropGovTestSwitch	0 = GOV, 2 = LOW
Left Engine Start Switch	L:var_StarterSwitch_L	0 = START, 2 = MTOR
Right Engine Start Switch	L:var_StarterSwitch_R	0 = START, 2 = MTOR
Ground Comm Button	L:var_GroundComOn	Boolean
Left Aft Fuel Tank Quantity Button	L:var_AftTankQuantityButton_L	Boolean

Right Aft Fuel Tank Quantity Button	L:var_AftTankQuantityButton_R	Boolean
Fuel Transfer Selector Knob	L:var_FuelTransferKnob	0 = RtoL, 2 = LtoR
Multimeter Battery Amps Button	L:var_BatteryAmpsMode	Boolean
Voltmeter Radio Buttons	L:var_MultimeterMode	0-5
Pitch Trim Mode Switch	L:var_PitchTrimModeSwitch	0 = NORM, 2 = STBY
Standby Pitch Trim Energize	L:var_StandbyTrimSwitch_L	0 = DOWN, 2 = UP
Standby Pitch Trim Direction	L:var_StandbyTrimSwitch_R	0 = DOWN, 2 = UP
Roll Trim Mode Switch	L:var_RollTrimModeSwitch	Boolean
Rudder Trim Mode Switch	L:var_RudderTrimModeSwitch	Boolean
Rudder Trim Control Knob	L:var_RudderTrimKnob	0 = LEFT, 2 = RIGHT
Rudder Trim Knob Slide to Test	L:var_RudderTrimSlideTest	0 = LEFT, 2 = RIGHT
Yoke Elevator Trim Switch	L:var_ElevatorTrimSwitch	-1 = UP, 1 = DOWN
Yoke Roll Trim Switch	L:var_AileronTrimSwitch	-1 = LEFT, 1 = RIGHT
Stall Warning Heat Switch	L:var_StallWarningHeatSwitch	Boolean
Left Pitot Heat Switch	L:var_PitotHeatSwitch_L	Boolean
Right Pitot Heat Switch	L:var_PitotHeatSwitch_R	Boolean
Pilot's Windshield Heat Switch	L:var_WindshieldAntiIceSwitch_L	0 = HI, 1 = LOW
Copilot's Windshield Heat Switch	L:var_WindshieldAntiIceSwitch_R	0 = HI, 1 = LOW
Left Inert. Sep. Actuator Select	…InertialSeparatorActuatorSwitch_L	Boolean
Right Inert. Sep. Actuator Select	…InertialSeparatorActuatorSwitch_R	Boolean
Left Inertial Separator Switch	L:var_InertialSeparatorSwitch_L	Boolean
Right Inertial Separator Switch	L:var_InertialSeparatorSwitch_R	Boolean
Pilot's Windshield Heat Mode Select	L:var_WindshieldHeatMode	Boolean
Ground Ice Detector Switch	L:var_IceDetectorTest	Boolean
Left Fuel Vent Heat Switch	L:var_FuelVentSwitchHeat_L	Boolean
Right Fuel Vent Heat Switch	L:var_FuelVentSwitchHeat_R	Boolean
Forward Wing Deicing Boots Switch	L:var_ForwardWingDeiceSwitch	0 = MAN, 2 = SEQ
Main Wing Deicing Boots Switch	L:var_MainWingDeiceSwitch	0 = INBD, 2= OUTBD

Antiskid Braking Switch	L:var_AntiSkidSwitch	Boolean
Alternate Static Air Source Selector	L:var_AlternateStaticSwitch	Boolean
Gear Downlock Release	L:var_DownlockLatching	0 = Pressed
Gear Warning Horn Silence	L:var_GearWarningHornLatching	2 = Silence
Left Fire Extinguisher Bottle Test	L:var_FireExtinguisherTest_L	Boolean
Right Fire Extinguisher Bottle Test	L:var_FireExtinguisherTest_R	Boolean
Left Fire Detector Loop Test	L:var_FireDetectorTest_L	Boolean
Right Fire Detector Loop Test	L:var_FireDetectorTest_R	Boolean
Left Flap Monitor Test	L:TestFlapMonitorButton_L	Boolean
Right Flap Monitor Test	L:TestFlapMonitorButton_R	Boolean
Auxiliary Battery Test	L:var_AuxBatteryTest	Boolean
Battery Monitor Test	L:var_BatteryMonitorTest	Boolean
Pressurization Test	L:var_PressurizationTest	Boolean
Low Fuel Warning Test	L:var_FuelWarningTest	Boolean
Stall Warning Horn Test	L:var_StallWarningTest	Boolean
Airspeed Warning Horn Test	L:var_AirspeedWarningTest	Boolean
Gear Warning Horn Test	L:var_GearWarningTest	Boolean
Annunciator Lights Test	L:var_AnnunciatorTest	Boolean
Bleed Air Warning Test	L:var_BleedAirTest	Boolean
Deicing Vacuum Suction Test	L:var_DeiceVacuumTest	Boolean
Standby Deicing System Test	L:var_DeiceStandbyTest	Boolean
Main Deicing System Test	L:var_DeiceMainTest	Boolean
Carbon Monoxide Detector Test	L:var_CoTest	Boolean
Marker Beacon Volume	L:var_MarkerBeaconVolume	0 - 100
DME Volume	L:var_DmeVolumeKnob	0 - 100
Windshield Wiper Knob	L:var_WiperKnob	0-3
Database Unit Latch	L:var_DbuLoaded	0 = Eject
Left Firewall Valve Push Button	L:var_FirewallValvePushed_L	Boolean

Right Firewall Valve Push Button	L:var_FirewallValvePushed_R	Boolean
Left Extinguisher Push Button	L:var_ExtinguisherPushed_L	Boolean
Right Extinguisher Push Button	L:var_ExtinguisherPushed_R	Boolean
Gear Position Indicator Test Button	L:var_GearLightPushTest	Boolean
Flap/Fwd Wing Indicator Test Button	L:var_FlapLightPushTest	Boolean
Standby Battery Indicator Test Button	L:var_StandbyBatteryPushTest	Boolean

Lighting Control Events & Variables

Description	Variable	Range
Panel Lighting Master	L:var_MasterPanelLights	Boolean
Cabin Overheat Lighting	L:var_CabinOverheadLighting	Boolean
Cabin Aisle Lighting	L:var_CabinAisleLighting	Boolean
Cabin Bar Lighting	L:var_CabinBarLighting	Boolean
No Smoking Signs	L:var_NoSmokingLights	Boolean
Seat Belt Signs	L:var_SeatBeltLights	Boolean
Wing Landing Lights	1 K:LANDING_LIGHTS_SET	
Nose Landing Lights	2 K:LANDING_LIGHTS_SET	
Taxi Lights	K:TOGGLE_TAXI_LIGHTS	
Wing Inspection Lights	K:TOGGLE_WING_LIGHTS	
Navigation Lights	K:TOGGLE_NAV_LIGHTS	
Strobe Lights Low	L:var_StrobeLight_Low	Boolean
Strobe Lights High	L:var_StrobeLight_High	Boolean
Instrument Panel Indirect Lighting	L:var_InstrumentIndirectLightingKnob	0 - 100
Cockpit Area Lighting	L:var_CockpitAreaLightingKnob	0 - 100
Cockpit Storm Flood Lights	L:var_CockpitStormLightsKnob	0-2
Pilot Display Brightness	L:var_PilotDisplaysKnob	0 - 100
Center Display Brightness	L:var_CenterDisplaysKnob	0 - 100
Subpanel LCD Display Brightness	L:var_SubpanelDisplayKnobs	0 - 100

Copilot Display Brightness	L:var_CopilotDisplaysKnob	0 - 100
Main Panel Integrity Lighting	L:var_MainPanelBacklightingKnob	0 - 100
Console Panel Integrity Lighting	L:var_ConsolePanelBacklightingKnob	0 - 100
Pilot’s Map Light	L:var_MapLightKnob_L	0 - 100
Copilot’s Map Light	L:var_MapLightKnob_R	0 - 100
Entry Panel Cockpit Lighting	L:var_CabinCockpitLighting	Boolean
Entry Panel Aisle Lighting	L:var_CabinEntryAisleLighting	Boolean
Entry Panel Entry Lighting	L:var_CabinEntryLight	Boolean
Entry Panel Door/Stairs Lighting	L:var_CabinDoorLight	Boolean
Left Lavatory Spot Lights	L:CabinLavSpotLightButton_L	Boolean
Right Lavatory Spot Lights	L:CabinLavSpotLightButton_R	Boolean
Passenger Reading Lights 1L	L:CabinReadingLightSwitch_1L	Boolean
Passenger Reading Lights 1R	L:CabinReadingLightSwitch_1R	Boolean
Passenger Reading Lights 2L	L:CabinReadingLightSwitch_2L	Boolean
Passenger Reading Lights 2R	L:CabinReadingLightSwitch_2R	Boolean
Passenger Reading Lights 3L	L:CabinReadingLightSwitch_3L	Boolean
Passenger Reading Lights 3R	L:CabinReadingLightSwitch_3R	Boolean

Environmental Control Variables

Description	Variable	Range
Pilot Oxygen Mask	L:var_pilotOxygen	Boolean
Copilot Oxygen Mask	L:var_copilotOxygen	Boolean
Oxygen System Ready Handle	L:XMLVAR_Cabin_Air_4_Position	0 - 100
Passenger Oxygen Manual Deploy	L:XMLVAR_Cabin_Air_5_Position	0 - 100
Pilot Air Valve	L:XMLVAR_Cabin_Air_1_Position	0 - 100
Copilot Air Valve	L:XMLVAR_Cabin_Air_2_Position	0 - 100
Defrost Air Valve	L:XMLVAR_Cabin_Air_3_Position	0 - 100
Bleed Air Valve Control Knob	L:var_BleedAirValveSwitch	0 - 5
Environmental Mode Knob	L:var_EnvironmentalModeKnob	0 = MAN, 2 = AUTO
Cabin Blower Fan Speed	L:var_CabinBlowerKnob	0 - 10
Cockpit Blower Fan Speed	L:var_CockpitBlowerKnob	0 - 10
Cabin Temperature Auto Set Point	L:var_CabinTemperatureKnob	0 - 25
Cockpit Temperature Auto Set Point	L:CockpitTemperatureKnob	0 - 25
Cabin Temperature Manual Set Switch	L:var_cabinTempManualSet	50 - 90
Pressurization Goal Knob	L:var_pressurizationGoal	-1000 - 15000
Pressurization Rate Knob	L:var_pressurizationClimbRate	150 - 2000
Pressurization Dump Knob	L:var_ManualCabinAltKnob	0 - 100

Instrument Variables

Description	Variable	Range
Autopilot Bank Angle Control Knob	L:var_ApTurnKnob	-30 - 30
Autopilot Transfer Button	L:var_AutopilotSource	Boolean
Autopilot Turbulence Mode Button	L:var_AutopilotTurbulenceMode	Boolean
Pilot Microphone Selector	L:var_PilotMicSelectKnob	0 = HAND, 2 = MASK
Copilot Microphone Selector	L:var_CopilotMicSelectKnob	0 = HAND, 2 = MASK
Pilot Transmitting Radio Selector	L:var_PilotTransmitSelector	0 - 4
Copilot Transmitting Radio Selector	L:var_CopilotTransmitSelector	0 - 4
Angle of Attack Gauge Sensor Source	L:var_aoaSource	Boolean
Left Composite Display Switch	…ReversionaryCompositeSwitch_L	0 = UP, 2 = DOWN
Right Composite Display Switch	…ReversionaryCompositeSwitch_R	0 = UP, 2 = DOWN
Left AHRS Display X-Side Switch	…ReversionaryAhrsXSideSwitch_L	Boolean
Right AHRS Display X-Side Switch	…ReversionaryAhrsXSideSwitch_R	Boolean
Left CDU Control X-Side Switch	…ReversionaryCduXSideSwitch_L	Boolean
Right CDU Control X-Side Switch	…ReversionaryCduXSideSwitch_R	Boolean
Left AHRS Reinitialize Switch	L:var_AhrsReinitSwitch_L	Boolean
Right AHRS Reinitialize Switch	L:var_AhrsReinitSwitch_R	Boolean
Left Fast Slave Switch	…ReversionaryFastSlaveSwitch_L	Boolean
Right Fast Slave Switch	…ReversionaryFastSlaveSwitch_R	Boolean
Left Altimeter Baro Unit Switch	L:var_ReversionaryBaroUnitSwitch_L	Boolean
Right Altimeter Baro Unit Switch	L:var_ReversionaryBaroUnitSwitch_R	Boolean
Left Altitude Alert Inhibit Switch	…TransitionAltitudeAlertSwitch_L	Boolean
Right Altitude Alert Inhibit Switch	…TransitionAltitudeAlertSwitch_R	Boolean
EICAS Reversionary Switch	L:EicasReversionarySwitch	Boolean
Left RTU Reversionary Switch	L:var_RtuReversionarySwitch_L	0 = ENG, 2 = X-SIDE
Right RTU Reversionary Switch	L:var_RtuReversionarySwitch_R	0 = ENG, 2 = X-SIDE
Auto Radio Tuning Disable	L:var_RtuAutoTuneDisableSwitch	Boolean

Transponder Select Switch	L:var_TransponderSelectSwitch	Boolean
Master Warning Button	L:var_MasterWarningLatching	2 = Silence
Master Caution Button	L:var_MasterCautionLatching	2 = Silence

Primary Control Events Events

Description	Event
Battery Master	K:BATTERY1_SET
Left Generator	K:TOGGLE_ALTERNATOR1
Right Generator	K:TOGGLE_ALTERNATOR2
Propeller Synchronizer	K:TOGGLE_PROPELLER_SYNC
Native CWS (pitch sync)	K:SYNC_FLIGHT_DIRECTOR_PITCH
Emergency Gear Extension	K:GEAR_PUMP
COM Volume Knob Increase	K:COM1_VOLUME_INC
COM Volume Knob Decrease	K:COM1_VOLUME_DEC
NAV Volume Knob Increase	K:NAV1_VOLUME_INC
NAV Volume Knob Decrease	K:NAV1_VOLUME_DEC
ADF Volume Knob Increase	K:ADF_VOLUME_INC
ADF Volume Knob Decrease	K:ADF_VOLUME_DEC

Instrument Events

Description	Variable
Autopilot Master	K:AP_MASTER
Yaw Damper Master	K:YAW_DAMPER_TOGGLE
Transponder Ident	K:XPNDR_IDENT_ON
Autopilot Heading Mode	H:MSP_Heading_1
Autopilot NAV Mode	H:MSP_Nav_1
Autopilot Approach Mode	H:MSP_Approach_1
Autopilot Half Bank Mode	H:MSP_HalfBank_1
Autopilot Altitude Hold Mode	H:MSP_Altitude_1
Autopilot Vertical Speed Hold Mode	H:MSP_VerticalSpeed_1
Autopilot IAS Hold Mode	H:MSP_Airspeed_1
Autopilot IAS Profile Mode	H:MSP_AirspeedProfile_1
Autopilot Descent Profile Mode	H:MSP_Descend_1
Autopilot Flight Director Off Button	H:MSP_FlightDirectorOff_1
Autopilot Go-Around Mode	K:AUTO_THROTTLE_TO_GA
Autopilot Pitch Control Knob	K:AP_PITCH_REF_INC_DN, K:AP_PITCH_REF_INC_UP
Toggle COM1 Receive	K:COM1_RECEIVE_SELECT
Toggle COM2 Receive	K:COM2_RECEIVE_SELECT
Toggle NAV1 Receive	K:RADIO_VOR1_IDENT_TOGGLE
Toggle NAV2 Receive	K:RADIO_VOR2_IDENT_TOGGLE
Toggle ADF Receive	K:RADIO_ADF_IDENT_TOGGLE
Toggle DME Receive	K:RADIO_DME1_IDENT_TOGGLE
Toggle Marker Receive	K:MARKER_SOUND_TOGGLE
Toggle Marker High Sensitivity	K:MARKER_BEACON_SENSITIVITY_HIGH
Attitude Indicator Reference Bars	K:ATTITUDE_BARS_POSITION_SET

Avionics Variables & Events

Replace the suffixes with either _1 or _R, as appropriate, to control copilot's side avionics.

HF9000

Description	Variable or Event
Squelch Knob	H:HF9000_Squelch_Inc, H:HF9000_Squelch_Dec
Volume Knob	H:HF9000_Volume_Inc, H:HF9000_Volume_Dec
Channel Knob	H:HF9000_Channel_Inc, H:HF9000_Channel_Dec
Cursor Knob	H:HF9000_Cursor_Inc, H:HF9000_Cursor_Dec
Value Knob	H:HF9000_Value_Inc, H:HF9000_Value_Dec
Squelch Disable Button	H:HF9000_Squelch_On
Frequency/ID Button	H:HF9000_Frequency

Working Title GNS 430

Description	Variable or Event
Radio Knob Push	H:AS430_LeftSmallKnob_Push
Radio Inner Knob Right	H:AS430_LeftSmallKnob_Right
Radio Inner Knob Left	H:AS430_LeftSmallKnob_Left
Radio Outer Knob Right	H:AS430_LeftLargeKnob_Right
Radio Outer Knob Left	H:AS430_LeftLargeKnob_Left
GPS Knob Push	H:AS430_RightSmallKnob_Push
GPS Inner Knob Right	H:AS430_RightSmallKnob_Right
GPS Inner Knob Left	H:AS430_RightSmallKnob_Left
GPS Outer Knob Right	H:AS430_RightLargeKnob_Right
GPS Outer Knob Left	H:AS430_RightLargeKnob_Left
Direct-To Button	H:AS430_DRCT_Push
Menu Button	H:AS430_MENU_Push
Clear Button Short	H:AS430_CLR_Push
Clear Button Long	H:AS430_CLR_Push_Long

Enter button	H:AS430_ENT_Push
COM Swap Button	H:AS430_COMSWAP_Push
NAV Swap Button	H:AS430_NAVSWAP_Push
NAV Ident Button	H:AS430_ID
CDI Button	H:AS430_CDI_Push
OBS Button	H:AS430_OBS_Push
Message Button	H:AS430_MSG_Push
Flightplan Button	H:AS430_FPL_Push
VNAV button	H:AS430_VNAV_Push
Procedure Button	H:AS430_PROC_Push

ECD-870 Engine/Caution Display (EICAS)

Description	Variable or Event
Line Select 1	H:EICAS_Line1
Line Select 2	H:EICAS_Line2
Line Select 3	H:EICAS_Line3

MFD-870 Multifunction Display (MFD)

Description	Variable or Event
Line Select 1 Left	H:MFD_Line1L
Line Select 2 Left	H:MFD_Line2L
Line Select 3 Left	H:MFD_Line3L
Line Select 4 Left	H:MFD_Line4L
Line Select 5 Left	H:MFD_Line5L
Line Select 6 Left	H:MFD_Line6L
Line Select 1 Right	H:MFD_Line1R
Line Select 2 Right	H:MFD_Line2R
Line Select 3 Right	H:MFD_Line3R

Line Select 4 Right	H:MFD_Line4R
Line Select 5 Right	H:MFD_Line5R
Line Select 6 Right	H:MFD_Line6R
Line Select 1 Bottom	H:MFD_Line1B
Line Select 2 Bottom	H:MFD_Line2B
Line Select 3 Bottom	H:MFD_Line3B
Line Select 4 Bottom	H:MFD_Line4B
Line Select 5 Bottom	H:MFD_Line5B
Line Select 6 Bottom	H:MFD_Line6B
Line Select 7 Bottom	H:MFD_Line7B
Checklist Line Advance Yoke Button	H:MFD_LineAdvance

CDU-850A Control Display Unit (CDU)

Description	Variable or Event
Range Knob CW	H:CDU_RangeKnob_Inc_1
Range Knob CCW	H:CDU_RangeKnob_Dec_1
Tilt Knob CW	H:CDU_TiltKnob_Inc_1
Tilt Knob CCW	H:CDU_TiltKnob_Dec_1
Tilt Knob Push	H:CDU_TiltKnobPush_1
HSI Button	H:CDU_HsiButton_1
Radar Toggle Button	H:CDU_RadarButton_1
Arc/Map Button	H:CDU_ArcMapButton_1
Nav Source Button	H:CDU_SourceButton_1
Radar Control Options Button	H:CDU_RadarControlButton_1
Bearing Pointer Source Button	H:CDU_BearingButton_1
Com Button	H:CDU_ComButton_1
Nav Button	H:CDU_NavButton_1
Adf Button	H:CDU_AdfButton_1

Transponder Button	H:CDU_TransponderButton_1
Flight Plan Button	H:CDU_FlightPlanButton_1
System Control Button	H:CDU_SystemControlButton_1
Index Button	H:CDU_IndexButton_1
Direct Button	H:CDU_DirectButton_1
Up Arrow Button	H:CDU_UpButton_1
Down Arrow Button	H:CDU_DownButton_1
VNAV Button	H:CDU_VnavButton_1
Message Button	H:CDU_MessageButton_1
Line Select 1 Left	H:CDU_Line1L_1
Line Select 1 Right	H:CDU_Line1R_1
Line Select 2 Left	H:CDU_Line2L_1
Line Select 2 Right	H:CDU_Line2R_1
Line Select 3 Left	H:CDU_Line3L_1
Line Select 3 Right	H:CDU_Line3R_1
Line Select 4 Left	H:CDU_Line4L_1
Line Select 4 Right	H:CDU_Line4R_1
Line Select 5 Left	H:CDU_Line5L_1
Line Select 5 Right	H:CDU_Line5R_1

ASI-850A Airspeed Indicator (ASI)

Description	**Variable or Event**
Airspeed Reference Adjust Increase	H:ASI_AirspeedKnob_Inc_1
Airspeed Reference Adjust Decrease	H:ASI_AirspeedKnob_Dec_1
Airspeed Reference Show/Hide	H:ASI_AirspeedKnobPush_1
Outside Air Temperature Mode Button	H:ASI_AirspeedTemperatureMode_1

ALI-850A Altitude/Vertical Speed Indicator (ALI)

Description	Variable or Event
Baro Adjust Increase	H:ALT_BaroAdjust_Inc_1
Baro Adjust Decrease	H:ALT_BaroAdjust_Dec_1
Baro Standard Push	H:ALT_BaroAdjustPush_1
Vertical Speed Reference Increase	H:ALT_VerticalSpeedKnob_Inc_1
Vertical Speed Reference Decrease	H:ALT_VerticalSpeedKnob_Dec_1
Vertical Speed Reference Show/Hide	H:ALT_VerticalSpeedKnobPush_1
Altitude Selector Increase	H:ALT_AltitudeSelectKnob_Inc_1
Altitude Selector Decrease	H:ALT_AltitudeSelectKnob_Dec_1
Altitude Alerter Silence	H:ALT_AltitudeSelectKnobPush_1

SDU-640A Sensor Display Unit (SDU)

Description	Variable or Event
Format Knob Increase	H:SDU_Format_Inc_1
Format Knob Decrease	H:SDU_Format_Dec_1
Left Knob Increase	H:SDU_Solid_Inc_1
Left Knob Decrease	H:SDU_Solid_Dec_1
Right Knob Increase	H:SDU_Hollow_Inc_1
Right Knob Decrease	H:SDU_Hollow_Dec_1

RTU-870A Radio Tuning Units (RTU)

Description	Variable or Event
OuterKnob Increase	H:RTU_KnobOuter_Inc_1
OuterKnob Decrease	H:RTU_KnobOuter_Dec_1
Inner Knob Increase	H:RTU_KnobInner_Inc_1
Inner Knob Decrease	H:RTU_KnobInner_Dec_1
Inner Knob Push (toggle 8.33kHz)	H:RTU_KnobInner_PUSH_1

ATC ID Button	H:RTU_TransponderIdentButton_1
DME Hold Button	H:RTU_DmeHoldButton_1
Com Squelch Button	H:RtuComSquelchButton_L
ATC Standby Button	H:RtuTransponderStandbyButton_L
Left RTU ½ Swap Button	L:var_RtuReversionarySwapMode_L
ADF Test Button	H:RtuAdfTestButton_L
Line Select Button 1	H:RtuLine1_L
Line Select Button 2	H:RtuLine2_L
Line Select Button 3	H:RtuLine3_L
Line Select Button 4	H:RtuLine4_L
Line Select Button 5	H:RtuLine5_L

CHP-850 Course/Heading Panel (CHP)

Description	Variable or Event
Joystick Move Left	H:MFD_Joystick_Left
Joystick Move Right	H:MFD_Joystick_Right
Joystick Move Up	H:MFD_Joystick_Up
Joystick Move Down	H:MFD_Joystick_Down
Joystick Recenter	H:MFD_Joystick_Center
Course Knob CCW	H:CHP_CourseKnob_Left_1
Course Knob CW	H:CHP_CourseKnob_Right_1
Course Knob Push	H:CHP_CourseKnobPush_1
Heading Knob CCW	H:CHP_HeadingKnob_Left
Heading Knob CW	H:CHP_HeadingKnob_Right
Heading Knob Push	H:CHP_HeadingKnobPush

APP-85D Autopilot Panel (APP)

Description	Variable or Event	Range
Mode Knob	H:PFD_DecisionHeightKnob_Inc_1	
Brightness Knob	H:PFD_DecisionHeightKnob_Dec_1	
Gain Knob	H:PFD_DecisionHeightKnobPush_1	
Altitude Alert Type Switch	L:var_AltitudeAlertSwitch_L	Boolean
Radar Altimeter Test Button	L:var_RadarAltimeterTest_L	Boolean
Range Increase Button	H:PFD_DescentAltitudeKnob_Inc_1	
Range Decrease Button	H:PFD_DescentAltitudeKnob_Dec_1	
Track Left Button	H:DescentAltitudeKnob_L_Push	

ARINC 429 Digital Clocks

Description	Variable or Event
Start/Stop Button	H:Chrono_StartStop_1
Left Select Button	H:Chrono_SelectLeft_1
Zero/Advance Button	H:Chrono_ZeroAdvance_1
Right Set Button	H:Chrono_Set_1
Right Select Button	H:Chrono_SelectRight_1

Outputs

Since the Black Square Starship has many custom underlying simulations beyond that of the native simulator, the following variables should be used to access what would normally be a simulator-level value. If the quantity you are interested in does not appear in this list, it is safe to assume it should be accessed via the native simulator variable.

Aircraft & Engine Variables

Description	**Variable**	**Units**
Left Propeller Torque	L:BKSQ_TQ_1	Number (FT-LBS)
Right Propeller Torque	L:BKSQ_TQ_2	Number (FT-LBS)
Left Interstage Turbine Temperature	L:BKSQ_ITT_1	Number (°C)
Right Interstage Turbine Temperature	L:BKSQ_ITT_2	Number (°C)
Left Gas Generator RPM	L:BKSQ_NG_1	Number (%)
Right Gas Generator RPM	L:BKSQ_NG_2	Number (%)
Left Fuel Pressure	L:BKSQ_FuelPressure_1	PSI
Right Fuel Pressure	L:BKSQ_FuelPressure_2	PSI
Left Propeller RPM	L:BKSQ_PROP_RPM_1	RPM
Right Propeller RPM	L:BKSQ_PROP_RPM_2	RPM
Left Fuel Flow	L:BKSQ_FuelFlow_1	GPH
Right Fuel Flow	L:BKSQ_FuelFlow_2	GPH
Left Oil Pressure	A:ENG OIL PRESSURE:1	PSI
Right Oil Pressure	A:ENG OIL PRESSURE:2	PSI
Left Oil Temperature	A:ENG OIL TEMPERATURE:1	Celsius
Right Oil Temperature	A:ENG OIL TEMPERATURE:2	Celsius
Left Main Fuel Quantity	A:FUEL TANK LEFT MAIN QUANTITY	GALLONS
Right Main Fuel Quantity	A:FUEL TANK RIGHT MAIN QUANTITY	GALLONS
Left Aft Tank Fuel Quantity	A:FUEL TANK LEFT AUX QUANTITY	GALLONS
Right Aft Tank Fuel Quantity	A:FUEL TANK RIGHT AUX QUANTITY	GALLONS
Turn Coordinator Ball	L:var_TurnCoordinatorBall	0 - 100

Battery Temperature	L:var_BatteryTemperature	Fahrenheit
Left Starter-Generator Temperature	L:var_StarterTemperature_L	Fahrenheit
Right Starter-Generator Temperature	L:var_StarterTemperature_R	Fahrenheit
Fuel Temperature	L:var_FuelTemperature	Celsius
Oxygen Pressure	L:var_oxygenPressure	PSI
Cabin Climb Rate	L:var_cabinClimbRate	FPM
Cabin Pressurization Altitude	L:var_cabinPressurizationAltitude	FEET
Cabin Differential Pressure	L:var_cabinPressureDifferential	PSI
Cabin Temperature	L:var_CabinTemperature	Fahrenheit
Instrument Panel Temperature	L:var_InstrumentTemperature	Fahrenheit
Nose Avionics Bay Temperature	L:var_AvionicsTemperature	Fahrenheit
Brake Temperature	L:var_BrakeTemperature	Fahrenheit

Annunciator Lights

The over 100 annunciators and indicator lamps in this aircraft are also accessible to home cockpit builders and 3rd party UI creators. There are too many to list here, but they can all be located in the Starship_Interior.XML. Search for “BKSQ_DIMMABLE_ANNUNCIATOR” to find them all. Each one is accessible via an L:Var named according to the “NODE_ID” of the annunciator in the XML file, following the pattern (L:var_**#NODE_ID#**_readonly, bool).

For example, the master warning annunciator NODE ID is “MasterWarning_EM”, therefore…

The master warning annunciator L:Var is (L:var_**MasterWarning_EM**_readonly, bool).

Frequently Asked Questions (Simulator Related)

How do I open/close or move the tablet interface?

Click the back of the tablet **in the document holder on the pilot's sidewall**. Click the same area to close the tablet. The tablet can be moved by dragging its frame. The tablet can be fixed in place above the pilot's oxygen mask for convenient VR use. For advanced users, the tablet position can also be set manually using L:var_efb_rot_x, L:var_efb_rot_y, and L:var_efb_dist.

Do I have to use the tablet interface to set fuel & payload?

NOTE: Currently, the tablet interface is required to set payload in MSFS 2024. The default MSFS EFB payload interface does not currently account for canard aircraft, and will incorrectly set the aircraft's empty weight center of gravity. The following applies to MSFS 2020:

Absolutely not. If you prefer to use the native fuel/payload interface, you may always do so. Be aware that, due to a core simulator bug, the native payload interface may become desynchronized with the actual state of the aircraft. This has no effect on operation, and making any change will resynchronize the native interface.

Why does the aircraft crash if I open the cockpit door?

Turn off "Aircraft Stress Damage" in the MSFS realism settings menu. This is the case for almost every addon aircraft with opening doors. The simulator interprets an open door as a catastrophic failure of the airframe.

Why is the autopilot behaving strangely with hardware inputs?

In order to implement altitude & VS preselect and more advanced features in the easiest way for cockpit builders to access, external hardware **must use the HTML events described in the "Instrument Events" section of this manual and NOT the native autopilot events.**

Why do my engines always fail or lose health?

Managing a turboprop engine without FADEC or automatic torque limiters may be easier than managing a reciprocating engine in some ways, but damage can happen much more easily. The most likely culprit is exceeding engine torque or ITT limits. Be sure to watch the engine instrumentation **for red exceedance warnings**. See the "Turboprop Engine Operation" section of this manual for more information.

Why do some switches not work, or avionics logic seem broken?

This is almost always caused by default control binding of hardware peripherals, especially the Honeycomb yoke and throttle system. Due to how the electronics in these peripherals work, they often "spam" their control events, or set them, rather than toggle them. In either case, this can interfere with the operation of more complex aircraft, such as this one.

Either create a control binding profile for this aircraft that does not attempt to send control inputs in the same manner as you would for default aircraft, but instead use the suggested method for this aircraft, or seek advice on using 3rd party hardware binding software, such as Axis and Ohs, SPAD.neXt, and FSUIPC.

Why is the state of my aircraft and radios not saved/recalled?

In order for the MSFS native state saving to work correctly, you must **shut down MSFS correctly** via the main menu, by clicking “Quit to Desktop”, NOT by pressing the red “X” on the application window, or otherwise terminating the application.

Why does the engine not fail when limits are clearly exceeded?

The engine will not fail immediately upon limit exceedances, as is true of the real engine. Different engine parameters contribute differently to reducing the health of the engine. The **“Engine Stress Failure” option must also be enabled in the MSFS Assistance menu** for the engine to fail completely. Engine condition can be monitored via the engine pages of the tablet interface.

Why do screens flicker at night when adjusting lighting intensity?

This is a long standing bug in MSFS with some graphics settings caused by the NanoVG renderer for legacy XML gauges. **Disabling NanoVG from the “Experimental” menu in General Settings** will stop the flickering. Black Square products do not use rendered XML or other legacy gauges, so there will be no impact on performance by disabling this feature.

Does this aircraft use SU 15 ground handling improvements?

Sim Update 15 in February of 2024 introduced improved ground handling simulation, **greatly enhancing crosswind landings, taxiing, and aircraft vibration**. These optional parameters were incorporated into the entire Black Square fleet within 24 hours, because the improvement was so dramatic.

Why does the flight director not disengage when I press the button on my yoke?

While the autopilot disconnect buttons in the virtual aircraft will always work as described in this manual, you must use a specific hardware binding for the autopilot disconnect button on your hardware to behave in the same way. **Use the event “AUTOPILOT_DISENGAGE_TOGGLE”, rather than “AUTOPILOT_OFF”.** This may cause the autopilots in other addon aircraft that have not implemented this feature correctly to not reengage. If this happens, just press your autopilot disconnect hardware button a second time to release the autopilot. For this reason, you can always use the “AUTOPILOT_OFF” event with Black Square aircraft, though you will have to disengage the flight director from the virtual cockpit.

Frequently Asked Questions (Aircraft Related)

Is beta range simulated?

Yes! This is a new addition to the Black Square turbine aircraft family. An accurate beta range is now fully simulated and **incorporated into the bottom 15% of forward throttle input travel**. Users who do not create virtual detents or have physical detents on their hardware peripherals will be using beta range anytime their throttle is below 15% See the “Beta Range” section of this manual for more information on beta range and the new turboprop engine simulation.

Why does it take so much power to get the aircraft moving?

The aircraft will begin moving on level ground as soon as the power lever is out of the beta range (15% throttle input). As this implementation of beta range may differ from other turboprop aircraft that you are used to flying, it may appear as if significantly more power is required to get the aircraft moving, when **in reality, you’re just advancing the power lever through the beta** range, where almost no thrust is produced. For more information on the realistic beta range implementation in this aircraft, see the “Beta Range” section of this manual.

Why do the avionics overheat or fade to black?

This aircraft has a detailed avionics temperature simulation. Properly managing avionics temperature is essential for equipment longevity and continued operation. The instrument panel and **avionics temperatures can be monitored via the cabin visualizer page on the tablet.** Detailed information on avionics temperature management can be found in the “Avionics Cooling” section of this manual.

Can you engage the autopilot without looking at the pedestal?

There is an **invisible clickspot between the two Autopilot Mode Select Panels** (MSP) that can be used to engage and disengage the autopilot.

Why do the engines overheat on start or airspeed shows “ADC”?

This aircraft will allow you to start the engines with the **engine covers installed**, and takeoff with the **pitot/static covers** installed. The covers can be removed via the payload page on the tablet. Watch for unusually slow gas generator RPM during start and the red “ADC” warning on the airspeed indicator to know if the covers are still installed.

Why will the gear not retract after takeoff?

This aircraft is equipped with **gear downlock pins**. These pins are installed after shutdown to prevent inadvertent gear retraction while the aircraft is being towed. Look in the wheel wells for red “REMOVE BEFORE FLIGHT” streamers or on the baggage shelves behind the copilot’s seat to see if the pins are removed. The pins can be removed by clicking on the baggage shelf, or via the payload page on the tablet.

Why do the yokes vibrate at high angles of attack?

This aircraft is equipped with a **stick shaker and column pusher**. When the flaps are retracted, computer systems continuously monitor the aircraft's angle of attack and airspeed to produce an early stall warning. When the stall warning is activated, the yoke will shake, and a clutched motor will attempt to lower the nose of the aircraft by pushing the yoke forward. The stall warning horn will only sound after 15 seconds of attempted stick shaker action.

Why does some equipment not work when on battery power?

This aircraft's electrical system is organized around a "triple-fed" bus system, which may be familiar to Black Square Analog King Air users. The triple-fed bus system allows for automatic load-shedding when the aircraft is operating on battery power only. **To power all the systems on the aircraft with only the battery, hold the "GEN TIES" switch to the "MAN CLOSED" position.** The electrical system can be monitored via the live schematic page on the tablet.

Why does the CRS2 knob not control the preset NAV course?

Counterintuitively, the CRS2 knob does not always control the preset NAV course. Instead, the CRS1 knob controls the pilot's side active NAV course, and the CRS2 knob controls the copilot's side active NAV course. **Both knobs will only control their respective side's preset NAV course when the on-side CDU is displaying the Preset NAV Source screen.**

Why can't I enable the autopilot?

There are **many computer systems simulated in this aircraft that may affect autopilot** operation, all of which may fail for several reasons. Check the Avionics Status screen on the MFD, the copilot's circuit breaker panel, and the tablet's failure page for any inoperative equipment that may preclude autopilot operation.

Why does the aircraft tip over or veer sideways during takeoff?

The ground handling physics added in SU15 make proper crosswind control deflection on takeoff essential. **With the ailerons deflected towards the wind, and nose-down pressure reduced during takeoff, the aircraft will not exhibit any of these behaviors**. While this might be more realistic than before SU15, the effect of nose wheel friction seems to be overdone, and will perhaps see improvements in future sim updates.

Why can't the autopilot follow GPS glideslope or procedure turns?

This aircraft was not originally equipped with GPS, and therefore is not capable of any onboard vertical guidance or modern GPS approaches; however, users of this aircraft can **use the GNS 430 mounted in the pedestal to drive the autopilot** and primary flight/navigation instrumentation by selecting the GNS as the "AP NAV SRC" on the CDU's System Control screen. See the "Garmin GNS 430 (GNS)" section of this manual for more information.

Change Log

v1.0 - Initial Release (after public preview build)

New Features:

-

Bug Fixes:

-

Credits

Black Square's Starship	Nicholas Cyganski
Publishing	Just Flight
Audio	Boris Audio Works
Starship Owners/Operators	Robert P. Scherer & Raj Narayanan
Manual	Nicholas Cyganski
Testing	Just Flight Testing Team

Dedication

It is my goal with this project to preserve one of the most innovative aircraft designs in history, along with the knowledge and techniques required to operate it. In doing so, I hope to familiarize aviation enthusiasts around the world with Starship, and the legacy of its designer. Burt Rutan is undoubtedly the greatest living aircraft designer, having been responsible for dozens of record breaking and notable aircraft, many of which hang from the ceilings of aviation museums, including the Smithsonian Institute. To name a few, Voyager - the first nonstop flight around the world without refueling, GlobalFlyer - the first solo nonstop flight around the world, Spaceship One - the first commercial human spaceflight, and Stratolaunch - the largest wingspan aircraft ever flown. Rutan has many other designs that push the boundaries of conventional aircraft design, like the commercially successful Long-EZ and Quickie homebuilts, the asymmetric twin Boomerang, and the long endurance Proteus. While most appreciate a Rutan design for its unique aesthetics, Burt Rutan's legacy of innovation has been a source of inspiration for engineering entrepreneurs for decades.

In our age of convenience and comfort, there are few opportunities to experience the harrowing stories of exploration and survival once common among sailors, pilots, and astronauts. Indeed, Dick Rutan and Jeana Yeager's flight aboard Voyager in 1986 has been called the last great aviation record. Yet, Burt Rutan has continued to set one record after another, each feeling like man's first steps upon the moon for a small group of engineers at Scaled Composites, and their reverent admirers. For those of us who wish to push the envelope of what is technologically possible, and shed a tear of respect upon the shoulders of the giants who inspired us, the many legacies of Burt Rutan surely stand among the greatest adventures of man and machine.

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